Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	9/25/2025	As build release
002	11/18/2025	General update according to input from CW, KBR logo removed from front page
003	12/3/2025	Update as agreed with S Bremner

Document Title:	**BLPH Project - Manufacturing Data Report (MDR)**
Document Number:	K559-2254-CWIWP4202202-M03-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-M03-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	M03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Sub Section M98

Index for MDR

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	1/27/2023	First Issue
002	2/10/2023	Reordered, missing items added
003	7/18/2025	Complete update of content
004	9/18/2025	Update, As build, Rev added for doc
005	11/17/2025	B99-002 included, E03-002 updated
006	12/3/2025	Updated as agreed with S Bremner

Document Title:	**BLPH Project - Index for M03**
Document Number:	K559-2254-CWIWP4202202-M98-001
Revision:	Rev006
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-M98-001Rev006
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	M98
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

MDR Index

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	J06	Rev 001	Hydrostatic and/or Pneumatic Testing Procedures
	J08-001	Rev 004	Acceptance Test Procedure (FAT)
	J08-002	Rev 001	Confirmation of Satisfactory FAT
	J08-003	Rev 003	FAT punch list
	J09-001	Rev 002	Leak Testing Procedure
	J99-001	Rev 005	Site Acceptance Test (SAT) Procedure
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	J99-003	Rev 002	Confirmation of Satisfactory SAT-Signature page
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	J99-007	Rev 001	EN 60204 Electrical safety test 40ft
	J99-008	Rev 001	EN 60204 Electrical safety test Cng Pltfrm
	J99-009	Rev 003	Ballard Method Statement
	J99-010	Rev 001	Ballard Risk assessment for container solution
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	K02-002	Rev 007	ATEX Register
	K02-003	Rev 005	ATEX Design Journal
	K02-004	Rev 002	Personnel Competences Ex Work
	K03	Rev 001	Performance Test Results
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	L09	Rev 002	Name Plate Photos
	L17	Rev 001	Proof Load Certification
	L19	Rev 001	Painting/Insulation Inspection Report

M			**Compiled Dossiers**
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	N01-002	Rev 004	Operator Manual
	N01-003	Rev 004	Service and Maintenance Manual
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	N01-006	Rev 002	Fuel Cell Module Integration Manual
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Section A

Commercial Data

Sub Subsection A01

Supplier Document Register (SDR-3)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
030	9/23/2025	As build
031	11/17/2025	Update according to comments
032	12/3/2025	Update as agreed with S Bremner

Document Title:	**BLPH Project - Supplier Document Register (SDR-3)**
Document Number:	K559-2254-CWIWP4202202-A01-001
Revision:	Rev032
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-A01-001Rev032
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	A01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Document No:	Aconex Number: BPSE-INN-BPH-REG-00005 *Legacy Number: K559-2254-CWIWP4202202-A01-001*				BLPH Project - Supplier Document Regist			
Actual Submission Date	**SDRL Code**	**Aconex Document Number**	**Legacy Document Number**	**Revision Number (All Revisions)**	**Document / Drawing Description**	**Date Returned by Purchaser**	**Purpose**	**Review code / Status**
Regularly	A01	BPSE-INN-BPH-REG-00005	K559-2254-CWIWP4202202-A01-001	Rev032	BLPH Project - Supplier Document Register (SDR-3)	3-Dec-2025	As Build	Code 1
17-Feb-2023	A03	-	K559-2254-CWIWP4202202-A03-001	Rev001	BLPH Project - Sub-Orders and Schedule	21-Mar-23	As Build	Code 1
29-Aug-2025	A99	BPSE-BMG-BPH-PLN-00005	K559-2254-CWIWP4202202-A99-001	Rev002	BLPH Project - Project-Execution-Plan	3-Sep-25	As Build	Code 1
8-Jul-2025	B01	BPSE-INN-BPH-DWG-00008	K559-2254-CWIWP4202202-B01-001	Rev010	BLPH Project - General Arrangements	11-Jul-25	As Build	Code 1
9-Aug-2024	B99	BPSE-INN-BPH-OTH-00022	K559-2254-CWIWP4202202-B99-001	Rev002	BLPH Project - Structural Calculations	9-Sep-24	As Build	Code 1
3-Oct-2025	B99	BPSE-INN-BPH-DWG-00019	K559-2254-CWIWP4202202-B99-004	Rev003	BLPH Project - Smoke and Fire detection	3-Oct-2025	As Build	Code 1
3-Oct-2025	B99	BPSE-INN-BPH-OTH-00027	K559-2254-CWIWP4202202-B99-002	Rev002	BLPH Project - Structural Calculations (Flatbed)	3-Oct-2025	As Build	Code 1
27-Jan-2025	B99	BPSE-INN-BPH-SPC-00006	K559-2254-CWIWP4202202-B99-003	Rev002	BLPH Project - Container fire resistance	N/A - For Info	As Build	Code 1
7-Oct-2025	C01	BPSE-BMG-BPH-OTH-00009	K559-2254-CWIWP4202202-C01-001	Rev003	BLPH Project - Instrument/Electrical Logic Diagrams	7-Oct-2025	As Build	Code 1
9-Sep-2025	C02	BPSE-BMG-BPH-RPT-00005	K559-2254-CWIWP4202202-C02-001	Rev003	BLPH Project - Process Flow Diagrams (PFD) & Heat/Mass Balances	15-Sep-25	As Build	Code 1
15-Sep-2025	C03	BPSE-INN-BPH-DWG-00009	K559-2254-CWIWP4202202-C03-001	Rev007	BLPH Project - P&IDs	17-Sep-25	As Build	Code 1
9-Sep-2025	C04	BPSE-BMG-BPH-OTH-00006	K559-2254-CWIWP4202202-C04-001	Rev003	BLPH Project - Bill of Materials	15-Sep-25	As Build	Code 1
15-Sep-2025	C05	BPSE-INN-BPH-DWG-00005	K559-2254-CWIWP4202202-C05-001	Rev003	BLPH Project - Piping Line List and Speciality Item List	16-Sep-25	As Build	Code 1
6-Nov-2025	C06	BPSE-ELE-BPH-DWG-00005	K559-2254-CWIWP4202202-C06-001	Rev008	BLPH Project - Electrical Single Line Diagrams	6-Nov-25	As Build	Code 1
15-Sep-2025	C07	BPSE-BMG-BPH-OTH-00008	K559-2254-CWIWP4202202-C07-001	Rev003	BLPH Project - Cause and Effects Charts	18-Sep-25	As Build	Code 1
21-Aug-2025	C08	BPSE-INN-BPH-REG-00006	K559-2254-CWIWP4202202-C08-002	Rev005	BLPH Project - Modbus Table for Main PLC	3-Sep-25	As Build	Code 1
10-Sep-2025	C08	BPSE-INN-BPH-TN-00006	K559-2254-CWIWP4202202-C08-003	Rev003	BLPH Project - Control System Alarm List	15-Sep-25	As Build	Code 1
5-Jun-2024	C08	BPSE-INN-BPH-OTH-00011	K559-2254-CWIWP4202202-C08-001	Rev004	BLPH Project - Control Philosophy & Block Logic Diagrams	23-Jul-24	As Build	Code 1
16-Apr-2024	C99	BPSE-INN-BPH-OTH-00019	K559-2254-CWIWP4202202-C99-001	Rev002	BLPH Project - Hydrogen Safety Concept	17-Apr-24	As Build	Code 1
23-Jan-2025	C99	BPSE-INN-BPH-OTH-00018	K559-2254-CWIWP4202202-C99-002	Rev002	BLPH Project - Hydrogen Preheating System Impact Assessment	7-Feb-25	As Build	Code 1
30-Nov-2023	D01	BPSE-INN-BPH-OTH-00006	K559-2254-CWIWP4202202-D01-001	Rev004	BLPH Project - Utilities Schedule	19-Dec-23	As Build	Code 1
20-Dec-2023	D03	BPSE-INN-BPH-DTS-00005	K559-2254-CWIWP4202202-D03-001	Rev002	BLPH Project - Data Sheet	23-Jan-24	As Build	Code 1
17-Feb-2023	D04	-	K559-2254-CWIWP4202202-D04-001	Rev001	BLPH Project - Noise Level Data Sheet	7-Mar-23	As Build	Code 1
2-Aug-2024	D05	BPSE-INN-BPH-DTS-00006	K559-2254-CWIWP4202202-D05-001	Rev001	BLPH Project - Material Safety Data Sheet	20-Aug-24	As Build	Code 1
15-Nov-2024	D99	BPSE-INN-BPH-DTS-00007	K559-2254-CWIWP4202202-D99-001	Rev002	BLPH Project - ATEX Components Data Sheets	2-Dec-24	As Build	Code 1
28-Oct-2025	E03	BPSE-INN-BPH-DWG-00016	K559-2254-CWIWP4202202-E03-006	Rev003	BLPH Project - Panel Cabinet Layout: UC50 AC Power Distribution	28-Oct-25	As Build	Code 1
1-Apr-2025	E03	BPSE-INN-BPH-DWG-00018	K559-2254-CWIWP4202202-E03-008	Rev001	BLPH Project - Panel Cabinet Layout: UC42 Ex Barrier Box	1-May-25	As Build	Code 1
10-Sep-2025	E03	BPSE-INN-BPH-DWG-00015	K559-2254-CWIWP4202202-E03-005	Rev002	BLPH Project - Panel Cabinet Layout: UC41 Coolant Skid VFD Cabinet	15-Sep-25	As Build	Code 1
10-Oct-2025	E03	BPSE-INN-BPH-DWG-00014	K559-2254-CWIWP4202202-E03-004	Rev003	BLPH Project - Panel Cabinet Layout: UC31 10ft Control Cabinet	10-Oct-2025	As Build	Code 1
10-Sep-2025	E03	BPSE-INN-BPH-DWG-00013	K559-2254-CWIWP4202202-E03-003	Rev002	BLPH Project - Panel Cabinet Layout: UC30 Coolant Skid Control Cabinet	15-Sep-25	As Build	Code 1
10-Oct-2025	E03	BPSE-INN-BPH-DWG-00012	K559-2254-CWIWP4202202-E03-002	Rev003	BLPH Project - Panel Cabinet Layout: UC20 40ft Control Cabinet	10-Oct-25	As Build	Code 1
27-Aug-2025	E03	BPSE-INN-BPH-DWG-00011	K559-2254-CWIWP4202202-E03-001	Rev002	BLPH Project - Panel Cabinet Layout: Introduction & Overview	1-Sep-25	As Build	Code 1
28-Mar-2025	E03	BPSE-INN-BPH-DWG-00017	K559-2254-CWIWP4202202-E03-007	Rev003	BLPH Project - Electrical Interface Documentation	16-Apr-25	As Build	Code 1
10-Sep-2025	E06	BPSE-BMG-BPH-OTH-00007	K559-2254-CWIWP4202202-E06-001	Rev003	BLPH Project - Computer System Documentation	15-Sep-25	As Build	Code 1
15-Aug-2025	E14	BPSE-INN-BPH-TN-00005	K559-2254-CWIWP4202202-E14-001	Rev003	BLPH Project - Load List	1-Sep-25	As Build	Code 1
24-Oct-2023	E99	BPSE-INN-BPH-RPT-00005	K559-2254-CWIWP4202202-E99-006	Rev001	BLPH Project - Harmonic Study Report	25-Oct-23	As Build	Code 1
26-Feb-2024	E99	BPSE-INN-BPH-OTH-00005	K559-2254-CWIWP4202202-E99-005	Rev001	BLPH Project - Fuel Cell Package Secure Remote Access	N/A - For Info	As Build	Code 1
11-Apr-2024	E99	BPSE-INN-BPH-DWG-00010	K559-2254-CWIWP4202202-E99-004	Rev002	BLPH Project - Earthing Layout	2-May-24	As Build	Code 1
28-Oct-2025	E99	BPSE-INN-BPH-OTH-00017	K559-2254-CWIWP4202202-E99-003	Rev002	BLPH Project - Cable Transits Schedule	28-Oct-2025	As Build	Code 1
30-Nov-2023	G02	BPSE-INN-BPH-OTH-00007	K559-2254-CWIWP4202202-G02-001	Rev003	BLPH Project - Process/Utility Calculations	19-Dec-23	As Build	Code 1
18-Sep-2025	G11	BPSE-BMG-BPH-SPC-00005	K559-2254-CWIWP4202202-G11-001	Rev002	BLPH Project - Reliability and Availability	22-Sep-25	As Build	Code 1
28-Oct-2025	G24	BPSE-INN-BPH-OTH-00008	K559-2254-CWIWP4202202-G24-001	Rev003	BLPH Project - Emergency Shut Down (ESD) Valve	28-Oct-2025	As Build	Code 1
20-Mar-2025	G99	BPSE-INN-BPH-OTH-00025	K559-2254-CWIWP4202202-G99-002	Rev003	BLPH Project - Intrinsically Safe Calculations	23-Apr-25	As Build	Code 1
1-May-2025	G99	BPSE-INN-BPH-OTH-00023	K559-2254-CWIWP4202202-G99-001	Rev004	BLPH Project - IEC60079-10 Analysis	13-May-25	As Build	Code 1
22-Sep-2023	H09	BPSE-INN-BPH-OTH-00009	K559-2254-CWIWP4202202-H09-001	Rev001	BLPH Project - General Performance Curves	7-Nov-23	As Build	Code 1
10-Sep-2025	J02	BPSE-INN-BPH-PRD-00006	K559-2254-CWIWP4202202-J02-001	Rev002	BLPH Project - WPS and PQR Records	15-Sep-25	As Build	Code 1
17-Jul-2024	J04	BPSE-INN-BPH-SPC-00005	K559-2254-CWIWP4202202-J04-001	Rev003	BLPH Project - Surface Preparation & Painting Specification	31-Jul-24	As Build	Code 1
15-Dec-2023	J06	BPSE-INN-BPH-OTH-00014	K559-2254-CWIWP4202202-J06-001	Rev001	BLPH Project - Hydrostatic and/or Pneumatic Testing Procedures	25-Jan-24	As Build	Code 1
19-Sep-2024	J08	BPSE-INN-BPH-PUNL-00005	K559-2254-CWIWP4202202-J08-003	Rev003	BLPH Project - FAT Punch List	N/A - For Info	As Build	Code 1
19-Sep-2024	J08	BPSE-INN-BPH-APS-00005	K559-2254-CWIWP4202202-J08-002	Rev001	BLPH Project - Confirmation of Satisfactory FAT	N/A - For Info	As Build	Code 1
4-Nov-2025	J08	BPSE-INN-BPH-OTH-00013	K559-2254-CWIWP4202202-J08-001	Rev004	BLPH Project - Acceptance Test Procedure (FAT)	4-Nov-25	As Build	Code 1
4-Nov-2025	J09	BPSE-BMG-BPH-SPC-00006	K559-2254-CWIWP4202202-J09-001	Rev002	BLPH Project - Leak Testing Procedure	4-Nov-25	As Build	Code 1
29-Nov-2024	J99	BPSE-INN-BPH-RISK-00005	K559-2254-CWIWP4202202-J99-010	Rev001	Risk Assessment - Installation of Fuel Cell Package	N/A - For Info	As Build	Code 1
16-Jan-2025	J99	BPSE-DEN-BPH-CKT-00005	K559-2254-CWIWP4202202-J99-004	Rev001	F10, Safety checklist	16-Jan-25	As Build	Code 1
24-Sep-2025	J99	BPSE-BMG-BPH-CKT-00006	K559-2254-CWIWP4202202-J99-005	Rev001	F07 u0026 F08, Electrical safety SAT	24-Sep-25	As Build	Code 1
16-Jan-2025	J99	BPSE-INN-BPH-ITP-00007	K559-2254-CWIWP4202202-J99-008	Rev001	EN 60204 Electrical safety test Cng Pltfrm	N/A - For Info	As Build	Code 1

16-Jan-2025	J99	BPSE-INN-BPH-DTS-00008	K559-2254-CWIWP4202202-J99-007	Rev001	EN 60204 Electrical safety test 40ft	N/A - For Info	As Build	Code 1
28-Feb-25	J99	BPSE-DEN-BPH-CKT-00006	K559-2254-CWIWP4202202-J99-006	Rev001	EN 60204 Electrical safety test 10ft	N/A - For Info	As Build	Code 1
16-Jan-2025	J99	BPSE-DEN-BPH-APS-00005	K559-2254-CWIWP4202202-J99-003	Rev002	Confirmation of Satisfactory SAT - Signature Page J99-003	N/A - For Info	As Build	Code 1
26-Aug-2025	J99	BPSE-INN-BPH-ITP-00006	K559-2254-CWIWP4202202-J99-002	Rev003	BLPH Project - Test Matrix for FAT and SAT	1-Sep-25	As Build	Code 1
21-Mar-2025	J99	BPSE-INN-BPH-PRD-00007	K559-2254-CWIWP4202202-J99-001	Rev005	BLPH Project - Site Acceptance Test (SAT) Procedure	1-Sep-25	As Build	Code 1
4-Nov-2025	J99	BPSE-INN-BPH-APS-00006	K559-2254-CWIWP4202202-J99-011	Rev001	BLPH Project - Completed SAT Procedure	4-Nov-25	As Build	Code 1
4-Feb-2025	J99	BPSE-INN-BPH-RISK-00006	K559-2254-CWIWP4202202-J99-010	Rev001	Ballard Risk assessment for container solution	N/A - For Info	As Build	Code 1
14-May-2025	J99	BPSE-INN-BPH-ITP-00008	K559-2254-CWIWP4202202-J99-009	Rev003	Ballard (fuel cell) Method Statement	4-Jun-25	As Build	Code 1
3-Dec-2025	K01	BPSE-INN-BPH-CER-00009	K559-2254-CWIWP4202202-K01-003	Rev004	BPSE -PED Compliance H2 Manifold addendum	1-Dec-25	As Build	Code 1
28-Feb-2025	K01	BPSE-INN-BPH-CER-00007	K559-2254-CWIWP4202202-K01-001	Rev004	BLPH Project - Code/Standard Compliance Certificate (FCwave)	29-Apr-25	As Build	Code 1
14-Feb-2025	K01	BPSE-INN-BPH-CER-00010	K559-2254-CWIWP4202202-K01-002	Rev002	BLPH Project - Code/Standard Compliance Certificate (Container Solution)	N/A - For Info	As Build	Code 1
20-Mar-2025	K02	BPSE-INN-BPH-OTH-00028	K559-2254-CWIWP4202202-K02-004	Rev002	BLPH Project - Personnel Competences Ex Work	23-Apr-25	As Build	Code 1
19-Mar-2025	K02	BPSE-INN-BPH-CER-00006	K559-2254-CWIWP4202202-K02-001	Rev005	BLPH Project - Equipment Hazardous Area Certificates & Schedule	29-Apr-25	As Build	Code 1
19-Mar-2025	K02	BPSE-INN-BPH-REG-00007	K559-2254-CWIWP4202202-K02-002	Rev007	BLPH Project - ATEX Register	23-Apr-25	As Build	Code 1
19-Mar-2025	K02	BPSE-INN-BPH-OTH-00026	K559-2254-CWIWP4202202-K02-003	Rev005	BLPH Project - ATEX Design Journal	26-Mar-25	As Build	Code 1
19-Sep-2024	K03	BPSE-INN-BPH-TRT-00006	K559-2254-CWIWP4202202-K03-001	Rev001	BLPH Project - Performance Test Results (FAT)	22-Oct-24	As Build	Code 1
13-Oct-2023	K11	BPSE-INN-BPH-TRT-00005	K559-2254-CWIWP4202202-K11-001	Rev001	BLPH Project - Ingress Protection Certificates	28-Nov-23	As Build	Code 1
1-May-2025	K12	BPSE-INN-BPH-CER-00005	K559-2254-CWIWP4202202-K12-001	Rev002	BLPH Project - Type Approval Certificates	13-May-25	As Build	Code 1
1-Dec-25	L01	BPSE-BMG-BPH-CER-00005	K559-2254-CWIWP4202202-L01-001	Rev002	BLPH Project - Material Test Certificates	1-Dec-25	As Build	Code 1
N/A	L03		K559-2254-CWIWP4202202-L03-001	Rev001	BLPH Project - Welder Performance Qualification Certificates	N/A	At Inspection	Code 1
N/A	L07		K559-2254-CWIWP4202202-L07-001	Rev001	BLPH Project - NDE Records	N/A	At Inspection	Code 1
11-Nov-2024	L09	BPSE-INN-BPH-OTH-00024	K559-2254-CWIWP4202202-L09-001	Rev002	BLPH Project - Name Plate Photos	28-Nov-24	As Build	Code 1
14-Oct-2024	L17	BPSE-INN-BPH-ITR-00005	K559-2254-CWIWP4202202-L17-001	Rev001	BLPH Project - Proof Load Certification	N/A - For Info	As Build	Code 1
15-Jul-2024	L19	BPSE-INN-BPH-INSP-00005	K559-2254-CWIWP4202202-L19-001	Rev001	BLPH Project - Painting/Insulation Inspection Report	23-Sep-24	As Build	Code 1
3-Dec-2025	M03	BPSE-BMG-BPH-RPT-00006	K559-2254-CWIWP4202202-M03-001	Rev003	BLPH Project - Manufacturing Data Report (MDR)	3-Dec-2025	As Build	Code 1
3-Dec-2025	M98	BPSE-DEN-BPH-REG-00005	K559-2254-CWIWP4202202-M98-001	Rev006	BLPH Project - Index for MDR	3-Dec-2025	As Build	Code 1
3-Dec-2025	M99	BPSE-BMG-BPH-OTH-00005	K559-2254-CWIWP4202202-M99-001	Rev006	BLPH Project - ATEX Verification Dossier	3-Dec-25	As Build	Code 1
4-Nov-2025	N01	BPSE-INN-BPH-MAN-00008	K559-2254-CWIWP4202202-N01-003	Rev004	BLPH Project - Service and Maintenance Manual	4-Nov-2025	As Build	Code 1
3-Sep-2025	N01	BPSE-INN-BPH-MAN-00007	K559-2254-CWIWP4202202-N01-002	Rev004	BLPH Project - Operator Manual	5-Sep-25	As Build	Code 1
2-Sep-2025	N01	BPSE-INN-BPH-PRD-00008	K559-2254-CWIWP4202202-N01-005	Rev002	BLPH Project - Lockout and Tagout Procedure	3-Sep-25	As Build	Code 1
11-Sep-2025	N01	BPSE-INN-BPH-MAN-00006	K559-2254-CWIWP4202202-N01-001	Rev002	BLPH Project - Integration Manual	15-Sep-25	As Build	Code 1
3-Mar-2025	N01	BPSE-INN-BPH-DTS-00009	K559-2254-CWIWP4202202-N01-006	Rev002	BLPH Project - Fuel Cell Module Integration Manual	10-Apr-25	As Build	Code 1
6-Feb-2025	N01	BPSE-INN-BPH-OTH-00031	K559-2254-CWIWP4202202-N01-007	Rev001	BLPH Project - Fuel Cell Maintenance Manual	26-Feb-25	As Build	Code 1
29-Oct-2024	N01	BPSE-INN-BPH-MAN-00009	K559-2254-CWIWP4202202-N01-004	Rev002	BLPH Project - ATEX Zone Components Maintenance	23-Apr-25	As Build	Code 1
30-Jan-2025	N02	BPSE-INN-BPH-OTH-00030	K559-2254-CWIWP4202202-N02-001	Rev003	BLPH Project - Recommended Start-up & Commissioning Spares List	3-Mar-25	As Build	Code 1
18-Sep-2025	N03	BPSE-BMG-BPH-DTS-00005	K559-2254-CWIWP4202202-N03-001	Rev003	BLPH Project - Recommended Spares for 2 Years Operating	22-Sep-25	As Build	Code 1
3-Nov-2025	N04	BPSE-BMG-BPH-CKT-00005	K559-2254-CWIWP4202202-N04-001	Rev003	BLPH Project - Special Tools List	3-Nov-25	As Build	Code 1
8-Mar-2024	N07	SHELL-INN-BPH-OTH-00056	K559-2254-CWIWP4202202-N07-001	Rev002	BLPH Project - Chemicals and Catalysts	2-May-24	As Build	Code 1
10-Jul-2024	N08	BPSE-INN-BPH-OTH-00020	K559-2254-CWIWP4202202-N08-001	Rev002	BLPH Project - Lubricants List	28-Aug-24	As Build	Code 1
10-Feb-2023	Q01	-	K559-2254-CWIWP4202202-Q01-001	Rev001	BLPH Project - Quality Manual	15-Feb-23	As Build	Code 1
27-Nov-2023	Q02	BPSE-INN-BPH-ITP-00005	K559-2254-CWIWP4202202-Q02-001	Rev003	BLPH Project - Quality Control Plan/ITP	2-Jan-24	As Build	Code 1
13-May-2025	Q99	BPSE-INN-BPH-ITR-00006	K559-2254-CWIWP4202202-Q99-001	Rev002	BLPH Project - ATEX inspections during manufacturing	16-May-25	As Build	Code 1
4-Nov-2024	R01	BPSE-INN-BPH-MAN-00005	K559-2254-CWIWP4202202-R01-002	Rev003	BLPH Project - Transport and Handling Manual	29-Nov-24	As Build	Code 1
5-Apr-2024	R01	BPSE-INN-BPH-PRD-00005	K559-2254-CWIWP4202202-R01-001	Rev001	BLPH Project - Storage Procedures and Winterization	1-May-24	As Build	Code 1
19-Sep-2025	R01	BPSE-INN-BPH-CKT-00005	K559-2254-CWIWP4202202-R01-003	Rev001	BLPH Project - Post-Transport Checklist	N/A - For Info	As Build	Code 1
27-Oct-2025	R04	BPSE-BMG-BPH-CKT-00007	K559-2254-CWIWP4202202-R04-001	Rev002	BLPH Project - Preservation and ready for Sail Away	27-Oct-2025	As Build	Code 1
8-Aug-2025		BPSE-INN-BPH-OTH-00021	CW HSSE Closeout sheet recommendation	Rev001	BLPH Project - HAZOP Close Out Sheets	12-Mar-25	As Build	Code 1

Sub Subsection A02

Fabrication-Production Schedule

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	20/01/2023	First Issue
002	17/02/2023	Modified according to comments
003	06/04/2023	Updated and expanded to L3

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NOT ACCEPTED	(Code 3)
NOT REVIEWED	(Code 4)

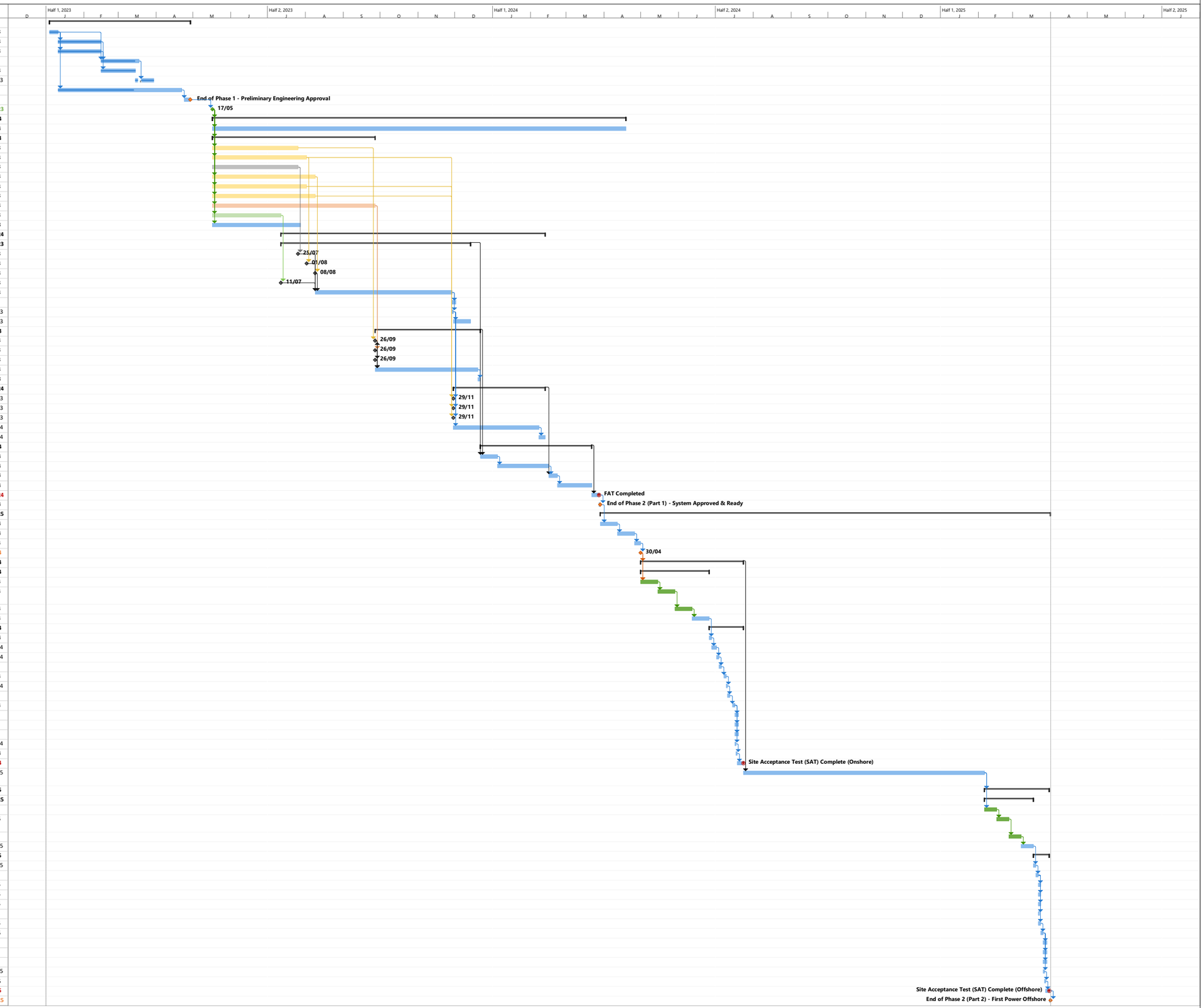
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DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - Fabrication/Production Schedule**
Document Number:	K559-2254-CWIWP4202202-A02-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-A02-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	A02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BLPH Project - Fabrication/Production Schedule

ID	Task Mode	Task	Duration	Start	Finish
1		**Phase 1 - Preliminary Engineering**	**83 days**	**Wed 04/01/23**	**Fri 28/04/23**
2	✓	Establish Activity & Resource Plan	5 days	Wed 04/01/23	Tue 10/01/23
3	✓	Develop Quality Plan	25 days	Wed 11/01/23	Tue 14/02/23
4	✓	Develop Procurement Plan	25 days	Wed 11/01/23	Tue 14/02/23
5		Project Execution Plan	23 days	Wed 15/02/23	Fri 17/03/23
6	✓	Marinization Gap Analysis	20 days	Wed 15/02/23	Tue 14/03/23
7	✓	L3 Schedule	10 days	Wed 15/03/23	Wed 29/03/23
8		Design & Verification - Document Elaboration as per SDR-3	73 days	Wed 11/01/23	Fri 21/04/23
9		**End of Phase 1 - Preliminary Engineering Approval**	5 days	Mon 24/04/23	Fri 28/04/23
10		Notice to Proceed	0 days	Wed 17/05/23	Wed 17/05/23
11		**Phase 2 (Part 1) - System Build-up**	**242 days?**	**Wed 17/05/23**	**Thu 18/04/24**
12		Further Document Elaboration as per SDR-3	242 days	Wed 17/05/23	Thu 18/04/24
13		**Procurement of Parts (Main Components)**	**95 days?**	**Wed 17/05/23**	**Tue 26/09/23**
14		Pumps	50 days?	Wed 17/05/23	Tue 25/07/23
15		Containers	55 days?	Wed 17/05/23	Tue 01/08/23
16		*FCwaves*	50 days?	Wed 17/05/23	Tue 25/07/23
17		DC/DC Cabinets	60 days?	Wed 17/05/23	Tue 08/08/23
18		Transformer	55 days?	Wed 17/05/23	Tue 01/08/23
19		DC/AC Cabinet	60 days?	Wed 17/05/23	Tue 08/08/23
20		HT & LT Coolers	95 days?	Wed 17/05/23	Tue 26/09/23
21		Master Controller Cabinet	40 days?	Wed 17/05/23	Tue 11/07/23
22		Prepare production	52 days	Wed 17/05/23	Thu 27/07/23
23		**Production of Systems**	**154 days**	**Tue 11/07/23**	**Mon 12/02/24**
24		**40' HC Container Build**	**111 days**	**Tue 11/07/23**	**Wed 13/12/23**
25		FCwaves on-site	0 days	Tue 25/07/23	Tue 25/07/23
26		40' HC Container on-site	0 days	Tue 01/08/23	Tue 01/08/23
27		DC/DC cabinets on-site	0 days	Tue 08/08/23	Tue 08/08/23
28		Master Controller cabinet on-site	0 days	Tue 11/07/23	Tue 11/07/23
29		40' HC Container Build	80 days	Wed 09/08/23	Tue 28/11/23
30		Build Control	3 days	Wed 29/11/23	Fri 01/12/23
31		Control Software Installation	1 day	Wed 29/11/23	Wed 29/11/23
32		Basic I/O Testing	10 days	Thu 30/11/23	Wed 13/12/23
33		**Cooler Platform Build**	**62 days**	**Tue 26/09/23**	**Thu 21/12/23**
34		Pumps on-site	0 days	Tue 26/09/23	Tue 26/09/23
35		HT & LT Coolers on-site	0 days	Tue 26/09/23	Tue 26/09/23
36		Platform on-site	0 days	Tue 26/09/23	Tue 26/09/23
37		Cooler Platform Build	60 days	Wed 27/09/23	Tue 19/12/23
38		Build Control	2 days	Wed 20/12/23	Thu 21/12/23
39		**10' HC Container Build**	**53 days**	**Wed 29/11/23**	**Mon 12/02/24**
40		10' HC Container on-site	0 days	Wed 29/11/23	Wed 29/11/23
41		DC/AC Cabinet on-site	0 days	Wed 29/11/23	Wed 29/11/23
42		Transformer on-site	0 days	Wed 29/11/23	Wed 29/11/23
43		10' HC Container Build	50 days	Thu 30/11/23	Wed 07/02/24
44		Build Control	3 days	Thu 08/02/24	Mon 12/02/24
45		**Integration Testing**	**65 days**	**Fri 22/12/23**	**Thu 21/03/24**
46		Installation of 40' HC Container with Cooler Platform	10 days	Fri 22/12/23	Thu 04/01/24
47		DC System Integration Testing	30 days	Fri 05/01/24	Thu 15/02/24
48		Integration with AC System	5 days	Fri 16/02/24	Thu 22/02/24
49		Full System Integration Testing	20 days	Fri 23/02/24	Thu 21/03/24
50		Factory Acceptance Test (FAT)	4 days	Fri 22/03/24	Wed 27/03/24
51		**End of Phase 2 (Part 1) - System Approved & Ready**	1 day	Thu 28/03/24	Thu 28/03/24
52		**Phase 2 (Part 2) - Installation & Commissioning**	**262 days**	**Fri 29/03/24**	**Mon 31/03/25**
53		System Disassembly	10 days	Fri 29/03/24	Thu 11/04/24
54		Preparation for Shipment	10 days	Fri 12/04/24	Thu 25/04/24
55		Shipment to site	3 days	Fri 26/04/24	Tue 30/04/24
56		**Delivery on site**	0 days	Tue 30/04/24	Tue 30/04/24
57		**On-site Installation & Commissioning (Onshore)**	**60 days**	**Wed 01/05/24**	**Tue 23/07/24**
58		**Installation**	**40 days**	**Wed 01/05/24**	**Tue 25/06/24**
59		Unloading, Lifting & Positioning (CrossWind Scope)	10 days	Wed 01/05/24	Tue 14/05/24
60		Mechanical Installation & Connection of Sub-Assemblies (CrossWind Scope)	10 days	Wed 15/05/24	Tue 28/05/24
61		Connection of Interfaces (CrossWind Scope)	10 days	Wed 29/05/24	Tue 11/06/24
62		Installation Check & Possible Adjustments (Joint Activity)	10 days	Wed 12/06/24	Tue 25/06/24
63		**Commissioning**	**20 days**	**Wed 26/06/24**	**Tue 23/07/24**
64		Safety Checklist	2 days	Wed 26/06/24	Thu 27/06/24
65		Supply Line Purging	2 days	Fri 28/06/24	Mon 01/07/24
66		Preliminary Mechanical & Electrical Connections Check	2 days	Tue 02/07/24	Wed 03/07/24
67		LV Electrical Interface Check	2 days	Thu 04/07/24	Fri 05/07/24
68		Safety System Check	2 days	Mon 08/07/24	Tue 09/07/24
69		Standby State Check	1 day	Wed 10/07/24	Wed 10/07/24
70		Fault Response Check	2 days	Thu 11/07/24	Fri 12/07/24
71		Coolant Fill & Dearate	2 days	Mon 15/07/24	Tue 16/07/24
72		Air Delivery Start Check	3 days	Wed 17/07/24	Fri 19/07/24
73		Hydrogen Delivery Start Check	3 days	Wed 17/07/24	Fri 19/07/24
74		Final Mechanical & Electrical Connections Check	3 days	Wed 17/07/24	Fri 19/07/24
75		Initial Operation in Low Power Mode	1 day	Wed 17/07/24	Wed 17/07/24
76		Operation at Rated Power	1 day	Thu 18/07/24	Thu 18/07/24
77		Site Acceptance Test (SAT) Complete (Onshore)	3 days	Fri 19/07/24	**Tue 23/07/24**
78		Onshore Demonstration/Testing Period (CrossWind Activity, Ballard to Support when needed)	141 days	Wed 24/07/24	Wed 05/02/25
79		**On-site Installation & Commissioning (Offshore)**	**53 days**	**Thu 06/02/25**	**Sun 30/03/25**
80		**Installation**	**28 days**	**Thu 06/02/25**	**Mon 17/03/25**
81		Transport to offshore location (CrossWind Scope)	10 days	Thu 06/02/25	Sat 15/02/25
82		Mechanical Installation & Fixation of Platform (CrossWind Scope)	10 days	Sun 16/02/25	Tue 25/02/25
83		Connection of Interfaces, as necessary (CrossWind Scop	10 days	Wed 26/02/25	Fri 07/03/25
84		Installation Check & Possible Adjustments (Joint Activity)	10 days	Sat 08/03/25	Mon 17/03/25
85		**Commissioning**	**13 days**	**Tue 18/03/25**	**Sun 30/03/25**
86		Safety Checklist	2 days	Tue 18/03/25	Wed 19/03/25
87		Supply Line Purging	2 days	Thu 20/03/25	Fri 21/03/25
88		Preliminary Mechanical & Electrical Connections Check	2 days	Sat 22/03/25	Sun 23/03/25
89		LV Electrical Interface Check	2 days	Sat 22/03/25	Sun 23/03/25
90		Safety System Check	2 days	Sat 22/03/25	Sun 23/03/25
91		Standby State Check	1 day	Sat 22/03/25	Sat 22/03/25
92		Fault Response Check	2 days	Sat 22/03/25	Sun 23/03/25
93		Coolant Fill & Dearate	2 days	Mon 24/03/25	Tue 25/03/25
94		Air Delivery Start Check	3 days	Wed 26/03/25	Fri 28/03/25
95		Hydrogen Delivery Start Check	3 days	Wed 26/03/25	Fri 28/03/25
96		Final Mechanical & Electrical Connections Check	3 days	Wed 26/03/25	Fri 28/03/25
97		Initial Operation in Low Power Mode	1 day	Wed 26/03/25	Wed 26/03/25
98		Operation at Rated Power	1 day	Thu 27/03/25	Thu 27/03/25
99		Site Acceptance Test (SAT) Complete (Offshore)	3 days	Fri 28/03/25	**Sun 30/03/25**
100		**End of Phase 2 (Part 2) - First Power Offshore**	1 day	Mon 31/03/25	Mon 31/03/25



Sub Subsection A03

Sub-Orders and Schedule

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	17/02/2023	First Issue

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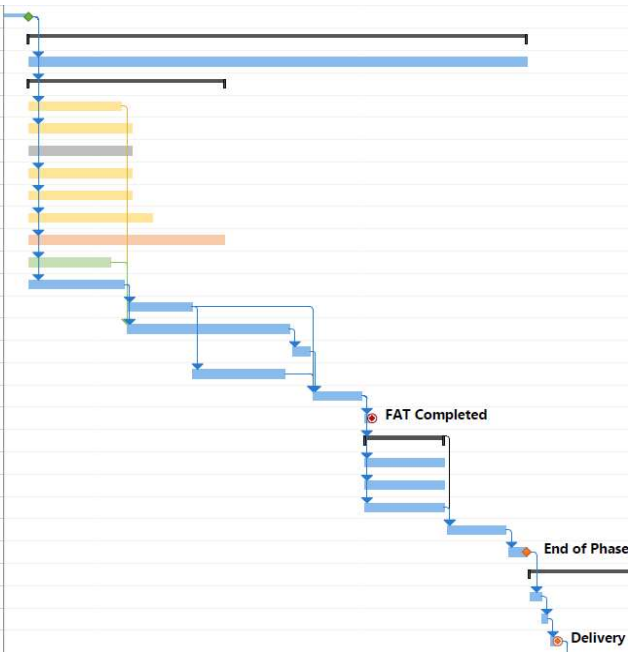
Document Title:	**BLPH Project - Sub-Orders and Schedule**
Document Number:	K559-2254-CWIWP4202202-A03-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-A03-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	A03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Title:	**Sub-Orders and Schedule**	Version:	Rev001
Description:	1 MW Power Container	Date:	February 17, 2023

Main Component	Expected Order Date	Supplier (if known)	Current Lead Time	Latest Date to Place Order*
HT Pumps	18/05/2023	Grundfos	9 weeks	01/06/2023
LT Pump	18/05/2023	Grundfos	9 weeks	01/06/2023
Container	18/05/2023		10 weeks	18/05/2023
FCwave™	-	Ballard	-	-
DC/DCs + Filters	18/05/2023	Danfoss	10+ weeks	18/05/2023
DC/AC + Filters	18/05/2023	Danfoss	12+ weeks	18/05/2023
Transformer	18/05/2023		10+ weeks	18/05/2023
HT Coolers	18/05/2023	Evapco	16-19 weeks	18/05/2023
LT Cooler	18/05/2023	Evapco	16-19 weeks	18/05/2023
Master Controller	18/05/2023	DEIF	8 weeks	08/06/2023

*For solution to be ready for shipment on April 30, 2024

11	Notice to Proceed	33 days	Mon 03/04/23	Wed 17/05/23
12	**Phase 2 (Part 1) - System Build-up**	**242 days?**	**Thu 18/05/23**	**Fri 19/04/24**
13	Further Document Elaboration as per SDR-3	242 days	Thu 18/05/23	Fri 19/04/24
14	**Procurement of Parts (Main Components)**	**95 days?**	**Thu 18/05/23**	**Wed 27/09/23**
15	Pumps	45 days?	Thu 18/05/23	Wed 19/07/23
16	Container	50 days?	Thu 18/05/23	Wed 26/07/23
17	*FCwaves*	50 days?	Thu 18/05/23	Wed 26/07/23
18	DC/DC Converters + Filters	50 days?	Thu 18/05/23	Wed 26/07/23
19	Transformer	50 days?	Thu 18/05/23	Wed 26/07/23
20	DC/AC Converter + Filters	60 days?	Thu 18/05/23	Wed 09/08/23
21	HT & LT Coolers	95 days?	Thu 18/05/23	Wed 27/09/23
22	Master Controller	40 days?	Thu 18/05/23	Wed 12/07/23
23	Prepare production	47 days	Thu 18/05/23	Fri 21/07/23
24	Prepare test setup	32 days	Mon 24/07/23	Tue 05/09/23
25	Production of Systems	80 days	Mon 24/07/23	Fri 10/11/23
26	System Review	10 days	Mon 13/11/23	Fri 24/11/23
27	SW Testing (according to test specifications)	45 days	Wed 06/09/23	Tue 07/11/23
28	Unit Testing (according to test specifications)	25 days	Mon 27/11/23	Fri 29/12/23
29	Factory Acceptance Test (FAT)	5 days	Mon 01/01/24	Fri 05/01/24
30	Documentation	40 days	Mon 01/01/24	Fri 23/02/24
31	Integration Manual	40 days	Mon 01/01/24	Fri 23/02/24
32	Service Manual	40 days	Mon 01/01/24	Fri 23/02/24
33	Work Instructions	40 days	Mon 01/01/24	Fri 23/02/24
34	Certification	30 days	Mon 26/02/24	Fri 05/04/24
35	**End of Phase 2 (Part 1) - System Approved & Ready**	10 days	Mon 08/04/24	Fri 19/04/24
36	**Phase 2 (Part 2) - Installation & Commissioning**	**311 days**	**Mon 22/04/24**	**Mon 30/06/25**
37	Preparation for Shipment	6 days	Mon 22/04/24	Mon 29/04/24
38	Shipment to site	4 days	Tue 30/04/24	Fri 03/05/24
39	**Delivery on site**	5 days	Mon 06/05/24	Fri 10/05/24



Sub Subsection A99

Project Execution Plan

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	Date.	Description
2	18/08-2025	Front page added

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Document Title:	BLPH Project - Project Execution Plan
Document Number:	K559-2254-CWIWP4202202-A99-1
Revision:	Rev002
Sequence Number:	1
File Name:	K559-2254-CWIWP4202202-A99-1Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	A99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BLPH Project

Project Execution Plan

1 MW Fuel Cell Containerized Solution

K559-2254

CW-I-WP4-2022-02

Prepared for:

CrossWind C.V.
Hofplein 20
3032 AC Rotterdam
The Netherlands

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3. Project Schedule 7
4. Project Resources 9
5. Project Budget 11
6. Quality Management 14
7. Risk Management 16
8. Project Closure 17

1. Introduction

The purpose of this Project Execution Plan is to provide a detailed overview of the project to design, build, deliver, and commission a 1 MW containerized fuel cell solution for CrossWind's BLPH (Baseload Power Hub) Project.

The BLPH project is a demonstrator project that encompasses several new technologies (i.e. a floating solar park, a short-term battery storage, an electrolyzer, a hydrogen storage system and a fuel cell system) that will be integrated with one of the wind turbine generators of an offshore wind farm, located 18.5km off the coast of The Netherlands. The combination of all these technologies is expected to balance the intermittent electricity production of the wind turbine, ensuring a continuous power supply regardless of the wind situation.

The 1 MW containerized fuel cell solution for the BLPH project will consist of hardware, software, and infrastructure components and will enable CrossWind to generate electricity from the onboard stored hydrogen during periods of low or no wind.

The scope of this project includes the design and development of the system, the procurement of all necessary components, the assembly and testing of the system, and the commissioning and handover of the system to CrossWind, as referred to in the contract CW-I-WP4-2022-02.

The project team will be composed of engineers, technicians, and project managers that will work closely together to ensure that the project is delivered on time, within budget, and to the satisfaction of all stakeholders. Effective and efficient communication, good collaboration, and strong decision-making will be critical to the success of the project. Ballard will establish clear lines of communication and decision-making authority throughout the project.

This plan outlines the organizational structure of the project team, including roles and responsibilities, reporting relationships, and communication channels. It also provides a detailed schedule that includes key milestones and deadlines. Additionally, the plan includes details about the project budget. Finally, the plan outlines the quality assurance and risk management strategies for the project and establishes a plan for closing out the project.

2. Project Organization and Communication

The project team will consist of the following individuals and/or roles:

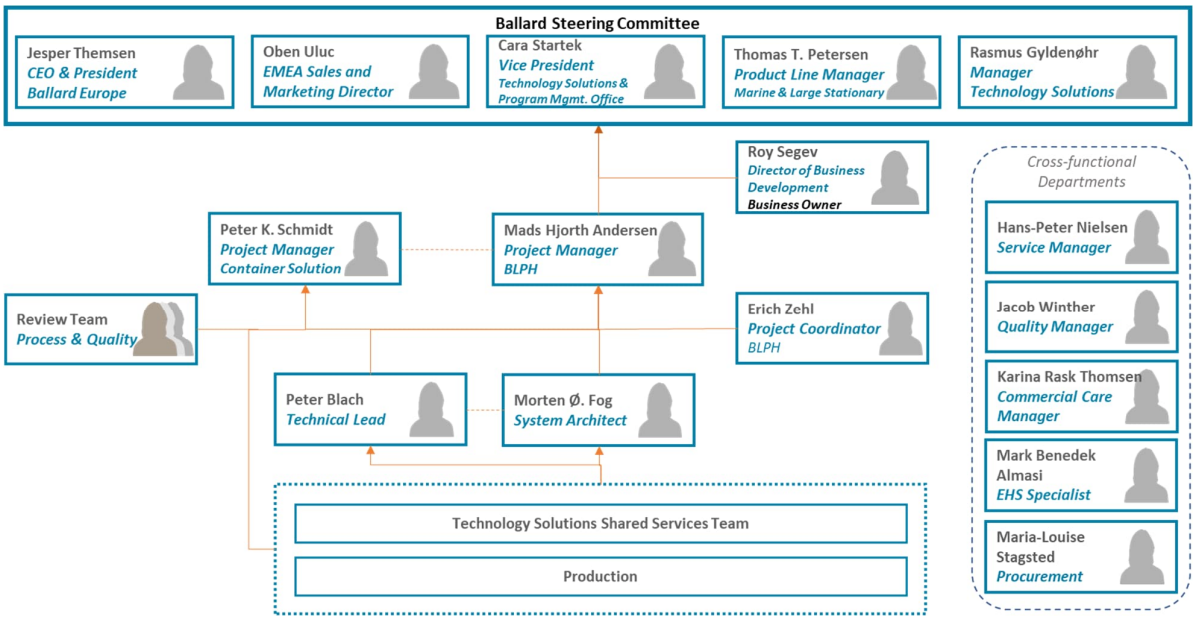


Figure 1. BLPH project organizational chart (Ballard internal).

Each team member has specific roles and responsibilities in the project. The Project Manager of the BLPH Project (henceforth referred to simply as Project Manager) is responsible for overall project management, including project planning, scheduling, budgeting, and reporting. The System Architect is responsible for overseeing the technical aspects of the project, including system design and development. The Technical Lead supports the System Architect and, together with the System Architect, coordinates activities within the Technology Solutions Shared Services Team. The Review Team evaluates and advises on design documentation, processes, methods, etc. The Review Team may have different members depending on the items being reviewed. The Project Manager of the Container Solution (not to be confused with Project Manager of the BLPH Project) coordinates closely with the Project Manager for the BLPH Project and is responsible for the overall project management of Ballard's "standard" container solution for large stationary applications, which serves as the technical basis for the BLPH Project. The Business Owner assists the Project Manager in providing leadership for and managing the team's performance of project activities.

Outside of the core project team, there are cross-functional departments that contribute to the project with their respective fields of expertise as required by the project. The Service Manager oversees and guides all activities related to service, including SLA (Service-level Agreement) creation and implementation. The Quality Manager is responsible for ensuring that the project meets all quality standards and requirements. The Commercial Care Manager is responsible for controlling project finances and deliverables. The EHS Specialist oversees the implementation of Ballard's safety policies and regulations. The Procurement Representative supports all purchasing activities and ensures the security of supply and quality of the product.

In addition to the project team, we will establish an internal Steering Committee composed of key managers. The Steering Committee will provide oversight and guidance throughout the project and will be responsible for making key decisions related to scope, budget, and schedule. The Project Manager will report regularly to the Steering Committee on project status, risks, and issues.

Effective communication is critical to the success of the project, therefore it is essential to ensure that project information is communicated to the relevant stakeholders in a timely and effective manner. To this purpose, the project team will meet regularly to review progress, discuss issues, and make decisions. The team will communicate primarily through internal weekly meetings and daily status updates, as well as through email, telephone, video calls and instant messaging. All team members are expected to communicate clearly and promptly, and to escalate any issues or concerns to the appropriate party as needed.

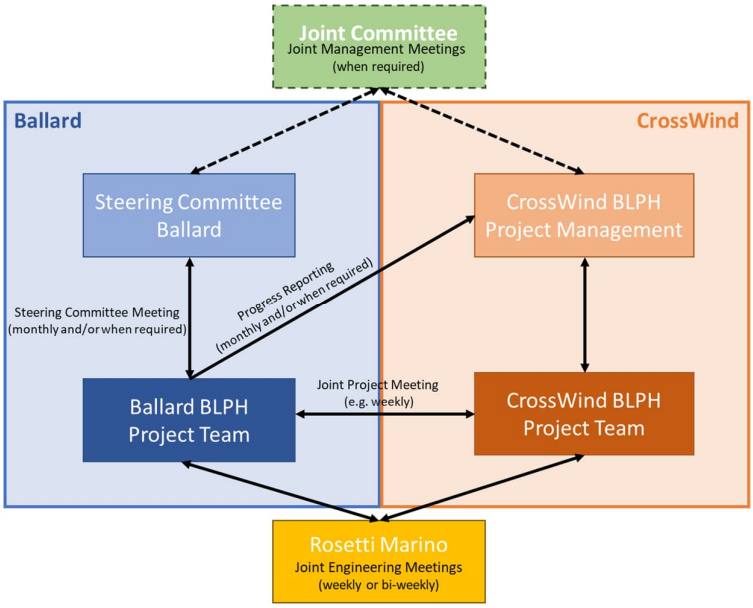


Figure 2. Communication diagram between Ballard, CrossWind and Rosetti Marino for the BLPH Project.

Communication with CrossWind will primarily take place through joint project meetings, for example in the form of technical regular meetings (weekly or bi-weekly), as well as through email, telephone, video calls and instant messaging, as needed. In addition, tripartite regular technical meetings (weekly or bi-weekly) between Rosetti Marino (Platform Integrator), CrossWind and Ballard will take place, organized and led by Rosetti Marino. Furthermore, the Project Manager will report monthly (and/or when required) to the CrossWind BLPH Project Management on project status, risks, and issues.

In case an issue with a potentially significant impact on the project arises and it is deemed that a further escalation step is needed to address the issue, a joint management meeting will be organized to discuss the matter. This process ensures that all stakeholders are adequately informed and have the opportunity to provide input and feedback before any decisions are made.

The Project Manager will be responsible for ensuring effective and timely communication throughout the project. If the Project Manager believes that adjustments to the project

organization and/or communication methods would improve communication, he or she may make those adjustments with prior approval of the Steering Committee, and in agreement with CrossWind, if applicable. This ensures that the Project Manager has the flexibility to adapt to the changing needs of the project.

General communication and updates regarding scheduling and technical updates from external suppliers to the CrossWind project is very much appreciated. Ballard is expecting updates from Shell/CrossWind if any significant changes which will have an impact on Ballard delivery and timing or if the external suppliers expect that there will be an impact. It is expected that those changes will be communicated in such time that Ballard is able to react appropriately to the changes if needed.

3. Project Schedule

The project schedule outlines the timeline for all project activities, including design, procurement, development, testing, commissioning, and handover. The schedule takes into account resource availability, critical paths, and potential risks and delays. The project will be executed in three phases, as outlined below:

Phase 1: Initial Delivery of Engineering Data / Project Initiation and Planning

During this phase, the project team will deliver engineering data (as per the SDRL) to enable the integration of the fuel cell system into the overall Topsides Design of the BLPH, develop a detailed project plan, carry out a marinization gap analysis, attend design reviews if needed, and update the technical specifications.

Phase 2: Container Solution Build, Installation and Commissioning

During this phase, the project team will conclude the development of the system and freeze the design, followed by the procurement, fabrication, construction, testing, shipping, erection, installation, and commissioning of the equipment, concluding with the handover of the container solution to CrossWind. The team will also provide further engineering data (as per the SDRL) and provide the final documentation.

This Phase is further divided into two parts; Part 1 includes System Build-Up and Testing, Part 2 includes Shipping, Installation & Commissioning.

Phase 3: Demonstration Period Support (not detailed in this Project Execution Plan)

During this phase, the project team will support the demonstration period of the BLPH Topsides by providing maintenance services of the system.

The project schedule will be updated regularly throughout the project to reflect progress and any changes in scope or timelines. The Project Manager will communicate any schedule changes internally to the project team and Steering Committee, as well as externally to the customer, as required.

Shown below is the baseline/original schedule at effective date (start of contract), considering the original set of key dates as discussed at the Kick-off meeting for Phase 1. The schedule can also be found in the separate file *BLPH-Ballard-Fuel-Cell_Proposed-Baseline_Rev001.pdf*.

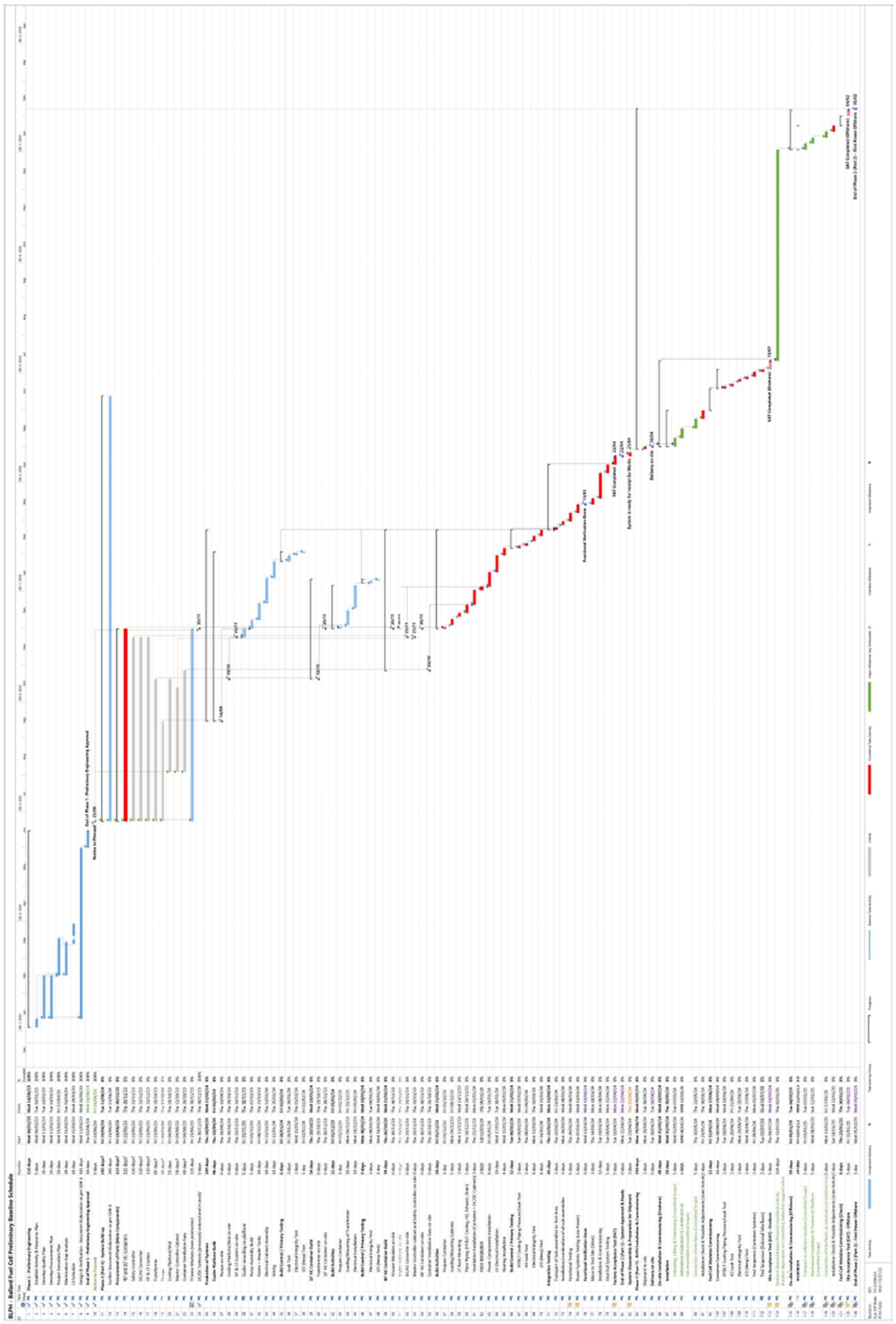


Figure 3. Baseline/original project schedule at effective date.

Assumptions and Constraints

Assumptions:

- Resources (i.e. facilities, supplies, materials, and personnel) are available when expected/required.
- Manufacturing activities run without major complications and personnel is capable of completing their tasks in the expected timeframe and at the expected level of quality.
- Testing runs without major unexpected complications.
- No major change in scope is required.

Constraints:

- Time: Handover date is April 30, 2024.
- Scope: As per contract and tech. specifications document K559-2254-ME-SPE-003.
- Resources: Available production/testing facilities and skilled personnel.

Available Facilities

Production/Warehouse:

- Location: Lupinvej 5, Hobro, Denmark.
  - Current production capacity (limited by floor area) is for 2 full container solutions (incl. all sub-assemblies) simultaneously.

Testing:

- Location: Majsmarken 1, Hobro, Denmark.
  - Capability for full system testing.
  - Hydrogen delivered by trailer.

Calendar Workability

- Important holidays are considered as non-working days and taken into account in the project schedule:
  - Christmas Break
  - Easter
  - Public holidays in Denmark
- A normal 5-day working week was assumed for all onshore work.

Critical Path

The critical path is defined by and can be impacted by the following points:

- Build activities of 40 ft container
  - Activities must be done in great part sequentially due to the limited space inside the containers.
- Integration testing
  - Initial/primary testing is done directly in the production facilities (where there is no access to hydrogen or a load bank) for each sub-assembly.
  - Integration testing is then carried out with all the sub-assemblies combined and carried out entirely at Ballard's own testing facilities.

4. Project Resources

For executing this project, Ballard was allocated some dedicated resources for this project to be successful. The resource allocation is a part of the structure in Ballard to prevent delays due to lack of personnel. The allocation is requested by the project manager. The project manager can request from a list of generic resources. The internal department manager from Ballard then reviews the requested resources, and afterwards allocates the resource to the project manager hereby making an agreement on the availability of the resource. As part of the agreement, the project manager and department manager will convert the generic resource to a specific team member hereby making the project team. The selection of which team members, who is to be a part of the project team, is an evaluation of personal competences and already allocated hours to the individual person on different projects. This ensures that the team members are of the right quality and are available for the project to be executed. Additionally, this also prevents overallocation, which can over time trigger unexpected absence for a team member.

For this project the agreement for the generic resources is as follows:

Table 1. Overview of estimated resources for Phase 2.

Resource Name	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
Project Manager	130	130	20	130	130	50	130	130	130	130	130	130	130	130	130	30	30	30	30	30
System Architect	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10					
Application Engineer	10	10	10	10	10	10	10	10	10	10	10	10	80	40	40					
Mechanical Engineer				40	40															
Electrical Engineer				40	40															
Software Engineer	20	20			40	40	40	50	50	20	20	20	20							
Production Technician					40	40	40	260	260	260	260	60	60							
Electrical Technician					10	10	10	130	130	130	130	60	60							
Test Engineer									20	40	60	60	130							
Documentation Engineer	20	20							40	40	40	40	40							
Supply Chain		10	10	10	10	10	10	10	10	10	10	10	10							

Note that this is only an estimation of the resource needed. The resource estimate will be reviewed once every month. This will be done internally in Ballard together with the department manager and the project managers for different projects in the department. At this review, the project managers can adjust their estimates. Adjustments will then have to go through the process of allocating/deallocating before having a new agreement. This will prevent loss of resources for projects which already have an agreement on the resources.

The project will also use external resources which are booked from either a different department within Ballard or from business partners in the field. The typical time from booking a resource to the resources starting to work will be around 14 days to a month depending on the business partner and requested time. The request of a resource from a different department within Ballard will be made by the project manager together with the department manager.

5. Project Budget

The total project budget for the design, build, delivery, and commissioning of the 1 MW containerized fuel cell solution for the BLPH project is EUR 4,067,004. The budget includes all costs associated with Phase 1 and Phase 2 of the project, including personnel, materials, and equipment, as specified in the contract.

The project budget is broken down as follows:

Table 2. Detailed breakdown of project budget.

	Description	Unit of Measurement	Quantity		Total
1	Stationary fuel cell system – AC solution	unit	1	€ 624,075	€ 624,075
2	Cooling	unit	1	€ 157,775	€ 157,775
3	FCwave™ - 200kW[4]	ea	6	€ 345,000	€ 2,070,000
4	Stationary fuel cell system 1,2 MW – Fuel cell power: - Integration of Fuel cell, power & heat management system - Skid/shelter/cover - Electrical/mechanical installation of Fuel Cells & related BOP - Safety system integration	unit	1	€ 991,018	€ 991,018
5	All Certificates required by the CONTRACT including offshore certification of Fuel Cell				included
6	Installation and Operation Manual				included

7	Packaging & Marking				included
8	Testing (All temporary and permanent testing)				included
9	Commissioning & Installation Spares	LOT	1	€ 35,136	€ 35,136
10	Final Documentation				included
11	Application engineering provided by Ballard's Application Engineers to support integration in phases 1 & 2. Includes Answering questions from the integration manual, interface control diagram and CAN matrix, Discussions and feedback on integration to other plant systems, FAT test results and, on/offshore support	LS			€ 80,000
12	Installation and/or start-up services incl. commissioning onshore and offshore	LS			€ 109,000
	FCA, Incoterms 2020, CONTRACTOR's Facility, Hobo, Denmark				€ 4,067,004

The above-mentioned budget is reflected in the project's payment schedule, which is broken down by milestones which is defined in the contract CW-I-WP4-2022-02 and is outlined below:

Table 3. Detailed breakdown of project milestones.

Milestone	Description	Documents	Issue Date	Amount
Phase 1 – Data Engineering Phase				
MS01	At contract signature	Signed contract, parental guarantee	January 2023	€ 81,340.02 (2%)
MS02	End of Phase 1	Phase 1 Completion Cert.	June 2023	€122,010.12 (3%)
MS03	Notice to Proceed	Signed NTP	June 2023	€ 203,350.20 (5%)
Phase 2 – Fabrication Activities				
MS04	Placement of POs for main components	Copies of unpriced POs	August 2023	€1,626,801.60 (40%)
MS05	Receipt of main components and start of manufacturing	Copies of material receipts with date of receival	December 2023	€813,400.80 (20%)
MS06	Satisfactory testing and plant ready for receipt EXW	Signed Handover Certificate	June 2024	€ 1,016,751.00 (25%)
MS07	Final documentation received	Code 1 achieved	August 2024	€ 203,350.20 (5%)

The Project Manager will monitor the budget throughout the project to ensure that costs are kept within the approved budget. The Project Manager will also report regularly to the Steering Committee (and where appropriate also to CrossWind Project Management) on budget status, any changes or issues, and recommendations for managing costs. Any significant changes to the budget will require approval firstly from the Steering Committee and finally by CrossWind Project Management by means of the Change Management process (to be agreed by CrossWind and Ballard).

6. Procurement

dafdafdafad

7. Quality Management

The goal of the quality management plan is to ensure that the 1 MW containerized fuel cell solution is designed, built, delivered, and commissioned to meet the highest standards of quality. The quality management plan will be executed by the project team in accordance with the company's quality management policies and procedures.

Ballard's quality policy is centered on customer satisfaction, doing things right first time, and continuous improvement in pursuit of zero defects. To achieve that, reviews, measurements and control processes are put in place, such as KPIs, monthly management reviews (in the form of a Quality Council), internal audits, and external audits (e.g. customers, IATF 16949, ISO 9001).

External certifications:

- ISO 9001:2015 – Successful surveillance audit in November 2022
- ISO 14001 (environmental) – Planed certification in Q2 2023
- ISO 45001:2018 (occupational health & safety) – Planed certification in Q2 2023

To ensure quality on procured goods, a supplier management process is implemented. The supplier management process is composed of the following elements:

1. Supplier Qualification: Audits of potential suppliers are carried out before approval for Quality Systems and capabilities (e.g. QMS, Ethics, Conflict Minerals, Cybersecurity, etc.)
2. Supplier APQP and PPAP: Suppliers are assessed according to their Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) and how well these suit Ballard's internal maturity levels (concept, prototype). Furthermore, change management control is also implemented, and Incoming Inspections (FAI) are carried out to verify product and supplier information.
3. Supplier Scorecard: KPIs (such as OTD, NCRs, Cost of Quality) are continuously monitored in a Supplier Scorecard.

For the BLPH 1 MW containerized fuel cell solution, the following Quality Control Plan / Inspection Test Plan will be implemented:

Table 4. High-level Quality Control Plan / Inspection Test Plan.

Step No.	Inspection and Test Plan Activity		Reference Document	Acceptance Criteria	Verifying Document	Expected Completion Date	Actual Completion Date	Client Witnessing
FCwave™ 200 kW Fuel Cell Modules								
1	Goods received		Delivery note	Specification	ERP system DAX			
2	Incoming inspection		IQC control plan / Aiman	Specification	ERP system DAX			
3	Inline production control		Work instruction / Aiman	Specification	Aiman			
4	Birth certificate is issued		Standard birth certificate	Completed birth certificate	Birth certificate			
5	1.0 FAT 001 Pre-operational tests		FAT procedure / FAT report	Specification	FAT report	November 15, 2023		Review
6	2.0 FAT 001 SYS LVL function check		FAT procedure / FAT report	Specification	FAT report	November 30, 2023		Review
7	3.0 FAT 001 Post FAT check		FAT procedure / FAT report	Specification	FAT report	November 30, 2023		Review
8	Down pol curve		FAT procedure / FAT report	Specification	FAT report	November 30, 2023		Review
9	Certificate of performance (CoA)		FAT procedure / FAT report	Specification	CoA certificate	December 1, 2023		Review
1 MW Fuel Cell Power Container								
10	Goods received (container components)		Delivery note	Specification	1. ERP system DAX (internal) 2. Copy of materials receipt with receival date (to client)	December 15, 2023		Review / Approval [MS05]
11	Incoming inspection		IQC control plan	Specification	ERP system DAX	December 15, 2023		-
12	Container build control (Assembly Verification)		Work instruction	Specification	Aiman (tbc)	February 29, 2024		Review
13	Container birth certificate is issued		Standard birth certificate	Completed birth certificate	Birth certificate	April 1, 2024		-
14	Container FAT	*(Pre-operational Testing)*	FAT procedure / FAT report	Specification	FAT report	March 15, 2024		Review
		(Operational Testing)				April 22, 2024		Witness
15	Container certificate of performance (CoA)		FAT procedure / FAT report	Specification	CoA certificate	April 26, 2024		Review
16	Container ready for receipt Ex-Works		FAT procedure / FAT report	Specification	Signed HANDOVER CERTIFICATE	April 30, 2024		Approval [MS06]

CrossWind will carry out an inspection at Ballard's facilities in Hobro during Phase 2 of the project to verify items from sub-section L of the SDRL, which will also form part of the Manufacturing Data Report (MDR):

- L = Certification Data (Works Review): Material Test Certificates, Welder Performance Qualification Certificates, NDE Operator Qualification Certificates, Production Test Results, NDE Records, Material traceability Records/System, Calibration Certificates, Pressure Test Certificates, Dimensional Report, Routine Test Certificate – Electrical Equipment, Measurement of Resistance (Bus Bars), Purchasers Inspection Completion Notes/Waivers, Painting/Insulation Inspection Report, Certificate of Conformity

The Project Manager will be responsible for ensuring that the quality management plan is implemented and executed effectively. The Project Manager will also report regularly to the Steering Committee on quality status, any potential issues, and recommendations for improving quality. Any significant changes to the quality management plan will need to be approved by the Steering Committee.

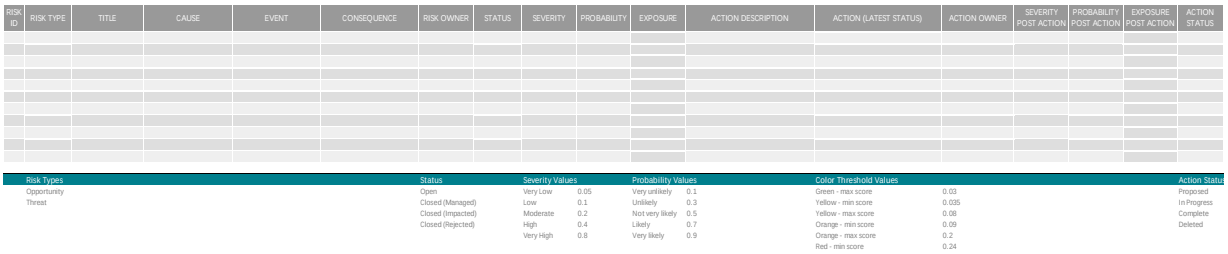
8. Risk Management

The project team will implement a risk management system used to identify, assess, and manage project risks throughout the project lifecycle. The goal of the risk management system is to minimize the impact of potential risks on the project's objectives, including schedule, budget, and quality/performance.

The risk management system will include the following elements:

1. Risk Identification: The project team will identify potential risks that could impact the project objectives. Risks will be identified through brainstorming sessions, review of project documents, and consultation with stakeholders.
2. Risk Assessment: The project team will assess the potential impact of each identified risk on the project objectives. Risks will be assessed based on their probability and severity of impact.
3. Risk Response Planning: The project team will define and implement risk response plans to mitigate potential risks. Risk response plans will be developed for each identified risk and will outline specific actions that will be taken to minimize the impact of the risk.
4. Risk Monitoring and Control: The project team will monitor and control identified risks throughout the project lifecycle. The Project Manager will be responsible for ensuring that the risk management plan is effectively implemented and that risk response plans are executed as needed.
5. Risk Reporting: The Project Manager will report regularly to the Steering Committee and CrossWind Project Management on the status of identified risks, any changes, and recommendations for managing risks. The Project Manager will also be responsible for ensuring that all project team members are aware of the identified risks and the risk response plans.
6. Contingency Planning: In case potential risks cannot be effectively mitigated through risk response plans, the project team will develop and implement contingency plans to address such risks.

The risk register used to document and track the above-mentioned elements is shown below:



RISK ID	RISK TYPE	TITLE	CAUSE	EVENT	CONSEQUENCE	RISK OWNER	STATUS	SEVERITY	PROBABILITY	EXPOSURE	ACTION DESCRIPTION	ACTION (LATEST STATUS)	ACTION OWNER	SEVERITY POST ACTION	PROBABILITY POST ACTION	EXPOSURE POST ACTION	ACTION STATUS

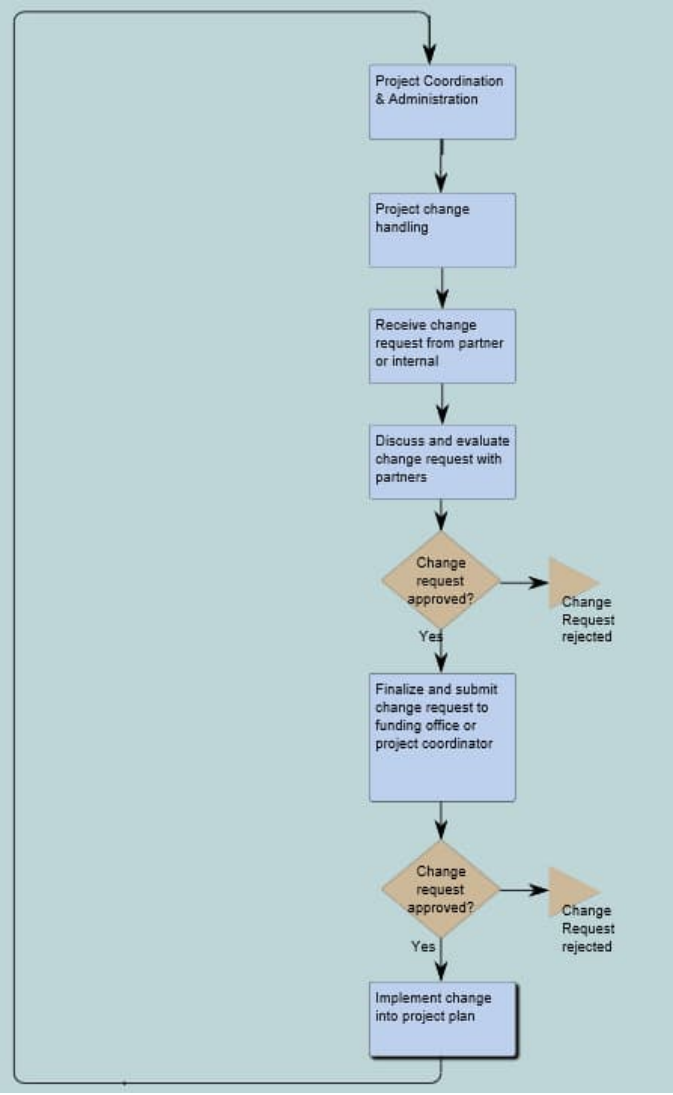
Risk Types	Status	Severity Values		Probability Values		Color Threshold Values		Action Status
Opportunity	Open	Very Low	0.05	Very unlikely	0.1	Green - max score	0.03	Proposed
Threat	Closed (Managed)	Low	0.1	Unlikely	0.3	Yellow - min score	0.035	In Progress
	Closed (Impacted)	Moderate	0.2	Not very likely	0.5	Yellow - max score	0.08	Complete
	Closed (Rejected)	High	0.4	Likely	0.7	Orange - min score	0.09	Deleted
		Very High	0.8	Very likely	0.9	Orange - max score	0.2	
						Red - min score	0.24	

Figure 4. Risk register template.

The Project Manager will be responsible for ensuring that the risk management system is implemented effectively and that risks are managed throughout the project lifecycle. Any significant changes to the risk management system will require approval from the Steering Committee and, if applicable, CrossWind Project Management.

9. Change Management

Gfsfsgfsfsgfs



10. Transport and Logistics

Dadafadfdaf

11. HSSE

Gfsfsgfsfsgfs

12. Project Closure

The project closure phase begins when all project objectives have been met and the project deliverables have been completed and accepted by CrossWind. The purpose of this phase is to ensure that the project is concluded in an organized and effective manner, and that all project documentation is properly archived for future reference.

The following activities will be performed during the project closure phase:

1. Final Deliverables: The project team will ensure that all project deliverables have been completed, accepted, and delivered to the stakeholders as per the project plan.
2. Contract Closure: The project team will ensure that all contracts related to the project have been closed, including final payments to contractors and suppliers.
3. Lessons Learned / Project Review: The project team will conduct a review of the project to evaluate its overall success and identify areas for improvement. The review will focus, among other things, on project objectives, schedule, budget, quality, and stakeholder satisfaction.
4. Project Closure Report: The project team will prepare a project closure report summarizing the project's results, including lessons learned, and providing recommendations for future projects.
5. Project Documentation: All project documentation, including project plans, reports, and records, will be adequately archived and stored for future reference according to company policy.
6. Project Hand-over to Customer Care: With the conclusion of Phases 1 and 2, the project will be handed over to the Customer Care Department, which will oversee Phase 3 of the project; service and support during demonstration period.

The Project Manager will be responsible for ensuring that all closure activities are performed in a timely and effective manner. The project closure phase will not be considered complete until all closure activities have been completed, and the project closure report has been approved by the Steering Committee.

Section B

General Arrangement

Sub Subsection B01

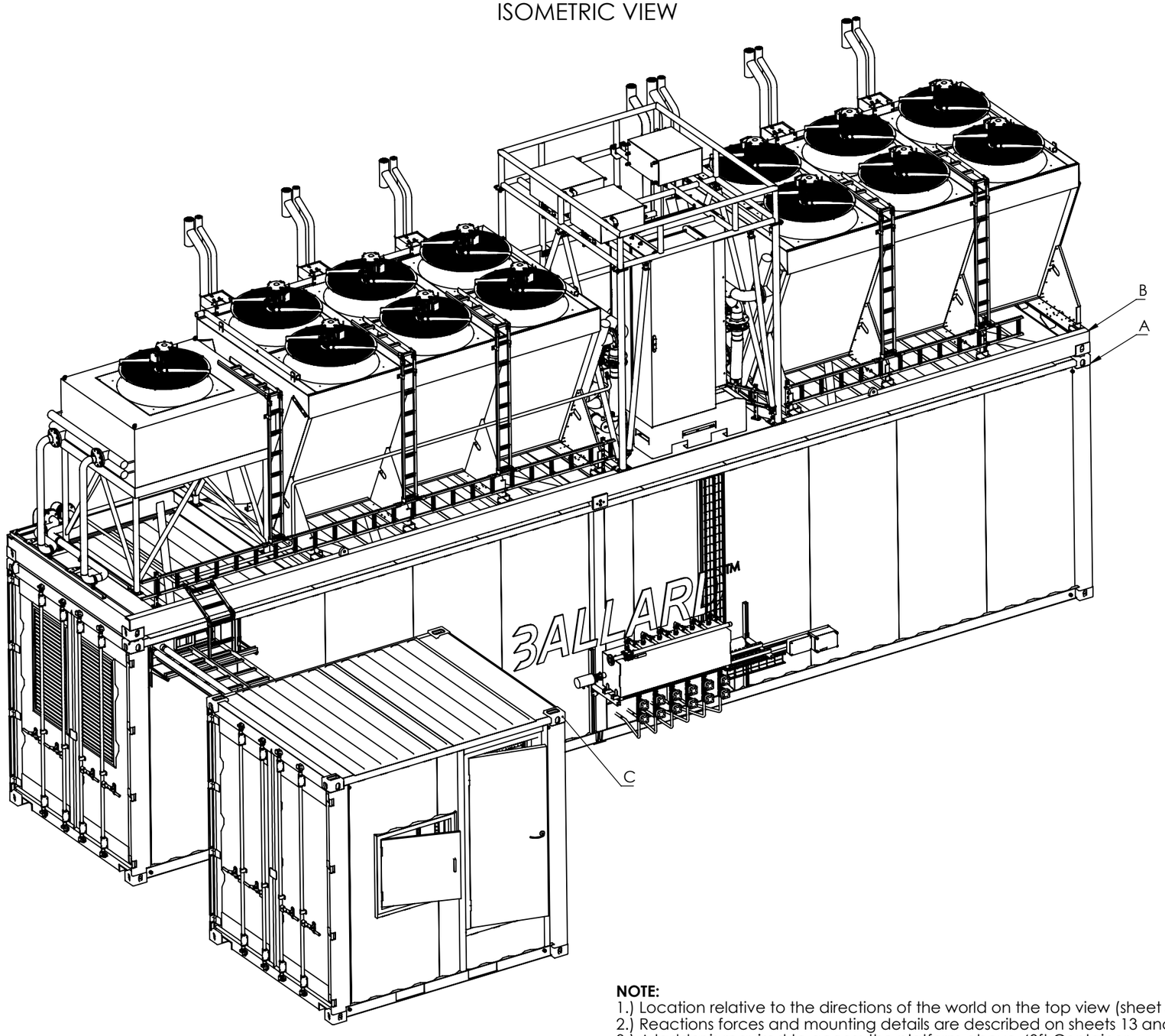
General Arrangement

(incl. Hazardous Area Layout)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	2/10/2023	First Issue
002	3/24/2023	Re-issue according to comments
003	5/30/2023	Re-issue according to comments
004	11/10/2023	Re-issue according to comments
005	11/24/2023	Re-issue according to comments
006	4/2/2024	Re-issue according to comments
007	7/17/2024	Re-issue according to comments
008	9/5/2024	Re-issue (as built)
009	11/21/2024	Re-issue according to comments
10	6/27/2025	Re-issue according to comments
Document Title:		**BLPH Project - General Arrangements**
Document Number:		K559-2254-CWIWP4202202-B01-001
Revision:		Rev010
Sequence Number:		001
File Name:		K559-2254-CWIWP4202202-B01-001Rev010
Purchaser Job:		K559-2254
Purchase Order:		CWIWP4202202
Code:		B01
Requsition Number:		n/a
Customer:		CrossWind C.V., Rotterdam, The Netherlands

ISOMETRIC VIEW



No	Name	Operating Masses	Dry Masses
A	40ft container	21680kg	21320kg
B	40ft fladbed	10060kg	9060kg
C	10ft container	7350kg	7310kg

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

BALLARD™

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

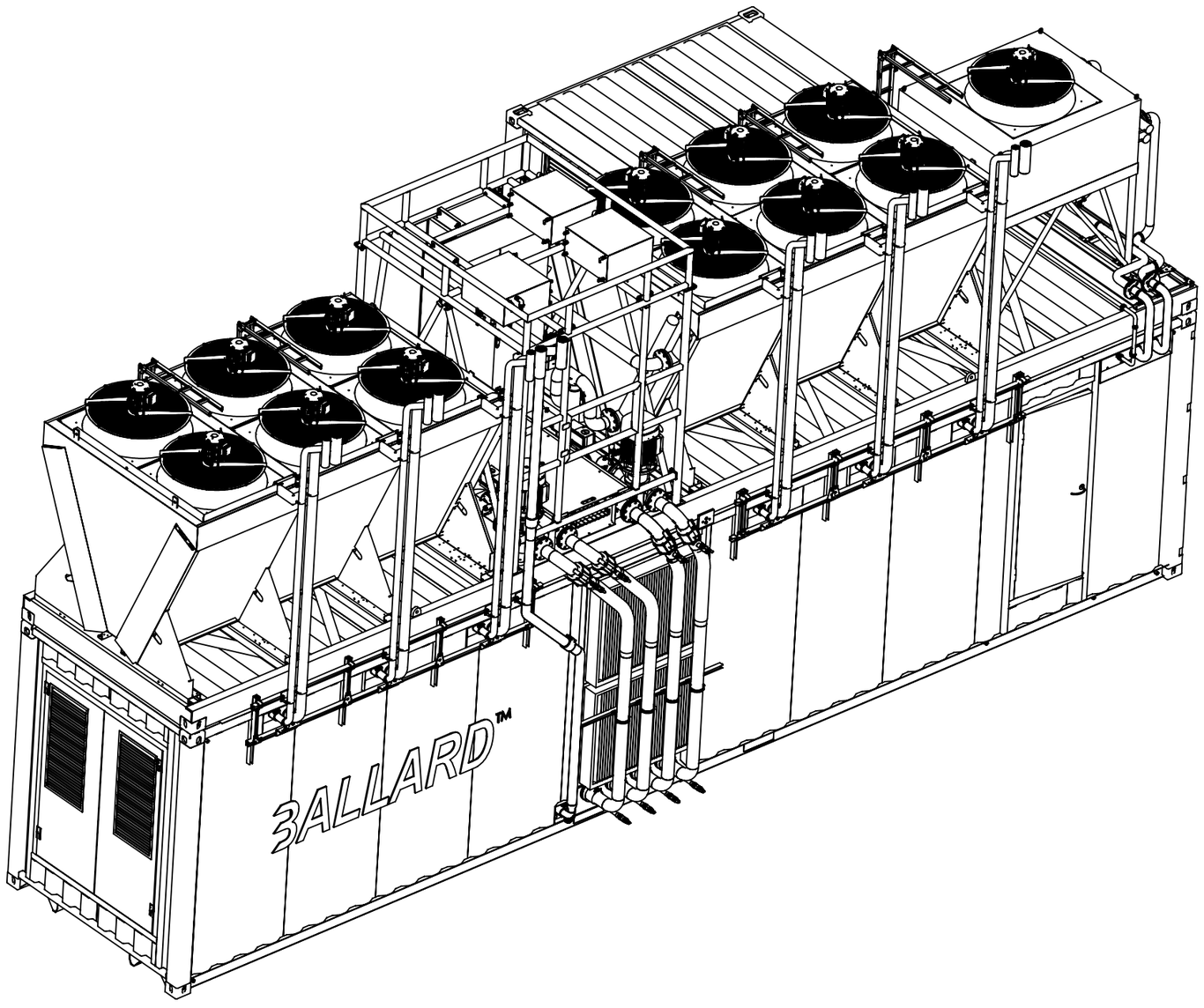
	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	1/14	1:50	601456B	10

ISOMETRIC VIEW



NOTE:
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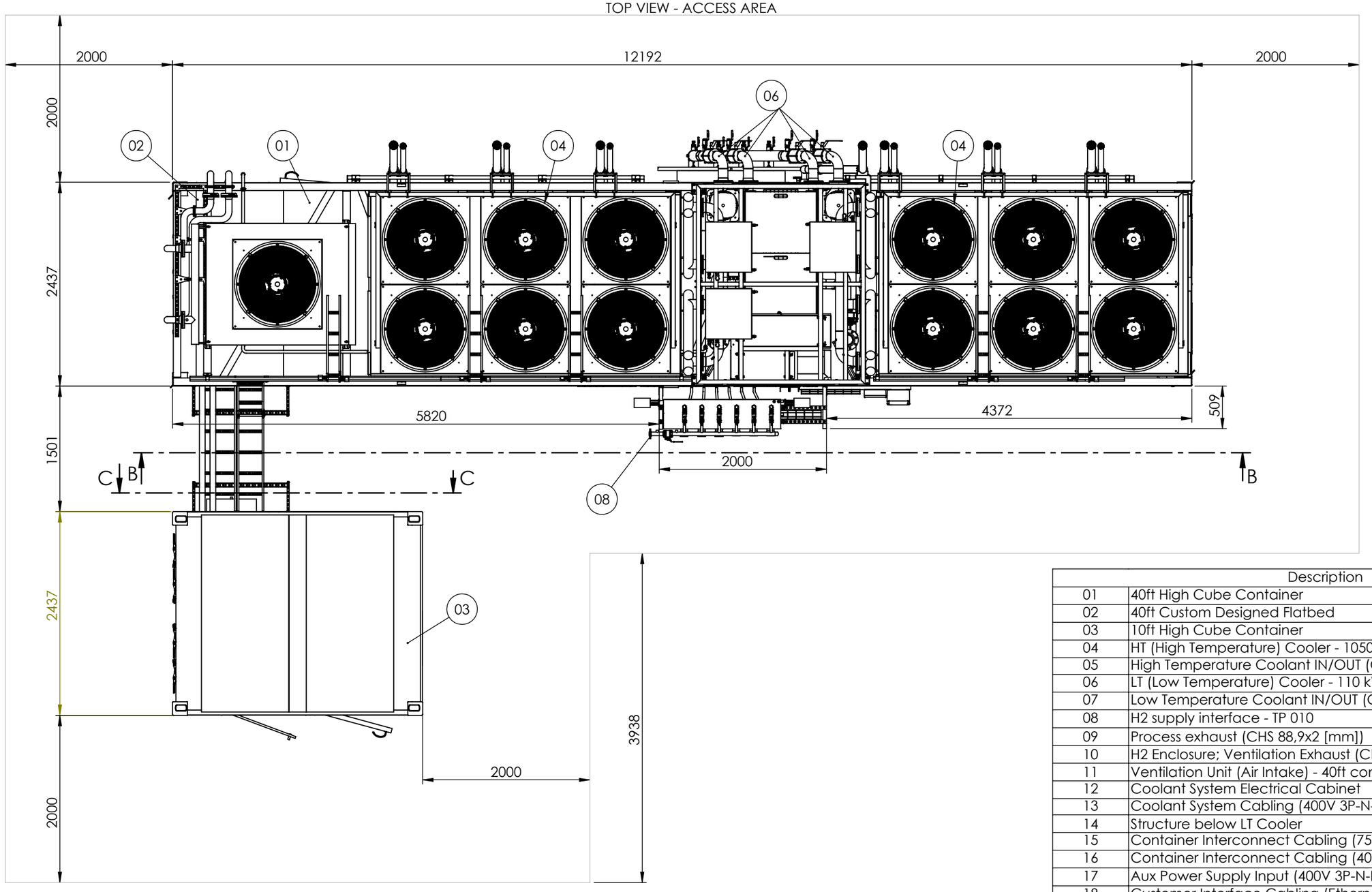
	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

General arrangement

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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	2/14	1:50	601456B	10

TOP VIEW - ACCESS AREA





	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

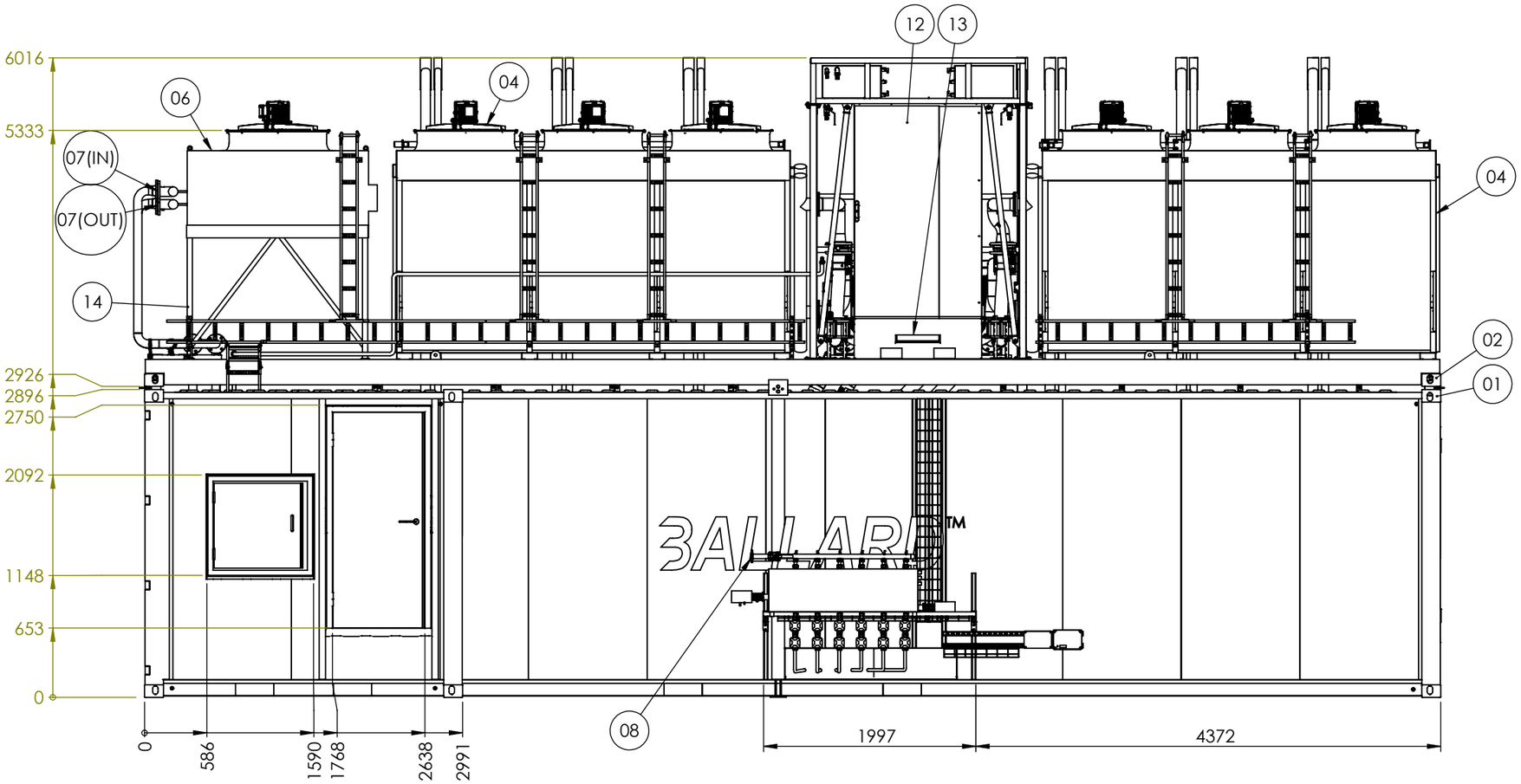
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BALLARD™

General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	3/14	1:50	601456B	10

FRONT VIEW
(LOOKING SOUTH)



	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

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WEIGHT 25596124 g

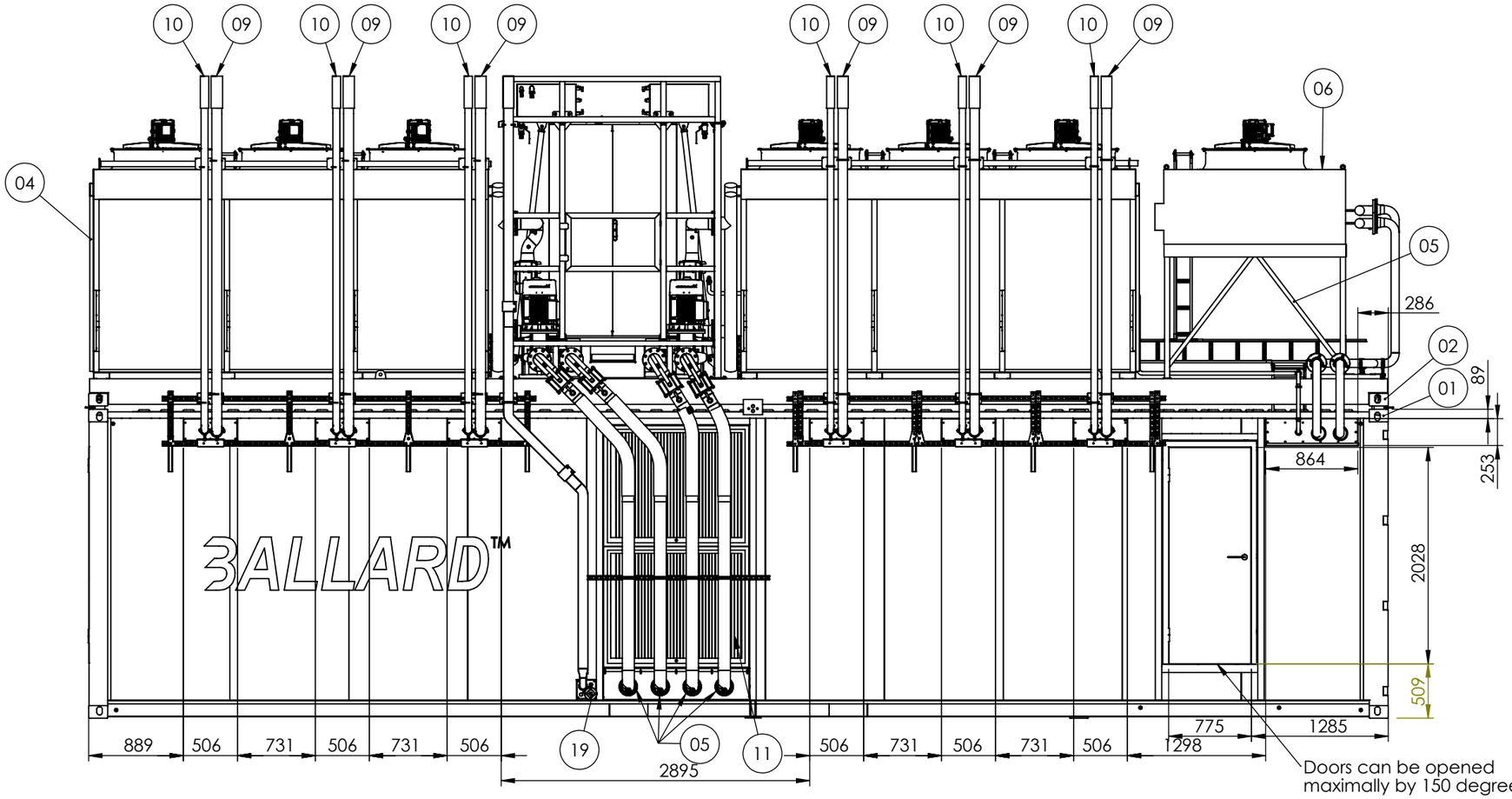
1st angle projection

BALLARD™

General arrangement

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	4/14	1:50	601456B	10

BACK VIEW
(LOOKING NORTH)



	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

BALLARD™

General arrangement

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

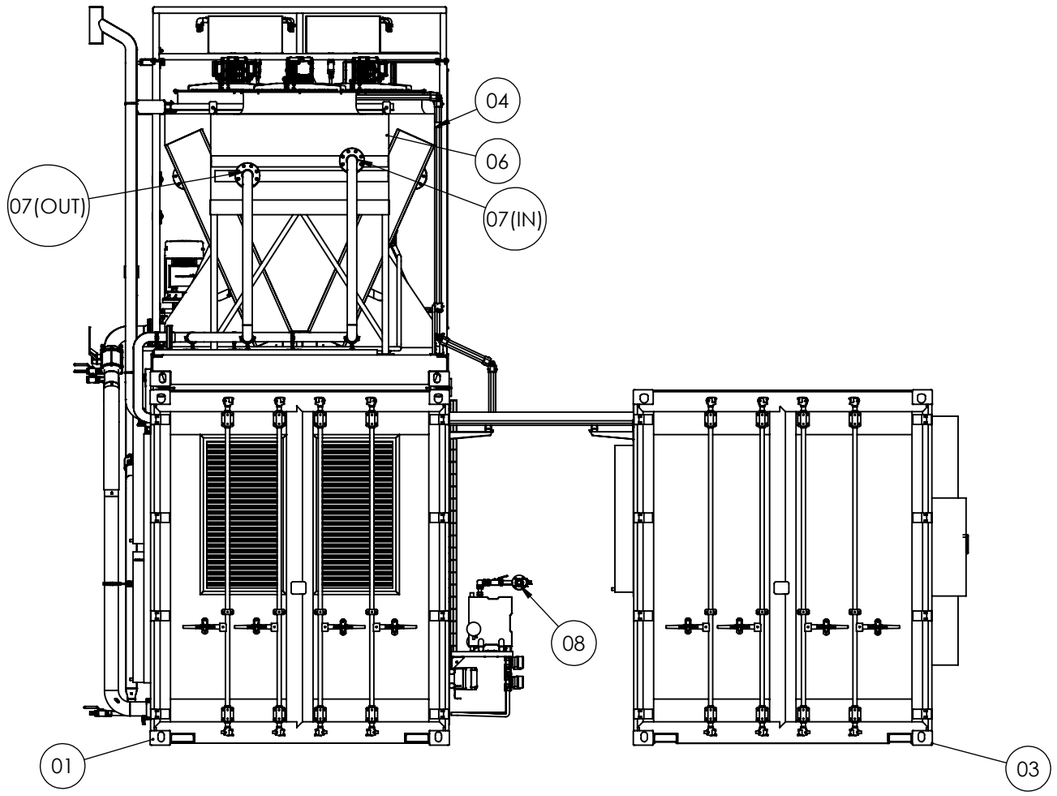
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

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Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

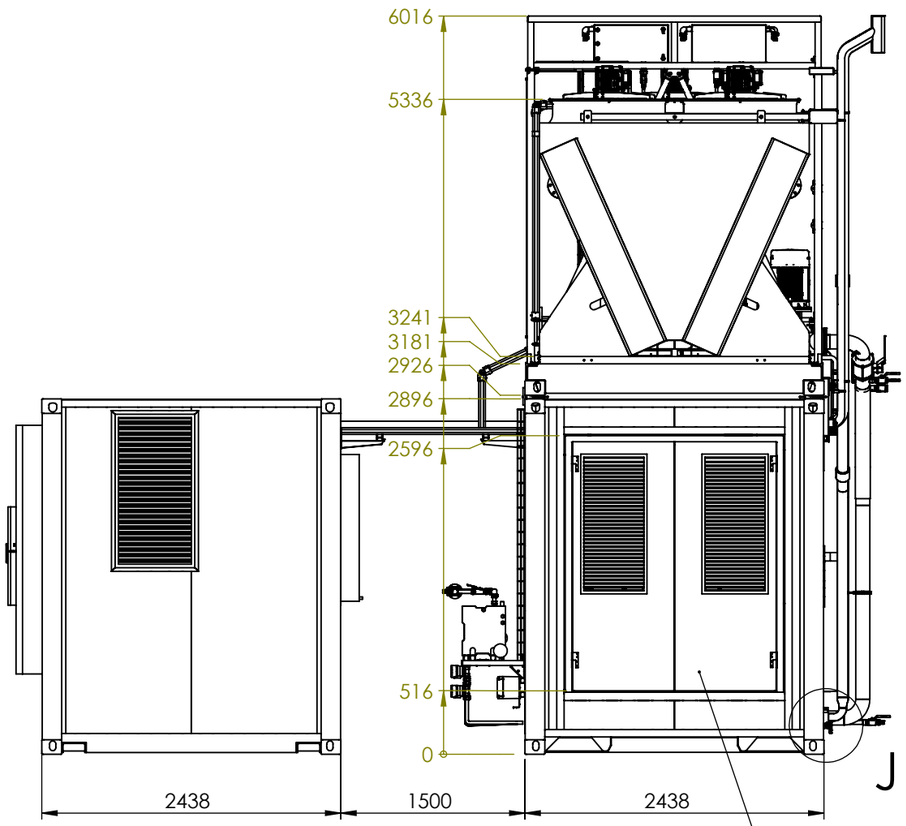
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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	5/14	1:50	601456B	10

RIGHT VIEW
(LOOKING WEST)

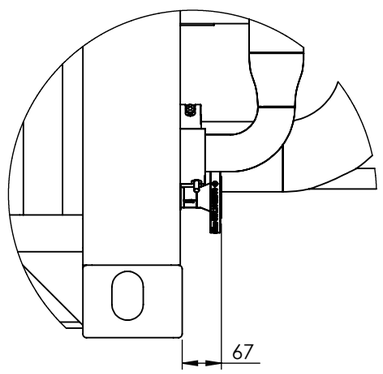


LEFT VIEW
(LOOKING EAST)



Doors can be opened
maximally by 150 degrees

	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		



DETAIL J
SCALE 1 : 10

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

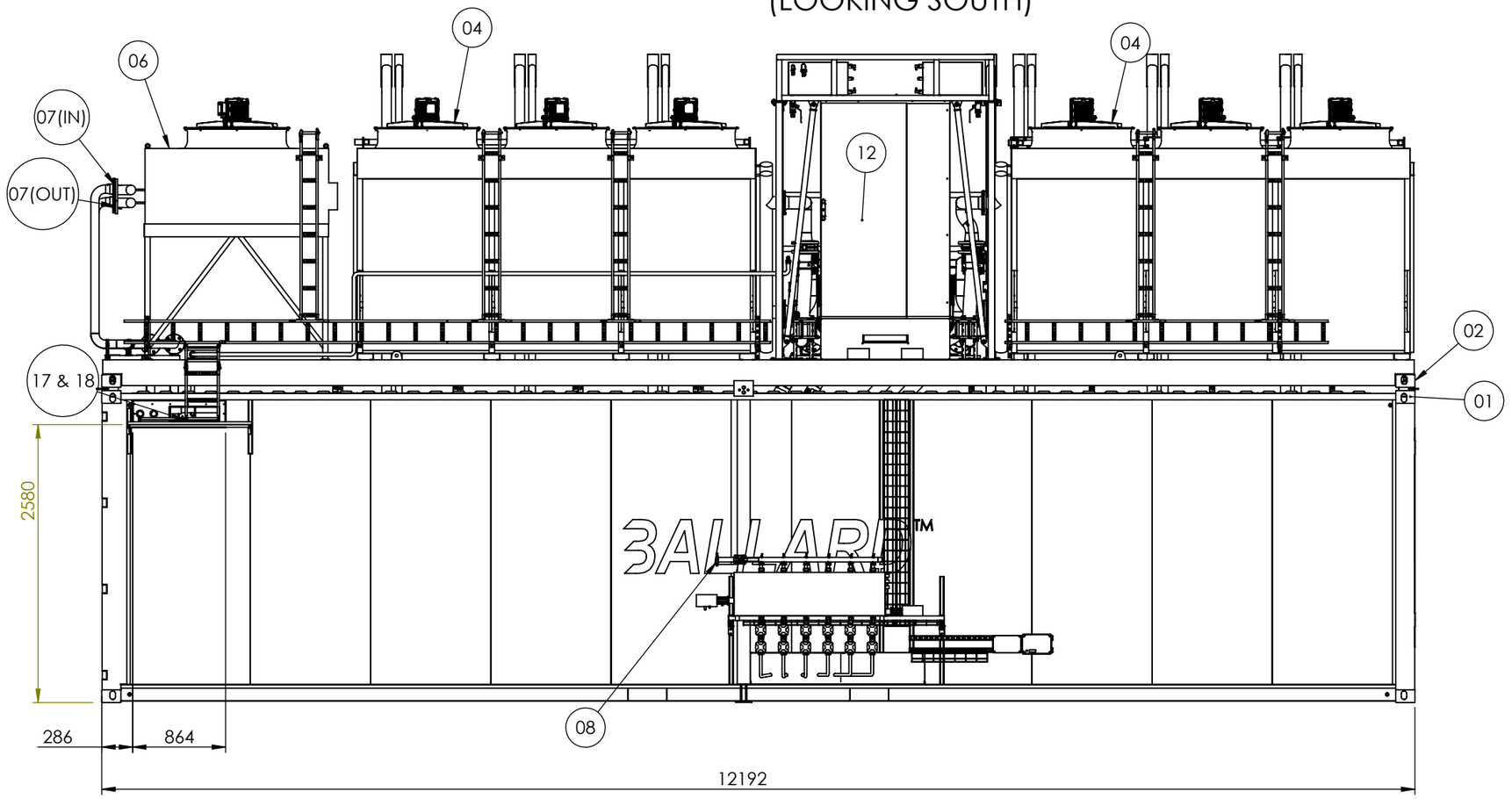
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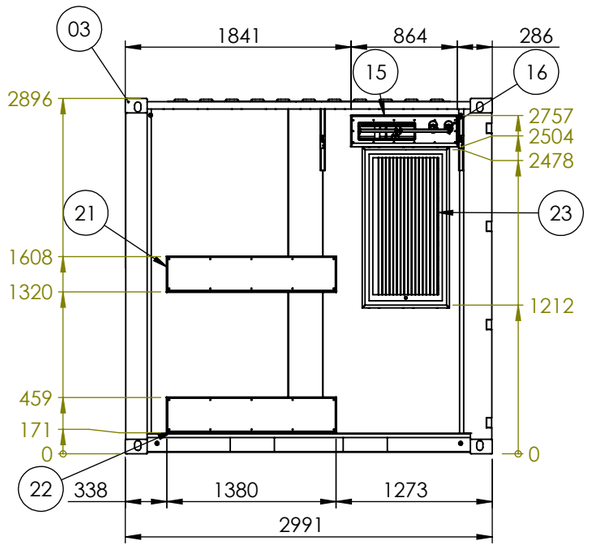
General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	6/14	1:50	601456B	10

FRONT VIEW
(LOOKING SOUTH)



SECTION B-B



SECTION C-C

	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

BALLARD™

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

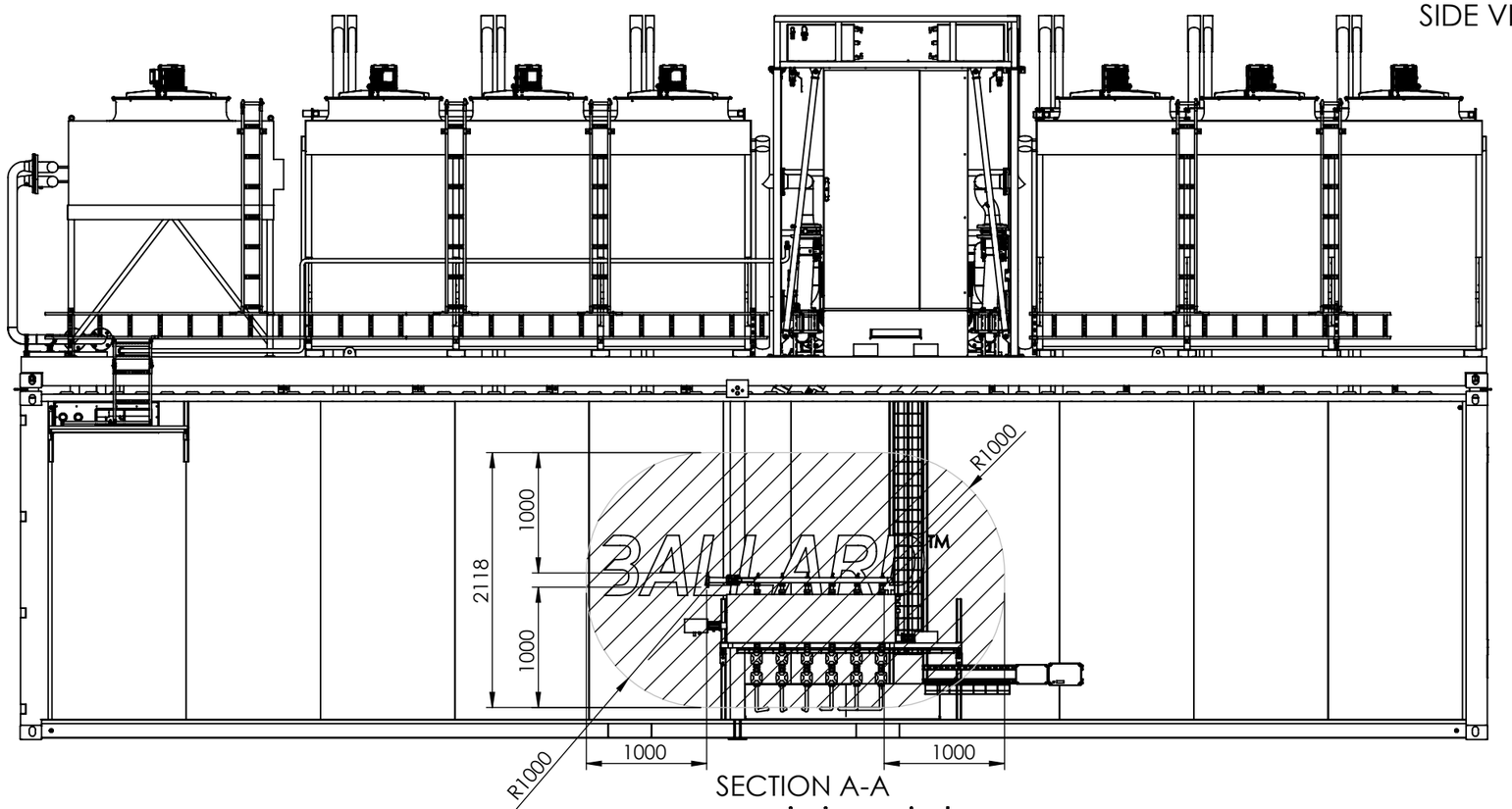
	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

General arrangement

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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	7/14	1:50	601456B	10

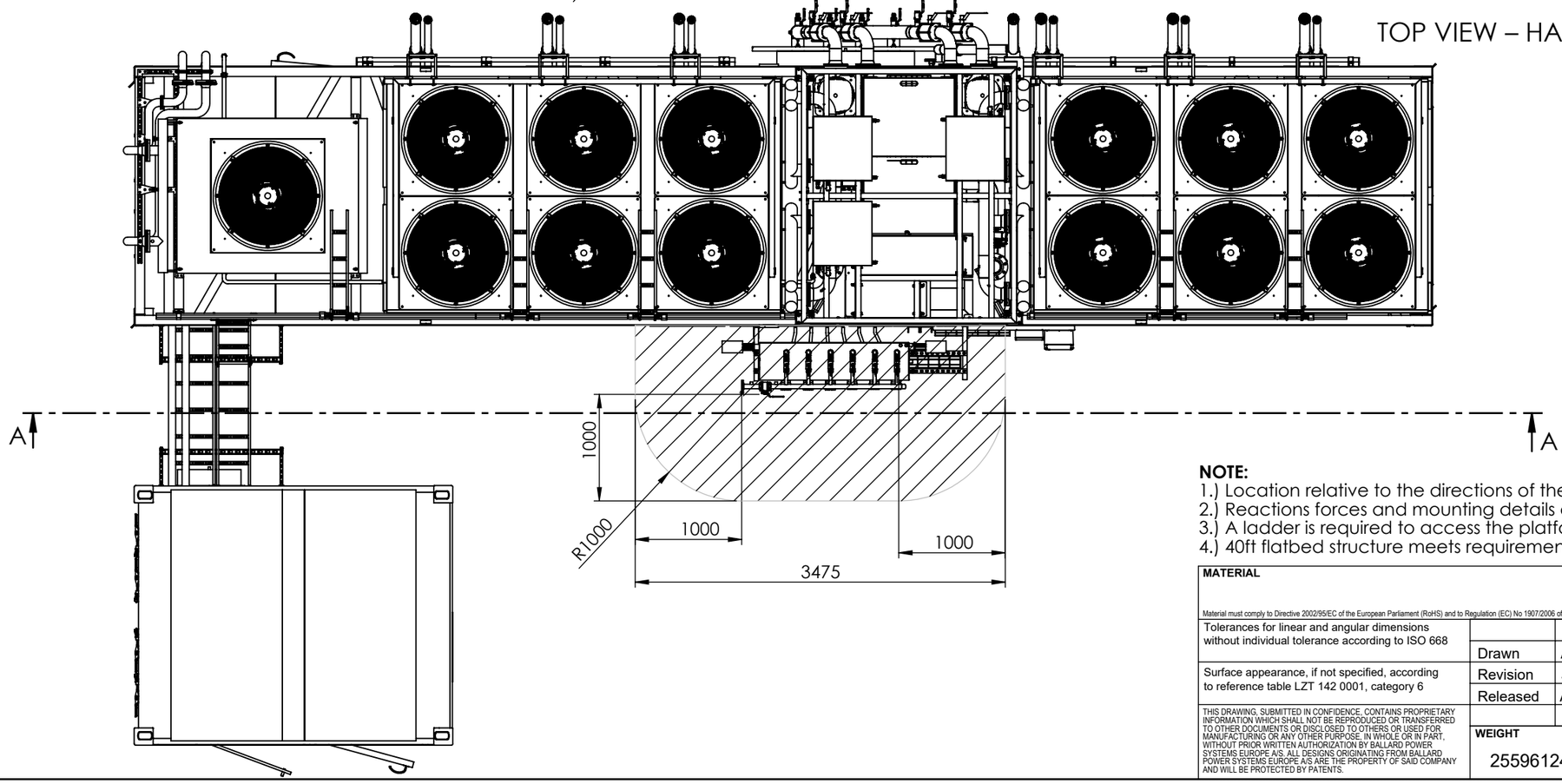
SIDE VIEW - HAZARD AREA



SECTION A-A

Zone 2 Gc IIC T1

TOP VIEW – HAZARD AREA



NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

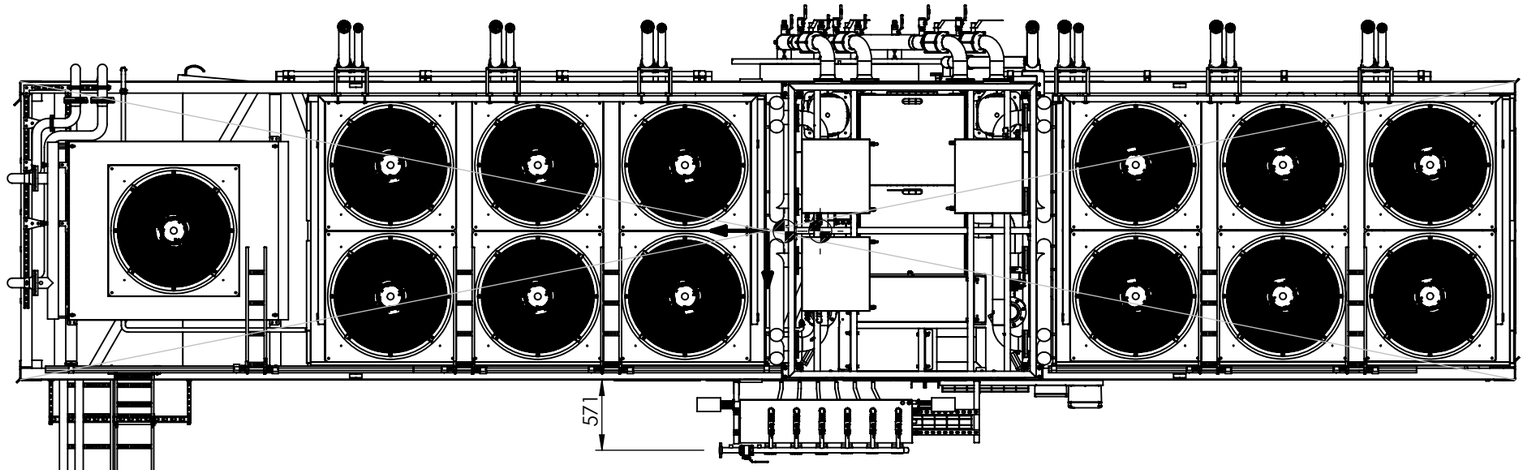
MATERIAL Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)			BALLARD™
Tolerances for linear and angular dimensions without individual tolerance according to ISO 668		By	Date
	Drawn	ASM	20-02-2024
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6	Revision	JTA	26-06-2025
	Released	ASM	26-06-2025
			General arrangement

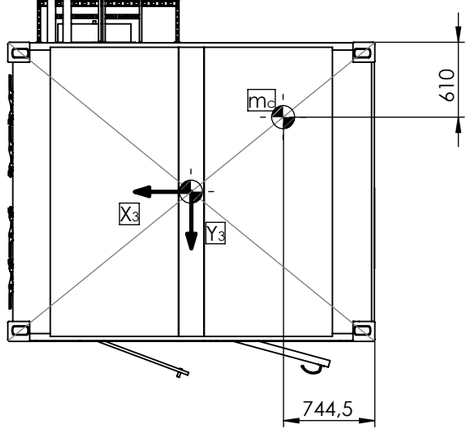
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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	8/14	1:50	601456B	10

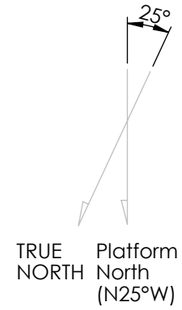
TOP VIEW - Center of Gravity

Access area





Access area



NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to		By	Date
	Drawn	ASM	20-02-2024
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6	Revision	JTA	26-06-2025
	Released	ASM	26-06-2025

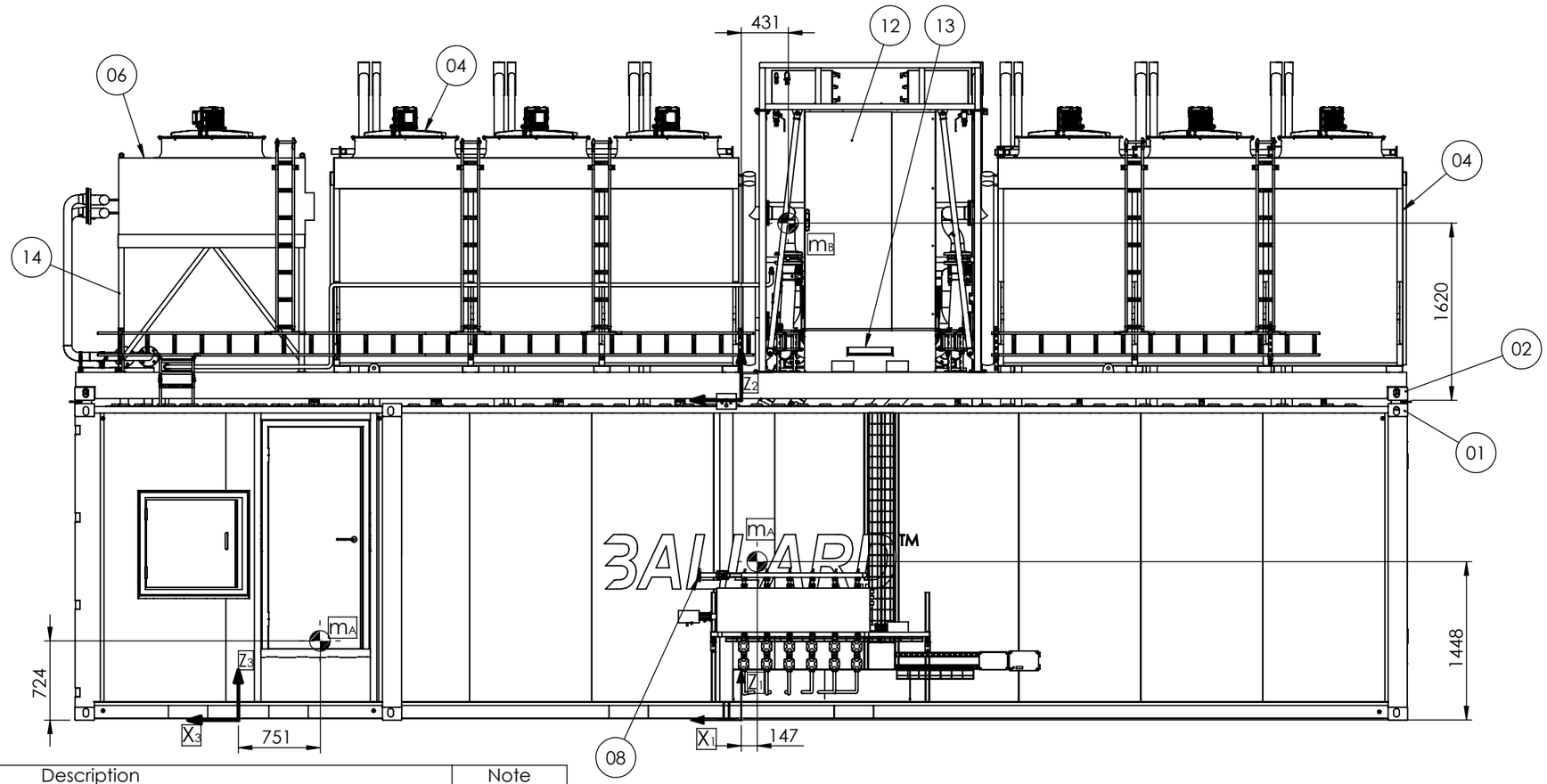
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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	9/14	1:50	601456B	10

FRONT VIEW - Center of Gravity
(LOOKING SOUTH)



	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
	CHS = Circular Hollow Section	
	CIP - Customer Interface Point	

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

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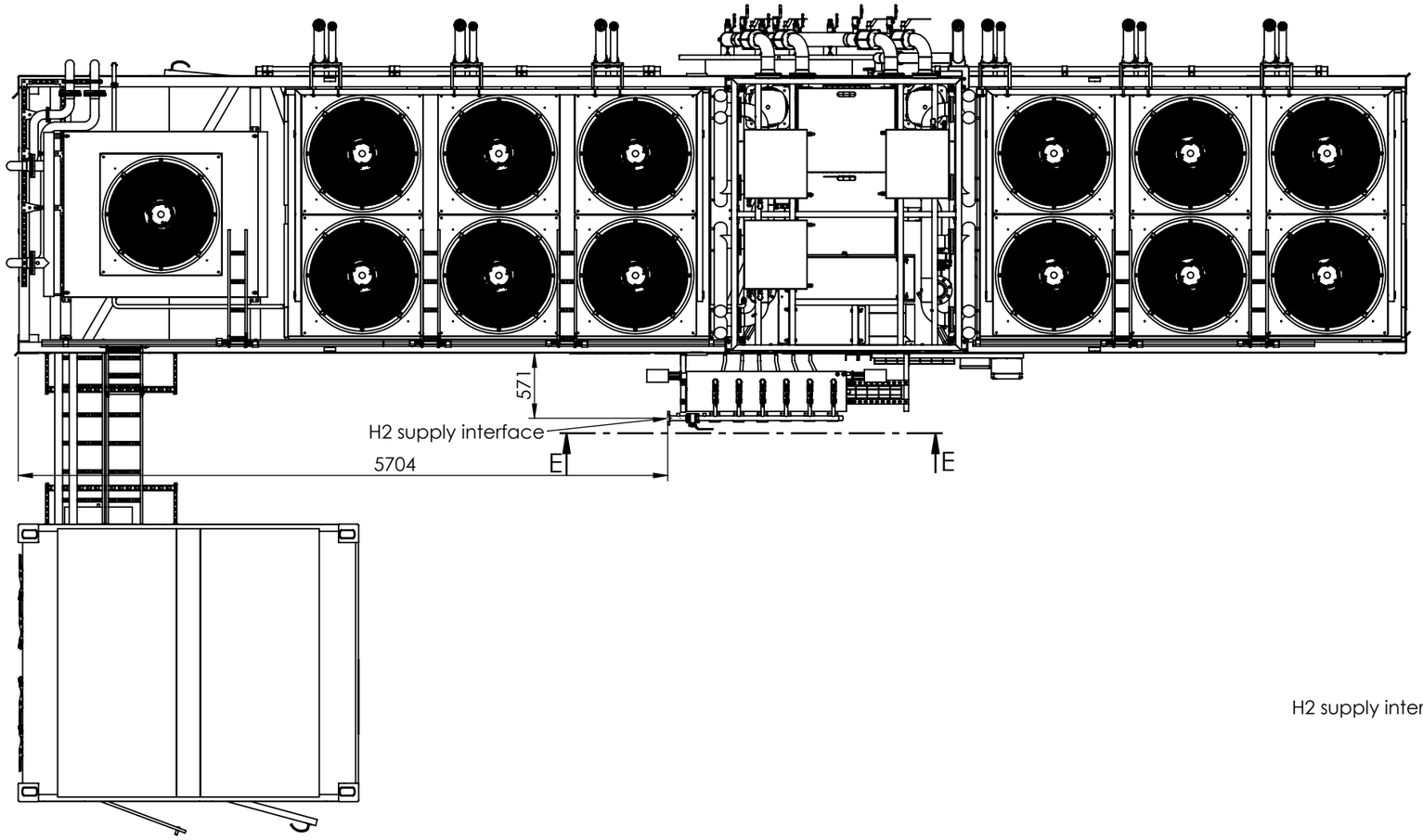
General arrangement

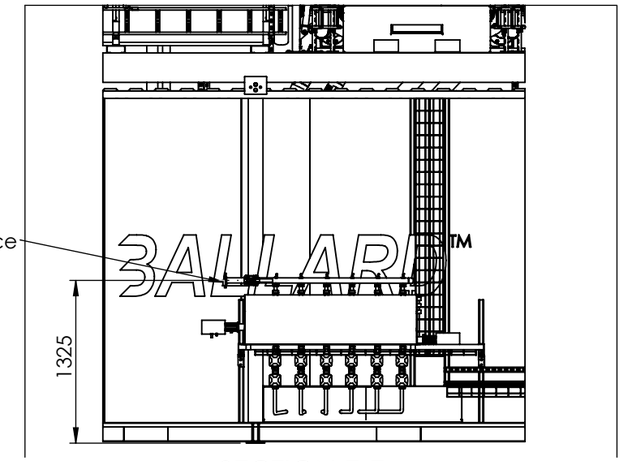
Tolerances for linear and angular dimensions without individual tolerance according to ISO 668		By	Date
	Drawn	ASM	20-02-2024
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6	Revision	JTA	26-06-2025
	Released	ASM	26-06-2025

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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	10/14	1:50	601456B	10

TOP VIEW - H2 SUPPLY INTERFACE





SECTION E-E

Reference	Interface	Dimension	Flange Standard	Pressure class	Flange face	Material	Allowable nozzle loads
08	H2 supply interface - TP 010	DN32	EN1759-1	300	RF	ANSI 316	50N*
* All interfacing flanges/connections must be fully supported and compensated for loads and moments.							

MATERIAL

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Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
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WEIGHT 25596124 g

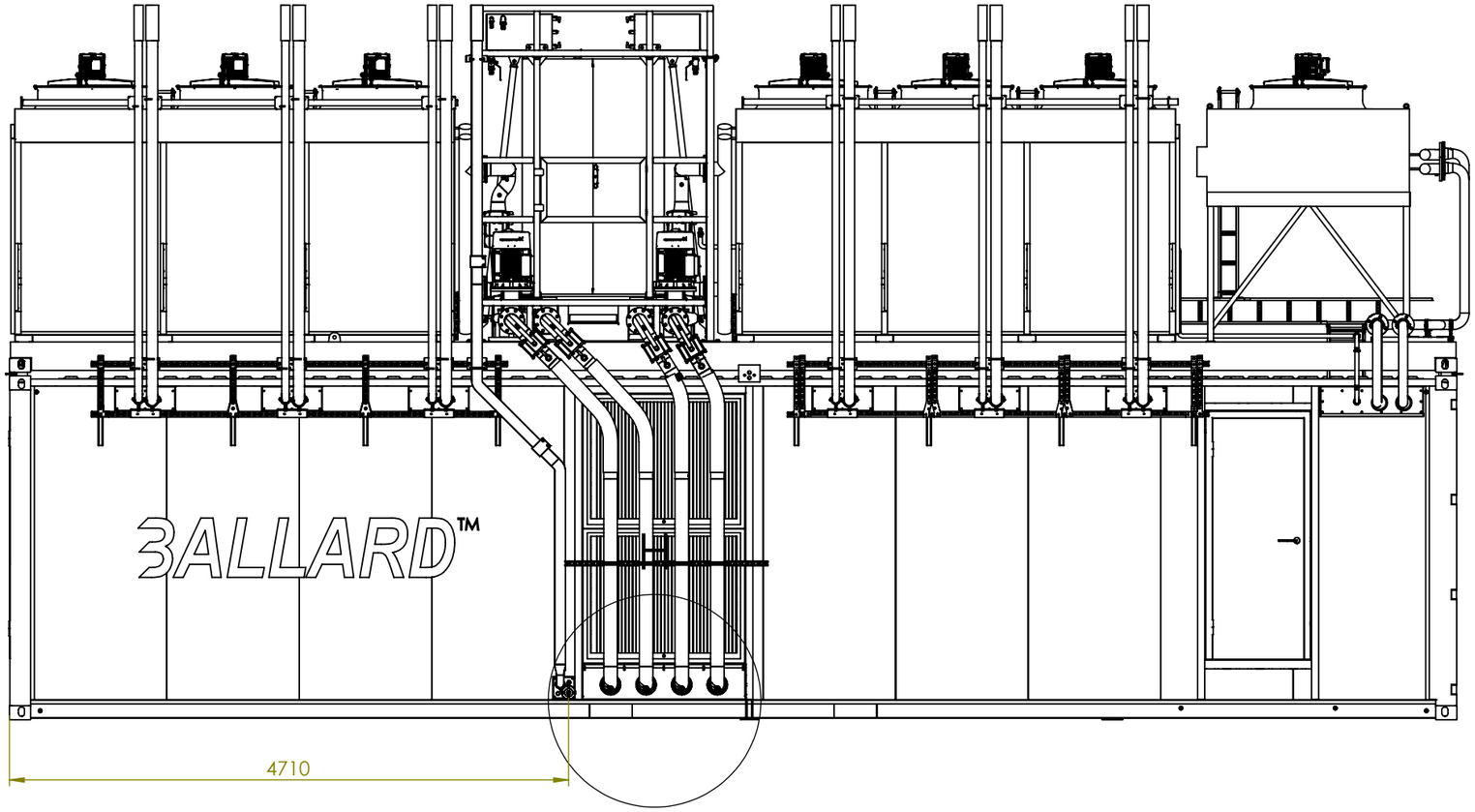
1st angle projection

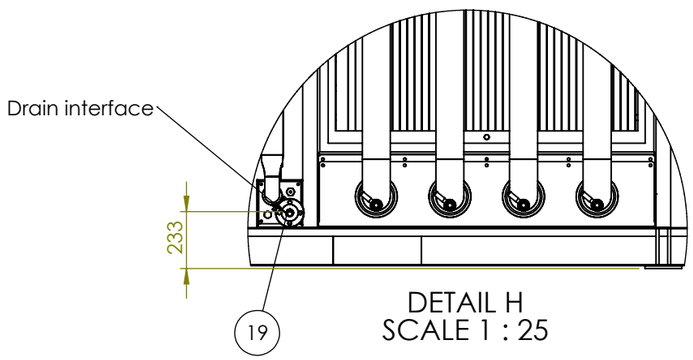
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General arrangement

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	11/14	1:50	601456B	10

FRONT VIEW LOOKING NORTH- DRAIN INTERFACE





DETAIL H
SCALE 1 : 25

Reference	Interface	Dimension	Flange Standard	Pressure class	Flange face	Material	Allowable nozzle loads
19	Drain interface - TP 015	1"	ASME B 16.5	150	RF	ANSI 316	50N*
* All interfacing flanges/connections must be fully supported and compensated for loads and moments.							

MATERIAL

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	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

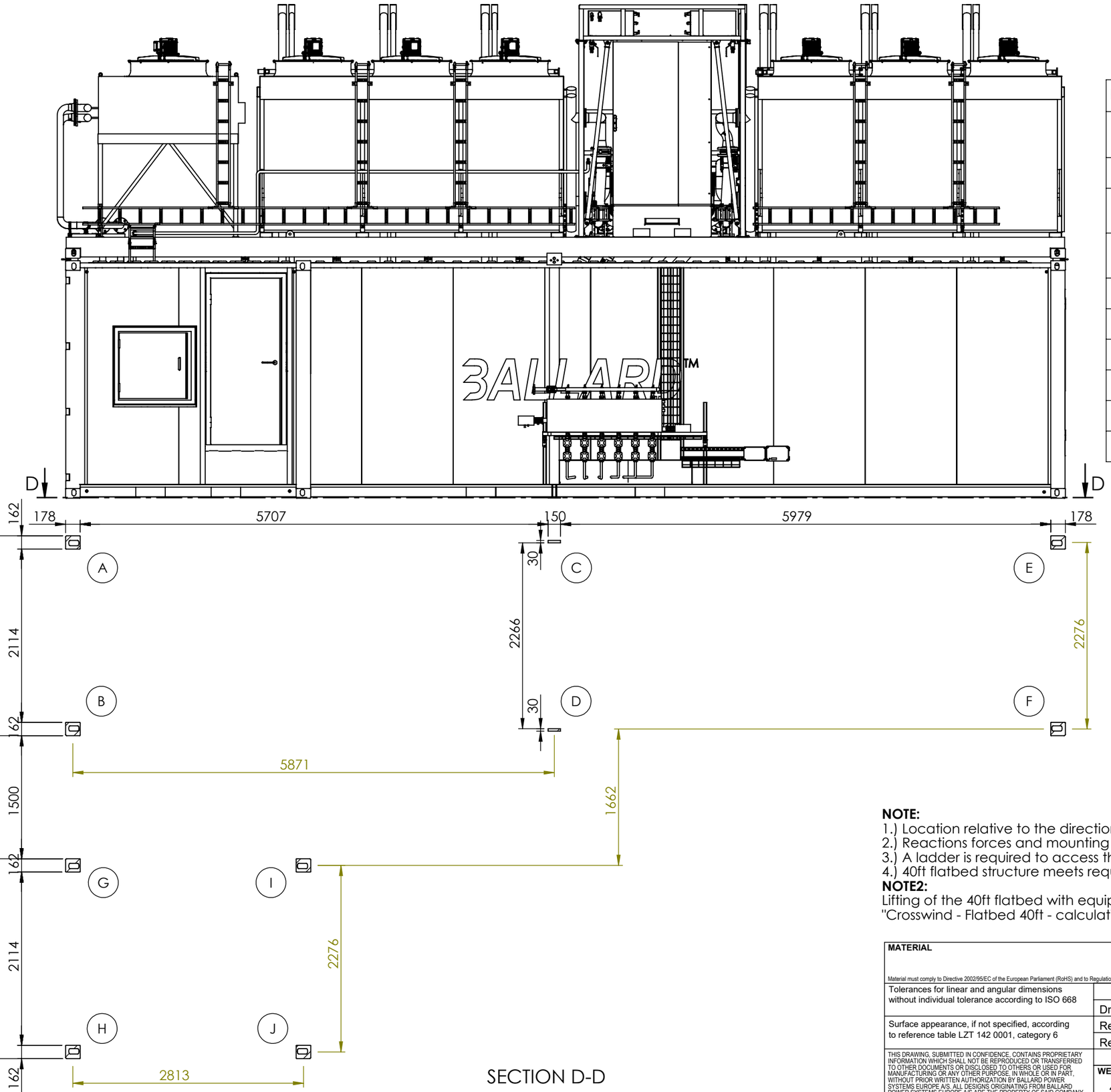
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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	12/14	1:50	601456B	10

REACTIONS BOTTOM



Pointer	Element description	Required support description
A	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
B	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
C	Support plate 12x30x150	Supporting plate 30x150 (blocked movement in direction Z) (no bolts, only compression reaction force)
D	Support plate 12x30x150	Supporting plate 30x150 (blocked movement in direction Z) (no bolts, only compression reaction force)
E	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
F	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
G	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
H	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
I	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
J	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

NOTE2:
Lifting of the 40ft flatbed with equipment in accordance to guidelines specified in structural calculation report: "Crosswind - Flatbed 40ft - calculation report rev_1.pdf"

MATERIAL

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Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

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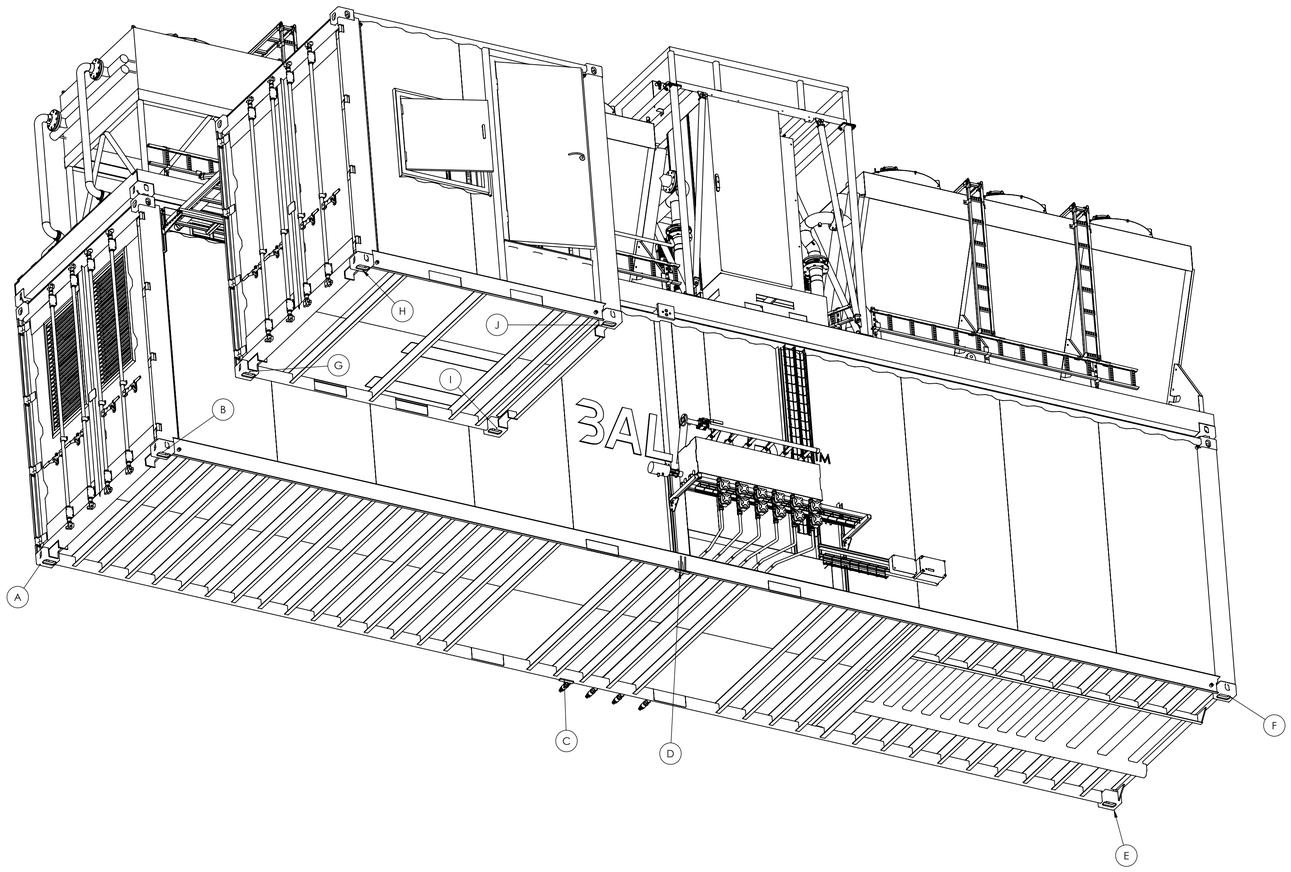
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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	13/14	1:50	601456B	10



40ft container							
Ultimate Limit State: LC5 - Lifting of 40ft container with full equipment							
LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]				LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-	-	126	A	-	-	125
B	-	-	133	B	-	-	134
C	-	-	-	C	-	-	-
D	-	-	-	D	-	-	-
E	-	-	133	E	-	-	134
F	-	-	128	F	-	-	128

40ft container							
Ultimate Limit State: LC5 - Lifting of 10ft container with full equipment							
LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]				LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-	-	25	G	-	-	25
H	-	-	17	H	-	-	16
I	-	-	100	I	-	-	99
J	-	-	22	J	-	-	23

40ft container + 40ft flatbed (CROSSWIND)							
Ultimate Limit State: LC7-LC14 - Sea transport on barge							
40ft container + 40ft flatbed (max self-weight) LC7 MAX-Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]				40ft container + 40ft flatbed (min self-weight) LC7 MIN-Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	39	-75	-158	A	65	-72	-217
B	-103	-63	300	B	-76	-63	234
C	-	-	113	C	-	-	53
D	-	-	130	D	-	-	24
E	11	-42	27	E	-24	-60	-70
F	53	-83	138	F	35	-67	93
40ft container + 40ft flatbed (max self-weight) LC8 MAX-Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]				40ft container + 40ft flatbed (min self-weight) LC8 MIN-Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-64	-39	-60	A	-42	-37	-98
B	-153	-49	263	B	-131	-50	207
C	-	-	101	C	-	-	34
D	-	-	127	D	-	-	41
E	-45	-33	30	E	-74	-48	-42
F	-37	-44	85	F	-52	-30	21
40ft container + 40ft flatbed (max self-weight) LC9 MAX-Sea transport on the barge Beam sea, bow down, X+ [Roll case 1]				40ft container + 40ft flatbed (min self-weight) LC9 MIN-Sea transport on the barge Beam sea, bow down, X+ [Roll case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-130	9	80	A	-111	10	48
B	-131	-12	141	B	-111	-13	90
C	-	-	99	C	-	-	31
D	-	-	124	D	-	-	47
E	-44	2	70	E	-70	-11	-10
F	-78	2	-4	F	-92	13	-41
40ft container + 40ft flatbed (max self-weight) LC10 MAX-Sea transport on the barge Quatering sea, stern down, X+ Y+ [Quatering 2]				40ft container + 40ft flatbed (min self-weight) LC10 MIN-Sea transport on the barge Quatering sea, stern down, X+ Y+ [Quatering 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-154	51	206	A	-132	53	172
B	-67	31	-6	B	-44	31	-65
C	-	-	105	C	-	-	30
D	-	-	126	D	-	-	49
E	-4	46	127	E	-32	32	61
F	-74	37	-39	F	-90	49	-82
40ft container + 40ft flatbed (max self-weight) LC11 MAX-Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]				40ft container + 40ft flatbed (min self-weight) LC11 MIN-Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-104	68	265	A	-79	71	225
B	33	65	-126	B	61	64	-164
C	-	-	118	C	-	-	23
D	-	-	130	D	-	-	59
E	77	85	178	E	43	67	101
F	-6	43	-13	F	-26	59	-79
40ft container + 40ft flatbed (max self-weight) LC12 MAX-Sea transport on the barge Quatering sea, stern down, X-Y- [Quatering 3]				40ft container + 40ft flatbed (min self-weight) LC12 MIN-Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	0	33	161	A	22	35	129
B	88	51	-101	B	111	51	-166
C	-	-	118	C	-	-	41
D	-	-	120	D	-	-	51
E	129	75	164	E	101	61	99
F	81	6	60	F	66	19	10
40ft container + 40ft flatbed (max self-weight) LC13 MAX-Sea transport on the barge Beam sea, bow down, X- [Roll case 2]				40ft container + 40ft flatbed (min self-weight) LC13 MIN-Sea transport on the barge Beam sea, bow down, X- [Roll case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	69	-14	19	A	88	-13	-13
B	66	14	9	B	87	13	-31
C	-	-	115	C	-	-	47
D	-	-	117	D	-	-	40
E	126	39	120	E	100	25	60
F	122	-38	120	F	107	-27	83
40ft container + 40ft flatbed (max self-weight) LC14 MAX-Sea transport on the barge Quatering sea, stern down, X-Y+ [Quatering 4]				40ft container + 40ft flatbed (min self-weight) LC14 MIN-Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	92	-57	-108	A	113	-55	-150
B	1	-29	170	B	24	-30	116
C	-	-	113	C	-	-	53
D	-	-	120	D	-	-	35
E	88	-5	70	E	59	-20	-5
F	119	-74	154	F	104	-61	116

10ft container (CROSSWIND)							
Ultimate Limit State: LC7-LC14 - Sea transport on barge							
10ft container (max self-weight) LC7 MAX-Sea transport on barge Head sea, bow down, Y+ [Pitch case 1]				10ft container (min self-weight) LC7 MIN-Sea transport on barge Head sea, bow down, Y+ [Pitch case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	3	-3	14	G	5	-7	1
H	-17	-19	15	H	-8	-11	5
I	11	-18	63	I	4	-16	7
J	2	-7	24	J	-1	-14	12
10ft container (max self-weight) LC8 MAX-Sea transport on barge Quatering sea, bow down, X+ Y+ [Quatering 1]				10ft container (min self-weight) LC8 MIN-Sea transport on barge Quatering sea, bow down, X+ Y+ [Quatering 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-23	3	24	G	-21	0	13
H	-27	-26	14	H	-20	-19	6
I	-7	-12	52	I	-13	-10	6
J	-7	5	19	J	-10	-1	10
10ft container (max self-weight) LC9 MAX-Sea transport on barge Beam sea, X+ [Roll case 1]				10ft container (min self-weight) LC9 MIN-Sea transport on barge Beam sea, X+ [Roll case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-33	10	29	G	-32	6	19
H	-27	-23	13	H	-21	-17	5
I	-13	-3	54	I	-19	-1	11
J	-9	16	13	J	-12	11	4
10ft container (max self-weight) LC10 MAX-Sea transport on barge Quatering sea, stern down, X+ Y+ [Quatering 2]				10ft container (min self-weight) LC10 MIN-Sea transport on barge Quatering sea, stern down, X+ Y+ [Quatering 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-29	14	28	G	-28	11	17
H	-21	-15	11	H	-13	-8	3
I	-9	7	63	I	-15	9	17
J	-5	25	8	J	-8	20	-2
10ft container (max self-weight) LC11 MAX-Sea transport on barge Head sea, stern down, Y- [Pitch case 2]				10ft container (min self-weight) LC11 MIN-Sea transport on barge Head sea, stern down, Y- [Pitch case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-8	14	19	G	-5	10	7
H	-6	-2	10	H	3	6	0
I	8	12	80	I	0	14	24
J	5	24	6	J	2	18	-6
10ft container (max self-weight) LC12 MAX-Sea transport on barge Quatering sea, stern down, X-Y- [Quatering 3]				10ft container (min self-weight) LC12 MIN-Sea transport on barge Quatering sea, stern down, X-Y- [Quatering 3]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	18	7	7	G	20	3	-3
H	6	5	10	H	13	12	1
I	25	7	84	I	19	8	37
J	15	12	9	J	12	6	0
10ft container (max self-weight) LC13 MAX-Sea transport on barge Beam sea, X- [Roll case 2]				10ft container (min self-weight) LC13 MIN-Sea transport on barge Beam sea, X- [Roll case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	29	0	3	G	30	-3	8
H	6	3	11	H	13	9	3
I	31	-3	80	I	26	-1	37
J	17	0	15	J	14	-6	6
10ft container (max self-weight) LC14 MAX-Sea transport on barge Quatering sea, stern down, X-Y+ [Quatering 4]				10ft container (min self-weight) LC14 MIN-Sea transport on barge Quatering sea, stern down, X-Y+ [Quatering 4]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	25	-4	4	G	26	-7	7
H	-1	-6	13	H	6	2	5
I	27	-12	73	I	21	-10	26
J	13	-8	21	J	10	14	11

40ft container + 40ft flatbed (CROSSWIND)							
Ultimate Limit State: LC15-LC18 - destination place (Offshore)							
40ft container + 40ft flatbed (max self-weight) LC15 MAX-Destination place - Offshore Wind X+				40ft container + 40ft flatbed (min self-weight) LC15 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-67	2	58	A	-61	3	48
B	-69	-4	99	B	-63	-4	83
C	-	-	84	C	-	-	63
D	-	-	102	D	-	-	78
E	1	10	71	E	-7	6	51
F	-23	-8	20	F	-27	-4	9
40ft container + 40ft flatbed (max self-weight) LC16 MAX-Destination place - Offshore Wind Y+				40ft container + 40ft flatbed (min self-weight) LC16 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	65	-95	-260	A	71	-95	-275
B	-115	-82	362	B	-108	-81	347
C	-	-	103	C	-	-	92
D	-	-	105	D	-	-	80
E	-4	-65	-38	E	-12	-69	-61
F	53	-95	158	F	50	-92	149
40ft container + 40ft flatbed (max self-weight) LC17 MAX-Destination place - Offshore Wind X+				40ft container + 40ft flatbed (min self-weight) LC17 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	16	-7	26	A	21	-6	17
B	13	6	39	B	19	6	21
C	-	-	97	C	-	-	76
D	-	-	102	D	-	-	78
E	69	24	91	E	61	20	72
F	60	-24	78	F	56	-20	66
40ft container + 40ft flatbed (max self-weight) LC18 MAX-Destination place - Offshore Wind Y+				40ft container + 40ft flatbed (min self-weight) LC18 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-117	90	332	A	-111	91	323
B	60	83	-237	B	67	83	-257
C	-	-	98	C	-	-	76
D	-	-	119	D	-	-	106
E	73	98	189	E	65	94	172
F	-17	66	-72	F	-21	69	-88

10ft container (CROSSWIND)							
Ultimate Limit State: LC15-LC18 - destination place (Offshore)							
10ft container (max self-weight) LC15 MAX-Destination place - Offshore Wind X+				10ft container (min self-weight) LC15 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-28	16	32	G	-24	13	28
H	-8	-14	-1	H	-7	-11	-1
I	6	-25	38	I	2	-21	26
J	-7	23	22	J	-8	19	17
10ft container (max self-weight) LC16 MAX-Destination place - Offshore Wind Y+				10ft container (min self-weight) LC16 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-19	0	4	G	-15	-4	0
H	-7	-26	13	H	-6	-23	13
I	21	-30	39	I	16	-26	27
J	6	7	36	J	4	3	31
10ft container (max self-weight) LC17 MAX-Destination place - Offshore Wind X+				10ft container (min self-weight) LC17 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-4	6	2	G	1	3	-2
H	6	-10	0	H	7	-7	1
I	27	-16	38	I	22	-12	56
J	8	19	21	J	7	15	16
10ft container (max self-weight) LC18 MAX-Destination place - Offshore Wind Y+				10ft container (min self-weight) LC18 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-23	28	35	G	-18	25	30
H	-2	2	-17	H	-1	5	-17
I	21	-10	60	I	17	-6	48
J	3	29	13	J	2	25	8

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach).

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

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BALLARD™

General arrangement

WEIGHT	SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	A1	14/14	1:30	601456B	10

1st angle projection

Sub Subsection B99-001

Structural Calculations

Ballard Power Systems Europe A/S
Majsmarken 1
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	06/03/2023	First Issue
002	28/03/2024	Expanded for all load cases (lifting, barge transport and on-site on open sea)

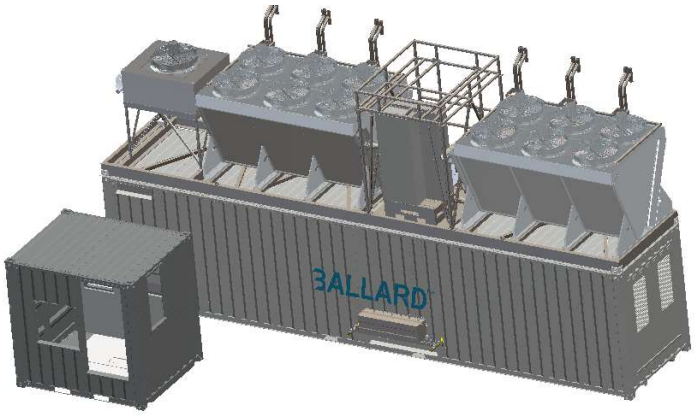
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Code:	B99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Reactions from
40ft container and 10ft container
on sea type barge (300’ x 90’ x 20’ or larger)

STRUCTURAL CALCULATIONS

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Calculations and report made by:	GREAT BACK OFFICE
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1. Abbreviations, symbols and definitions

The most important abbreviations and definitions are listed in that point of the document as they can differ in different standards.

Platform container – a container having only the base and the floor, whose width and length correspond to the dimensions of a general-purpose container, fitted with the top and bottom corner fittings

R – rating, i. e. maximum gross mass of the container including permanent equipment and its cargo, in kg, but excluding the lifting set
T – tare mass, i. e. the mass of the empty container including any permanent equipment but excluding cargo and lifting set, in kg
P – payload, i. e. the maximum permissible mass of cargo which may be safely transported by the container, in kg

$$P = R - T$$

L – external length of the container
W – external width of the container
H – external height of the container
S – distance between the centeres of apertures in corner fittings on the length of the container
P – distance between the centers of apertures in corner fittings on the breadth of the container
D – diagonals of the container measure between the centers of apertures in corner fittings (D1, D2, D3, D4, D5, D6)
K1 – difference between D1 and D2 or D3 and D4 (K1=|D1-D2| or K1=|D3-D4|)
K2 – difference between D5 and D6 (i. e. K2=|D5-D6)

2. Introduction

The main purpose of this study is to determine the most unfavorable reactions from the load of a 40-foot High Cube container with coolers mounted on it and 10 foot High Cube container placed on North Sea type barge defined by DNVGL to have a minimum size of 300' x 90' x 20' or larger.

Localization of barge (north coast of the Netherlands) on open sea.

Designed flatbed on which stands coolers is container type 1AX :
L=12192 (+0)(-10) [mm]
W=2438 (+0)(-5) [mm]
H<2438 (+0)(-5) [mm]

Dimensions between ISO 1161 Corners (with assumed tolerances in cubes and dimensions tolerances of the structure) P=2260 (+3)(-5) [mm] S=11989 (+3)(-10) [mm]

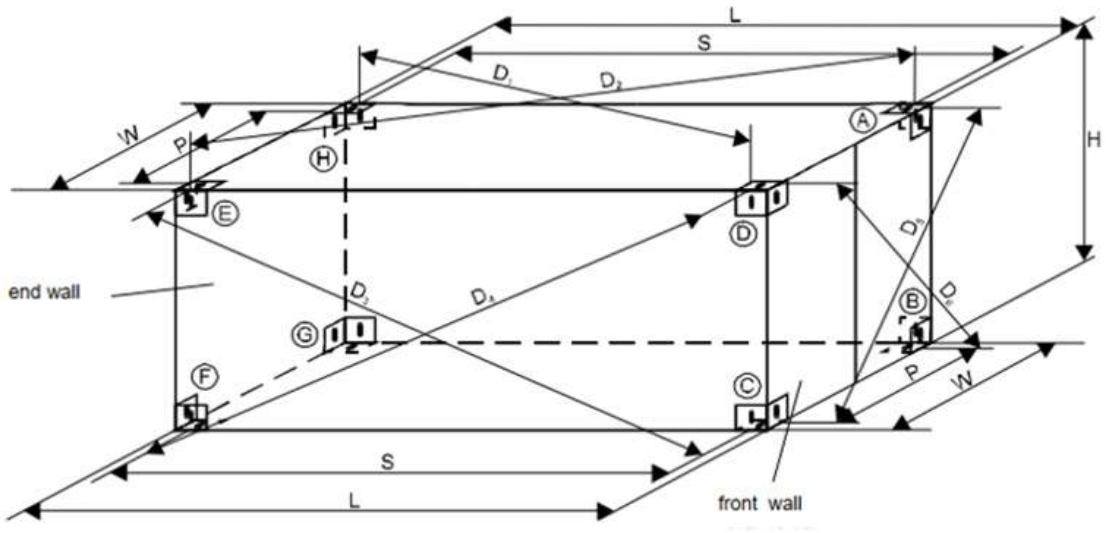


Fig 1: Dimension of the container (Polski Rejestr Statków, Rules for the Construction of Containers, Gdańsk, 2014)

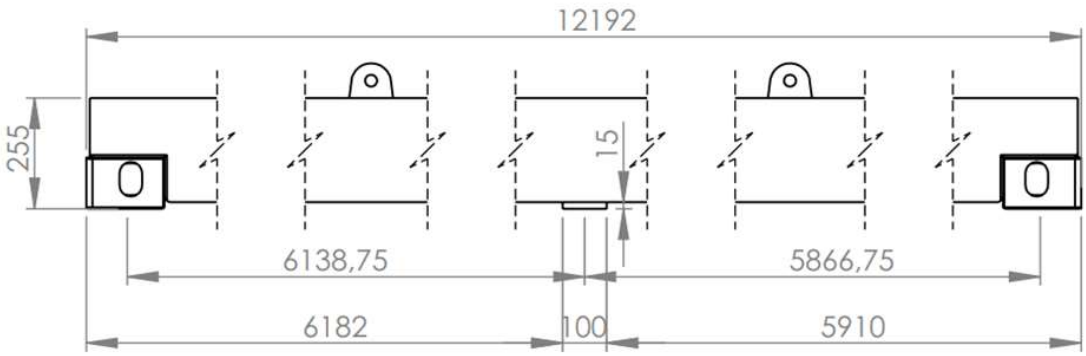


Fig 2: Dimensions of the flatbed standing on the top of the 40ft High-Cube container (supports and lifting points)

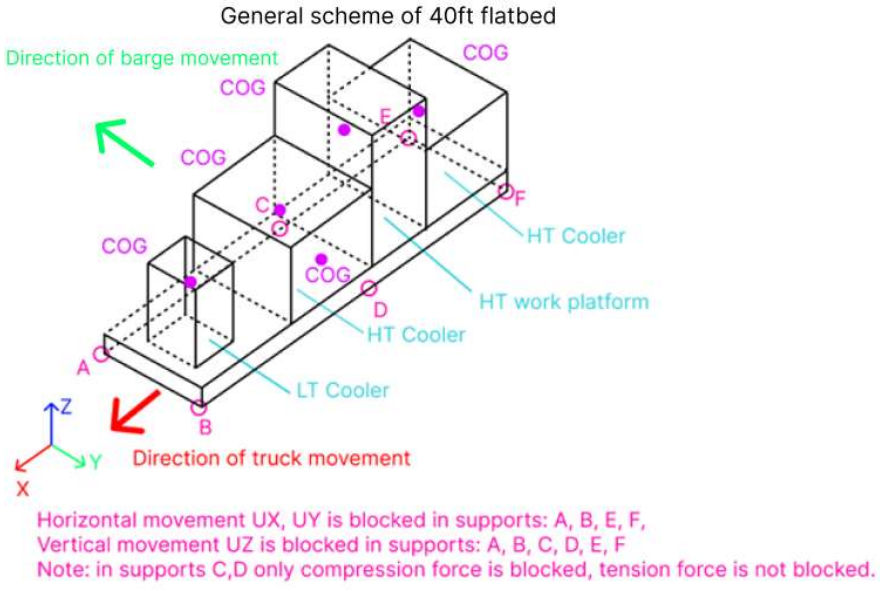


Fig 3: General scheme of 40ft flatbed (COG – Center of gravity)

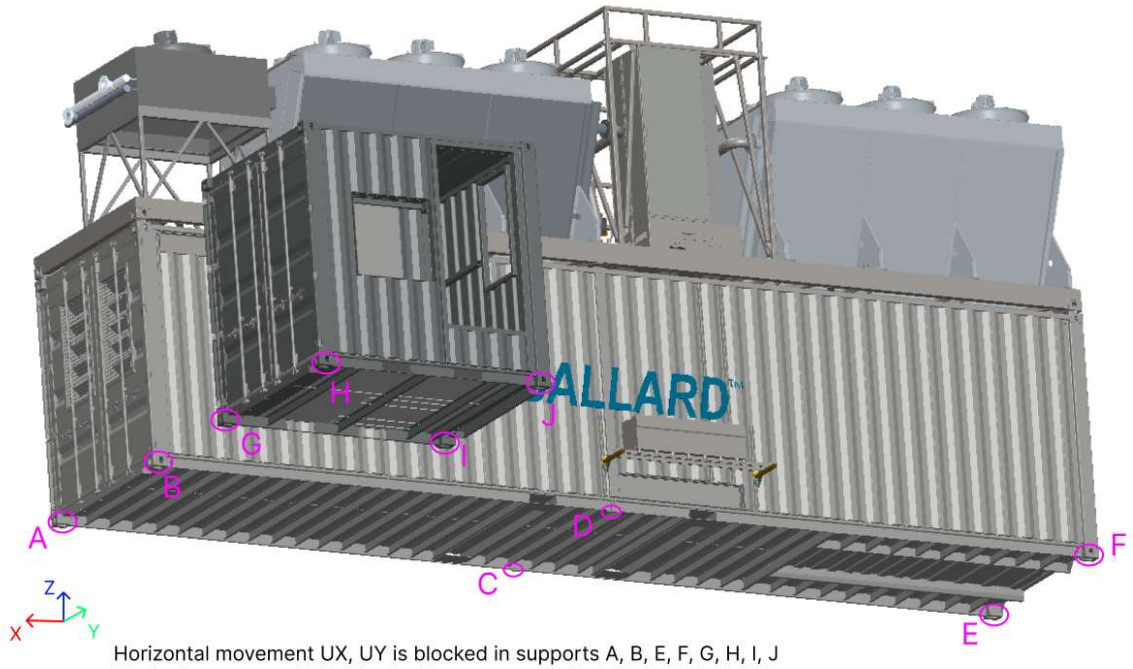


Fig 4: 40ft and 20ft supports

3. European standards and regulations

1.)	EN 12195-1	Load restraining on road vehicle – safety – part 1 – calculation of securing forces
2.)	EN 13155	Cranes – Safety – Non-fixed load lifting attachments
3.)	ISO 1161	Series 1 freight containers – Corner and intermediate fittings Specifications
4.)	EN 1990	Basis of structural design
5.)	EN 1993-1-1	Design of steel structures; General rules and rules for buildings
6.)	EN 1993-1-8	Design of steel structures – Part 1-8: Design of joints
7.)	DNVGL-ST-N001	Marine operations and marine warranty
8.)	EN 13001-1	Cranes – General design – Part 1: General principles and requirements
9.)	EN 13001-3-1	Cranes – General design – Part 3-1: Limit states and proof of compentence of steel strucutres

Additional documents:

10.) Polski Rejestr Statków, Rules for the Construction of Containers, Gdańsk, 2014
11.) Vendor Design Data RevB.pdf (guidelines from client)
12.) CW-BALL-TQ-0007 - Transportation forces.pdf (guidelines from client)
13.) Recommended practice – Design of lifting, transport, storage and accessory equipment – OE-RP-01; Edition March 2018; offshoreenergy.dk

4. Geometry assumptions

4.1. Bottom and top corner fittings

Bottom and top corner fittings should be made in accordance to ISO 1611

4.2. Geometry of transported High Temperature Coolers

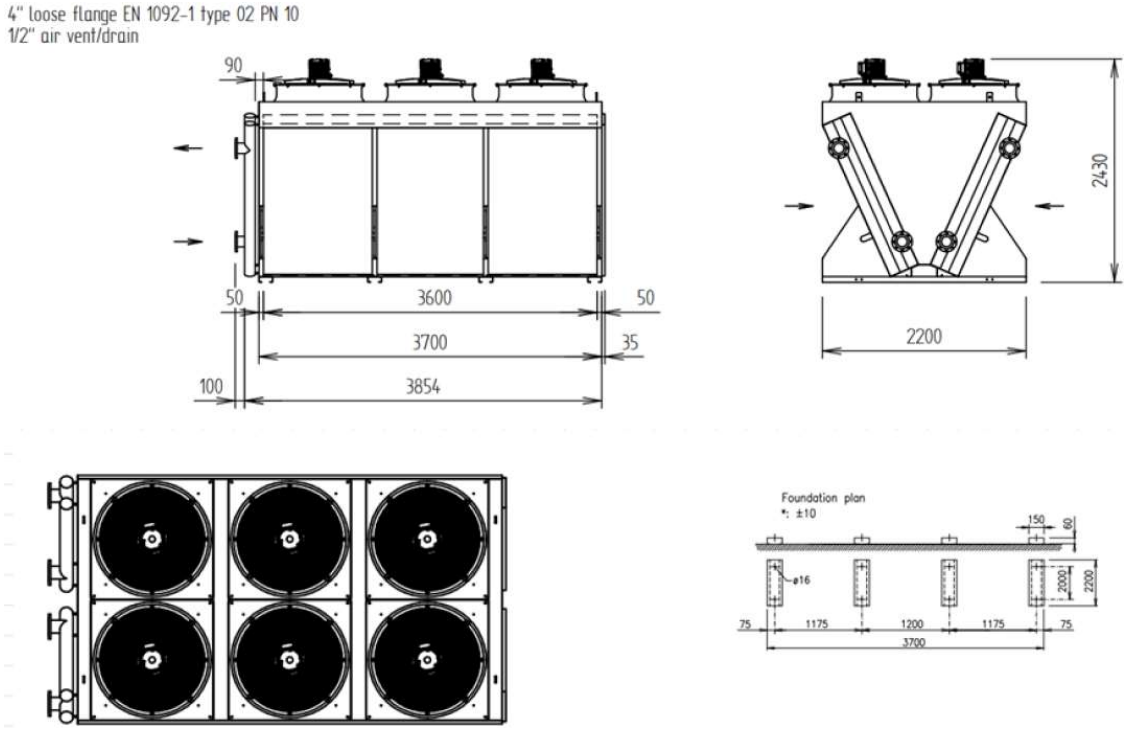


Fig 5: Evapco High Temperature Cooler – dimensions

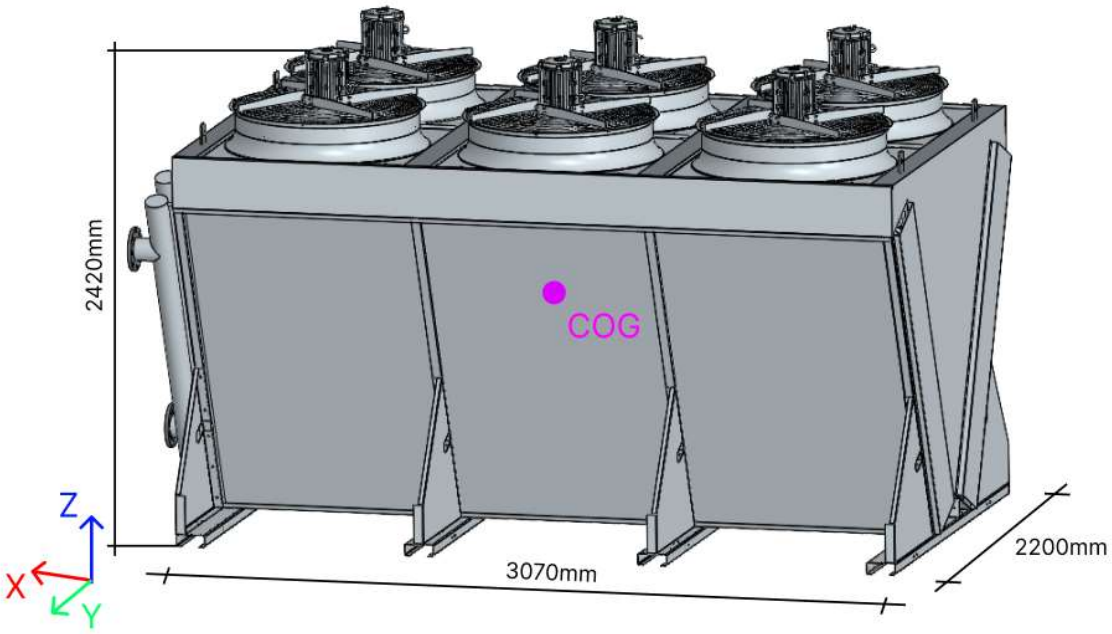


Fig 6: Geometry of HT Cooler

4.3. Geometry of transporte Low Temperature Coolers

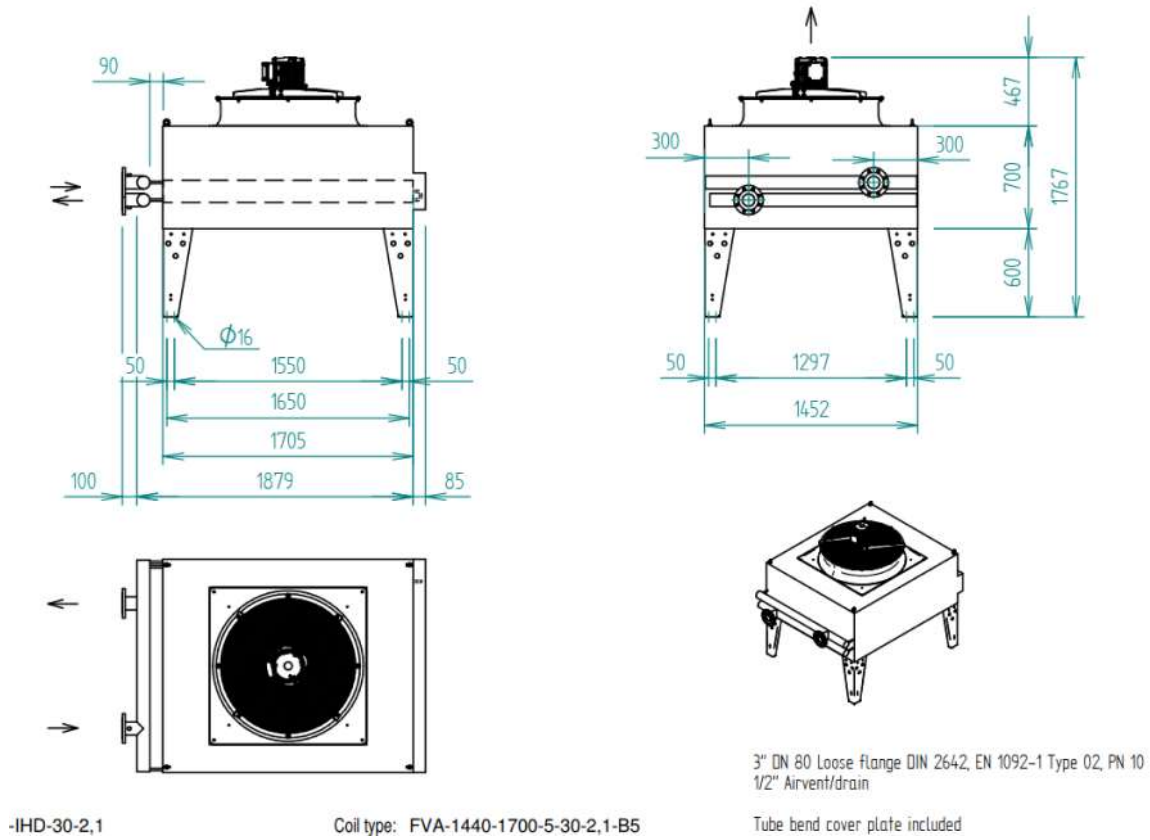


Fig 7: Evapco Low Temperature Cooler – dimensions

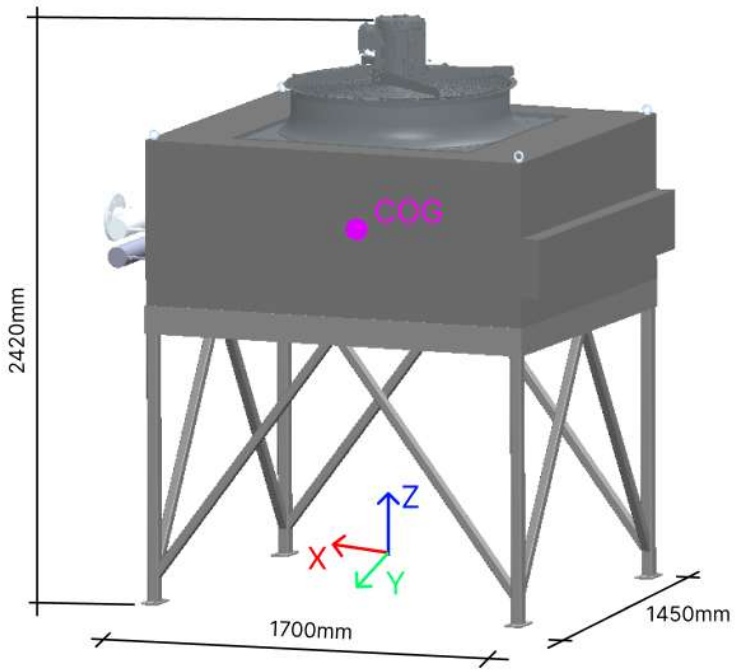


Fig 8: Geometry of LT Cooler with additional support steel frame

4.4. HT Work platform – Middle frame

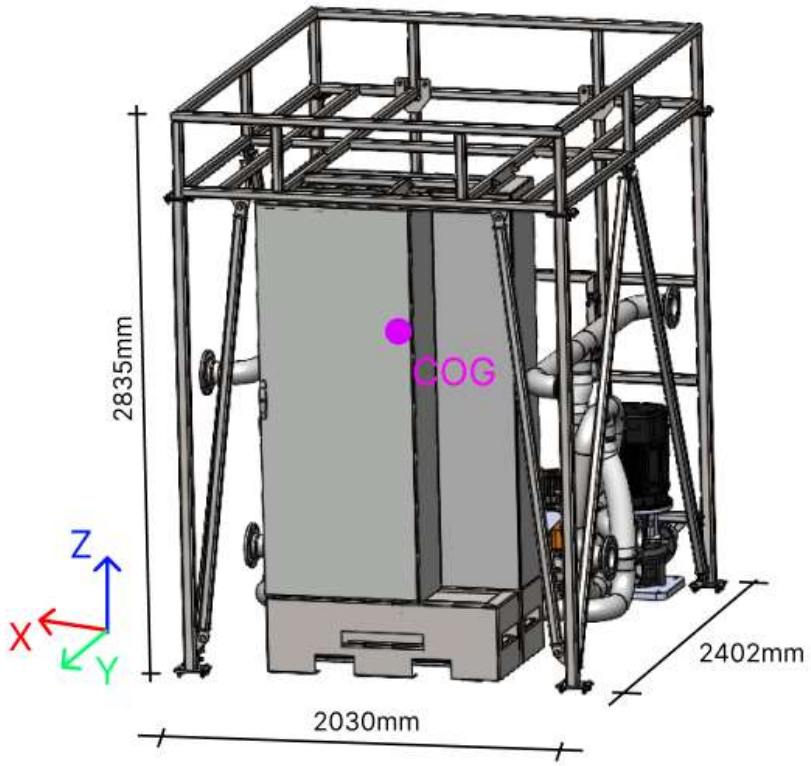


Fig 9: HT Work platform – Middle frame geometry

4.5. 40ft flatbed

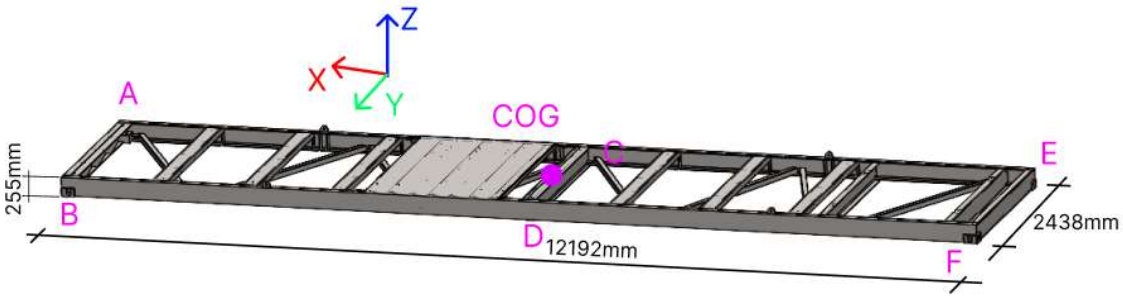


Fig 10: 40ft flatbed geometry

4.6. 40ft High Cube Container

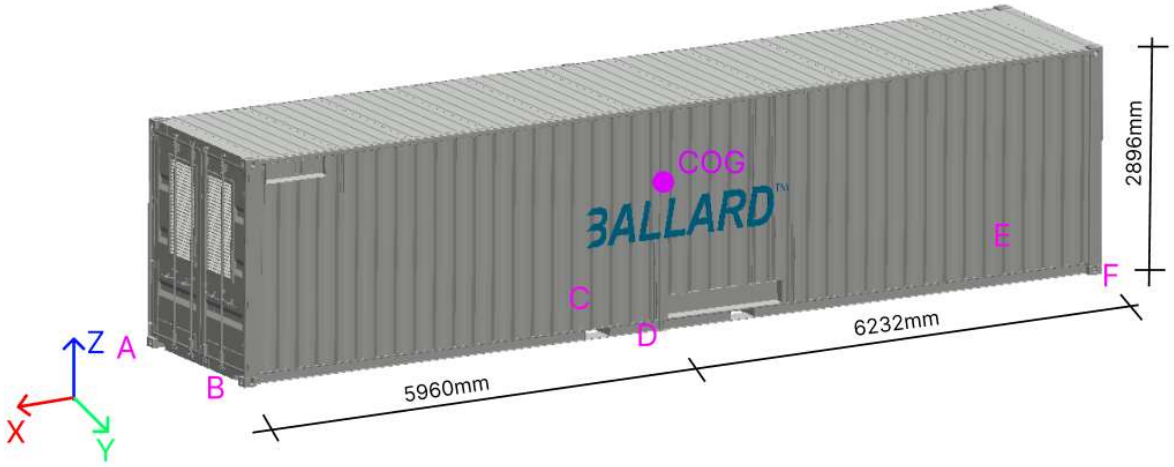


Fig 11: 40ft High Cube container – custom modified – geometry – Front view

40ft High Cube container – Center of gravity (COG):

- In X direction:
- measured from the end of the container (E, F): 6095mm
- measured from the end of the container (A, B): 6095mm
- In Y direction:
- measured from the end of the container (A, E): 1219mm
- measured from the end of the container (B, F): 1219mm
- in Z direction:
- measured from the bottom of the container (A, B, C, D, E, F): 1931mm

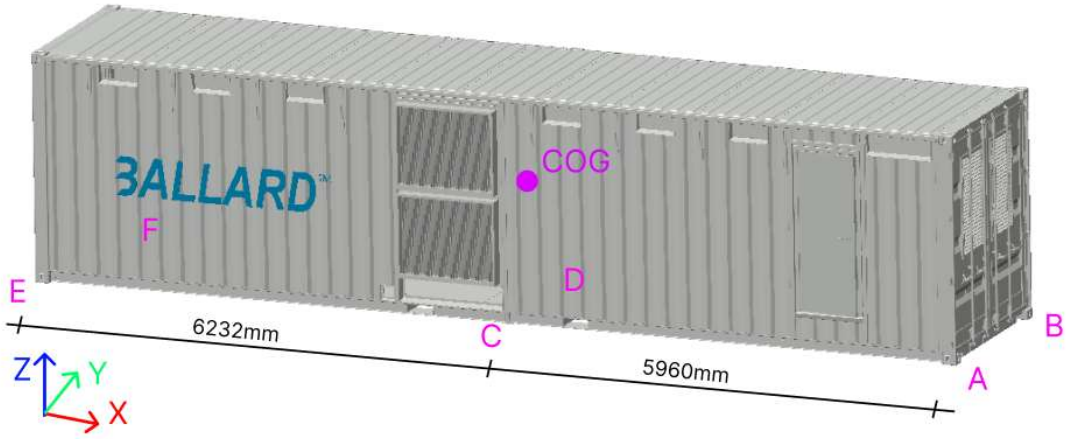


Fig 12: 40ft High Cube container – custom modified – geometry – Back view

4.7. 10ft High Cube Container

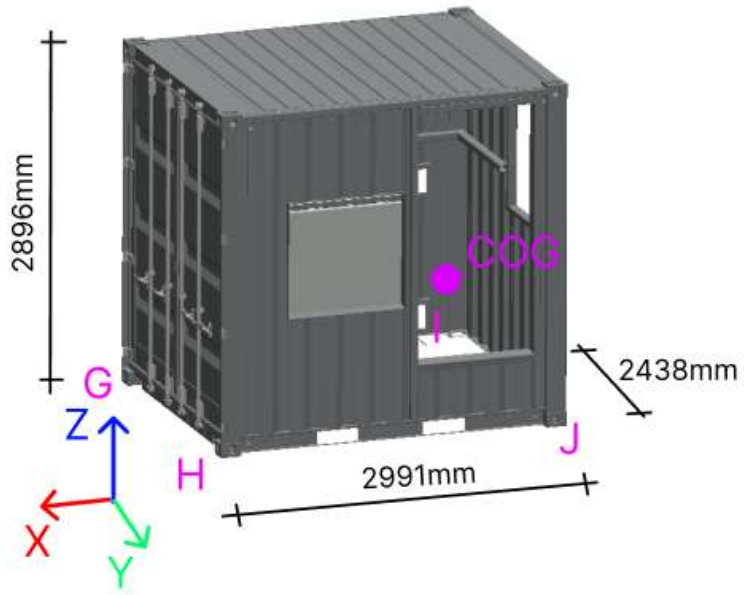


Fig 13: 10ft High Cube container – custom modified – geometry – Front view

10ft High Cube container – Center of gravity (COG):

- In X direction:
- measured from the end of the container (I, J): 745mm
- measured from the end of the container (G, H): 2246mm
- In Y direction:
- measured from the end of the container (G, I): 610mm
- measured from the end of the container (H, J): 1828mm
- in Z direction:
- measured from the bottom of the container (G, H, I, J): 724mm

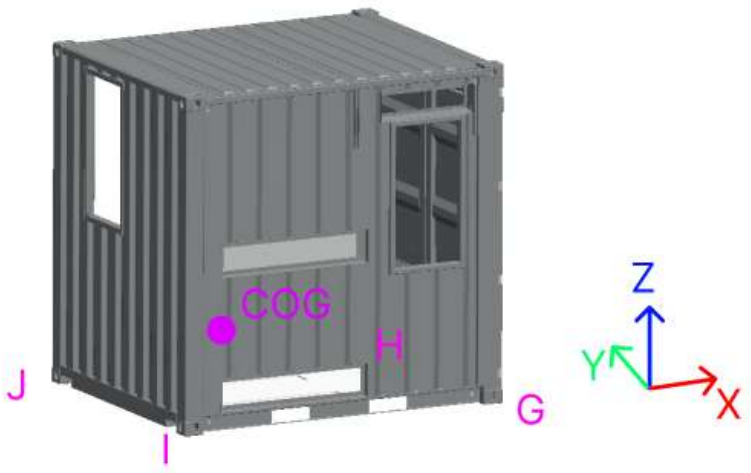


Fig 14: 10ft High Cube container – custom modified – geometry – Back view

5. Design conditions and safety factors

Safety factor for lifting offshore have been assumed for 10 tons load for 40ft flatbed with equipment. The same safety factor have been assumed for lifting of 40ft High Cube container with equipment and for 10ft High Cube container with equipment, as it is conservative assumption.

$$SHL = 10\ t = 10000kg$$

$$DAF_{onshore} = 1{,}10$$

$$DAF_{inshore} = 1{,}07 + 0{,}05 \cdot \sqrt{\frac{100t}{SHL}} = 1{,}23$$

$$DAF_{offshore} = 1 + 0{,}25 \cdot \sqrt{\frac{100t}{SHL}} = 1{,}79$$

Above dynamic safety factor combined with LRFD Table 5.8 of DNV standard gives below safety factor for lifting permanent loads:

$$SF_{DAF} = 1{,}3 \cdot 1{,}79 = 2{,}32$$

Description	Symbol	Value	Reference
Load safety factors for supported structure (road transport)	*SF*	1,6	*DNVGL-ST-N001*
Partial factor for resistance of structural members (road transport and offshore lifting)	γ_m	1,15	*DNVGL-ST-N001*
Partial factor for resistance of joints (bolts and welds) (road transport and offshore lifting)	γ_{mw}	1,30	*DNVGL-ST-N001*
Lifting with lifting sets – DAF (Dynamic Amplification Factor)- (lifting offshore)	*DAF*	1,8	*DNVGL-ST-N001 (Table 16.1)*
Lifting with lifting sets (lifting onshore)	*SF*	2	*EN 13155*
Partial factor for resistance of structural members (lifting)	γ_m	1	*EN 13155*
Partial factor for resistance of joints (bolts and welds) (lifting)	γ_{mw}	1,1	*EN 13155*
Load safety factors for supported structure (in destination place)	*SF*	1,35/1,5	*EN 1990-1-1*
Partial factor for resistance of structural members (in destination place)	γ_m γ_{M0}, γ_{M1}	1	*EN 1993-1-1*
Partial factor for resistance of joints (bolts and welds) (in destination place)	γ_{mw} γ_{M2}	1,25	*EN 1993-1-1*

Fig 15: Table of main safety factors

In destination place (offshore) has been assumed the same safety factors as for transport on barge in accordance with DNVGL-ST-N001 point 5.9.8 which states as below:

Table 5-8 Load factors for Ultimate Limit State (LRFD – Load and resistance factor design) According to DNVGL-ST-N001

Load condition	G	Q	D	E	A
ULS-a	1,3	1,3	1,0	0,7	NA
ULS-b	1,0	1,0	1,0	1,3	NA

G – permanent loads
Q – variable functional loads
D – deformation load
E – environmental loads (wind, waves, current, storm surge, tide, ice)
A – accidental loads

Fig 16: Table 5.8 of DNVGL-ST-N001 standard

6. Material properties and stress limits in appropriate load cases

40ft flatbed is made of steel S355J2
Containers are provided by external suplier. It has been assumed that these containers are also made of steel S355.

Steel grade: S355
Young modulus: $E = 210GPa$
Shear modulus: G= $81GPa$
Yield strength: $f_y = 355MPa$
Ultimate tensile strength: $f_u = 490MPa$
Possion's ratio in elastic stage: $\nu = 0{,}3$

Load cases			Load safety factors			Material partial safety factors				
	Description	Standard	Load safety factor		Dynamic safety factor	Material characteristic strength [MPa]	Partial factor for resistance of structural members	Partial factor for resistance of bolts and welds	Design strength of members	Design strength of welds
LC1	Road transport - braking	DNVGL-ST-N001	1,6			355	1,15	1,3	309	273
LC2	Road transport - accelerating	DNVGL-ST-N001	1,6				1,15	1,3	309	273
LC3	Road transport - turning	DNVGL-ST-N001	1,6				1,15	1,3	309	273
LC4	Road transport - uneven surface	DNVGL-ST-N001	1,6				1,15	1,3	309	273
LC5	Offshore lifting	DNVGL-ST-N001	LRFD Table 5.8		1,8		1,15	1,3	309	273
LC6	Onshore lifting	EN 13155	2				1	1,1-welds 1,25-bolts	355	323
			ULS-a	ULS-b						
LC7-1	Sea transport on the barque LC7-1 - Head sea, bow down, from Y+ [Pitch case 1]	DNVGL-ST-N001	G			355	1,15	1,3	309	273
LC8-2	Sea transport on the barque LC8-2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	DNVGL-ST-N001	1,3	1			1,15	1,3	309	273
LC9-3	Sea transport on the barque LC9-3 - Beam Sea, from X+ [Roll case 1]	DNVGL-ST-N001	Q				1,15	1,3	309	273
LC10-4	Sea transport on the barque LC10-4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	DNVGL-ST-N001	1,3	1			1,15	1,3	309	273
LC11-5	Sea transport on the barque LC11-5 - Head Sea, stern down, from Y- [Pitch case 2]	DNVGL-ST-N001	D				1,15	1,3	309	273
LC12-6	Sea transport on the barque LC12-6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	DNVGL-ST-N001	1	1			1,15	1,3	309	273
LC13-7	Sea transport on the barque LC13-7 - Beam Sea, from X- [Roll case 2]	DNVGL-ST-N001	E				1,15	1,3	309	273
LC14-8	Sea transport on the barque LC14-8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	DNVGL-ST-N001	0,7	1,3			1,15	1,3	309	273
LC15	Destination place (offshore) X+	DNVGL-ST-N001	A				1,15	1,3	309	273
LC16	Destination place (offshore) Y+	DNVGL-ST-N001	-	-			1,15	1,3	309	273

LRFD Table 5.8
G-pernament loads
Q-variable functional loads
D-deformation loads
E-environmental loads (wind, waves, storm, surge, tide, ice)
A-accidental loads

Fig 17: Stress limit in appropriate load cases

7. Calculations of basic wind velcotiy in destination place

7.1. First guidelines from customer

In-place Wind Loads:

Table 3.6 - Omni-Directional Extreme Values at 125 m MSL [9]

Averaging Time	Return period (years)						
	1	2	5	10	50	100	1,000
1hr	31.8	33.4	35.1	36.4	39.1	40.1	43.4
10min	33.7	35.5	37.4	38.8	41.7	42.9	46.5
3s	39.4	41.6	44.1	45.9	49.7	51.1	56.0

To adjust wind speeds to any specified averaging time or elevation, the following equations are to be used [8]:

$U(z, t) = U(z) * [1 - 0.41 * Iu(z) * \ln(t/t_0)]$

$U(z)$ = 1-hour mean wind speed given by:

$U(z) = U_0 * [1 + C * \ln(z/z_r)]$

$C = 0.0573 * (1 + 0.15 * U_0)^{1/2}$

$Iu = 0.06 * [1 + 0.043 * U_0] * (z/z_r)^{-0.22}$

U_0 = 1-hour average at the reference elevation, z_r

z_r = 10 m above sea level.

Directional exceedance data for wind is presented in Figure 3.6. The wind predominantly blows from the south-west.

Fig 18: Wind values provided by customer

In accordance to Eurokode 1991-1-4 - Wind actions:

v_{b0} - fundamental basic wind velocity is the 10 minute mean wind velocity with an annual risk of bein exceeded of 0,02 (which corrseponds with 50 years return period), irrespective of wind direction a height of 10m above flat open country terrain.

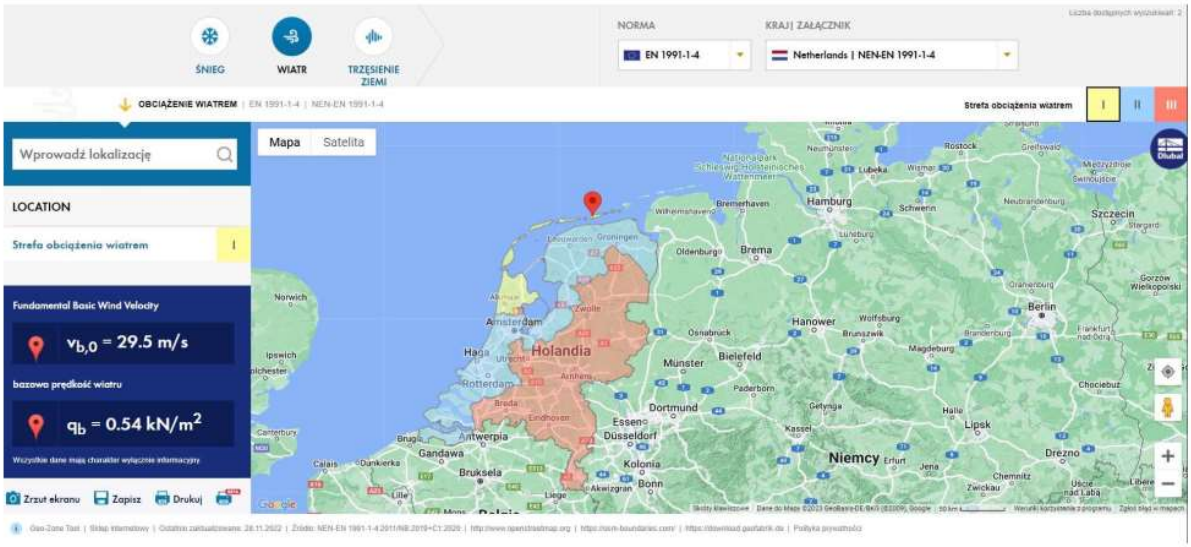


Fig 19: Wind actions according to EC1991-1-4 (Dlubal software website)

In accordance to Netherlands Eurocode 1991-1-4, North part of Netherlands is in zone 1, with fundamental basic wind velocity equals 29,5m/s.

In accordance to the above table 3.6 Omni Directional Extreme values at 125m for averaging time 10 minutes and return period 50 years, U(z) = 41,7m/s.

I am looking for fundamental basic wind velocity (averaging time 10 minuts, return period 50 years at reference elevation 10 meters):

Assumed: $v_{b,0} := 31,0 \ \frac{m}{s}$

$z := 125 \ m$

$z_r := 10 \ m$

Calculations:

$$C := 0,0573 \cdot \sqrt{1 + 0,15 \cdot v_{b,0} \ \frac{s}{m}} = 0,1362$$

Mean wind velocity (z=125m, averaging time 10 minutes, return period 50 years):

$$v_m := v_{b,0} \cdot \left(1 + C \cdot \ln\left(\frac{z}{z_r}\right)\right) = 41,7 \ \frac{m}{s}$$ U(z) = 41,7m/s

As shown above, for obtained guideliness the basic wind velocity (h=10m, 10minutes, 50years) is equal to:

$v_{b,0} := 31 \ \frac{m}{s}$

Obtained value is very similar to the value from the Netherlands Eurocode for wind (29,5), but a little bit bigger what is reasonable as the value of wind were measured on open sea.

7.2. Second guidelines from customer

Description	Unit	Value
Ambient Conditions		
Ambient Temperature (min/nom/max) – hourly @ +10m	°C	-8.4 / 10.5 / 25
Atmospheric Pressure (nominal) – hourly @ +10m	mbar	1013.7
Specific Humidity (min/nom/max) – hourly @ +10m	X 10^{-3}	4.2 / 6.5 / 9.5
Wind Conditions		
Annual average wind speed (at 100 m)	m/s	9.56
Extreme Wind Speed for 1-Year Recurrence Period (at 100 m)	m/s	33.1
Extreme Wind Speed for 50-Year Recurrence Period (at 100 m)	m/s	41.0
Marine Conditions		
Sea Water Temperature (min/max)	°C	1.3 / 20.2
Average Sea Water Density	Kg/m	1025
Highest Astronomical Tide (HAT)	m	2.2 (LAT)
Lowest Astronomical Tide (HAT)	m	0 (LAT)
Extreme High-Water Level for 50 -Year Recurrence Period	m	12.3 (LAT
Extreme High-Water Level for 1-Year Recurrence Period	m	9.1 (LAT)
Extreme Low-Water Level for 1-Year Recurrence Period	m	-0.5 (LAT)
Extreme Low-Water Level for 50-Year Recurrence Period	m	

Fig 20: Second guidelines from customer regarding the wind speed

Extreme wind speed for 50-year recurrence period at 100m:

$$v_{b,max,50y,100m} := 41\ \frac{m}{s}$$

I am looking for fundamental basic wind velocity (averaging time 10 minuts, return period 50 years at reference elevation 10 meters):

Assumed:

$$v_{b,0} := 31,2\ \frac{m}{s}$$

$$z := 100\ m$$

$$z_r := 10\ m$$

Calculations:

$$C := 0,0573 \cdot \sqrt{1 + 0,15 \cdot v_{b,0}\ \frac{s}{m}} = 0,1366$$

Mean wind velocity (z=100m, averaging time 10 minutes, return period 50 years):

$$v_m := v_{b,0} \cdot \left(1 + C \cdot \ln\left(\frac{z}{z_r}\right)\right) = 41\ \frac{m}{s}$$

U(z) = 41,0m/s

Fundamental basic wind velocity	vb0 [m/s2]
1. Calculated in acc. to 1st guidelines	31
2. From EC1991-1-4 for Norht part of Netherlands	29,5
3. Calculated in acc. to 2nd guidelines	31,2

Fig 21: Comparison of obtained basic wind velocities

8. Pre-processing

8.1. Assumptions

Strength of the 40ft flatbed have been checked in document "CrossWind – Flatbed 40ft – calculations report rev_1.pdf" from which reaction on the 40ft container were taken.
In this paper will be calculated reactions from 40ft HC Container nad 10ft HC Container during transport on barge and in destination place offshore near North Coast of Netherland and also during lifting offshore (which gives more conservative results then lifting onshore).

8.2. Loads definition

8.2.1. Accelerations during transport on barge

Customer provided guidelines of wind during transport on barge in document "Vendor Design Data RevB.pdf" which describe it as below:

Default motion criteria for unrestricted world-wide tows, provided in DNV-ST-N001 [23], shall be used. The LRFD design criteria are presented in Table 4.2.

Table 4.2 – Topside Transport Barge Motions [23]

Acceleration / Wind Force	Roll Case	Quartering Case	Pitch Case
Ay at waterline	0.50 g	0.40 g	0
Ay increase for each metre (z) above waterline	0.017 g/m	0.013 g/m	0
Ax at waterline	0	0.15 g	0.25 g
Ax incr. each metre (z) above waterline	0	0.005 g/m	0.007 g/m
Az at centre (C) barge	0.20 g	0.15 g	0.10 g
Az incr. each metre (y, d or x respectively) from C	0.017 g/m	0.012 g/m	0.007 g/m
Wind Pressure	1.0 kN/m²	1.0 kN/m²	1.0 kN/m²

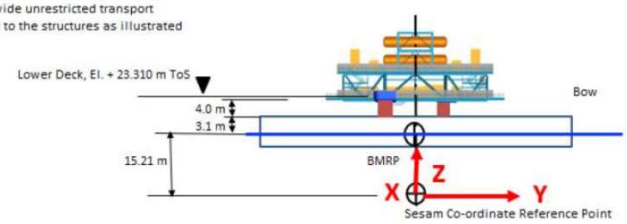
Notes:

1. x = distance from barge mid ship.
2. y = distance from barge centreline.
3. d = distance used for calculating az in quartering seas, $d = \sqrt{(y^2 + 0.5x^2)}$.
4. z = height above waterline.
5. ay = transverse acceleration parallel with barge deck.
6. ax = longitudinal acceleration parallel with barge deck.
7. az = acceleration normal to the barge deck.

Transport Analysis

Ref. 1: - In the absence of barge motions analysis, the topsides is considered to be transported on a North Sea type barge, defined by DNVGL to have a minimum size of 300' x 90' x 20', or larger. DNVGL simplified worldwide unrestricted transport motion criteria for this type of barge will be used to determine transport accelerations applied to the structures as illustrated below. Design methodology for LRFD.

Acceleration / Wind Force	Roll Case	Quartering	Pitch Case
Ay at waterline	0.50 g	0.40 g	0
Ay increase for each metre (z) above waterline	0.017 g/m	0.013 g/m	0
Ax at waterline	0	0.15 g	0.25 g
Ax incr. each metre (z) above waterline	0	0.005 g/m	0.007 g/m
Az at centre (C) barge	0.20 g	0.15 g	0.10 g
Az incr. each metre (y, d or x respectively) from C	0.017 g/m	0.012 g/m	0.007 g/m
Wind Pressure	1.0 kN/m²	1.0 kN/m²	1.0 kN/m²



Gravity assumed to be vertical (adjusted in the heave value) = 9.807 m/sec²

THE ABOVE ACCELERATIONS ARE CONVERTED TO PROVIDE ACCELERATIONS FOR SESAM ANALYSIS AT MRP

Description	Linear Acceleration Amplitude, (m/Sec²)				Angular Acceleration Amplitude, (Rad/Sec²)		
	Surge, Y	Sway, X	Max.	Min. Heave,	Roll, RotY	Pitch, RotX	Yaw, RotZ
Head Sea, Bow Down	2.45	0.00	10.79	8.83	0.0000	-0.0686	0.0000
Quartering Sea, Stbd Bow Down	1.47	3.92	11.28	8.34	0.1275	-0.0490	0.0000
Beam Sea, Stbd Down	0.00	4.90	11.77	7.85	0.1667	0.0000	0.0000
Quartering Sea, Stbd Stern Down	-1.47	3.92	11.28	8.34	0.1275	0.0490	0.0000
Head Sea, Stern Down	-2.45	0.00	10.79	8.83	0.0000	0.0686	0.0000
Quartering Sea, Port Stern Down	-1.47	-3.92	11.28	8.34	-0.1275	0.0490	0.0000
Beam Sea, Port Down	0.00	-4.90	11.77	7.85	-0.1667	0.0000	0.0000
Quartering Sea, Port Bow Down	1.47	-3.92	11.28	8.34	-0.1275	-0.0490	0.0000

Notes:
1) - Accelerations applied at the Barge Motions Reference Point (BMRP)
2) - Both +ve and -ve heave to be considered.

Using the Sesam co-ordinates shown above, the most onerous location of the centre of a hydrogen storage tank is:

- X = 4.0 m, (4 m off the barge centre)
- Y = 0.0 m, (at the barge centre)
- Z = 23.0 m, (above the barge water plane area)

For all other equipment, a generic centre location may be considered at:

- X = 8.0 m, (8 m off the barge centre)
- Y = 19.0 m, (19.0 m towards bow / stern)
- Z = 18.0 m, (above the barge water plane area)

Fig 9: Acceleration values during transport on barge (Vendor Design Data Rev B.pdf)

Figure 4.2 – Barge Transport Arrangement

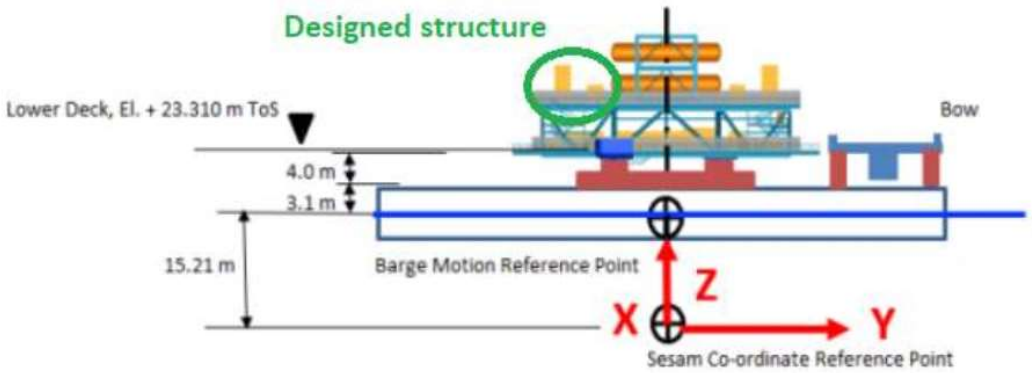


Fig 22: Designed structure on barge

Calculation of acceleration of analyzed 40ft container with 40ft flatbed at localization X=8m; Y=19m; Z=18m						
	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
Main data: X=8m Y=19m Z=h=18m g=9,807m/s2	LC1	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	3,69		12,09	7,52
	LC2	LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	2,35	6,22	13,61	6,00
	LC3	LC3 - Beam Sea, from X+ [Roll case 1]		7,90	13,10	6,51
	LC4	LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	-2,35	6,22	13,61	6,00
	LC5	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-3,69		12,09	7,52
	LC6	LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	-2,35	-6,22	13,61	6,00
	LC7	LC7 - Beam Sea, from X- Roll case 2]		-7,90	13,10	6,51
	LC8	LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	2,35	-6,22	13,61	6,00

Fig 23: Calculated accelerations on barge in according to guidelines (Vendor Design Data Rev B.pdf)

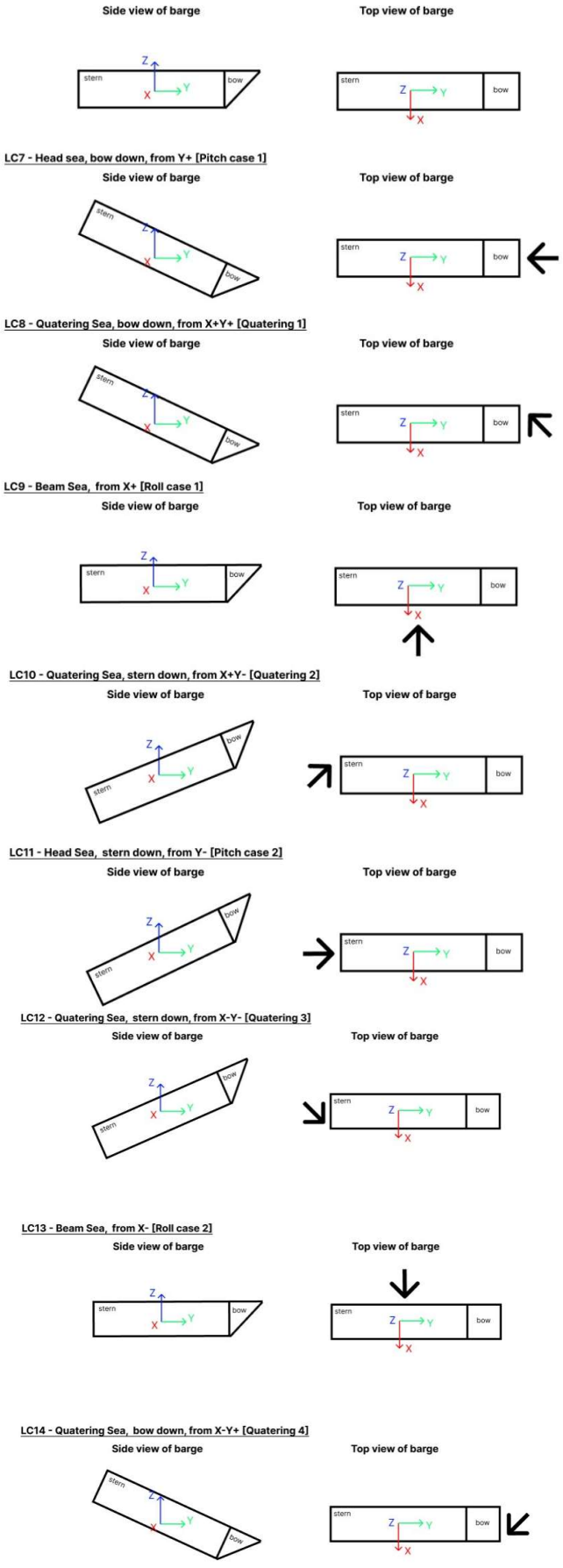


Fig 24: Schematic representation of transport on barge

8.2.2. Accelerations during transport on barge (Second guidelines from customer)

2024.01.24 – New transport guidelines were obtained from customer: "CW-BALL-TQ-0007-Transportation forces.docx" in accordance to which:

The supplier is to design the equipment to be suitable for the offshore barge transportation from the fabrication yard in Italy to the offshore site in The Netherlands.

The calculation can be done based on option 1 or 2.

For option 1: Determine if equipment is on the lower or upper deck and the orientation of the equipment on the plotplan and apply the loadcases from option 1.

For option 2: Determine if equipment is on the lower or upper deck and use the loadcases from option 2.

Option 1 Orientation specific transportation criteria			
	X (Roll)	**Y (Pitch)**	Z (incl. gravity)
Lower deck - roll	**+ / - 0.60 G**		**1G + / - 0.30 G**
Loadcase 1	-0.60 G in X		1.3 G Vertical
Loadcase 2	-0 .60 G in X		0.7 G vertical
Loadcase 3	+0.60 G in X		1.3 G Vertical
Loadcase 4	+0.60 G in X		0.7 G vertical
Lower deck - pitch		**+ / - 0.35G**	**1 G + / - 0.50 G**
Loadcase 5		-0.35 G in X	1.5 G Vertical
Loadcase 6		-0.35 G in X	0.5 G vertical
Loadcase 7		+0.35 G in X	1.5 G Vertical
Loadcase 8		+0.35 G in X	0.5 G vertical
Upper deck – roll	**+ / - 0.70 G**		**1G + / - 0.30 G**
Loadcase 1	-0.70 G in X		1.3 G Vertical
Loadcase 2	-0 .70 G in X		0.7 G vertical
Loadcase 3	+0.70 G in X		1.3 G Vertical
Loadcase 4	+0.70 G in X		0.7 G vertical
Upper deck -pitch		**+ / - 0.40 G**	**1G + / - 0.50 G**
Loadcase 5		-0.40 G in Y	1.5 G Vertical
Loadcase 6		-0.40 G in Y	0.5 G vertical
Loadcase 7		+0.40 G in Y	1.5 G Vertical
Loadcase 8		+0.40 G in Y	0.5 G vertical

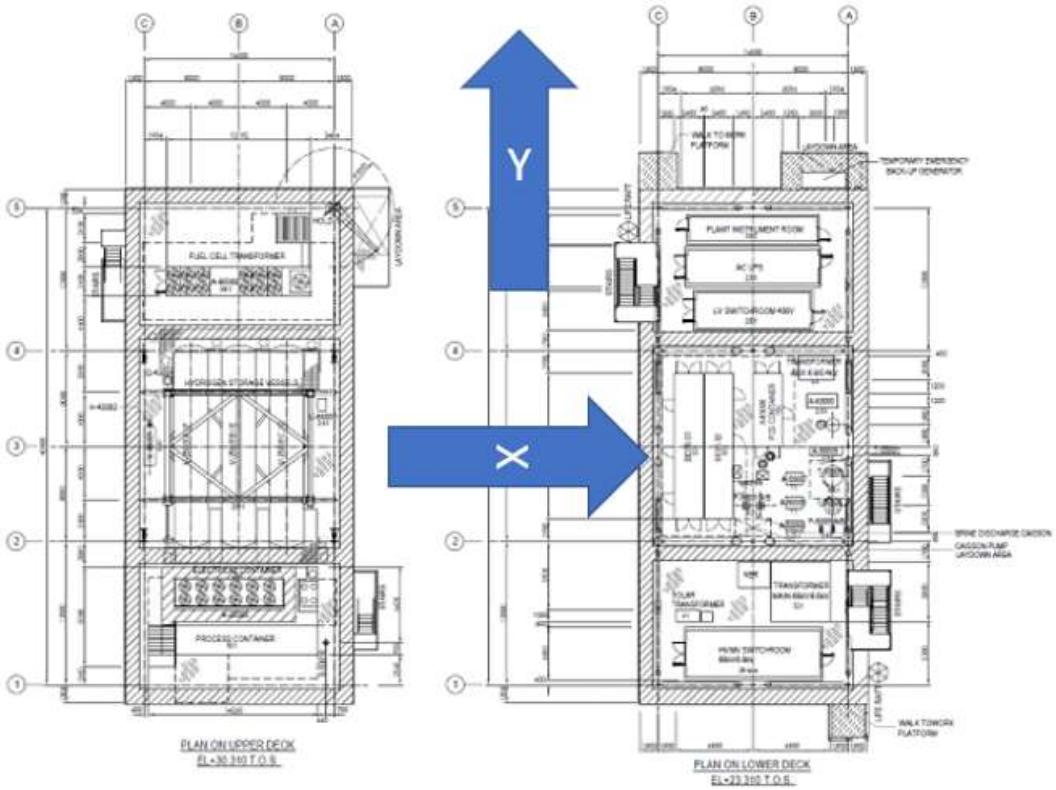
Fig 25: Second transportation guidelines from customer

Lower deck criteria	**+ / - 0.60 G**		**1 G + / - 0.50 G**
Loadcase 1	-0.60 G in X		1.5 G vertical
Loadcase 2	-0.60 G in X		0.5 G vertical
Loadcase 3	+0.60 G in X		1.5 G vertical
Loadcase 4	+0.60 G in X		0.5 G vertical
Loadcase 5	-0.60 G in Y		1.5 G vertical
Loadcase 6	-0.60 G in Y		0.5 G vertical
Loadcase 7	+0.60 G in Y		1.5 G vertical
Loadcase 8	+0.60 G in Y		0.5 G vertical
Upper deck deck criteria	**+ / - 0.70 G**		**1 G + / - 0.50 G**
Loadcase 1	-0.70 G in X		1.5 G vertical
Loadcase 2	-0.70 G in X		0.5 G vertical
Loadcase 3	+0.70 G in X		1.5 G vertical
Loadcase 4	+0.70 G in X		0.5 G vertical
Loadcase 5	-0.70 G in Y		1.5 G vertical
Loadcase 6	-0.70 G in Y		0.5 G vertical
Loadcase 7	+0.70 G in Y		1.5 G vertical
Loadcase 8	+0.70 G in Y		0.5 G vertical

Transportation acceleration to be combined with wind forces in the same direction as the horizontal acceleration.

The plot below shows the main axis as used in the table, X corresponds with roll and sway accelerations and Y with pitch and surge accelerations.

Fig 26: Second transportation guidelines from customer



Contractor to confirm that this is implemented in their package design and advise on any external seafastening requirement.

Fig 27: Second transportation uidelines from customer

In our case, as we know that our solution is placed on upper deck and in which direction will be installed, we choose to use **Option 1** which is less conservative.

DNV-ST-N001 - Old calculations

Calculation of acceleration of analyzed 40ft container with 40ft flatbed at localization X=8m; Y=19m; Z=18m						
Main data: X=8m Y=19m Z=h=18m g=9,807m/s2	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
	LC1	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	3,69		12,09	7,52
	LC2	LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	2,35	6,22	13,61	6,00
	LC3	LC3 - Beam Sea, from X+ [Roll case 1]		7,90	13,10	6,51
	LC4	LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	-2,35	6,22	13,61	6,00
	LC5	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-3,69		12,09	7,52
	LC6	LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	-2,35	-6,22	13,61	6,00
	LC7	LC7 - Beam Sea, from X- Roll case 2]		-7,90	13,10	6,51
	LC8	LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	2,35	-6,22	13,61	6,00

1st option - New Italian guidelines

Calculation of acceleration of analyzed 40ft container with 40ft flatbed according to Italian guidelines 2024.01.22 - OPTION 1						
Main data: Upper deck g=9,807m/s2	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
	O1 LC1&LC2	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	3,92 (6,2%)		14,71 (21,5%)	4,90 (35%)
		LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]				
	O1 LC3&LC4	LC3 - Beam Sea, from X+ [Roll case 1]		(10,3%) 6,86	12,75 (2,7%)	6,86 (5,4%)
		LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]				
	O1 LC5&LC6	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-3,92 (6,2%)		14,71 (21,5%)	4,90 (35%)
		LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]				
	O1 LC7&LC8	LC7 - Beam Sea, from X- Roll case 2]		(10,3%) -6,86	12,75 (2,7%)	6,86 (5,4%)
		LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]				

2nd option - New Italian guidelines

Calculation of acceleration of analyzed 40ft container with 40ft flatbed according to Italian guidelines 2024.01.22 - OPTION 2						
LC7 / Main data: Upper deck g=9,807m/s2 / LC9 LC11 LC13	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
	O2 LC1&LC2	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	6,86 (86%)		14,71 (21,5%)	4,90 (35%)
		LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]				
	O2 LC3&LC4	LC3 - Beam Sea, from X+ [Roll case 1]		(10,3%) 6,86	14,71 (12,2%)	4,90 (7,5%)
		LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]				
	O2 LC5&LC6	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-6,86 (86%)		14,71 (21,5%)	4,90 (35%)
		LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]				
	O2 LC7&LC8	LC7 - Beam Sea, from X- Roll case 2]		(10,3%) -6,86	14,71 (12,2%)	4,90 (7,5%)
		LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]				

Fig 28: Comparision between different gudelines

As shown above, the acceleration values differ between the DNV guidelines and the 2 options provided by the customer.

The 2 customer-defined options apply to only 4 load cases, while DNV takes into account as many as 8 load cases. Therefore, 6 load cases from DNV were adopted in the calculations and 2 cases (LC7 - Head sea, bow down and LC11 - head sea - stern down) were adopted from the client's guidelines because they give higher impact values than the corresponding DNV guidelines.

8.2.3. Wind at destination place acting on 40ft flatbed with equipment

These calculations can be found in document “Cross_Wind – Flatbed 40ft – calculations report rev_1.pdf”

8.2.4. Wind at destination place acting on 40ft High Cube container

40ft and 10ft High Cube containers will be placed on sea type barge.
When the barge is its destination (at sea near the coast of the Netherlands), the whole solution will be at a height of 30,31m above sea level (according to the client’s instructions)

Assumed Terrain category: 0 (Sea, coastal area exposed to the open sea)
Fundamental value of the basic wind velocity has been calculated in regards to obtained guidelines.

Basic wind velocity:

Fundamental value of the basic wind velocity: $v_{b,0} := 31,2 \frac{m}{s}$

Directional factor: $c_{dir} := 1$

Seasonal factor: $c_{season} := 1$

Basic wind velocity: $v_b := c_{dir} \cdot c_{season} \cdot v_{b,0} = 31,2 \frac{m}{s}$ (eq:4.1-EC1991-1-4)

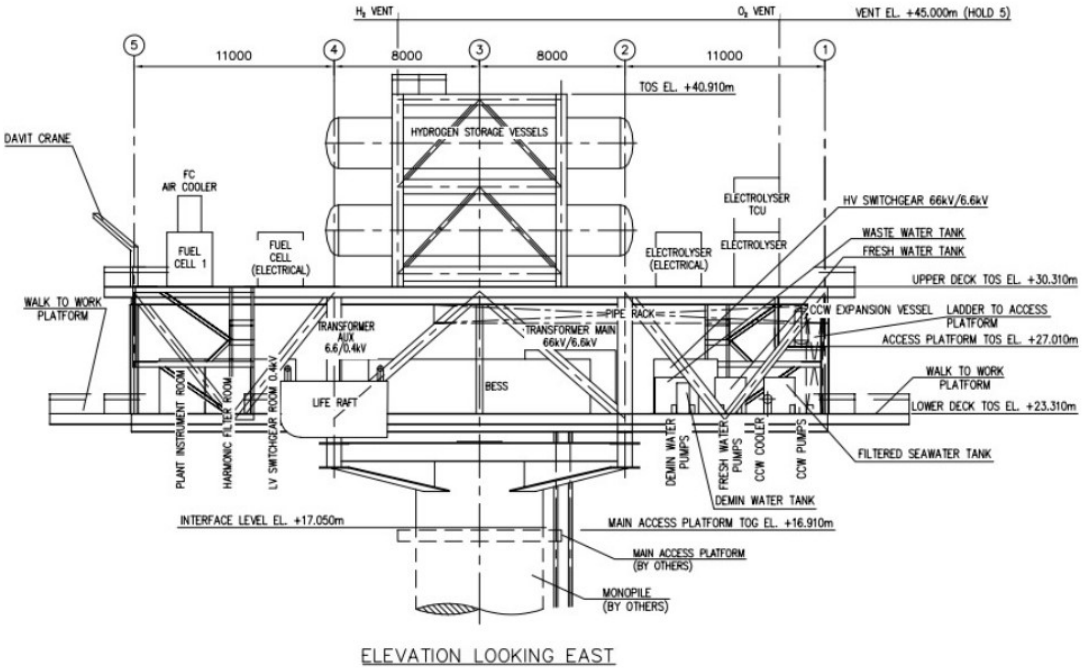


Fig 29: Guidelines from client – desitnation place of the designed structure

Maximum height at destination place:

$z := 30,31\ m + 2,896\ m + 30\ mm + 3,5\ m = 36,74\ m$

Length of 40ft HC container: $L_{40ft_container} := 12192\ mm$

Width of 40ft HC container: $W_{40ft_container} := 2438\ mm$

Height of 40ft HC container: $H_{40ft_container} := 2896\ mm$

Mean wind velocity:

$z_{0,II} := 0,05\ m$

$z_0 := 0,003\ m$

$z_{min} := 1\ m$

$z = 36,736\ m$

Orography factor:

$c_0 := 1$

Table 4.1 — Terrain categories and terrain parameters

	Terrain category	z_0 m	z_{min} m
0	Sea or coastal area exposed to the open sea	0,003	1
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	0,01	1
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0,05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0,3	5
IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1,0	10
NOTE: The terrain categories are illustrated in A.1.			

Terrain factor: $k_r := 0,19 \cdot \left(\frac{z_0}{z_{0,II}}\right)^{0,07} = 0,156$ (eq:4.5-EC1991-1-4)

Roughness factor: $c_r := k_r \cdot \ln\left(\frac{z}{z_0}\right) = 1,4687$ (eq:4.4-EC1991-1-4)

Mean wind velocity: $v_m := c_r \cdot c_0 \cdot v_b = 45,825\ \frac{m}{s}$ (eq:4.3-EC1991-1-4)

Wind turbulence:

Turbulence factor: $k_I := 1$

Standard deviation of the turbulence: $\sigma_v := k_r \cdot v_b \cdot k_I = 4,8683\ \frac{m}{s}$ (eq:4.7-EC1991-1-4)

Turbulence intensity: $I_v := \frac{\sigma_v}{v_m} = 0,1062$ (eq:4.7-EC1991-1-4)

Peak velocity pressure:

Air density: $\rho := 1,25\ \frac{kg}{m^3}$

Peak velocity pressure: $q_p := \left(1 + I_v\right) \cdot \frac{1}{2} \cdot \rho \cdot v_m^{\ 2} = 1,4519\ kPa$

Reference mean (basic) velocity pressure: (eq:4.7-EC1991-1-4)

$q_b := \frac{1}{2} \cdot \rho \cdot v_b^{\ 2} = 0,6084\ kPa$ (eq:4.10-EC1991-1-4)

Exposure factor: $c_e := \frac{q_p}{q_b} = 2,3864$ (eq:4.9-EC1991-1-4)

Structural factor: $c_s := 1$ $c_d := 1$ $c_s \cdot c_d = 1$

Consideration of wind acting on whole structure as on a structural element with rectangular section:

Rounded corners effect factor: $\psi_r := 1$ (fig. 7.24-EC1991-1-4)

Solidity ratio: $\varphi := 1$ (eq:7.28-EC1991-1-4)

Effective slenderness:

$$\lambda_{big} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{L_{40ft_container}}{H_{40ft_container}} \\ 70 \end{array}\right]\right) = 8,4199$$

(table:7.16-EC1991-1-4)

$$\lambda_{small} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{H_{40ft_container}}{W_{40ft_container}} \\ 70 \end{array}\right]\right) = 2,3757$$

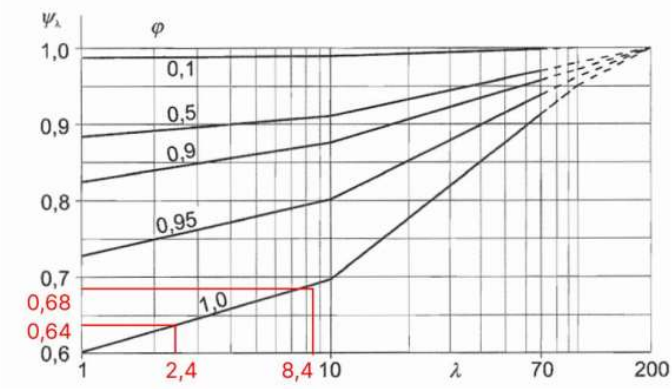


Fig 30: End effect factor from the figure 7.36 – EC1991-1-4

As slenderness in both directions is similar one value for two direction has been assumed:

End effect factor: $\psi_\lambda := 0,68$

$d_{small} := L_{40ft_container} = 12,192\ m$

$b_{small} := H_{40ft_container} = 2,9\ m$

$$\frac{d_{small}}{b_{small}} = 4,2099$$

$d_{big} := W_{40ft_container} = 2,438\ m$

$b_{big} := H_{40ft_container} = 2,896\ m$

$$\frac{d_{big}}{b_{big}} = 0,8419$$

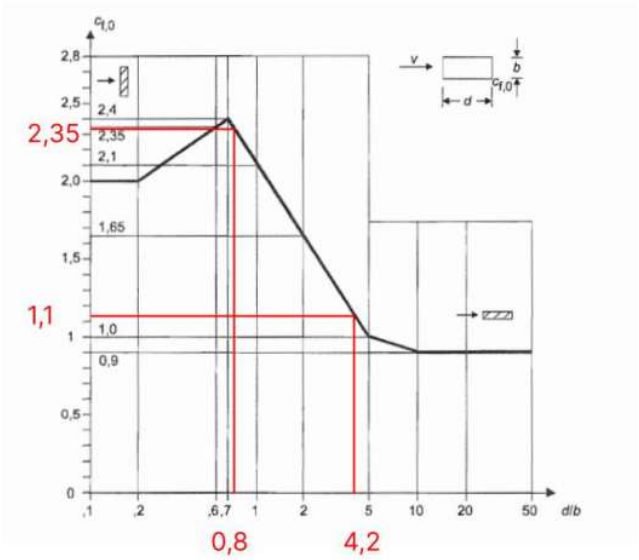


Fig 31: Force coefficient from the figure 7.23 – EC1991-1-4

The coefficient were slightly modified to more corresponds with the coefficients assumed for 40ft flatbed.

$c_{f,0,small} := 1,3$ $c_{f,0,big} := 2,20$

Force acting on small side of the 40ft HC container

$A_{40ft_container,small} := W_{40ft_container} \cdot H_{40ft_container} = 7,0604\ m^2$

$W_{40ft_container,s} := c_s \cdot c_d \cdot c_{f,0,small} \cdot q_p \cdot A_{40ft_container,small} = 13,33\ kN$

Force acting on big side of the 40ft HC container:

$A_{40ft_container,big} := L_{40ft_container} \cdot H_{40ft_container} = 35,308\ m^2$

$W_{40ft_container,b} := c_s \cdot c_d \cdot c_{f,0,big} \cdot q_p \cdot A_{40ft_container,big} = 112,78\ kN$

8.2.5. Wind at destination place acting on 10ft High Cube container

40ft and 10ft High Cube containers will be placed on sea type barge.
When the barge is its destination (at sea near the coast of the Netherlands), the whole solution will be at a height of 30,31m above sea level (according to the client's instructions)

Assumed Terrain category: 0 (Sea, coastal area exposed to the open sea)
Fundamental value of the basic wind velocity has been calculated in regards to obtained guidelines.

Basic wind velocity:

Fundamental value of the basic wind velocity: $v_{b,0} := 31,2 \frac{m}{s}$

Directional factor: $c_{dir} := 1$

Seasonal factor: $c_{season} := 1$

Basic wind velocity: $v_b := c_{dir} \cdot c_{season} \cdot v_{b,0} = 31,2 \frac{m}{s}$ (eq:4.1-EC1991-1-4)

Length of 10ft HC container: $L_{10ft_container} := 2991\ mm$

Width of 10ft HC container: $W_{10ft_container} := 2438\ mm$

Height of 10ft HC container: $H_{10ft_container} := 2896\ mm$

Maximum height in destination place:

$z := 30,31\ m + 2,896\ m = 33,206\ m$

Mean wind velocity:

$z_{0,II} := 0,05\ m$

$z_0 := 0,003\ m$

$z_{min} := 1\ m$

$z = 33,206\ m$

Orography factor:

$c_0 := 1$

Table 4.1 — Terrain categories and terrain parameters

Terrain category		z_0 m	z_{min} m
0	Sea or coastal area exposed to the open sea	0,003	1
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	0,01	1
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0,05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0,3	5
IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1,0	10
NOTE: The terrain categories are illustrated in A.1.			

Terrain factor: $k_r := 0,19 \cdot \left(\frac{z_0}{z_{0,II}}\right)^{0,07} = 0,156$ (eq:4.5-EC1991-1-4)

Roughness factor: $c_r := k_r \cdot \ln\left(\frac{z}{z_0}\right) = 1,453$ (eq:4.4-EC1991-1-4)

Mean wind velocity: $v_m := c_r \cdot c_0 \cdot v_b = 45,3331 \frac{m}{s}$ (eq:4.3-EC1991-1-4)

Wind turbulence:

Turbulence factor: $k_I := 1$

Standard deviation of the turbulence: $\sigma_v := k_r \cdot v_b \cdot k_I = 4,8683 \ \frac{m}{s}$ (eq:4.7-EC1991-1-4)

Turbulence intensity: $I_v := \frac{\sigma_v}{v_m} = 0,1074$ (eq:4.7-EC1991-1-4)

Peak velocity pressure:

Air density: $\rho := 1,25 \ \frac{kg}{m^3}$

Peak velocity pressure: $q_p := \left(1 + I_v\right) \cdot \frac{1}{2} \cdot \rho \cdot v_m^{\ 2} = 1,4224 \ kPa$

Reference mean (basic) velocity pressure: (eq:4.7-EC1991-1-4)

$q_b := \frac{1}{2} \cdot \rho \cdot v_b^{\ 2} = 0,6084 \ kPa$ (eq:4.10-EC1991-1-4)

Exposure factor: $c_e := \frac{q_p}{q_b} = 2,3379$ (eq:4.9-EC1991-1-4)

Structural factor: $c_s := 1$ $c_d := 1$ $c_s \cdot c_d = 1$

Consideration of wind acting on whole structure as on a structural element with rectangular section:

Rounded corners effect factor: $\psi_r := 1$ (fig. 7.24-EC1991-1-4)

Solidity ratio: $\varphi := 1$ (eq:7.28-EC1991-1-4)

Effective slenderness:

$$\lambda_{big} := \min\left(\left[\left[2 \cdot \frac{L_{10ft_container}}{H_{10ft_container}}\right]\right], 70\right) = 2,0656$$

(table:7.16-EC1991-1-4)

$$\lambda_{small} := \min\left(\left[\left[2 \cdot \frac{H_{10ft_container}}{W_{10ft_container}}\right]\right], 70\right) = 2,3757$$

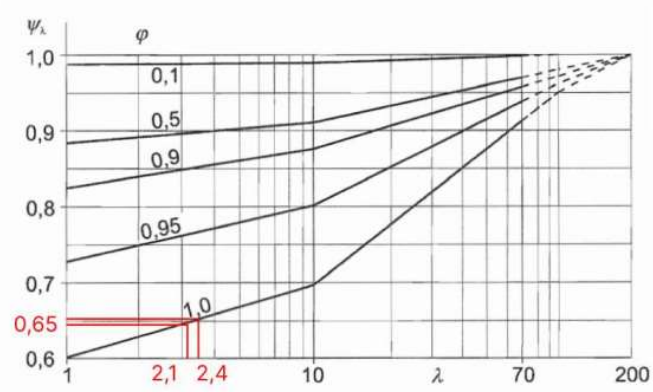


Fig 32: End effect factor from the figure 7.36 – EC 1991-1-4

As slenderness in both directions is similar one value for two direction has been assumed:

End effect factor: $\psi_\lambda := 068$

$d_{small} := L_{10ft_container} = 2,991\ m$

$b_{small} := H_{10ft_container} = 2,896\ m$

$\frac{d_{small}}{b_{small}} = 1,0328$

$d_{big} := W_{10ft_container} = 2,438\ m$

$b_{big} := H_{10ft_container} = 2,896\ m$

$\frac{d_{big}}{b_{big}} = 0,8419$

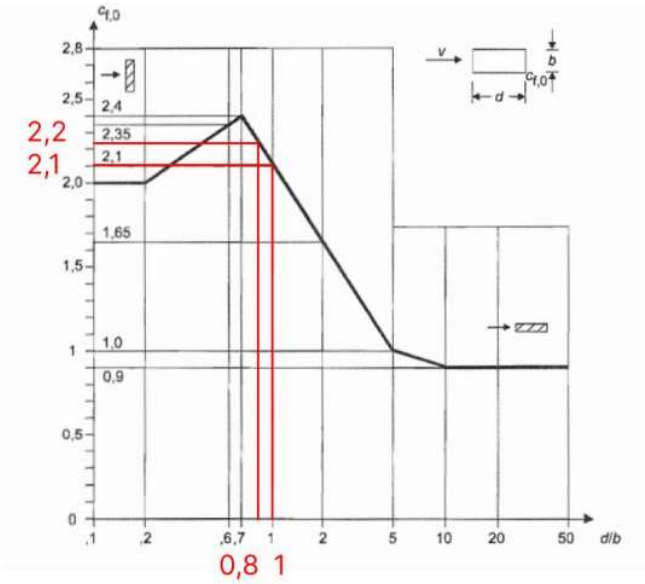


Fig 33: Force coefficient from the figure 7.23 – EC1991-1-4

$c_{f,0,small} := 2,1$ $c_{f,0,big} := 2,20$

Force acting on small side of the 10ft HC container

$A_{10ft_container,small} := W_{10ft_container} \cdot H_{10ft_container} = 7,0604\ m^2$

$W_{10ft_container,s} := c_s \cdot c_d \cdot c_{f,0,small} \cdot q_p \cdot A_{10ft_container,small} = 21,0894\ kN$

Force acting on big side of the 10ft HC container

$A_{10ft_container,big} := L_{10ft_container} \cdot H_{10ft_container} = 8,6619\ m^2$

$W_{10ft_container,b} := c_s \cdot c_d \cdot c_{f,0,big} \cdot q_p \cdot A_{10ft_container,big} = 27,105\ kN$

8.2.6. Self-weight of the solution

No	Masses	
A	40ft container	22685kg
B	40ft flatbed	11332kg
C	10ft container	7138kg

Fig 34: Self-weight of each component with equipment (wet)

8.3. Load combinations

In document "Cross_Wind – Flatbed 40ft – calculations report rev_1.pdf" the following load cases have been assumed:

Symbol:	Description	Standard	Load safety factor
LC1	Road transport – braking	DNVGL-ST-N001	1,6
LC2	Road transport – accelerating	DNVGL-ST-N001	1,6
LC3	Road transport – turning	DNVGL-ST-N001	1,6
LC4	Road transport – uneven surface	DNVGL-ST-N001	1,6
LC5	Offshore lifting	DNVGL-ST-N001	LRFD (Table 5.8) + dynamic safety factor = 1,8
LC6	Onshore lifting	EN 13155	2
LC7	Sea transport on the barge LC7-1 Head sea, bow down, From Y+ [Pitch case 1]	DNVGL-ST-N001	LRFD (Table 5.8)
LC8	Sea transport on the barge LC8-2 – Quatering sea, bow down From X+ Y+ [Quatering 1]	DNVGL-ST-N001	LRFD (Table 5.8)
LC9	Sea transport on the barge LC9-3 – Beam sea, From X+ [Roll case 1]	DNVGL-ST-N001	LRFD (Table 5.8)
LC10	Sea transport on the barge LC10-4 – Quatering sea, stern down From X+ Y- [Quatering 2]	DNVGL-ST-N001	LRFD (Table 5.8)
LC11	Sea transport on the barge LC11-5 Head sea, stern down, From Y- [Pitch case 2]	DNVGL-ST-N001	LRFD (Table 5.8)
LC12	Sea transport on the barge LC12-6 – Quatering sea, stern down From X- Y- [Quatering 3]	DNVGL-ST-N001	LRFD (Table 5.8)
LC13	Sea transport on the barge LC13-7 – Beam sea, From X- [Roll case 2]	DNVGL-ST-N001	LRFD (Table 5.8)
LC14	Sea transport on the barge LC14-8 – Quatering sea, bow down From X- Y+ [Quatering 4]	DNVGL-ST-N001	LRFD (Table 5.8)
LC15	Destination place (offshore) X+	DNVGL-ST-N001	LRFD (Table 5.8)
LC16	Destination place (offshore) Y+	DNVGL-ST-N001	LRFD (Table 5.8)
LC17	Destination place (offshore) X-	DNVGL-ST-N001	LRFD (Table 5.8)
LC18	Destination place (offshore) Y-	DNVGL-ST-N001	LRFD (Table 5.8)

This document focus on reactions from 40ft HC container and 10ft HC container during transport on barge (LC7-LC14), during lifting (LC5-LC6), and during opereting on open sea (LC14-LC18). LC1-LC4 for 40ft container were not performed, but were performed for 10ft container

8.3.1. Load combinations for 40ft HC Container

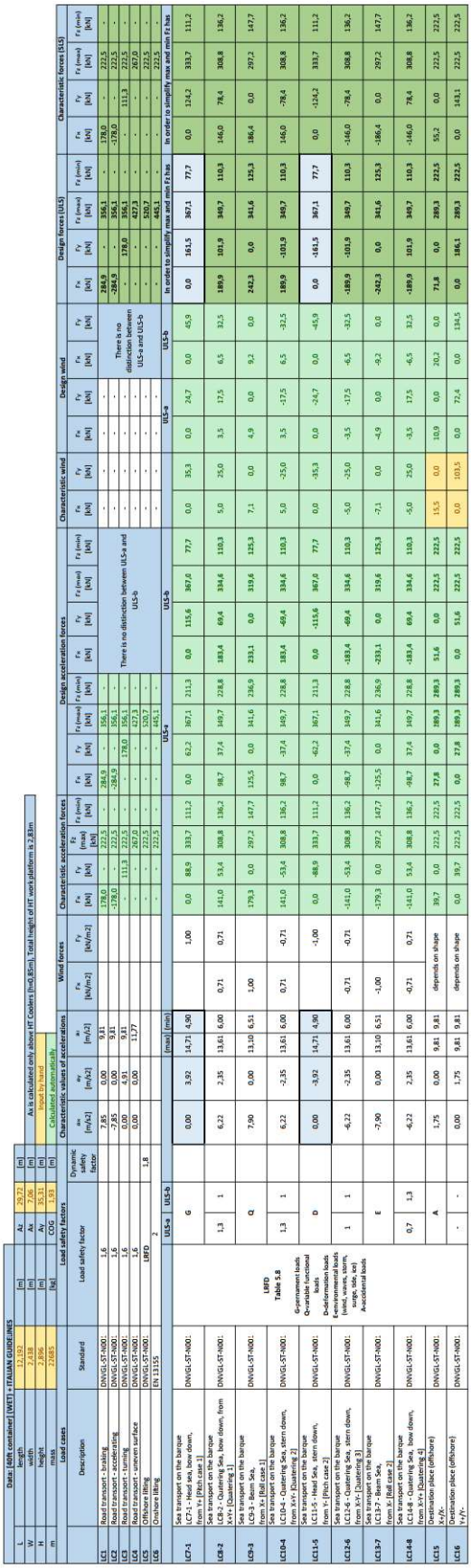


Fig 35: 40ft HC Continer – loads combinations

8.3.2. Load combinations for 10ft HC Container

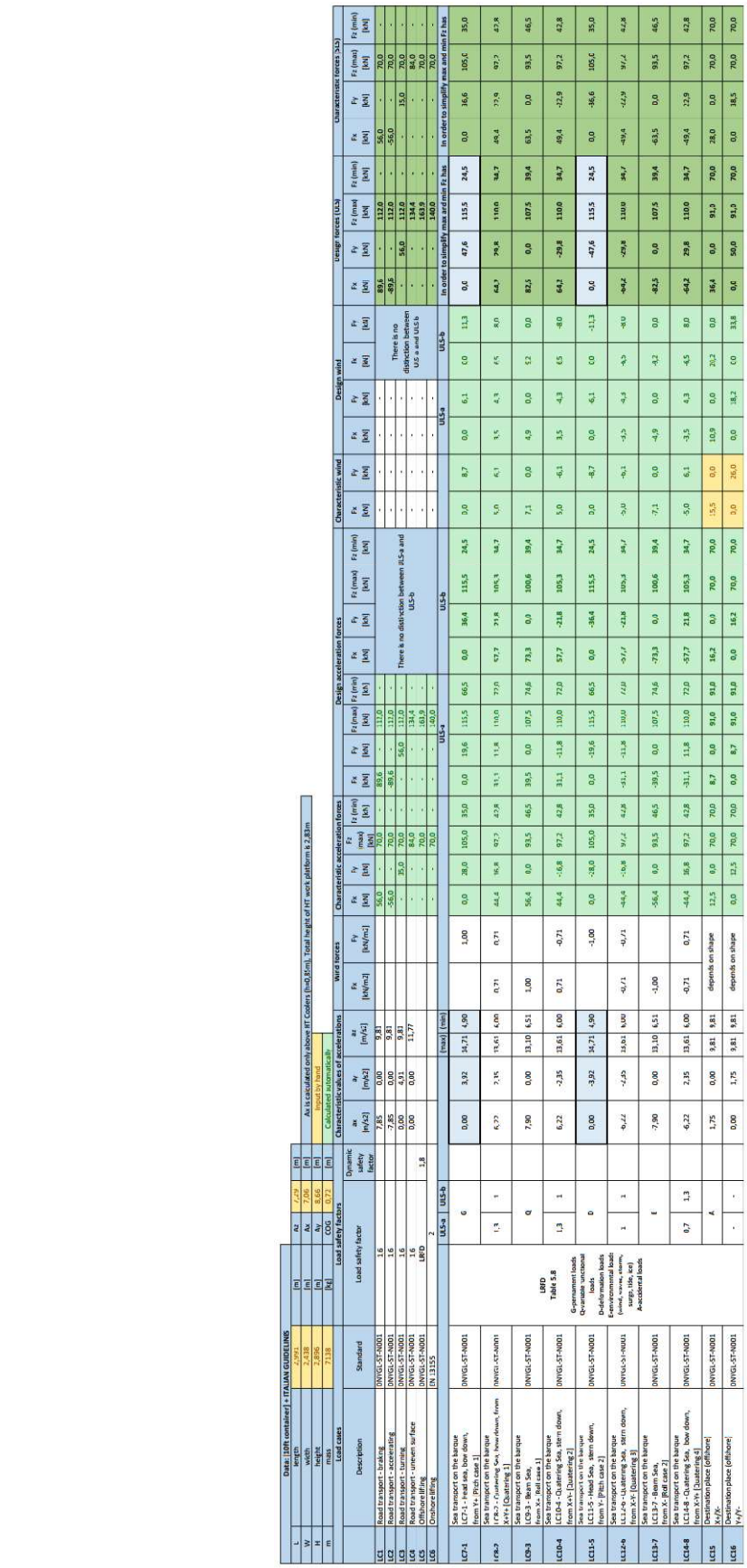


Fig 36: 10ft HC Continer – loads combinations

8.3.3. Reactions from LC1-LC18 – 40ft flatbed

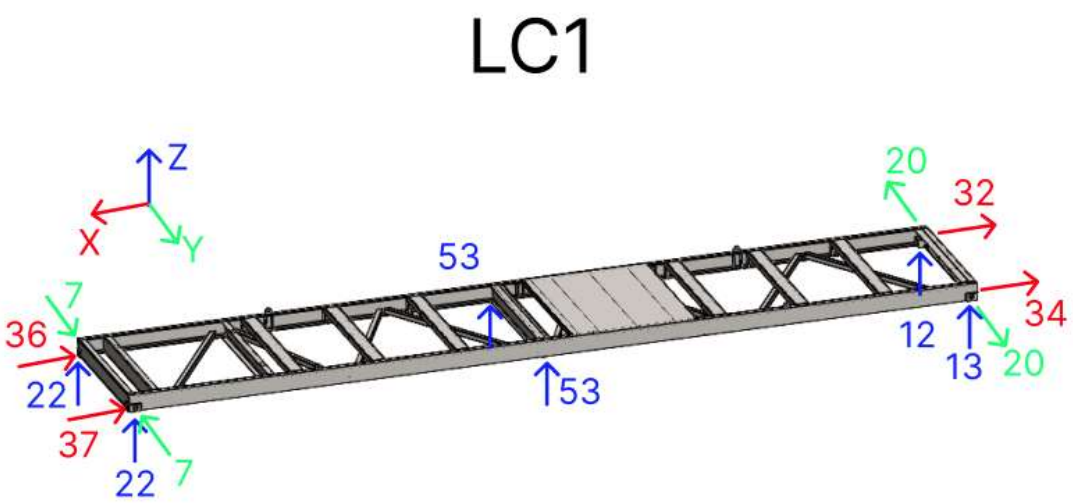


Fig 37: 40ft flatbed – LC1

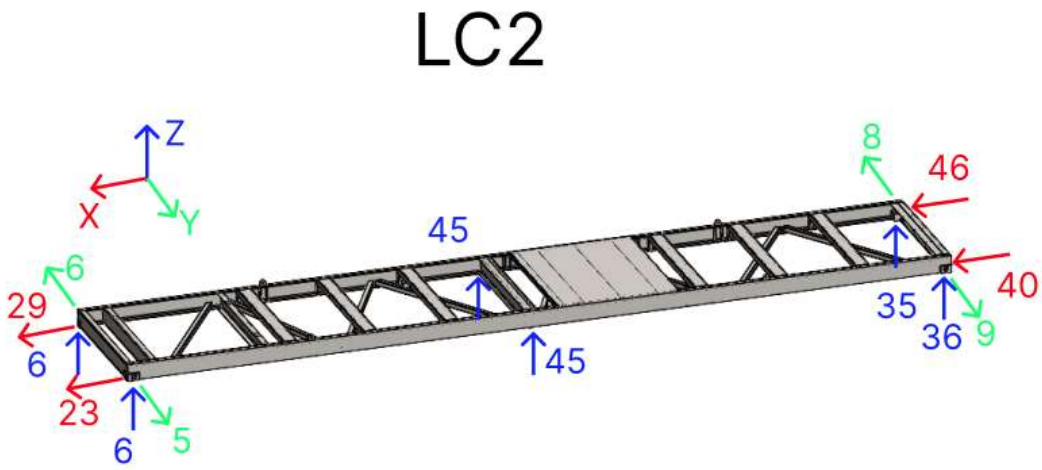


Fig 38: 40ft flatbed – LC2

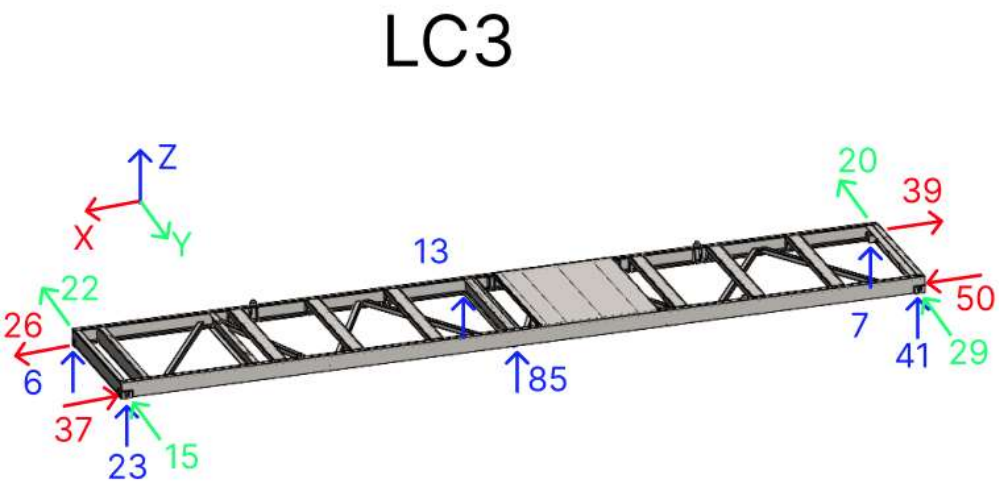


Fig 39: 40ft flatbed – LC3

LC4

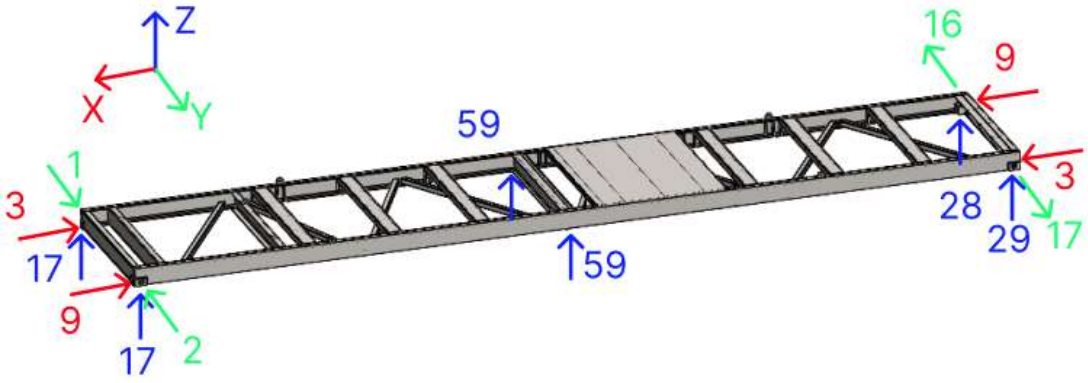


Fig 40: 40ft flatbed – LC4

LC5

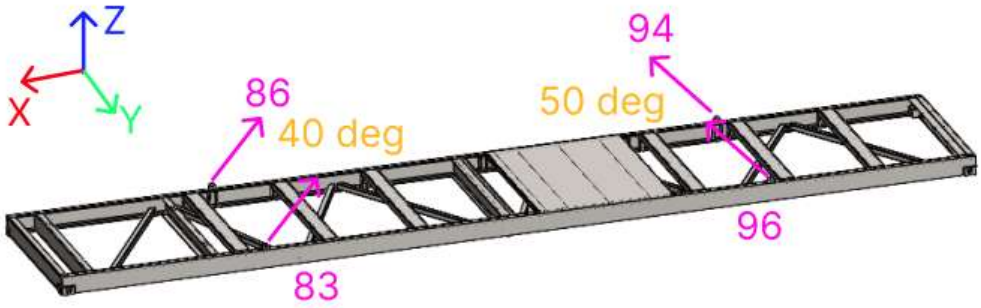


Fig 41: 40ft flatbed – LC5

LC6

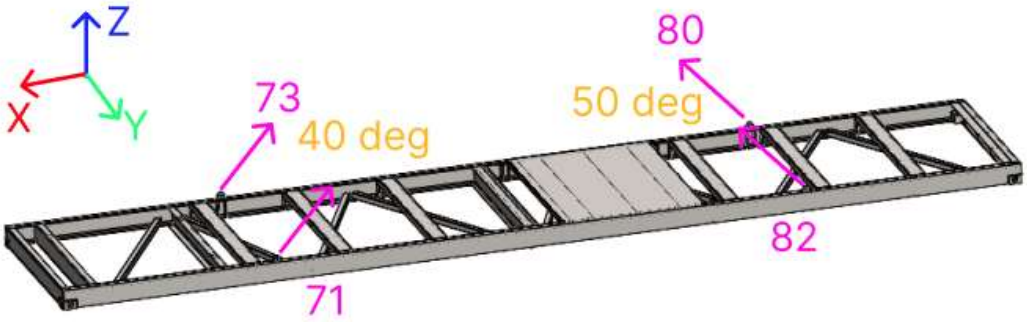


Fig 42: 40ft flatbed – LC6

LC7max (Italian)

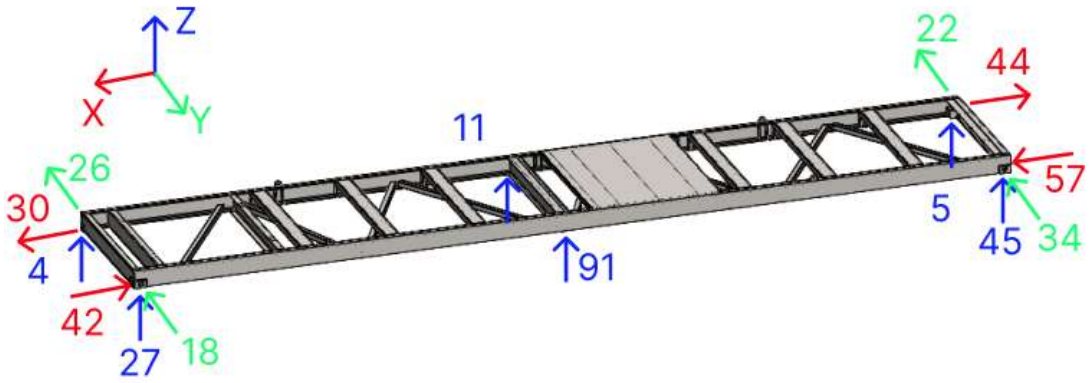


Fig 43: 40ft flatbed – LC7max (Italian 1st option)

LC7min (Italian)

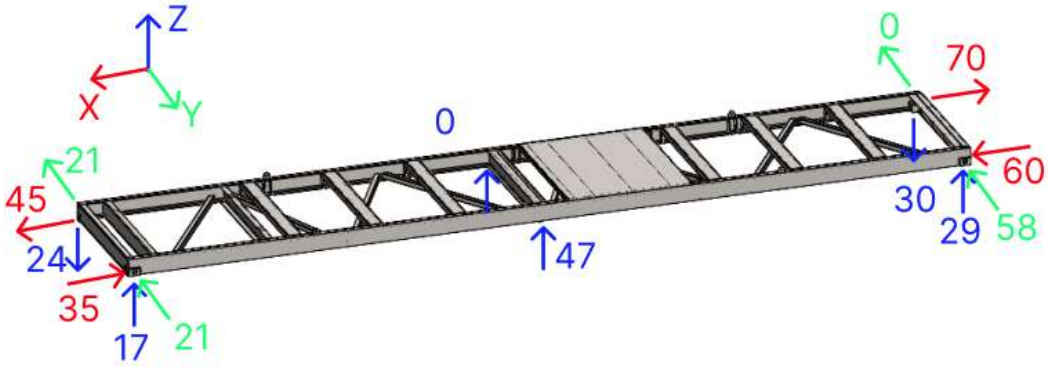


Fig 44: 40ft flatbed – LC7min (Italian 1st option)

LC8max

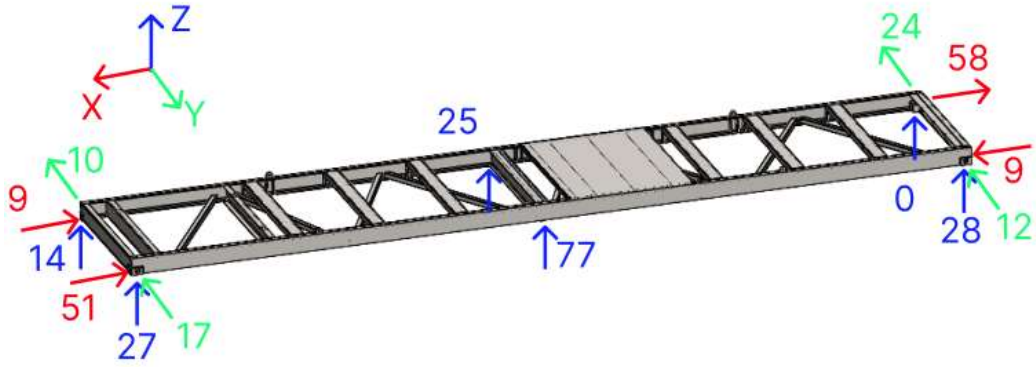


Fig 45: 40ft flatbed – LC8max

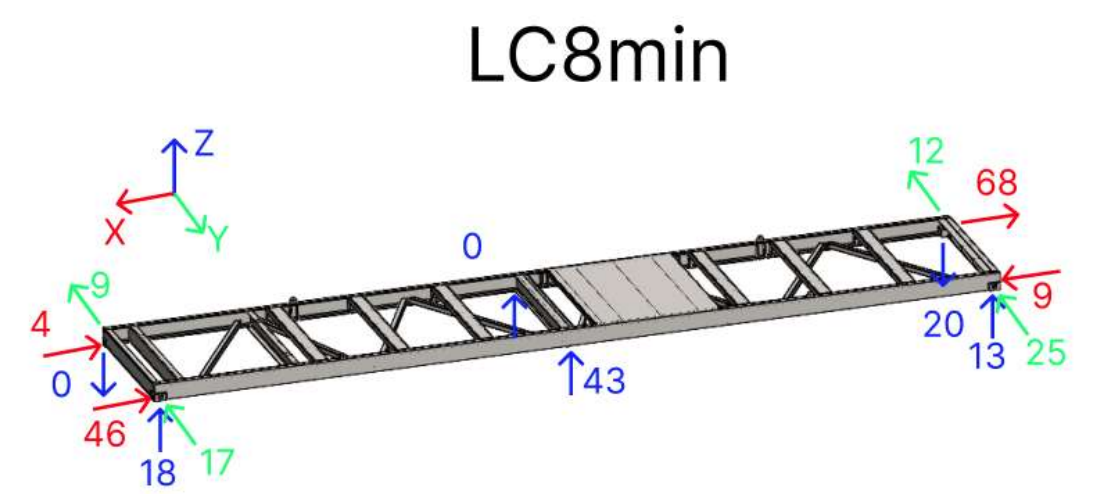


Fig 46: 40ft flatbed – LC8min

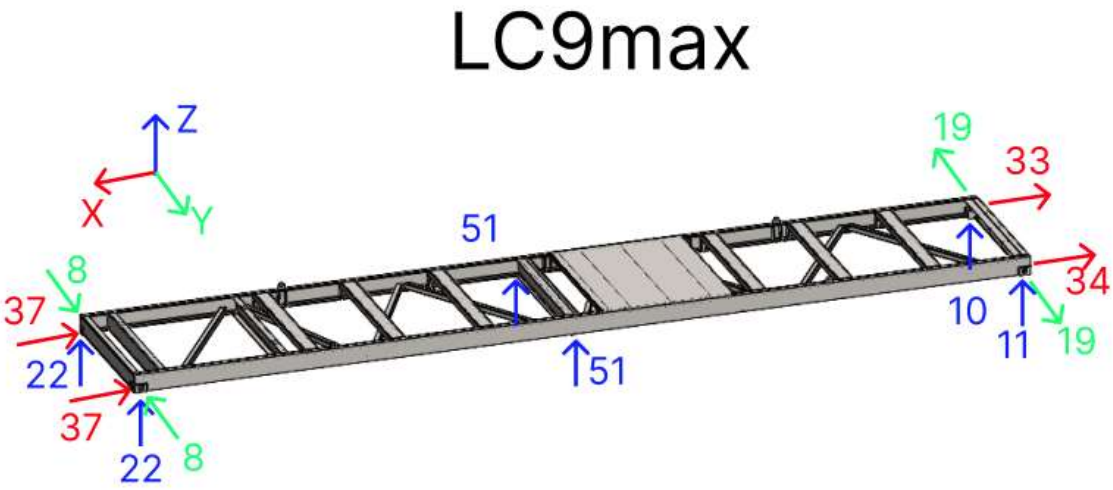


Fig 47: 40ft flatbed – LC9max

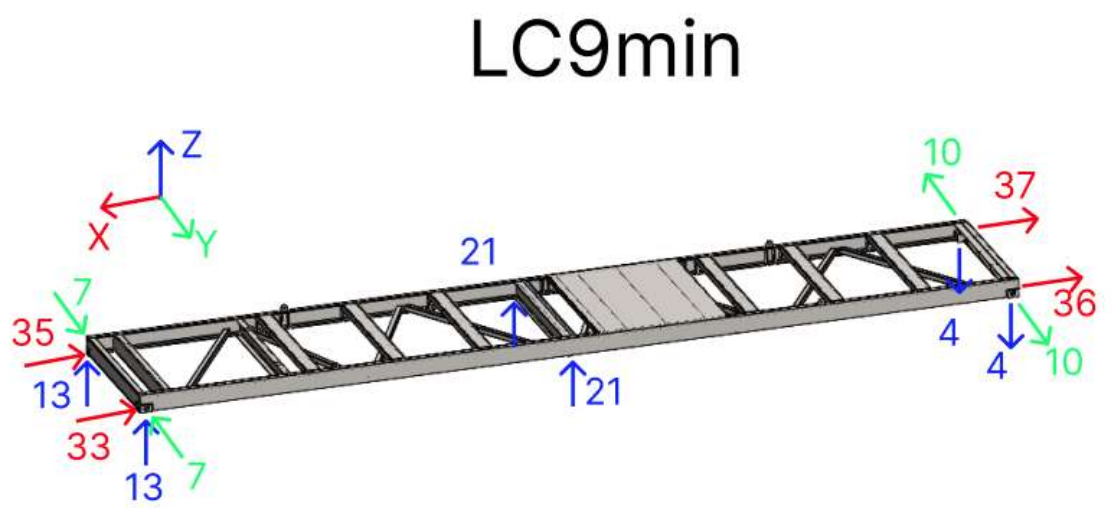


Fig 48: 40ft flatbed – LC9min

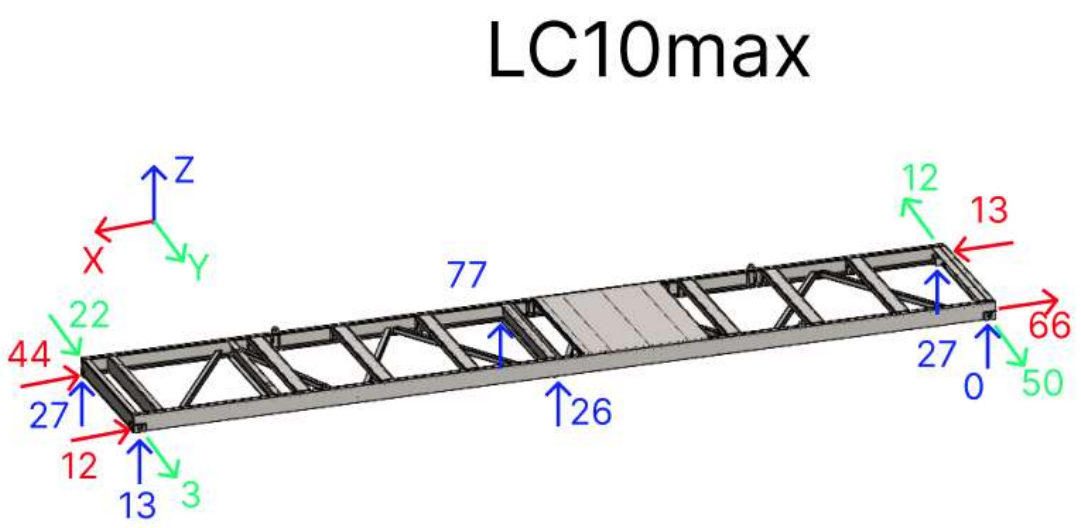


Fig 49: 40ft flatbed – LC10max

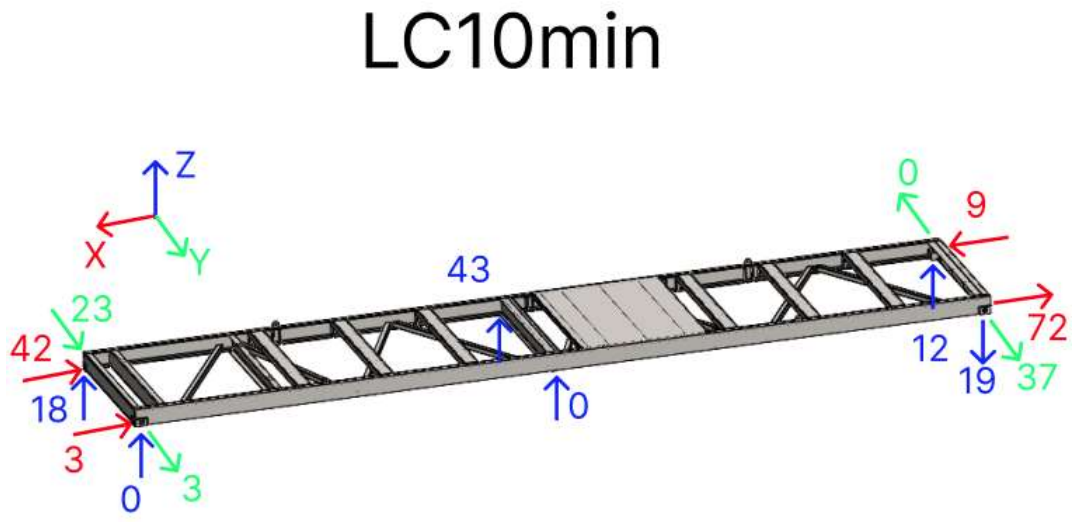


Fig 50: 40ft flatbed – LC10min

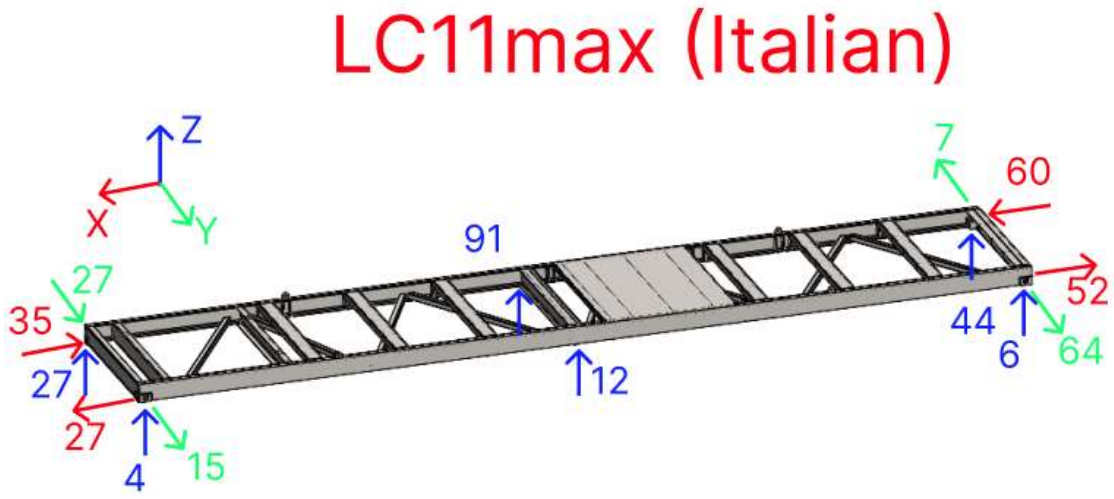


Fig 51: 40ft flatbed – LC11max (Italian 1st option)

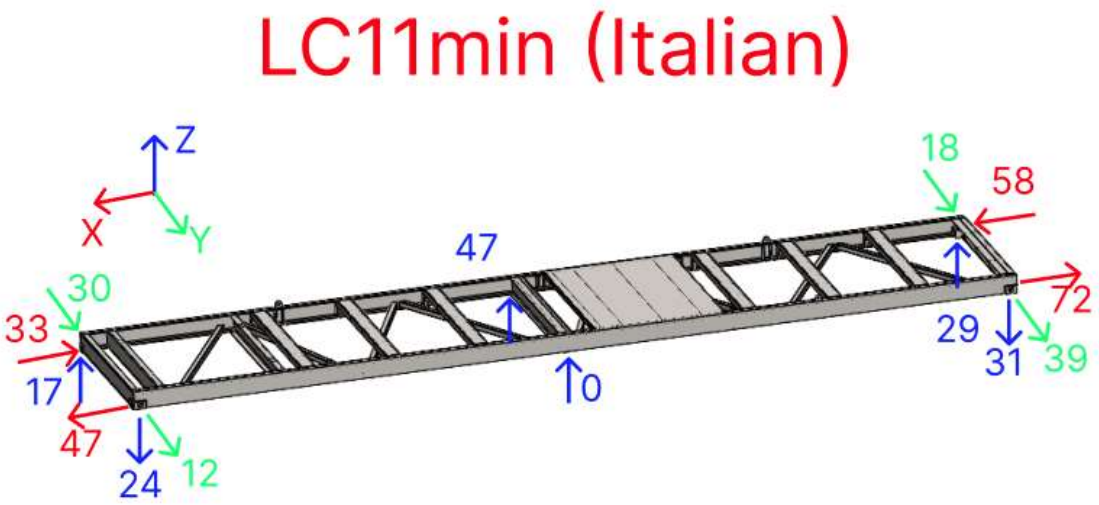


Fig 52: 40ft flatbed – L11min (Italian 1st option)

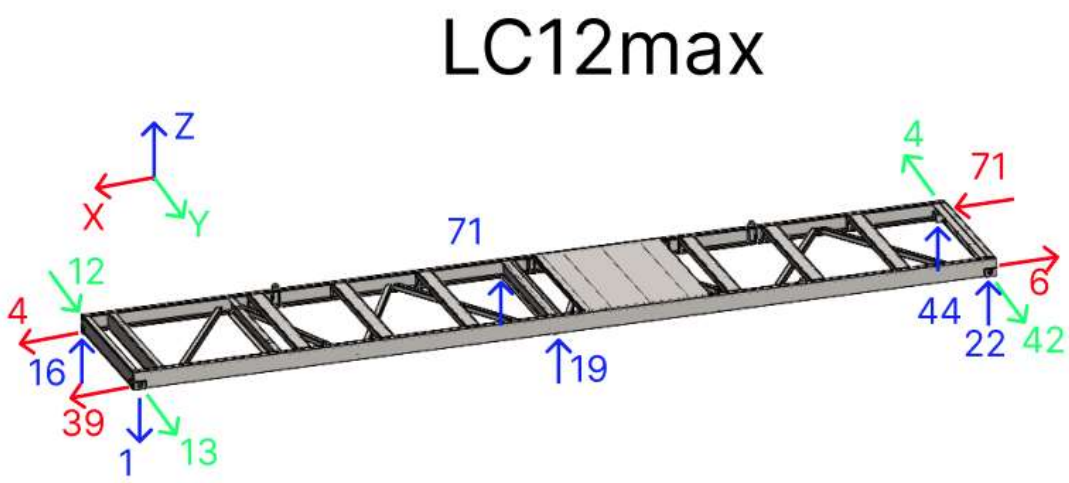


Fig 53: 40ft flatbed – LC12max

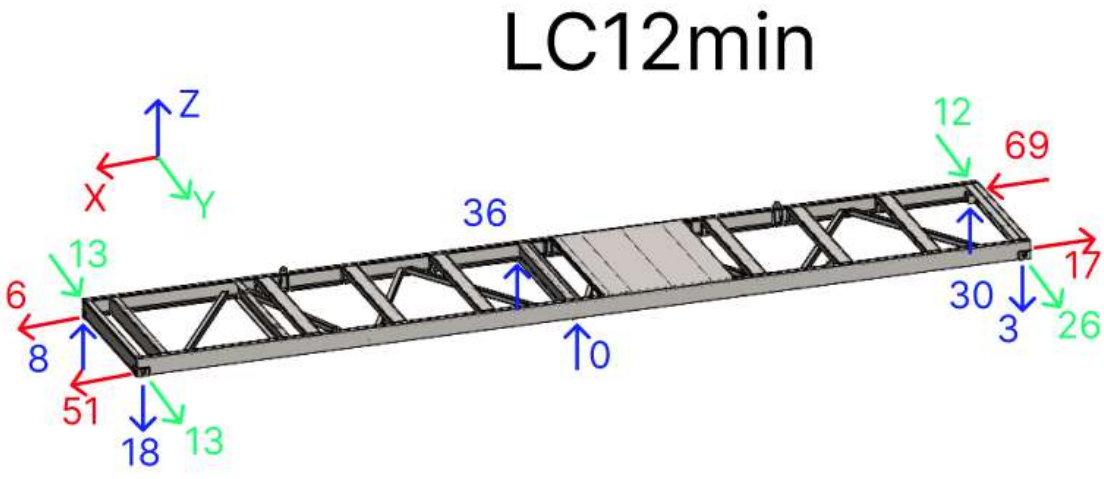


Fig 54: 40ft flatbed – LC12min

LC13max

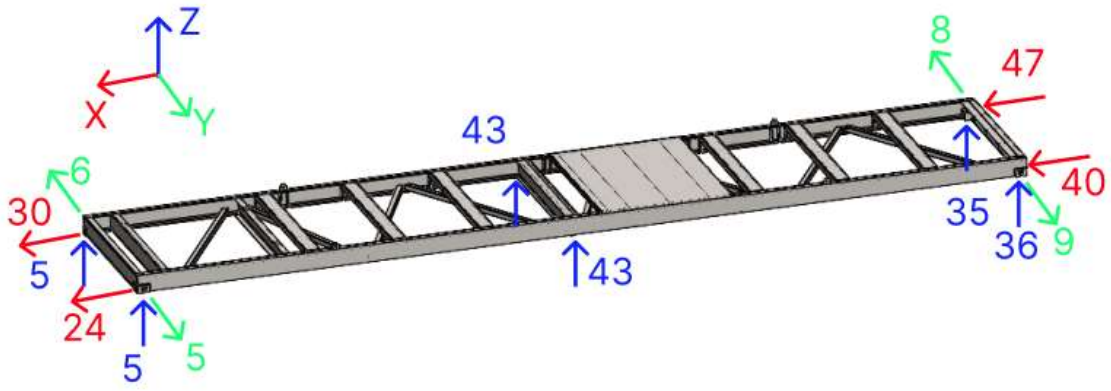


Fig 55: 40ft flatbed – LC13max

LC13min

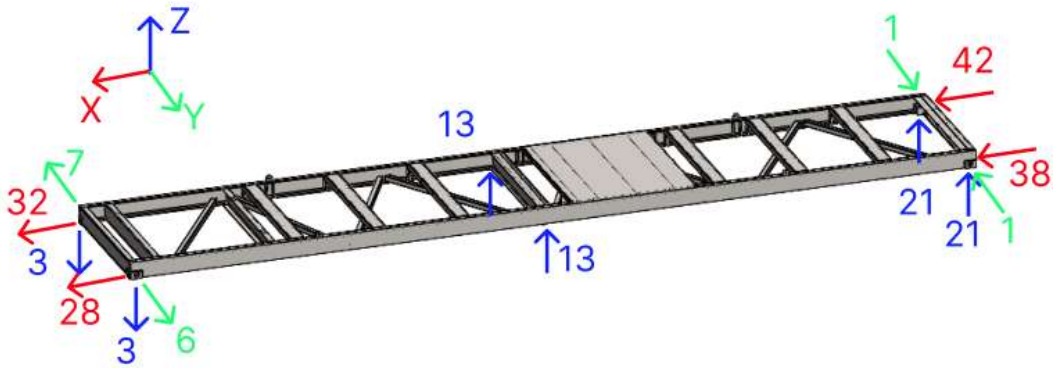


Fig 56: 40ft flatbed – LC13min

LC14max

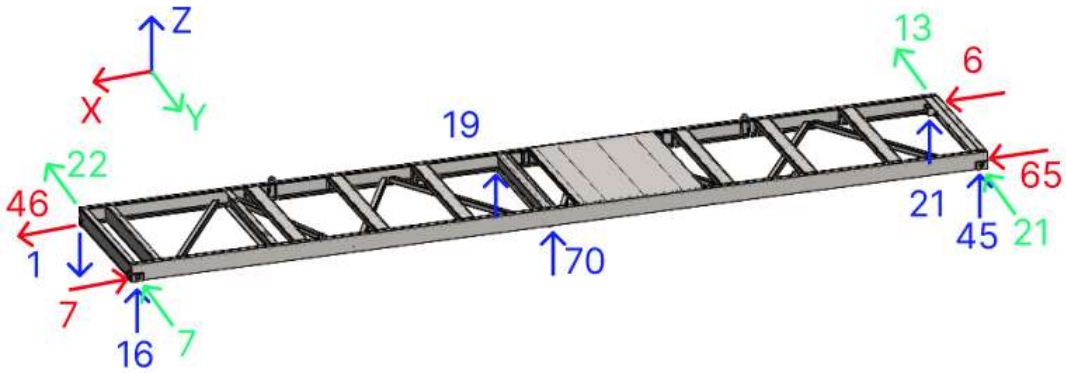


Fig 57: 40ft flatbed – LC14max

LC14min

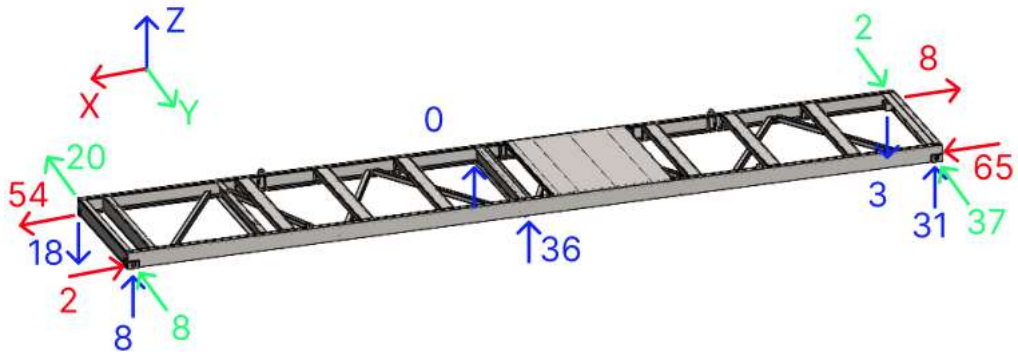


Fig 58: 40ft flatbed – LC14min

LC15max

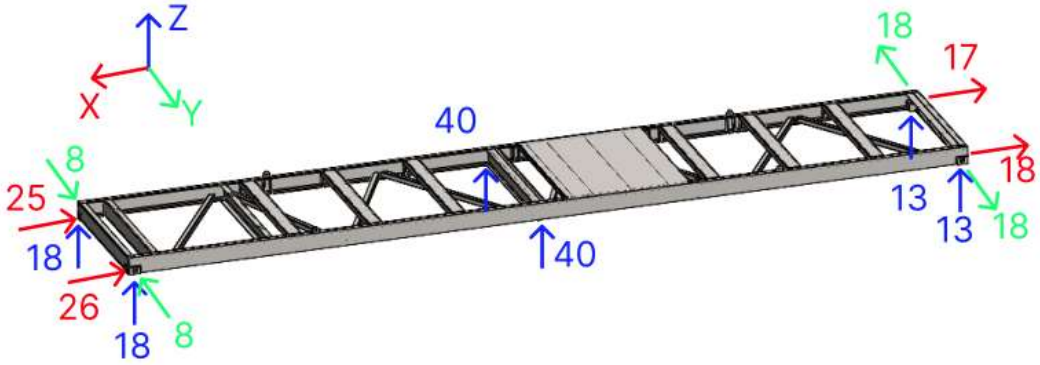


Fig 59: 40ft flatbed – LC15max

LC15min

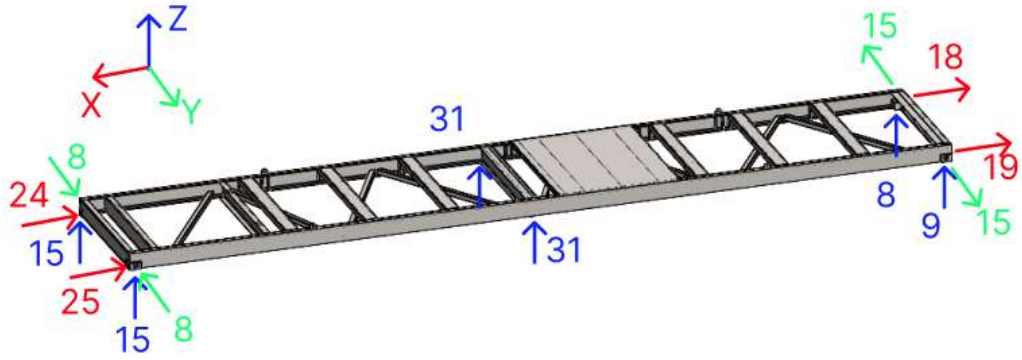


Fig 60: 40ft flatbed – LC15min

LC16max

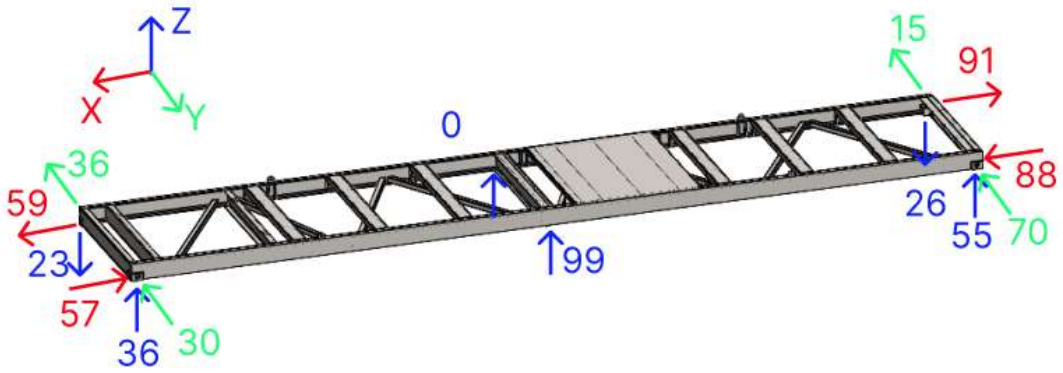


Fig 61: 40ft flatbed – LC16max

LC16min

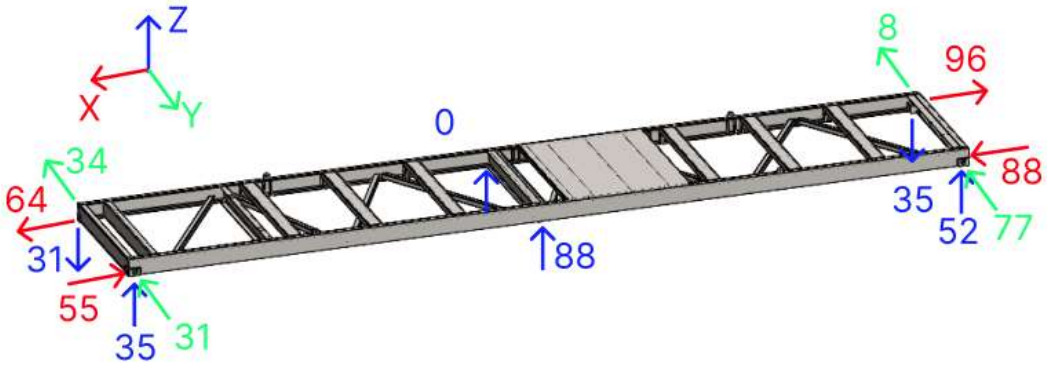


Fig 62: 40ft flatbed – LC16min

LC17max

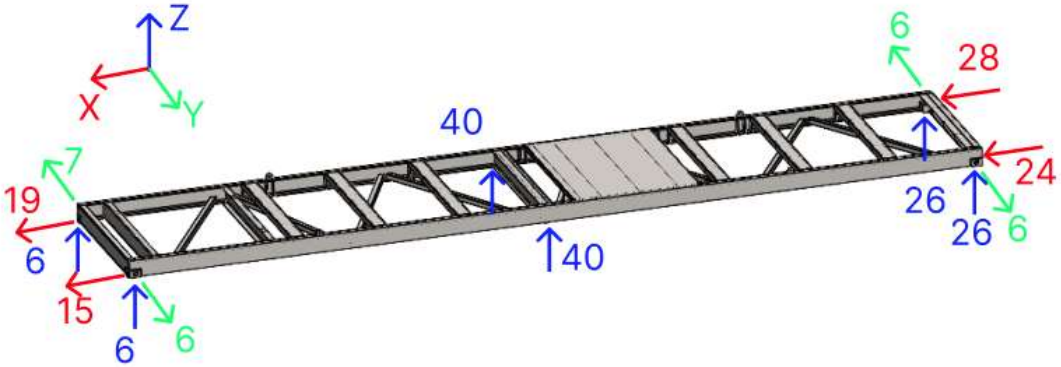


Fig 63: 40ft flatbed – LC17max

LC17min

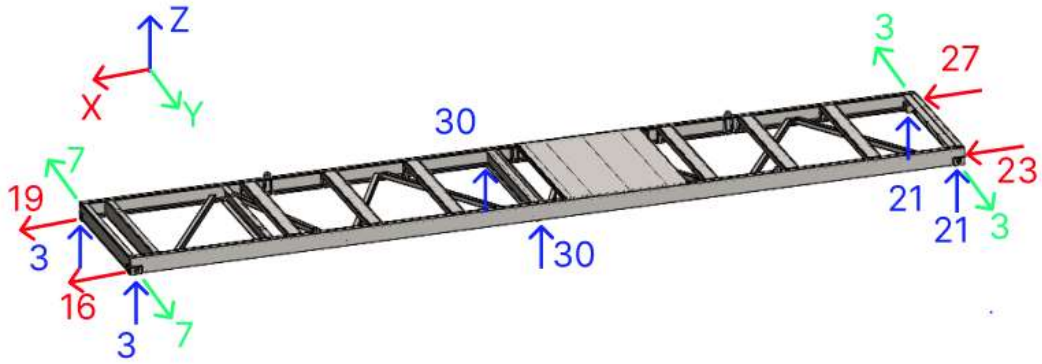


Fig 64: 40ft flatbed – LC17min

LC18max

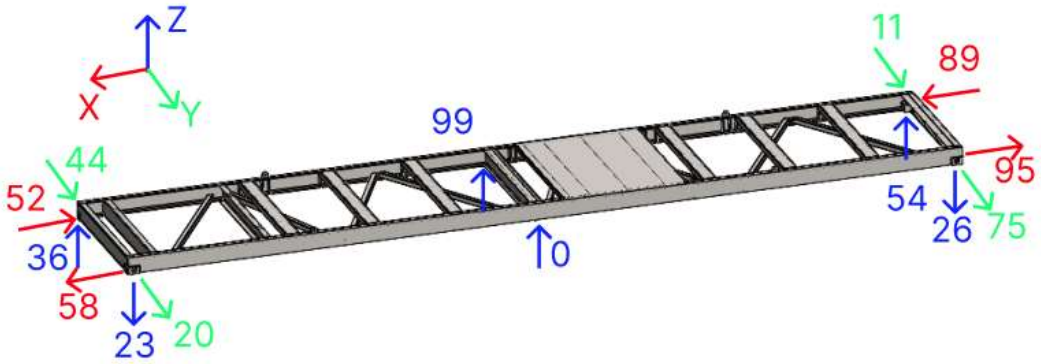


Fig 65: 40ft flatbed – LC18max

LC18min

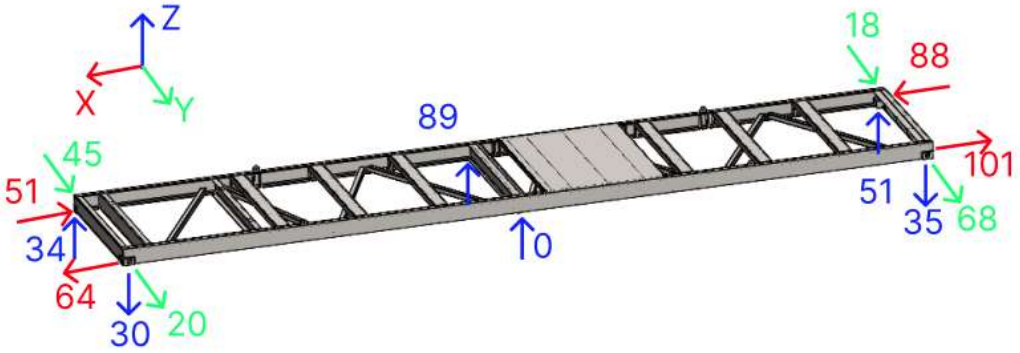


Fig 66: 40ft flatbed – LC18min

8.4. Boundary conditions and mesh definition

8.4.1. 40ft HC Container

The model has been properly prepared for simulation.
All cutouts in the container were included.
The model included only the original container door on the left side. Additional doors, fans and other fittings were not included in the calculations. The calculations included welded-in additional elements such as interior columns, sheet metal or columns and beams at the locations of the additional doors.

Mesh type: Blended curvature-based mesh
Max Element Size: 1200mm
Min Element Size: 60mm
Big mesh size because of the big model and computer capabilities to handle calculations. Nevertheless, the simulations carried out still better represent reality than manual calculations because takes into account different materials (S355 and wood Gl20C), and all cutouts and additional elements welded to the container.

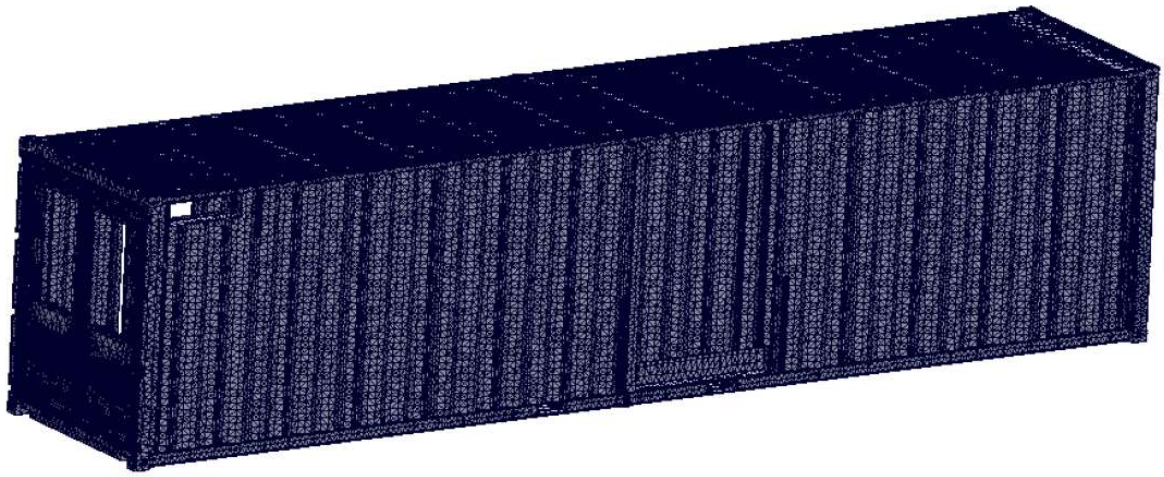


Fig 67: 40ft HC Container – Mesh – Front view

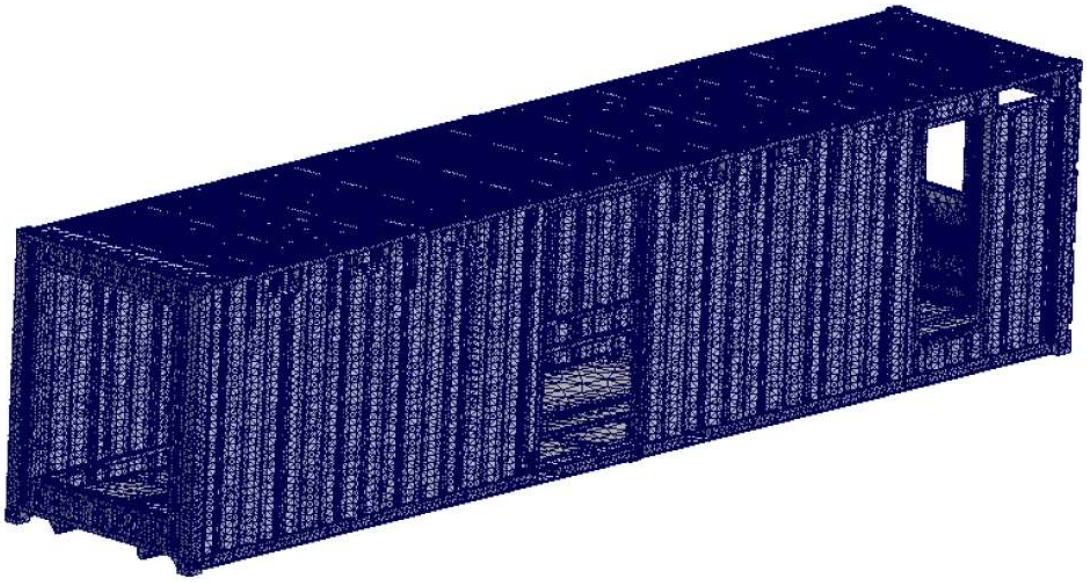


Fig 68: 40ft HC Container – Mesh – Back view

Wooden floor material properties (assumed glued laminated wood: GL20c):

- Elastic Modulus: 6720MPa
- Poisson's Ratio: 0,3
- Shear Modulus: 520MPa
- Mass Density: 340kg/m3
- Tensile strength: 7,68MPa
- Yield Strength 1,68MPa

Support conditions depends on particular load case.

8.4.2. 10ft HC Container

The model has been properly prepared for simulation.
All cutouts in the container were included.
The model included only the original container door on the left side. Additional doors, fans and other fittings were not included in the calculations. The calculations included welded-in additional elements such as interior columns, sheet metal or columns and beams at the locations of the additional doors.

Mesh type: Blended curvature-based mesh
Max Element Size: 1200mm
Min Element Size: 60mm
Big mesh size because of the big model and computer capabilities to handle calculations.
Nevertheless, the simulations carried out still better represent reality than manual calculations because takes into account different materials (S355 and wood Gl20C), and all cutouts and additional elements welded to the container

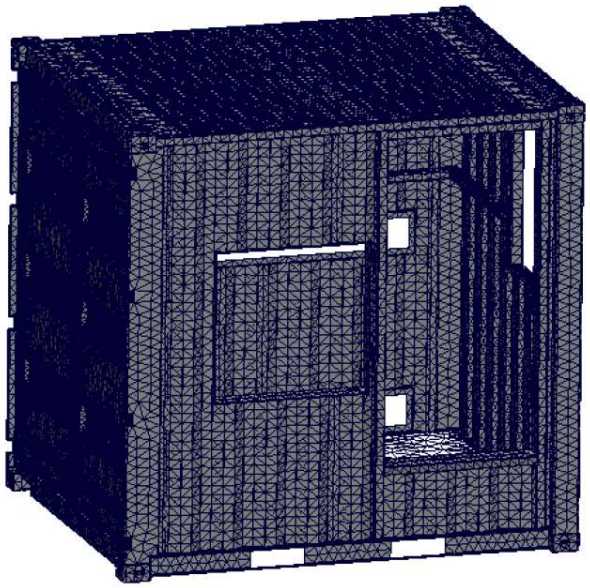


Fig 69: 10ft HC Container – Mesh – Front view

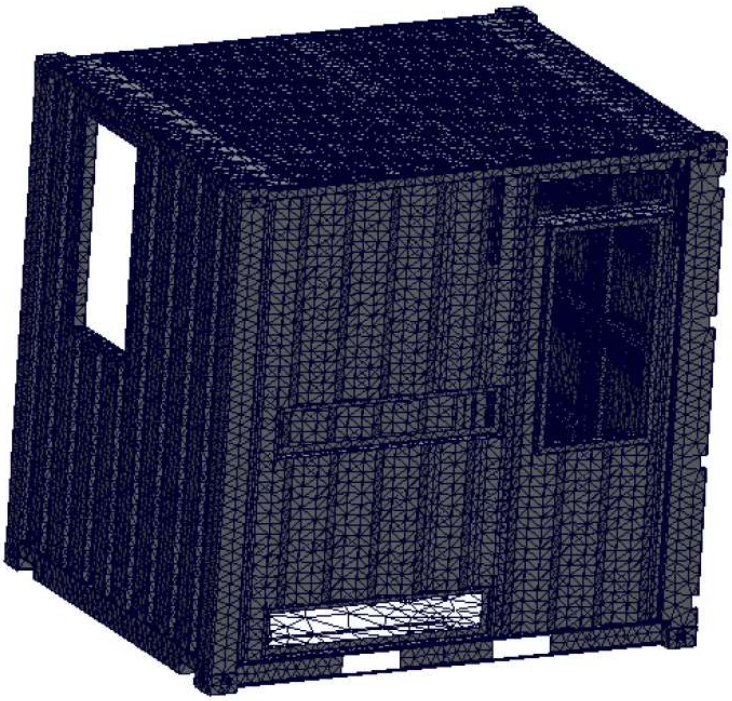


Fig 70: 10ft HC Container – Mesh – Back view

9. 40ft High Cube Container – FEM simulations

9.1. LC5_TOP (only 40ft container with equipment inside)

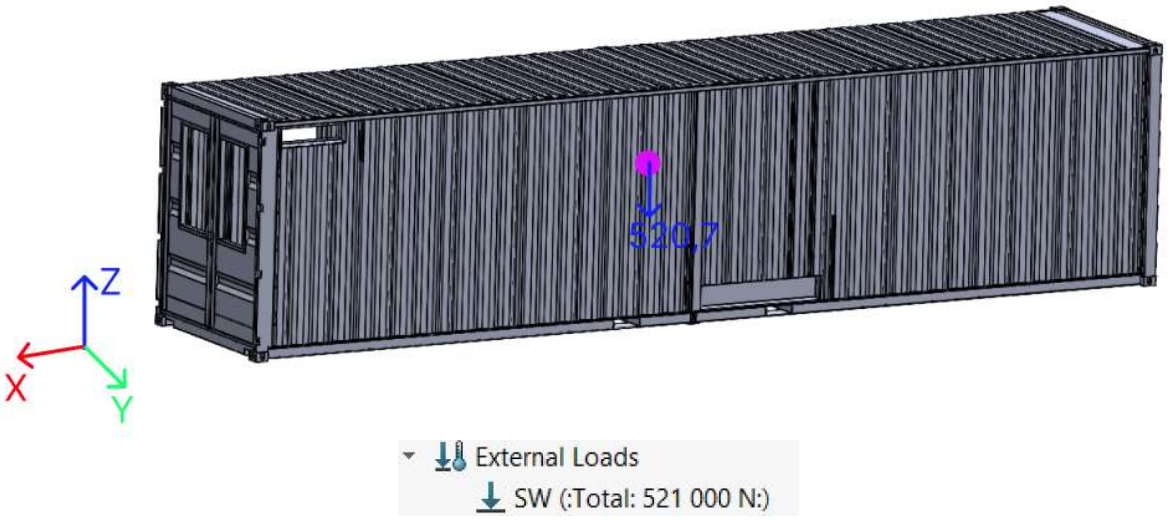


Fig 71: LC5_TOP – 40ft container – Loads



Fig 72: LC5 _TOP-Boundary conditions

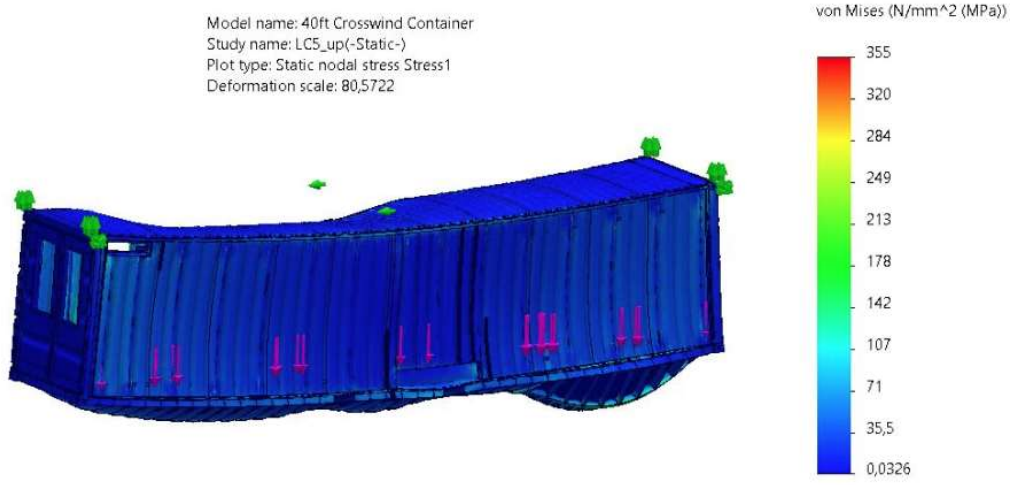


Fig 73: LC5 _TOP-Stress plot

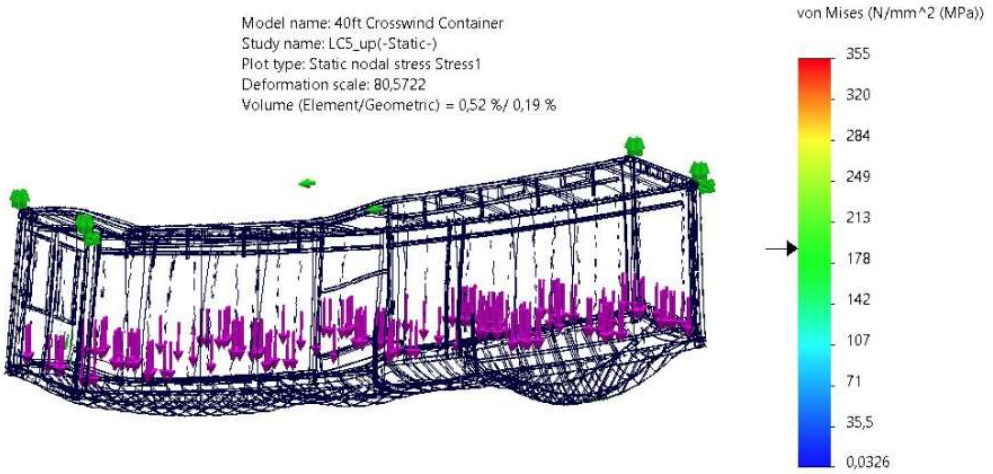


Fig 74: LC5 _TOP-Stress plot (the biggest stress in 0,5% of element volume)

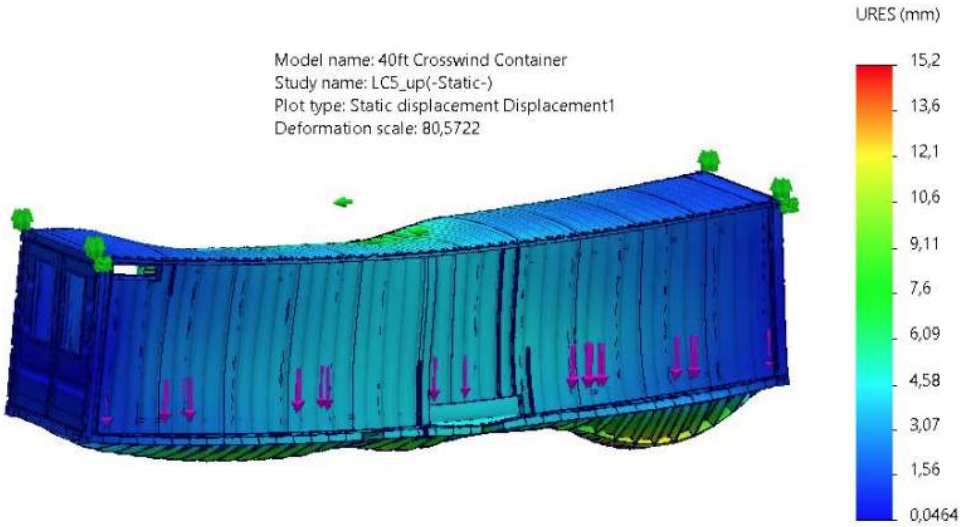


Fig 75: LC5_TOP-Displacement plot

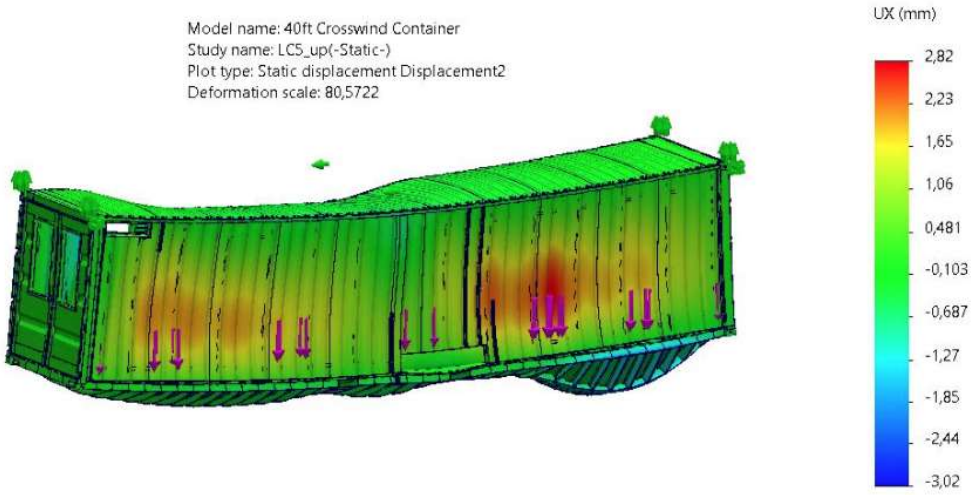


Fig 76: LC5_TOP-Displacement plot-UX

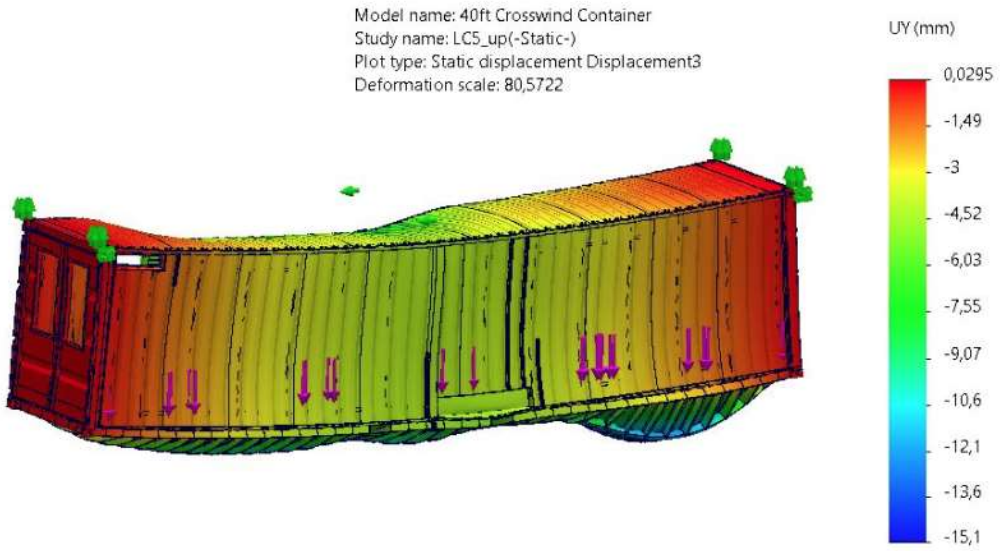


Fig 77: LC5_TOP-Displacement plot-UY

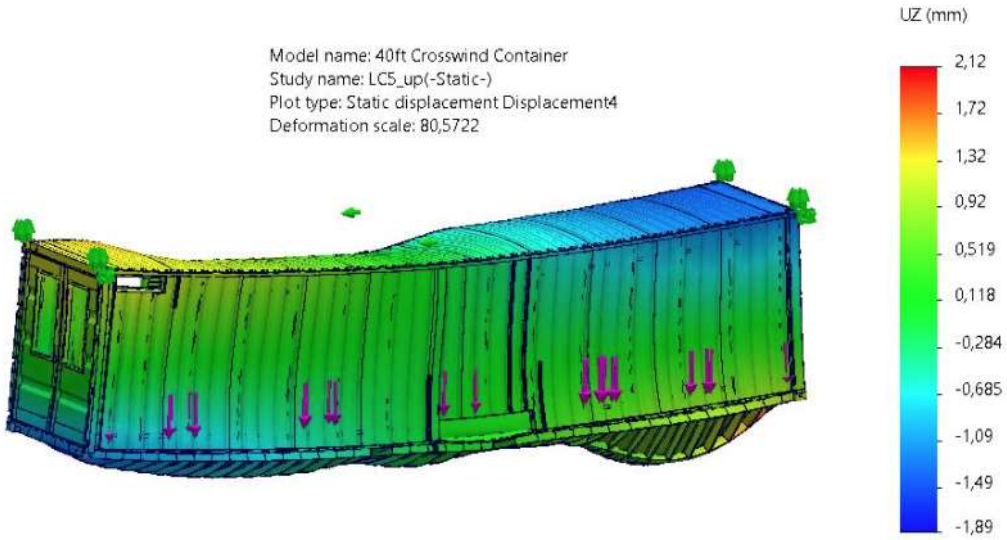


Fig 78: LC5_TOP-Displacement plot-UZ

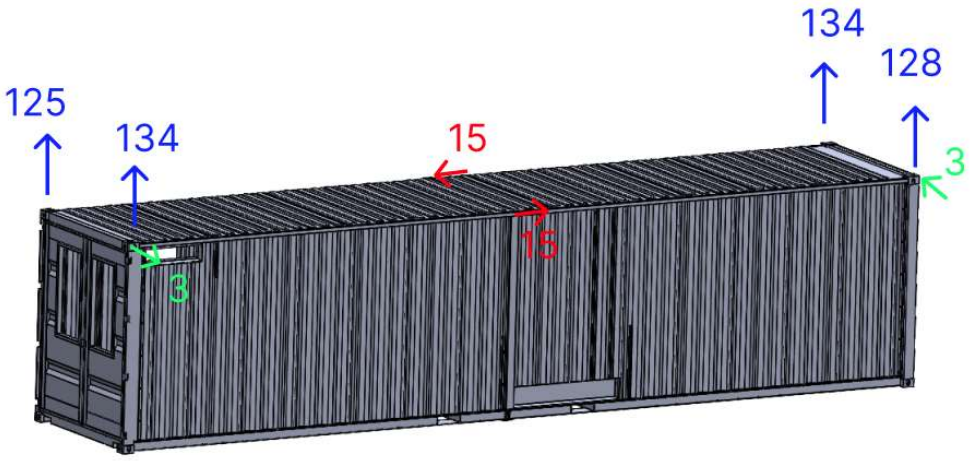


Fig 79: LC5_TOP-Reactions

9.2. LC5_BOTTOM (only 40ft container with equipment inside)



Fig 80: LC5_BOTTOM – 40ft container – Loads

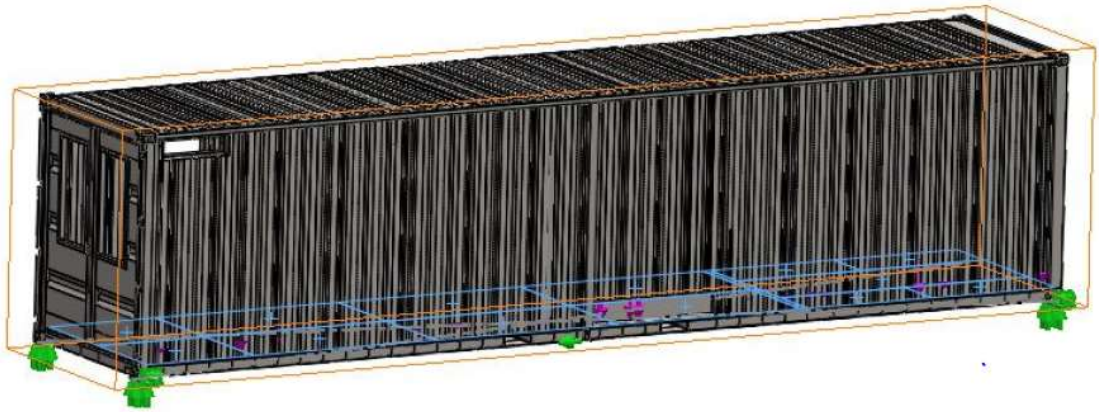


Fig 81: LC5 _ BOTTOM -Boundary conditions

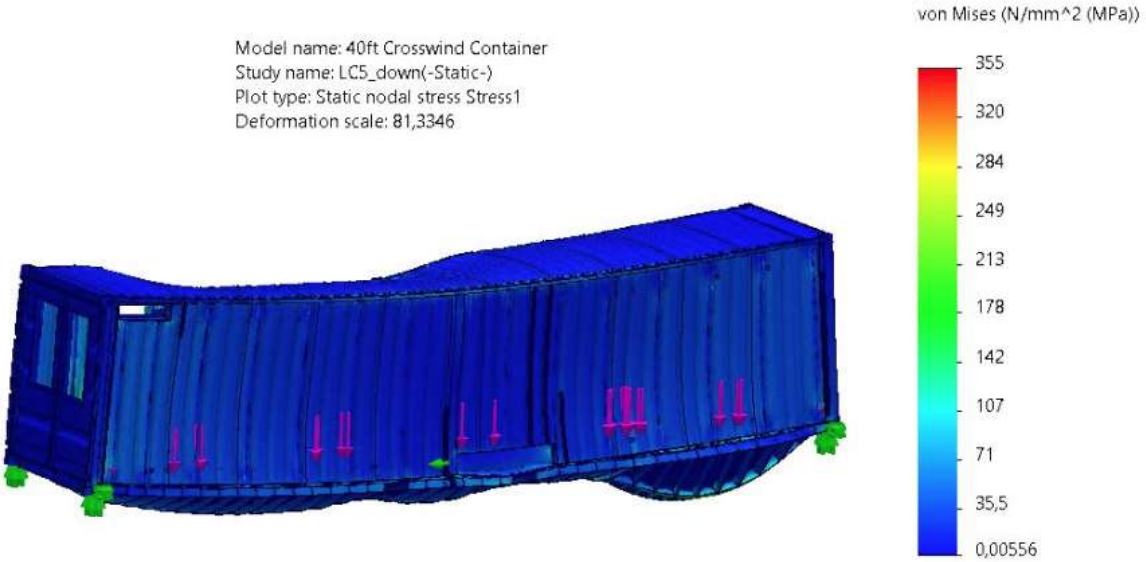


Fig 82: LC5 _ BOTTOM -Stress plot

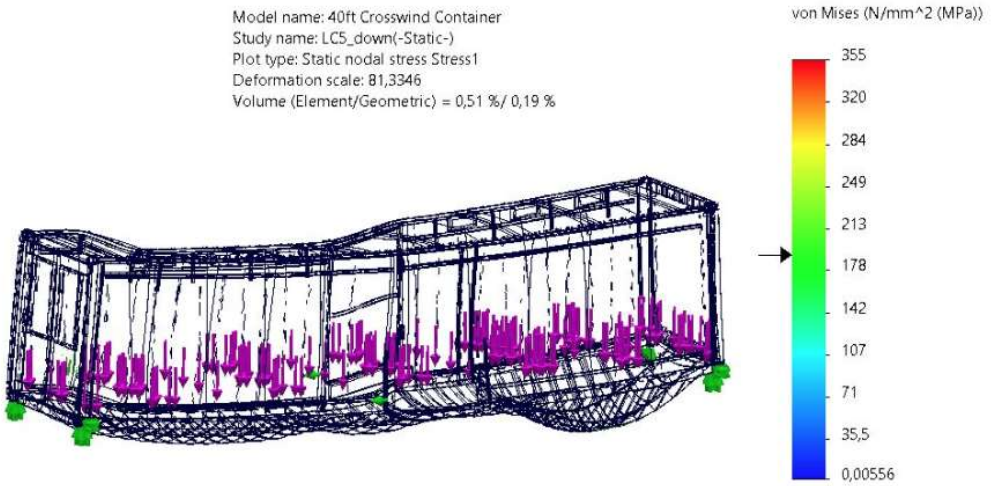


Fig 83: LC5 _ BOTTOM -Stress plot (the biggest stress in 0,5% of element volume)

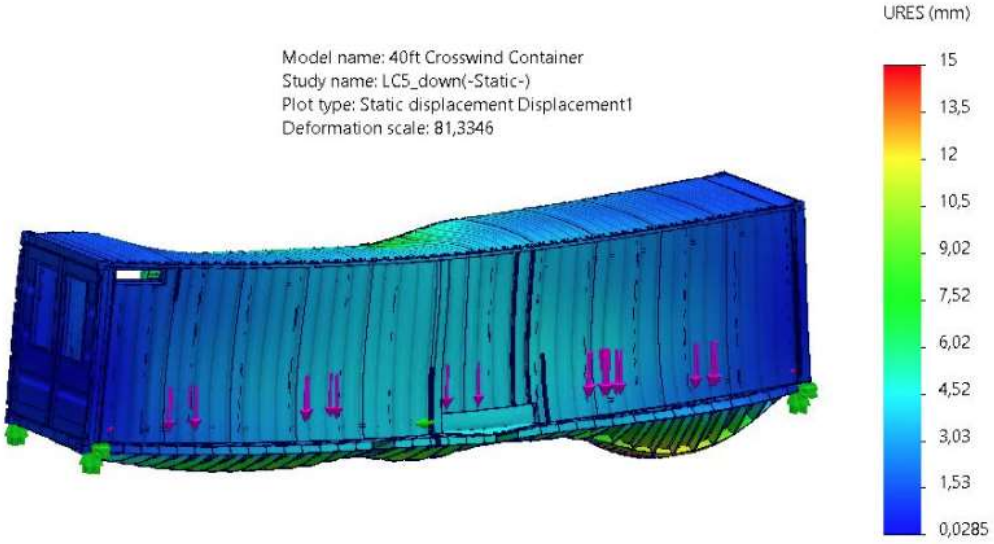


Fig 84: LC5_ BOTTOM -Displacement plot

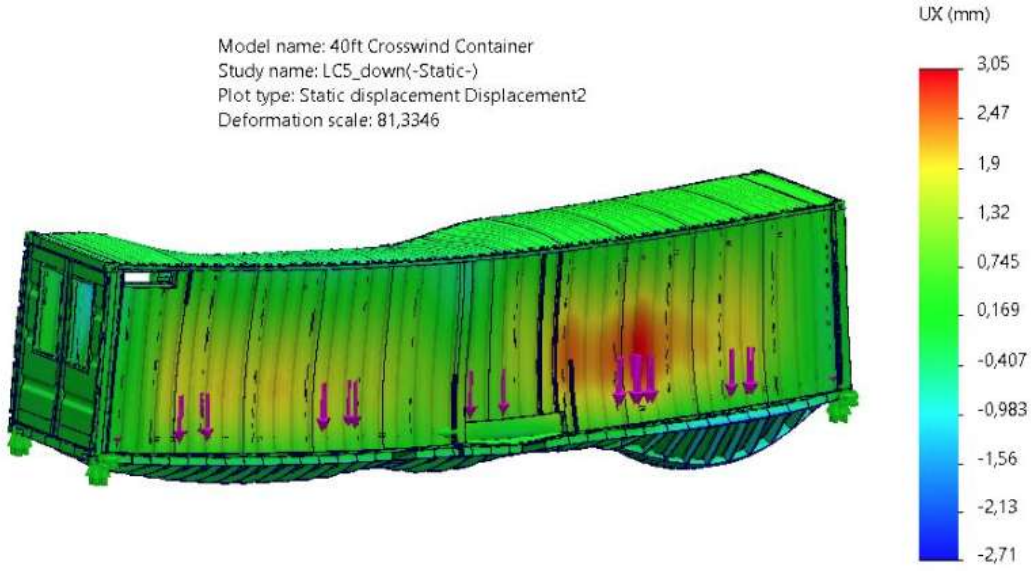


Fig 85: LC5_ BOTTOM -Displacement plot-UX

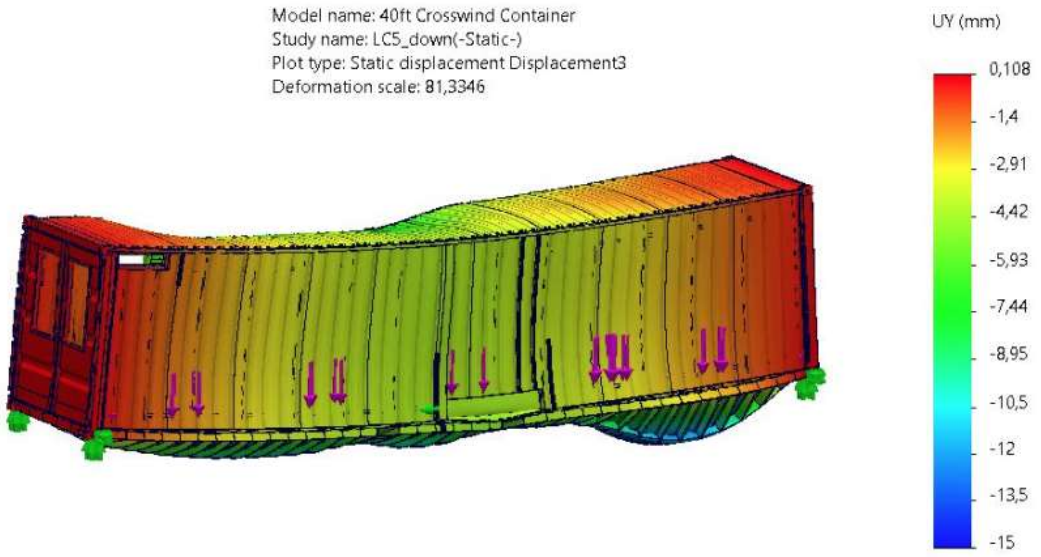


Fig 86: LC5_ BOTTOM -Displacement plot-UY

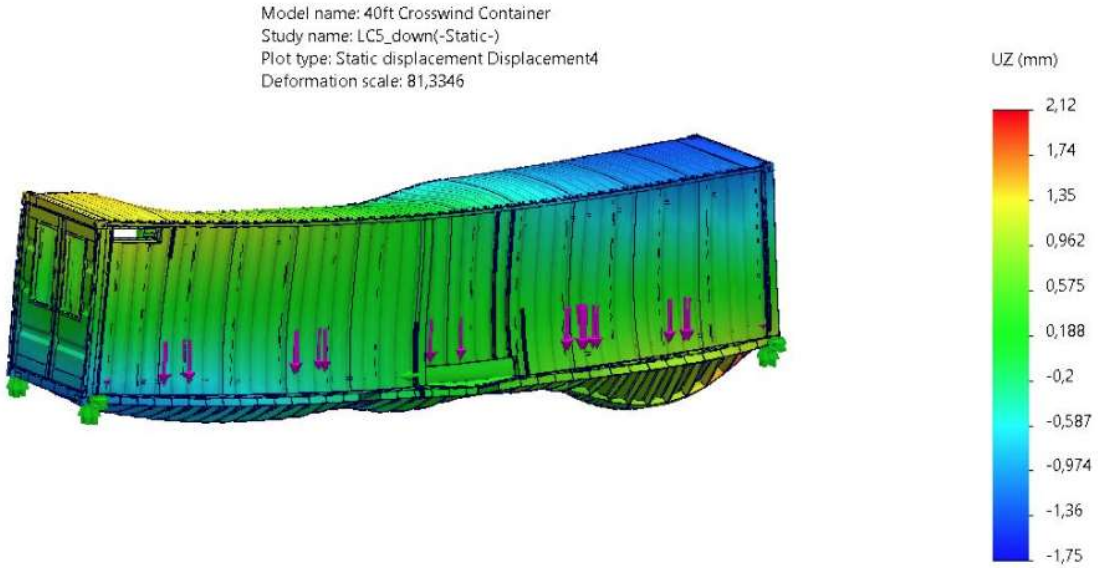


Fig 87: LC5_ BOTTOM -Displacement plot-UZ

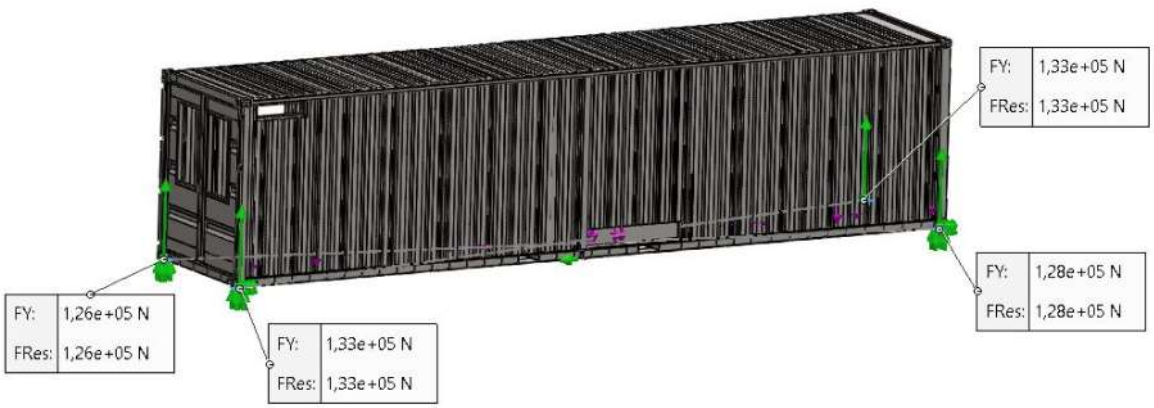


Fig 88: LC5_ BOTTOM -Reactions

9.3. LC7-MAX (40ft container + 40ft flatbed)

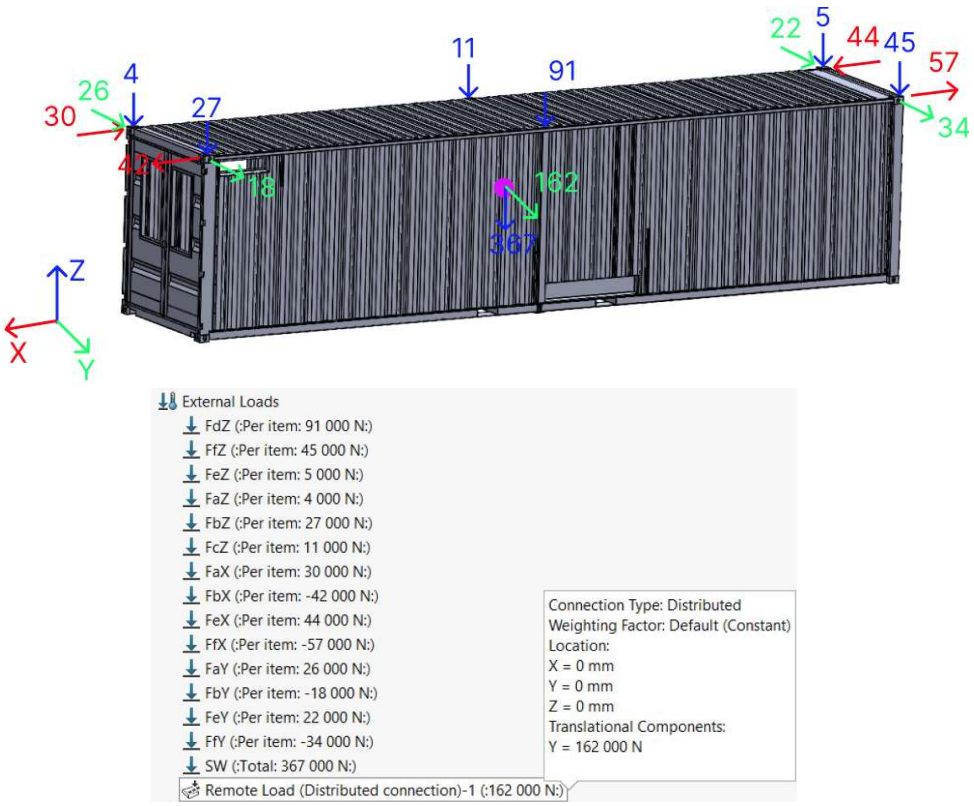


Fig 89: LC7_MAX – 40ft container – Loads

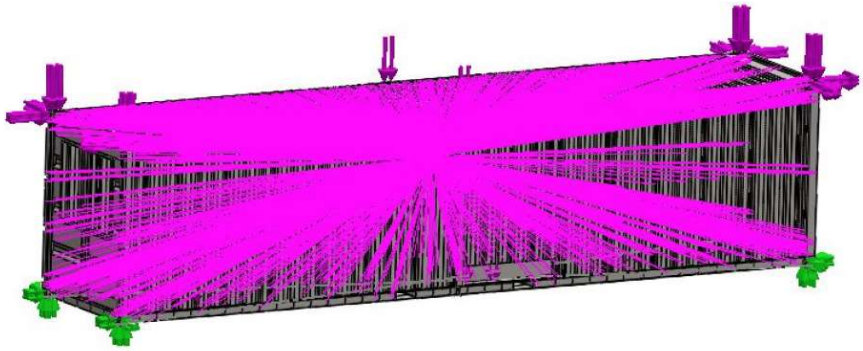


Fig 90: LC7_MAX -Boundary conditions

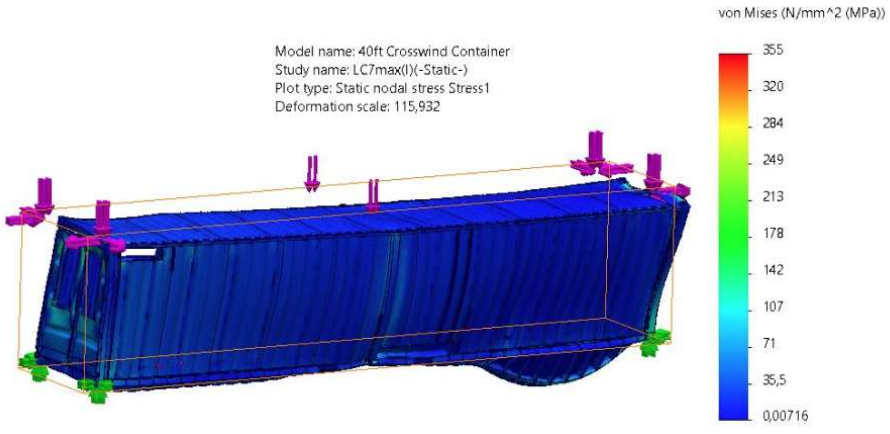


Fig 91: LC7_MAX -Stress plot

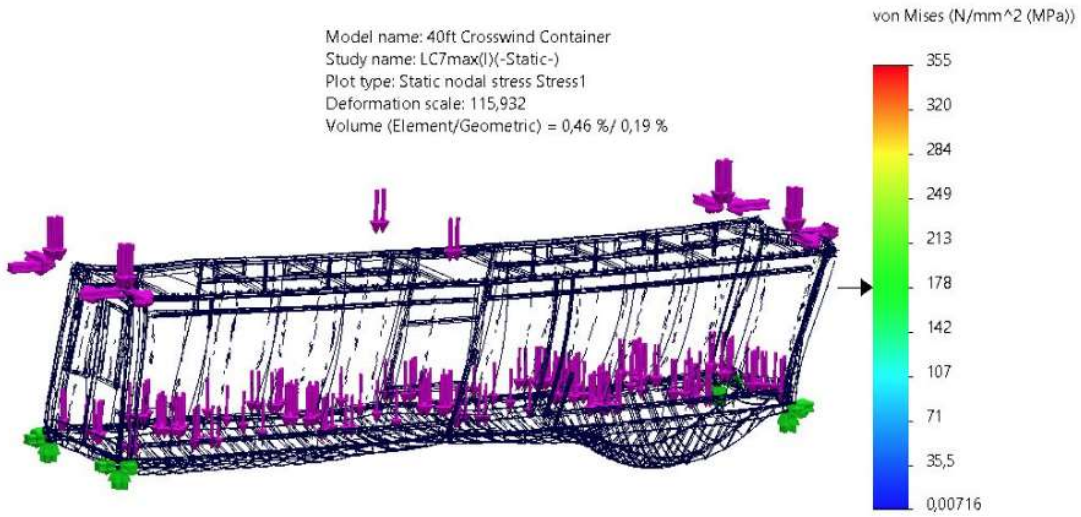


Fig 92: LC7_MAX -Stress plot (the biggest stress in 0,5% of element volume)

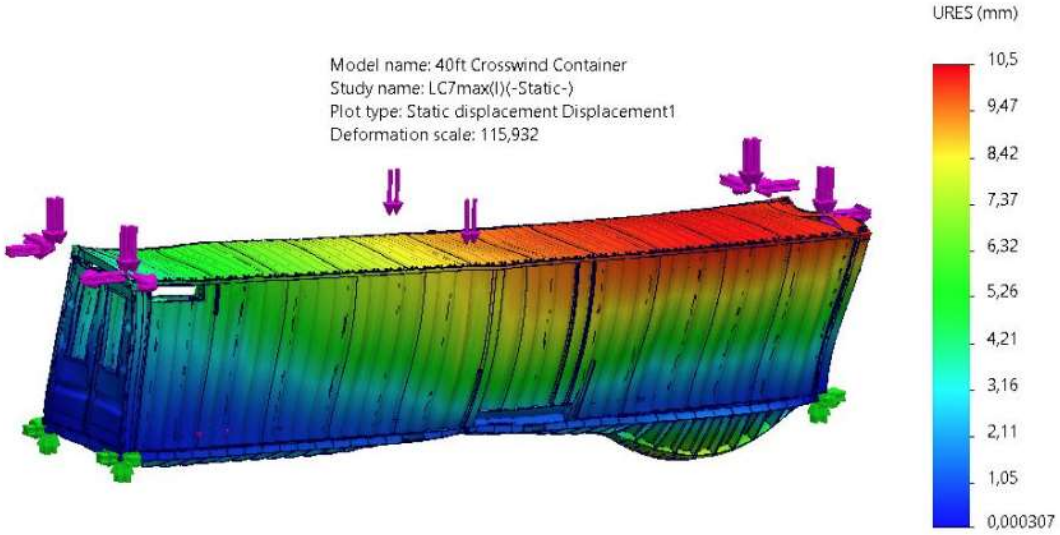


Fig 93: LC7_MAX -Displacement plot

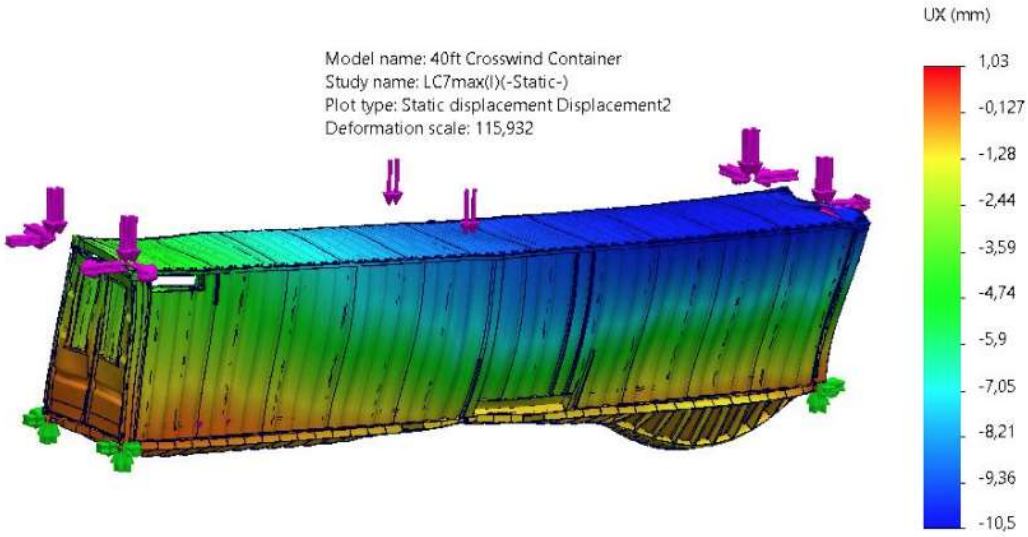


Fig 94: LC7_MAX -Displacement plot-UX

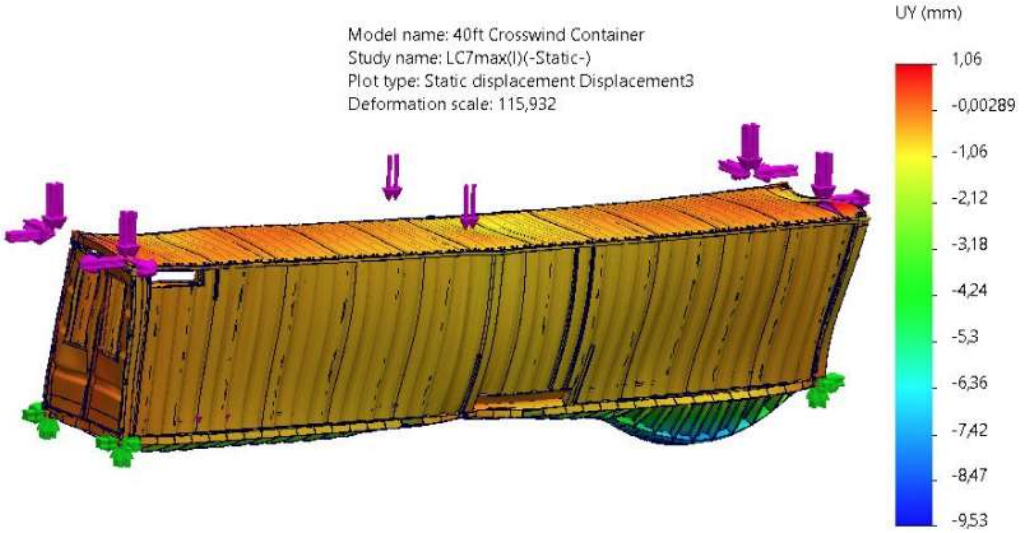


Fig 95: LC7_MAX -Displacement plot-UY

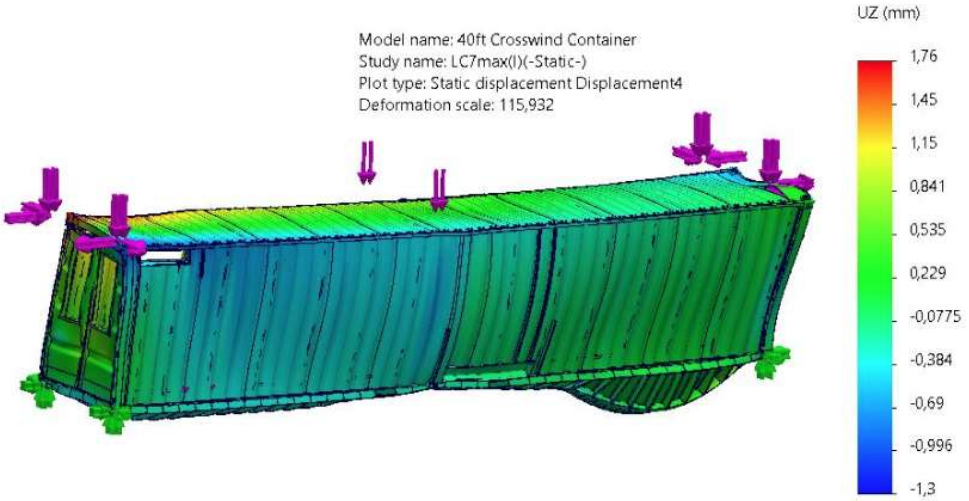


Fig 96: LC7_MAX -Displacement plot-UZ

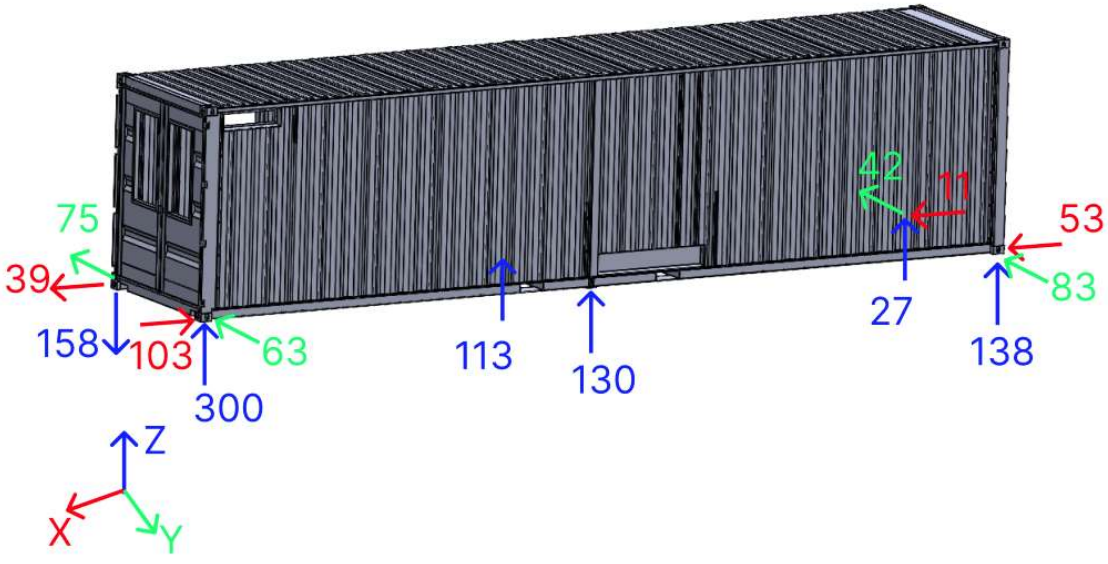
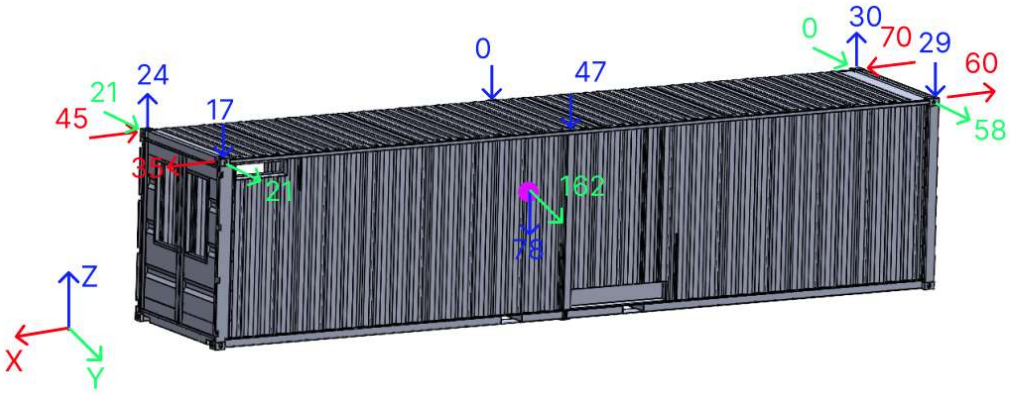


Fig 97: LC7_MAX -Reactions

9.4. LC7-MIN (40ft container + 40ft flatbed)



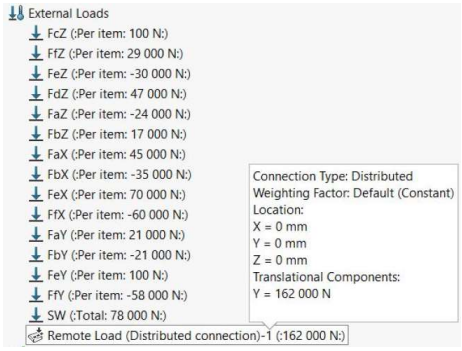


Fig 98: LC7_MIN – 40ft container – Loads

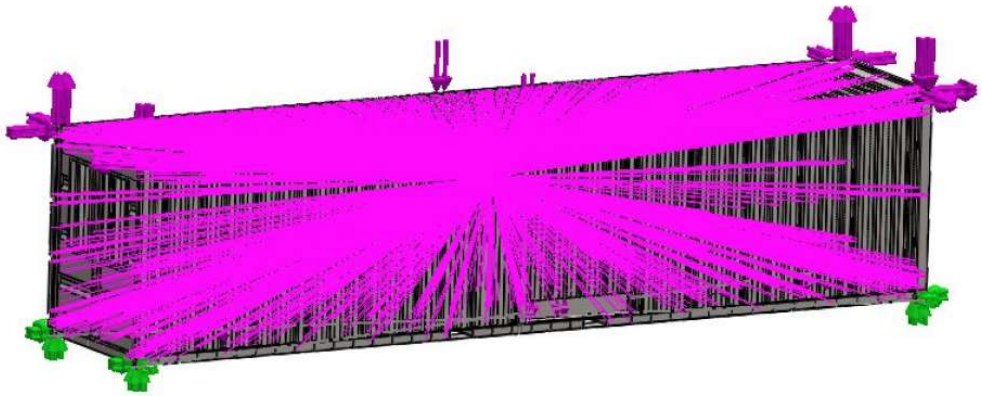


Fig 99: LC7_ MIN -Boundary conditions

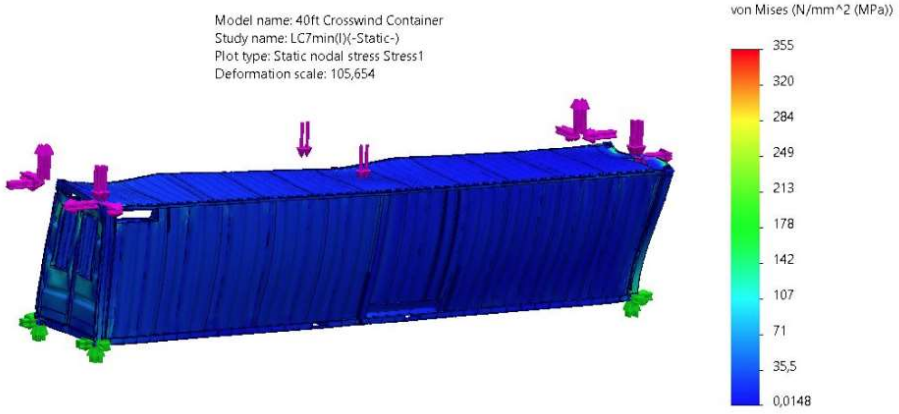


Fig 100: LC7_ MIN -Stress plot

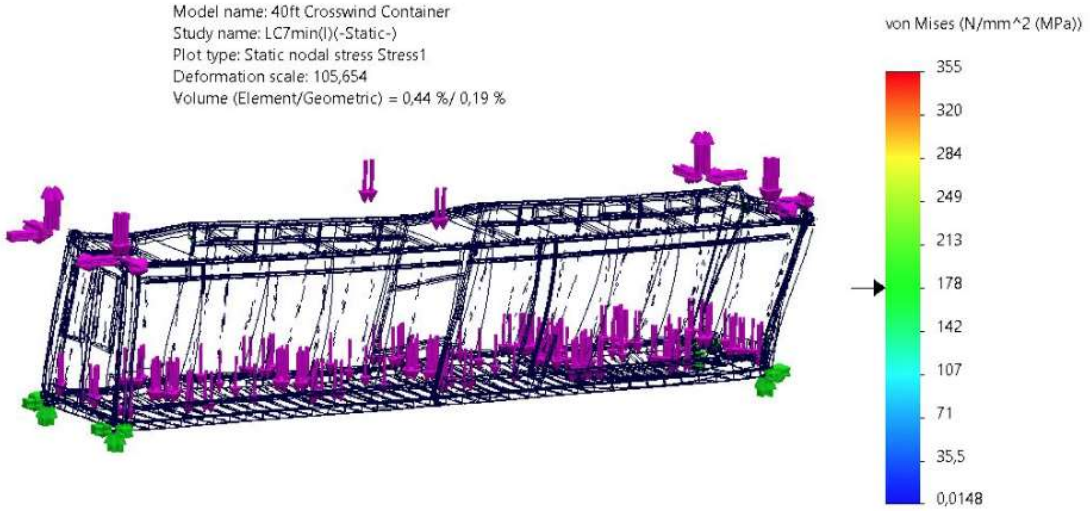


Fig 101: LC7_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

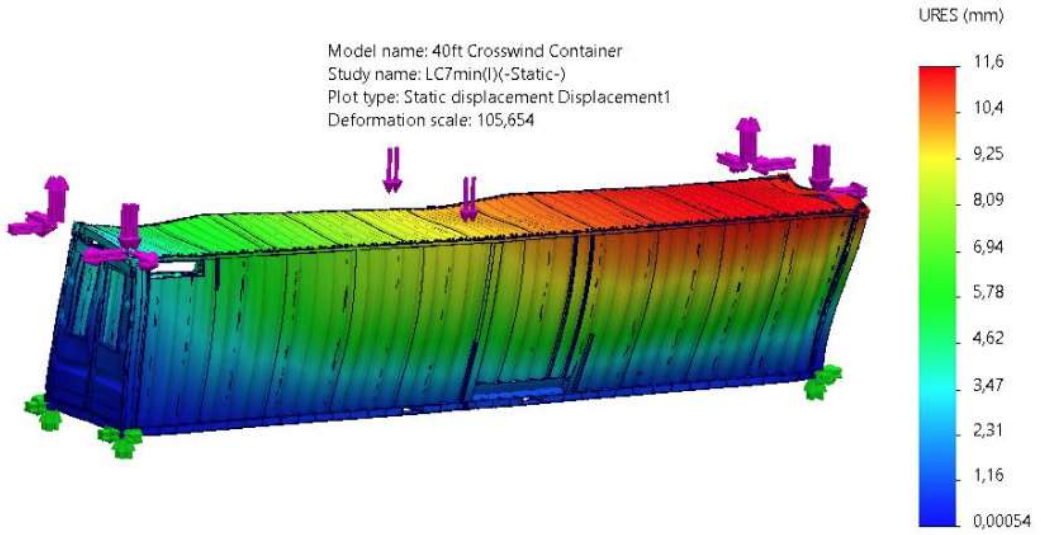


Fig 102: LC7_ MIN -Displacement plot

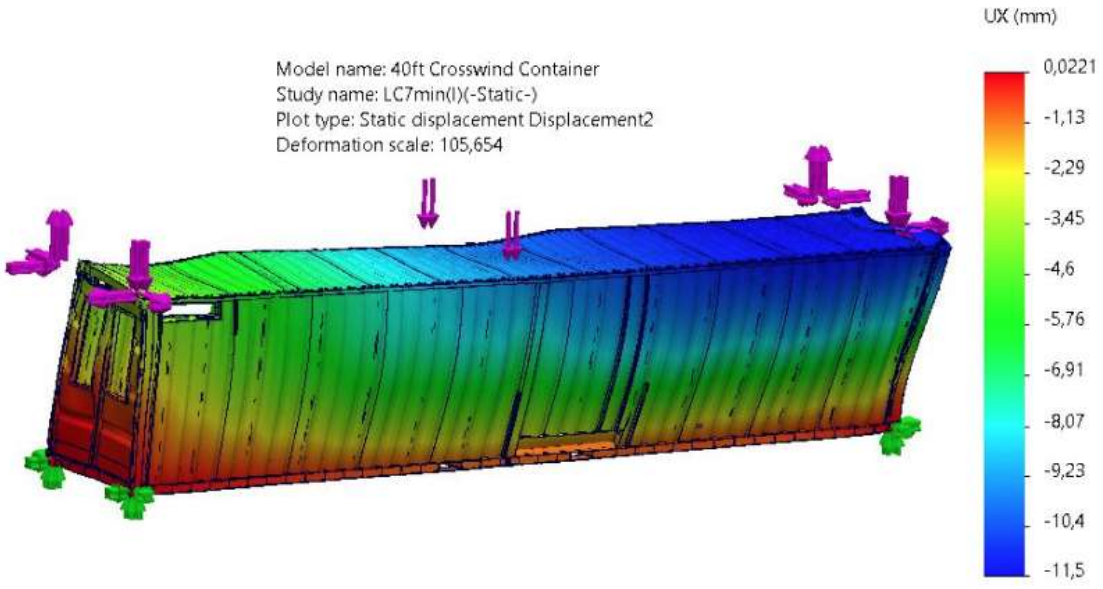


Fig 103: LC7_ MIN -Displacement plot-UX

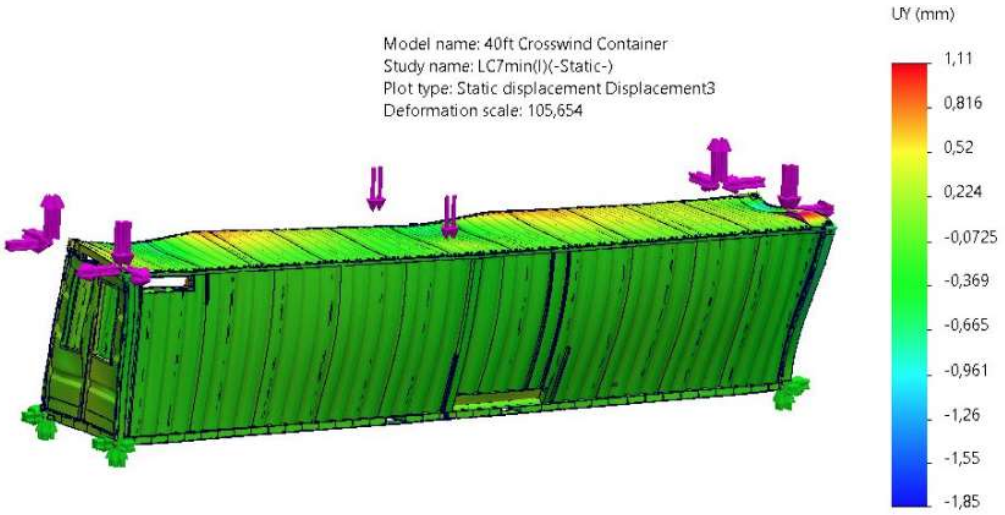


Fig 104: LC7_ MIN -Displacement plot-UY

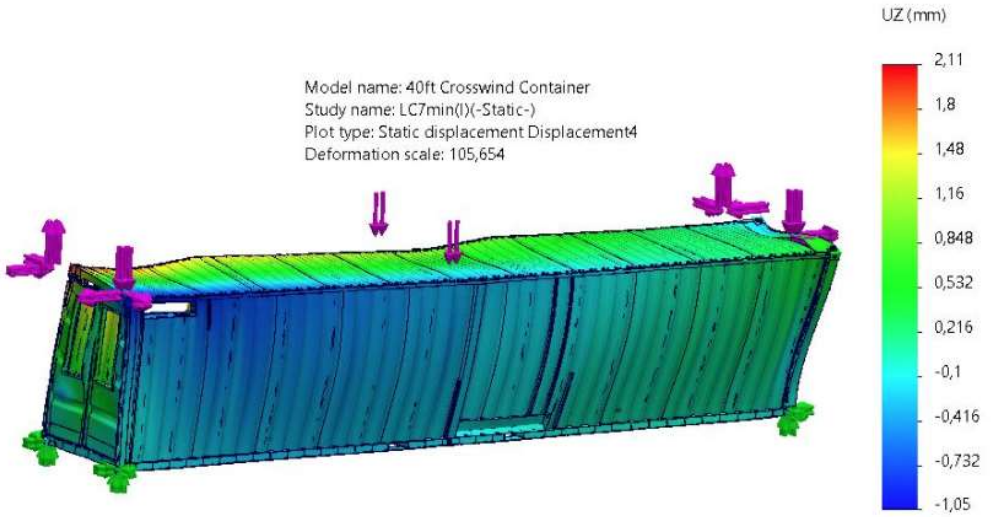


Fig 105: LC7_ MIN -Displacement plot-UZ

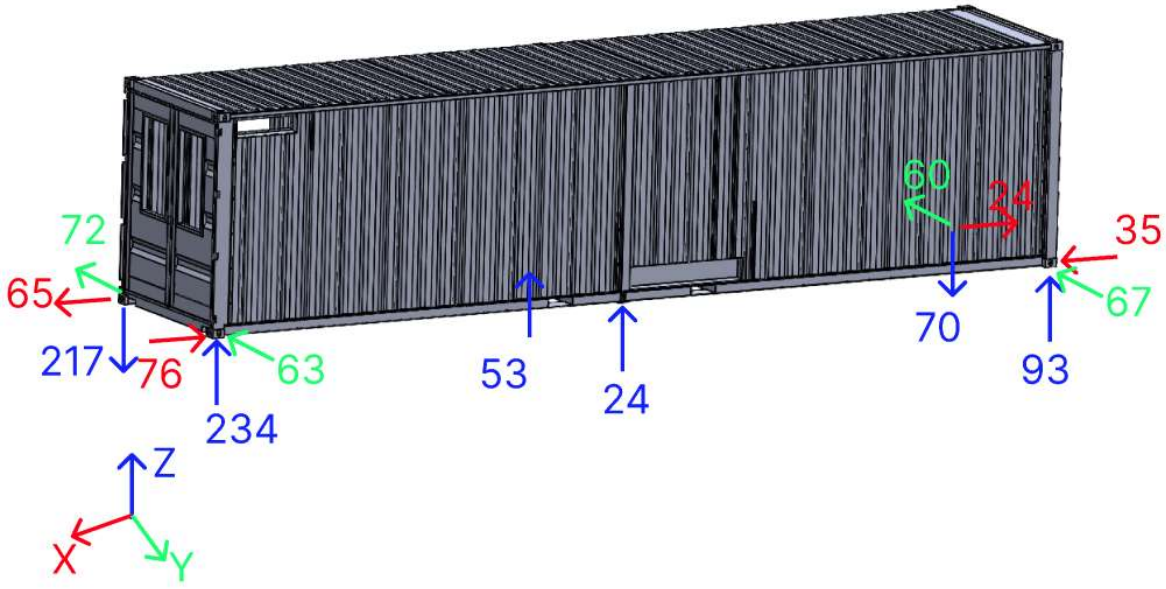


Fig 106: LC7_ MIN -Reactions

9.5. LC8-MAX (40ft container + 40ft flatbed)

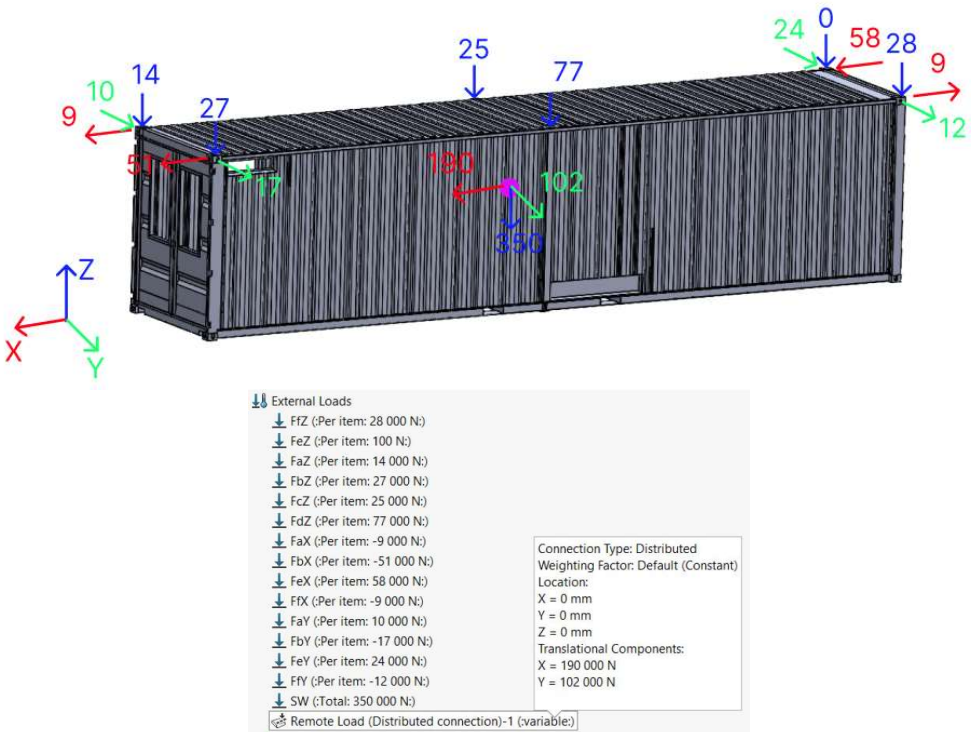


Fig 107: LC8_MAX – 40ft container – Loads

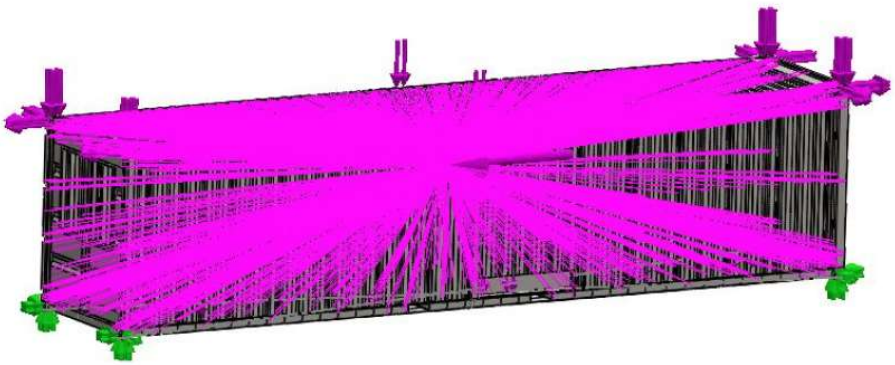


Fig 108: LC8_MAX -Boundary conditions

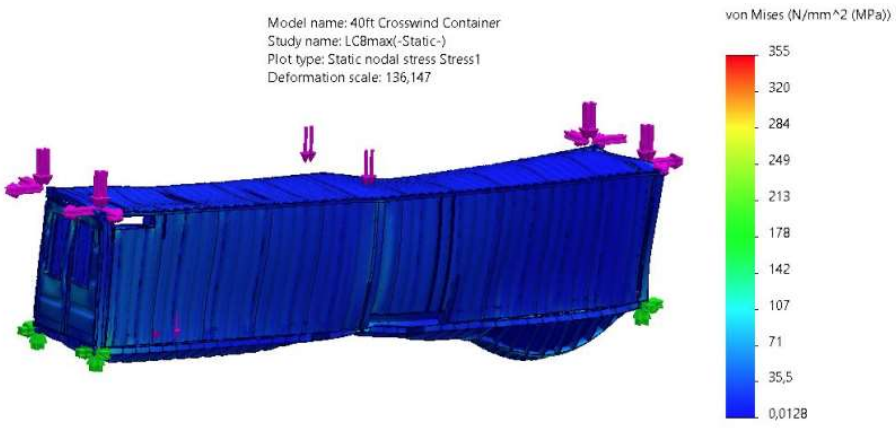


Fig 109: LC8_MAX -Stress plot

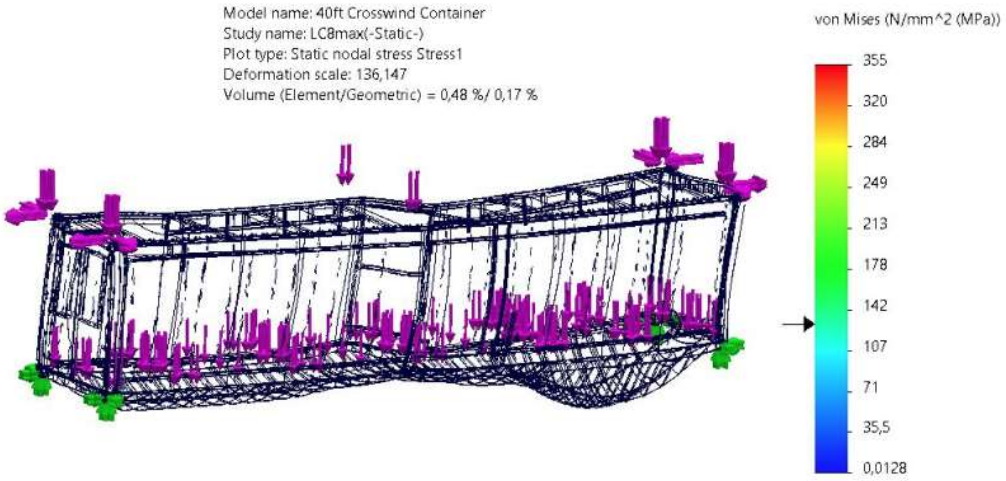


Fig 110: LC8_MAX -Stress plot (the biggest stress in 0,5% of element volume)

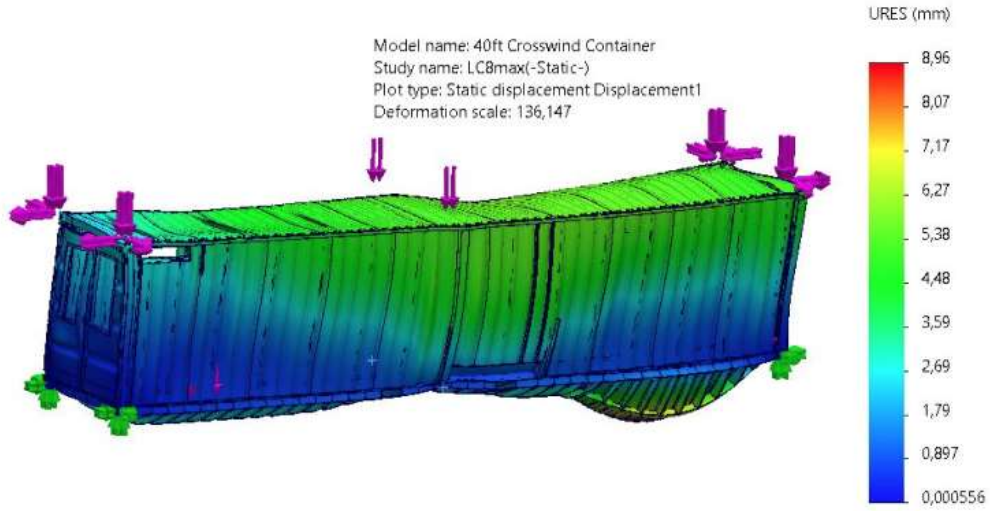


Fig 111: LC8_MAX -Displacement plot

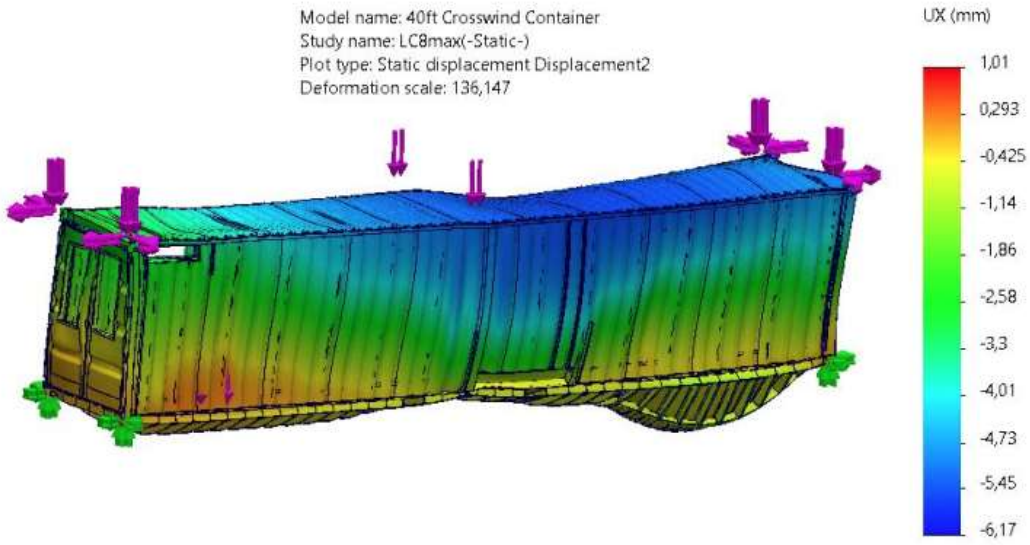


Fig 112: LC8_MAX -Displacement plot-UX

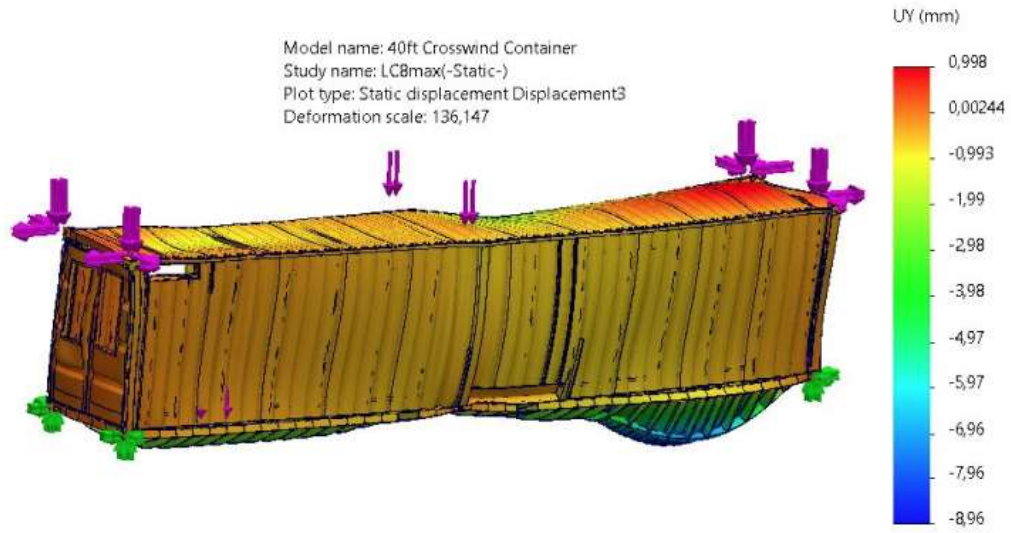


Fig 113: LC8_MAX -Displacement plot-UY

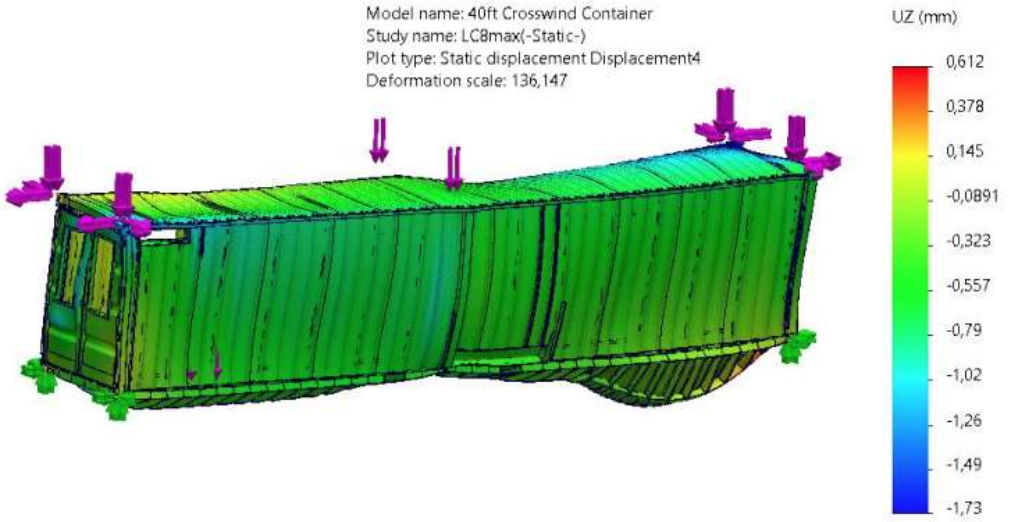


Fig 114: LC8_MAX -Displacement plot-UZ

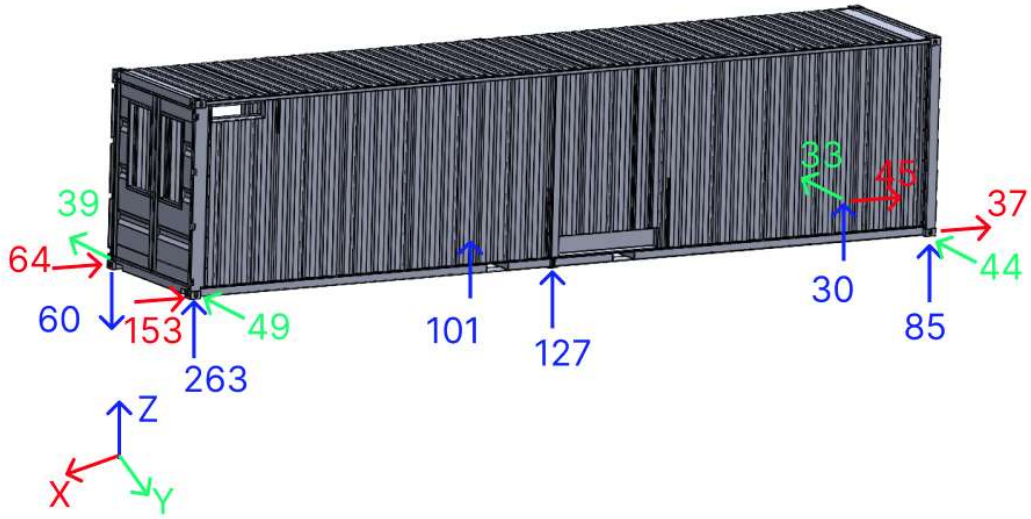
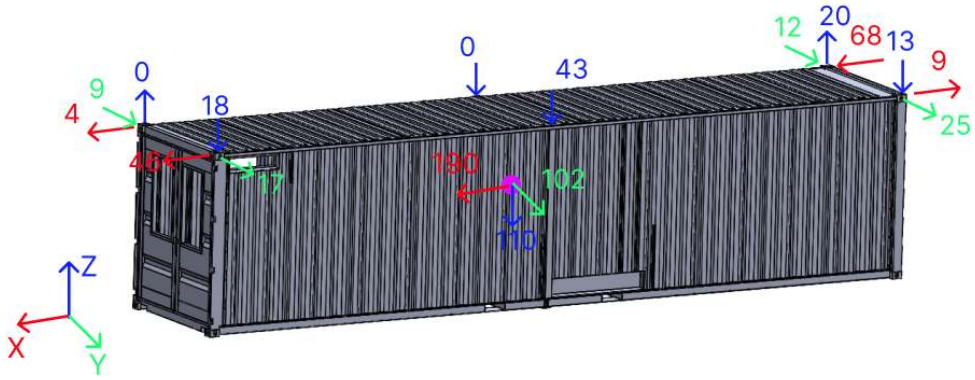


Fig 115: LC8_MAX -Reactions

9.6. LC8-MIN (40ft container + 40ft flatbed)



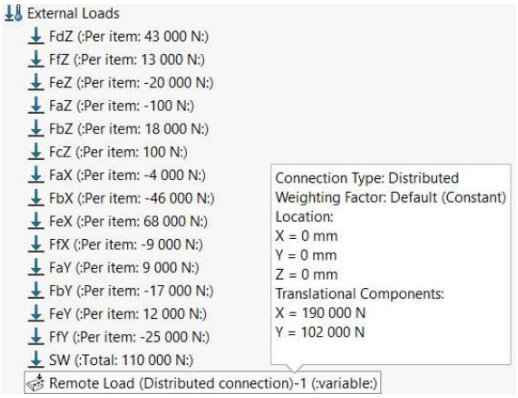


Fig 116: LC8_MIN – 40ft container – Loads

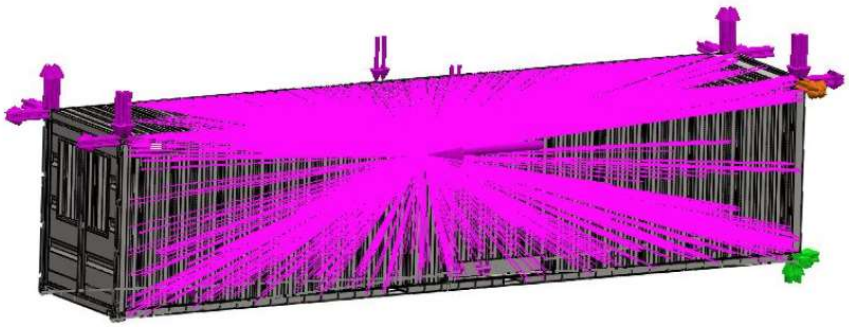


Fig 117: LC8_ MIN -Boundary conditions

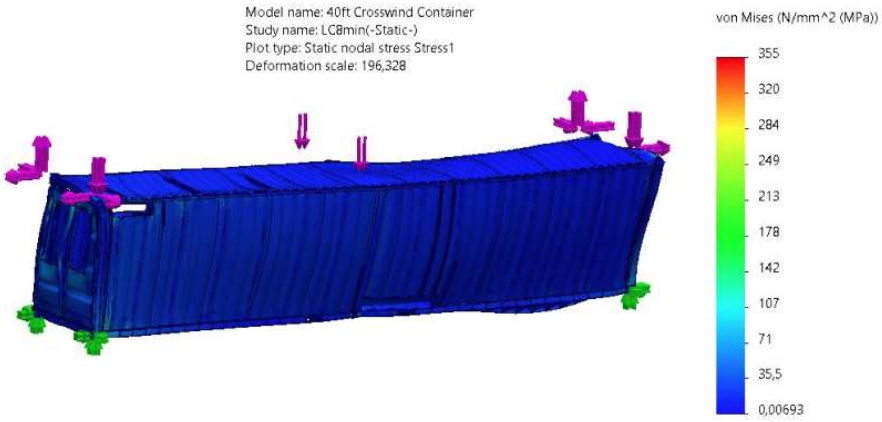


Fig 118: LC8_ MIN -Stress plot

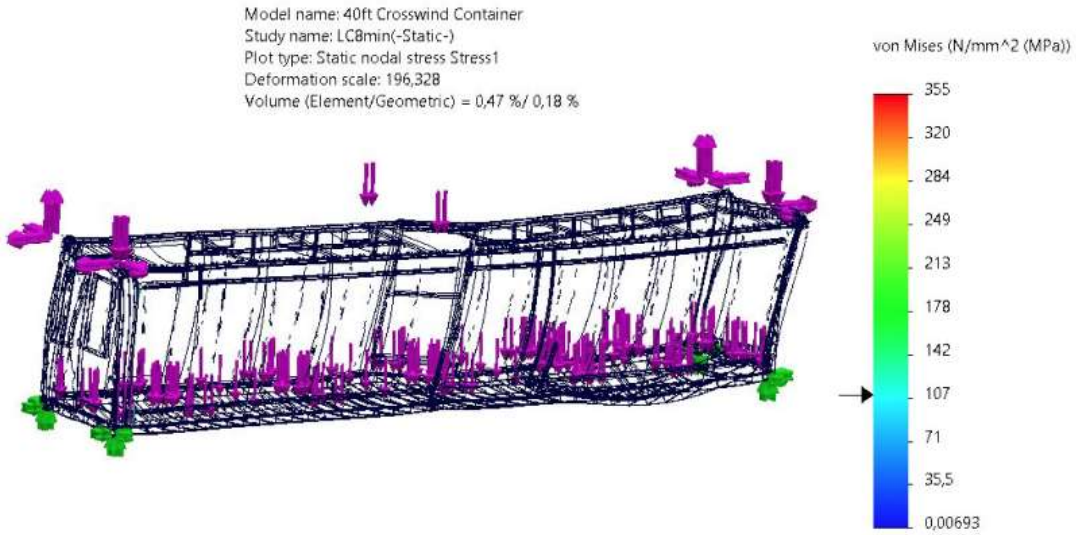


Fig 119: LC8_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

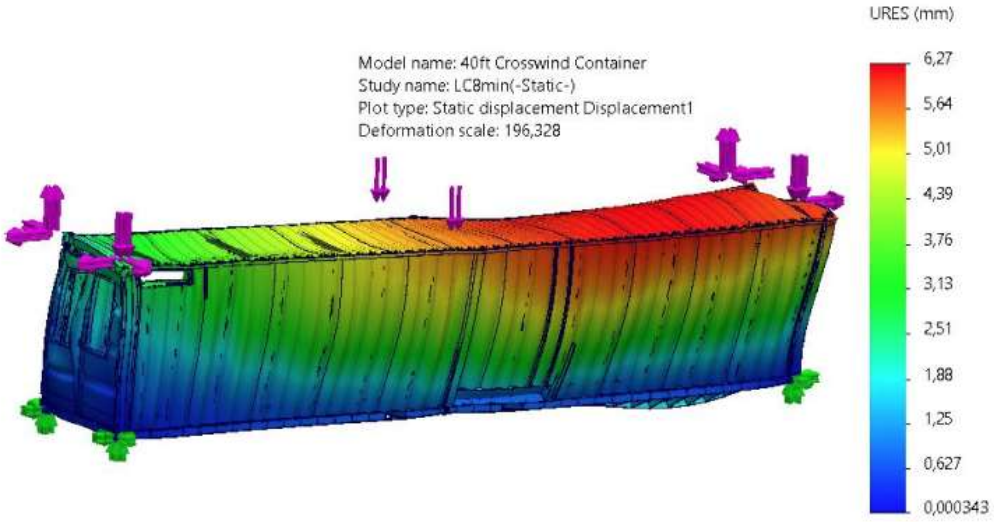


Fig 120: LC8_ MIN -Displacement plot

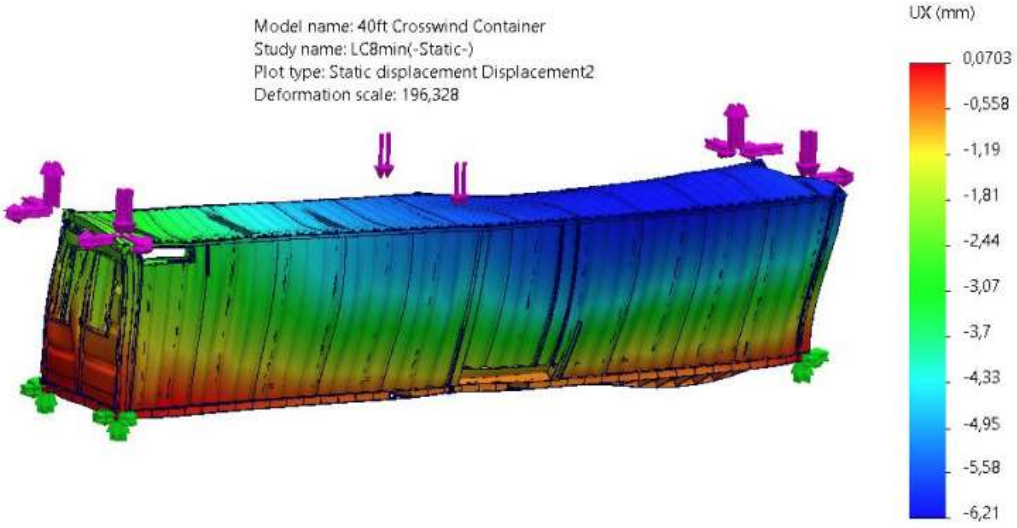


Fig 121: LC8_ MIN -Displacement plot-UX

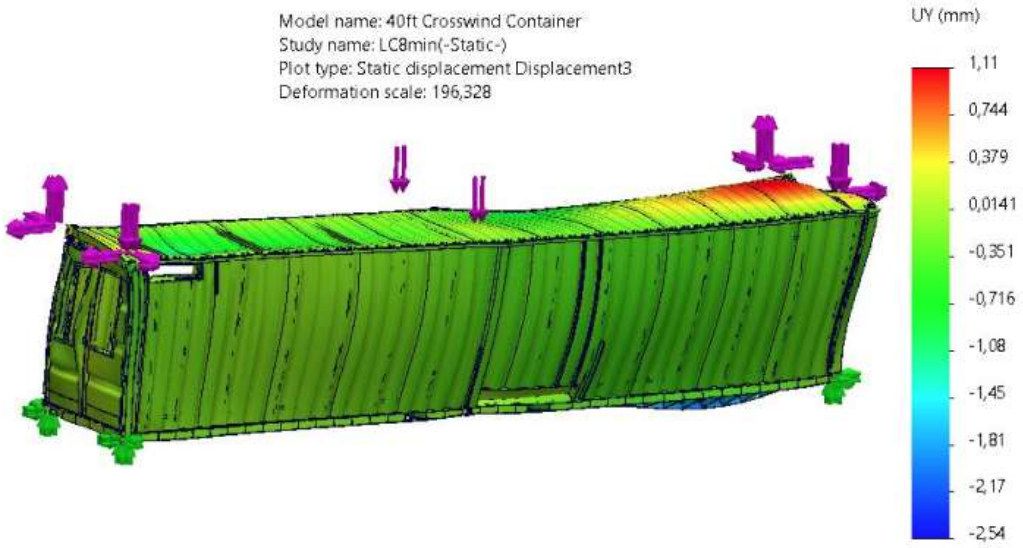


Fig 122: LC8_ MIN -Displacement plot-UY

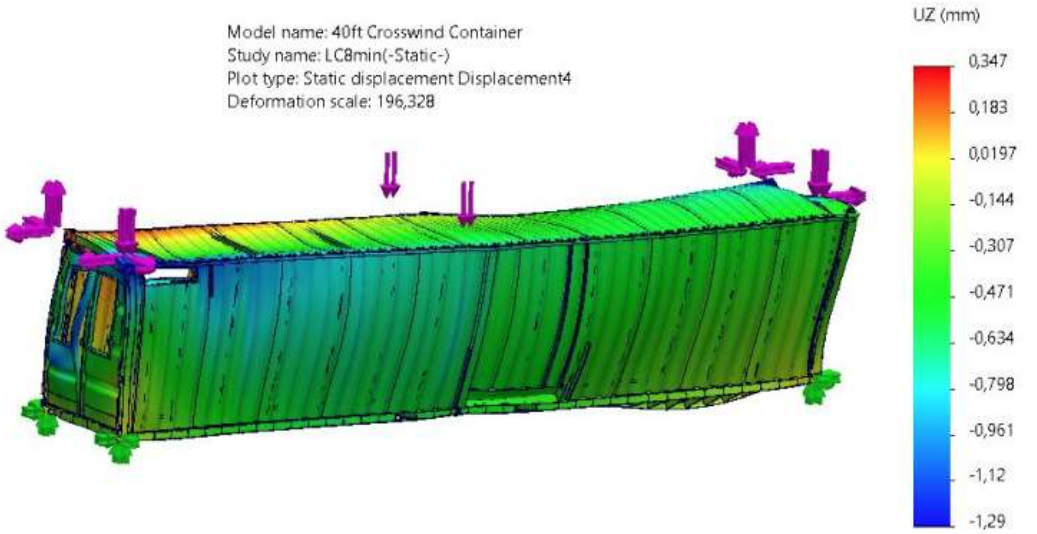


Fig 123: LC8_ MIN -Displacement plot-UZ

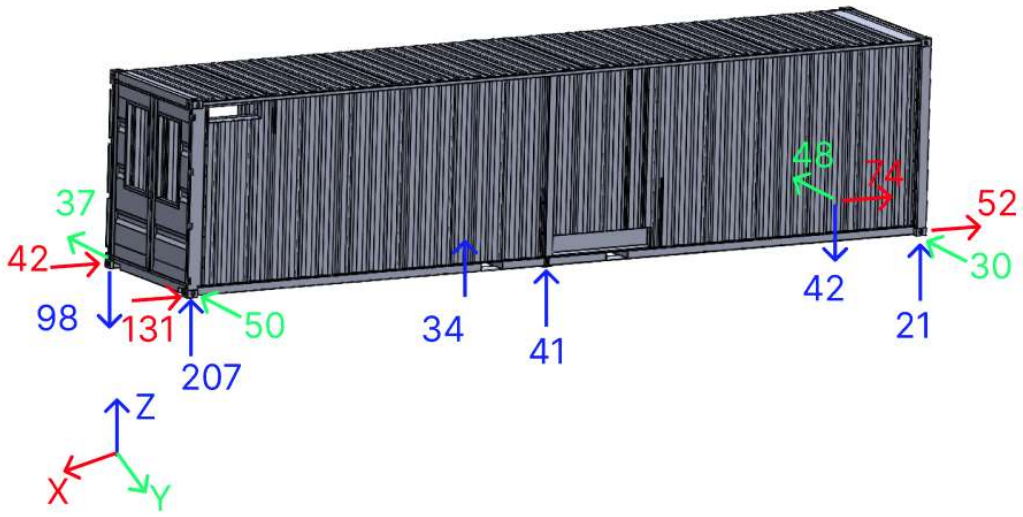


Fig 124: LC8_ MIN -Reactions

9.7. LC9-MAX (40ft container + 40ft flatbed)

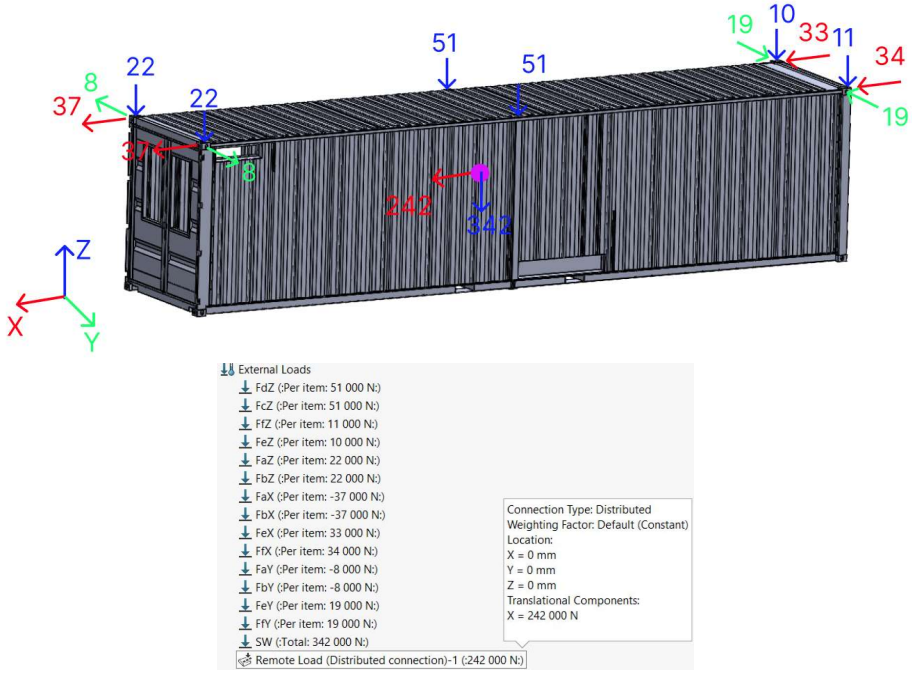


Fig 125: LC9_MAX – 40ft container – Loads

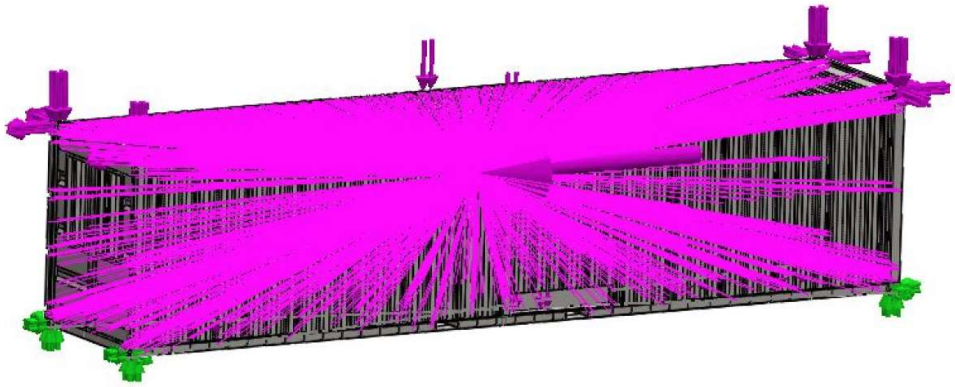


Fig 126: LC9_MAX -Boundary conditions

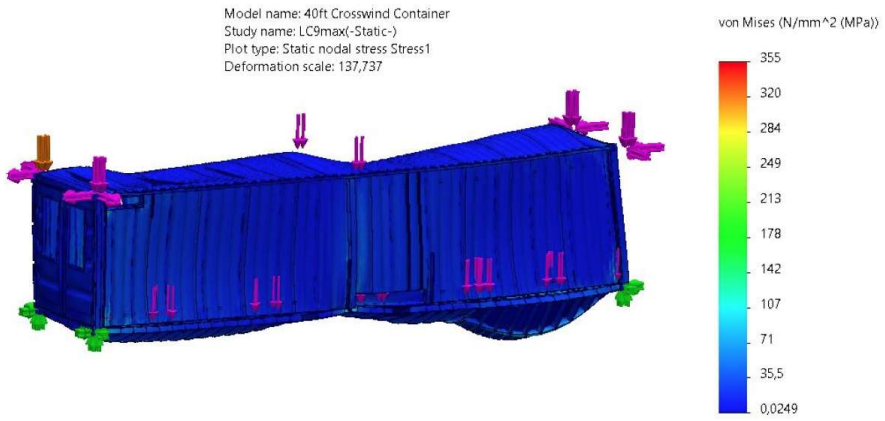


Fig 127: LC8_MAX -Stress plot

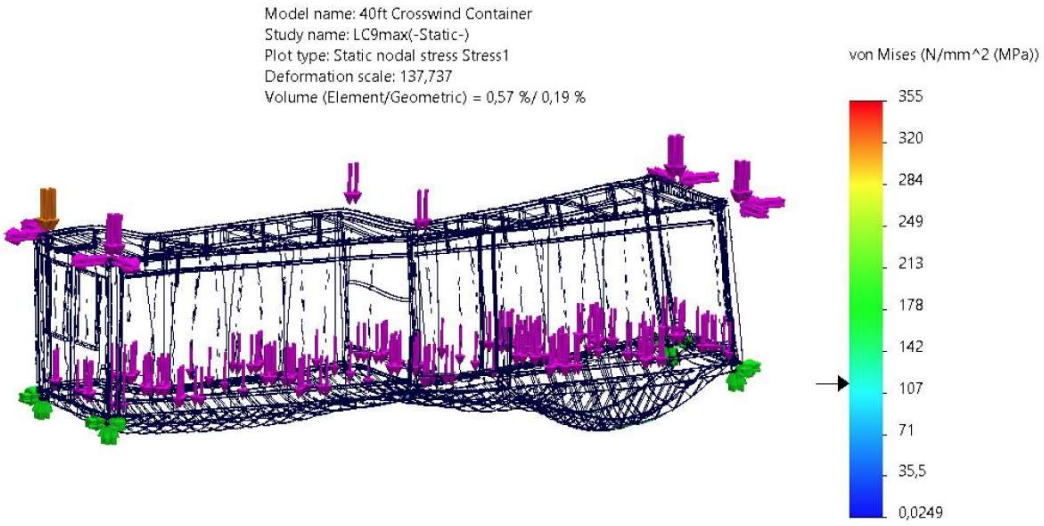


Fig 128: LC8_MAX -Stress plot (the biggest stress in 0,5% of element volume)

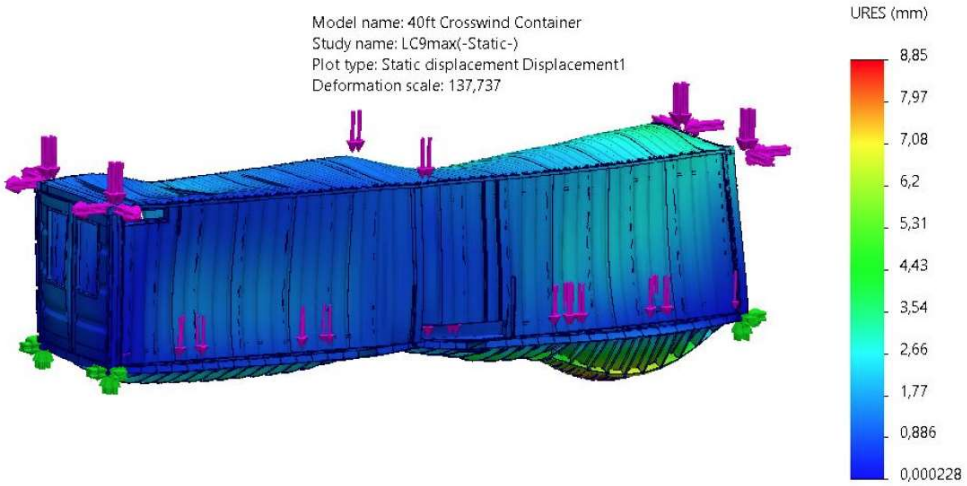


Fig 129: LC8_MAX -Displacement plot

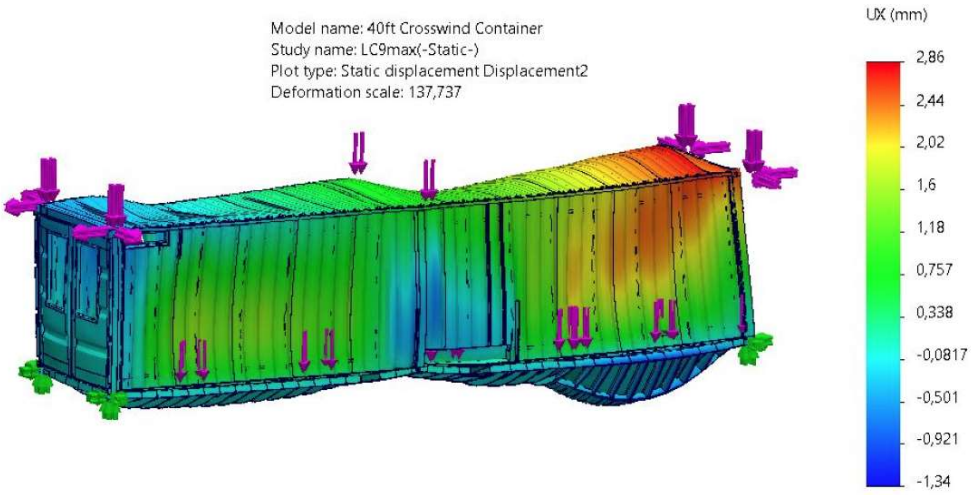


Fig 130: LC8_MAX -Displacement plot-UX

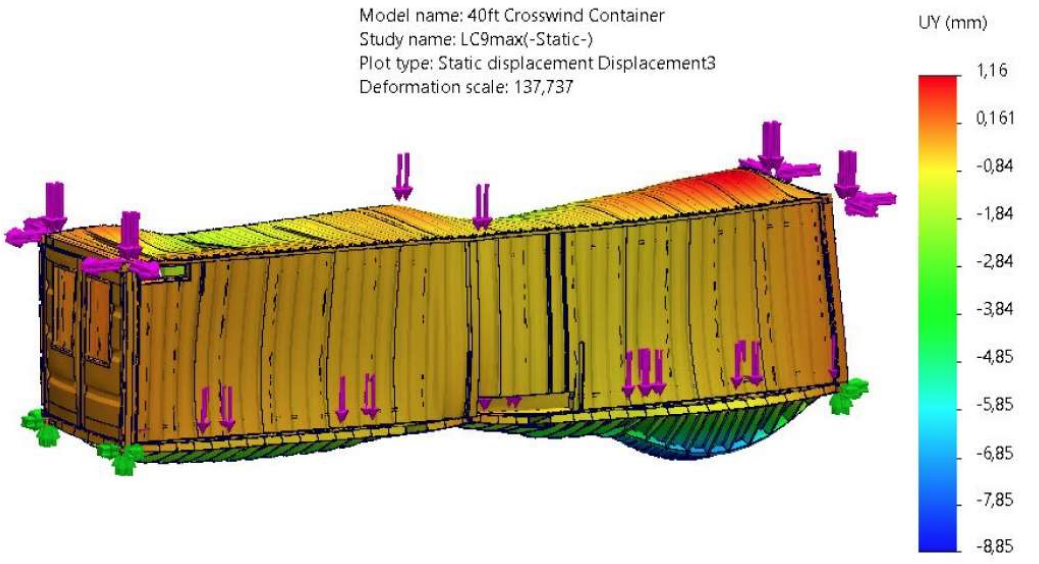


Fig 131: LC8_MAX -Displacement plot-UY

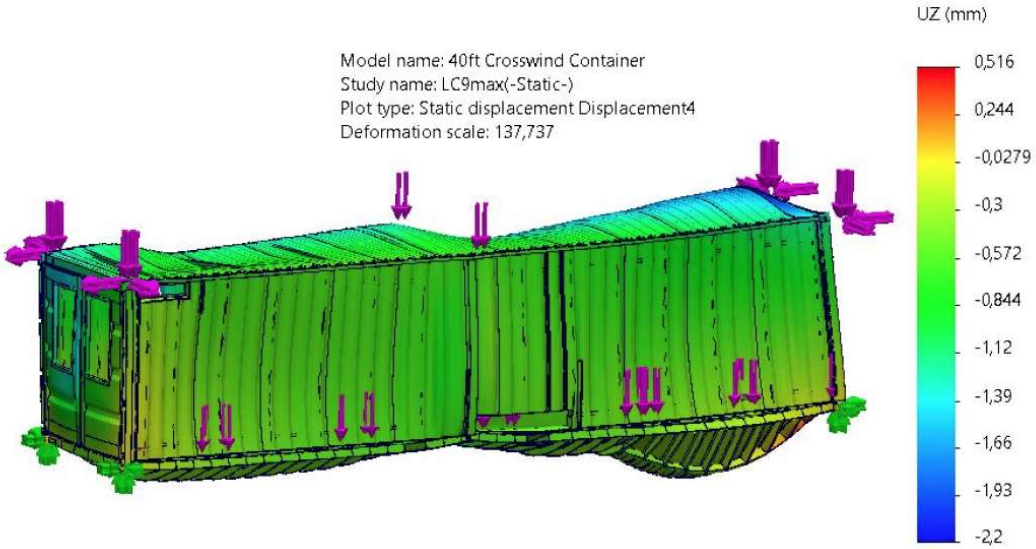


Fig 132: LC8_MAX -Displacement plot-UZ

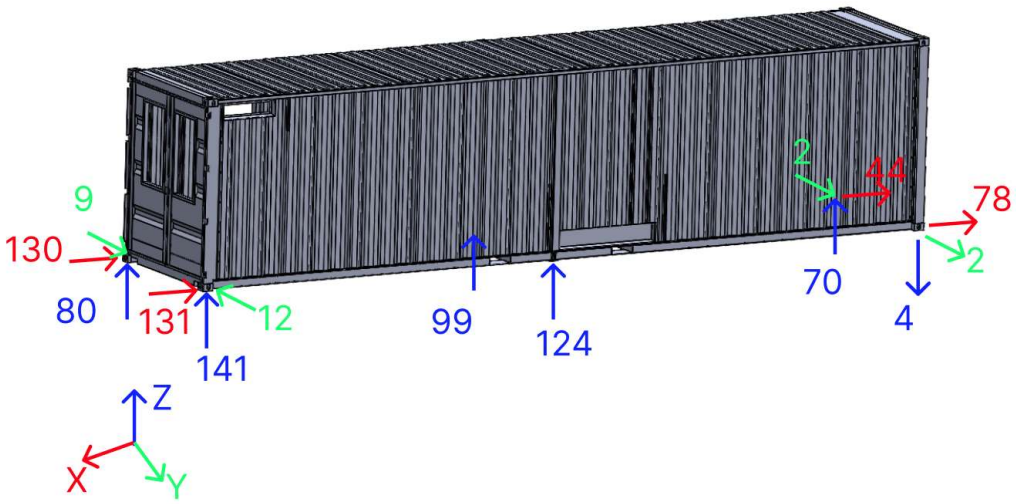


Fig 133: LC8_MAX -Reactions

9.8. LC9-MIN (40ft container + 40ft flatbed)

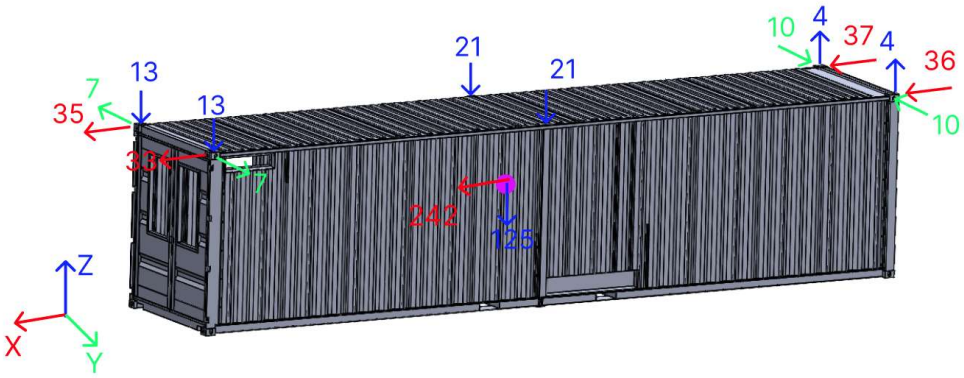


Fig 134: LC9_MIN – 40ft container – Loads

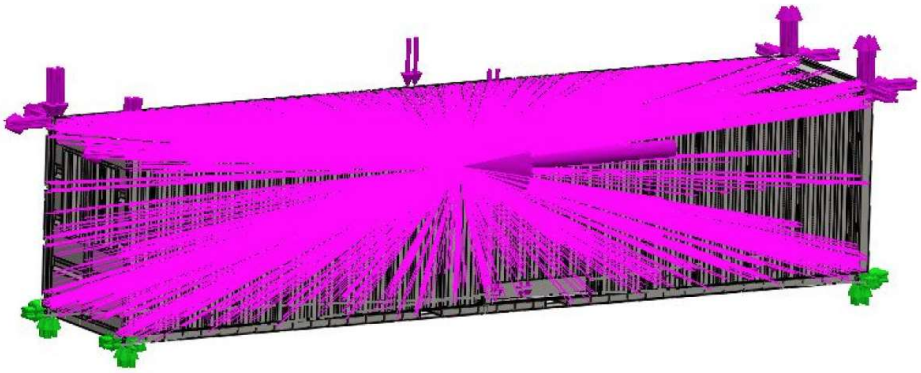


Fig 135: LC9_ MIN -Boundary conditions

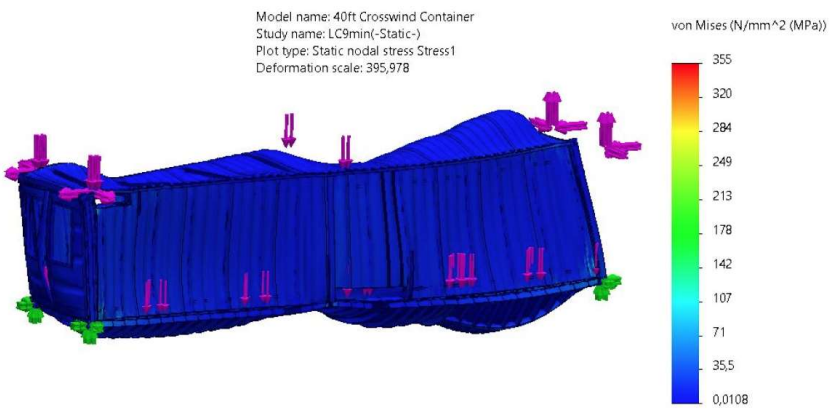


Fig 136: LC9_ MIN -Stress plot

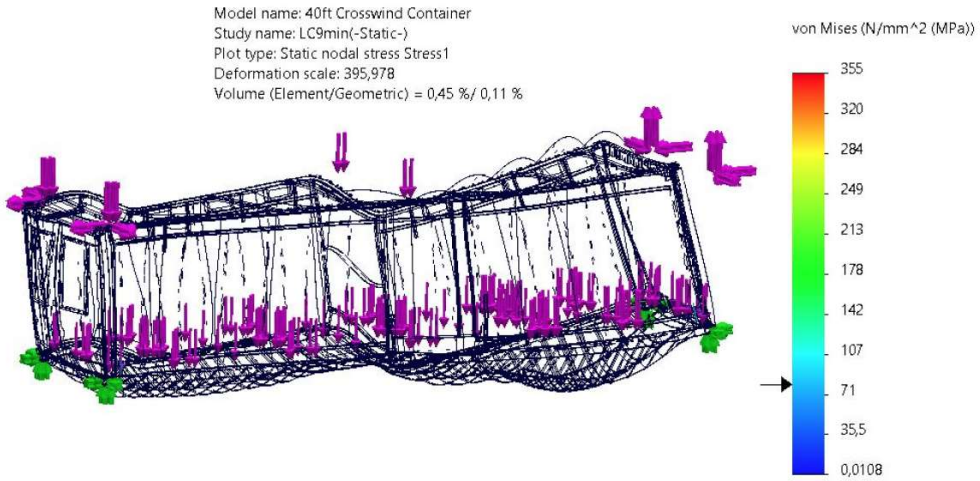


Fig 137: LC9_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

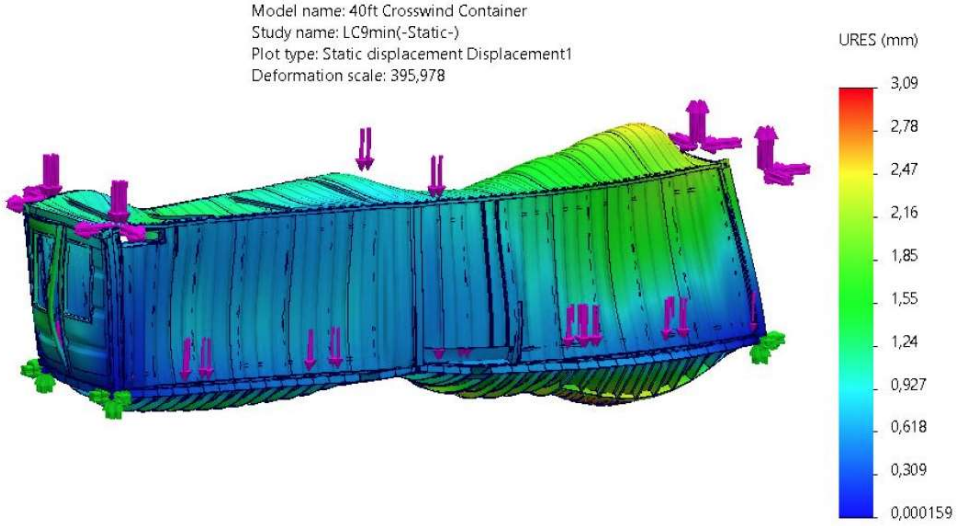


Fig 138: LC9_ MIN -Displacement plot

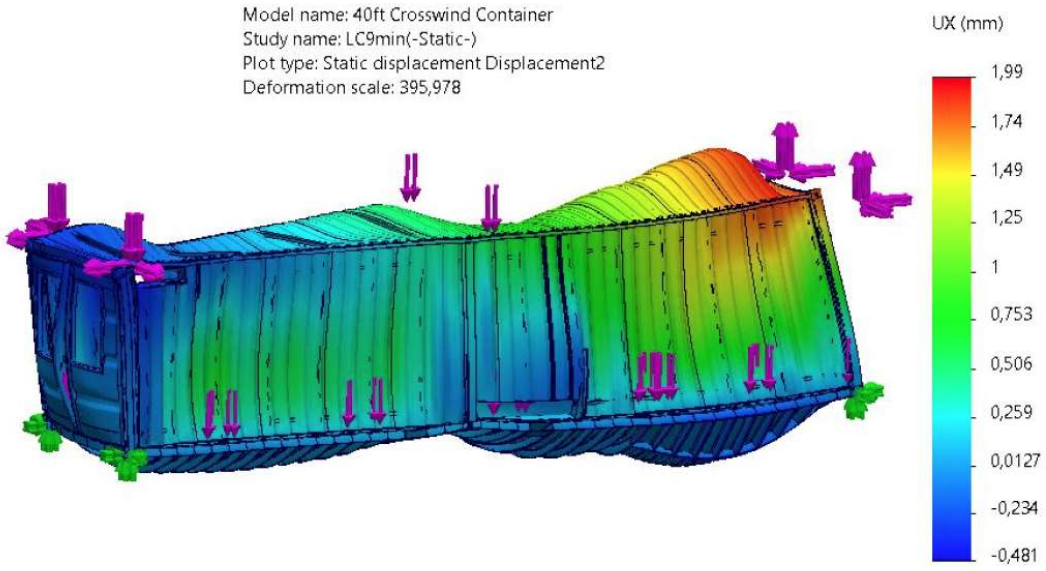


Fig 139: LC9_ MIN -Displacement plot-UX

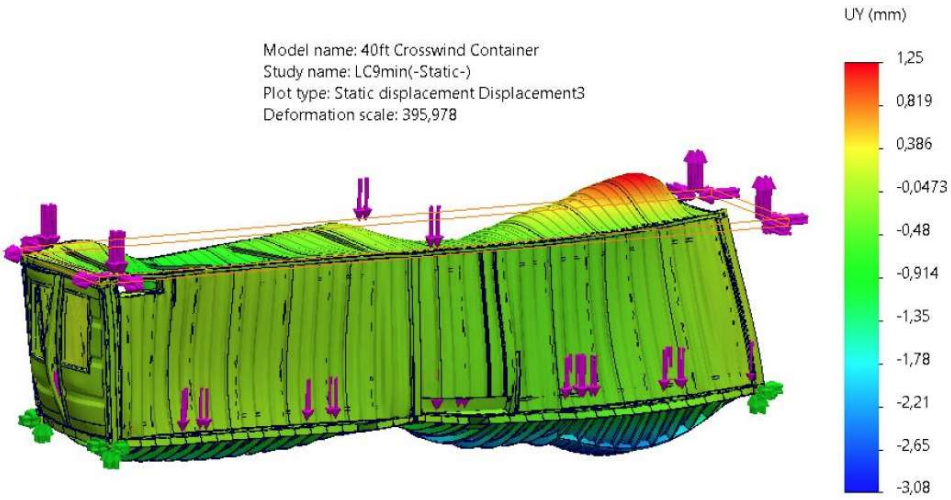


Fig 140: LC9_ MIN -Displacement plot-UY

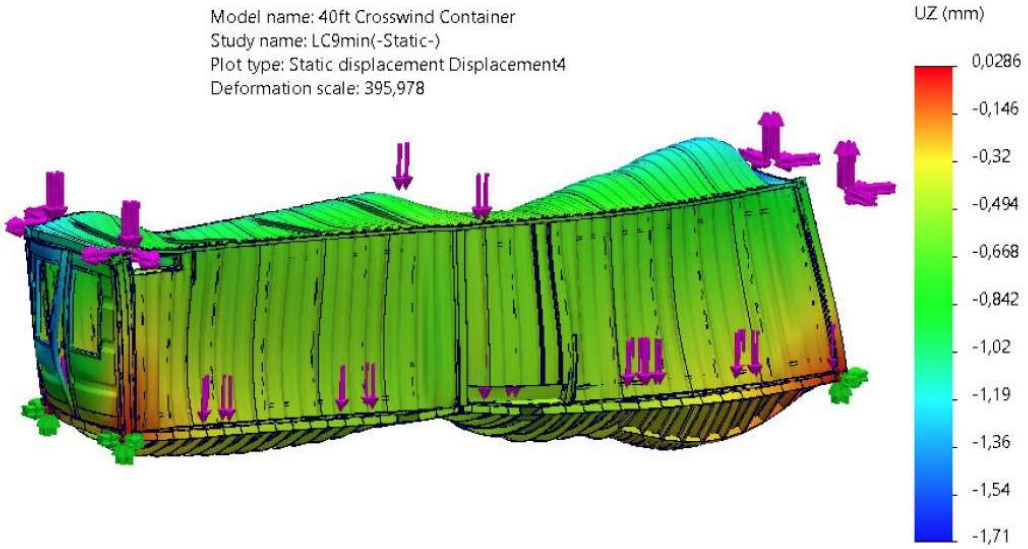


Fig 141: LC9_ MIN -Displacement plot-UZ

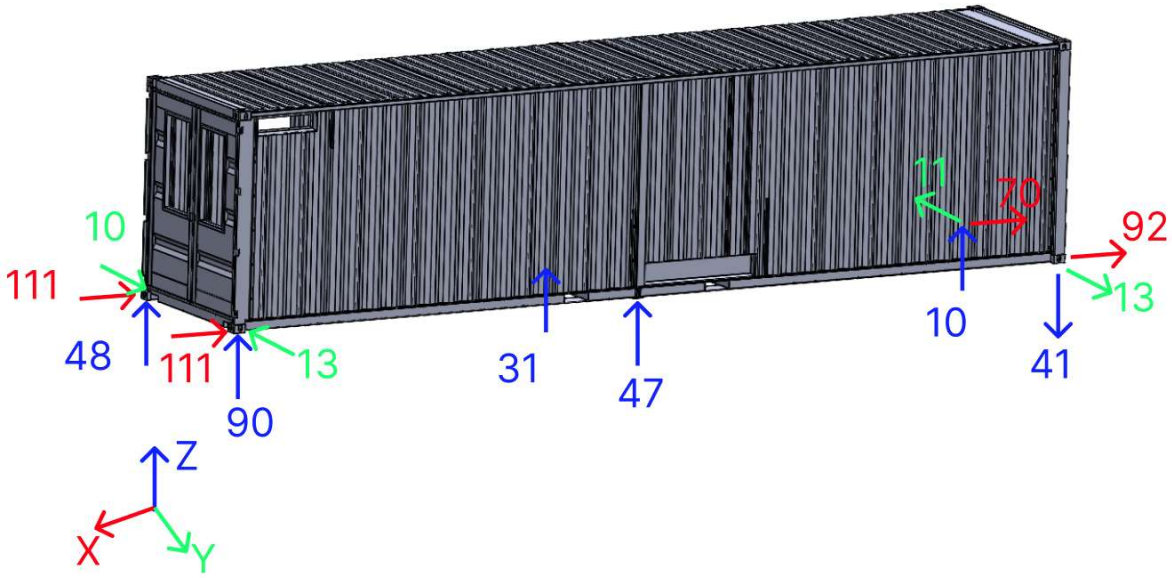
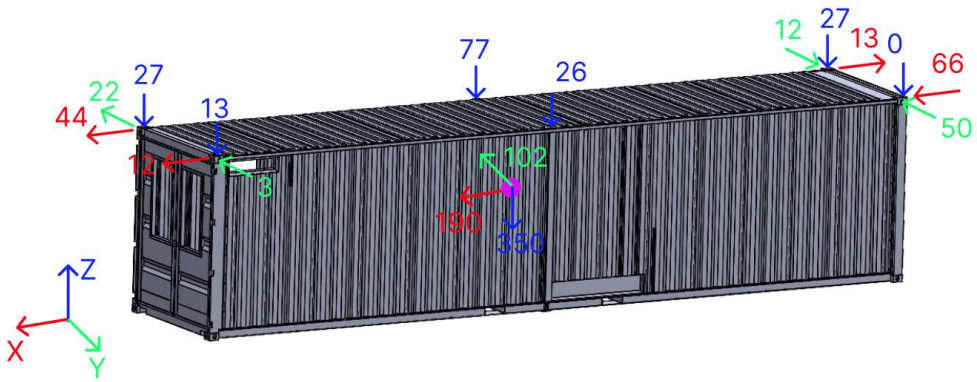


Fig 142: LC9_ MIN -Reactions

9.9. LC10-MAX (40ft container + 40ft flatbed)



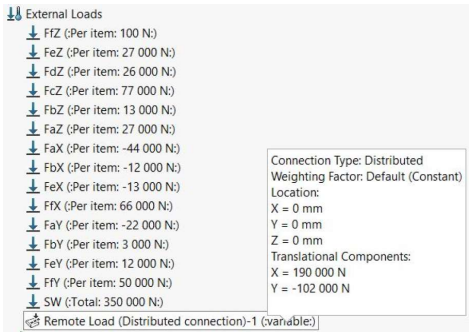


Fig 143: LC10_MAX – 40ft container – Loads

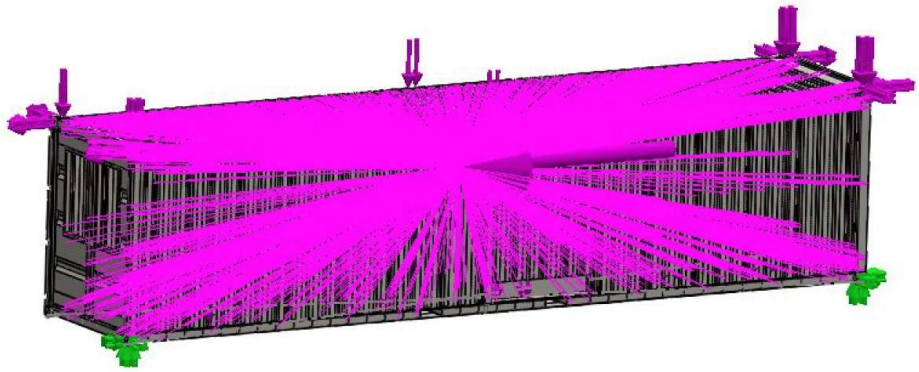


Fig 144: LC10_MAX -Boundary conditions

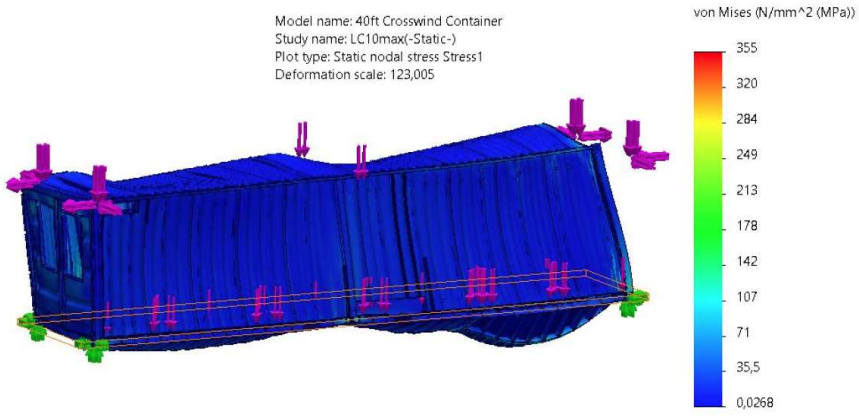


Fig 145: LC10_MAX -Stress plot

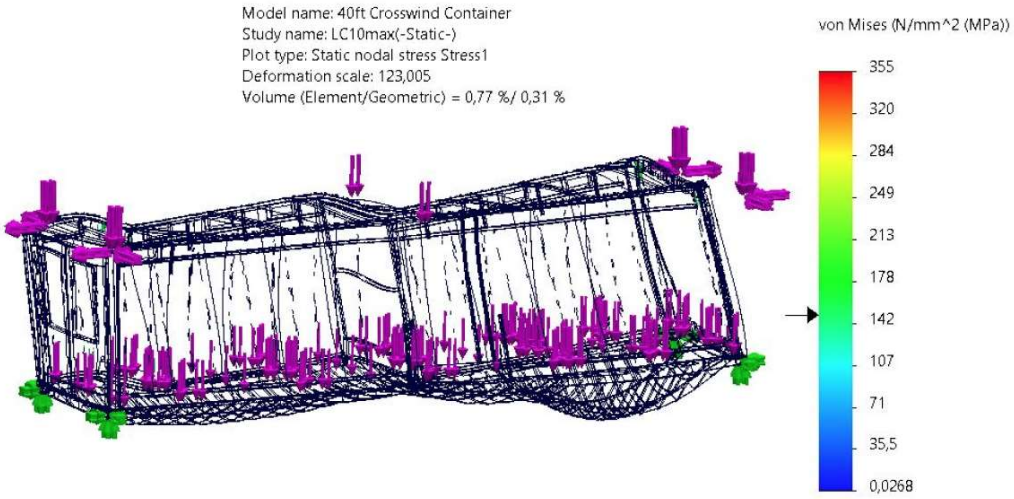


Fig 146: LC10_MAX -Stress plot (the biggest stress in 0,5% of element volume)

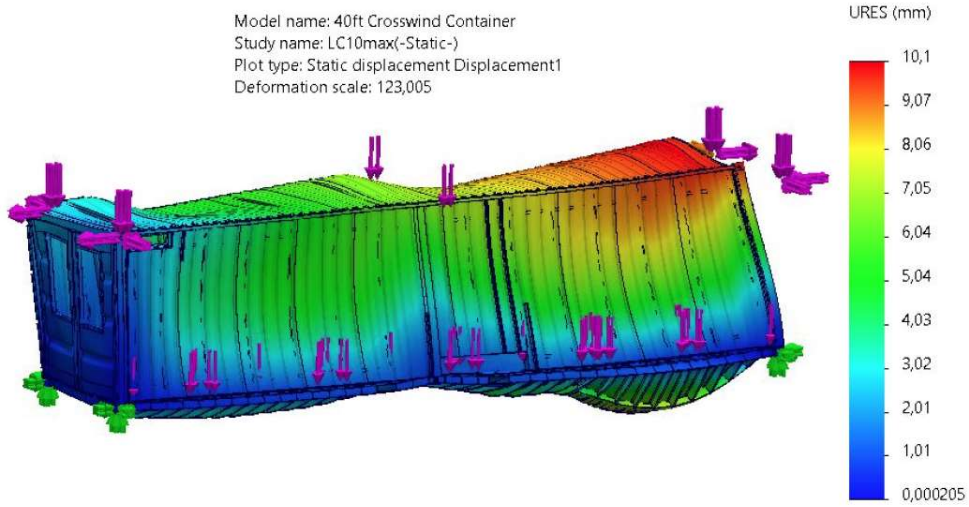


Fig 147: LC10_MAX -Displacement plot

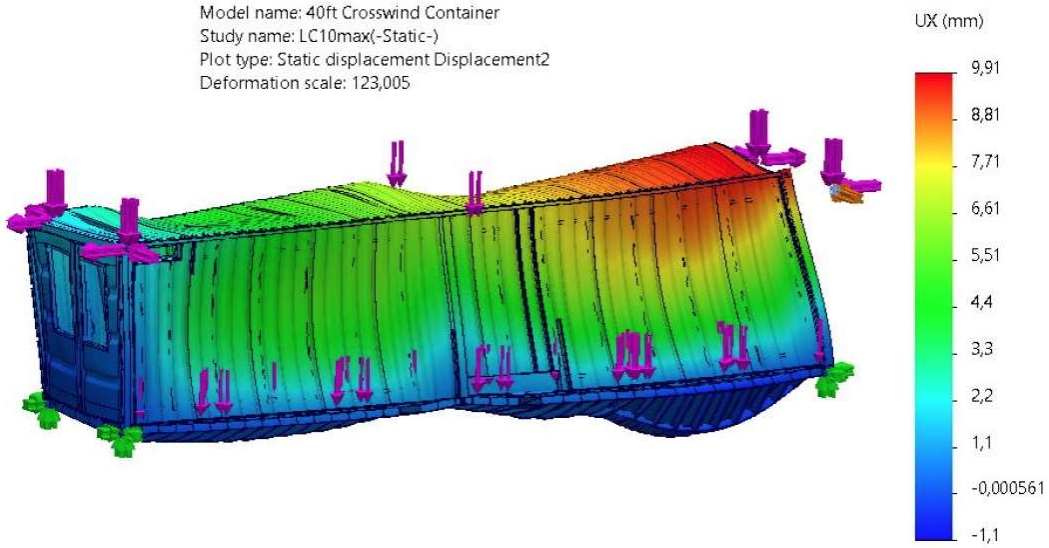


Fig 148: LC10_MAX -Displacement plot-UX

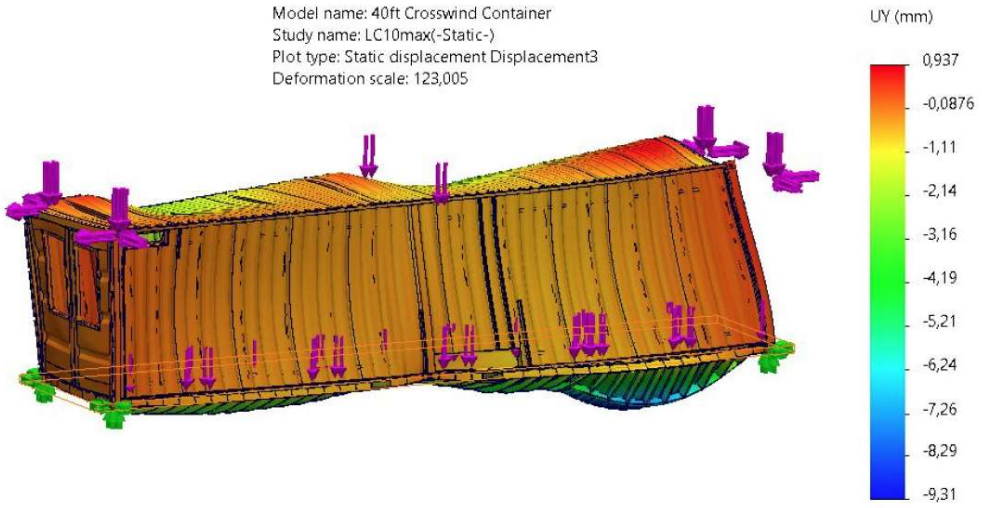


Fig 149: LC10_MAX -Displacement plot-UY

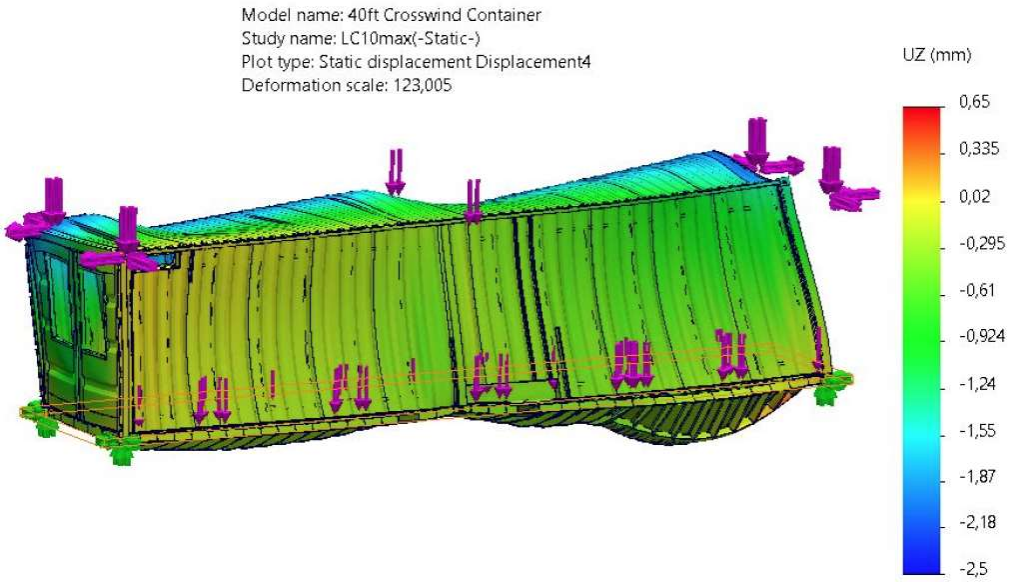


Fig 150: LC10_MAX -Displacement plot-UZ

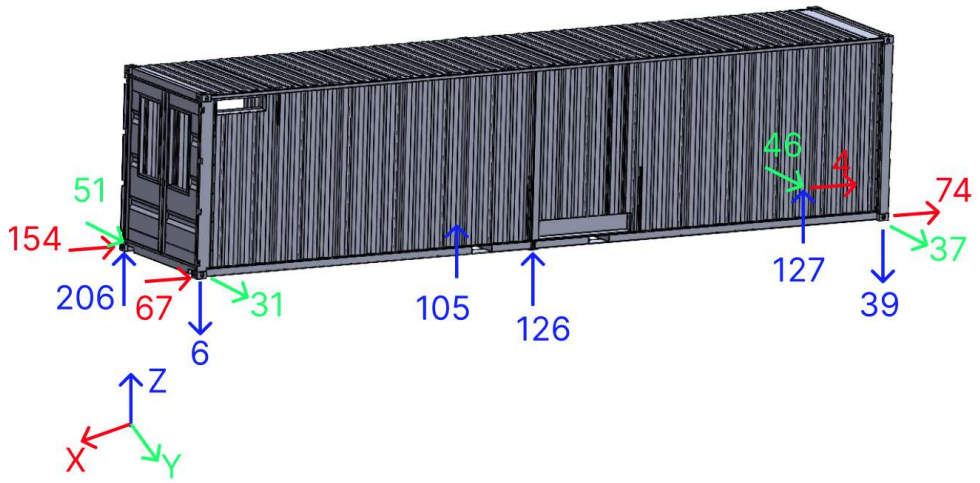
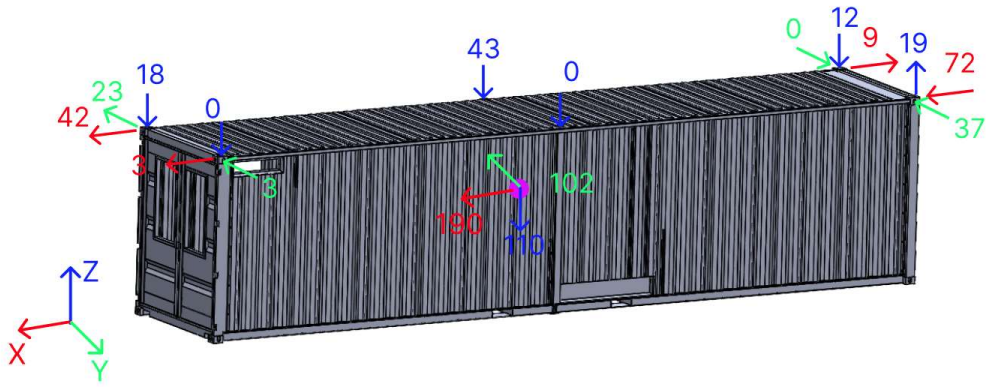


Fig 151: LC10_MAX -Reactions

9.10. LC10-MIN (40ft container + 40ft flatbed)



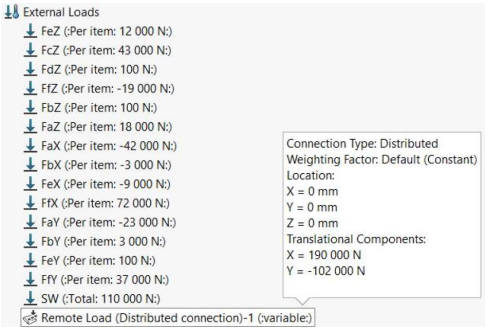


Fig 152: LC10_MIN – 40ft container – Loads

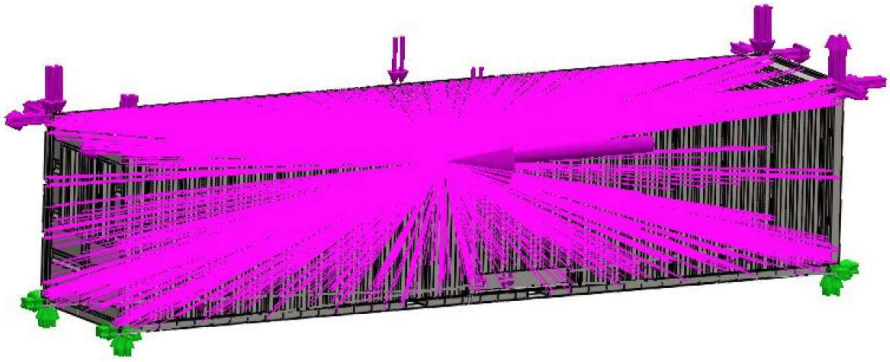


Fig 153: LC10_ MIN -Boundary conditions

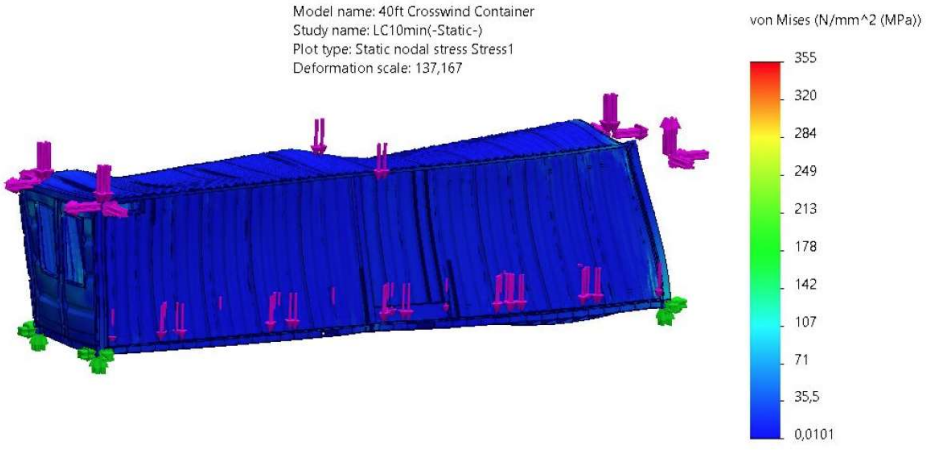


Fig 154: LC10_ MIN -Stress plot

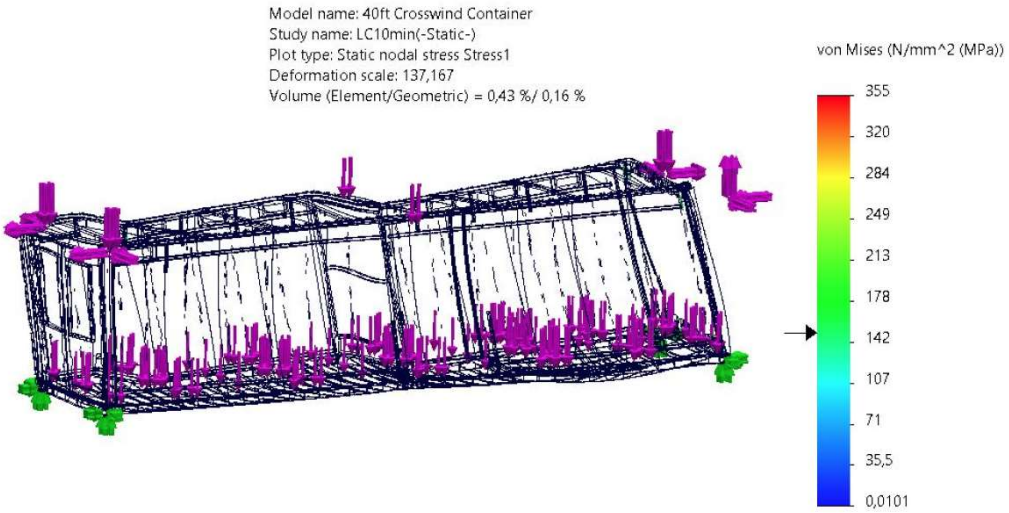


Fig 155: LC10_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

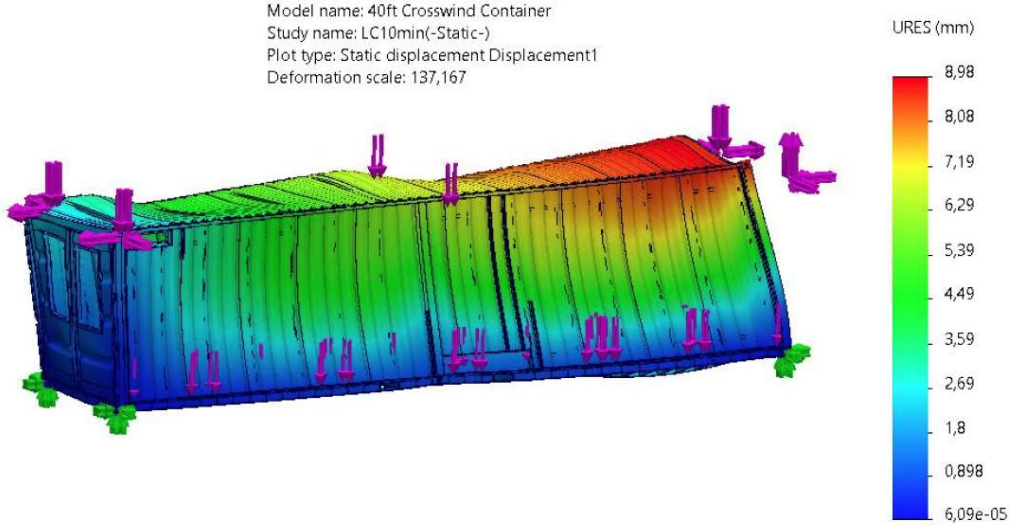


Fig 156: LC10_ MIN -Displacement plot

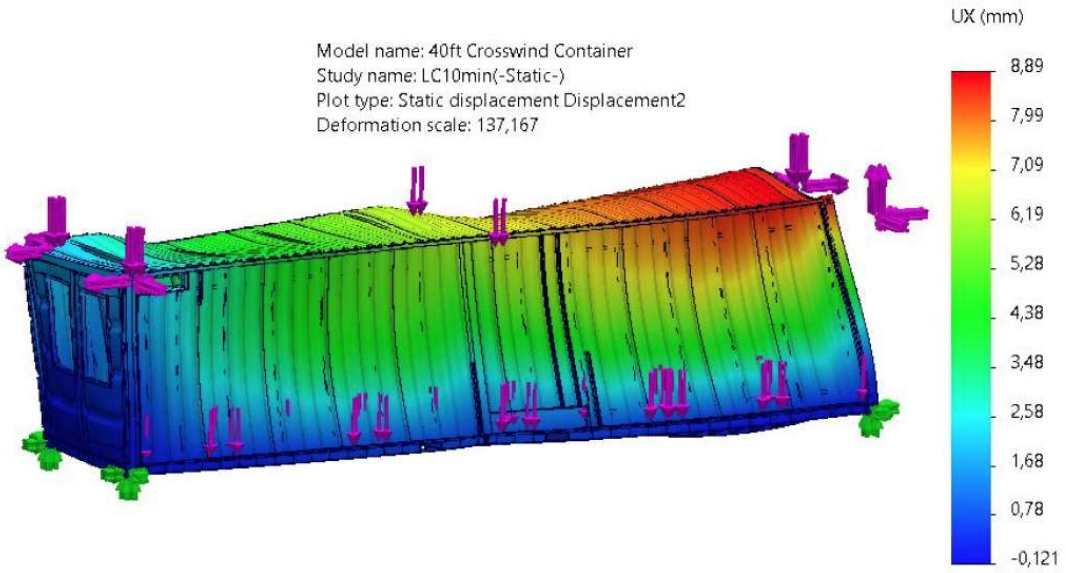


Fig 157: LC10_ MIN -Displacement plot-UX

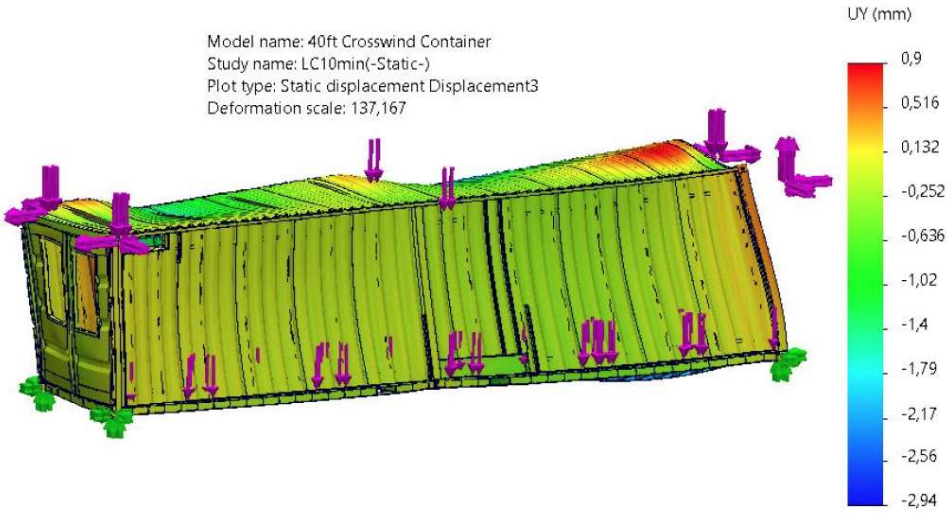


Fig 158: LC10_ MIN -Displacement plot-UY

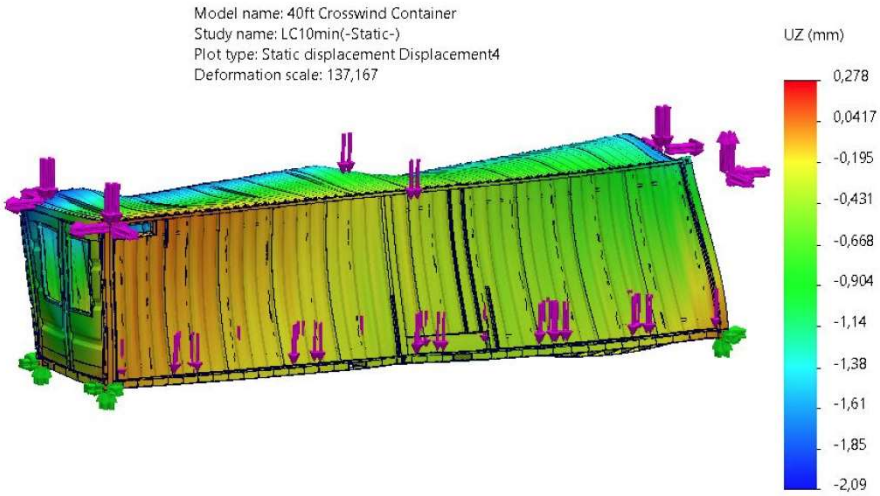


Fig 159: LC10_ MIN -Displacement plot-UZ

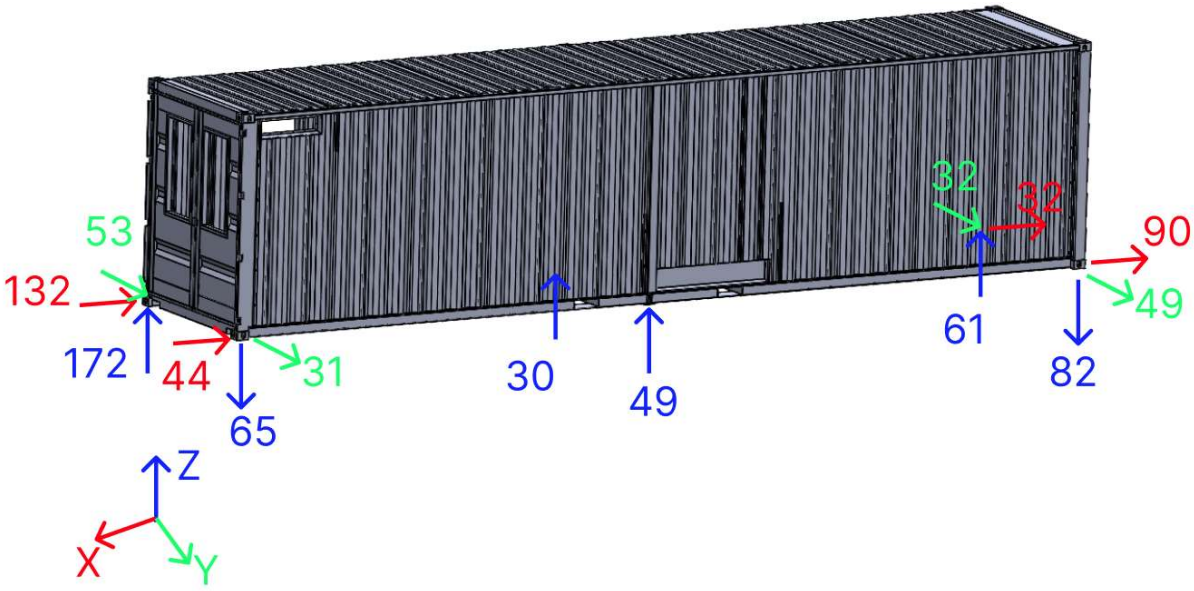
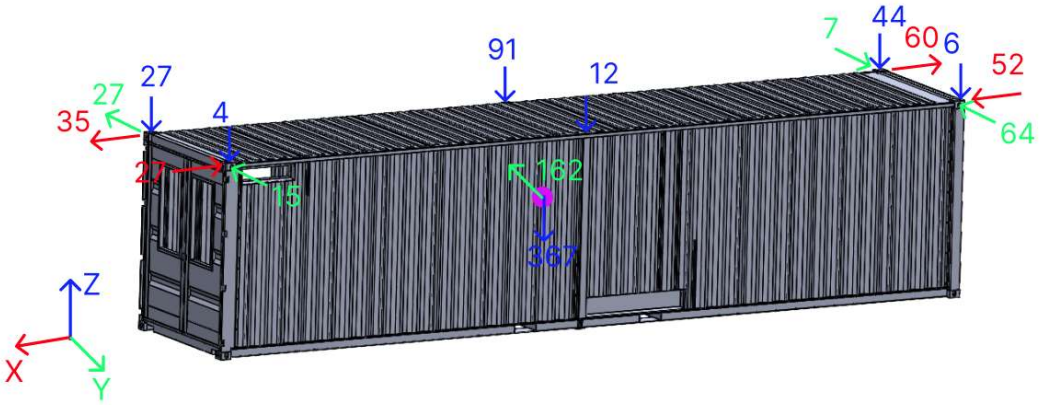


Fig 160: LC10_ MIN -Reactions

9.11. LC11-MAX (40ft container + 40ft flatbed)



External Loads
FcZ (:Per item: 91 000 N:)
FfZ (:Per item: 6 000 N:)
FeZ (:Per item: 44 000 N:)
FdZ (:Per item: 12 000 N:)
FbZ (:Per item: 4 000 N:)
FaZ (:Per item: 27 000 N:)
FaX (:Per item: -35 000 N:)
FbX (:Per item: 27 000 N:)
FeX (:Per item: -60 000 N:)
FfX (:Per item: 52 000 N:)
FaY (:Per item: -27 000 N:)
FbY (:Per item: 15 000 N:)
FeY (:Per item: 7 000 N:)
FfY (:Per item: 64 000 N:)
SW (:Total: 367 000 N:)
Remote Load (Distributed connection)-1 (:-162 000 N:)

Connection Type: Distributed
Weighting Factor: Default (Constant)
Location:
X = 0 mm
Y = 0 mm
Z = 0 mm
Translational Components:
Y = -162 000 N

Fig 161: LC11_MAX – 40ft container – Loads

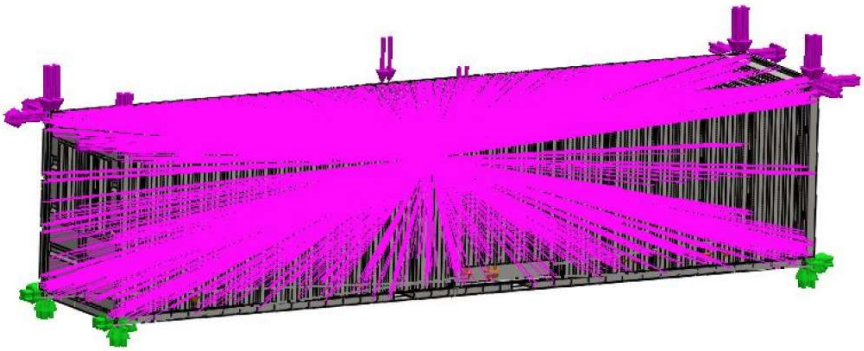


Fig 162: LC11_MAX -Boundary conditions

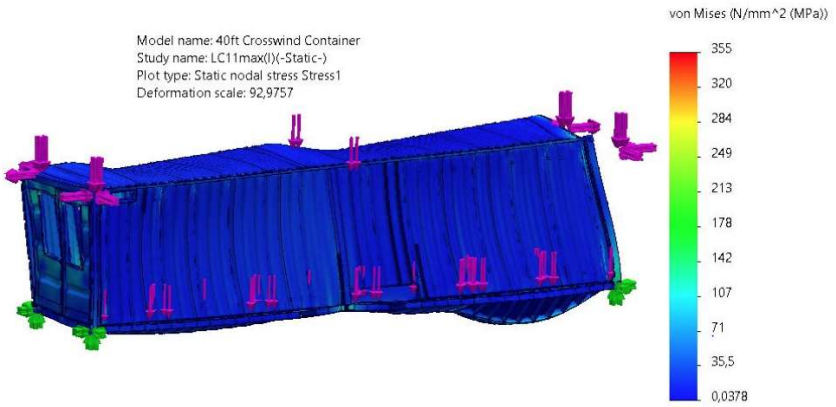


Fig 163: LC11_MAX -Stress plot

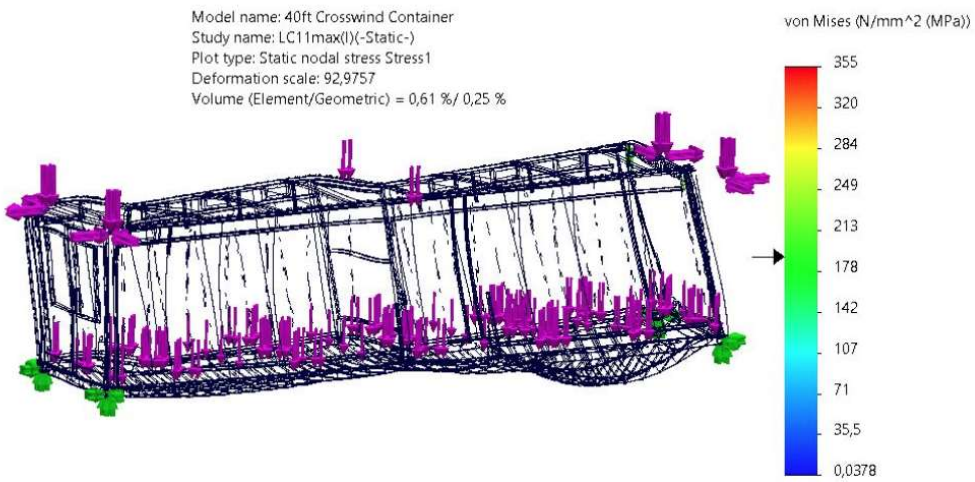


Fig 164: LC11_MAX -Stress plot (the biggest stress in 0,5% of element volume)

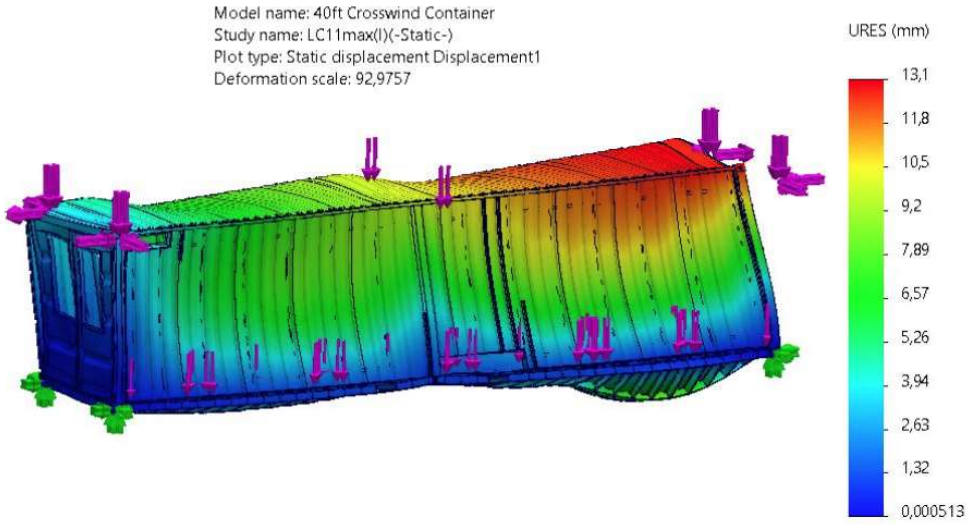


Fig 165: LC11_MAX -Displacement plot

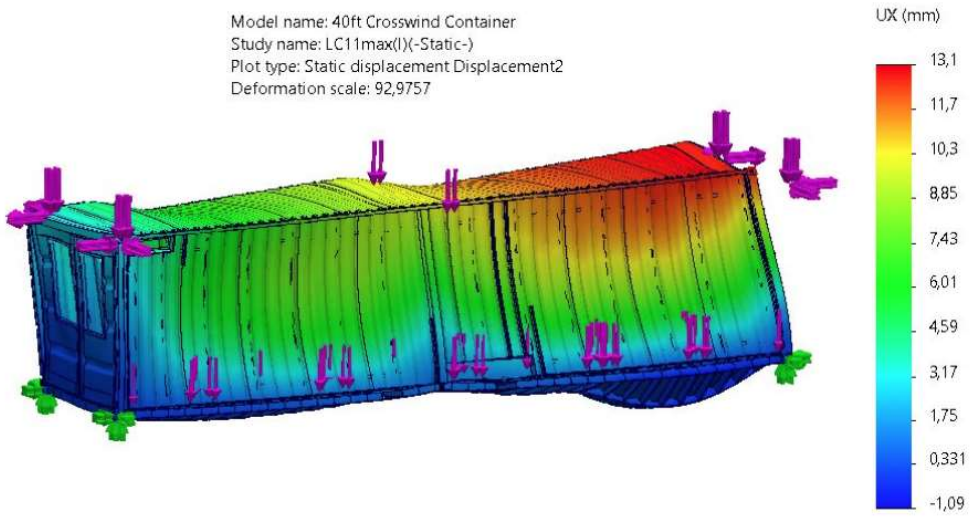


Fig 166: LC11_MAX -Displacement plot-UX

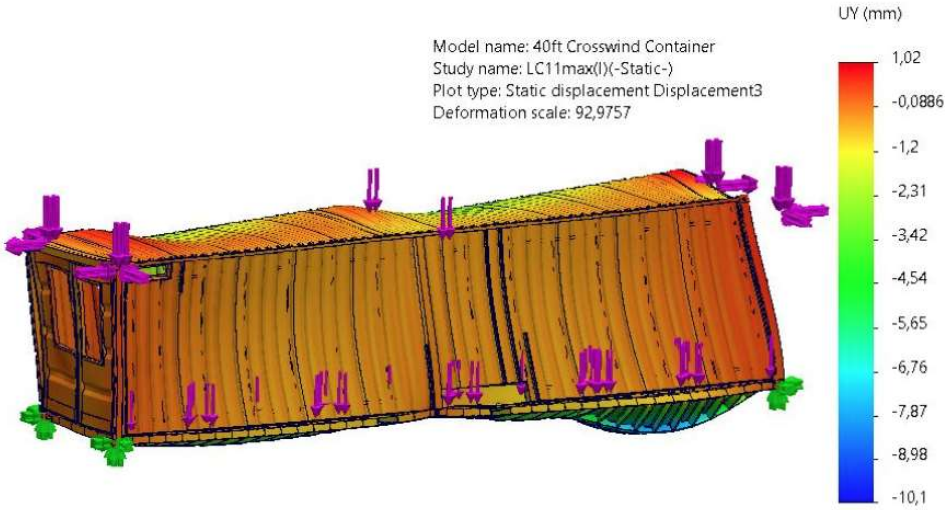


Fig 167: LC11_MAX -Displacement plot-UY

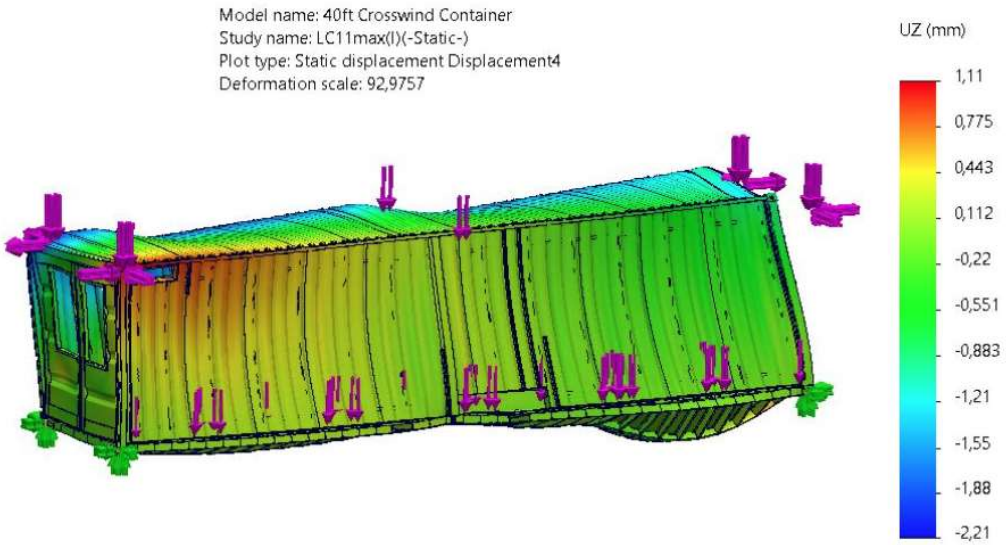


Fig 168: LC11_MAX -Displacement plot-UZ

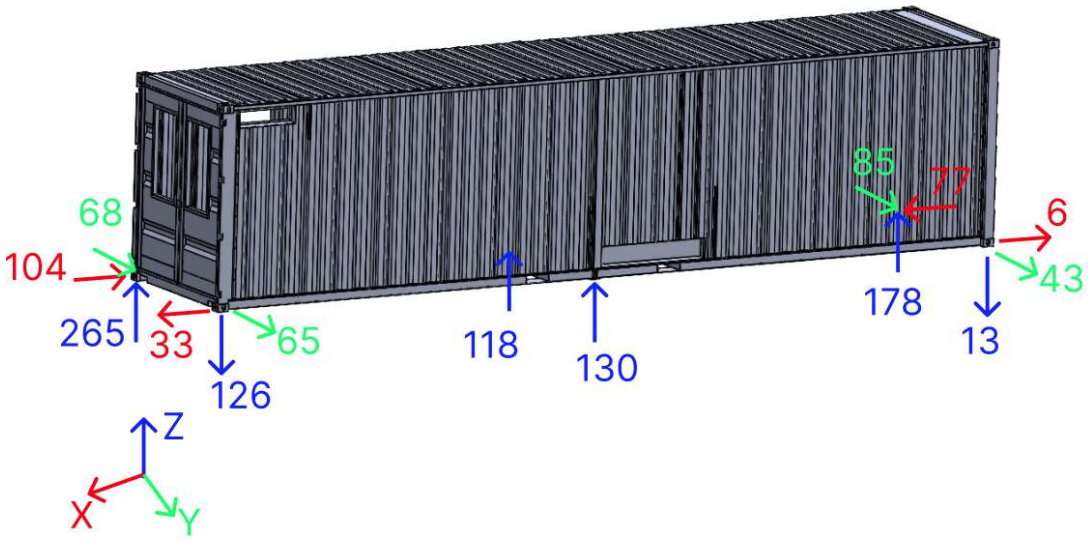
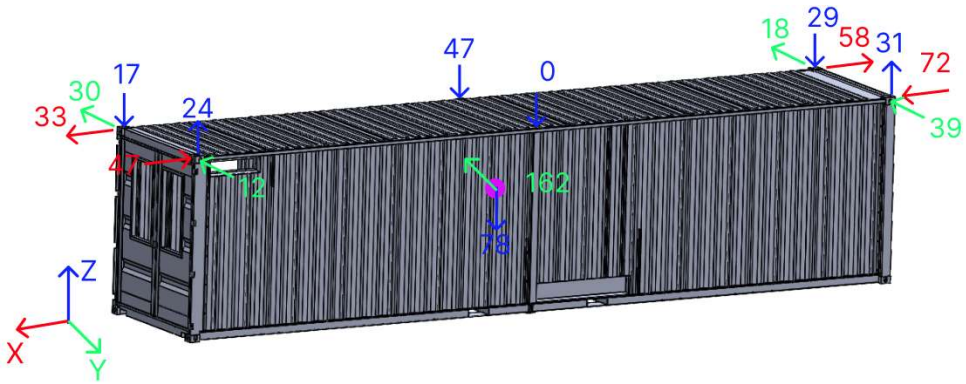


Fig 169: LC11_MAX -Reactions

9.12. LC11-MIN (40ft container + 40ft flatbed)



External Loads
- FeZ (:Per item: 29 000 N:)
- FbZ (:Per item: 24 000 N:)
- FcZ (:Per item: 47 000 N:)
- FfZ (:Per item: -31 000 N:)
- FdZ (:Per item: 100 N:)
- FaZ (:Per item: 17 000 N:)
- FaX (:Per item: -33 000 N:)
- FbX (:Per item: 47 000 N:)
- FeX (:Per item: -58 000 N:)
- FfX (:Per item: 72 000 N:)
- FaY (:Per item: -30 000 N:)
- FbY (:Per item: 12 000 N:)
- FeY (:Per item: -18 000 N:)
- FfY (:Per item: 39 000 N:)
- SW (:Total: 78 000 N:)
- Remote Load (Distributed connection) Y (:-162 000 N:)

Connection Type: Distributed
Weighting Factor: Default (Constant)
Location:
X = 0 mm
Y = 0 mm
Z = 0 mm
Translational Components:
Y = -162 000 N

Fig 170: LC11_MIN – 40ft container – Loads

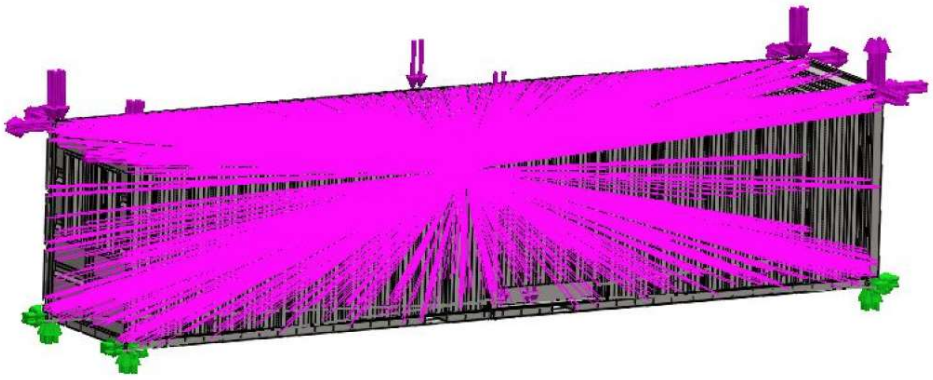


Fig 171: LC11_ MIN -Boundary conditions

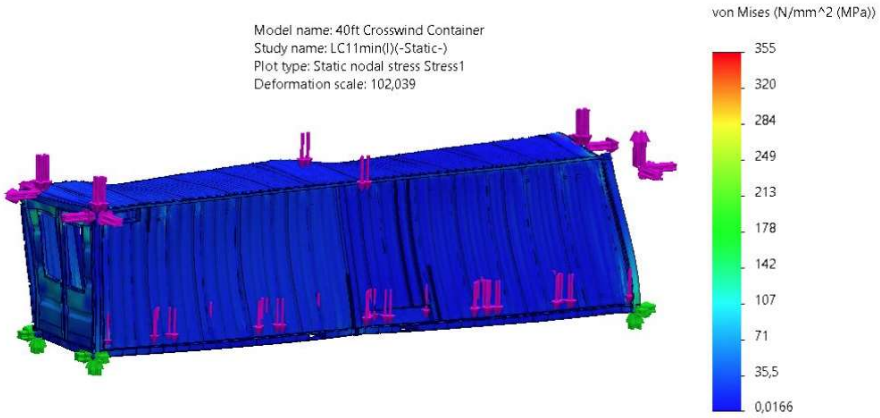


Fig 172: LC11_ MIN -Stress plot

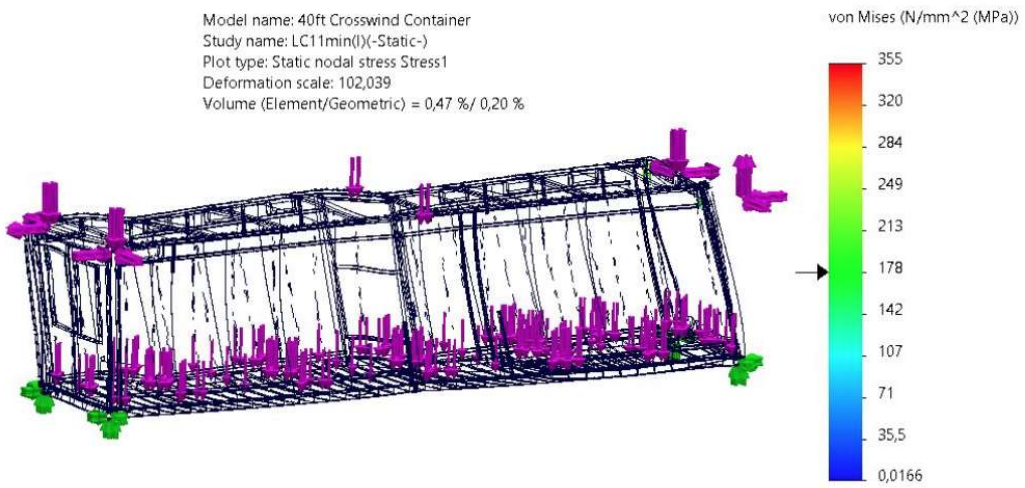


Fig 173: LC11_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

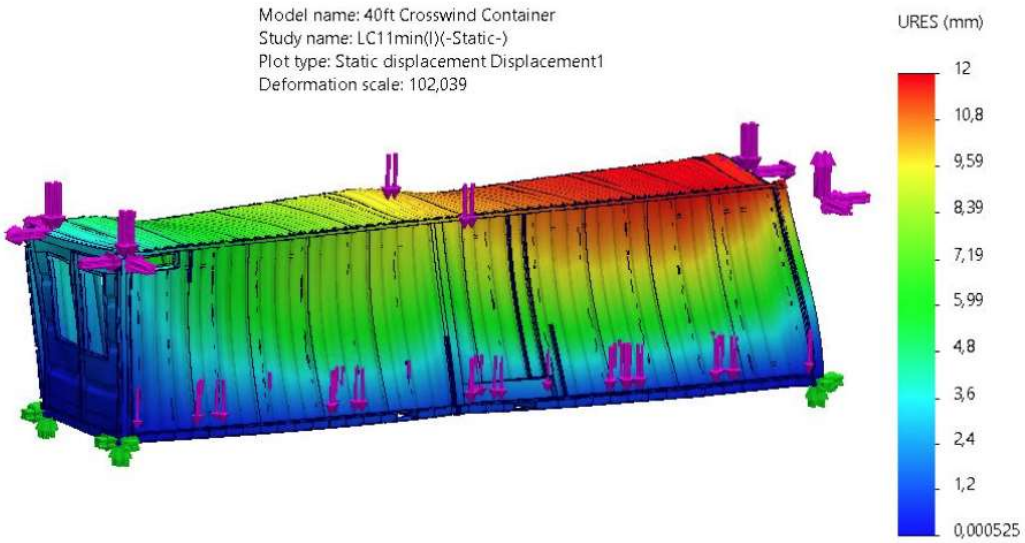


Fig 174: LC11_ MIN -Displacement plot

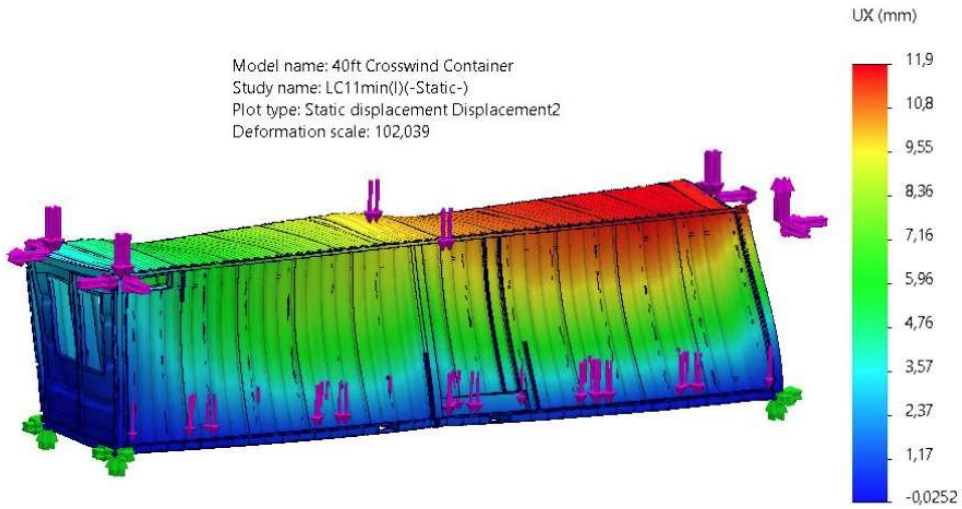


Fig 175: LC11_ MIN -Displacement plot-UX

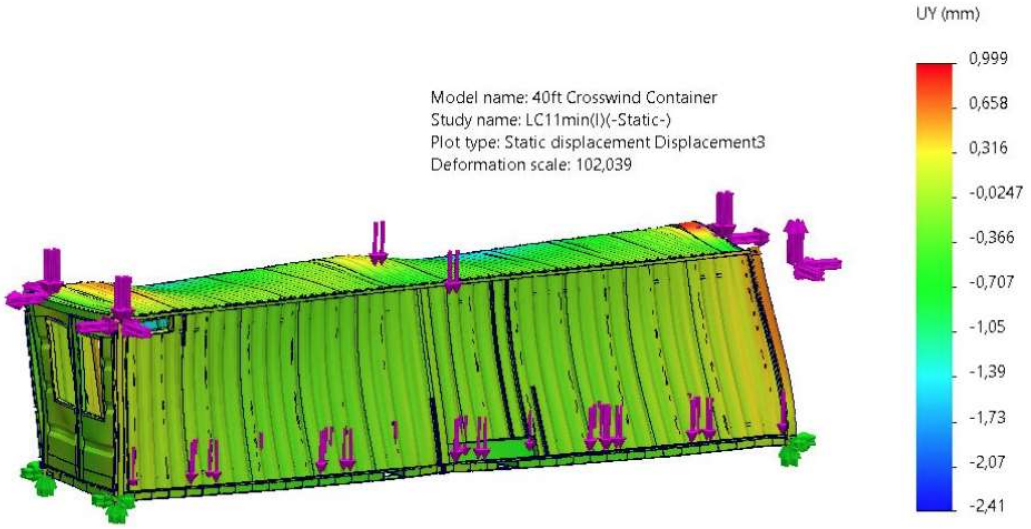


Fig 176: LC11_ MIN -Displacement plot-UY

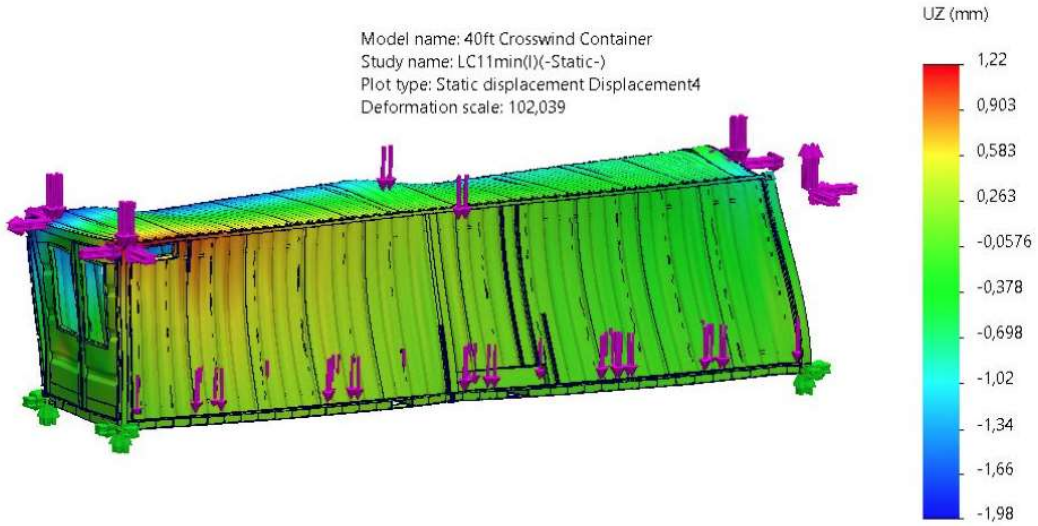


Fig 177: LC11_ MIN -Displacement plot-UZ

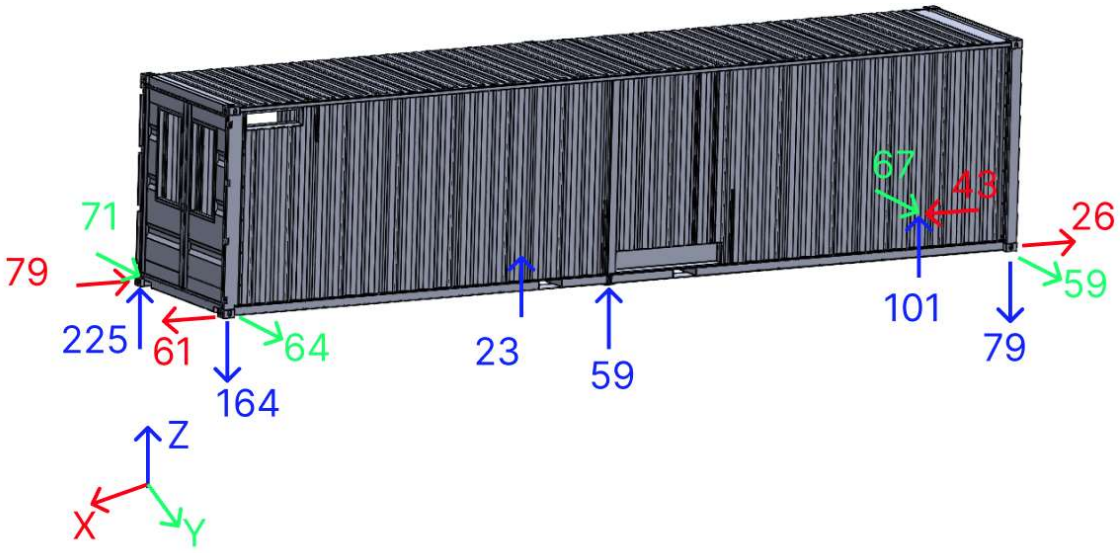


Fig 178: LC11_ MIN -Reactions

9.13. LC12-MAX (40ft container + 40ft flatbed)

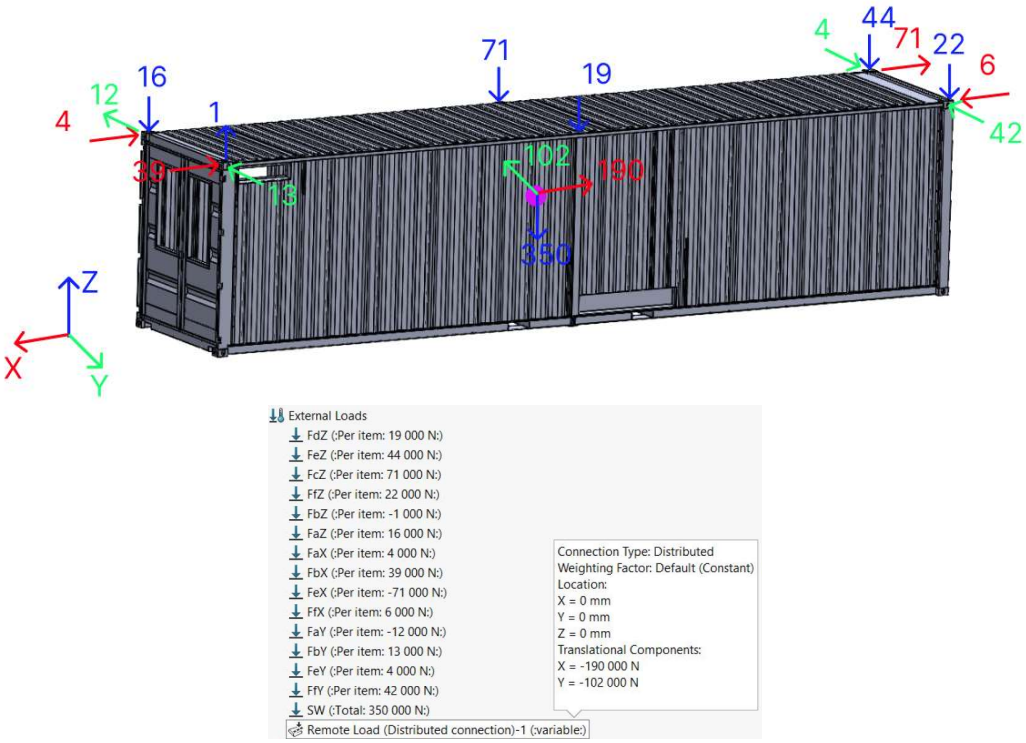


Fig 179: LC12_MAX – 40ft container – Loads

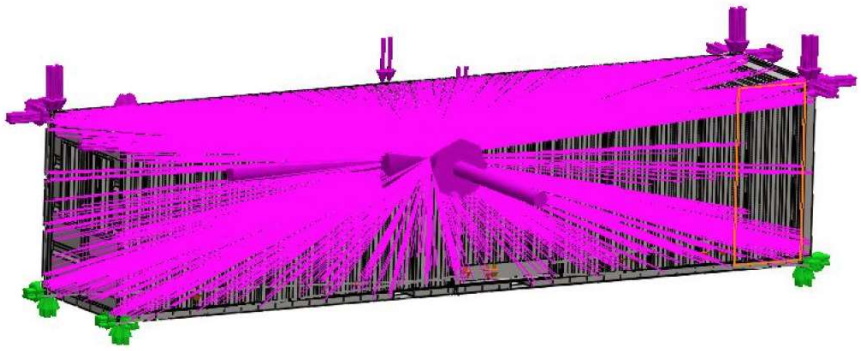


Fig 180: LC12_MAX -Boundary conditions

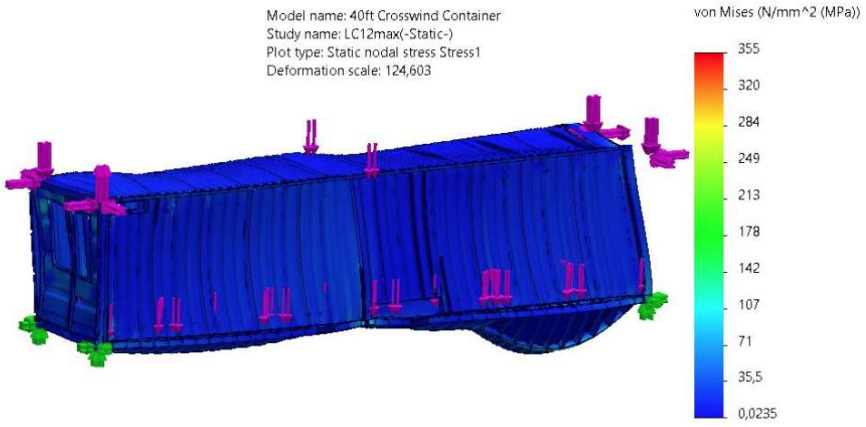


Fig 181: LC12_MAX -Stress plot

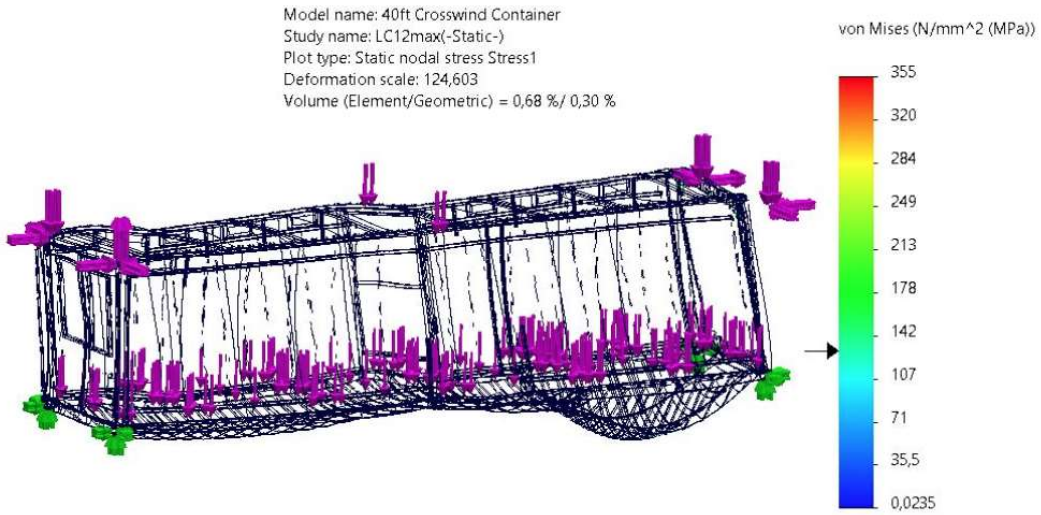


Fig 182: LC12_MAX -Stress plot (the biggest stress in 0,5% of element volume)

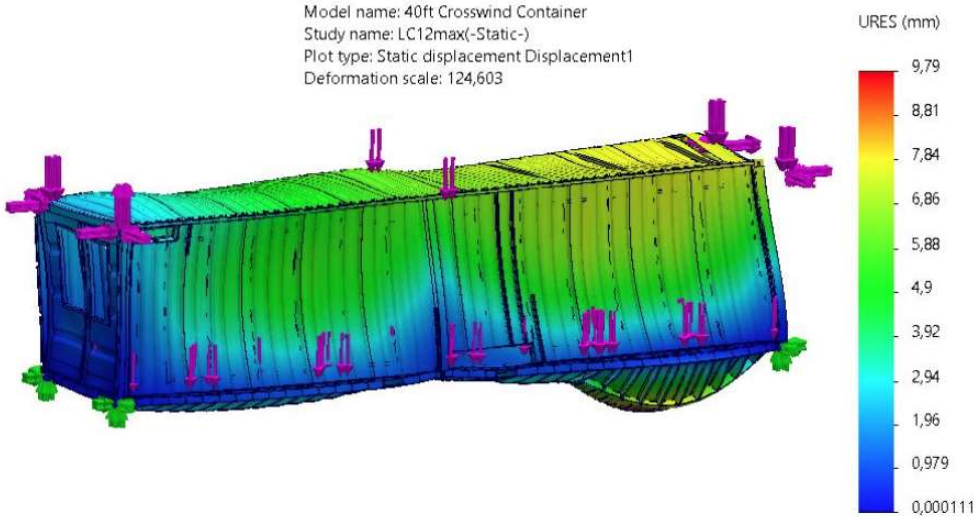


Fig 183: LC12_MAX -Displacement plot

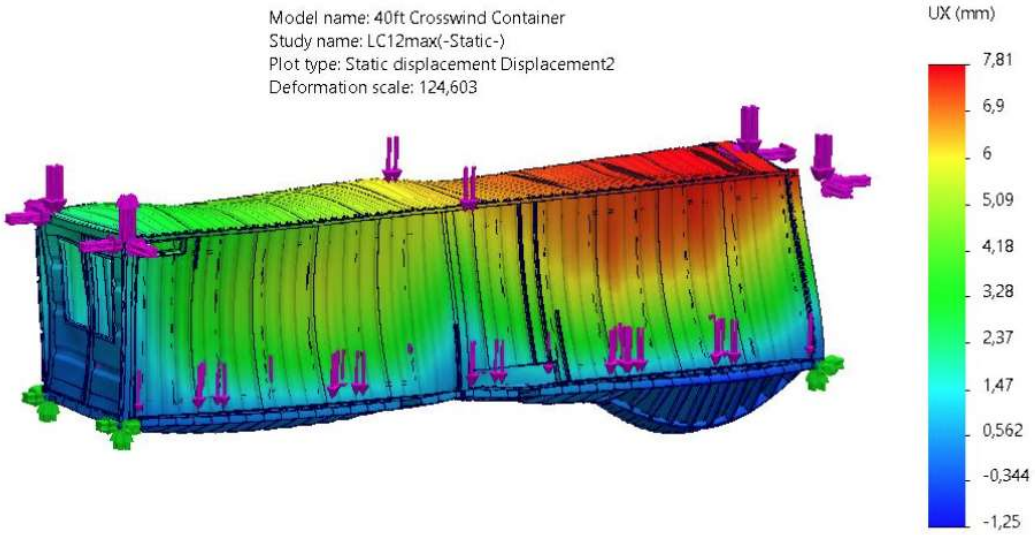


Fig 184: LC12_MAX -Displacement plot-UX

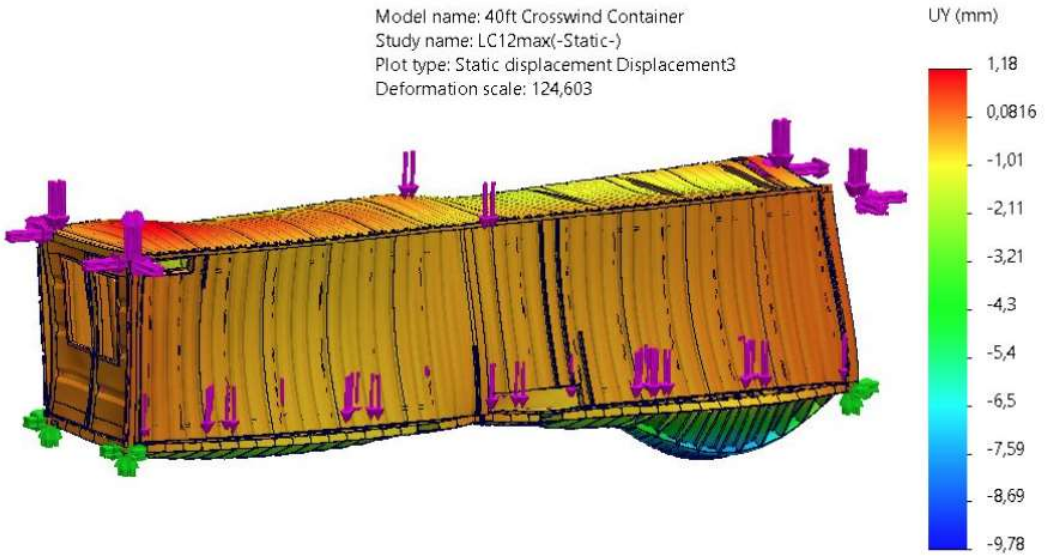


Fig 185: LC12_MAX -Displacement plot-UY

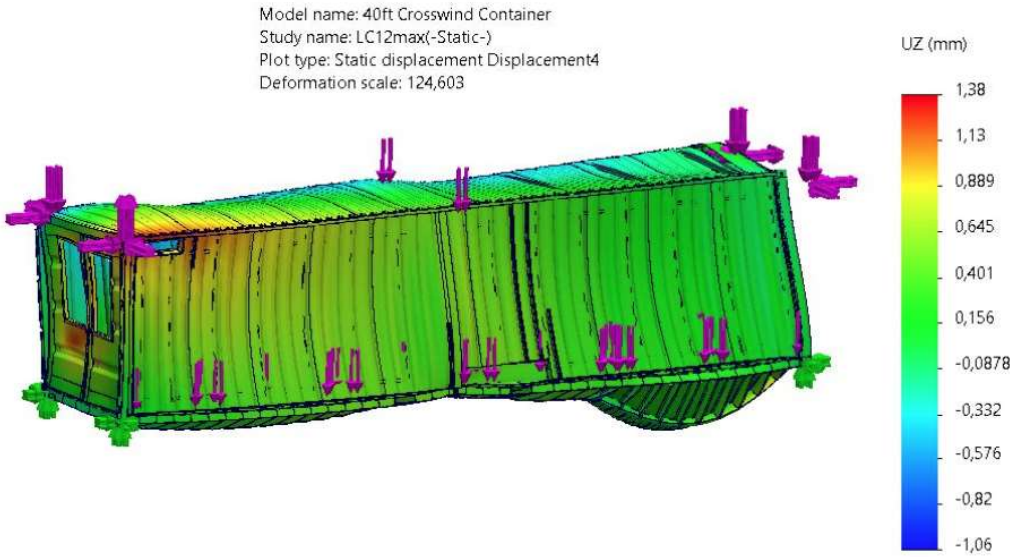


Fig 186: LC12_MAX -Displacement plot-UZ

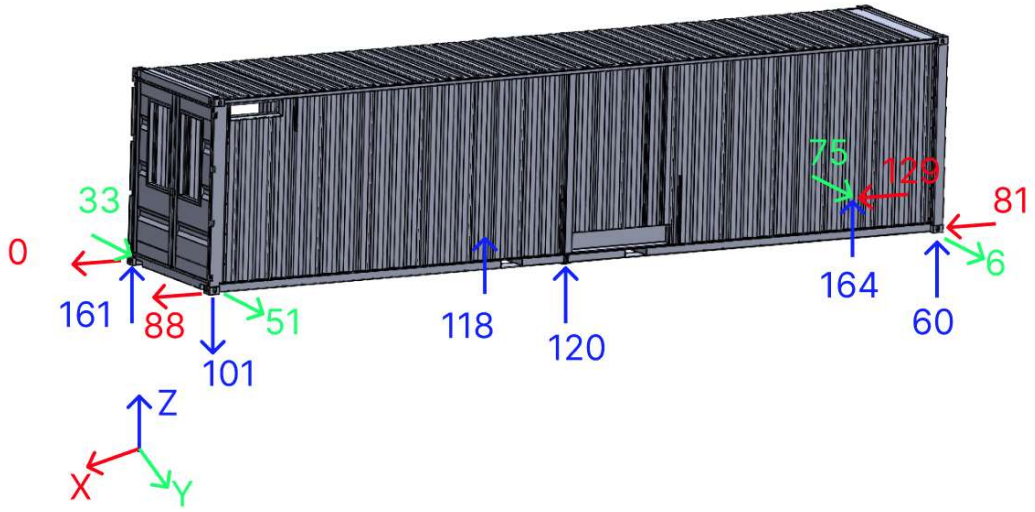
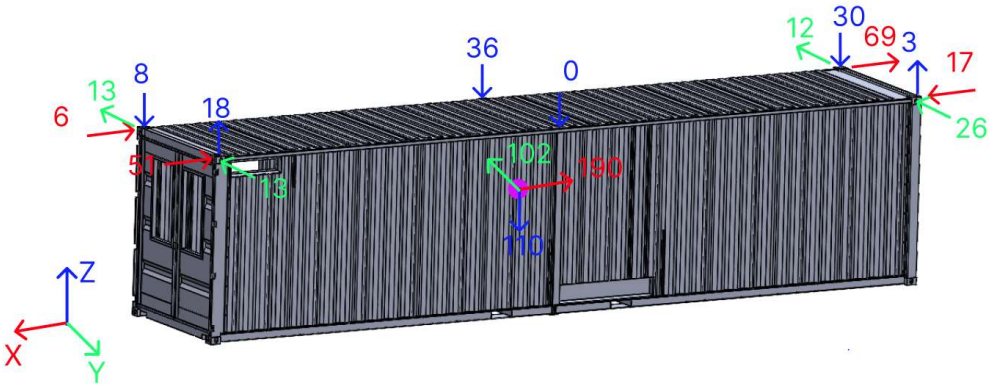


Fig 187: LC12_MAX -Reactions

9.14. LC12-MIN (40ft container + 40ft flatbed)



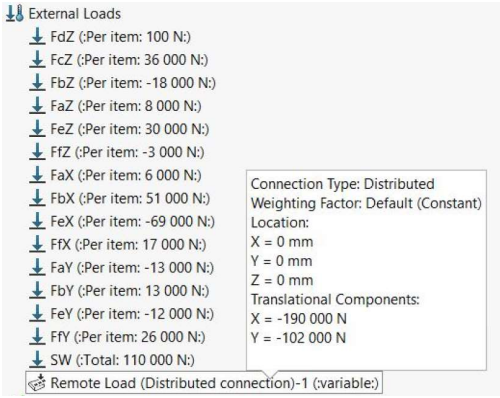


Fig 188: LC12_MIN – 40ft container – Loads

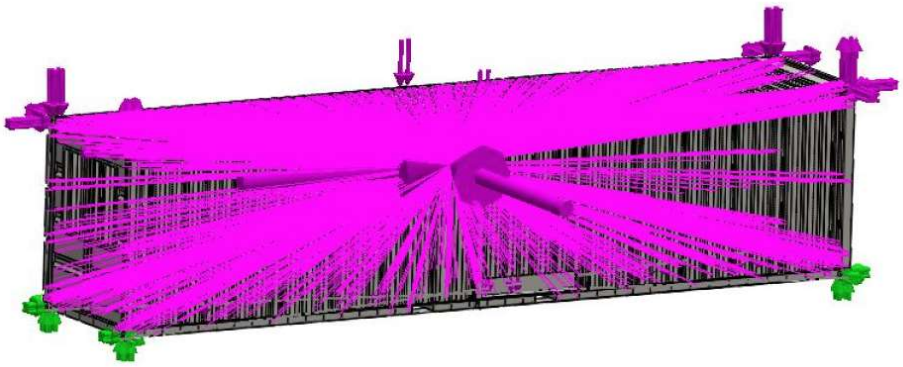


Fig 189: LC12_ MIN -Boundary conditions

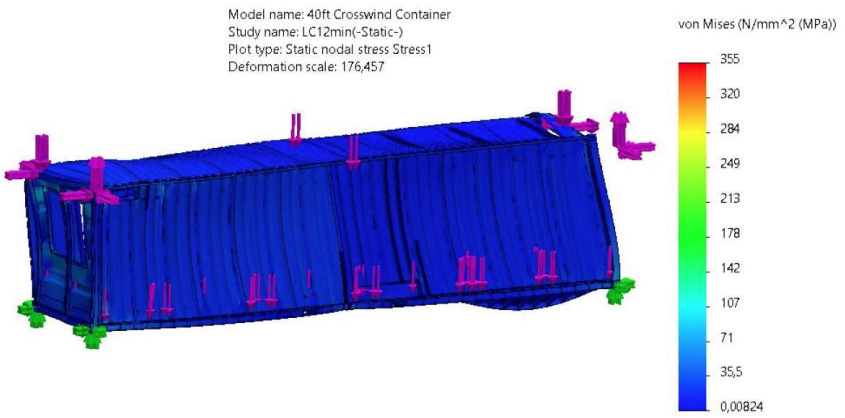


Fig 190: LC12_ MIN -Stress plot

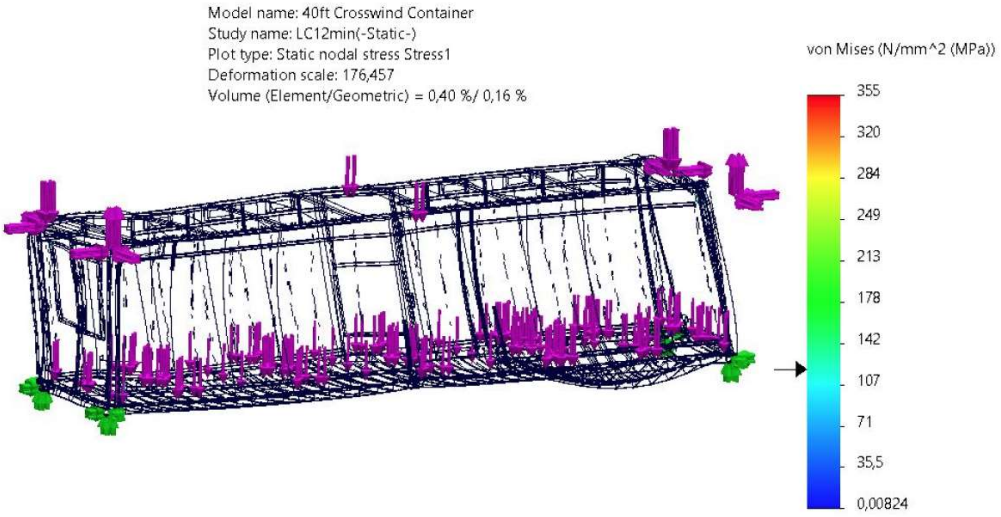


Fig 191: LC12_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

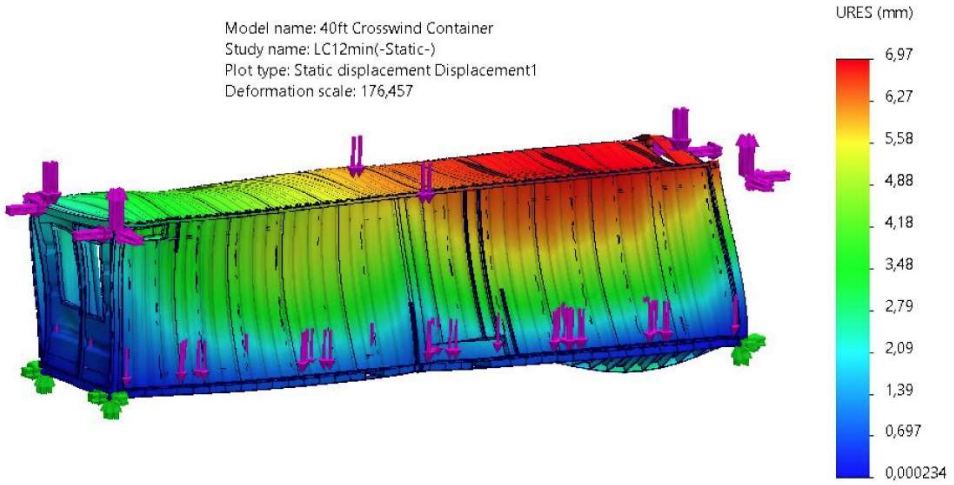


Fig 192: LC12_ MIN -Displacement plot

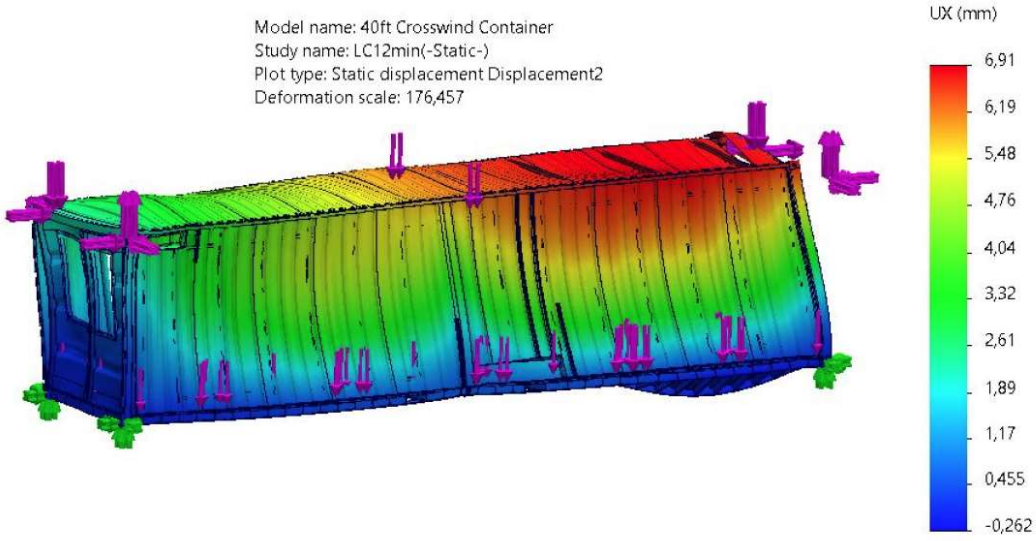


Fig 193: LC12_ MIN -Displacement plot-UX

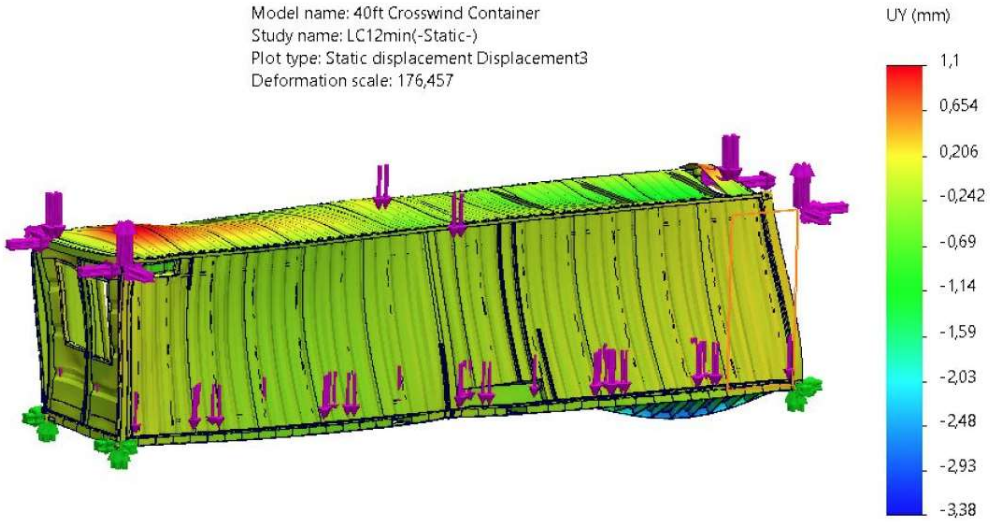


Fig 194: LC12_ MIN -Displacement plot-UY

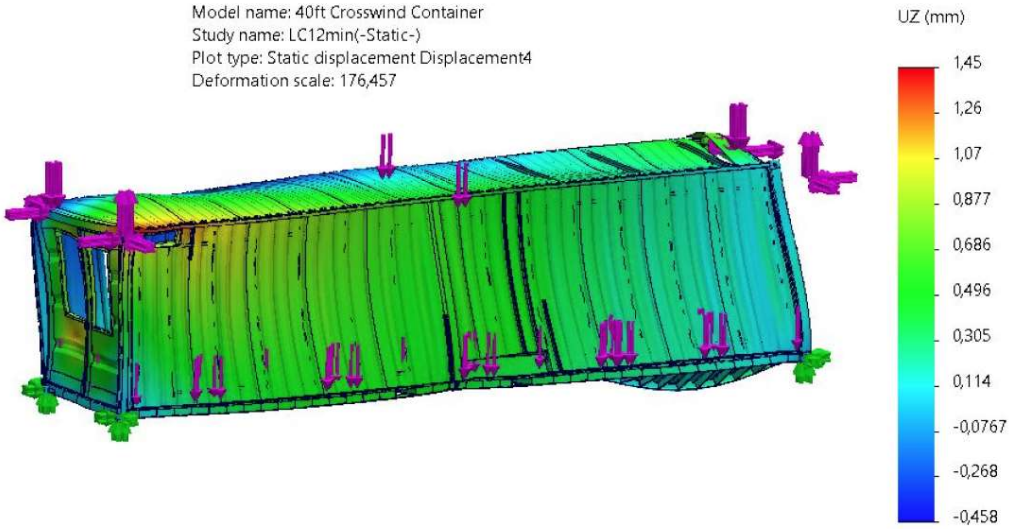


Fig 195: LC12_ MIN -Displacement plot-UZ

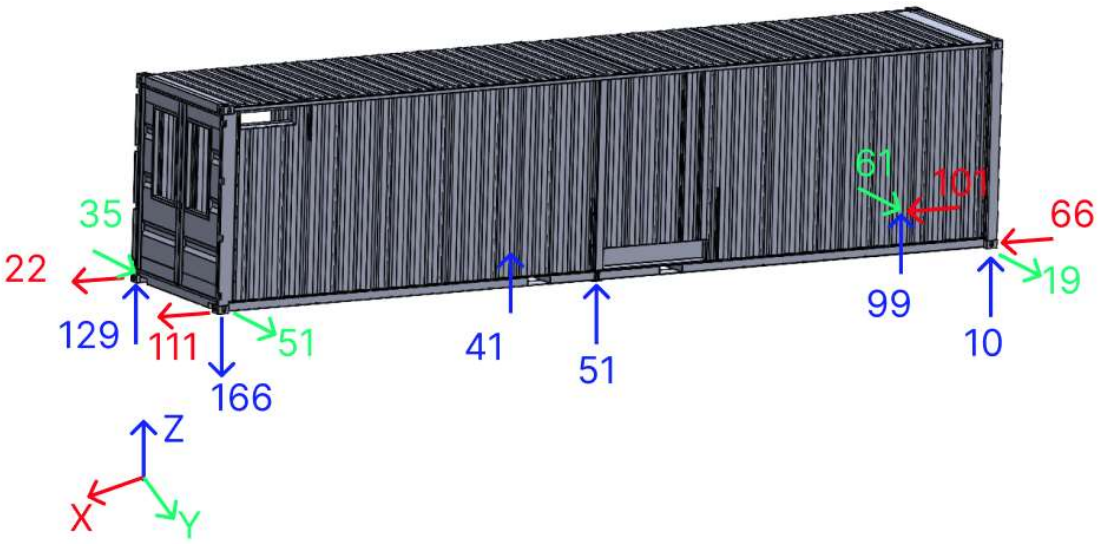
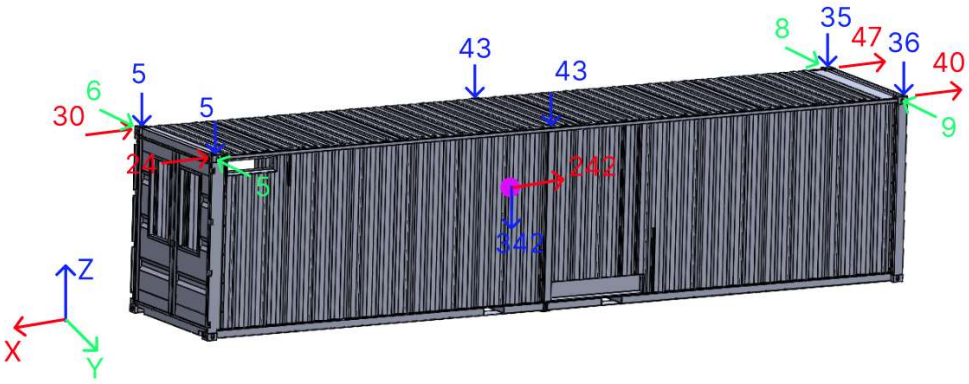


Fig 196: LC12_MIN -Reactions

9.15. LC13-MAX (40ft container + 40ft flatbed)



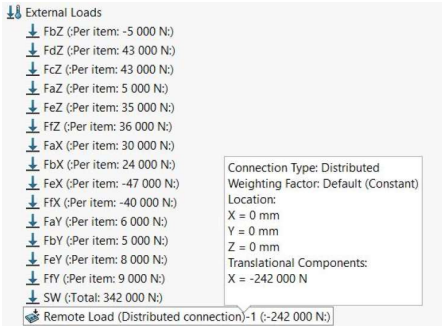


Fig 197: LC13_MAX – 40ft container – Loads

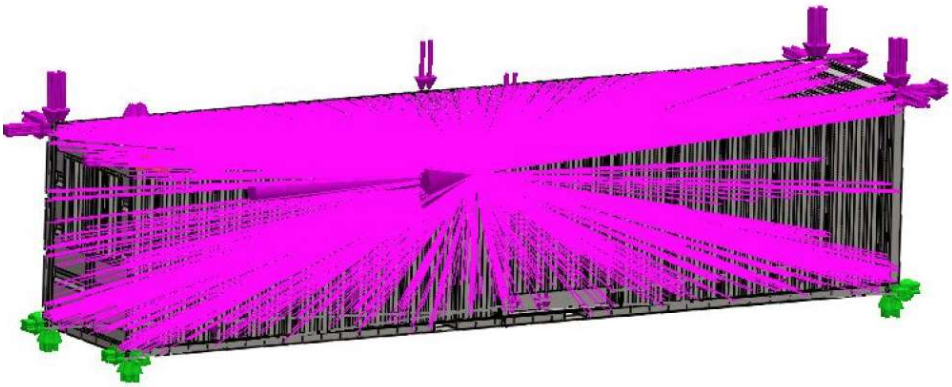


Fig 198: LC13_MAX -Boundary conditions

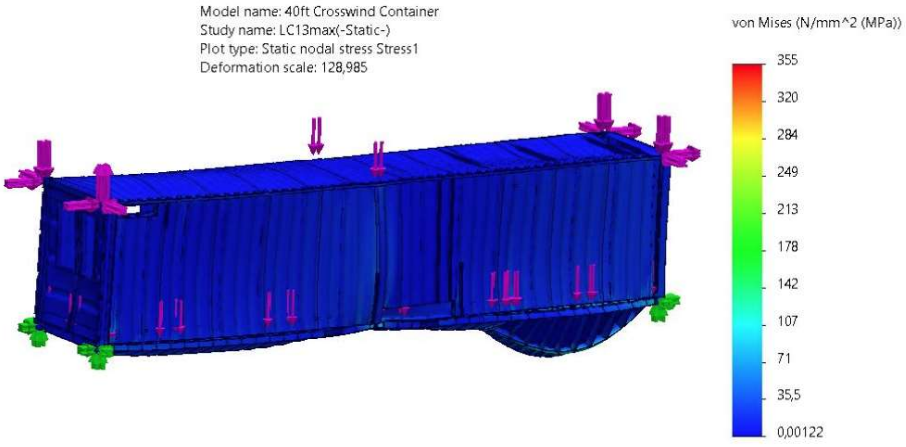


Fig 199: LC13_MAX -Stress plot

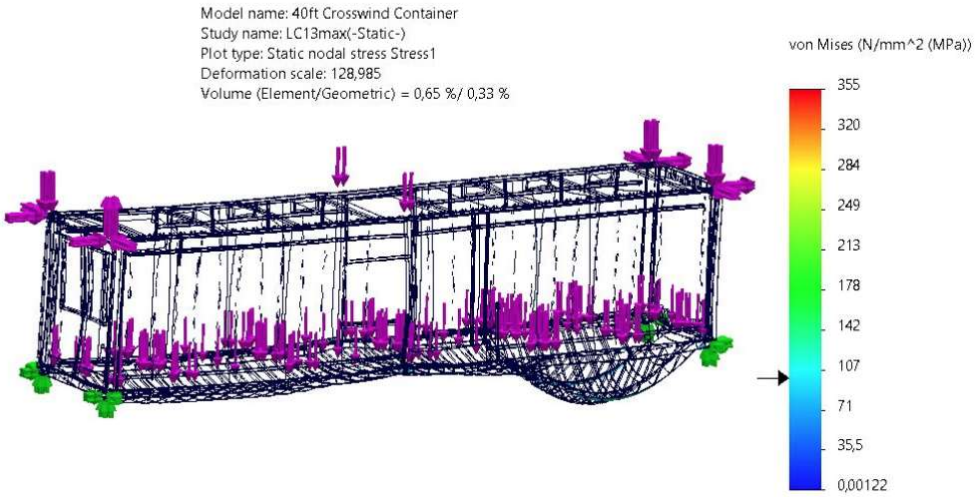


Fig 200: LC13_MAX -Stress plot (the biggest stress in 0,5% of element volume)

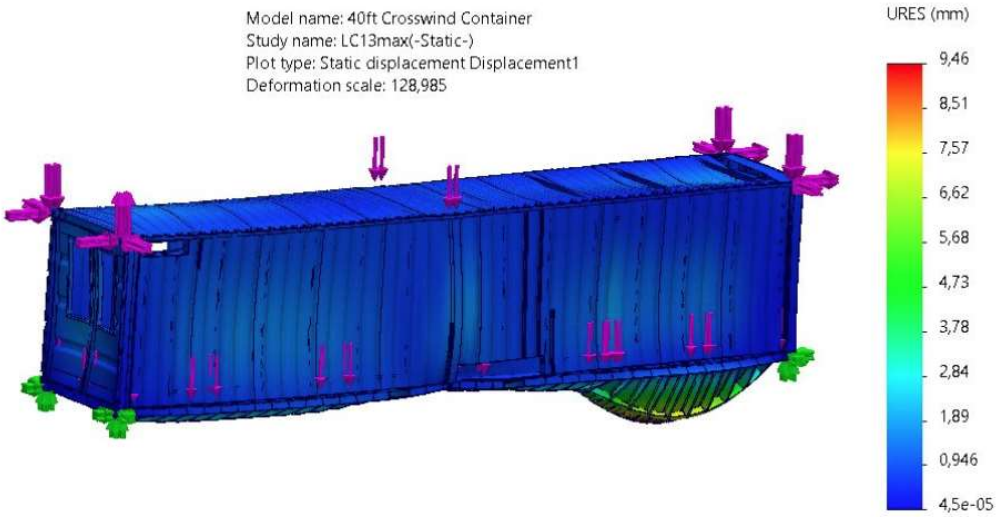


Fig 201: LC13_MAX -Displacement plot

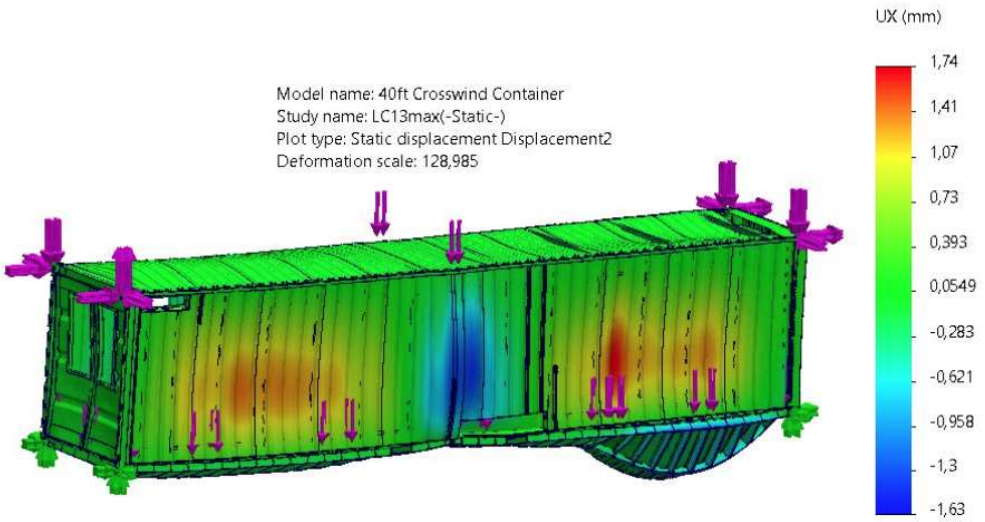


Fig 202: LC13_MAX -Displacement plot-UX

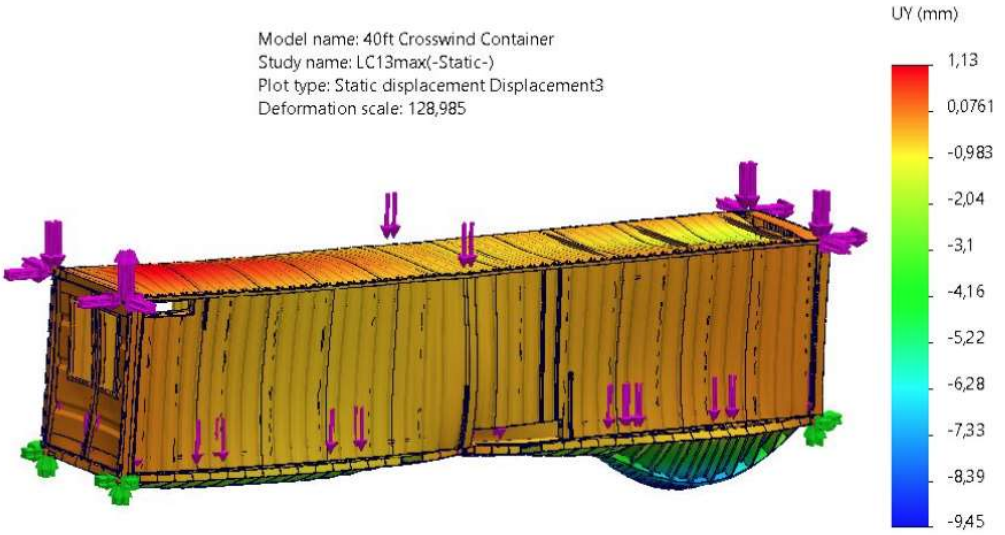


Fig 203: LC13_MAX -Displacement plot-UY

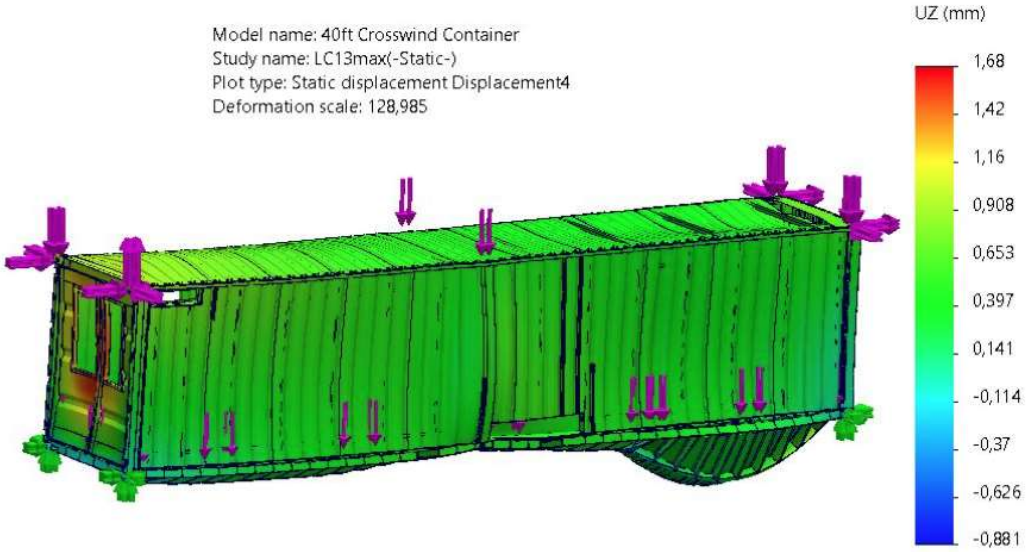


Fig 204: LC13_MAX -Displacement plot-UZ

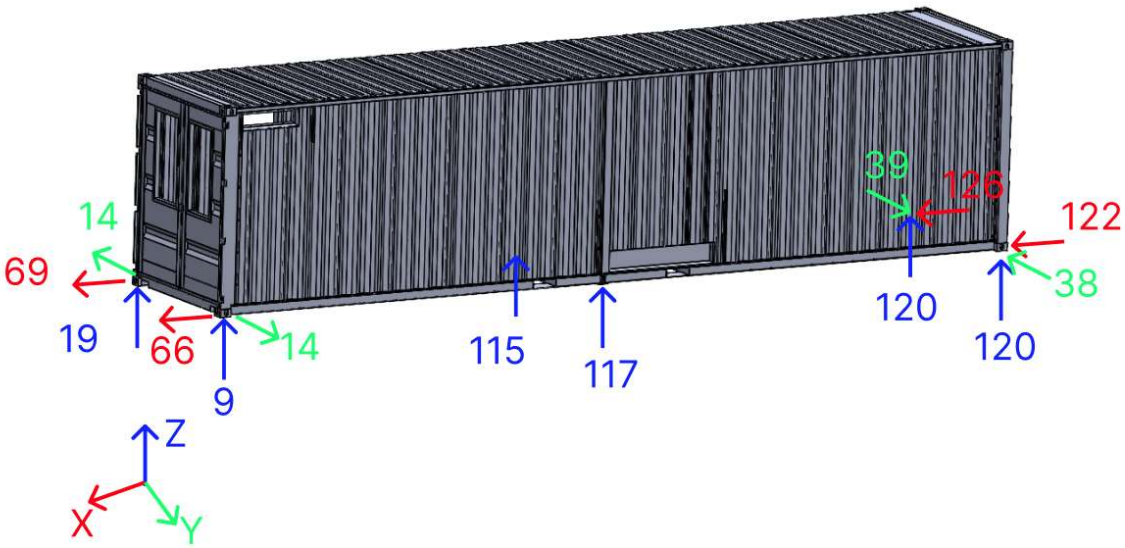
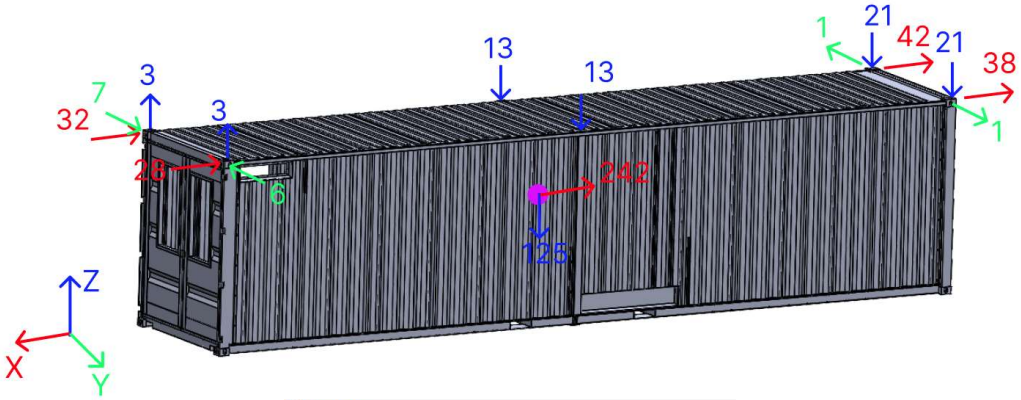


Fig 205: LC13_MAX -Reactions

9.16. LC13-MIN (40ft container + 40ft flatbed)



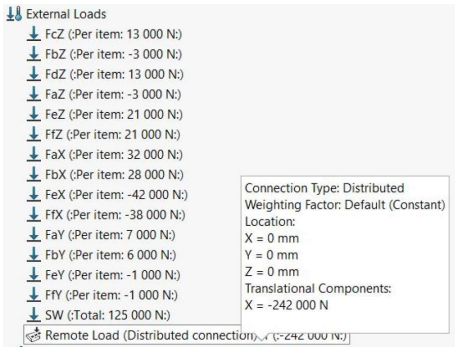


Fig 206: LC13_MIN – 40ft container – Loads

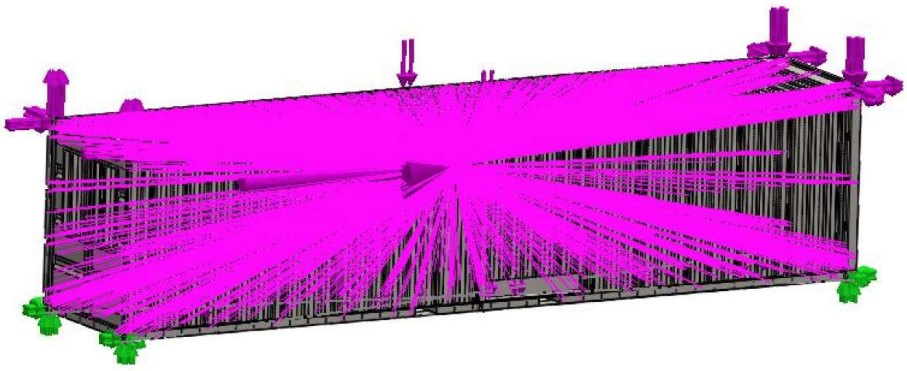


Fig 207: LC13_ MIN -Boundary conditions

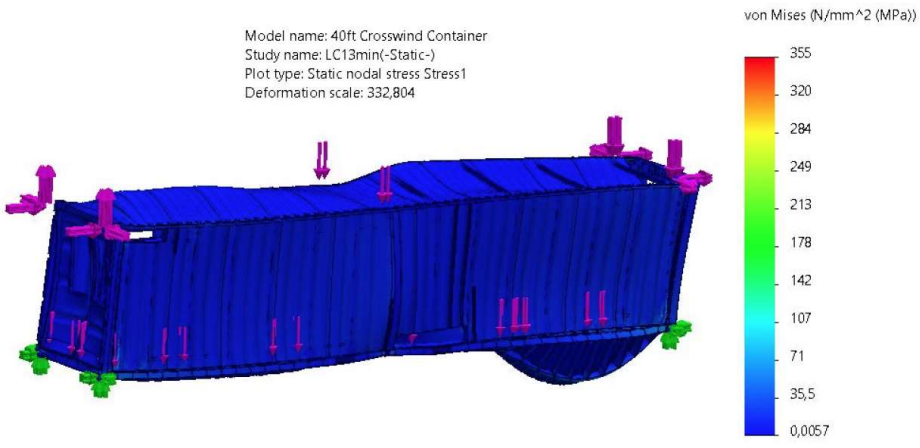


Fig 208: LC13_ MIN -Stress plot

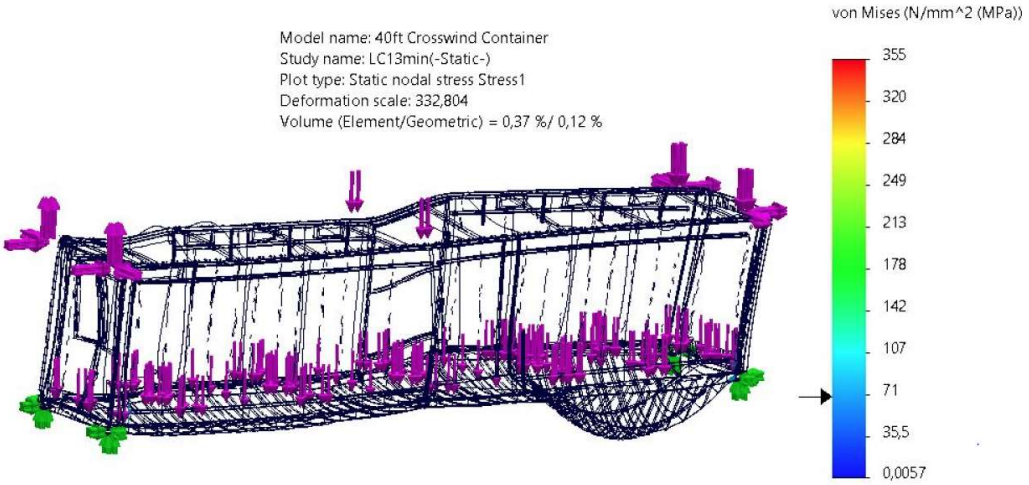


Fig 209: LC13_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

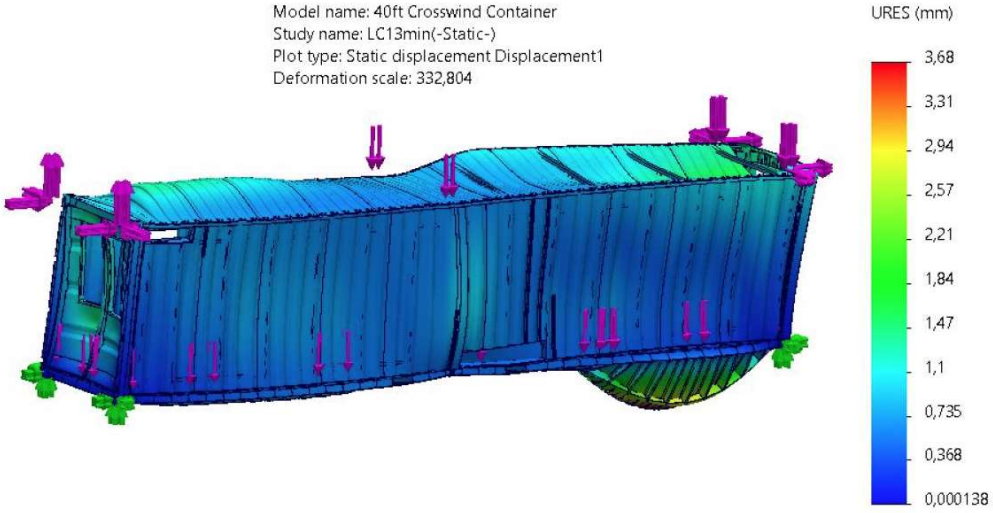


Fig 210: LC13_ MIN -Displacement plot

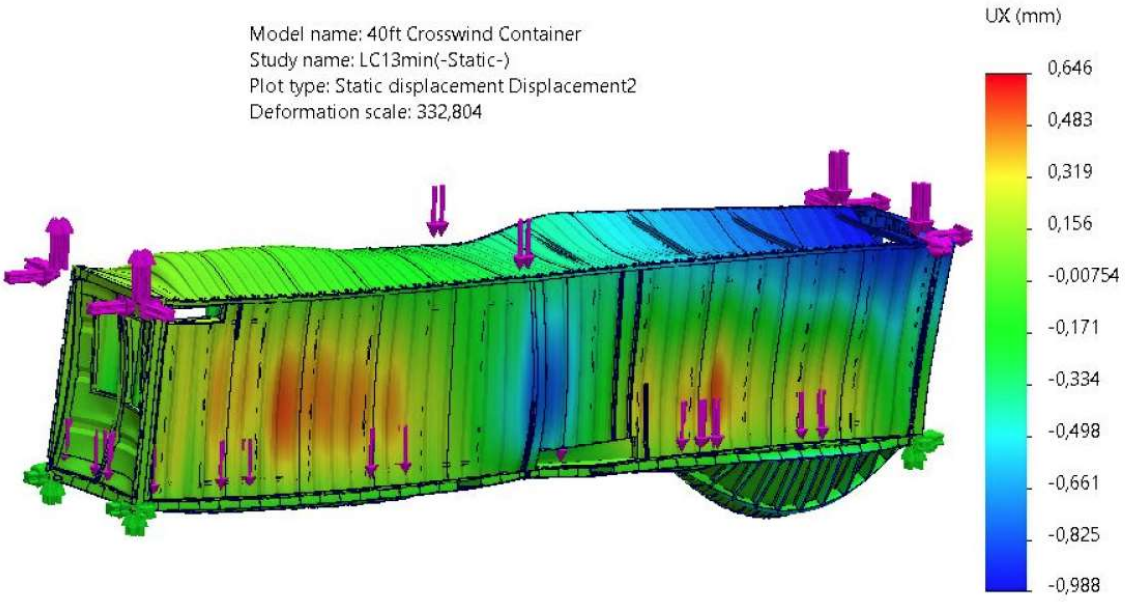


Fig 211: LC13_ MIN -Displacement plot-UX

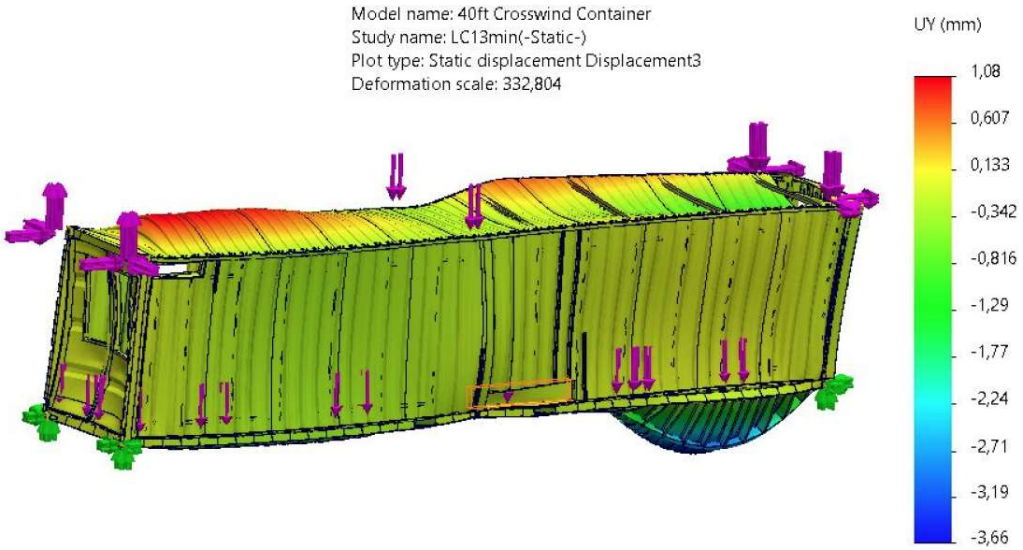


Fig 212: LC13_ MIN -Displacement plot-UY

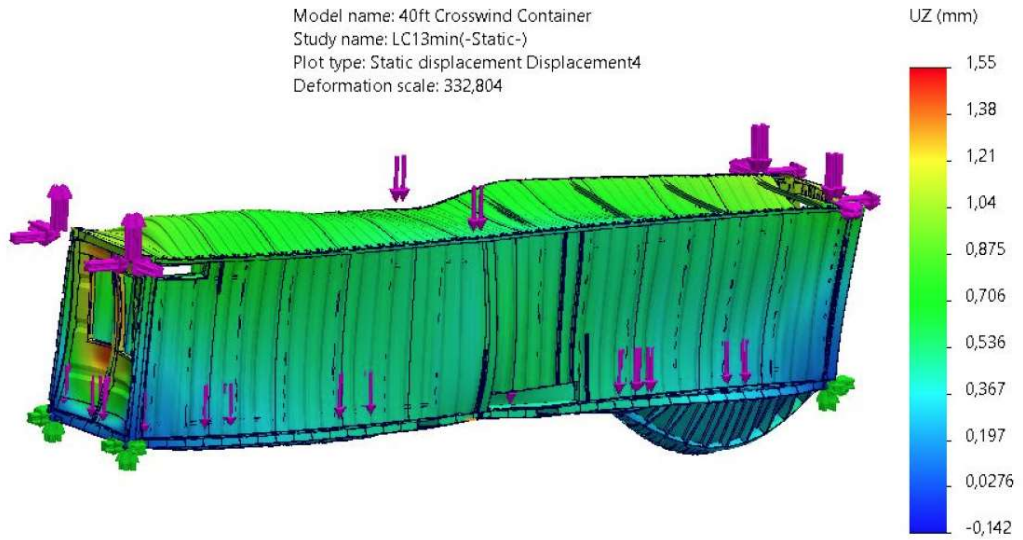


Fig 213: LC13_ MIN -Displacement plot-UZ

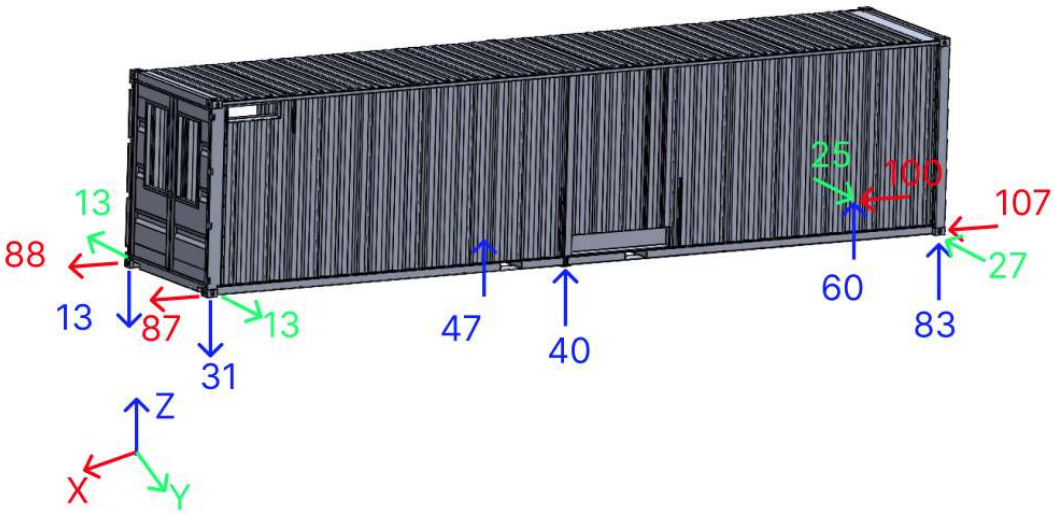
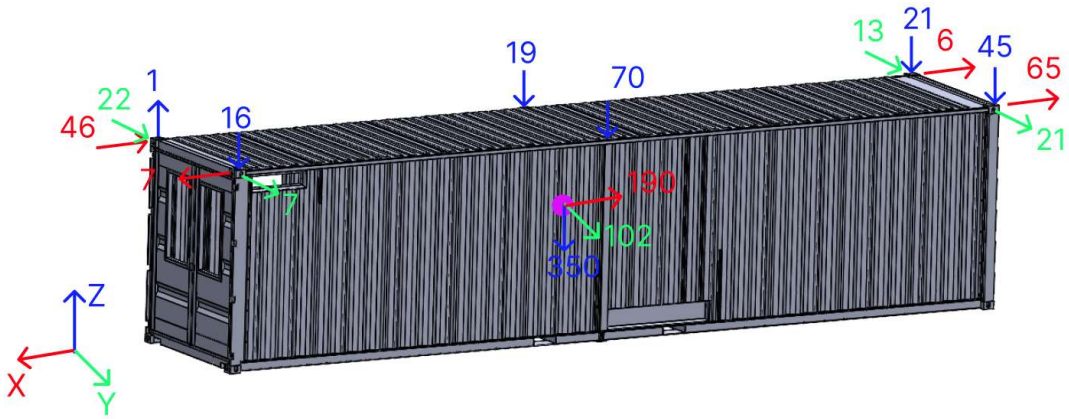


Fig 214: LC13_MIN -Reactions

9.17. LC14-MAX (40ft container + 40ft flatbed)



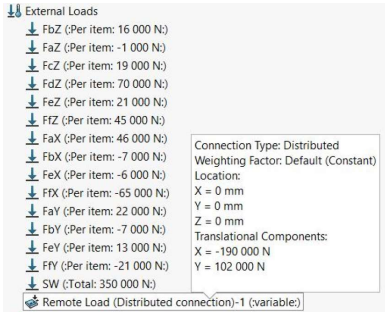


Fig 215: LC14_MAX – 40ft container – Loads

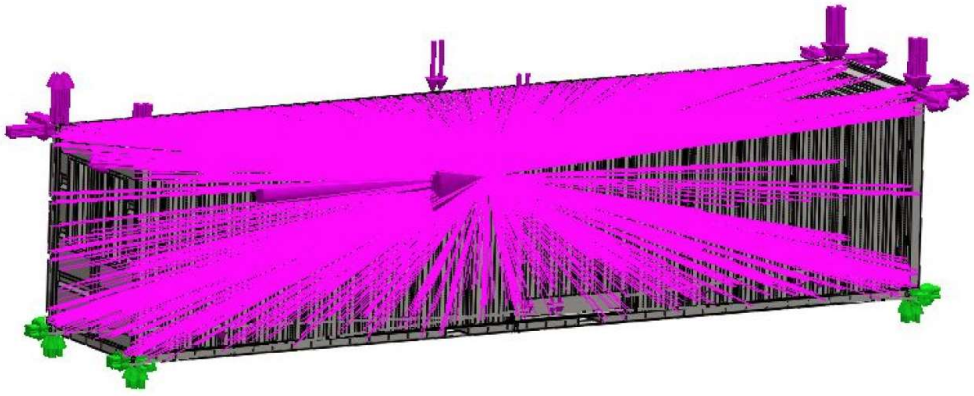


Fig 216: LC14_MAX -Boundary conditions

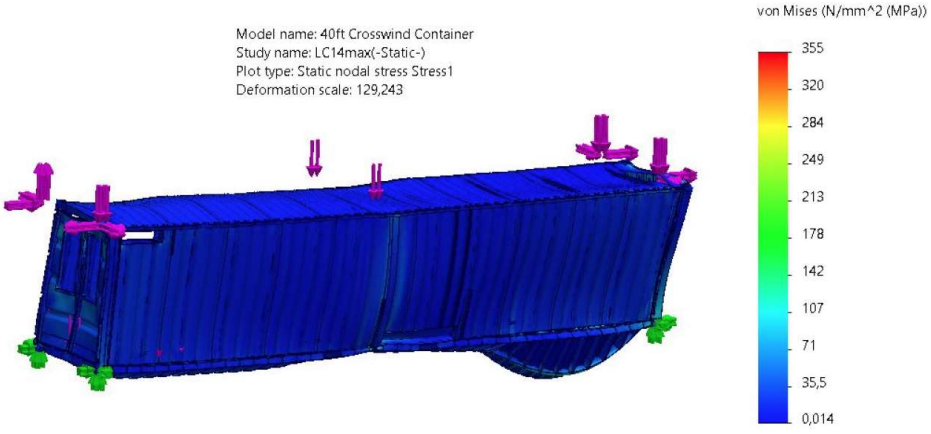


Fig 217: LC14_MAX -Stress plot

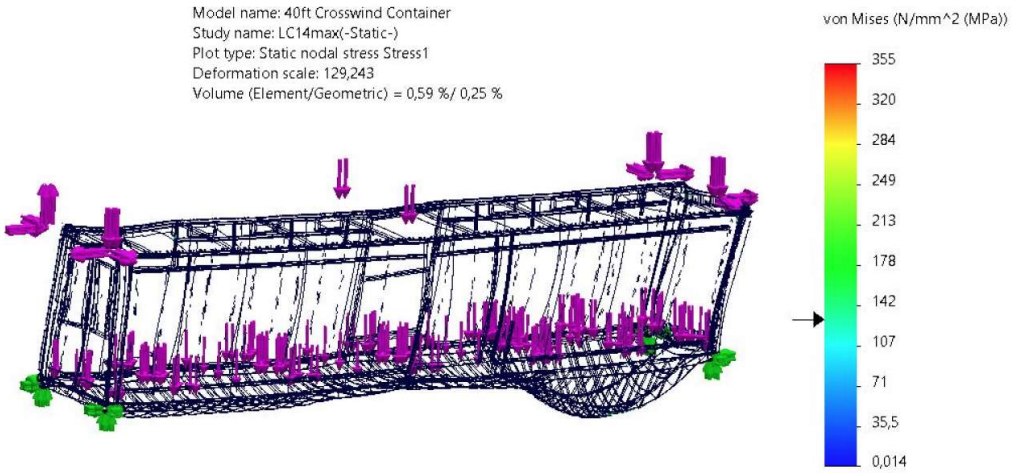


Fig 218: LC14_MAX -Stress plot (the biggest stress in 0,5% of element volume)

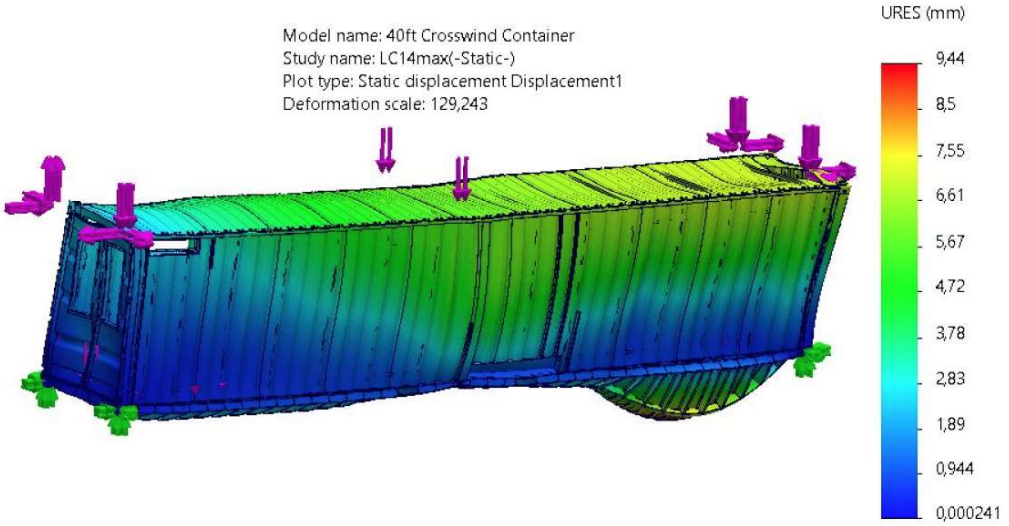


Fig 219: LC14_MAX -Displacement plot

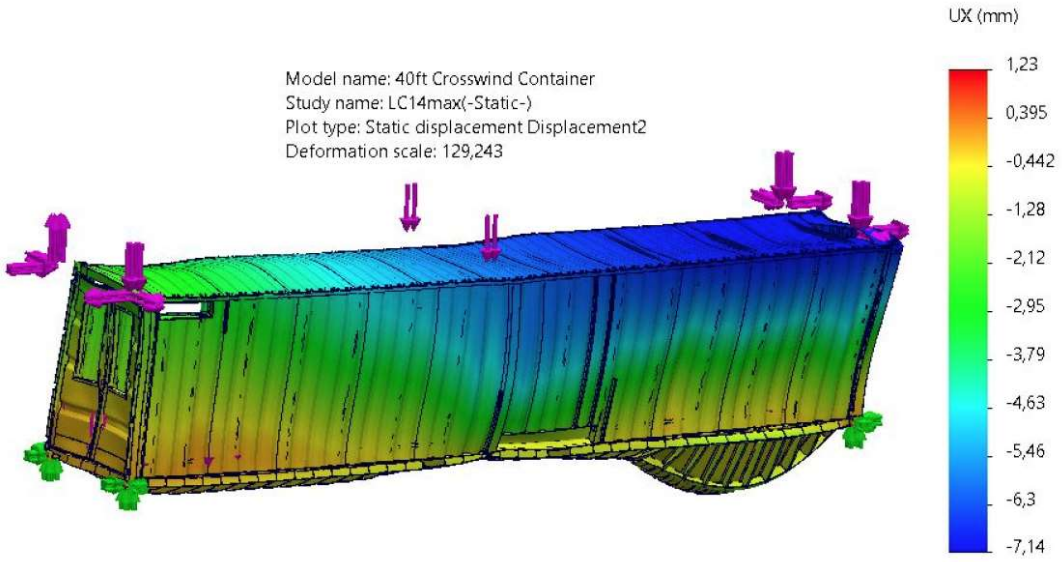


Fig 220: LC14_MAX -Displacement plot-UX

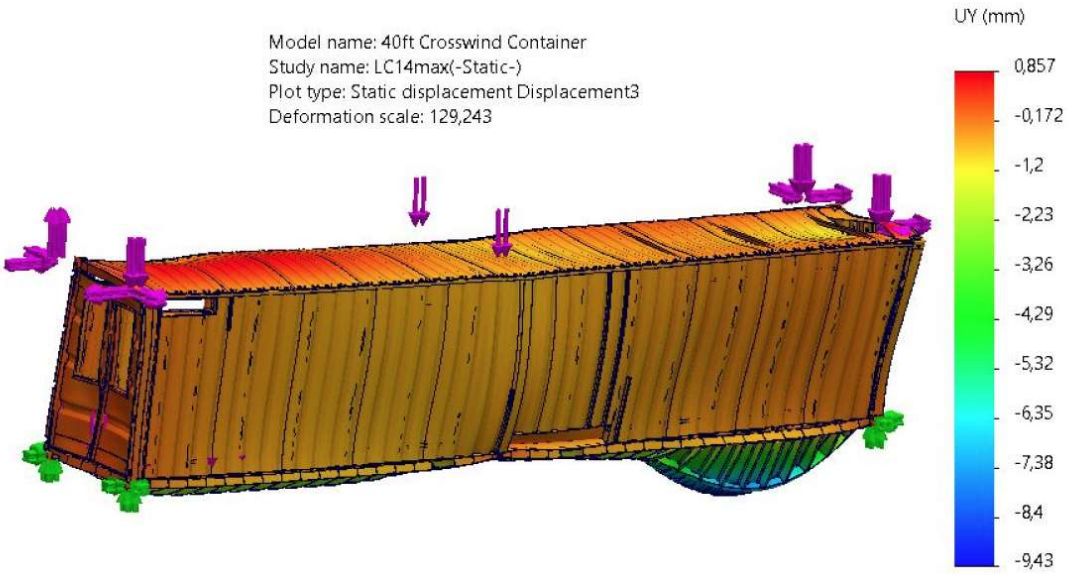


Fig 221: LC14_MAX -Displacement plot-UY

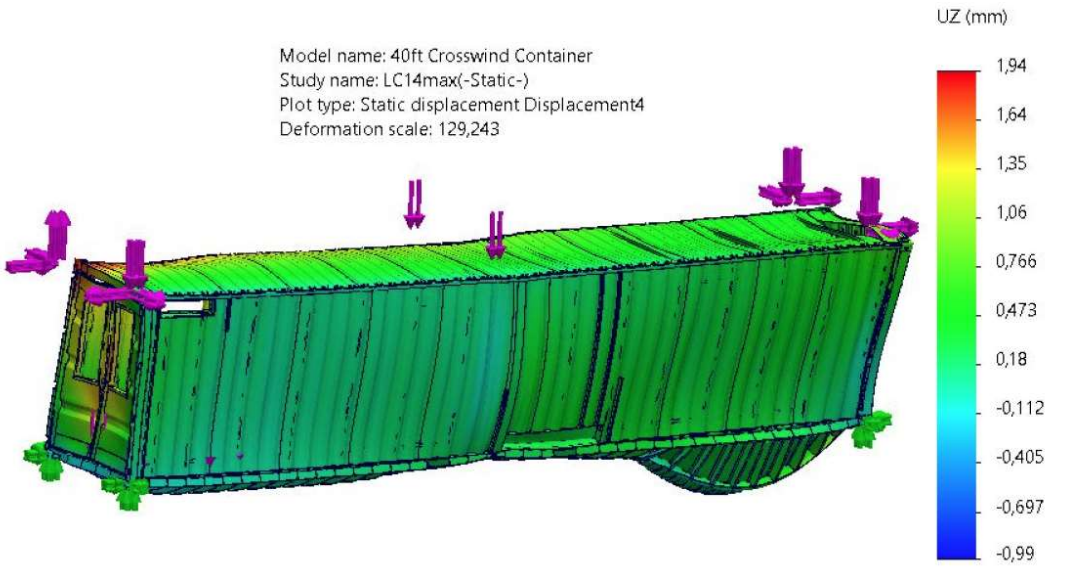


Fig 222: LC14_MAX -Displacement plot-UZ

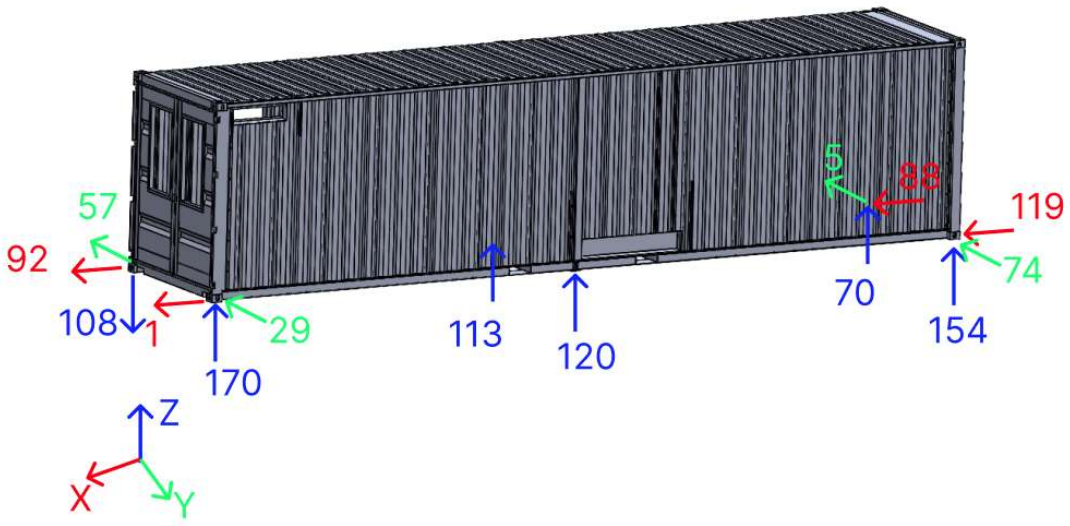
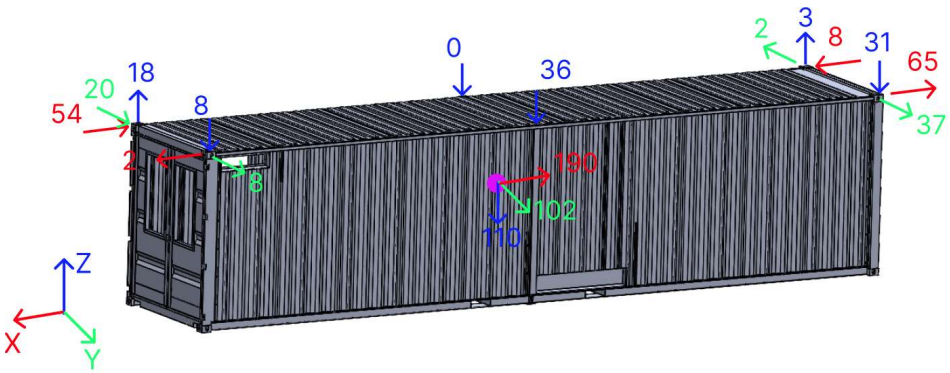


Fig 223: LC14_MAX -Reactions

9.18. LC14-MIN (40ft container + 40ft flatbed)



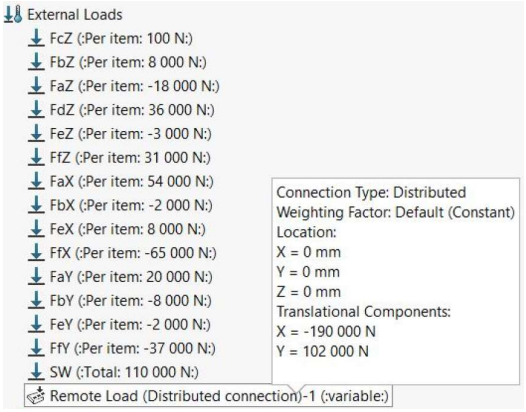


Fig 224: LC14_MIN – 40ft container – Loads

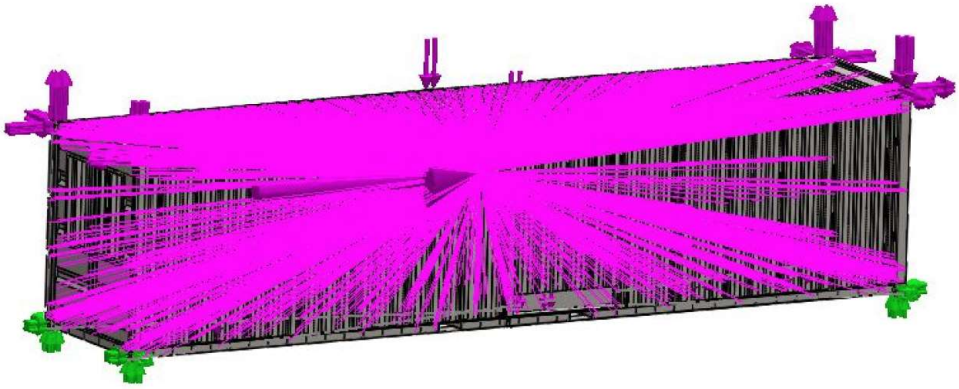


Fig 225: LC14_ MIN -Boundary conditions

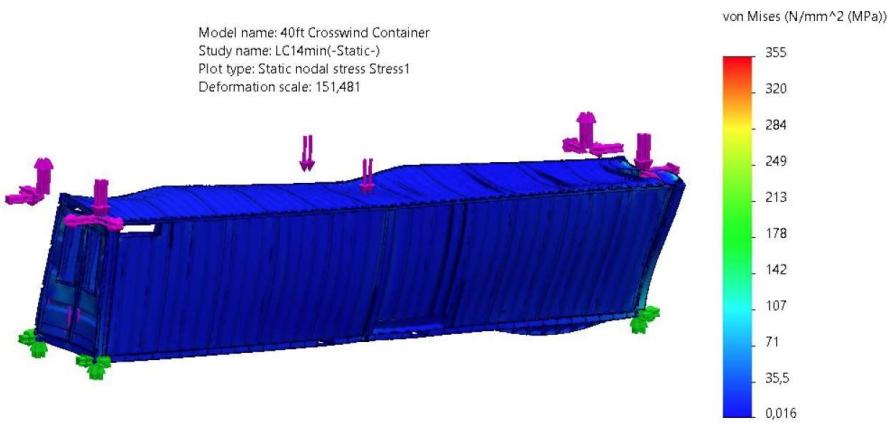


Fig 226: LC14_ MIN -Stress plot

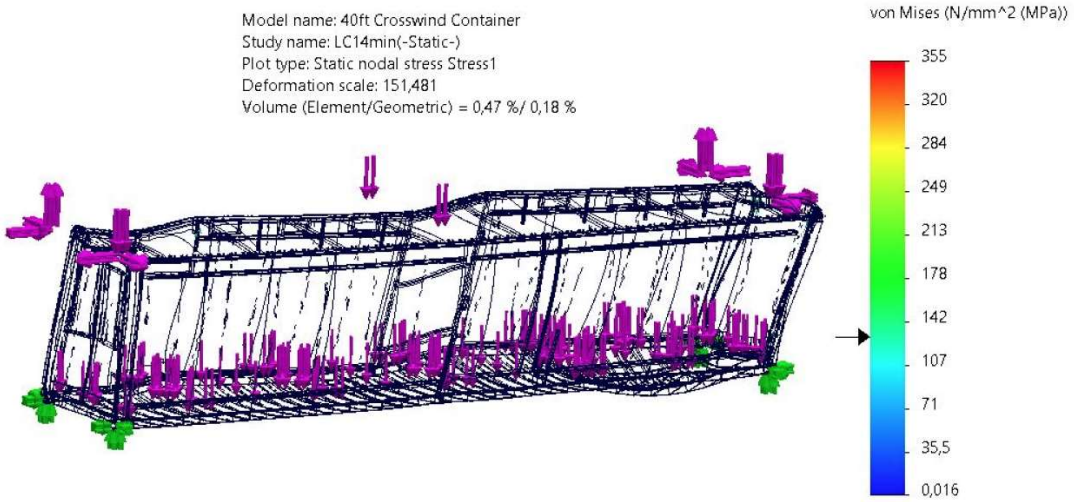


Fig 227: LC14_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

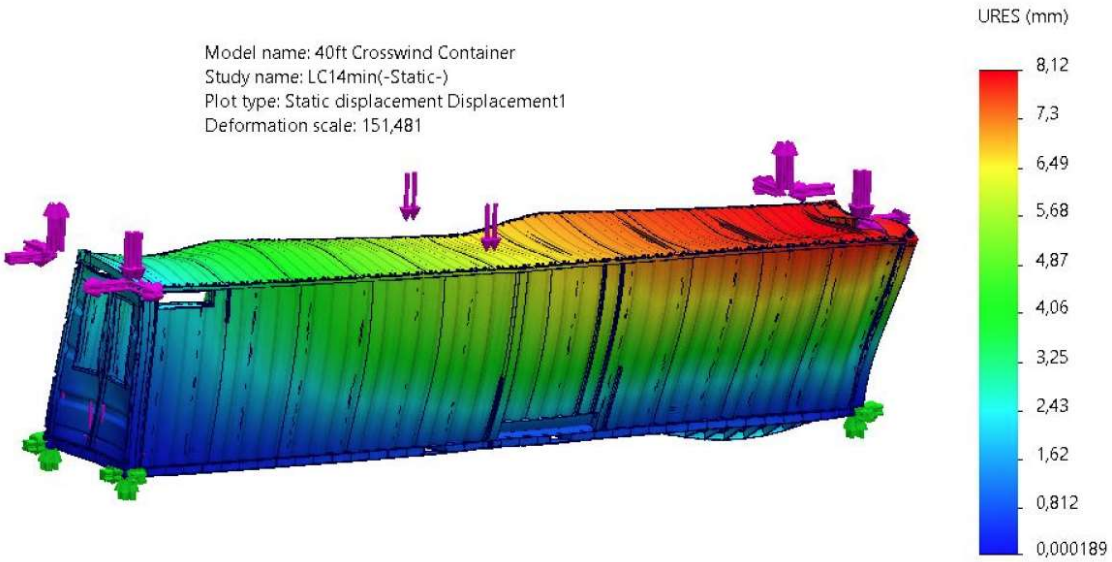


Fig 228: LC14_ MIN -Displacement plot

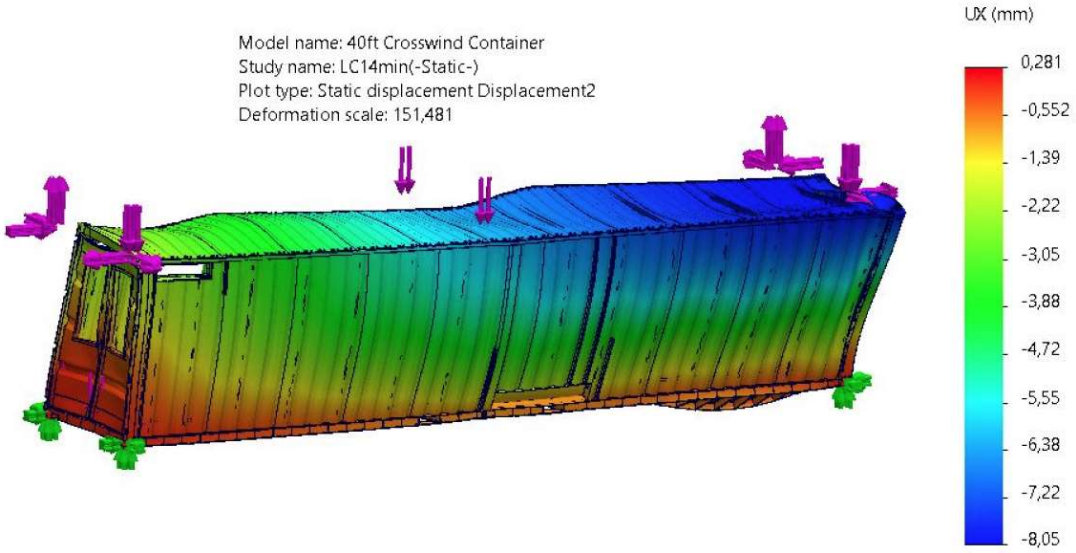


Fig 229: LC14_ MIN -Displacement plot-UX

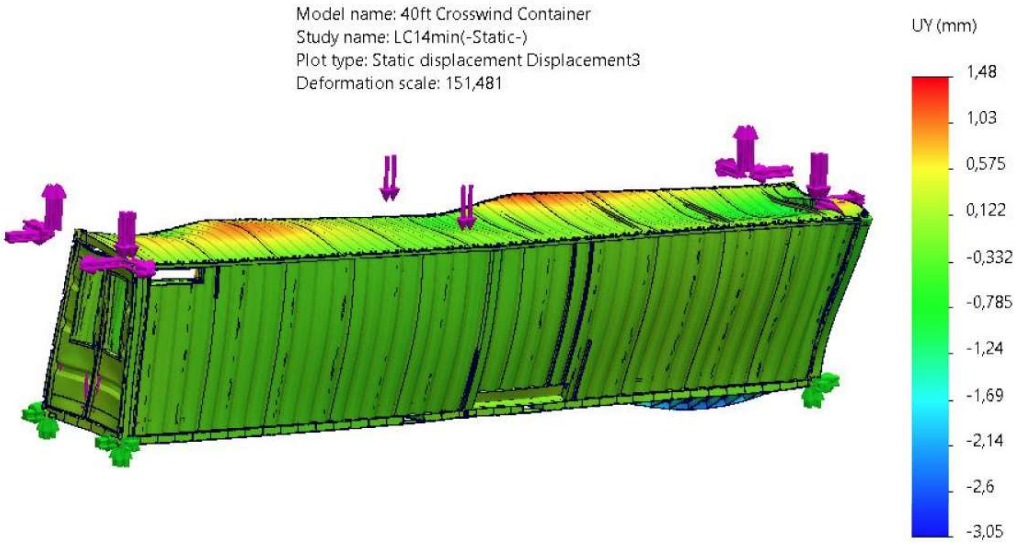


Fig 230: LC14_ MIN -Displacement plot-UY

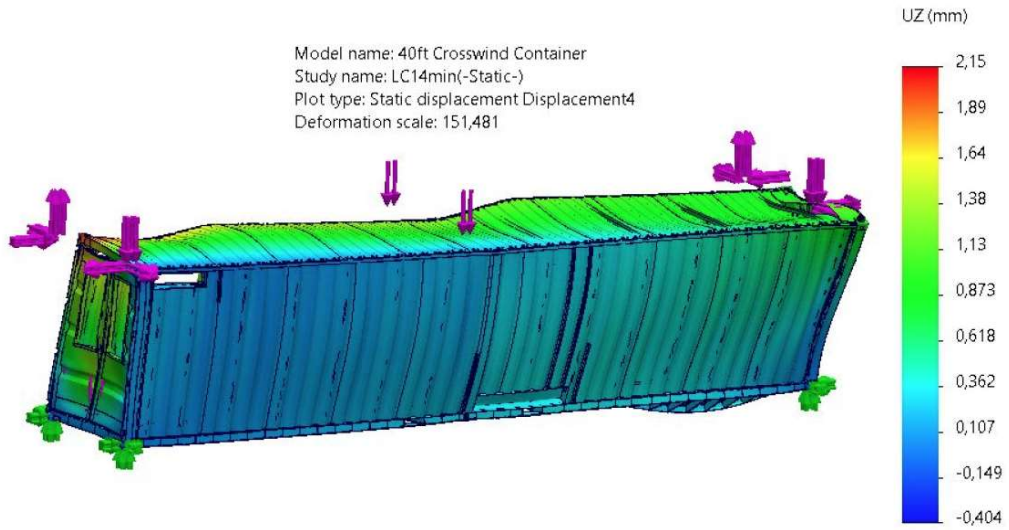


Fig 231: LC14_ MIN -Displacement plot-UZ

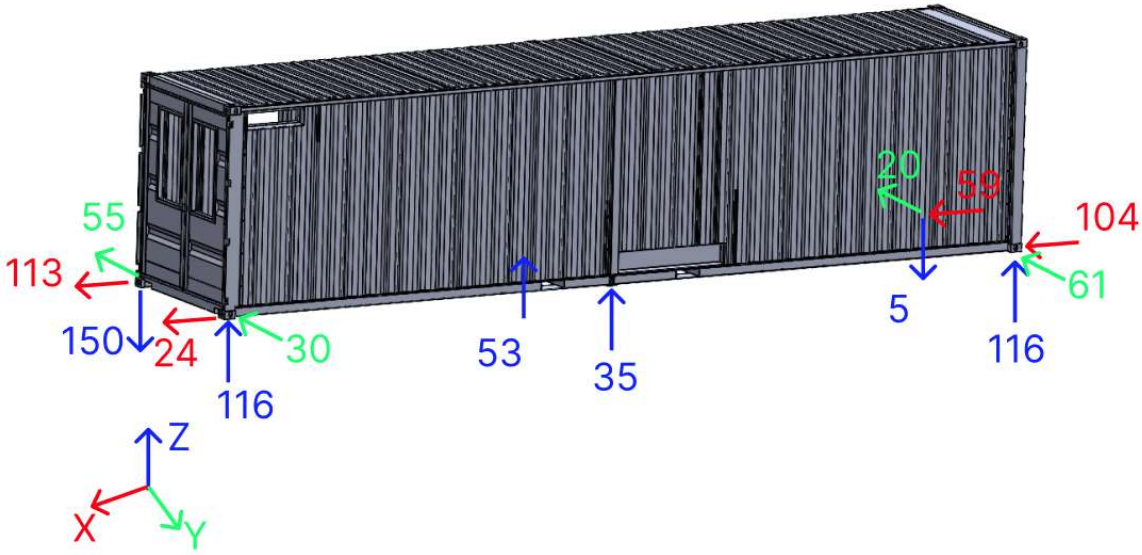
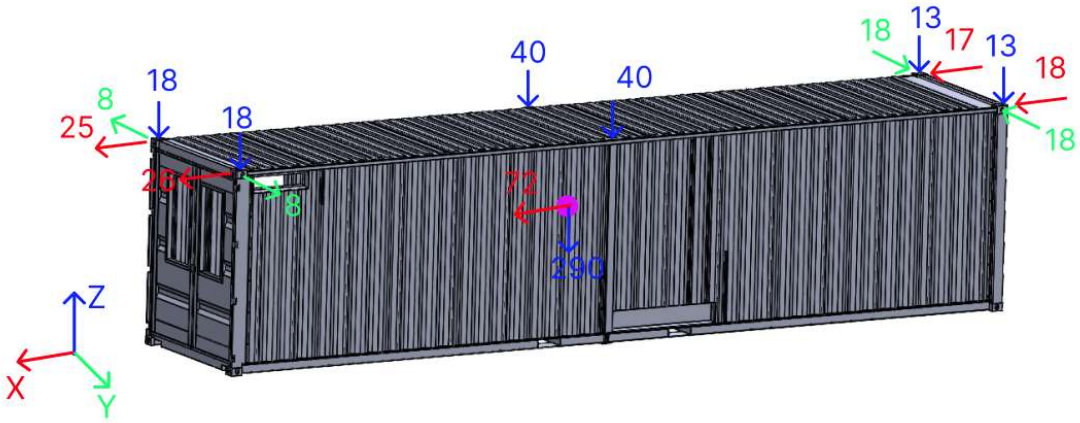


Fig 232: LC14_MIN -Reactions

9.19. LC15-MAX (40ft container + 40ft flatbed)



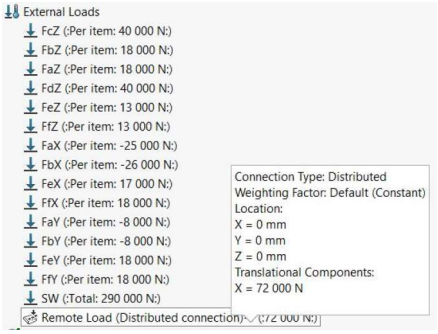


Fig 233: LC15_MAX – 40ft container – Loads

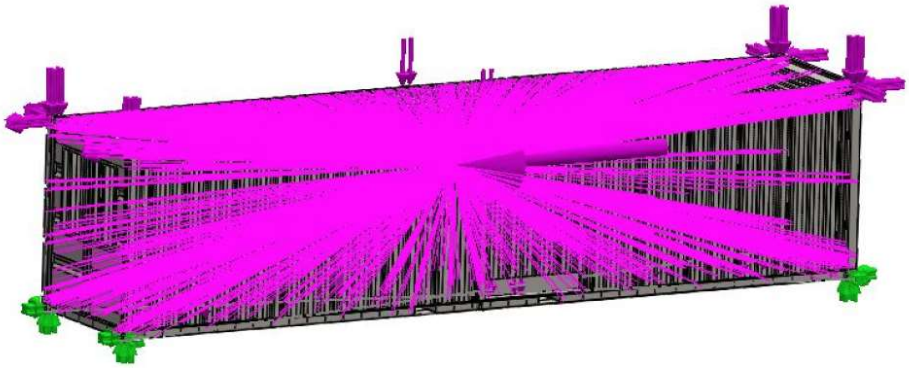


Fig 234: LC15_MAX -Boundary conditions

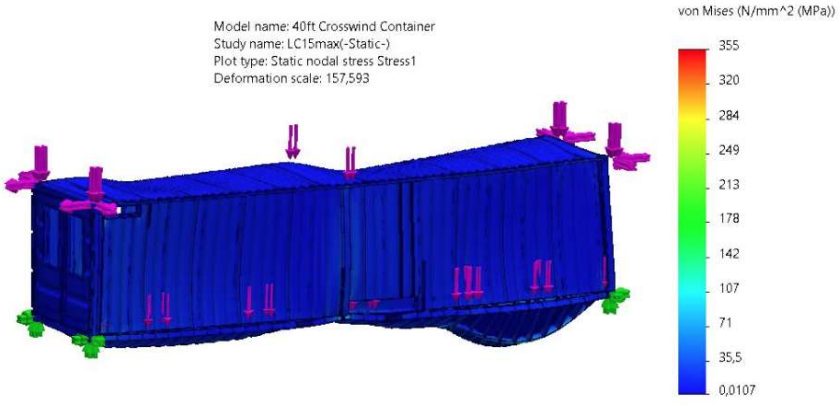


Fig 235: LC15_MAX -Stress plot

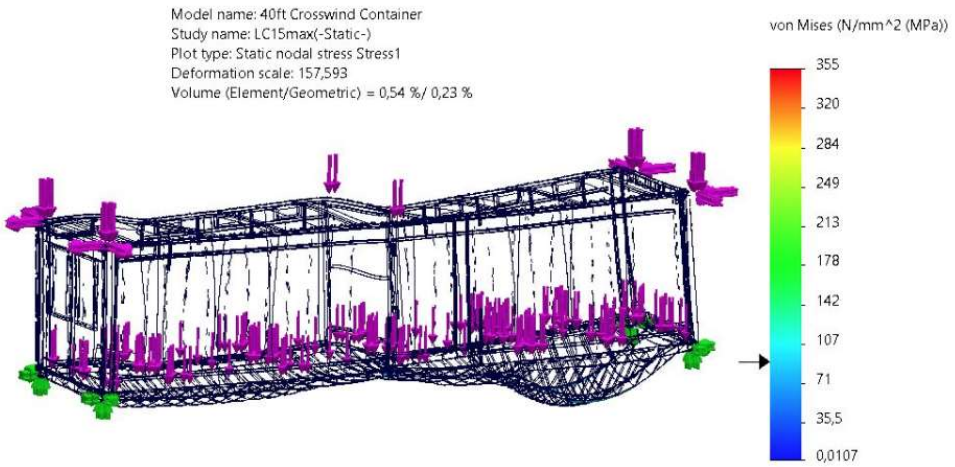


Fig 236: LC15_MAX -Stress plot (the biggest stress in 0,5% of element volume)

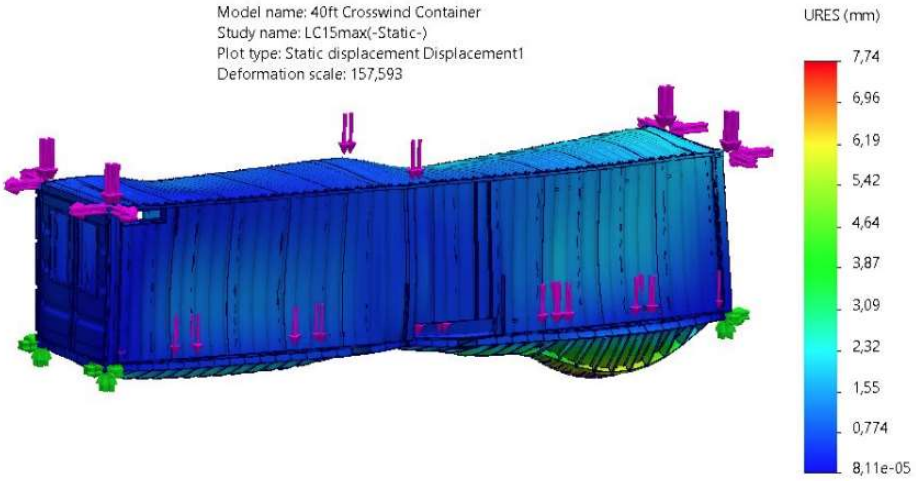


Fig 237: LC15_MAX -Displacement plot

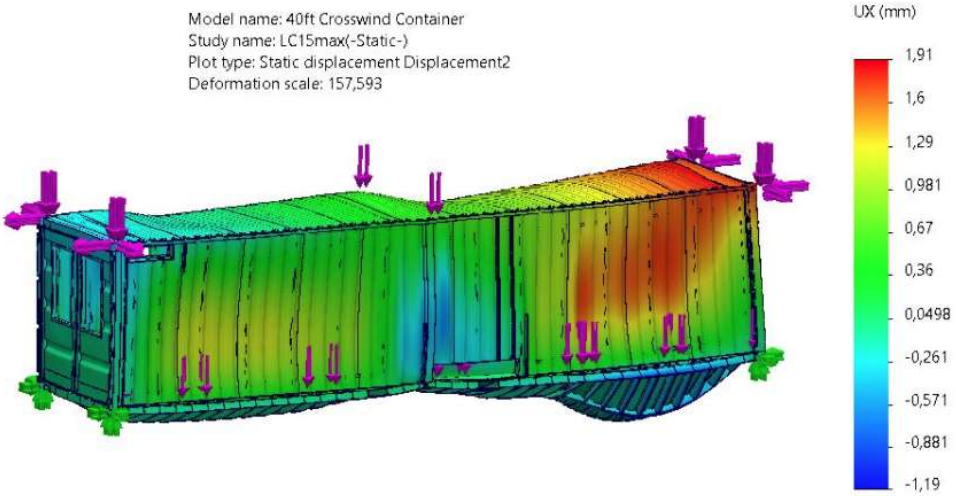


Fig 238: LC15_MAX -Displacement plot-UX

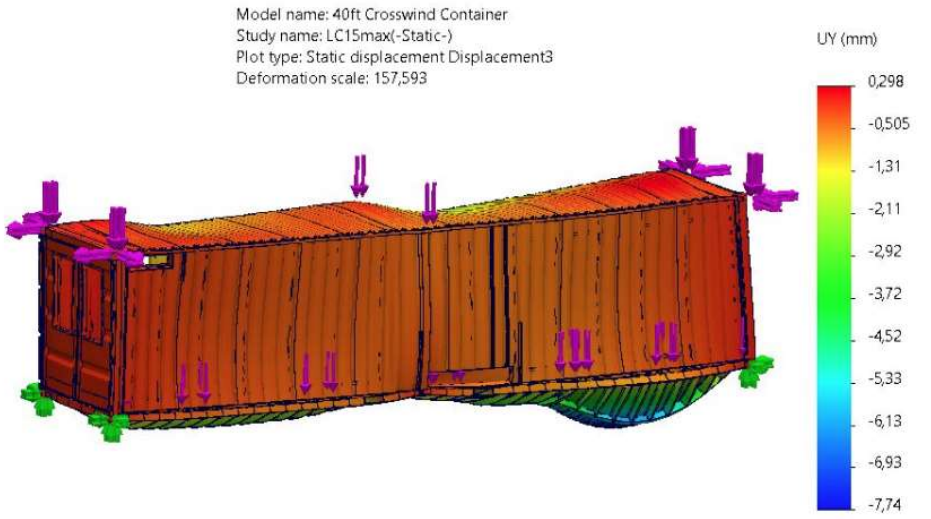


Fig 239: LC15_MAX -Displacement plot-UY

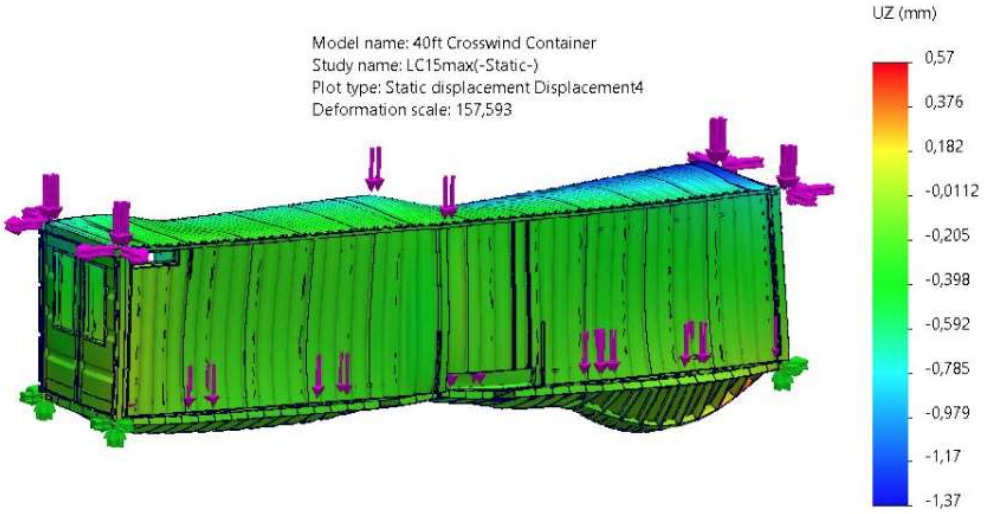


Fig 240: LC15_MAX -Displacement plot-UZ

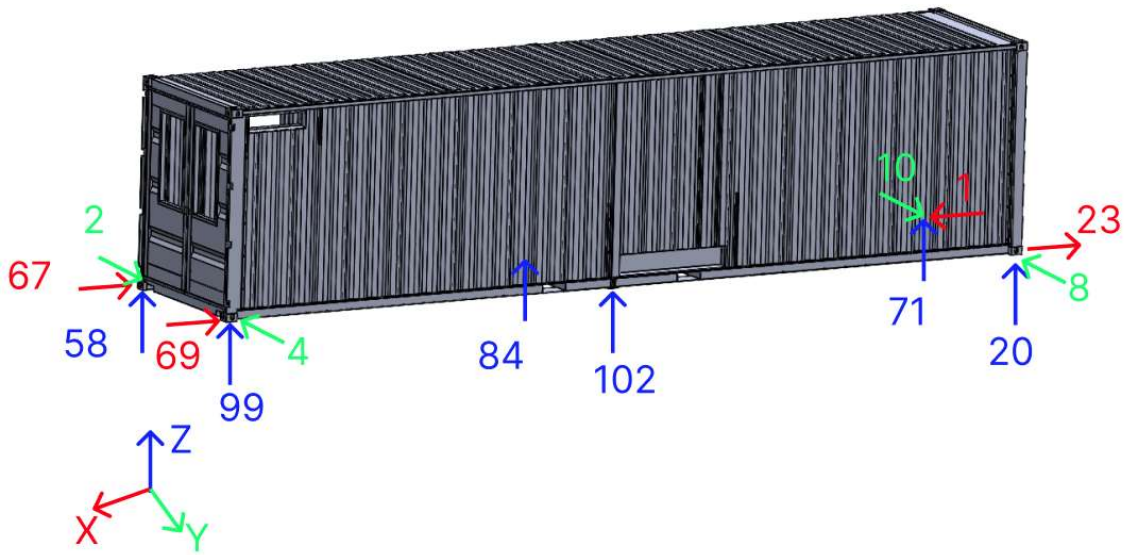
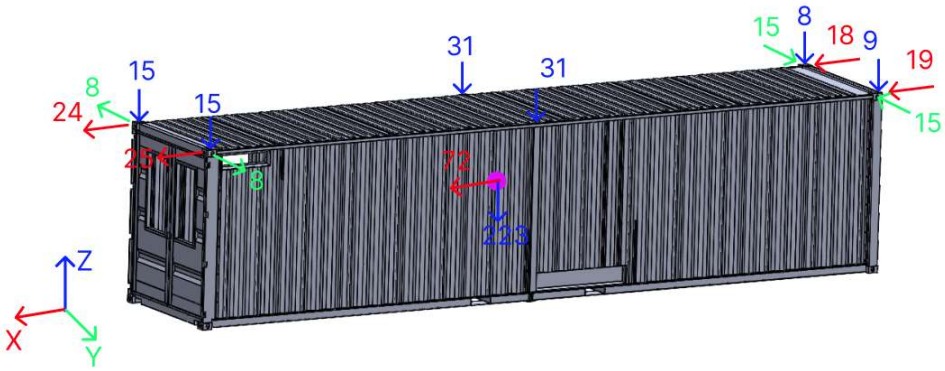


Fig 241: LC15_MAX -Reactions

9.20. LC15-MIN (40ft container + 40ft flatbed)



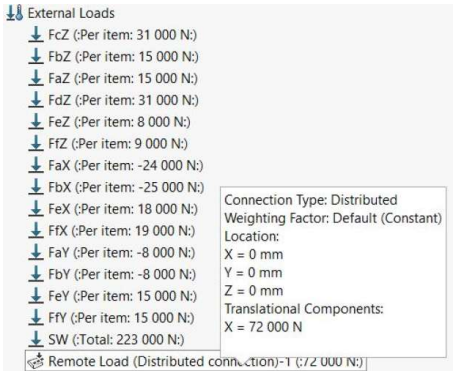


Fig 242: LC15_MIN – 40ft container – Loads

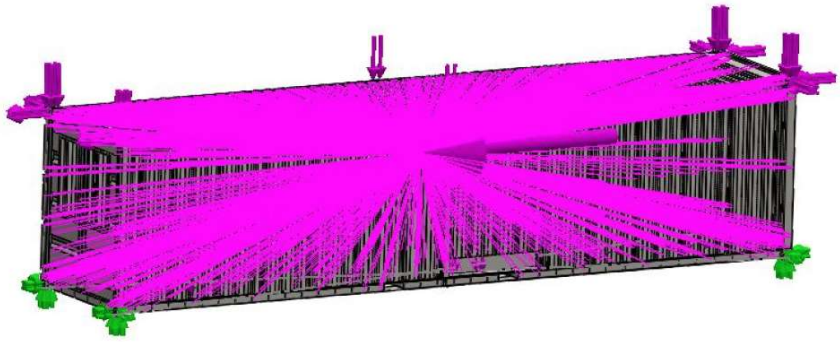


Fig 243: LC15_ MIN -Boundary conditions

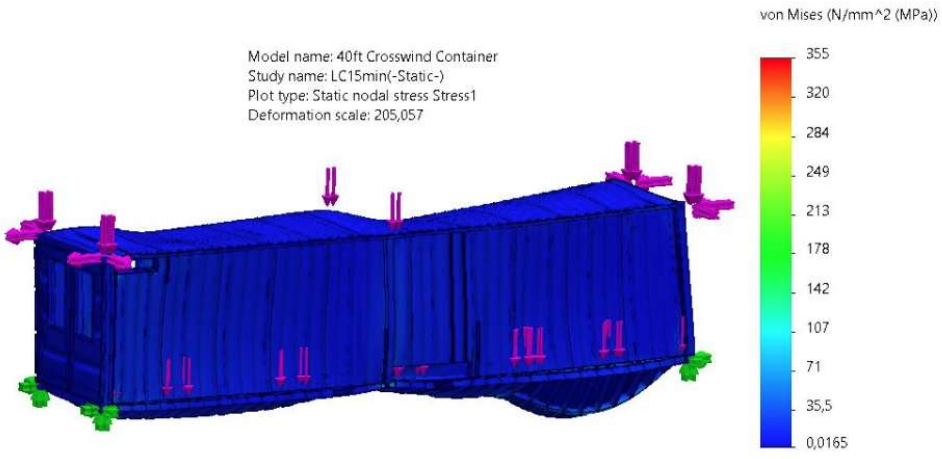


Fig 244: LC15_ MIN -Stress plot

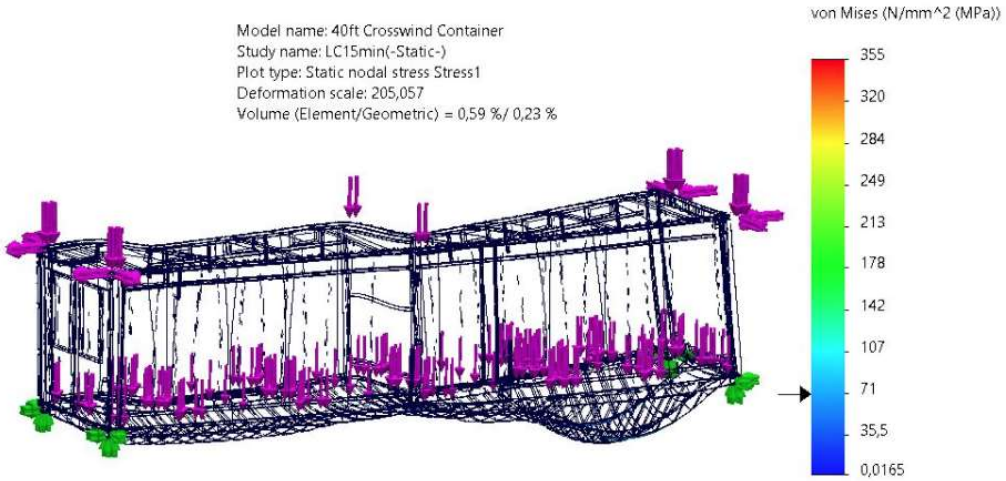


Fig 245: LC15_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

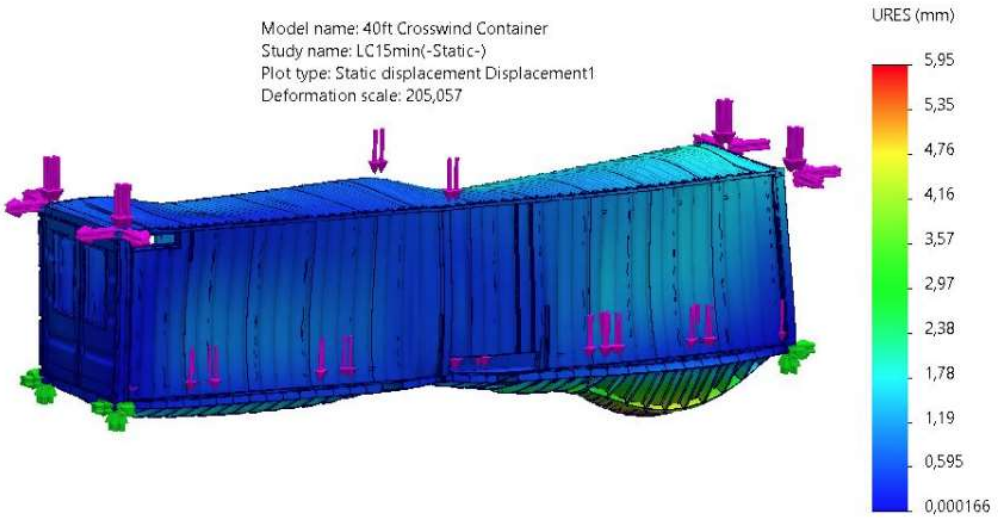


Fig 246: LC15_ MIN -Displacement plot

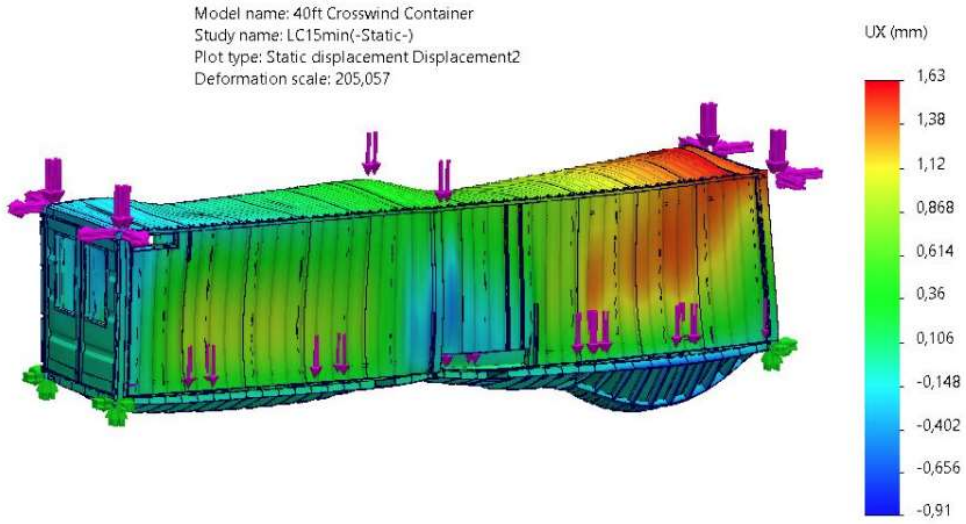


Fig 247: LC15_ MIN -Displacement plot-UX

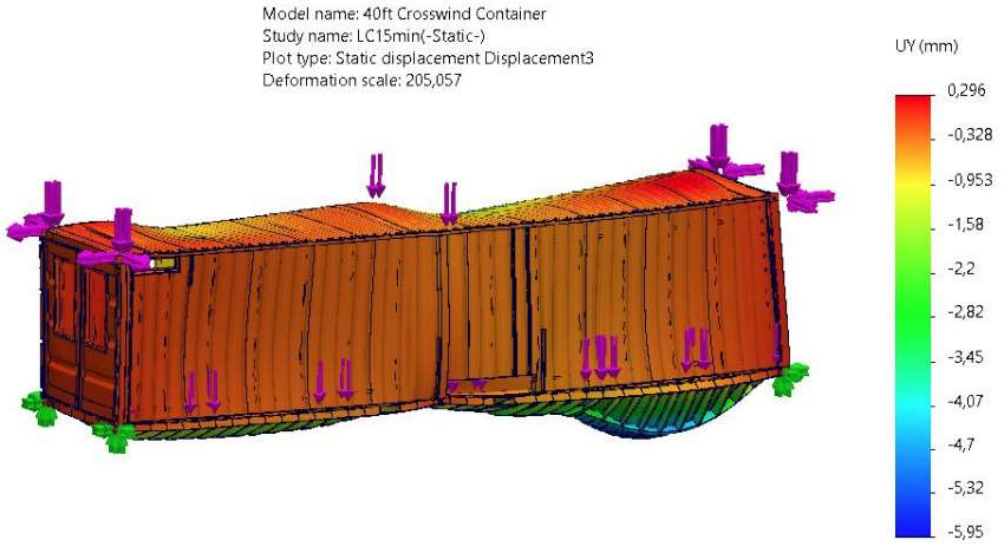


Fig 248: LC15_ MIN -Displacement plot-UY

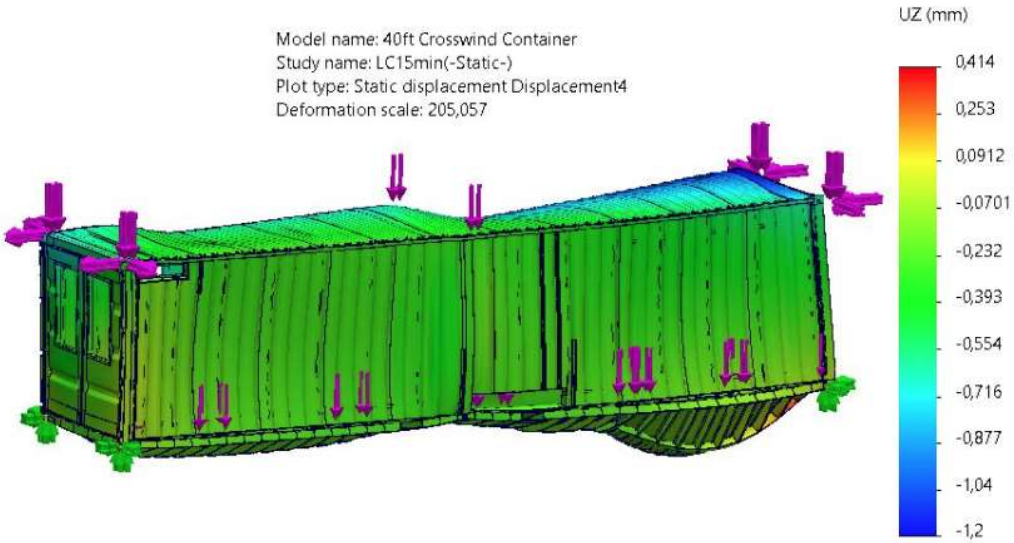


Fig 249: LC15_ MIN -Displacement plot-UZ

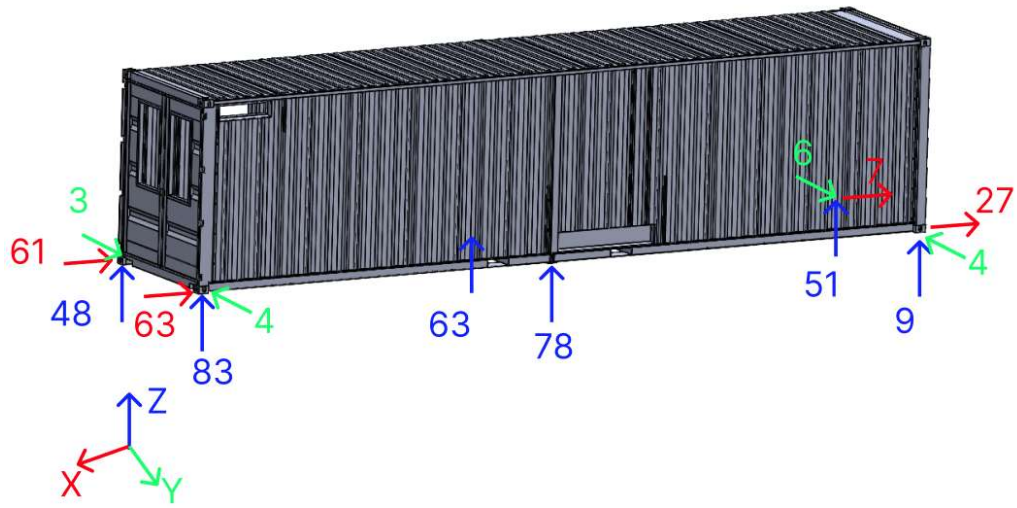
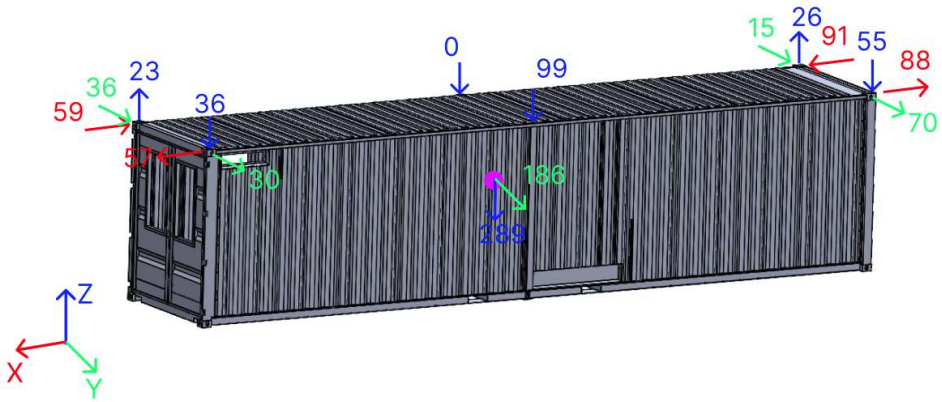


Fig 250: LC15_MIN -Reactions

9.21. LC16-MAX (40ft container + 40ft flatbed)



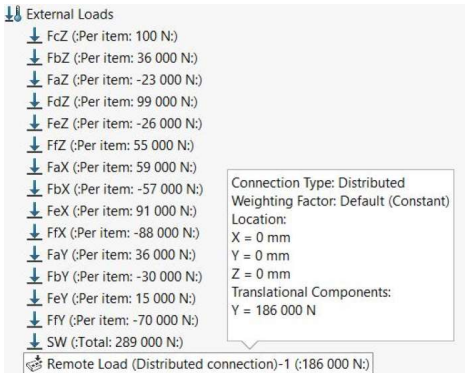


Fig 251: LC16_MAX – 40ft container – Loads

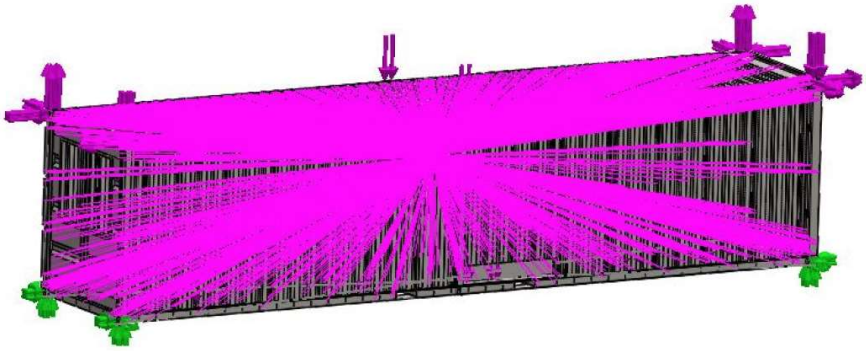


Fig 252: LC16_MAX -Boundary conditions

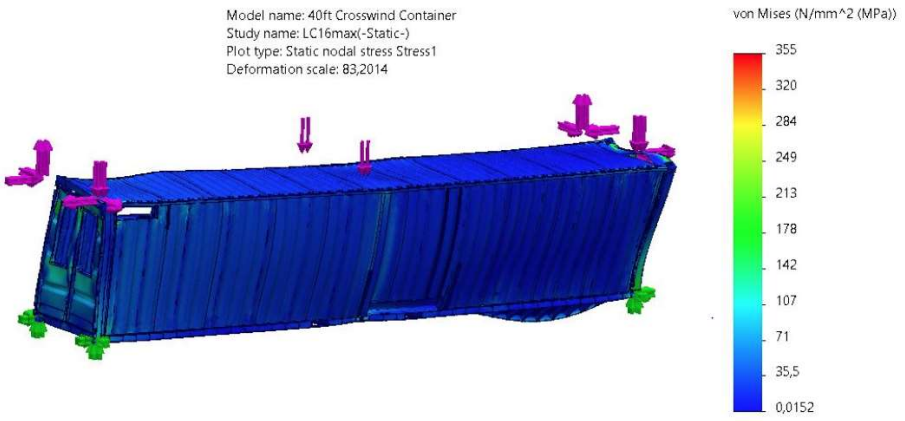


Fig 253: LC16_MAX -Stress plot

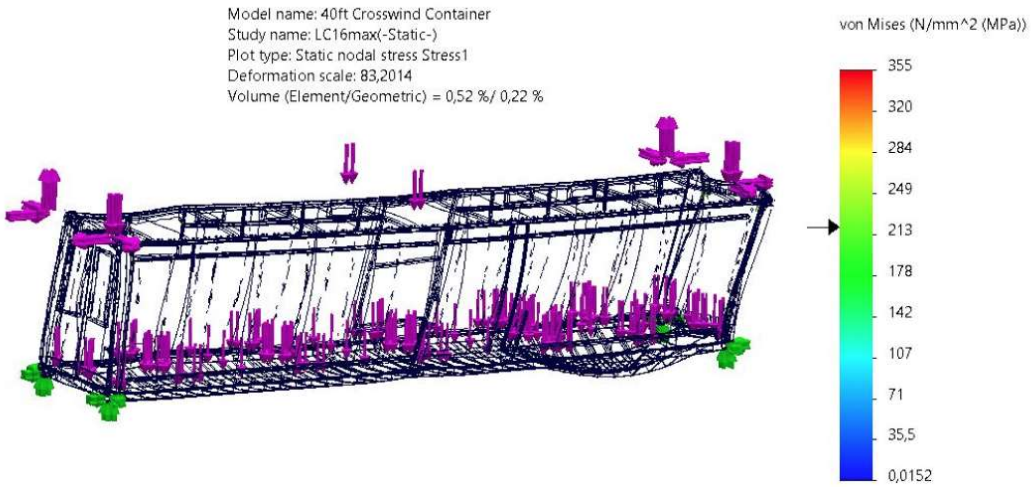


Fig 254: LC16_MAX -Stress plot (the biggest stress in 0,5% of element volume)

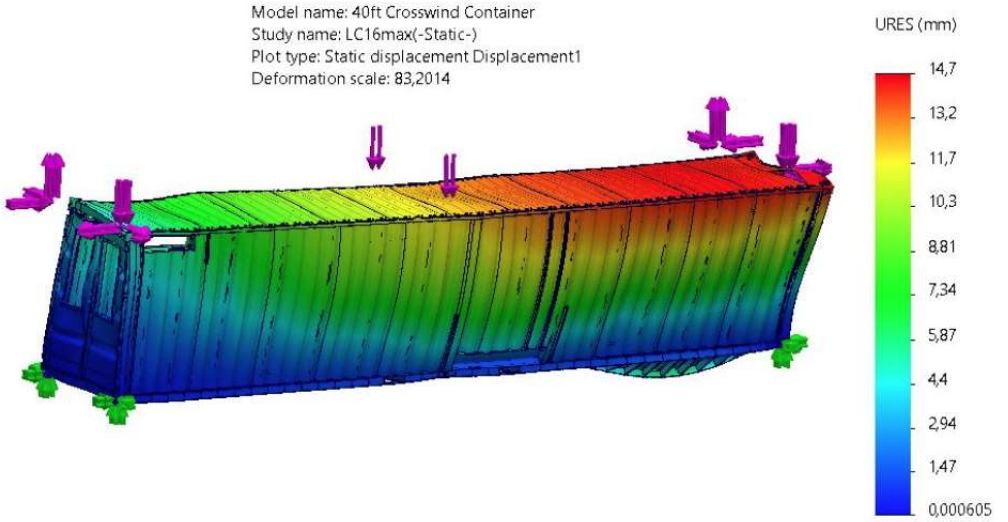


Fig 255: LC16_MAX -Displacement plot

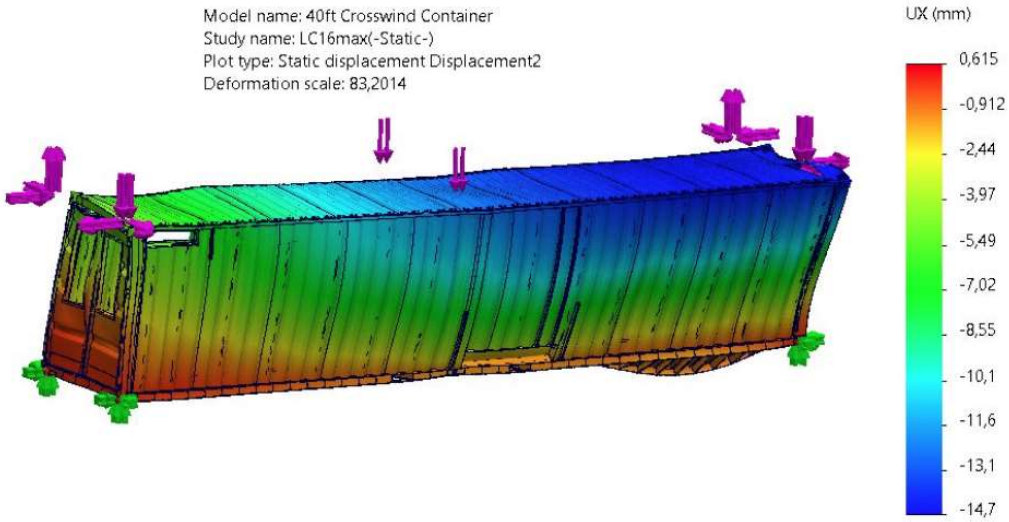


Fig 256: LC16_MAX -Displacement plot-UX

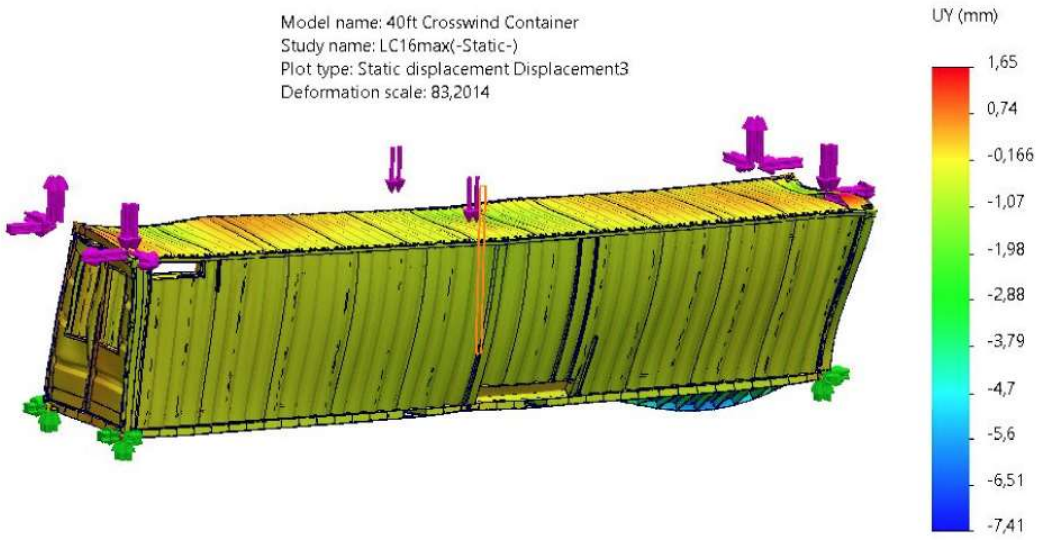


Fig 257: LC16_MAX -Displacement plot-UY

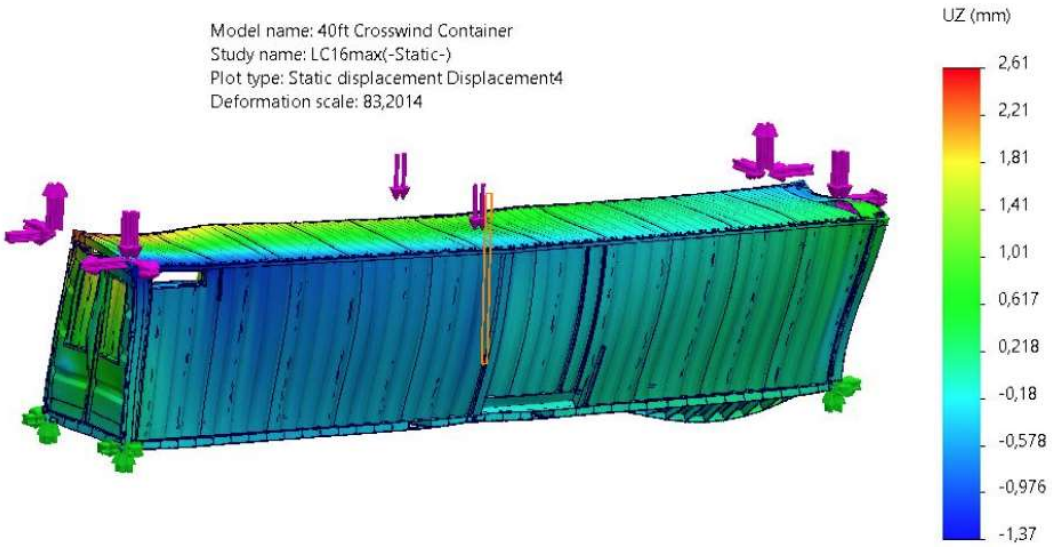


Fig 258: LC16_MAX -Displacement plot-UZ

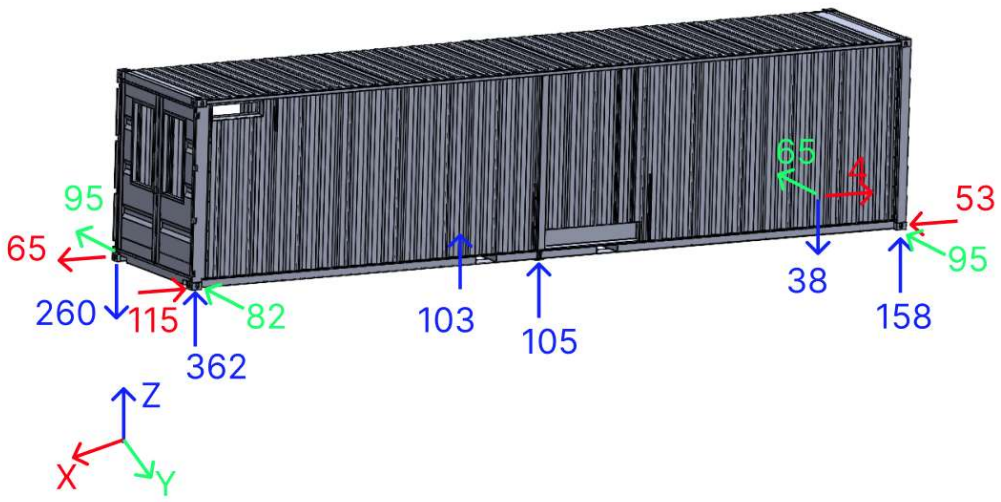
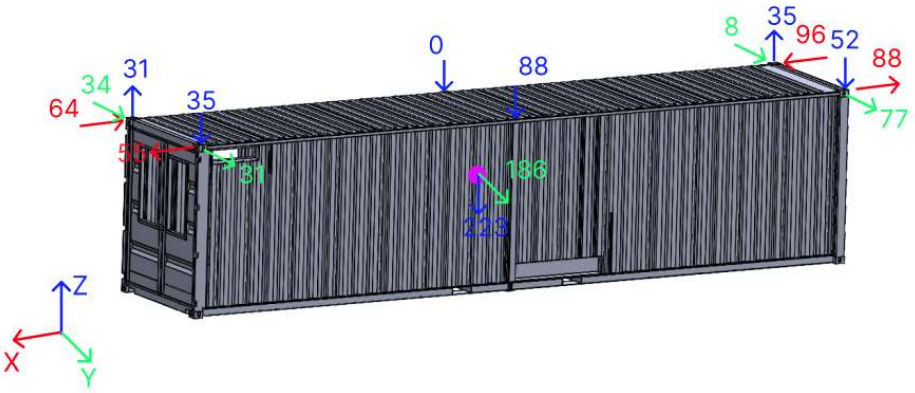


Fig 259: LC16_MAX -Reactions

9.22. LC16-MIN (40ft container + 40ft flatbed)



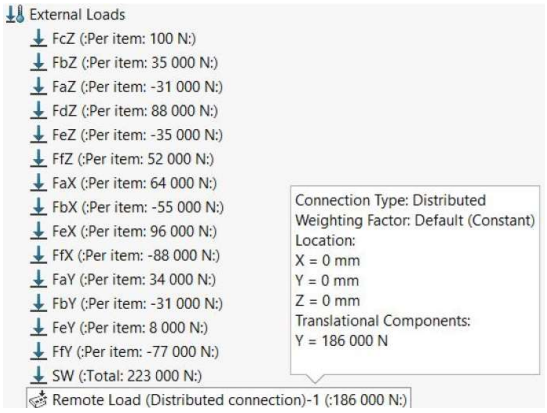


Fig 260: LC16_MIN – 40ft container – Loads

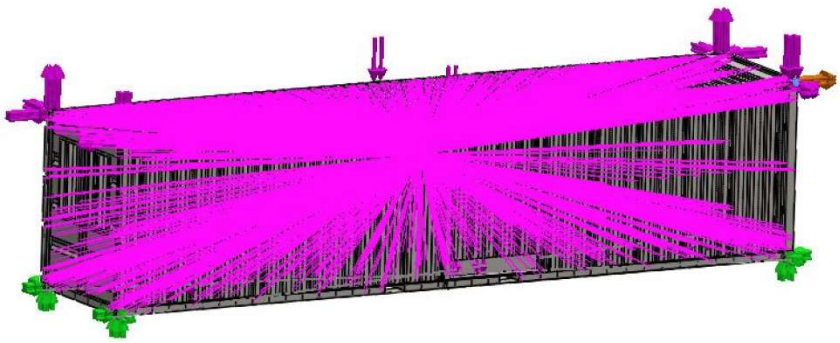


Fig 261: LC16_ MIN -Boundary conditions

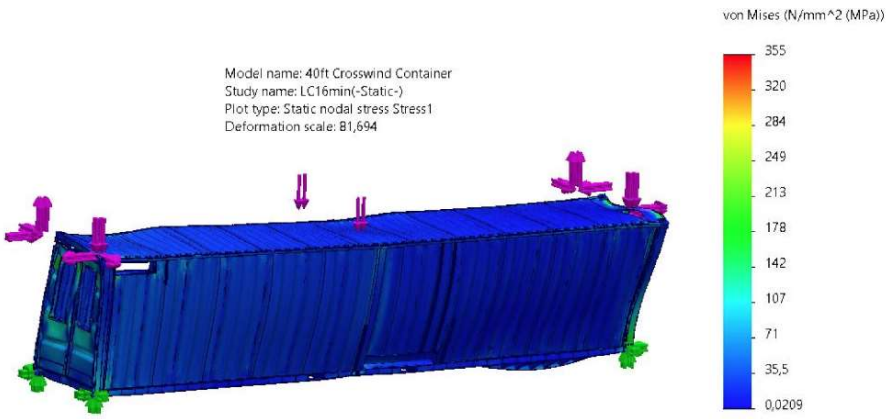


Fig 262: LC16_ MIN -Stress plot

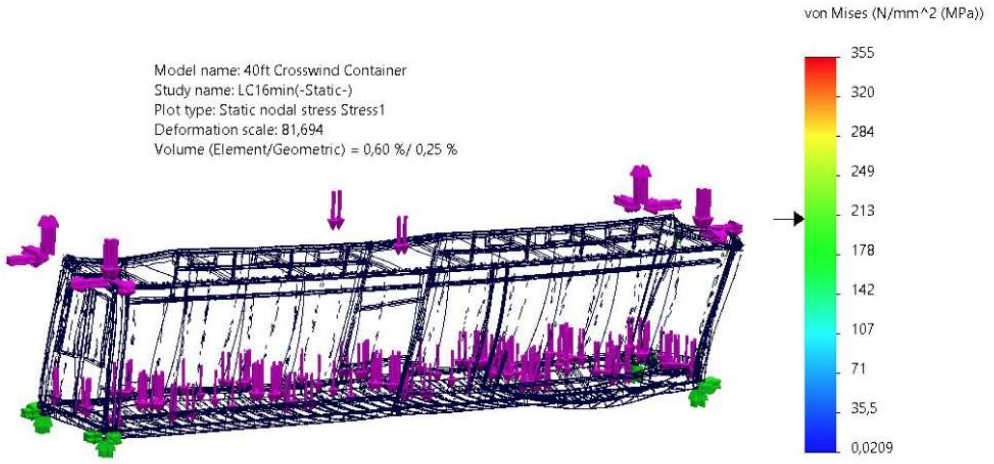


Fig 263: LC16_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

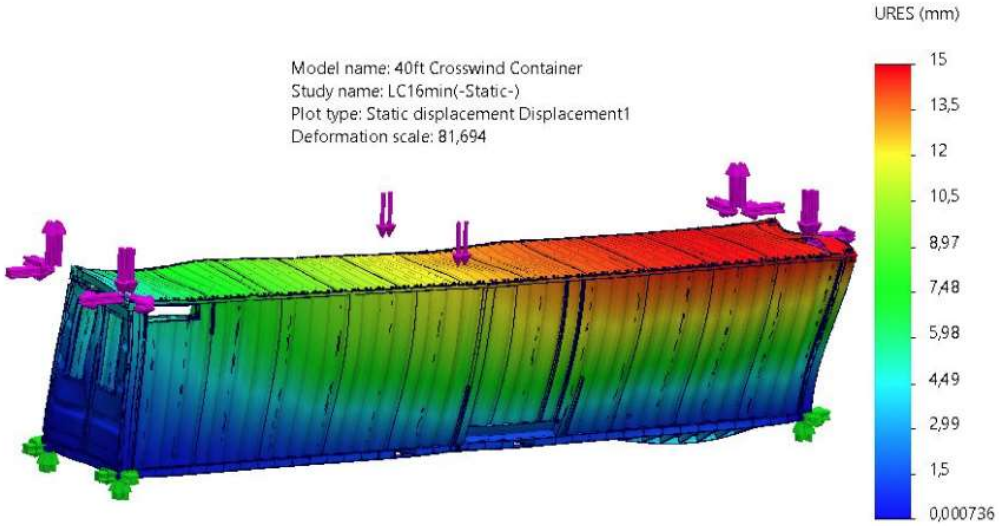


Fig 264: LC16_ MIN -Displacement plot

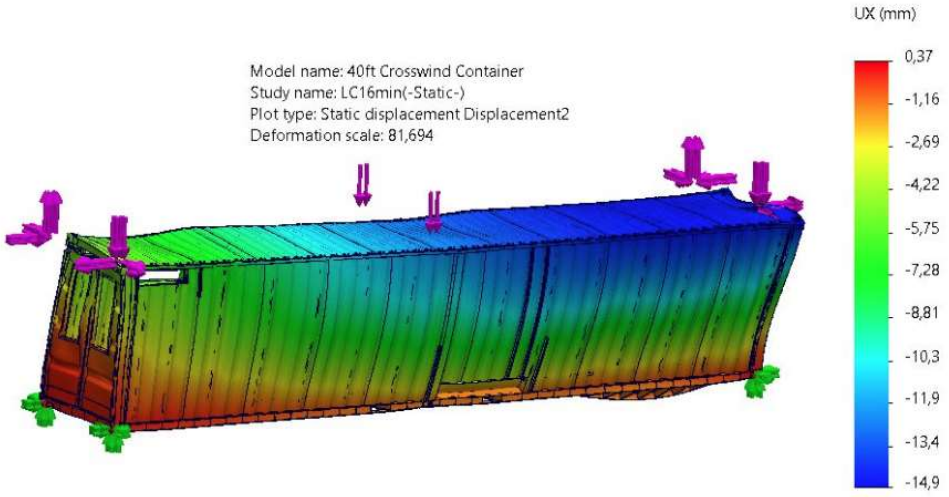


Fig 265: LC16_ MIN -Displacement plot-UX

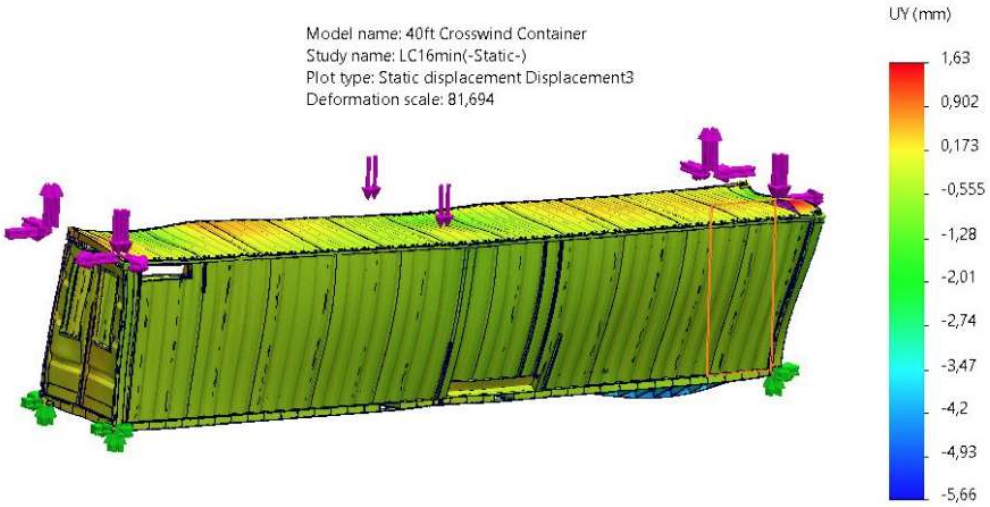


Fig 266: LC16_ MIN -Displacement plot-UY

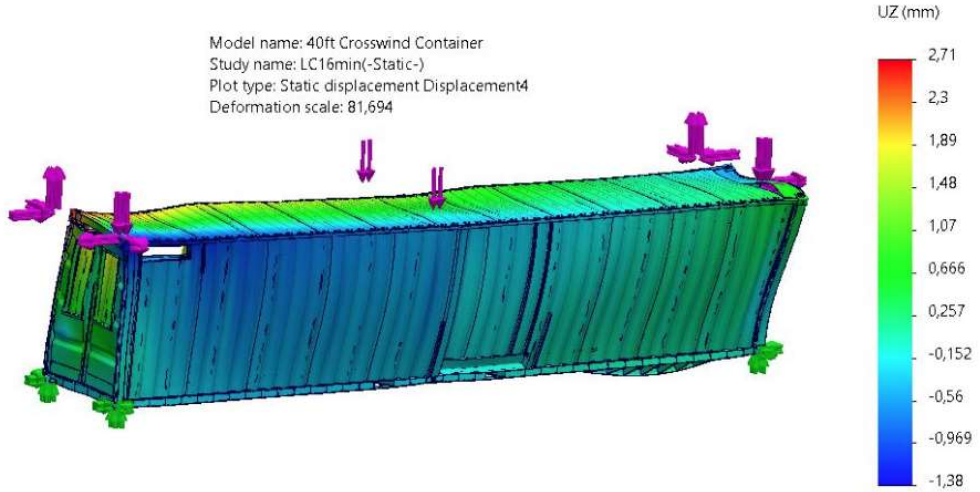


Fig 267: LC16_ MIN -Displacement plot-UZ

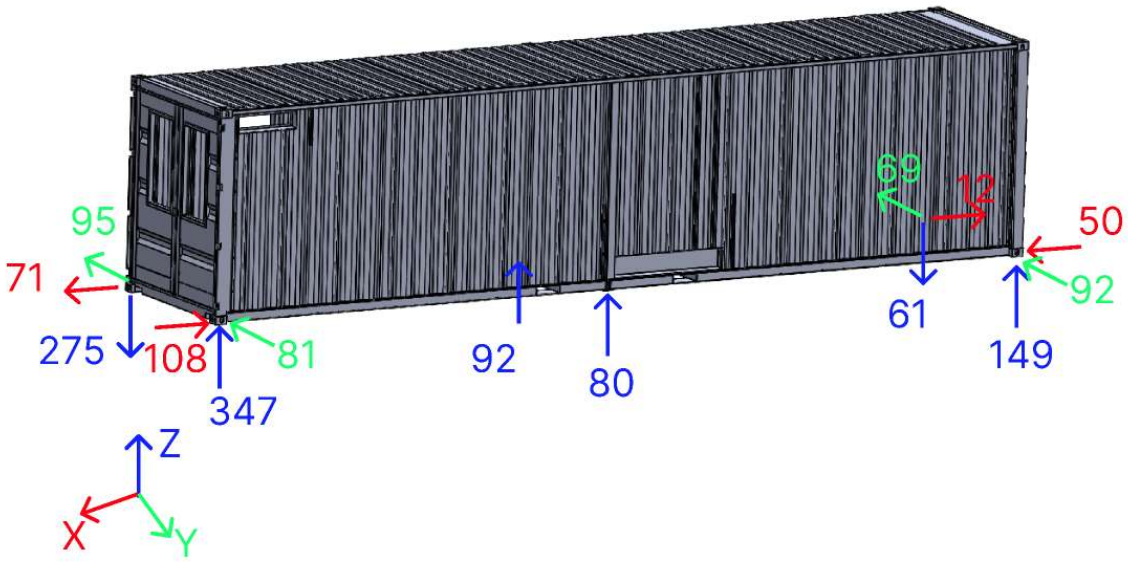


Fig 268: LC16_MIN -Reactions

9.23. LC17-MAX (40ft container + 40ft flatbed)

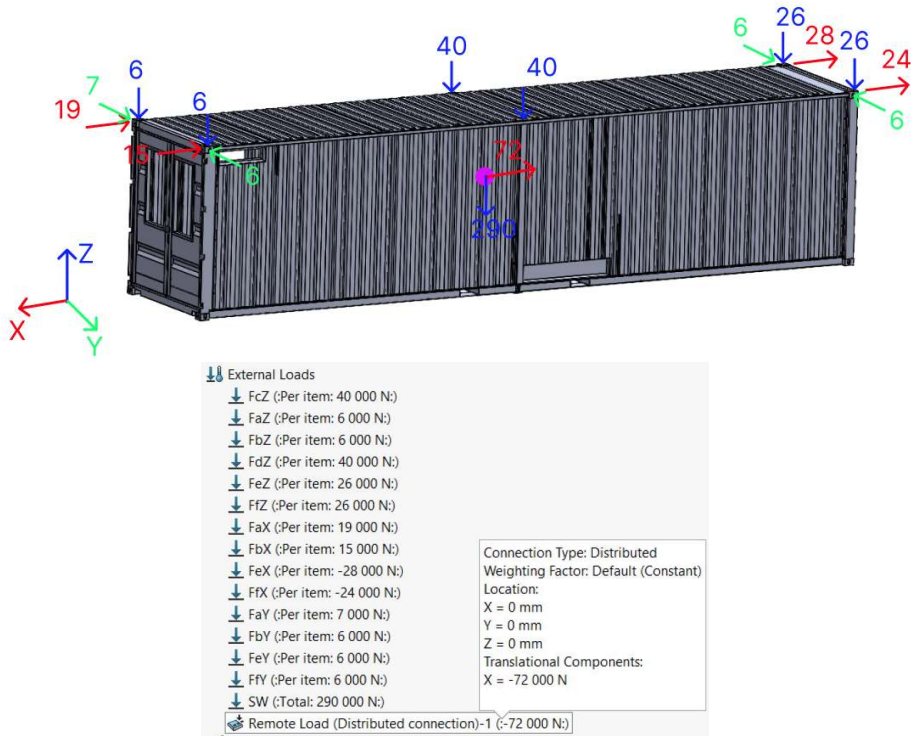


Fig 269: LC17_MAX – 40ft container – Loads

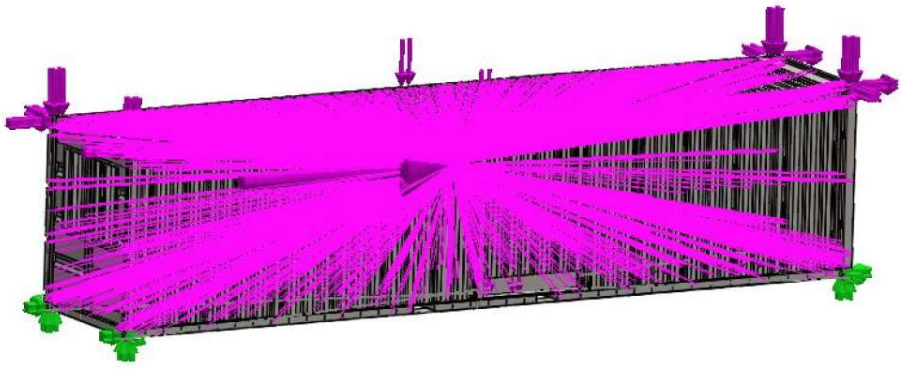


Fig 270: LC17_MAX -Boundary conditions

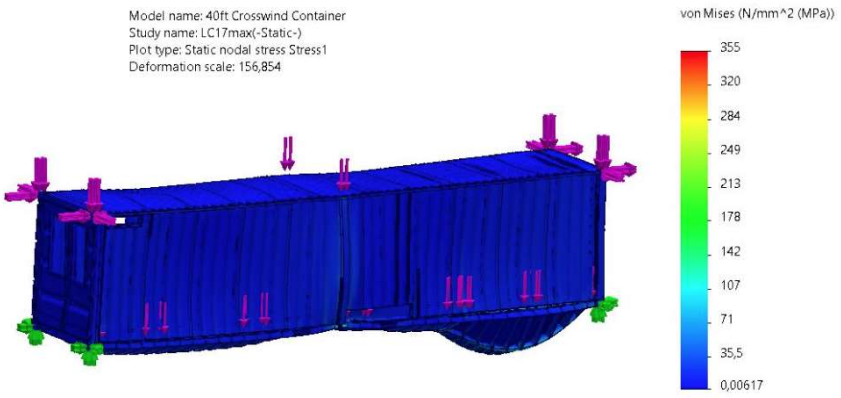


Fig 271: LC17_MAX -Stress plot

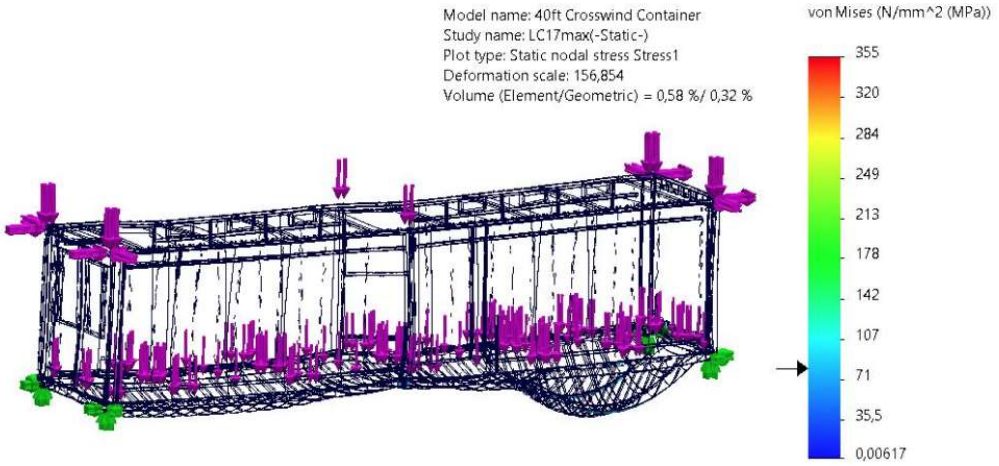


Fig 272: LC17_MAX -Stress plot (the biggest stress in 0,5% of element volume)

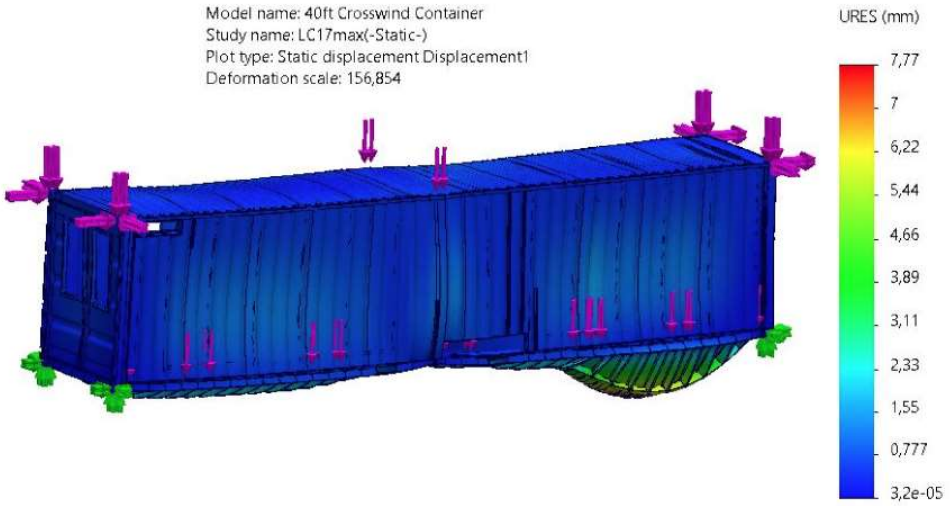


Fig 273: LC17_MAX -Displacement plot

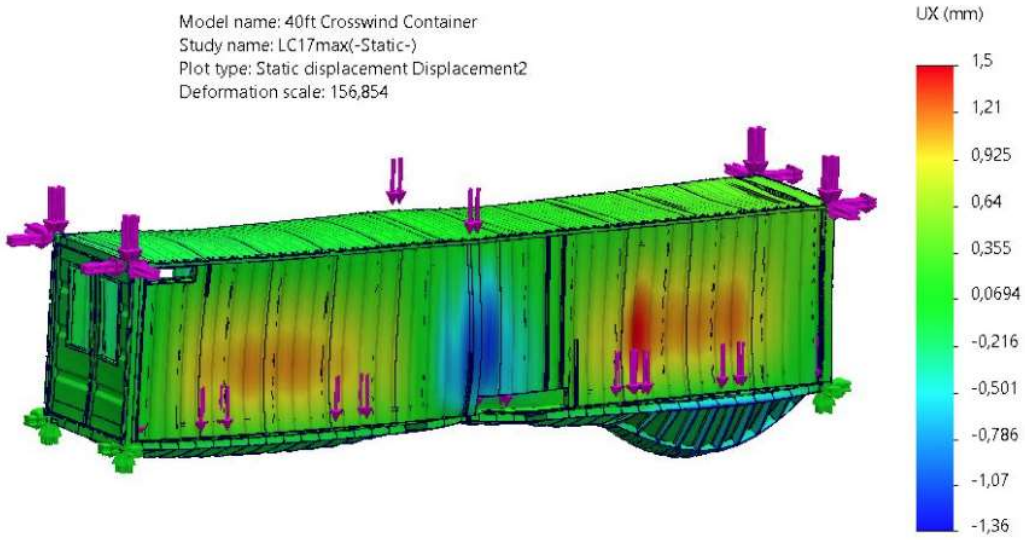


Fig 274: LC17_MAX -Displacement plot-UX

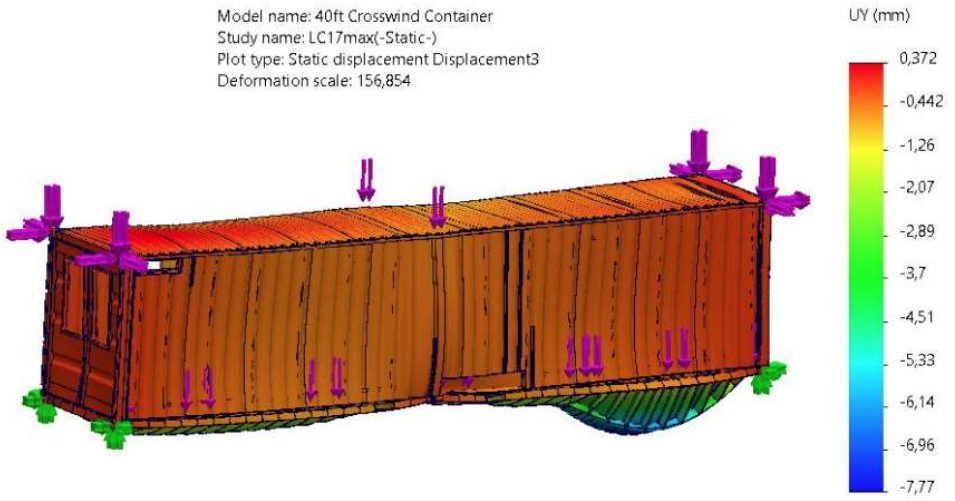


Fig 275: LC17_MAX -Displacement plot-UY

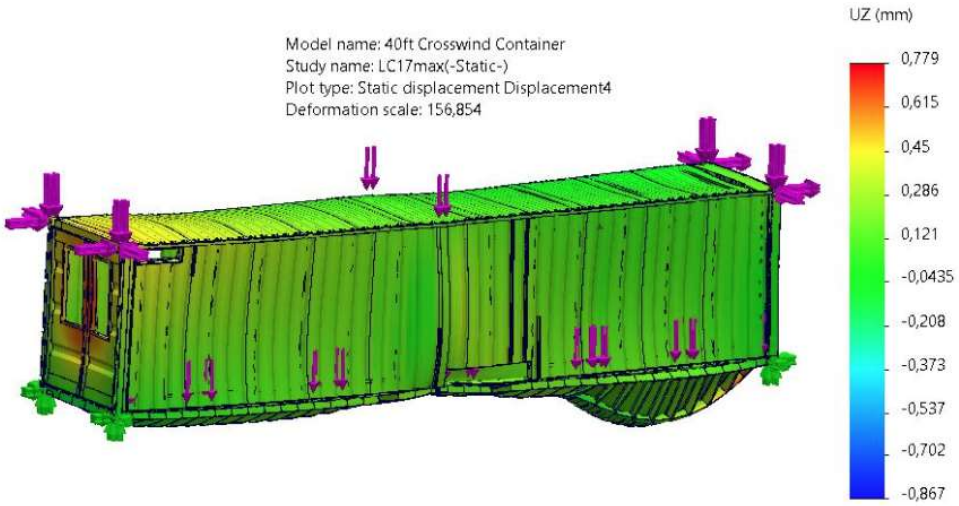


Fig 276: LC17_MAX -Displacement plot-UZ

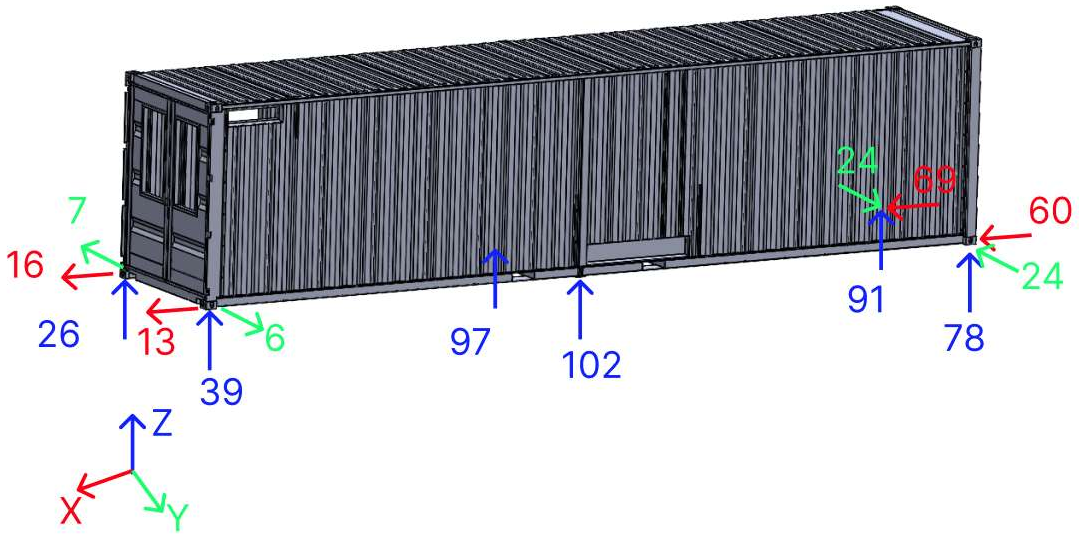
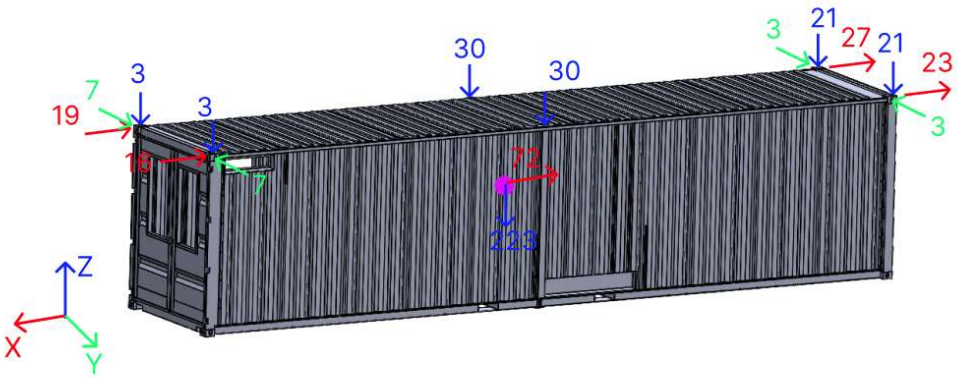


Fig 277: LC17_MAX -Reactions

9.24. LC17-MIN (40ft container + 40ft flatbed)



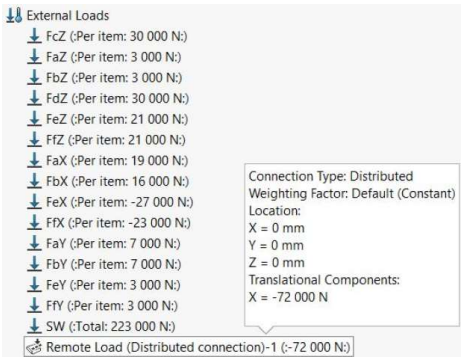


Fig 278: LC17_MIN – 40ft container – Loads

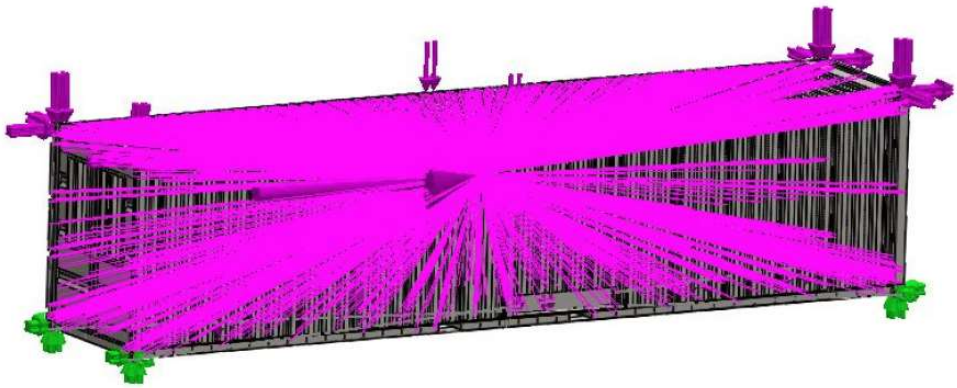


Fig 279: LC17_ MIN -Boundary conditions

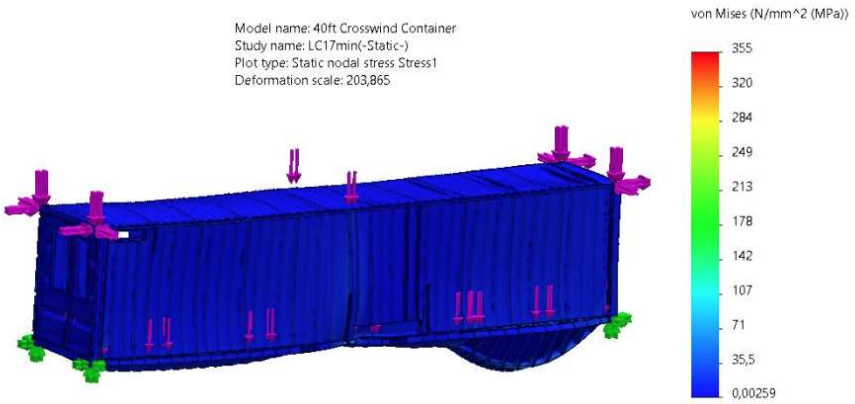


Fig 280: LC17_ MIN -Stress plot

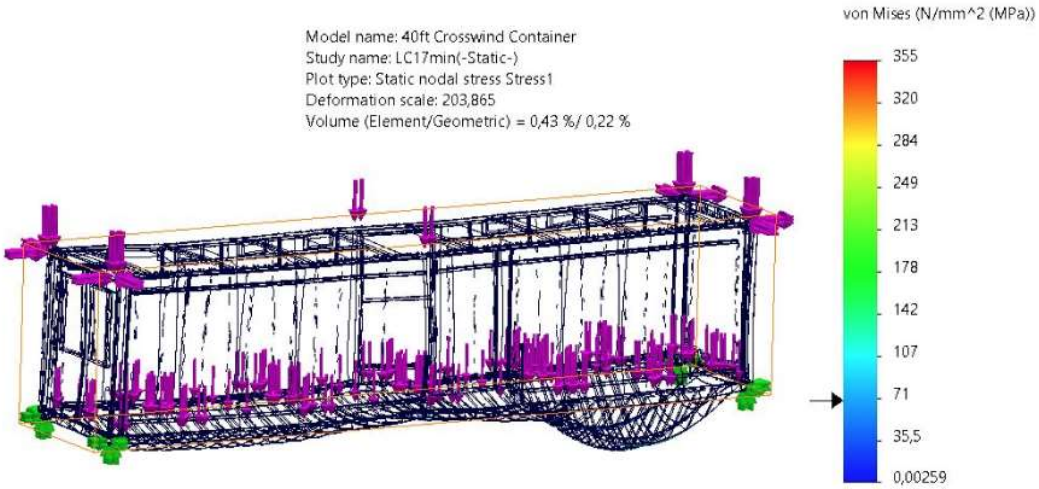


Fig 281: LC17_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

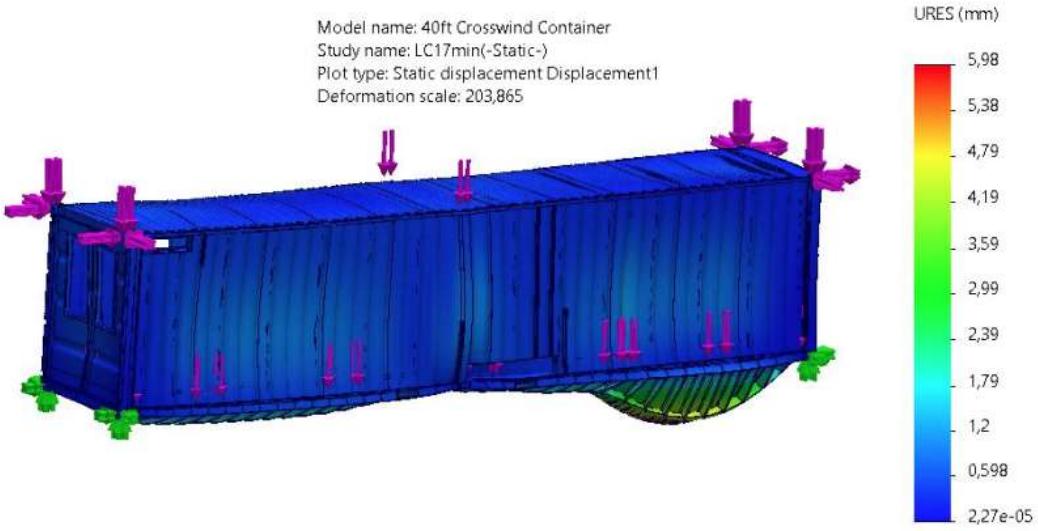


Fig 282: LC17_ MIN -Displacement plot

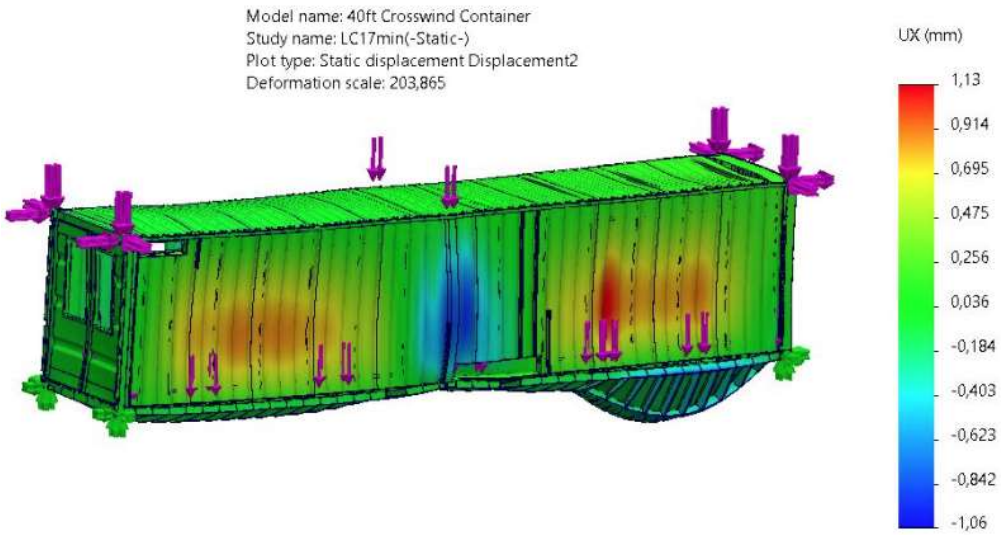


Fig 283: LC17_ MIN -Displacement plot-UX

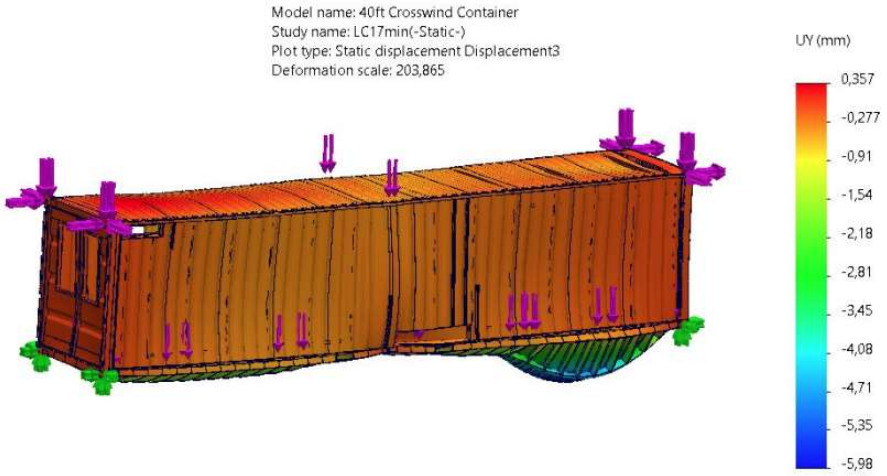


Fig 284: LC17_ MIN -Displacement plot-UY

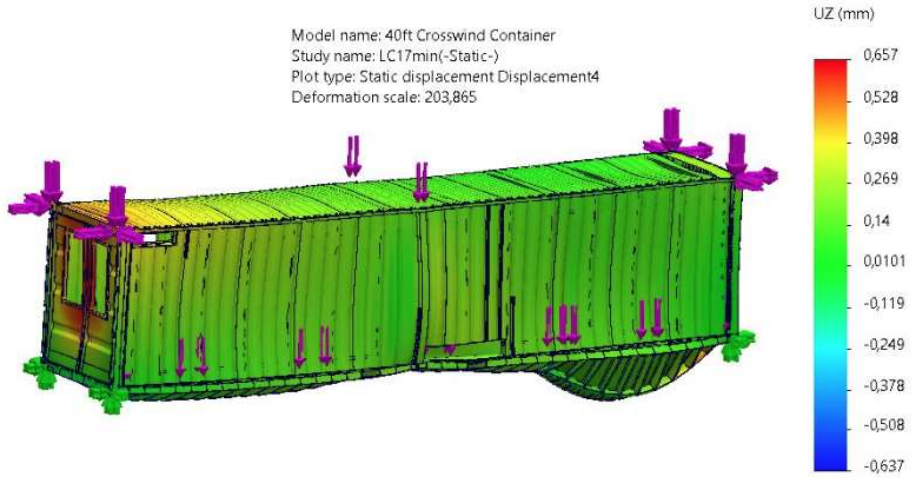


Fig 285: LC17_ MIN -Displacement plot-UZ

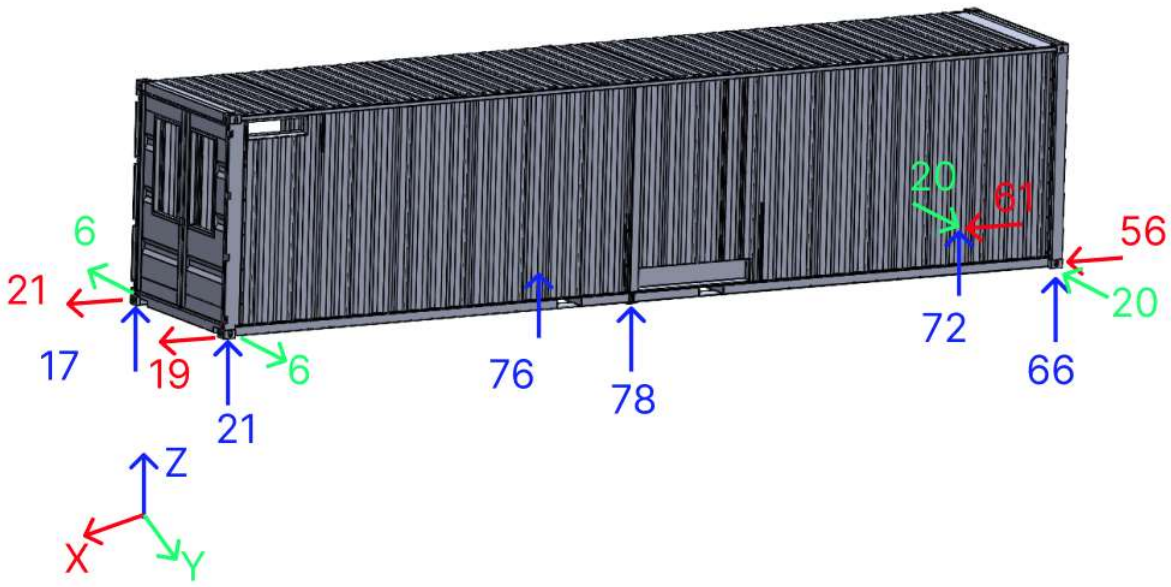


Fig 286: LC17_MIN -Reactions

9.25. LC18-MAX (40ft container + 40ft flatbed)

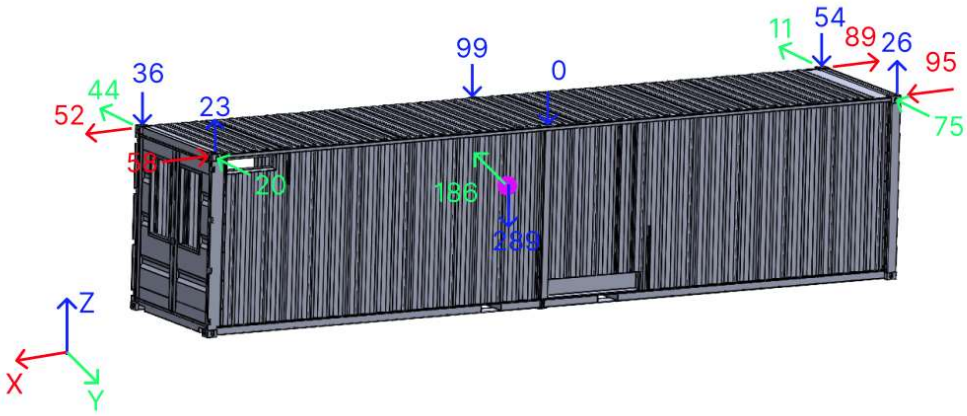




Fig 287: LC18_MAX – 40ft container – Loads

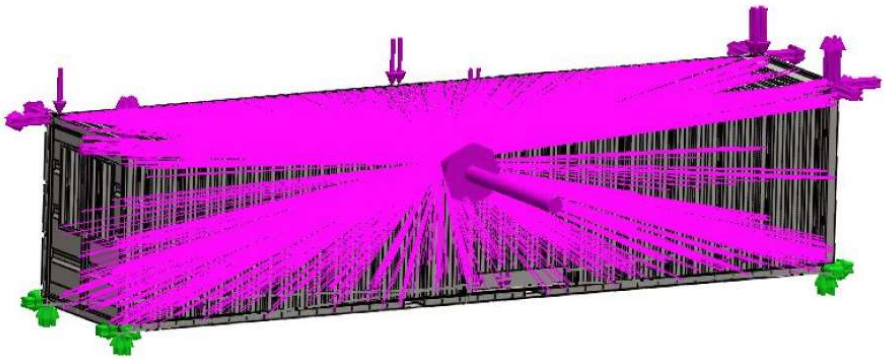


Fig 288: LC18_MAX -Boundary conditions

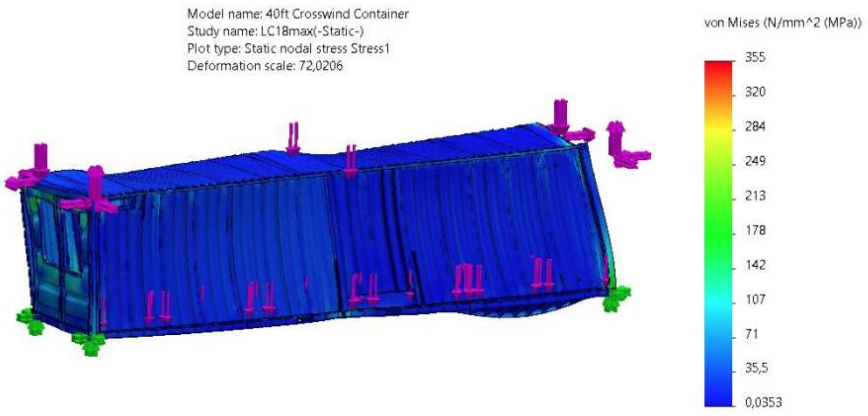


Fig 289: LC18_MAX -Stress plot

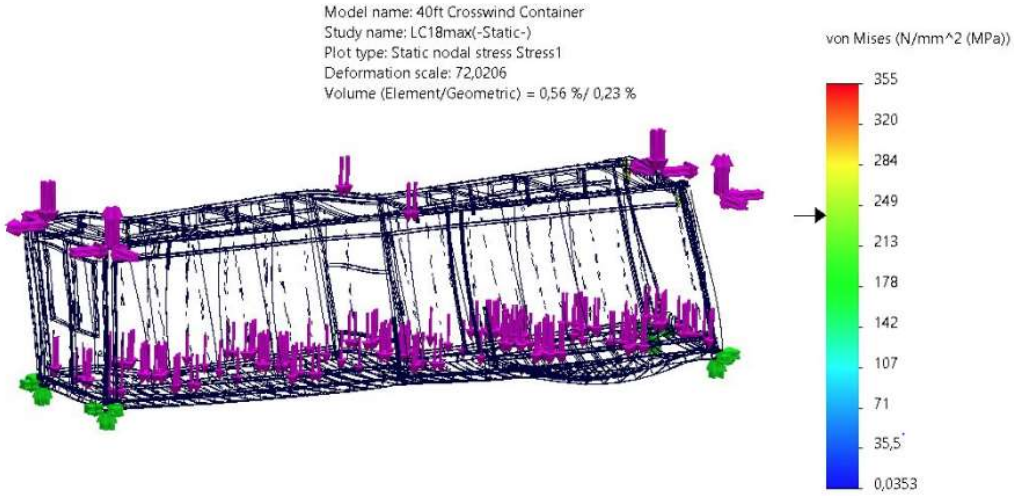


Fig 290: LC18_MAX -Stress plot (the biggest stress in 0,5% of element volume)

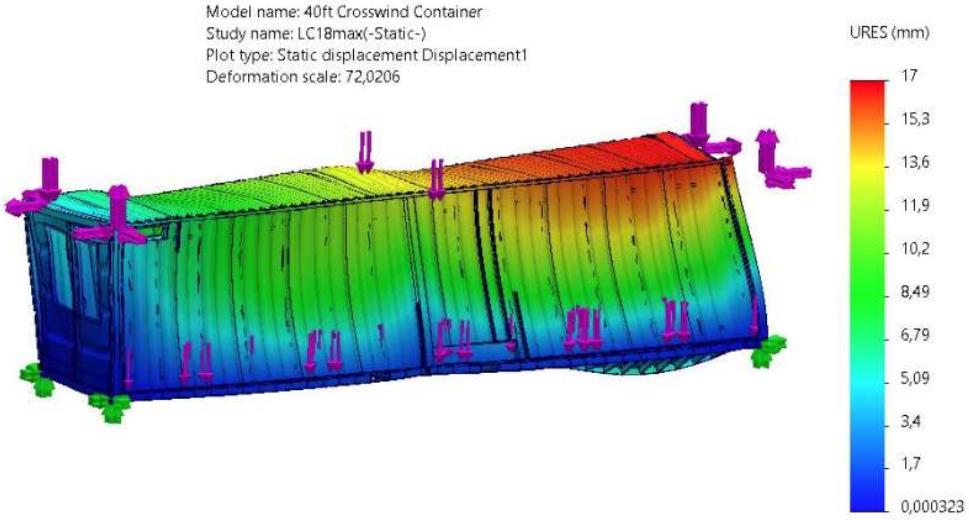


Fig 291: LC18_MAX -Displacement plot

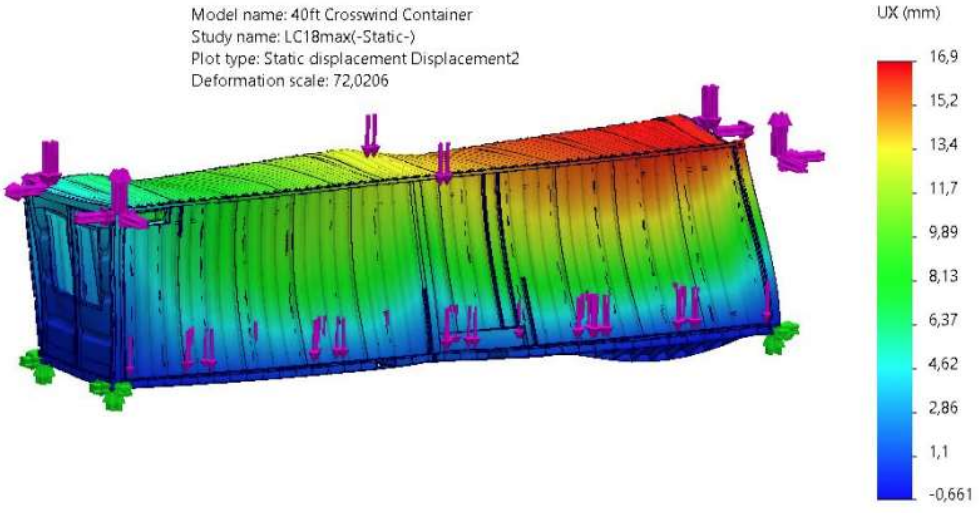


Fig 292: LC18_MAX -Displacement plot-UX

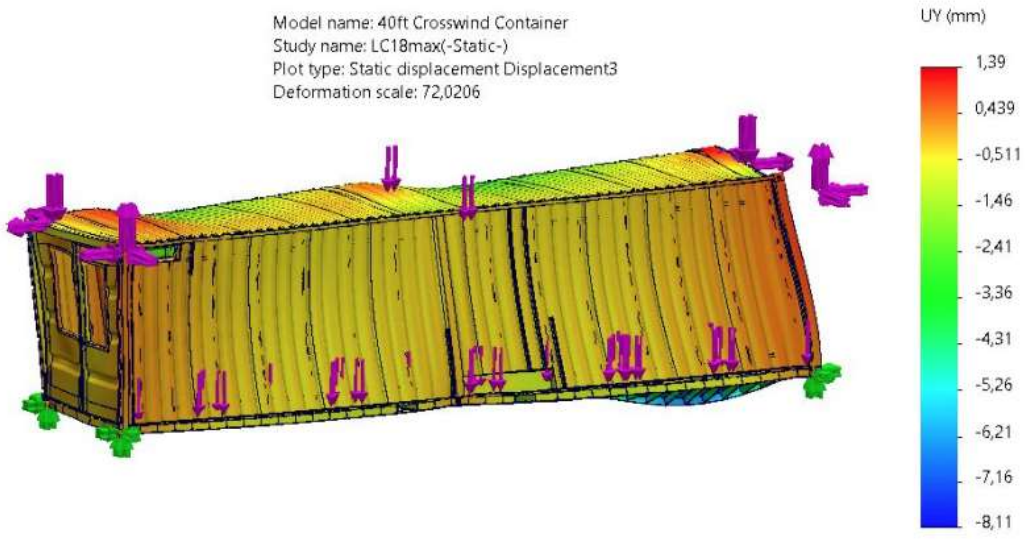


Fig 293: LC18_MAX -Displacement plot-UY

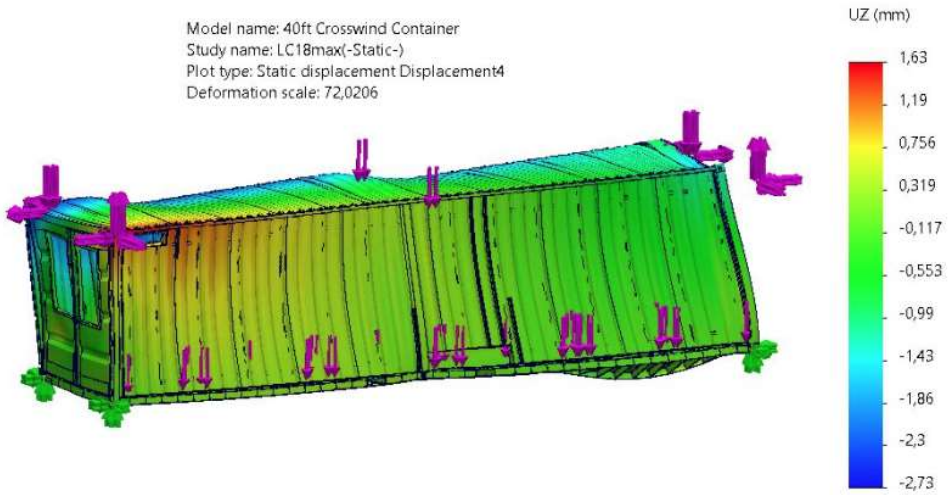


Fig 294: LC18_MAX -Displacement plot-UZ

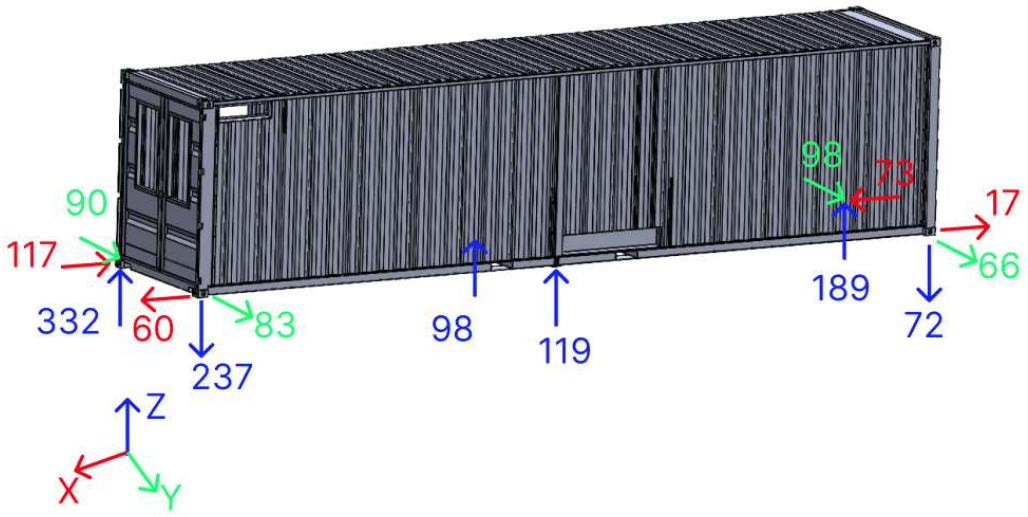
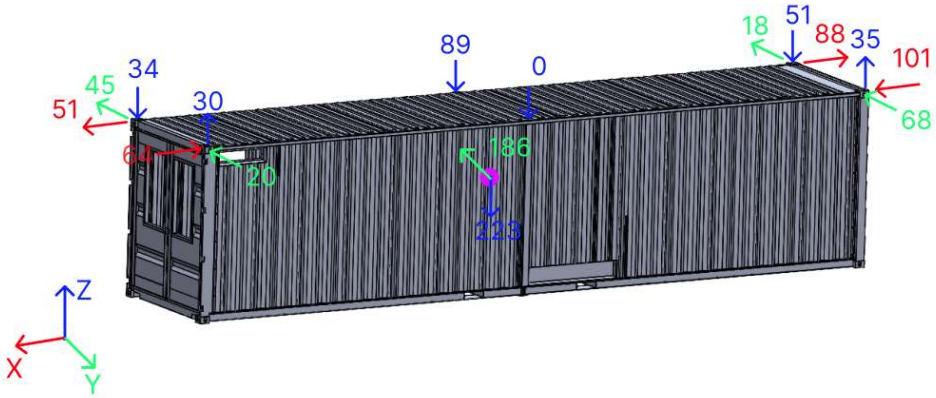


Fig 295: LC18_MAX -Reactions

9.26. LC18-MIN (40ft container + 40ft flatbed)



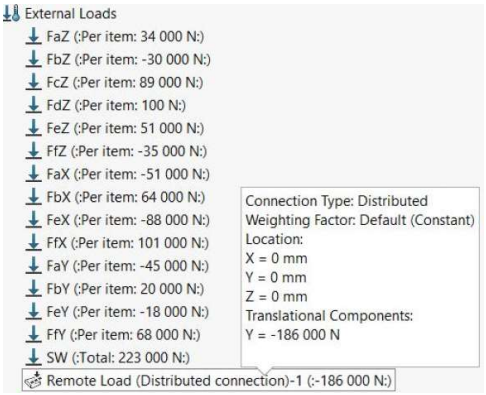


Fig 296: LC18_MIN – 40ft container – Loads

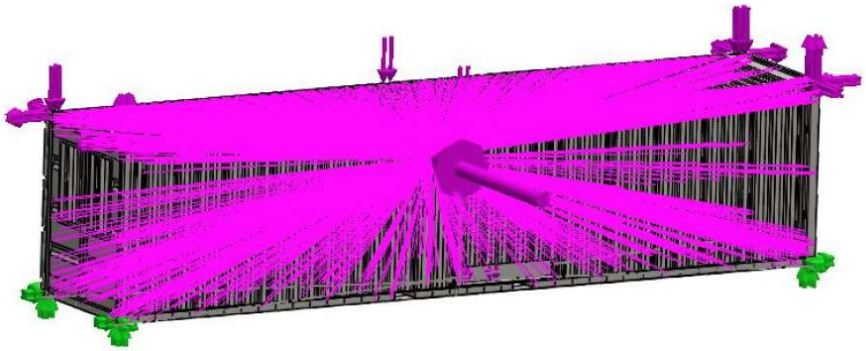


Fig 297: LC18_ MIN -Boundary conditions

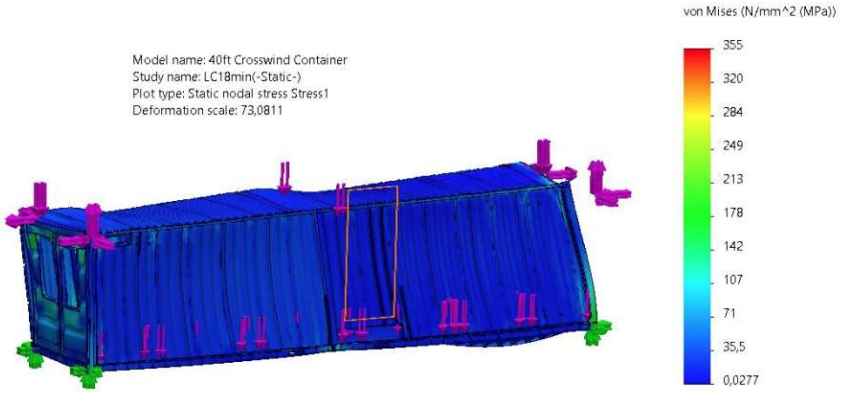


Fig 298: LC18_ MIN -Stress plot



Fig 299: LC18_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

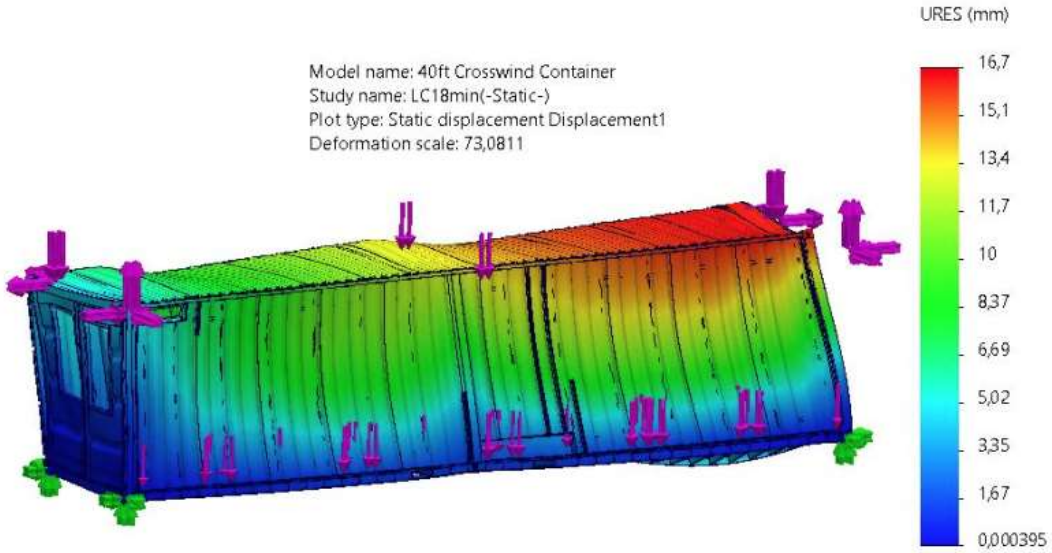


Fig 300: LC18_ MIN -Displacement plot

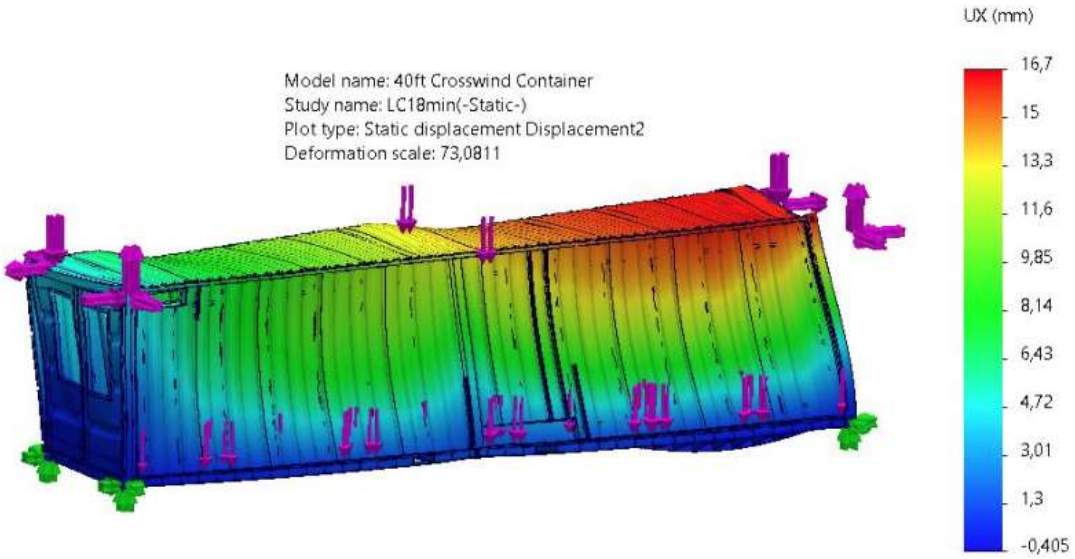


Fig 301: LC18_ MIN -Displacement plot-UX

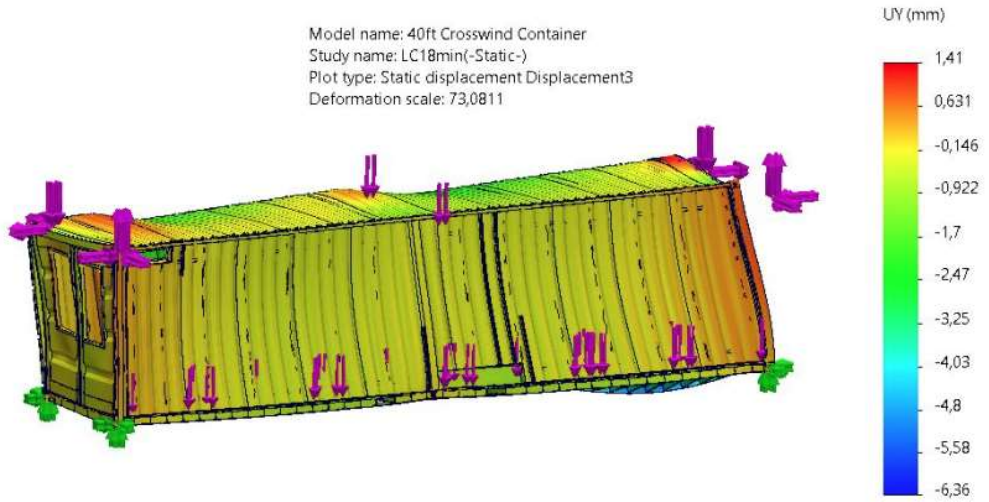


Fig 302: LC18_ MIN -Displacement plot-UY

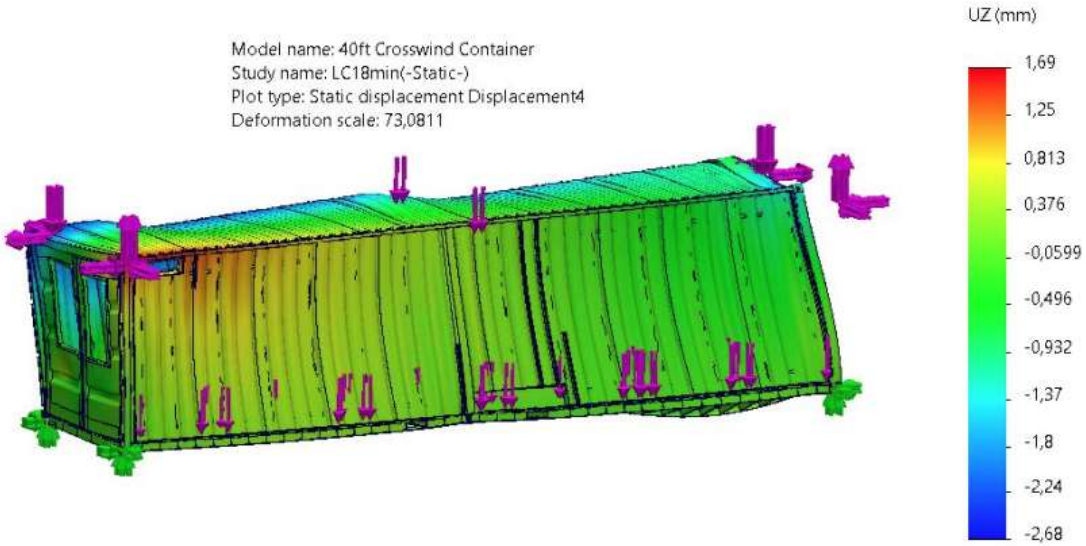


Fig 303: LC18_ MIN -Displacement plot-UZ

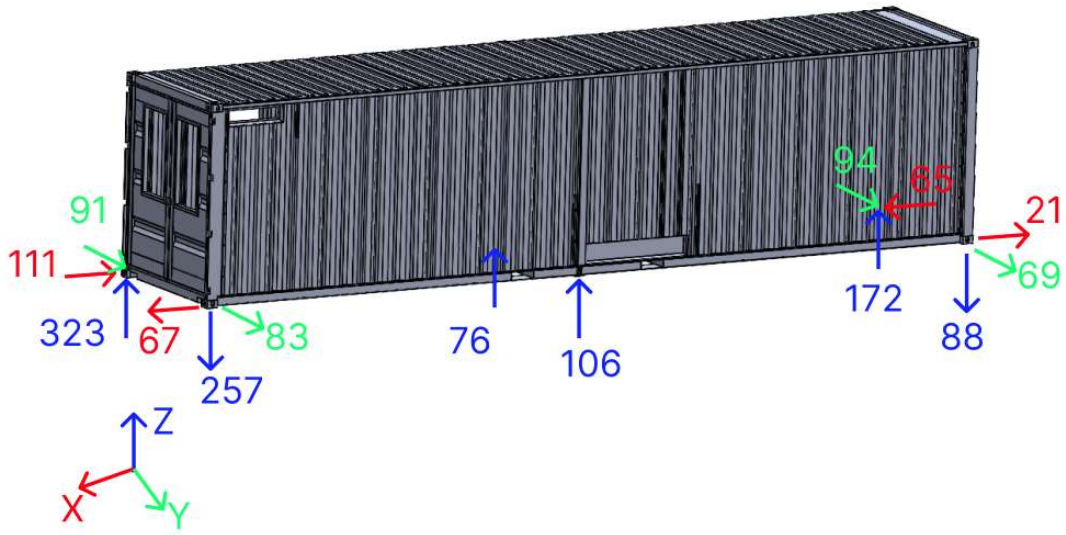


Fig 304: LC18_MIN -Reactions

10. 10ft High Cube Container – FEM simulations

10.1. LC1

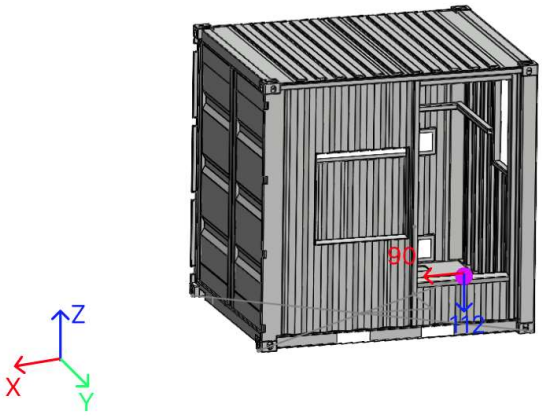


Fig 305: LC1 – 10ft container – Loads

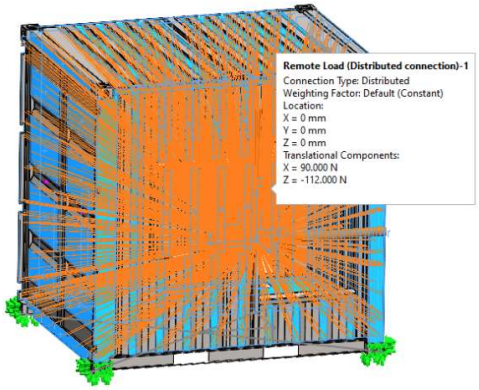


Fig 306: LC1 -Boundary conditions

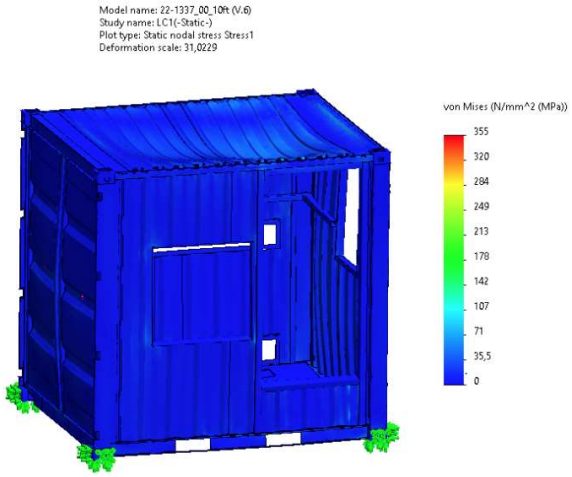


Fig 307: LC1 -Stress plot

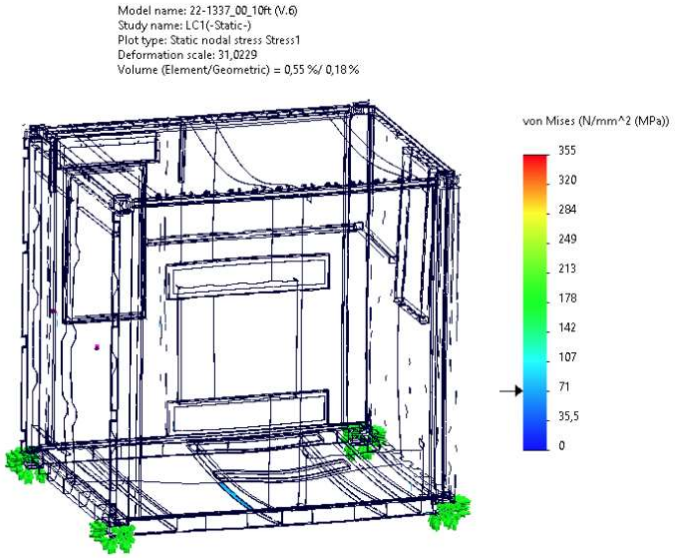


Fig 308: LC1 -Stress plot (the biggest stress in 0,5% of element volume)

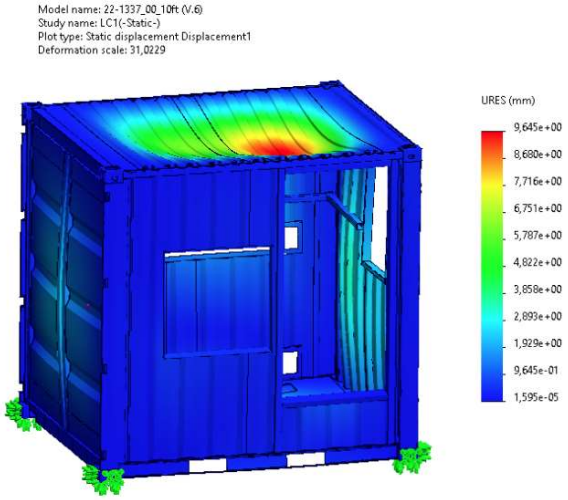


Fig 309: LC1 -Displacement plot

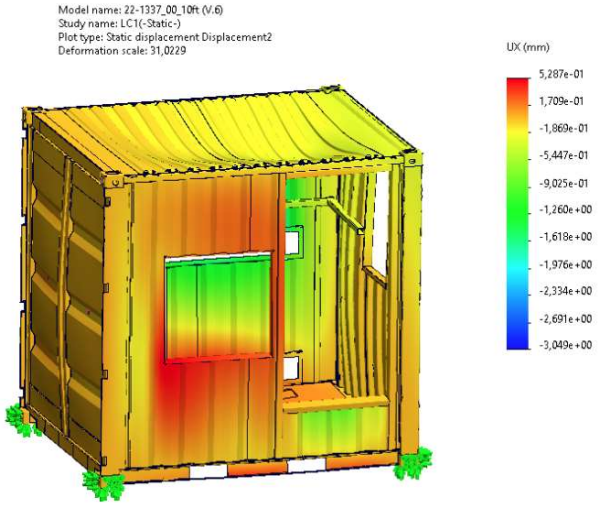


Fig 310: LC1 -Displacement plot-UX

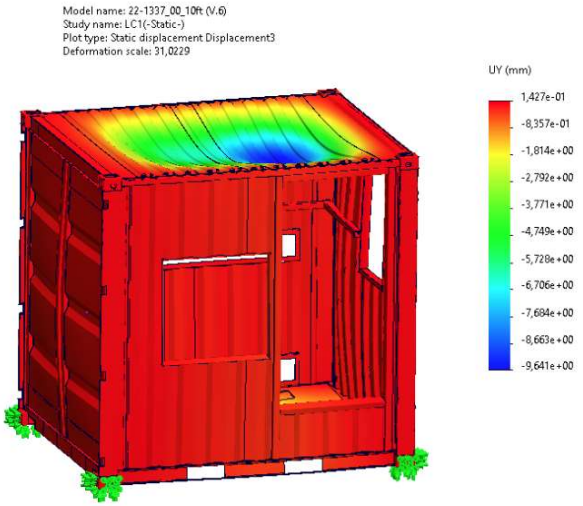


Fig 311: LC1 -Displacement plot-UY

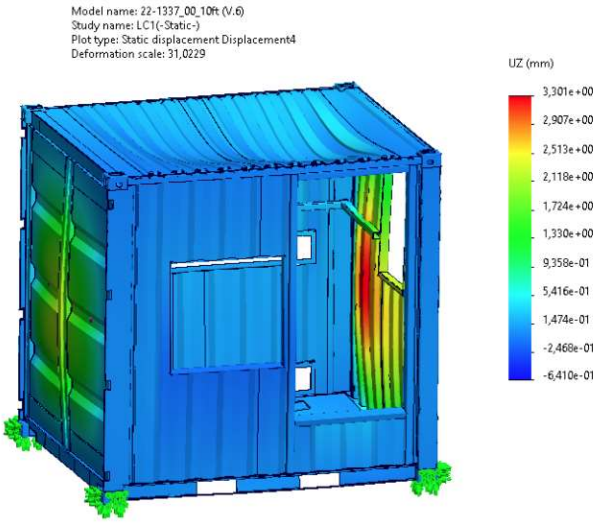


Fig 312: LC1 -Displacement plot-UZ

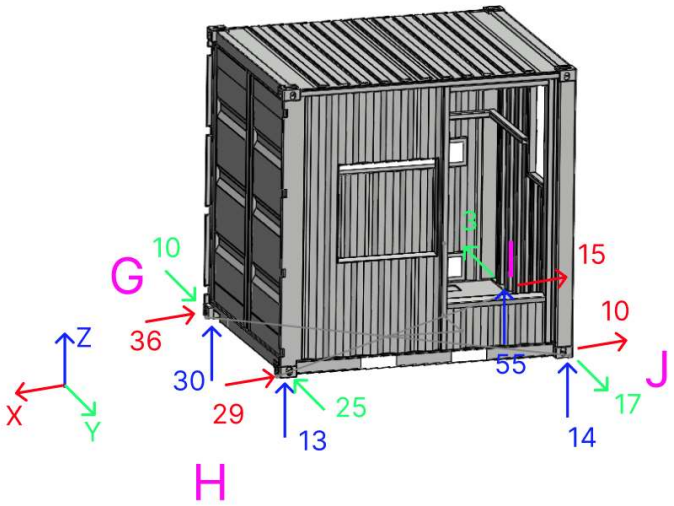


Fig 313: LC1 -Reactions

10.2. LC2

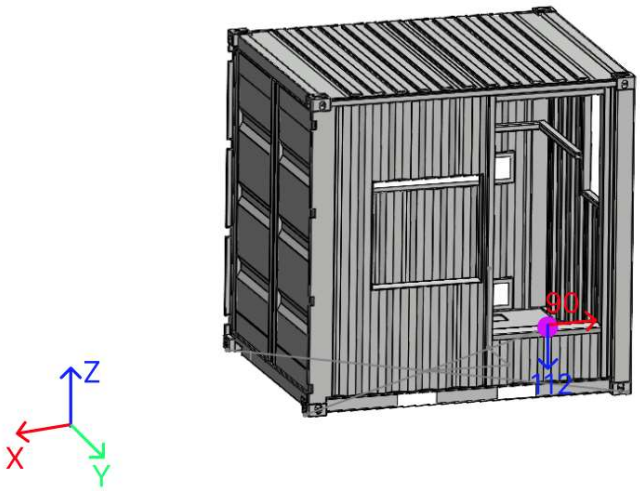


Fig 314: LC2 – 10ft container – Loads

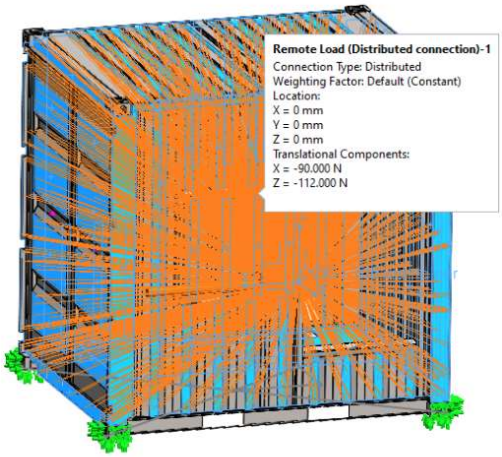


Fig 315: LC2 -Boundary conditions

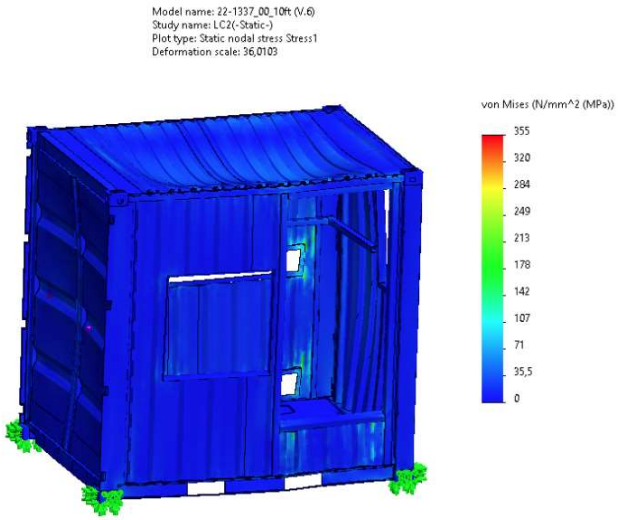


Fig 316: LC2 -Stress plot

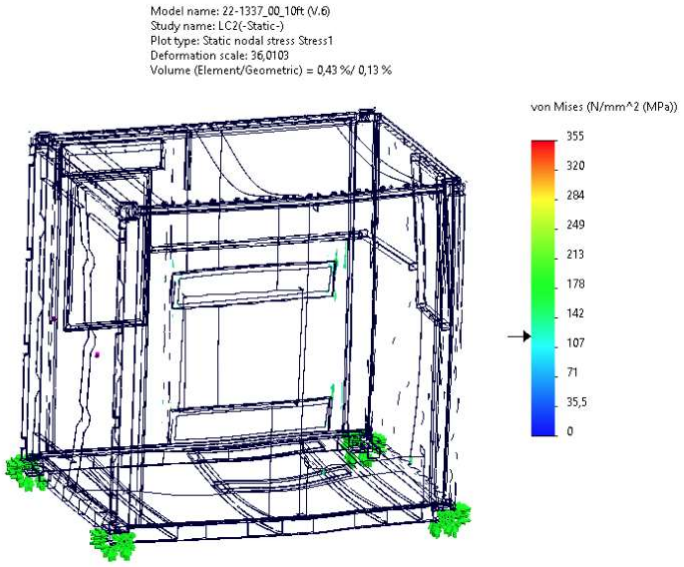


Fig 317: LC5_ BOTTOM -Stress plot (the biggest stress in 0,5% of element volume)

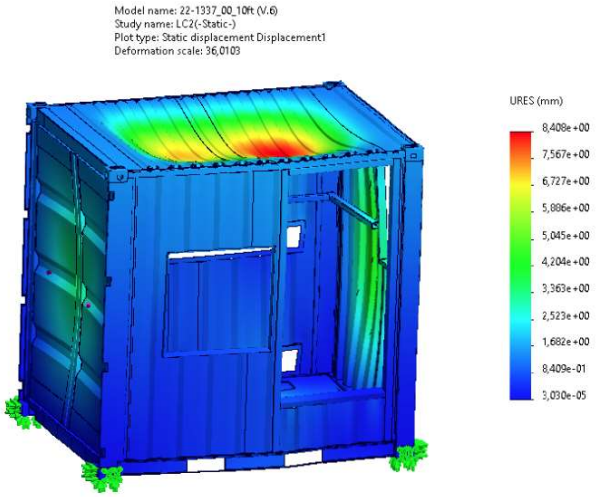


Fig 318: LC5_ BOTTOM -Displacement plot

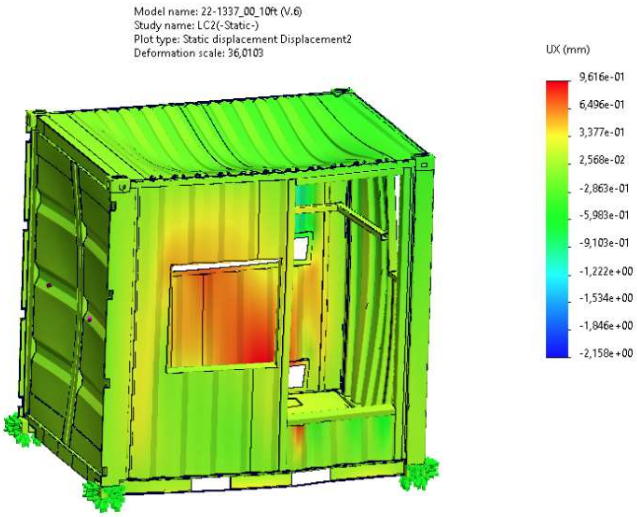


Fig 319: LC5_ BOTTOM -Displacement plot-UX

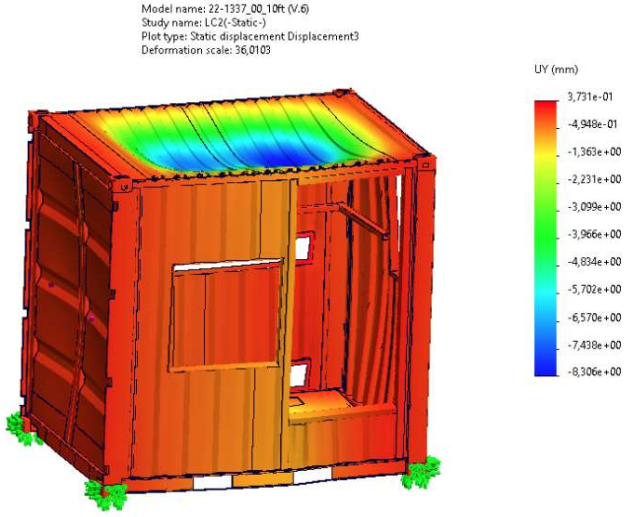


Fig 320: LC2 -Displacement plot-UY

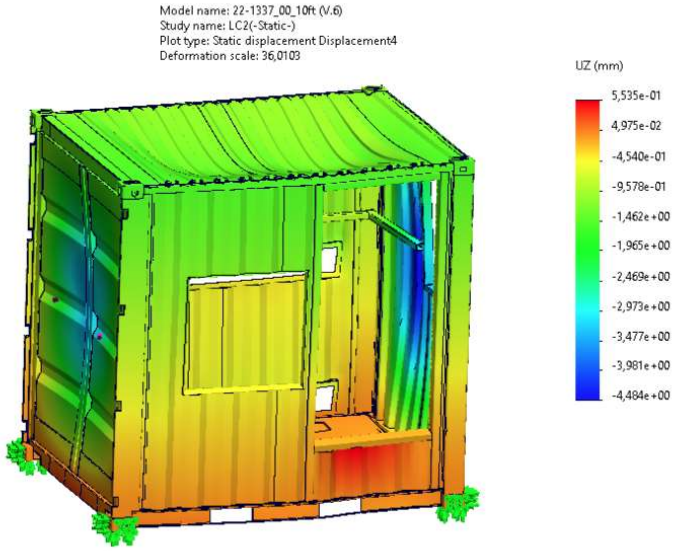


Fig 321: LC2 -Displacement plot-UZ

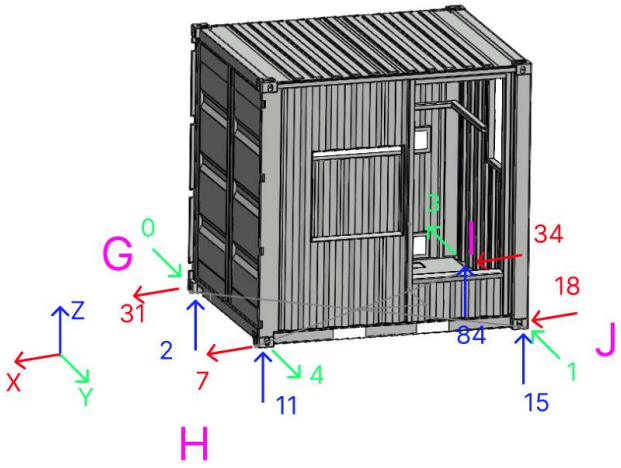


Fig 322: LC2 -Reactions

10.3. LC3

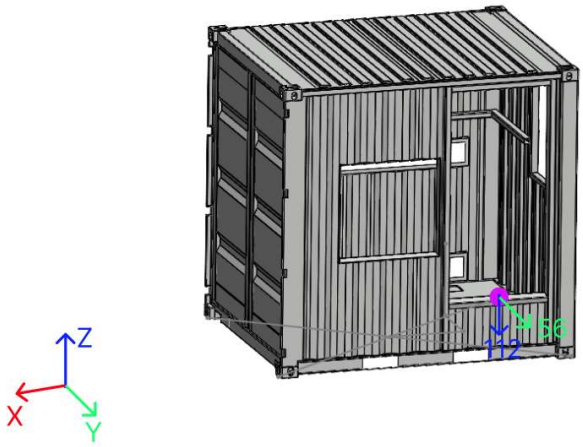


Fig 323: LC3 – 10ft container – Loads

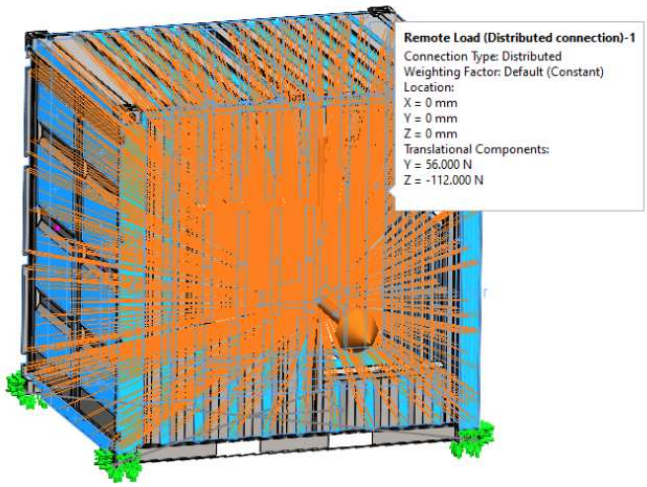


Fig 324: LC3 -Boundary conditions

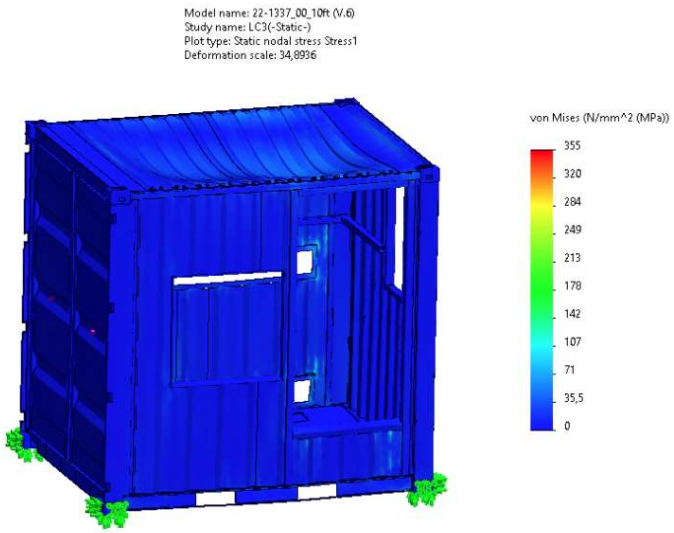


Fig 325: LC3 -Stress plot

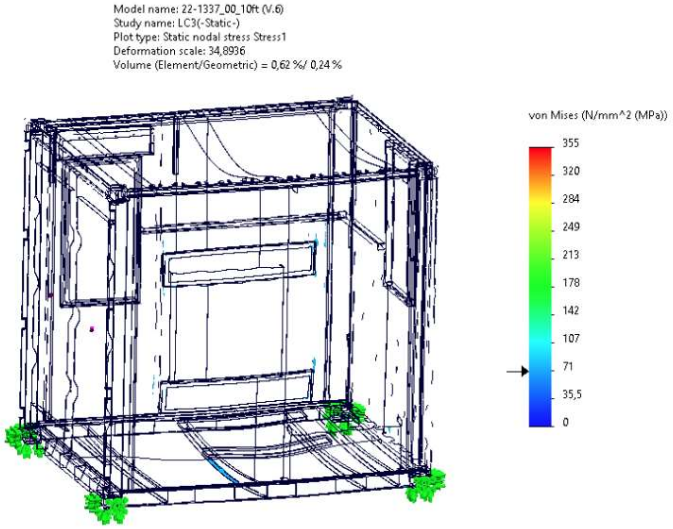


Fig 326: LC3 -Stress plot (the biggest stress in 0,5% of element volume)

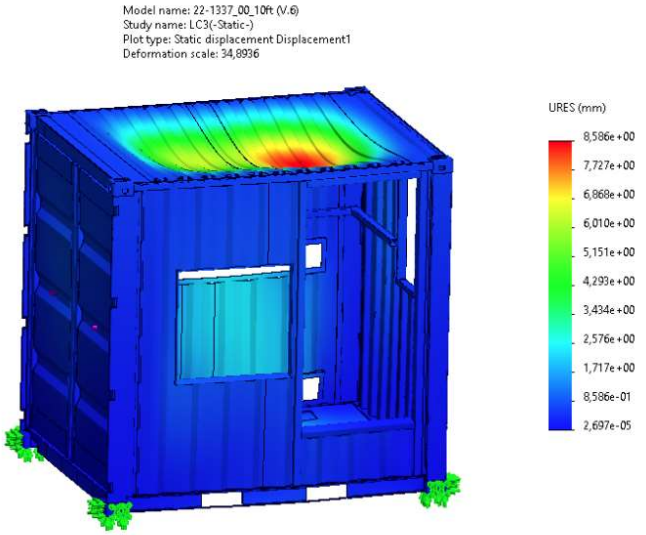


Fig 327: LC3 -Displacement plot

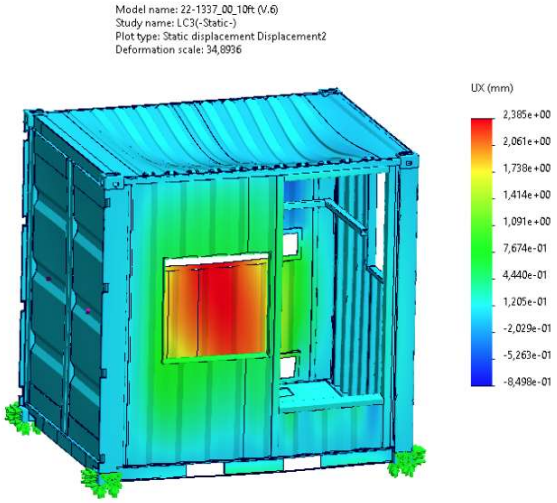


Fig 328: LC3 -Displacement plot-UX

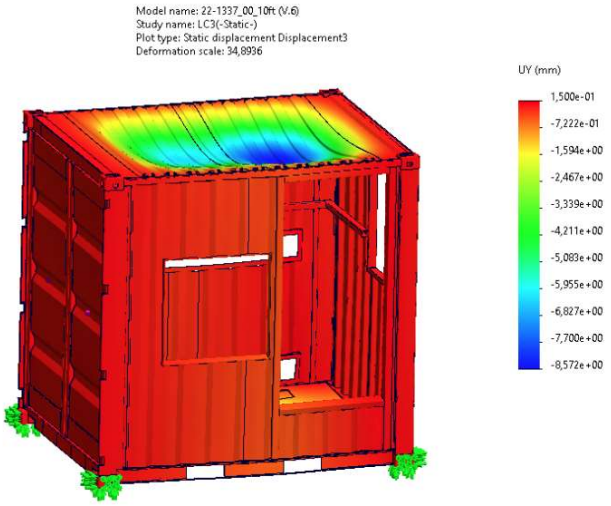


Fig 329: LC3 -Displacement plot-UY

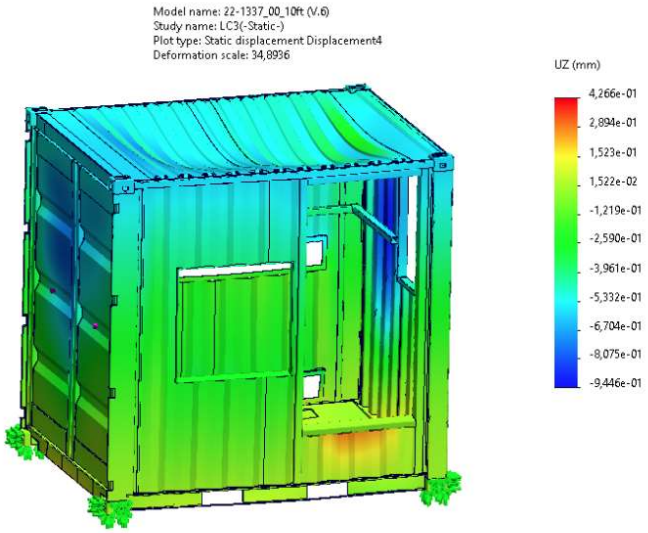


Fig 330: LC3 -Displacement plot-UZ

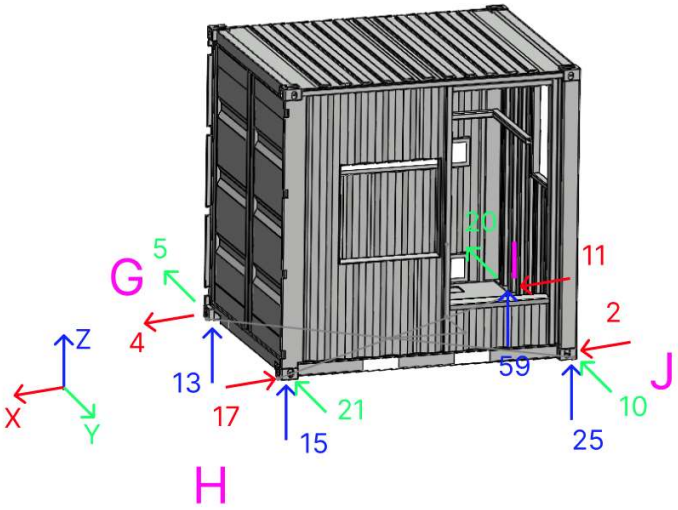


Fig 331: LC3 -Reactions

10.4. LC4

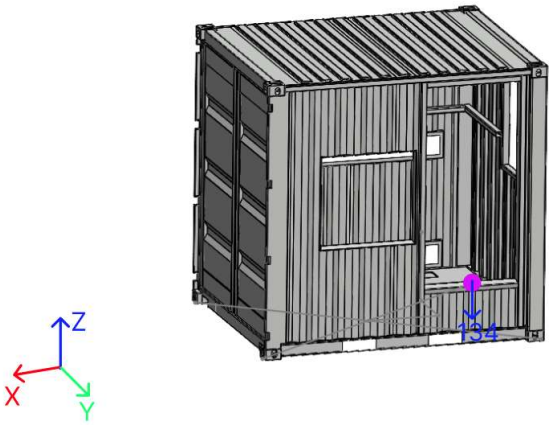


Fig 332: L4 – 10ft container – Loads

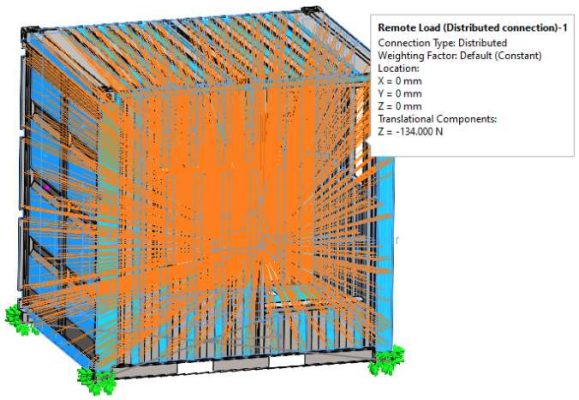


Fig 333: LC4 -Boundary conditions

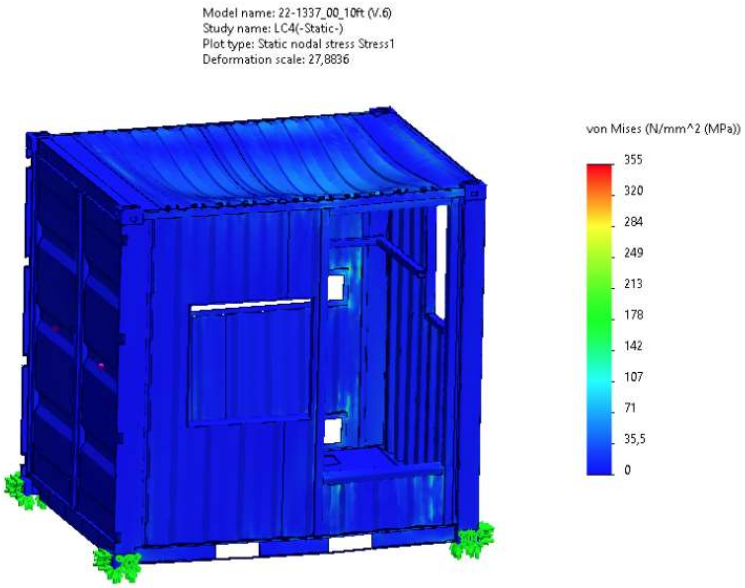


Fig 334: LC4 -Stress plot

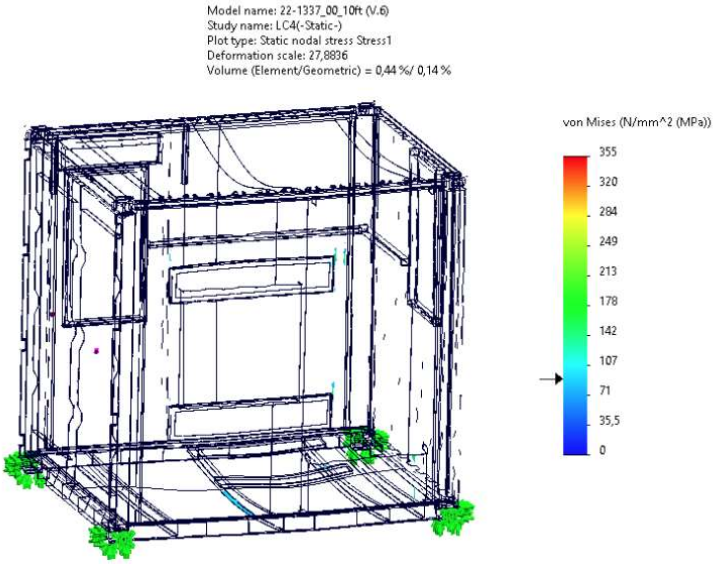


Fig 335: LC4 -Stress plot (the biggest stress in 0,5% of element volume)

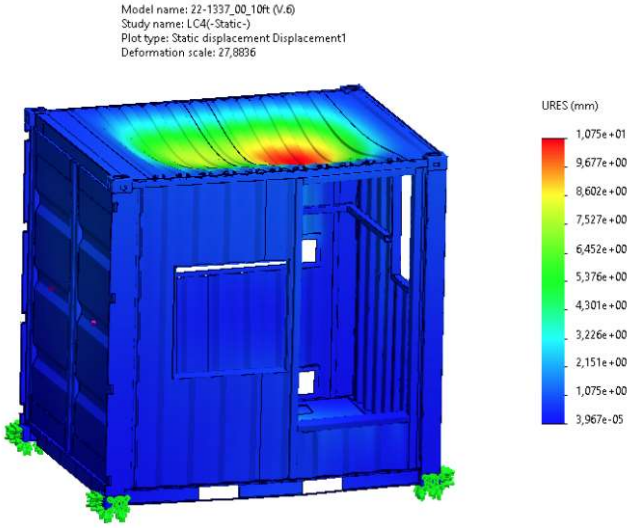


Fig 336: LC4 -Displacement plot

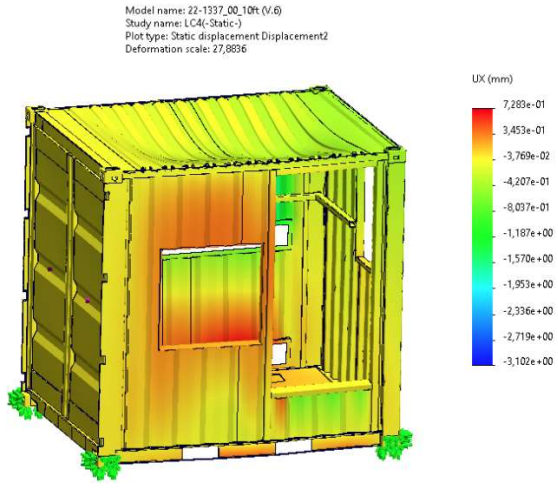


Fig 337: LC4 -Displacement plot-UX

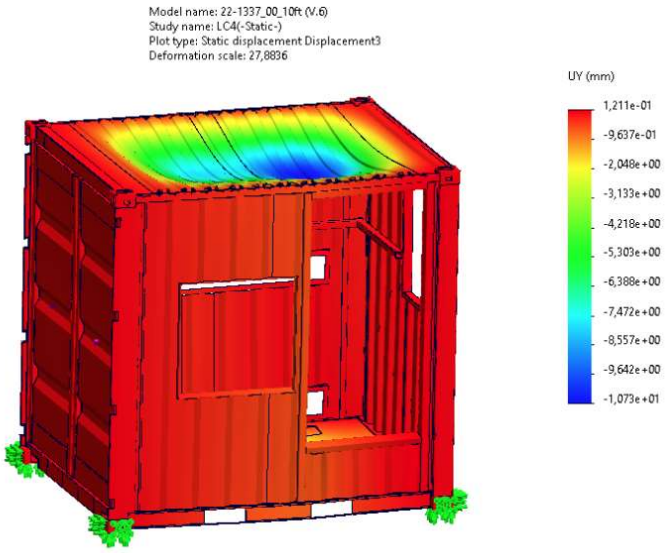


Fig 338: LC4 -Displacement plot-UY

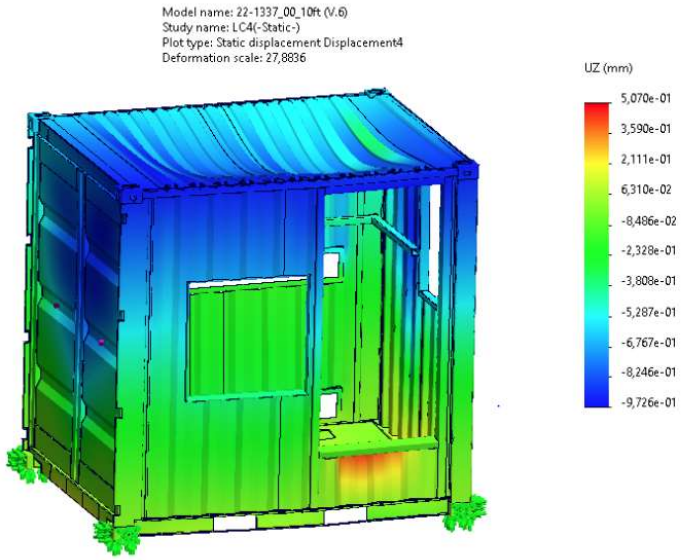


Fig 339: LC4 -Displacement plot-UZ

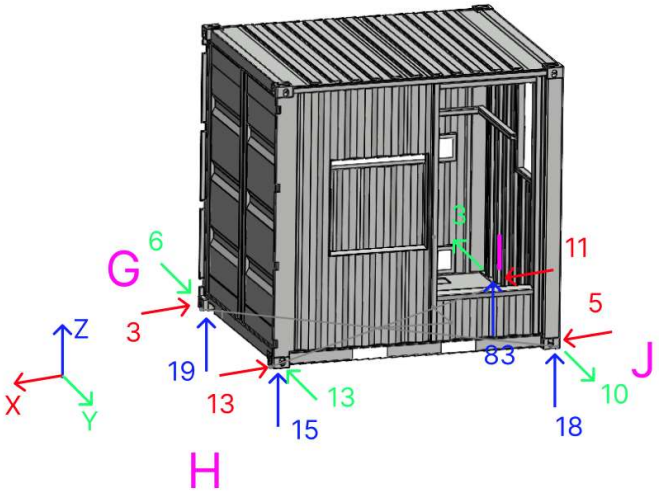


Fig 340: LC4 -Reactions

10.5. LC5_TOP

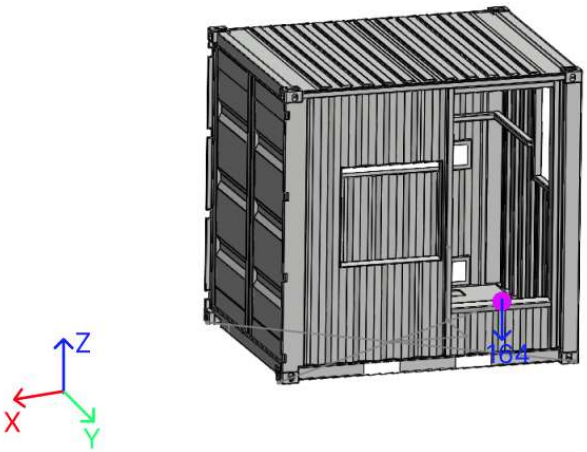


Fig 341: LC5_TOP – 10ft container – Loads

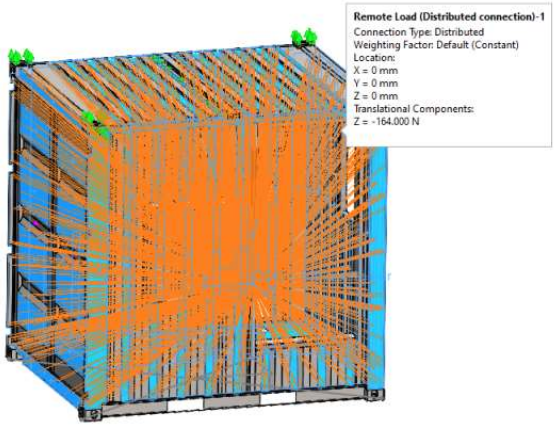


Fig 342: LC5_ TOP -Boundary conditions

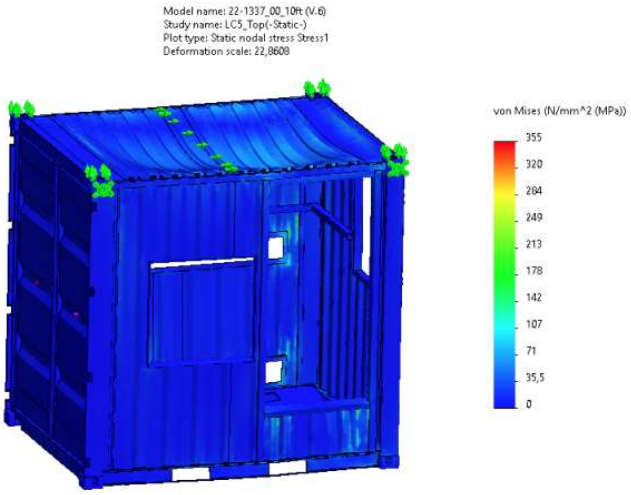


Fig 343: LC5_ TOP -Stress plot

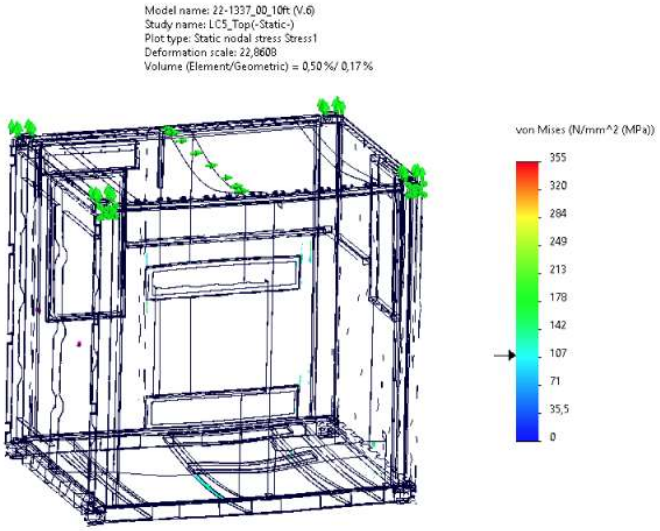


Fig 344: LC5_ TOP -Stress plot (the biggest stress in 0,5% of element volume)

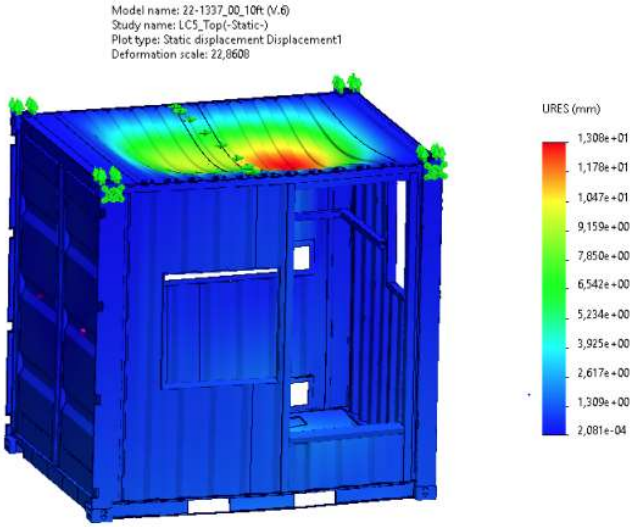


Fig 345: LC5_ TOP -Displacement plot

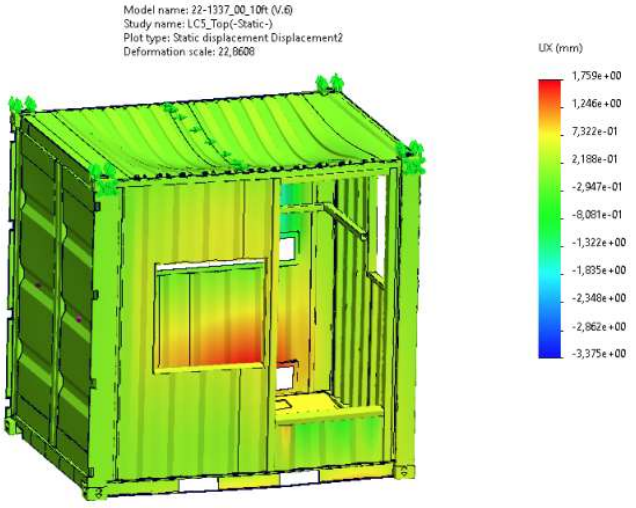


Fig 346: LC5_ TOP -Displacement plot-UX

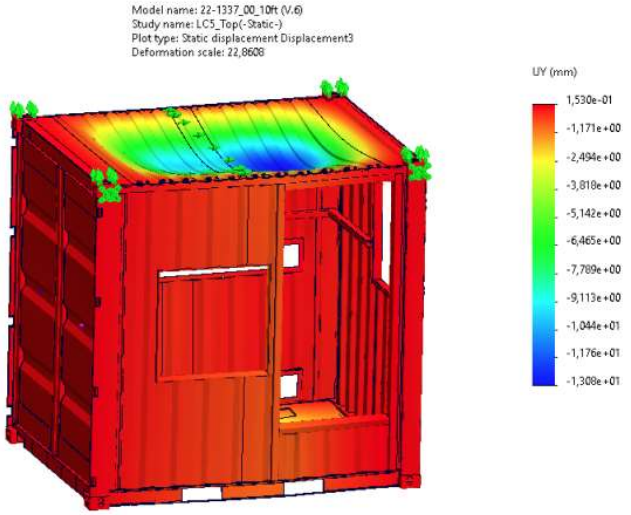


Fig 347: LC5_ TOP -Displacement plot-UY

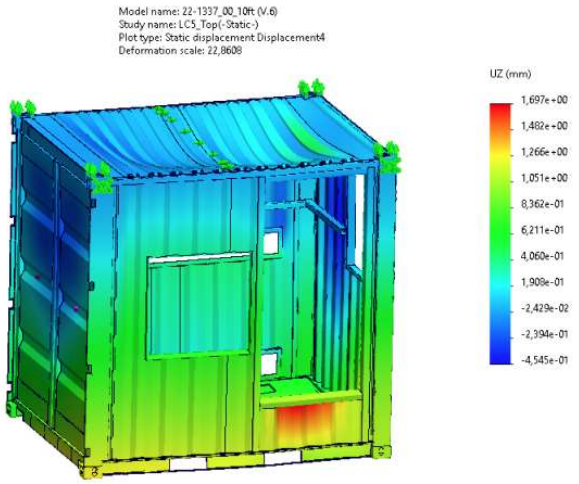


Fig 348: LC5_ TOP -Displacement plot-UZ

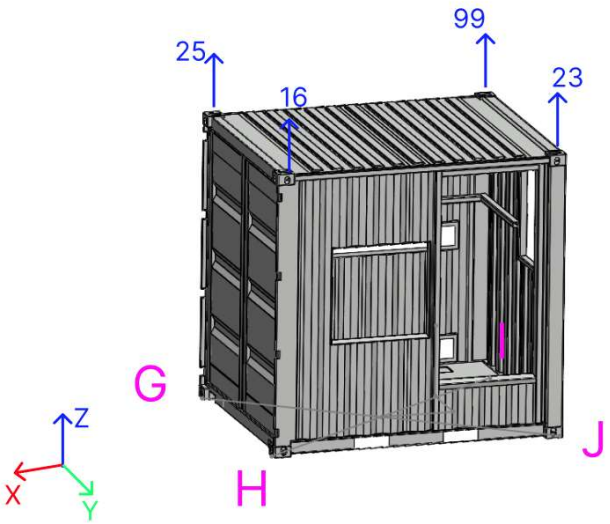


Fig 349: LC5_ TOP -Reactions

10.6. LC5_ BOTTOM

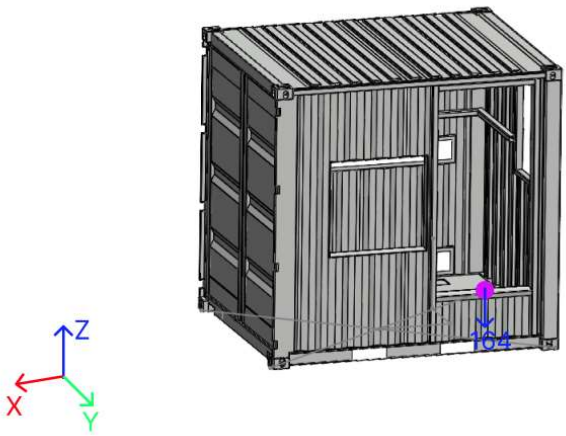


Fig 350: LC5_BOTTOM – 10ft container – Loads

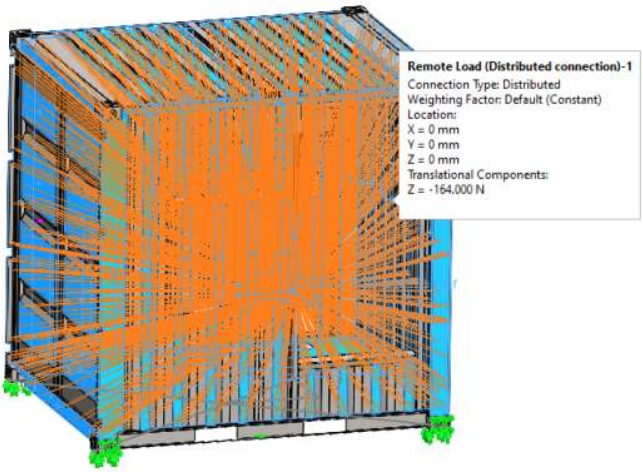


Fig 351: LC5_ BOTTOM -Boundary conditions

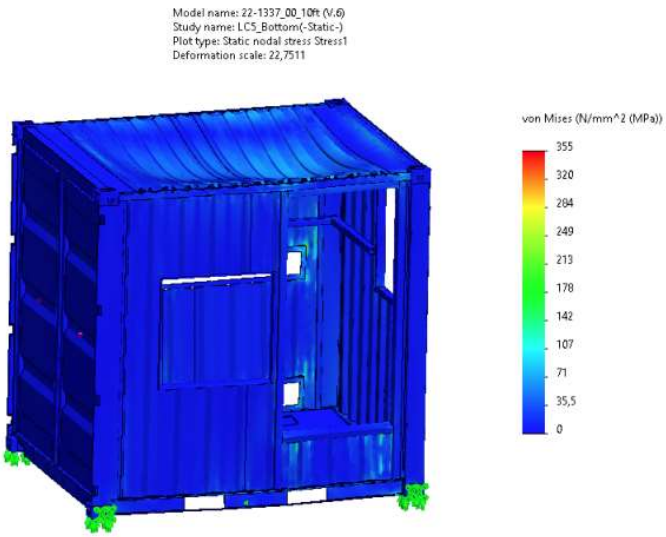


Fig 352: LC5_ BOTTOM -Stress plot

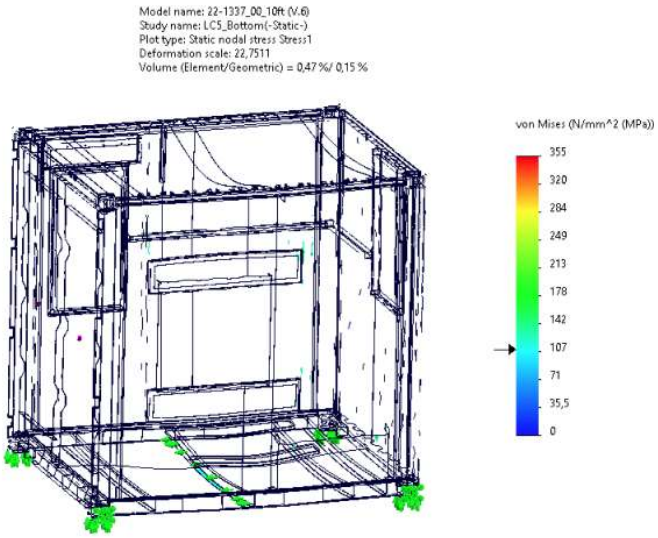


Fig 353: LC5_ BOTTOM -Stress plot (the biggest stress in 0,5% of element volume)

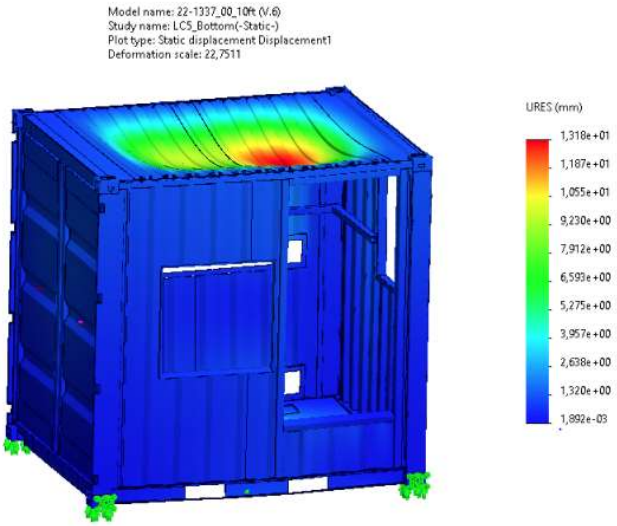


Fig 354: LC5_ BOTTOM -Displacement plot

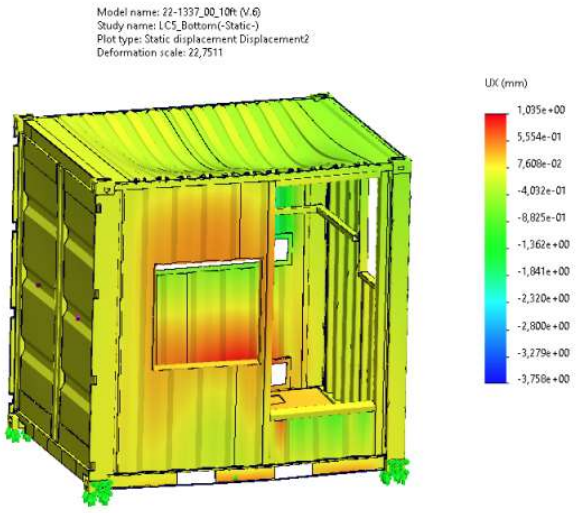


Fig 355: LC5_ BOTTOM -Displacement plot-UX

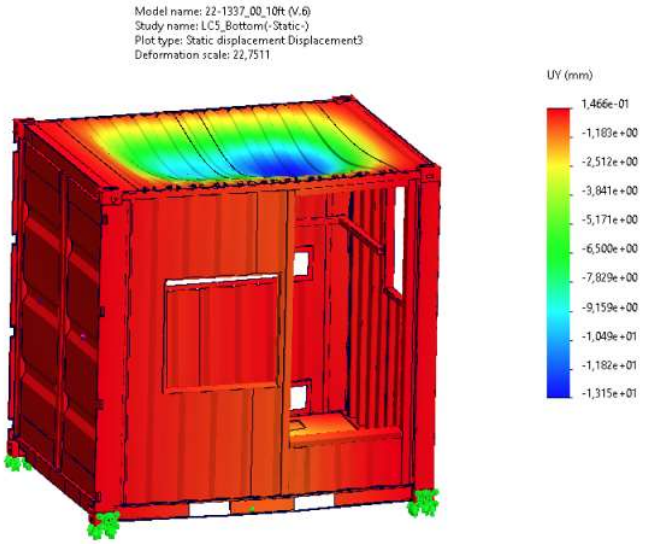


Fig 356: LC5_ BOTTOM -Displacement plot-UY

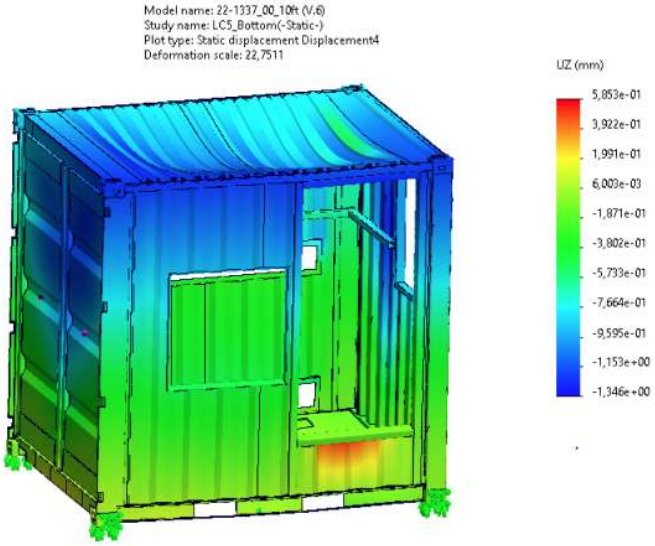


Fig 357: LC5_ BOTTOM -Displacement plot-UZ

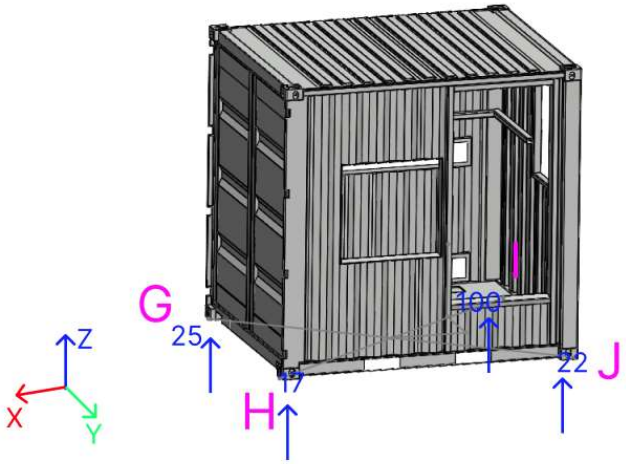


Fig 358: LC5_ BOTTOM -Reactions

10.7. LC7-MAX

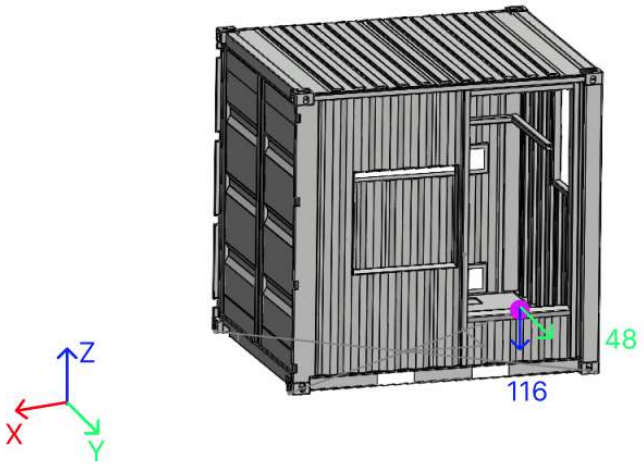


Fig 359: LC7_MAX – 10ft container – Loads

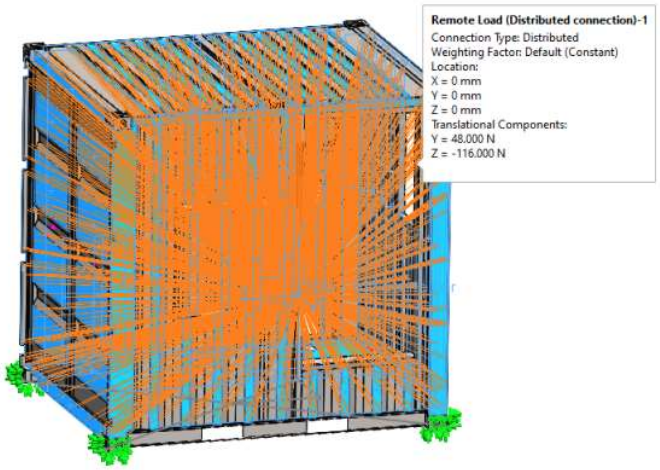


Fig 360: LC7_ MAX -Boundary conditions

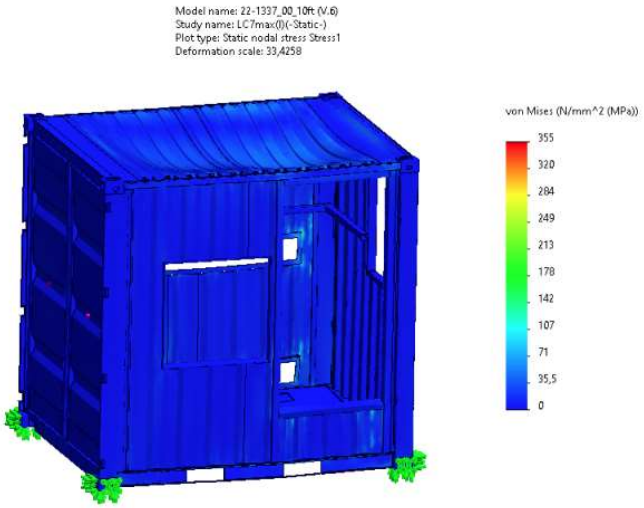


Fig 361: LC7_ MAX -Stress plot

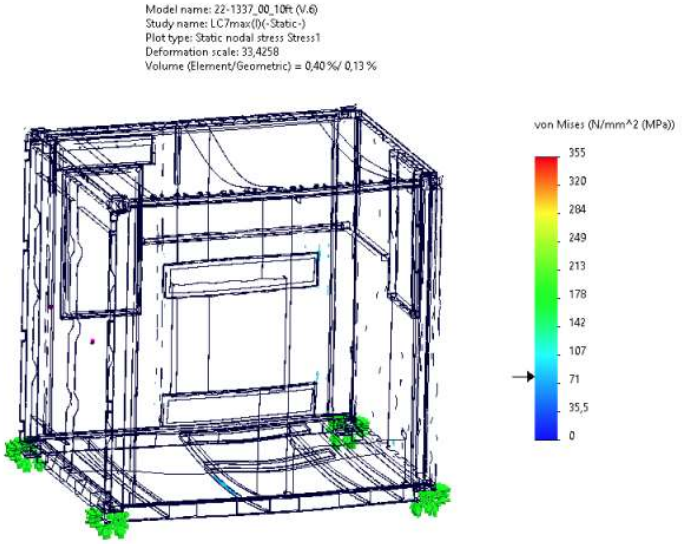


Fig 362: LC7_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

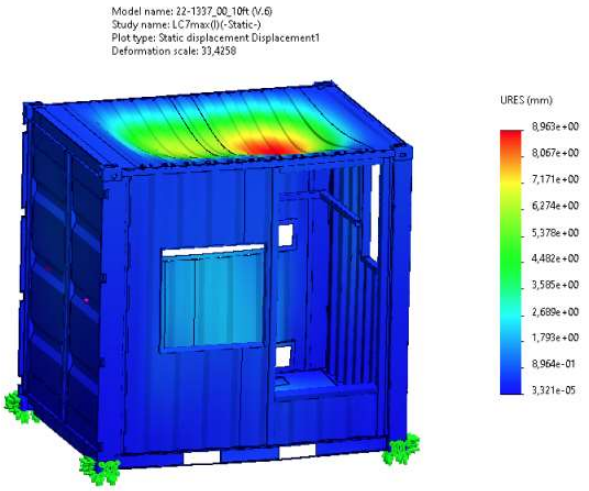


Fig 363: LC7_ MAX -Displacement plot

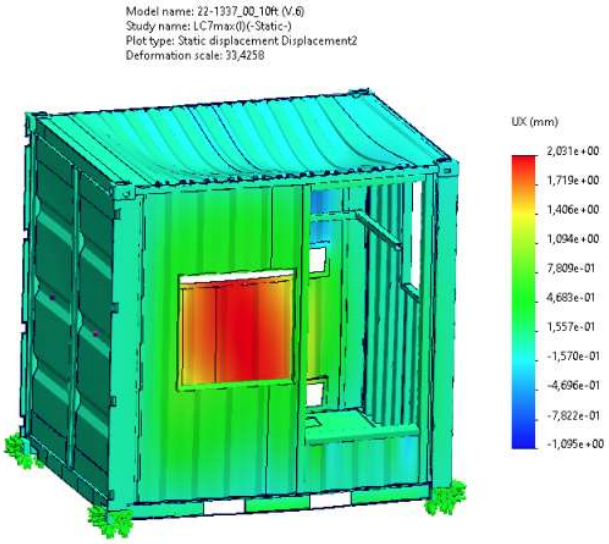


Fig 364: LC7_ MAX -Displacement plot-UX

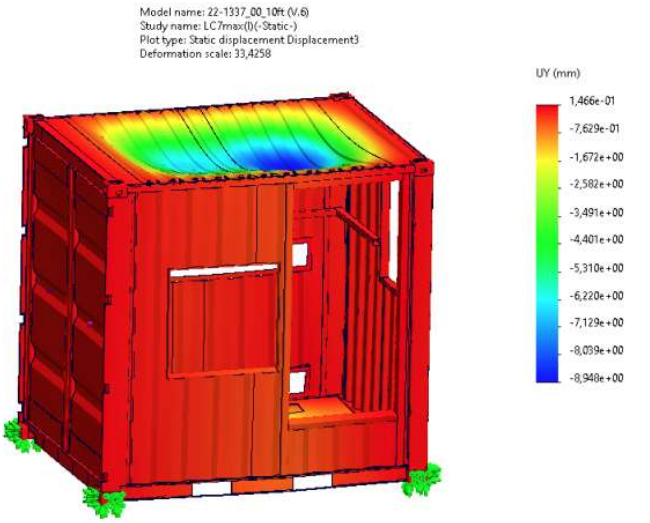


Fig 365: LC7_ MAX -Displacement plot-UY

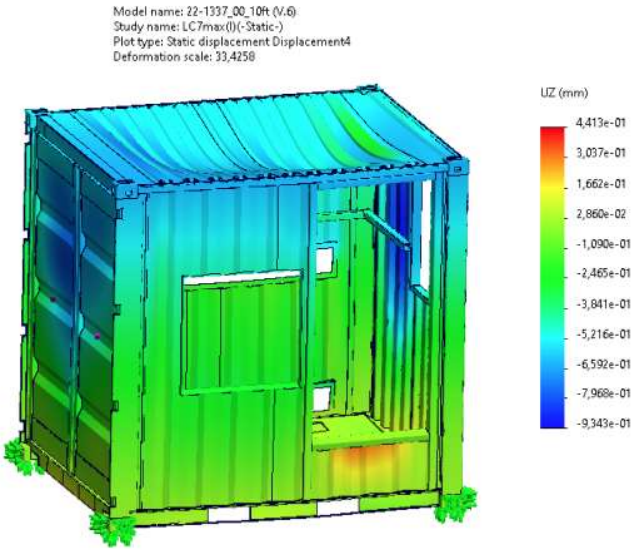


Fig 366: LC7_ MAX -Displacement plot-UZ

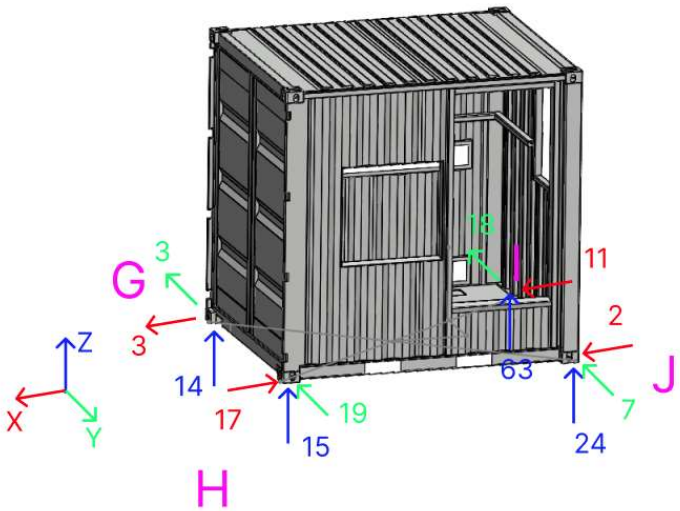


Fig 367: LC7_ MAX -Reactions

10.8. LC7-MIN

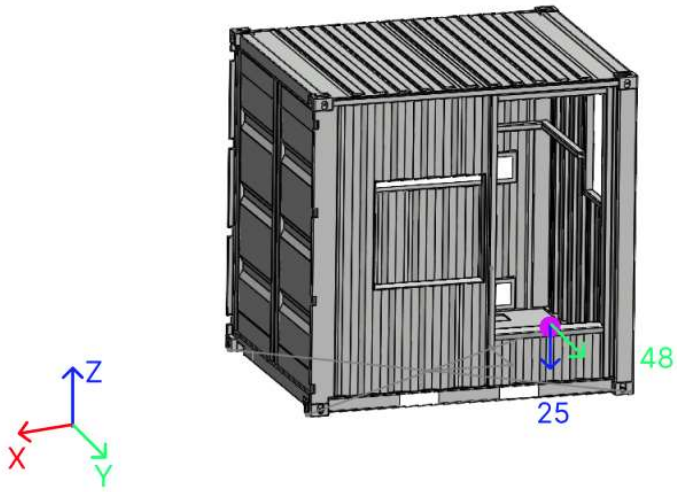


Fig 368: LC7_MIN – 10ft container – Loads

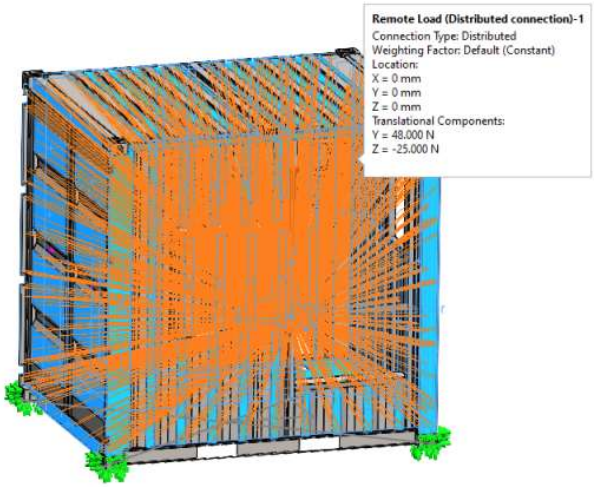


Fig 369: LC7_ MIN -Boundary conditions

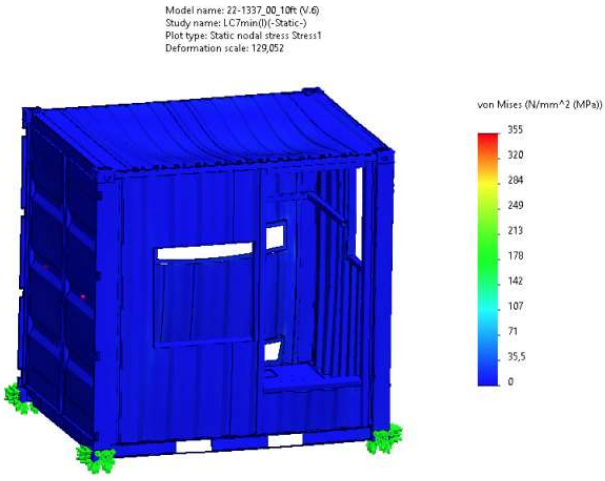


Fig 370: LC7_ MIN -Stress plot

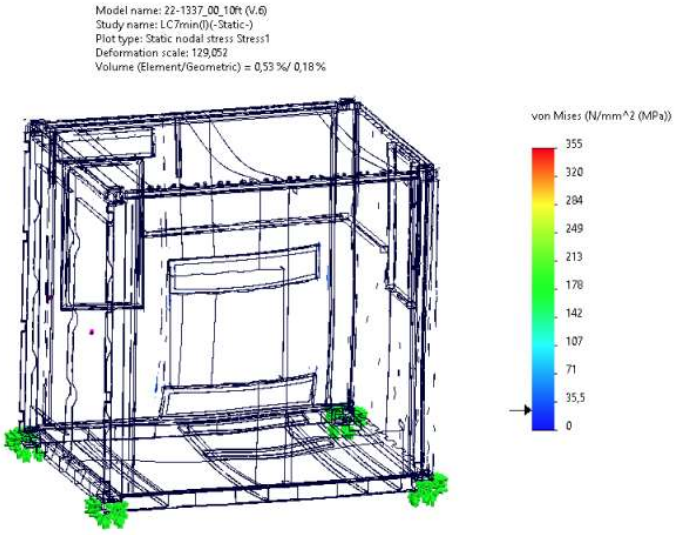


Fig 371: LC7_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

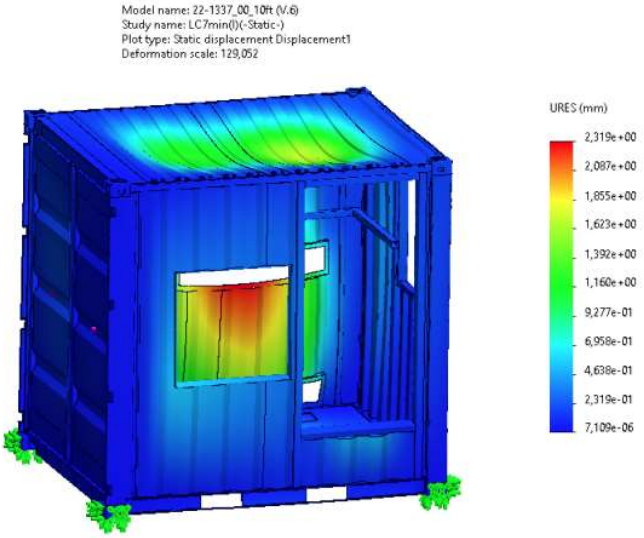


Fig 372: LC7_ MIN -Displacement plot

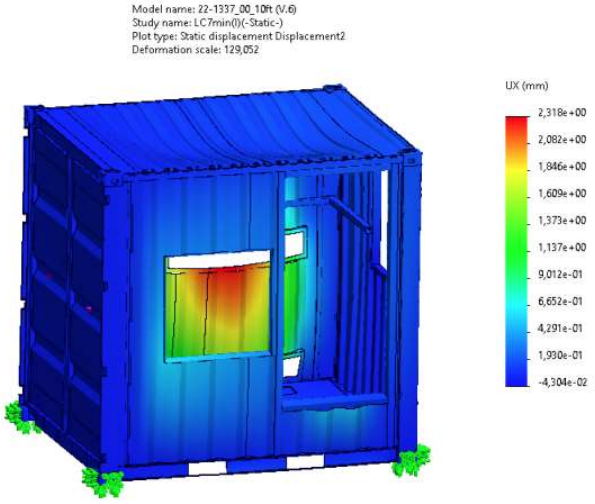


Fig 373: LC7_ MIN -Displacement plot-UX

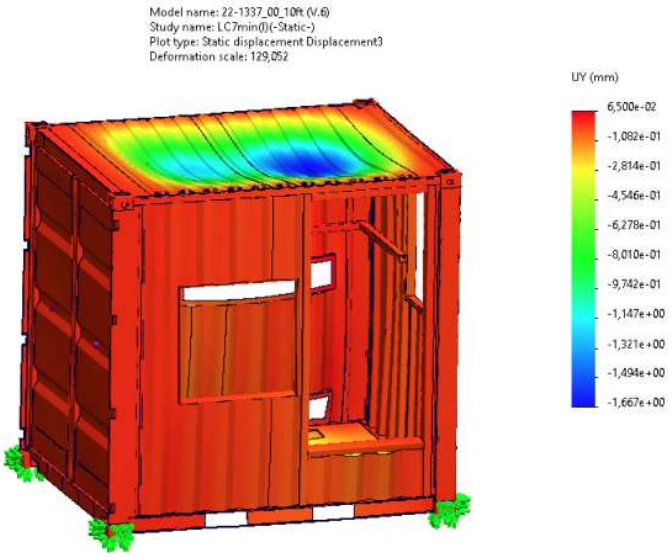


Fig 374: LC7_ MIN -Displacement plot-UY

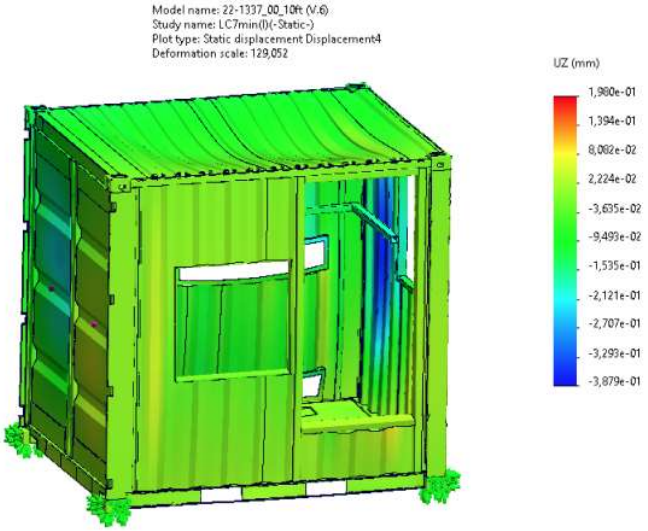


Fig 375: LC7_ MIN -Displacement plot-UZ

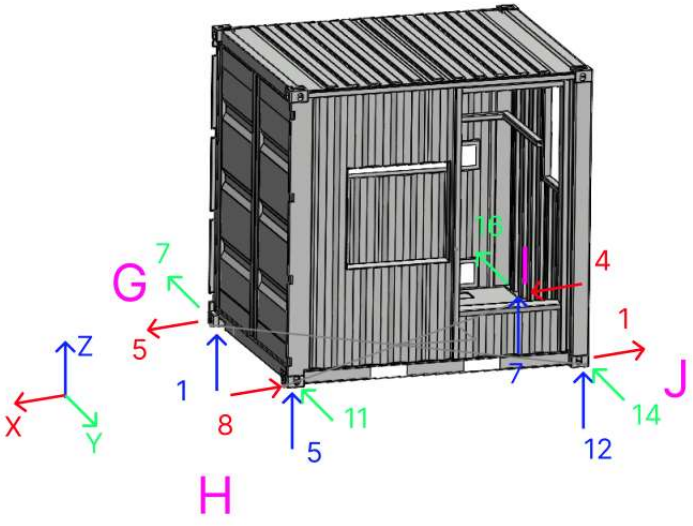


Fig 376: LC7_ MIN -Reactions

10.9. LC8-MAX

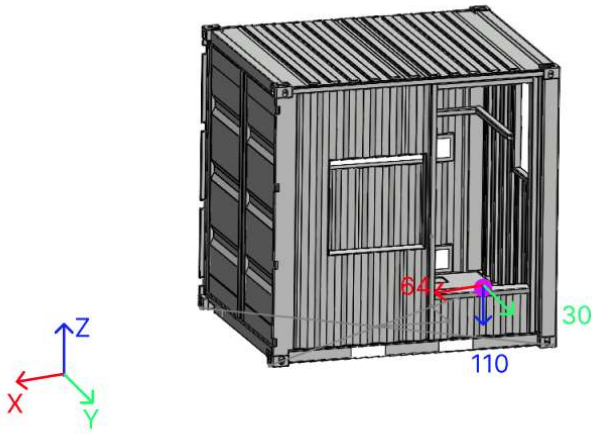


Fig 377: LC8_MAX – 10ft container – Loads

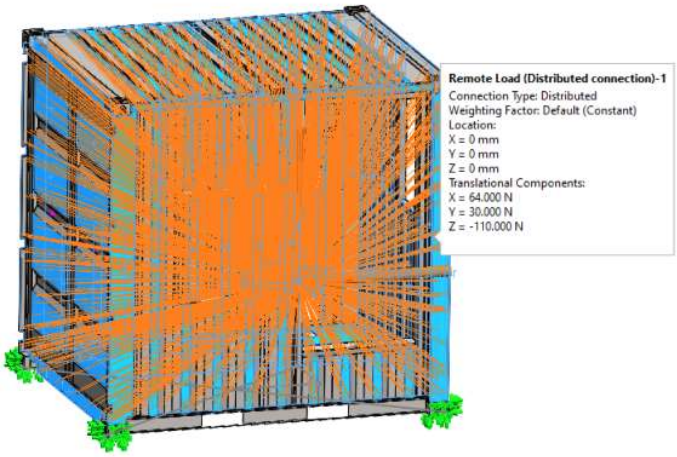


Fig 378: LC8_ MAX -Boundary conditions

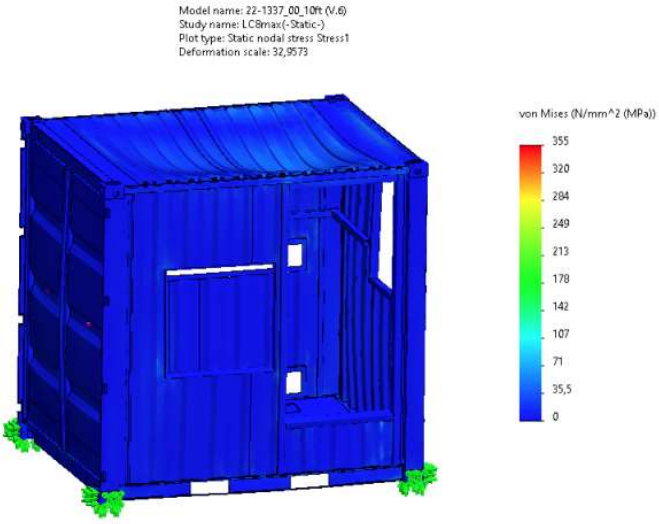


Fig 379: LC8_ MAX -Stress plot

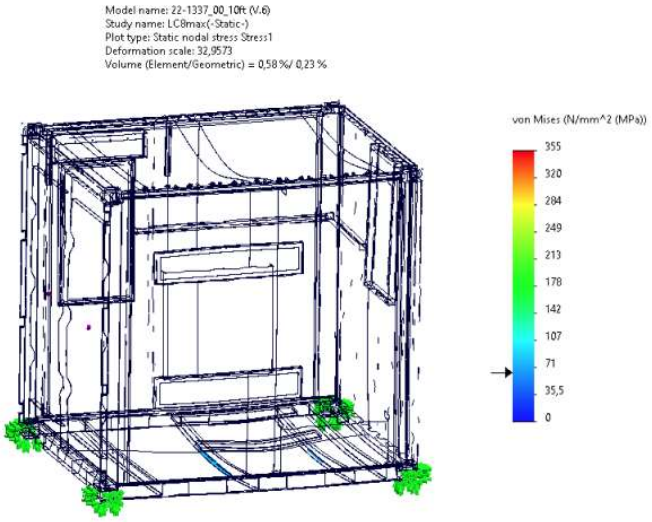


Fig 380: LC8_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

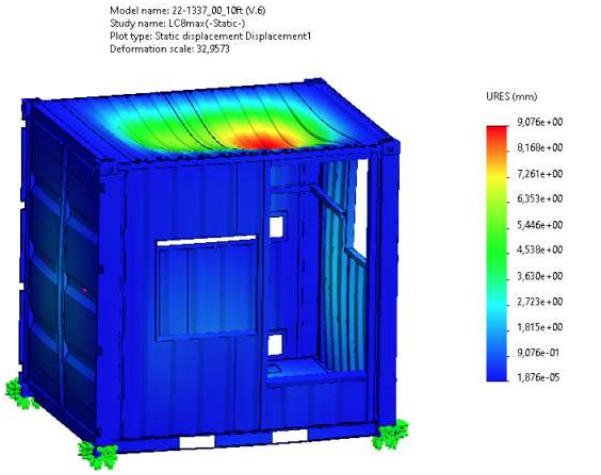


Fig 381: LC8_ MAX -Displacement plot

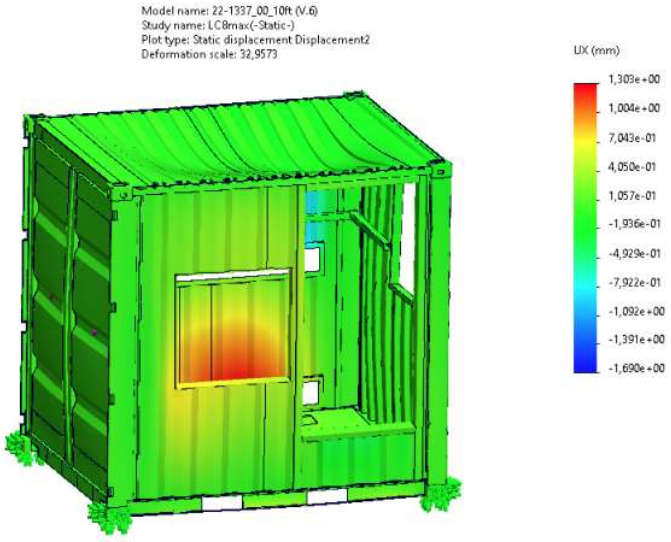


Fig 382: LC8_ MAX -Displacement plot-UX

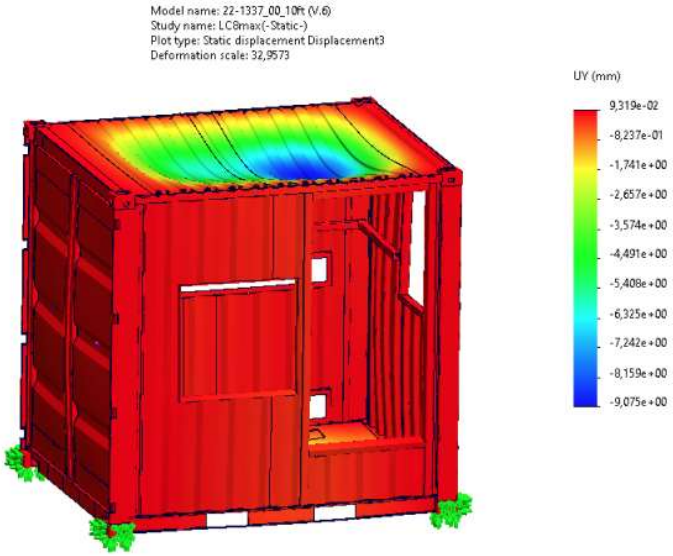


Fig 383: LC8_ MAX -Displacement plot-UY

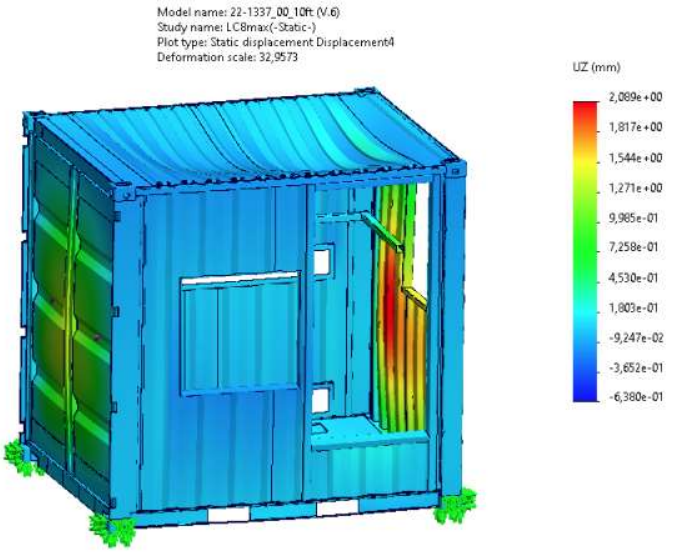


Fig 384: LC8_ MAX -Displacement plot-UZ

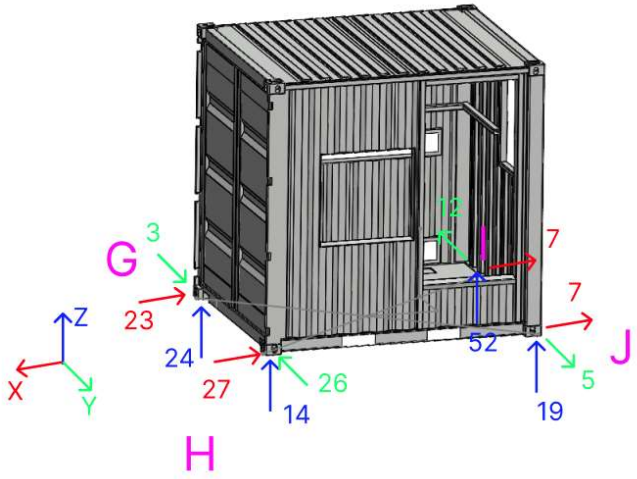


Fig 385: LC8_ MAX -Reactions

10.10.LC8-MIN

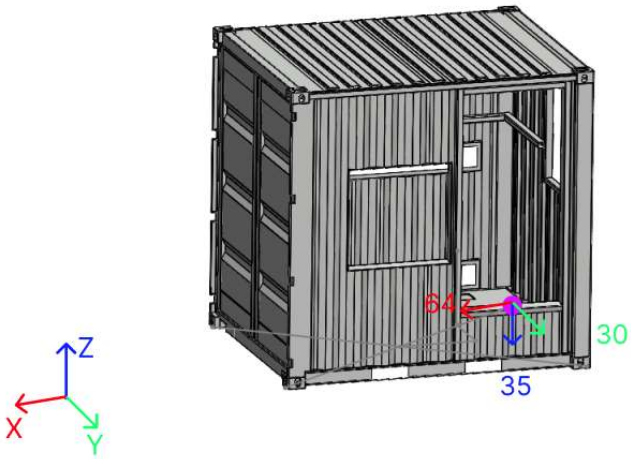


Fig 386: LC8_MIN – 10ft container – Loads

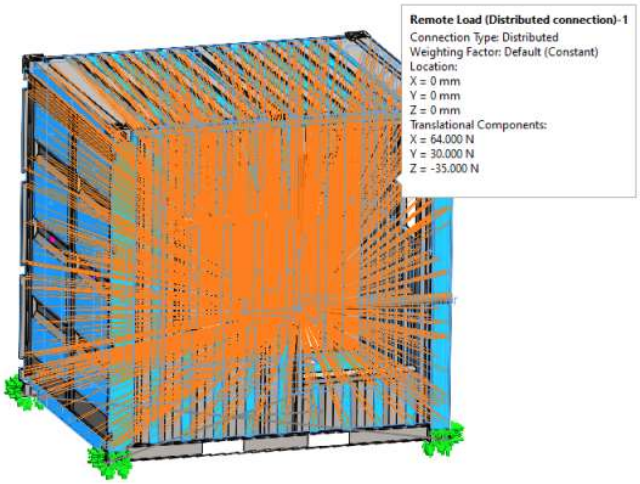


Fig 387: LC8_ MIN -Boundary conditions

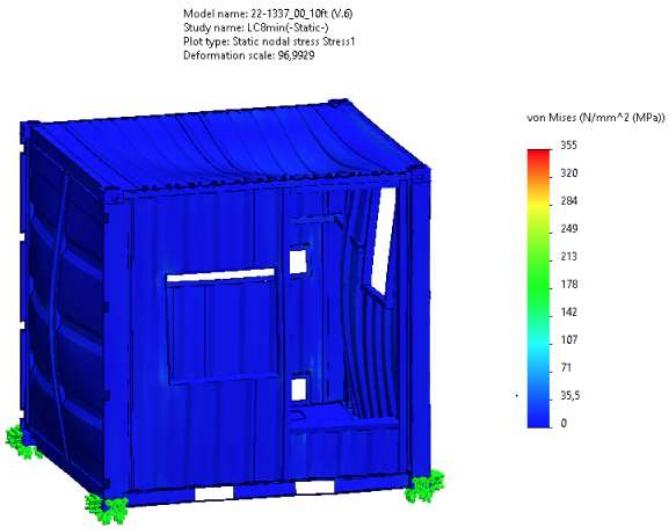


Fig 388: LC8_ MIN -Stress plot

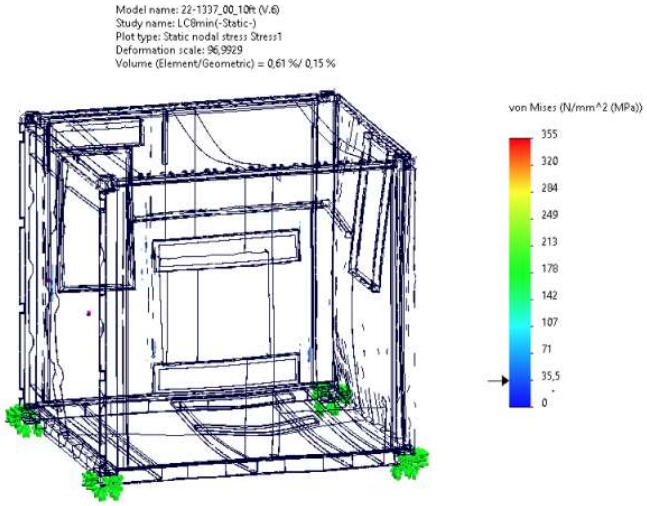


Fig 389: LC8_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

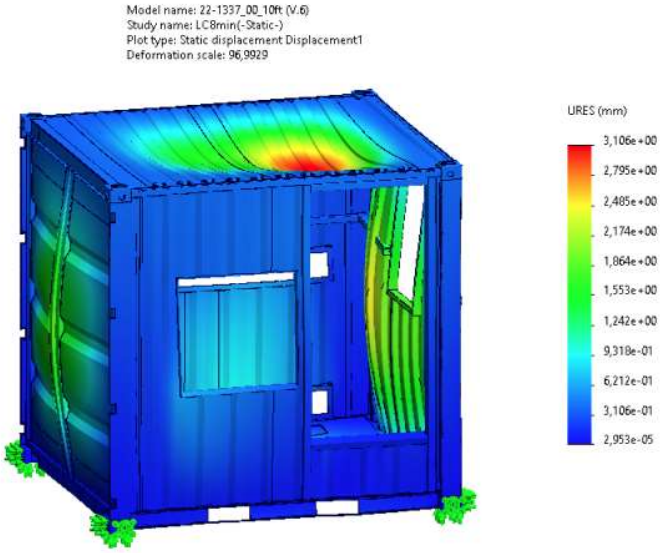


Fig 390: LC8_ MIN -Displacement plot

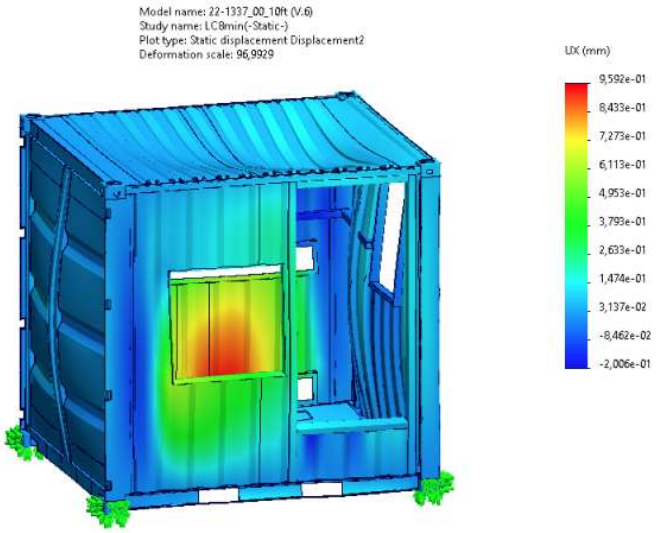


Fig 391: LC8_ MIN -Displacement plot-UX

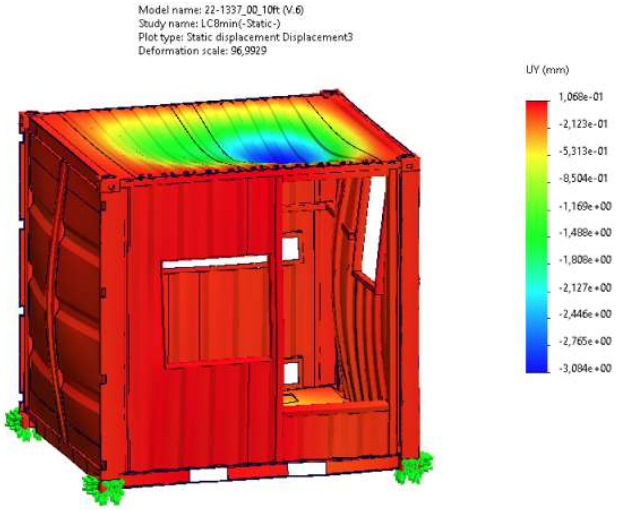


Fig 392: LC8_ MIN -Displacement plot-UY

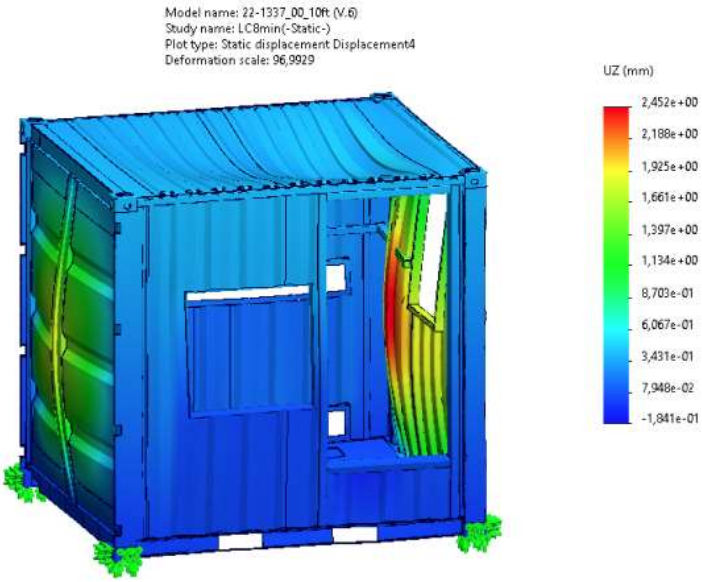


Fig 393: LC8_ MIN -Displacement plot-UZ

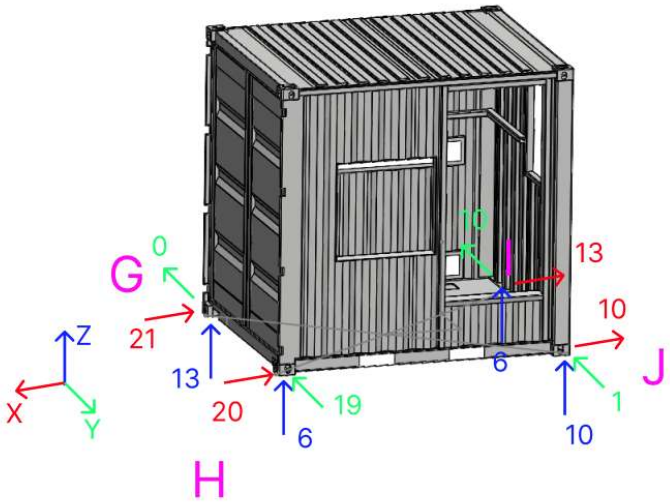


Fig 394: LC8_ MIN -Reactions

10.11.LC9-MAX

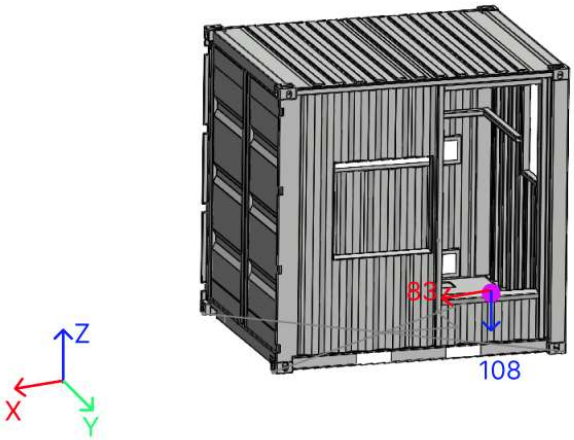


Fig 395: LC9_MAX – 10ft container – Loads

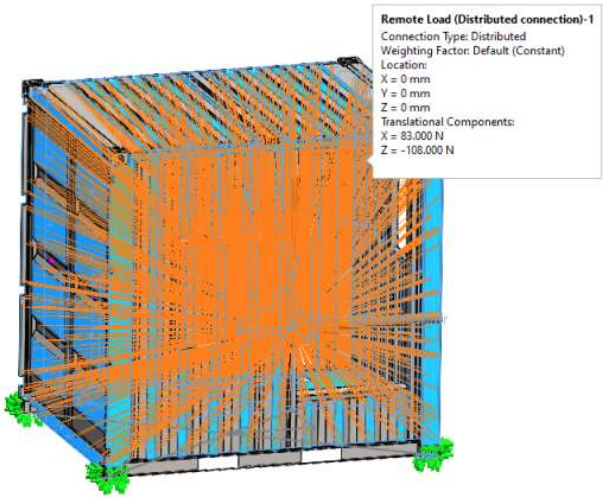


Fig 396: LC9_ MAX -Boundary conditions

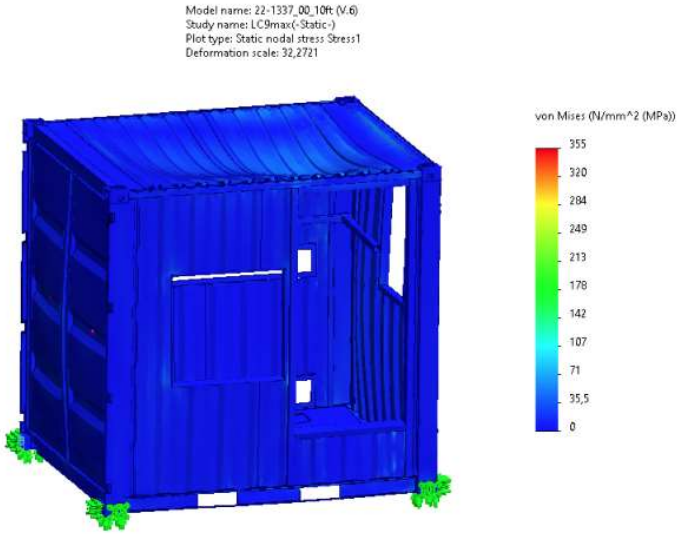


Fig 397: LC9_ MAX -Stress plot

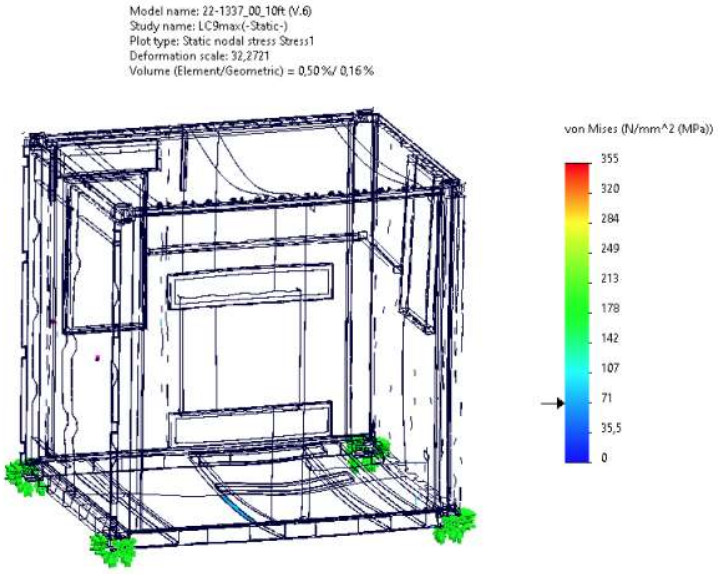


Fig 398: LC9_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

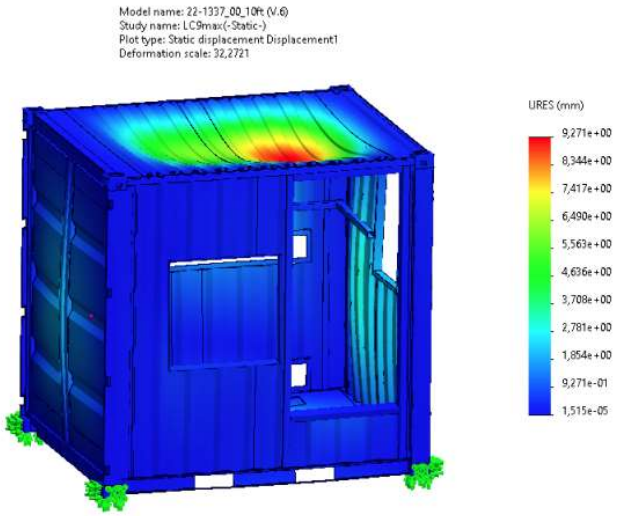


Fig 399: LC9_ MAX -Displacement plot

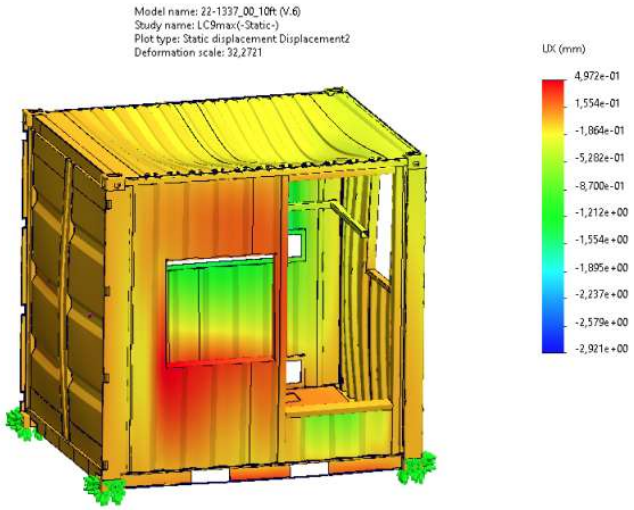


Fig 400: LC9_ MAX -Displacement plot-UX

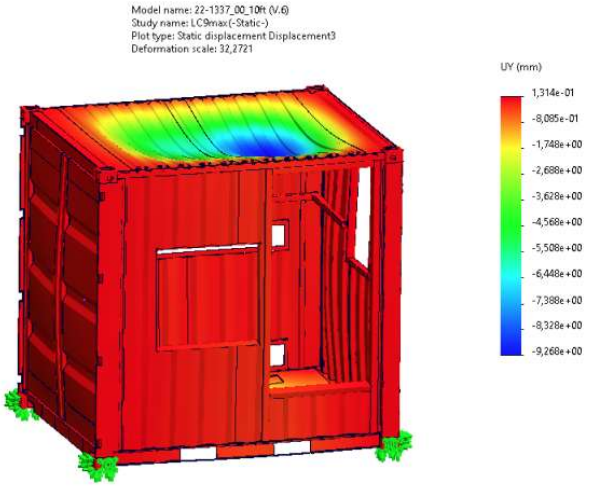


Fig 401: LC9_ MAX -Displacement plot-UY

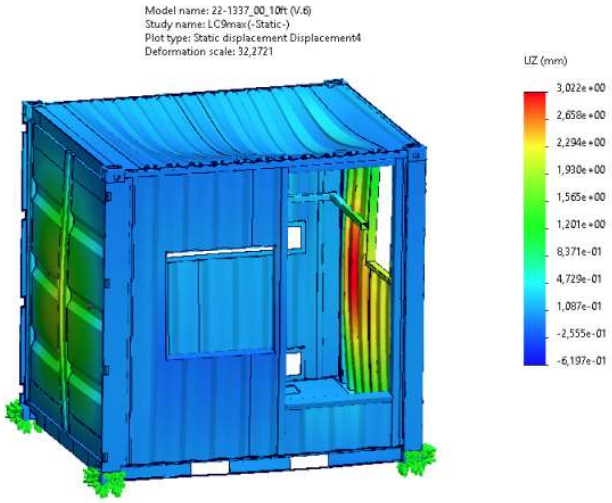


Fig 402: LC9_ MAX -Displacement plot-UZ

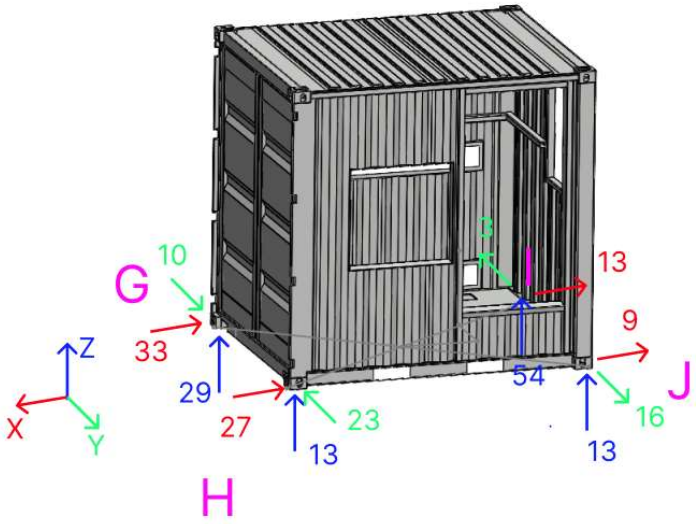


Fig 403: LC9_ MAX -Reactions

10.12.LC9-MIN

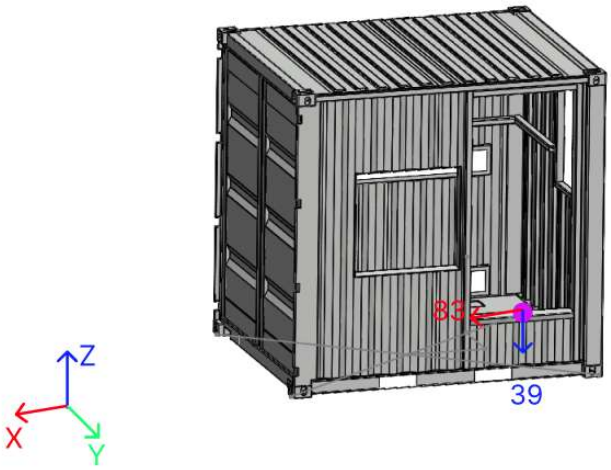


Fig 404: LC9_MIN – 10ft container – Loads

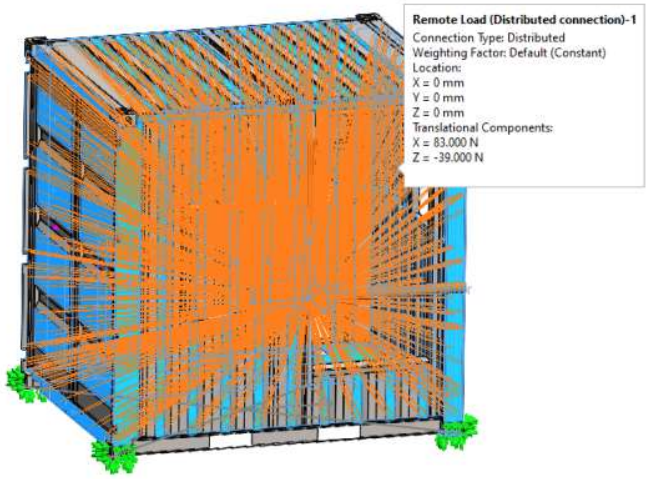


Fig 405: LC9_ MIN -Boundary conditions

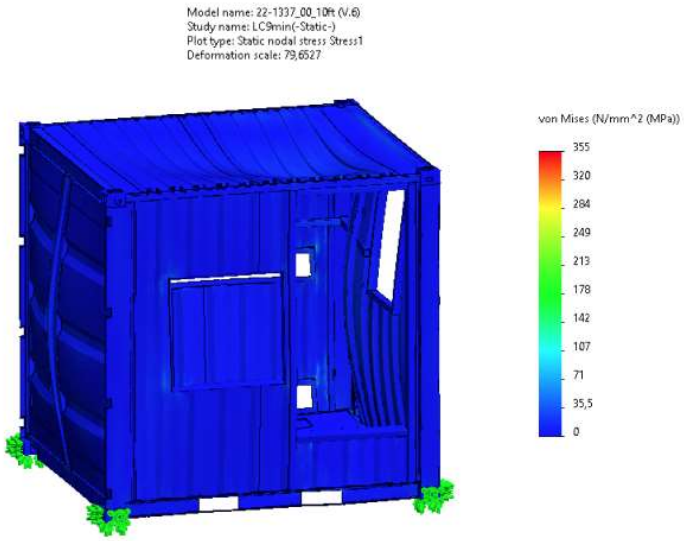


Fig 406: LC9_ MIN -Stress plot

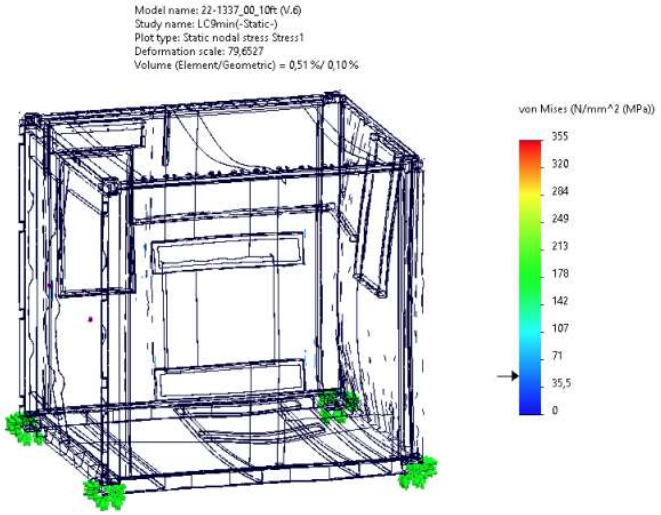


Fig 407: LC9_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

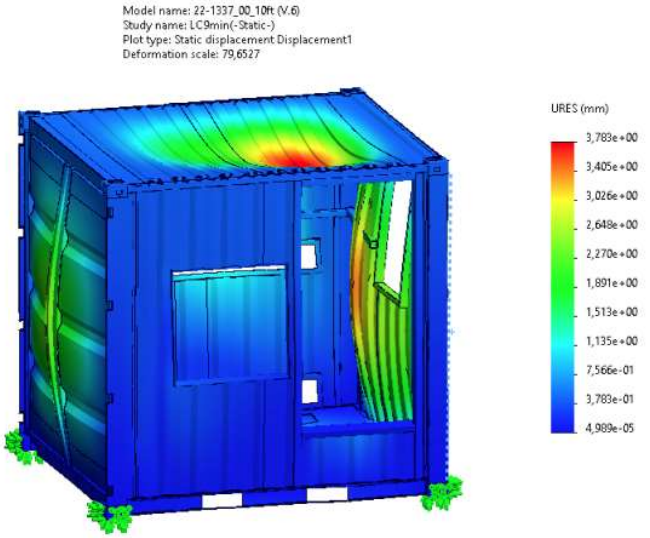


Fig 408: LC9_ MIN -Displacement plot

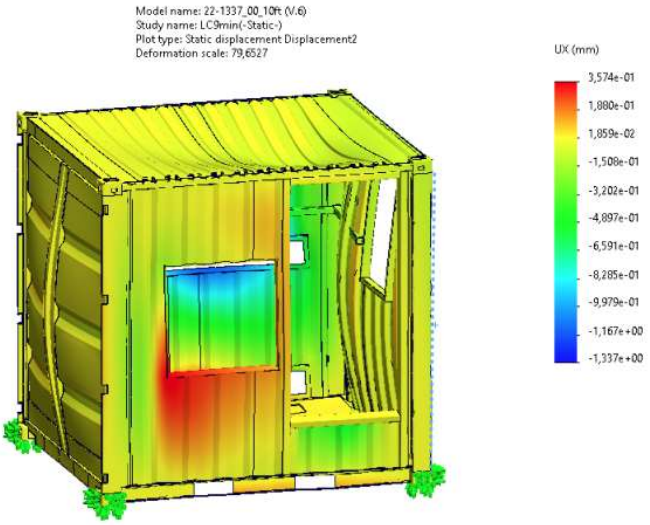


Fig 409: LC9_ MIN -Displacement plot-UX

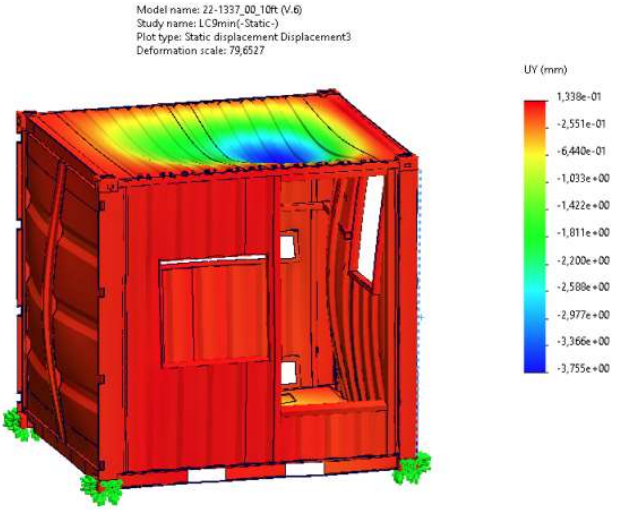


Fig 410: LC9_ MIN -Displacement plot-UY

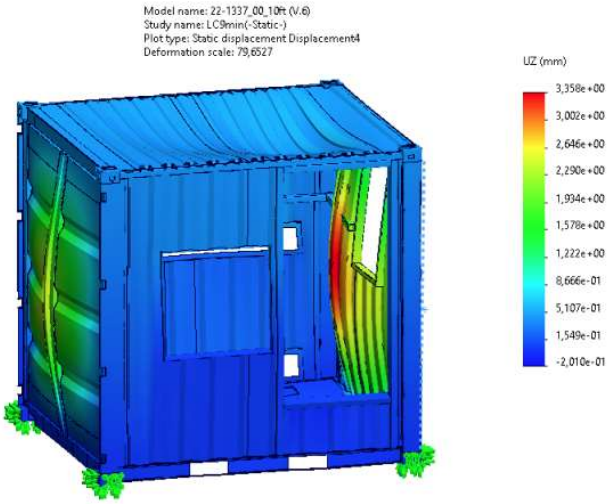


Fig 411: LC9_ MIN -Displacement plot-UZ

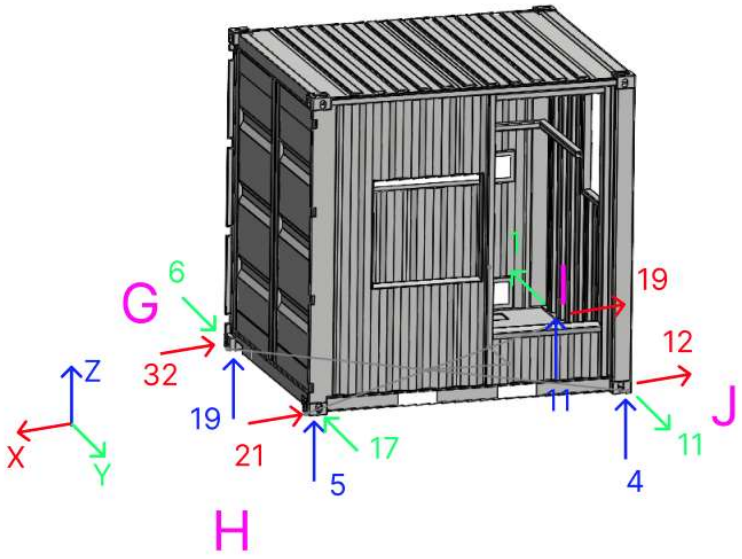


Fig 412: LC9_ MIN -Reactions

10.13.LC10-MAX

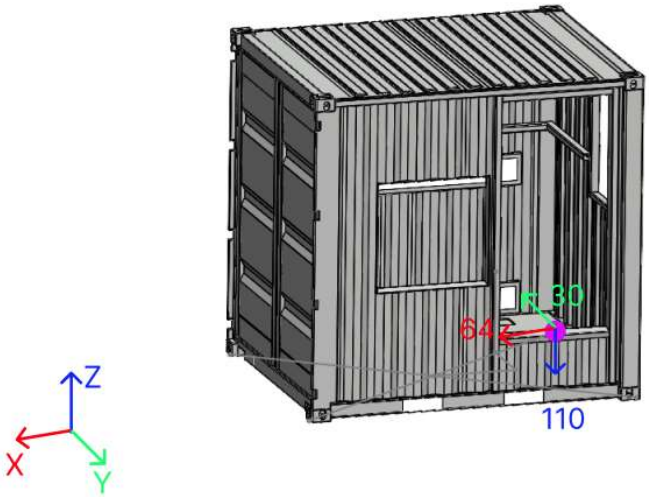


Fig 413: LC10_MAX – 10ft container – Loads

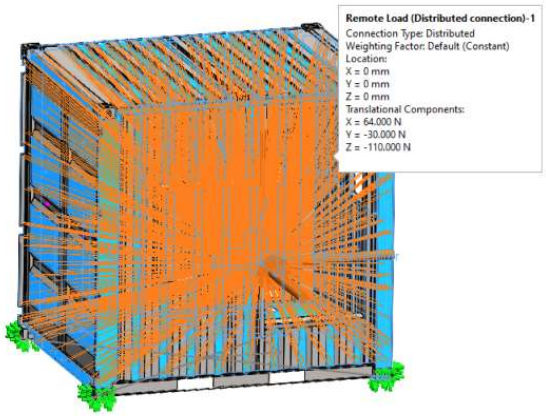


Fig 414: LC10_ MAX -Boundary conditions

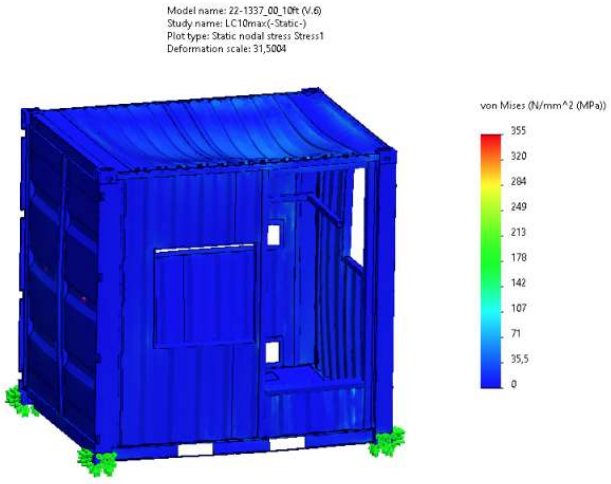


Fig 415: LC10_ MAX -Stress plot

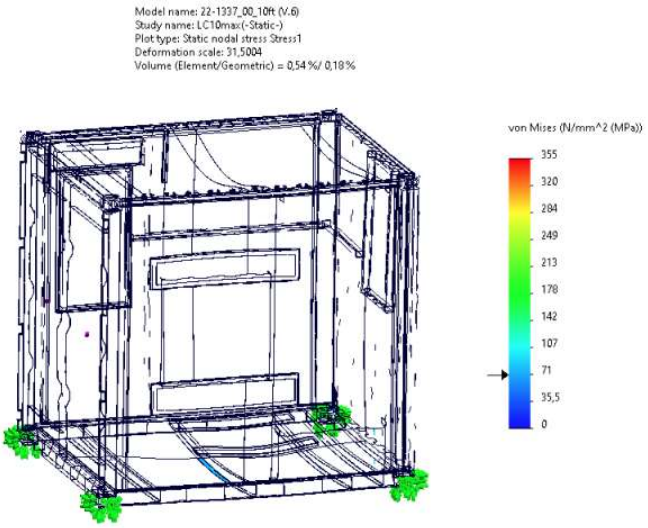


Fig 416: LC10_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

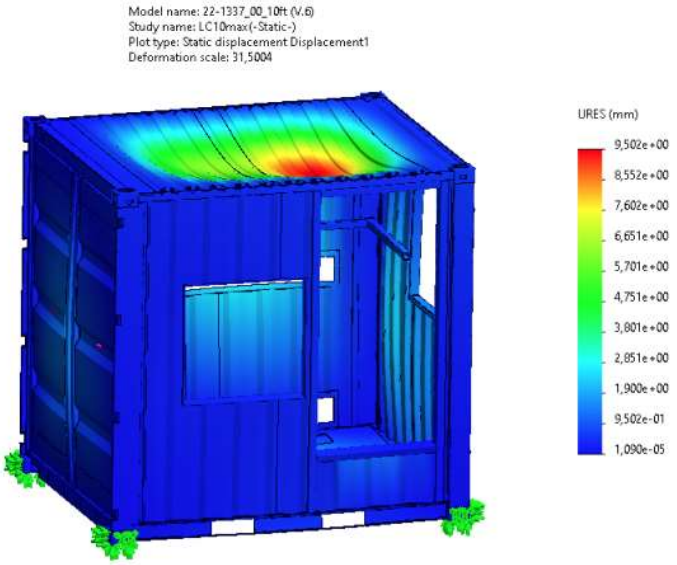


Fig 417: LC10_ MAX -Displacement plot

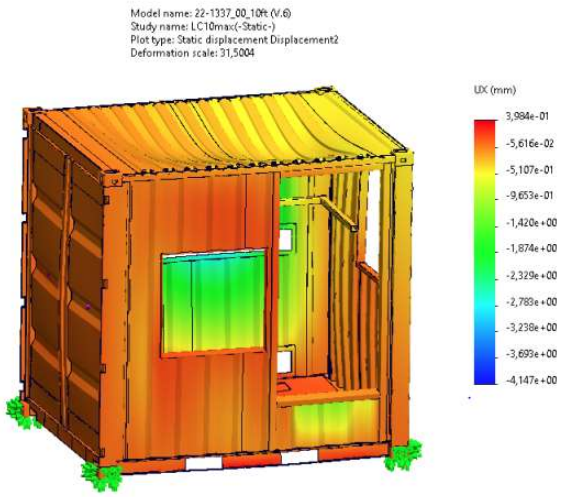


Fig 418: LC10_ MAX -Displacement plot-UX

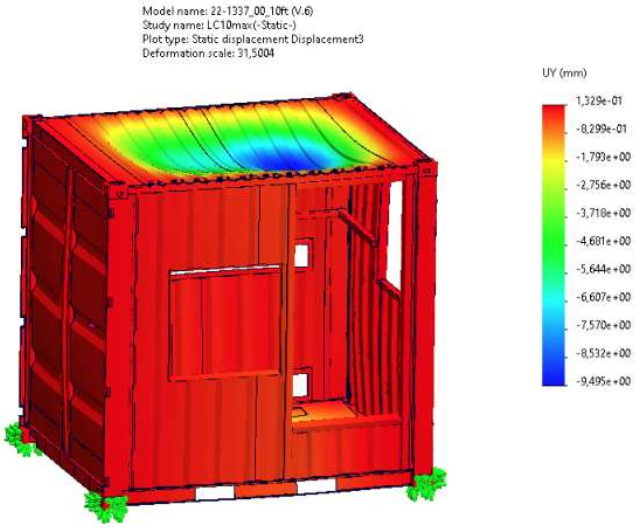


Fig 419: LC10_ MAX -Displacement plot-UY

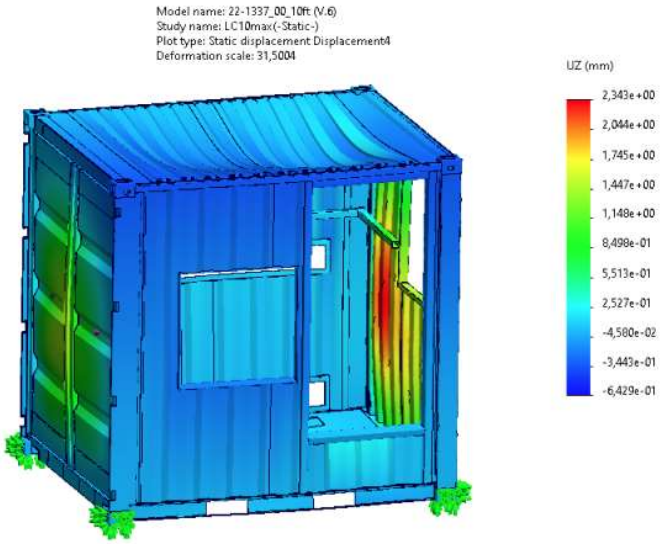


Fig 420: LC10_ MAX -Displacement plot-UZ

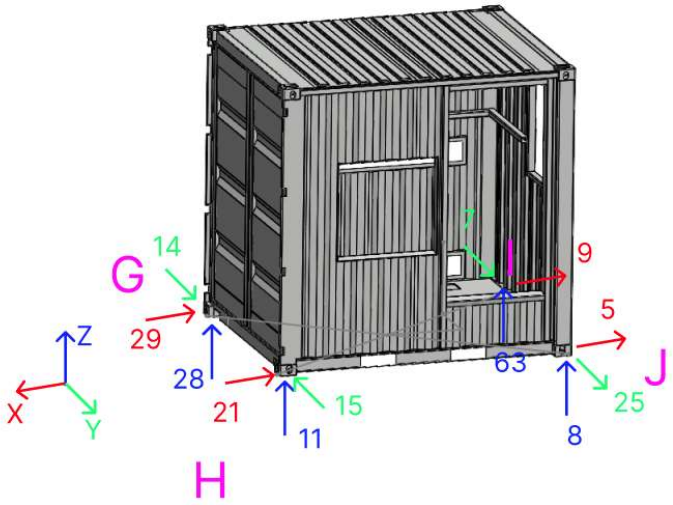


Fig 421: LC10_ MAX -Reactions

10.14.LC10-MIN

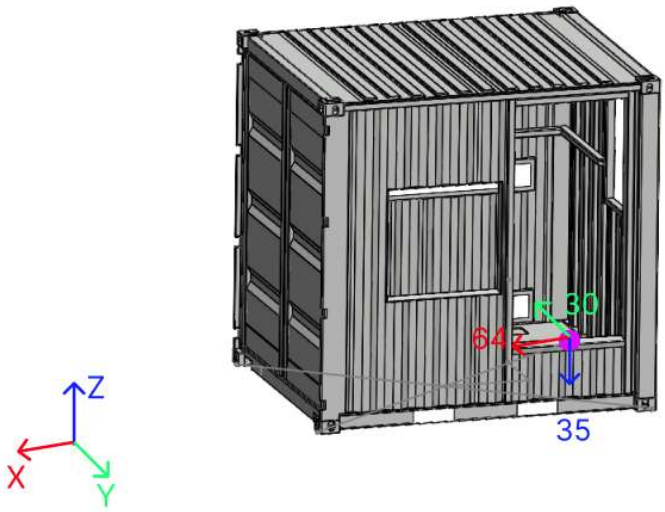


Fig 422: LC10_MIN – 10ft container – Loads

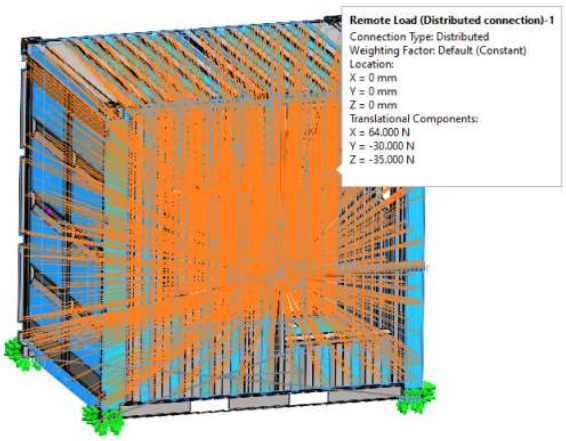


Fig 423: LC10_ MIN -Boundary conditions

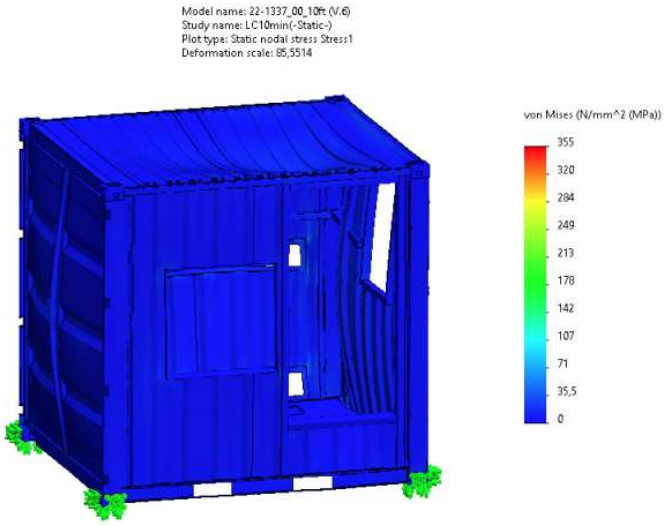


Fig 424: LC10_ MIN -Stress plot

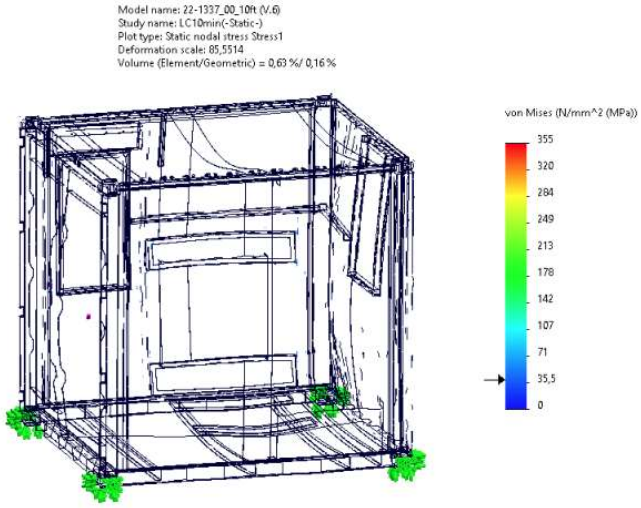


Fig 425: LC10_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

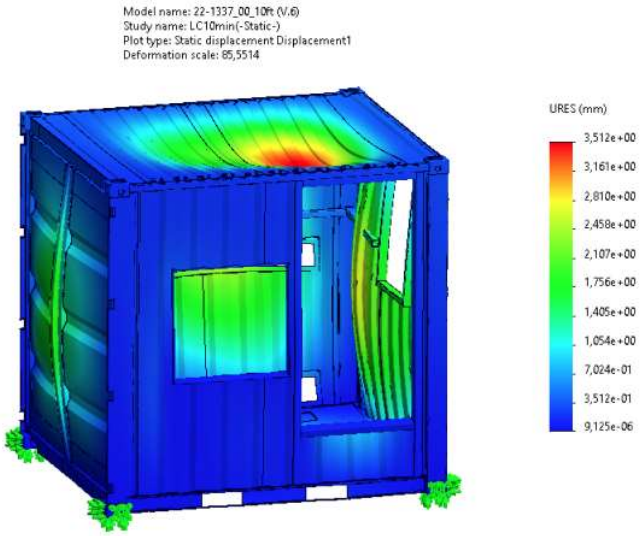


Fig 426: LC10_ MIN -Displacement plot

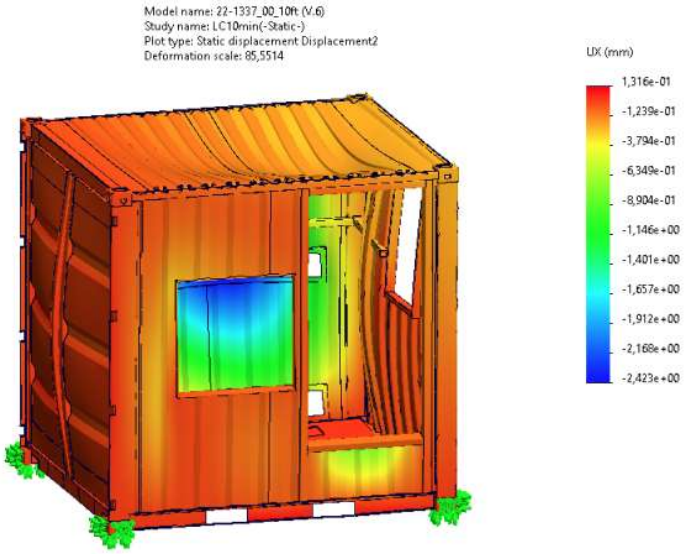


Fig 427: LC10_ MIN -Displacement plot-UX

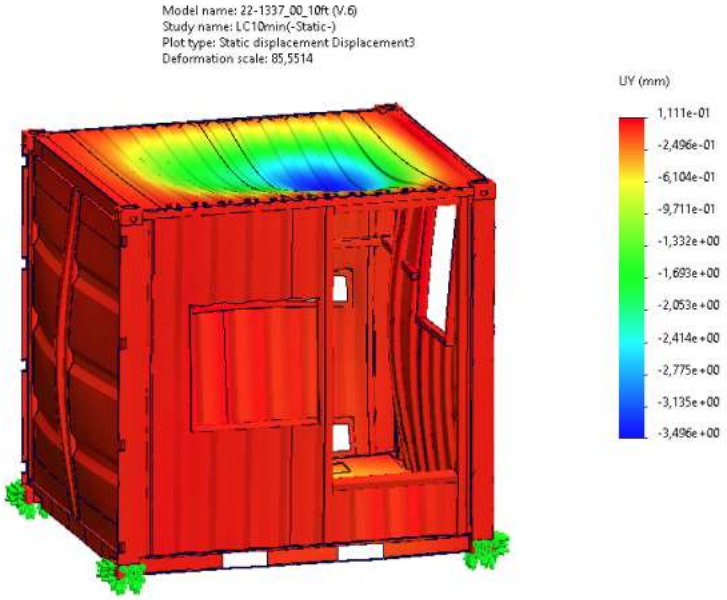


Fig 428: LC10_ MIN -Displacement plot-UY

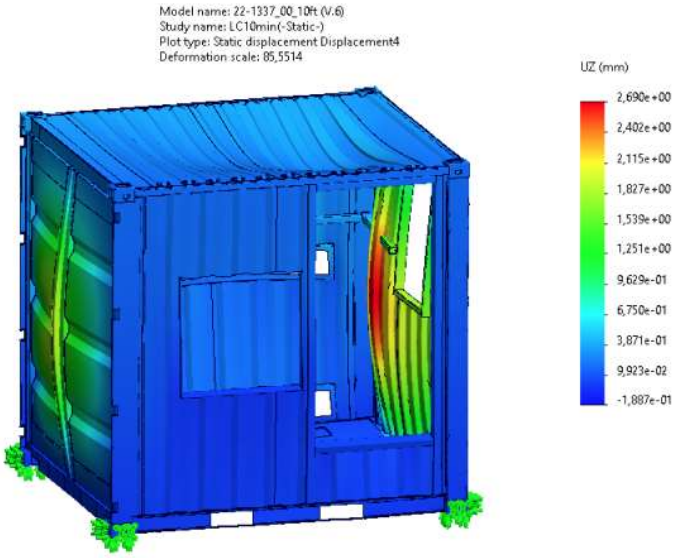


Fig 429: LC10_ MIN -Displacement plot-UZ

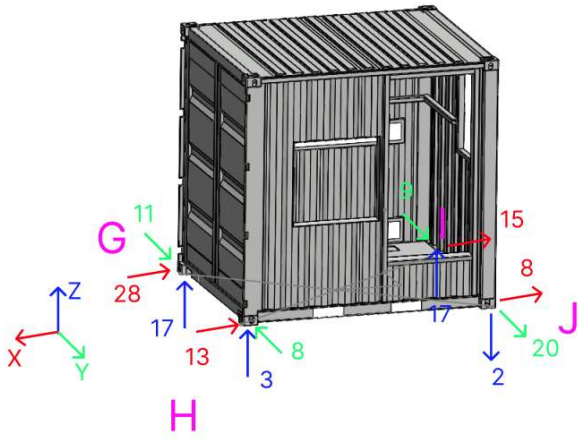


Fig 430: LC10_ MIN -Reactions

10.15.LC11-MAX

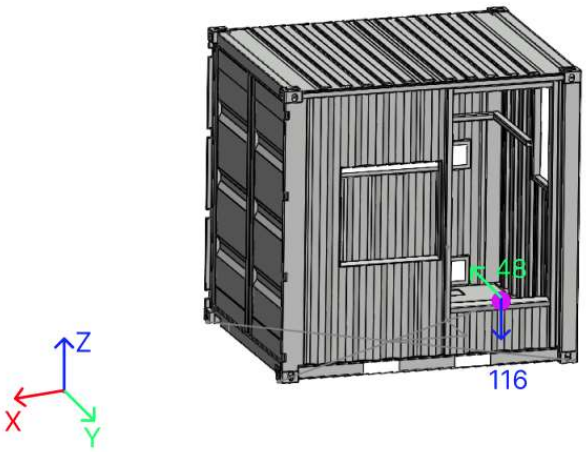


Fig 431: LC11_MAX – 10ft container – Loads

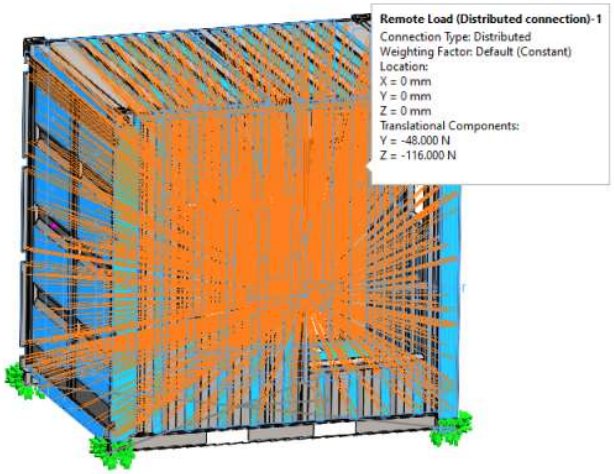


Fig 432: LC11_ MAX -Boundary conditions

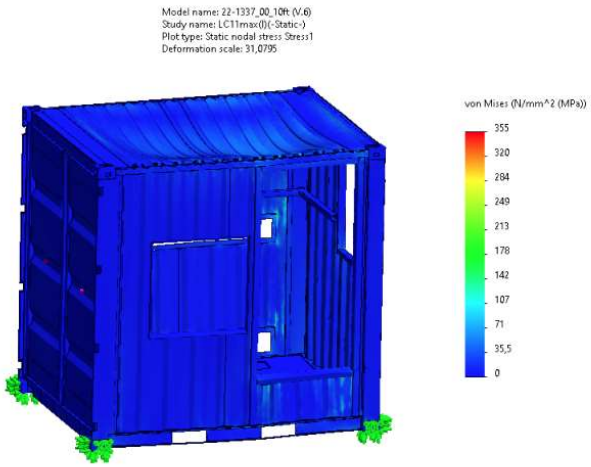


Fig 433: LC11_ MAX -Stress plot

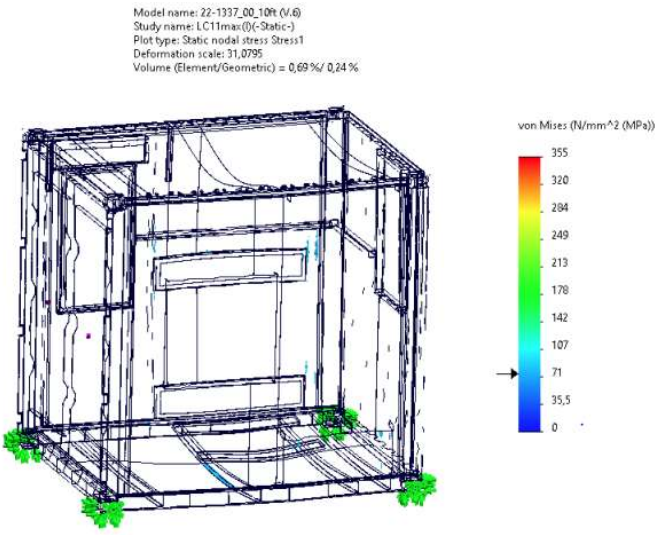


Fig 434: LC11_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

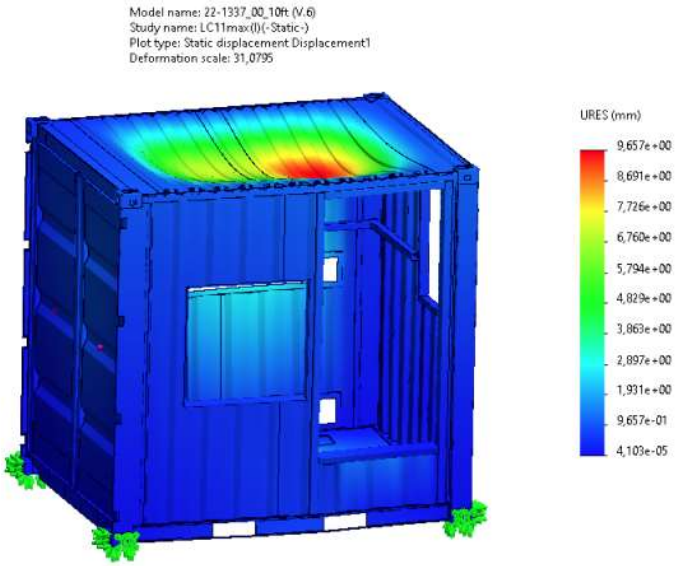


Fig 435: LC11_ MAX -Displacement plot

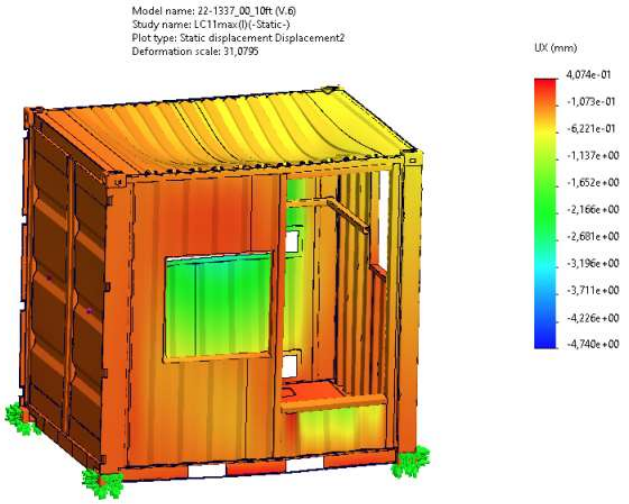


Fig 436: LC11_ MAX -Displacement plot-UX

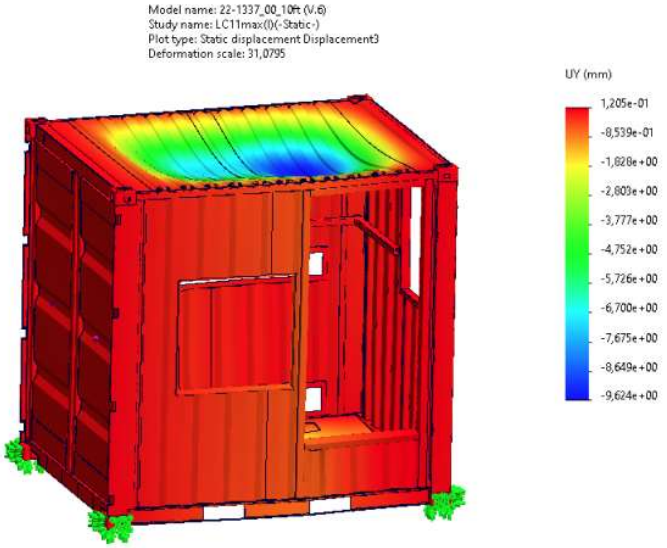


Fig 437: LC11_ MAX -Displacement plot-UY

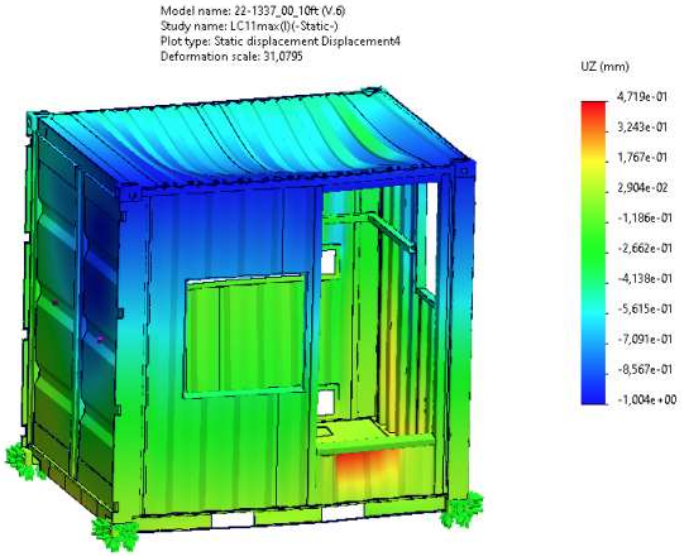


Fig 438: LC11_ MAX -Displacement plot-UZ

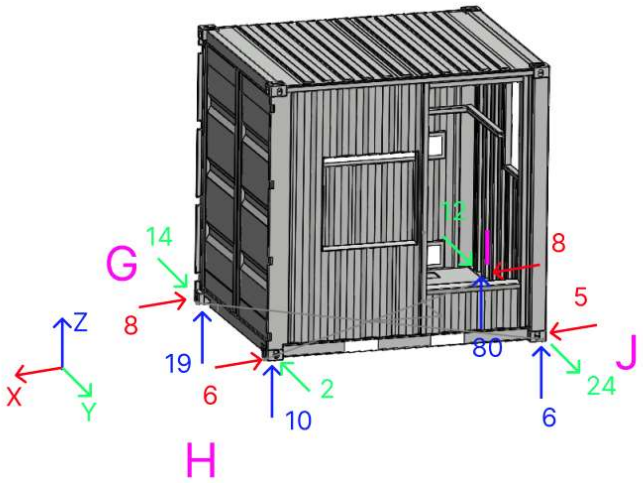


Fig 439: LC11_ MAX -Reactions

10.16.LC11-MIN

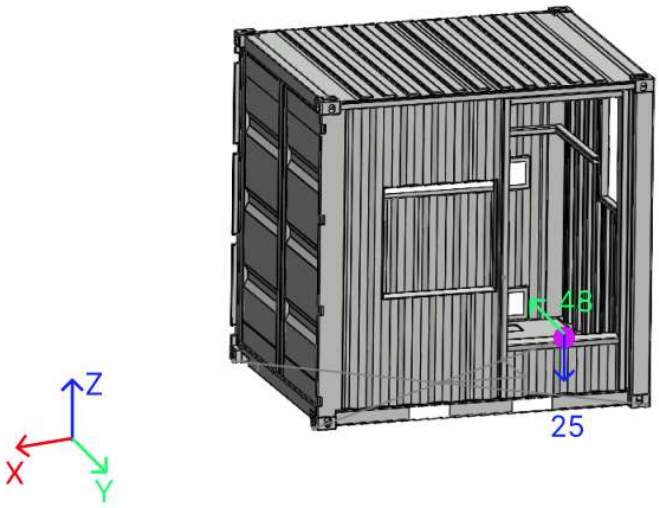


Fig 440: LC11_MIN – 10ft container – Loads

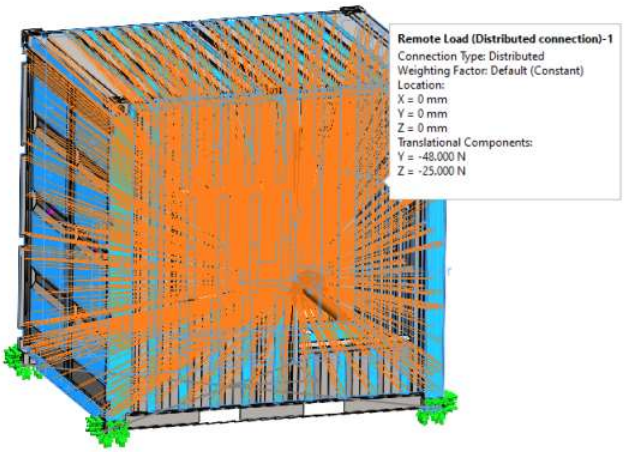


Fig 441: LC11_ MIN -Boundary conditions

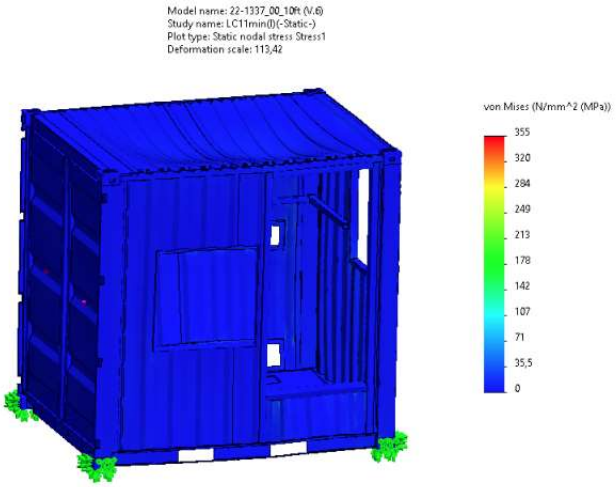


Fig 442: LC11_ MIN -Stress plot

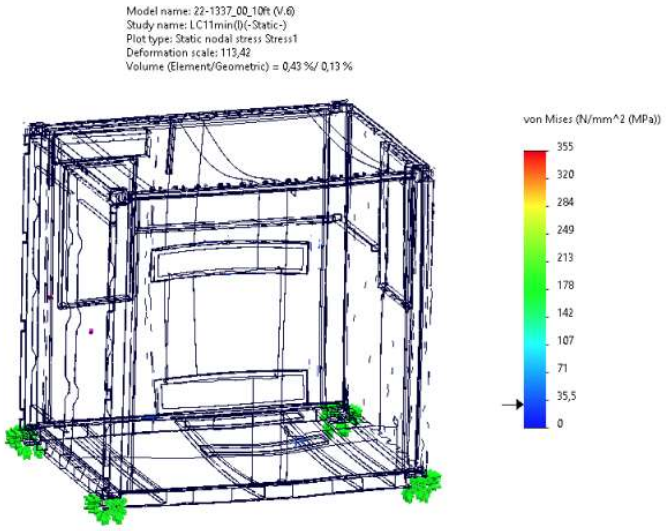


Fig 443: LC11_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

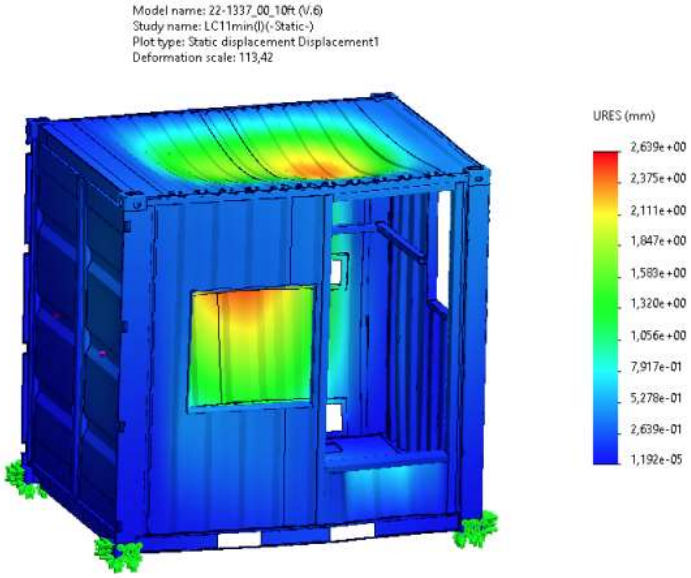


Fig 444: LC11_ MIN -Displacement plot

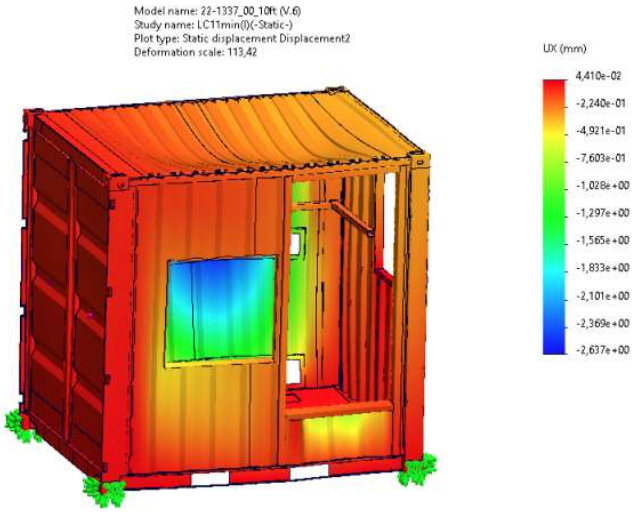


Fig 445: LC11_ MIN -Displacement plot-UX

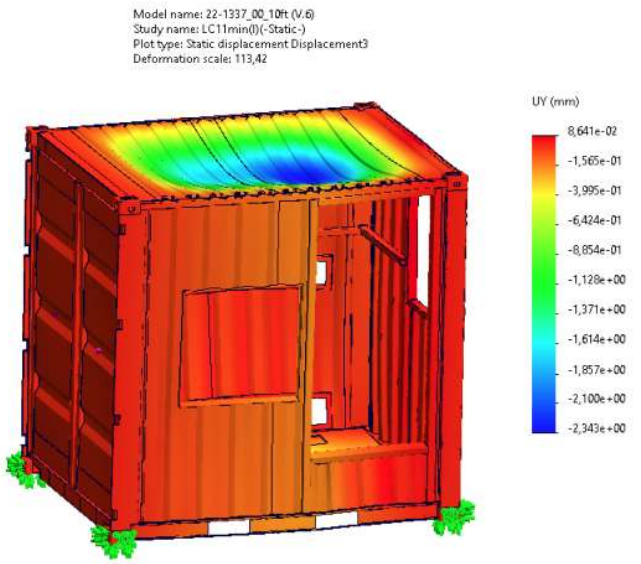


Fig 446: LC11_ MIN -Displacement plot-UY

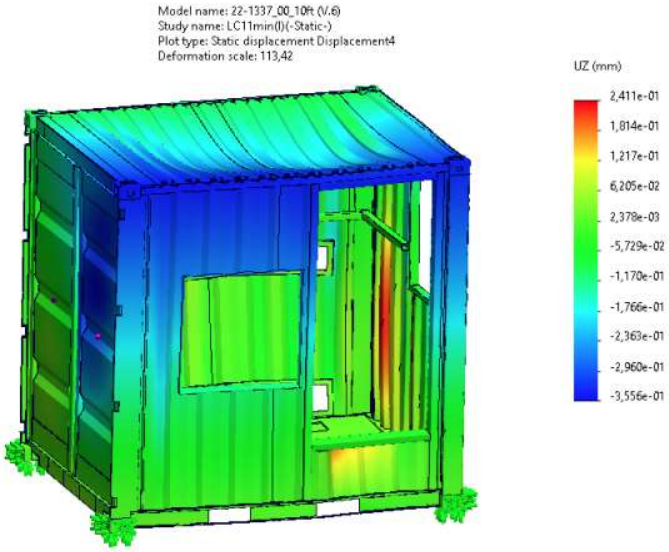


Fig 447: LC11_ MIN -Displacement plot-UZ

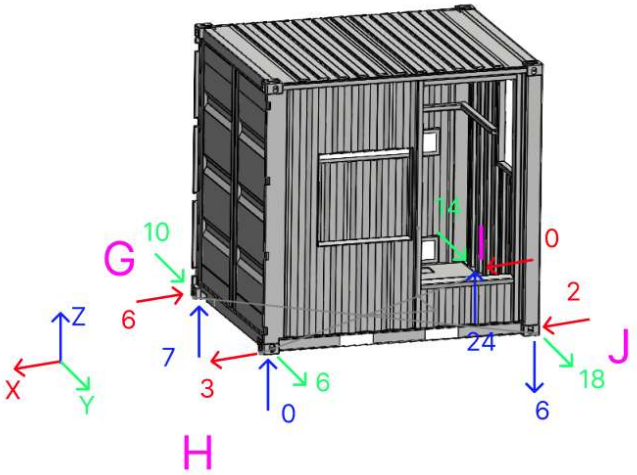


Fig 448: LC11_ MIN -Reactions

10.17.LC12-MAX

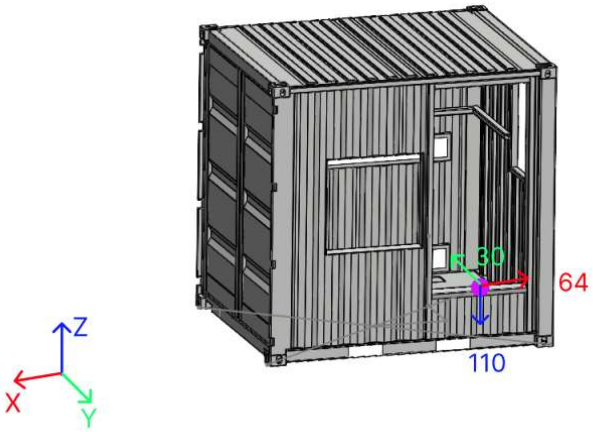


Fig 449: LC12_MAX – 10ft container – Loads

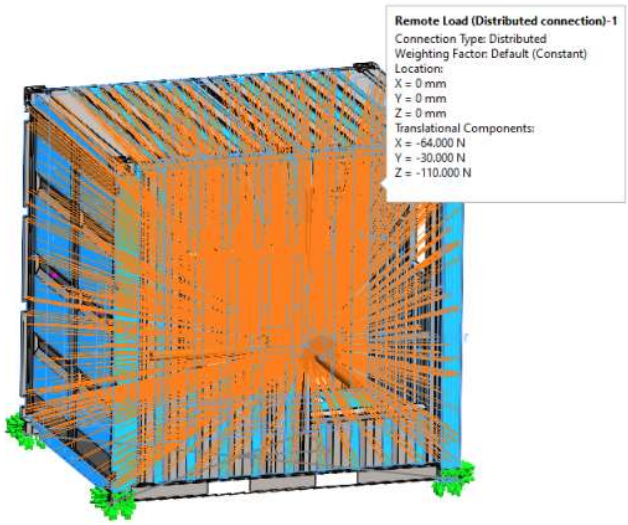


Fig 450: LC12_ MAX -Boundary conditions

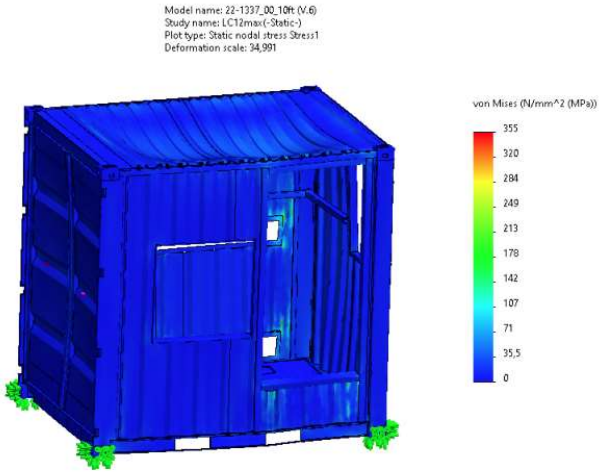


Fig 451: LC12_ MAX -Stress plot

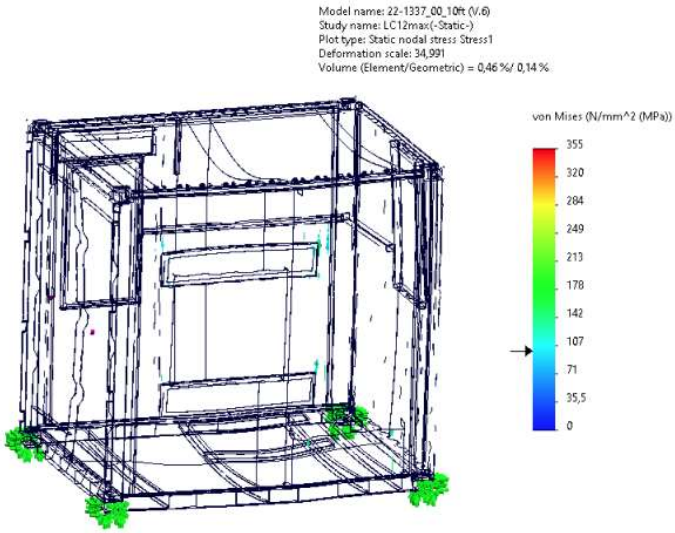


Fig 452: LC12_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

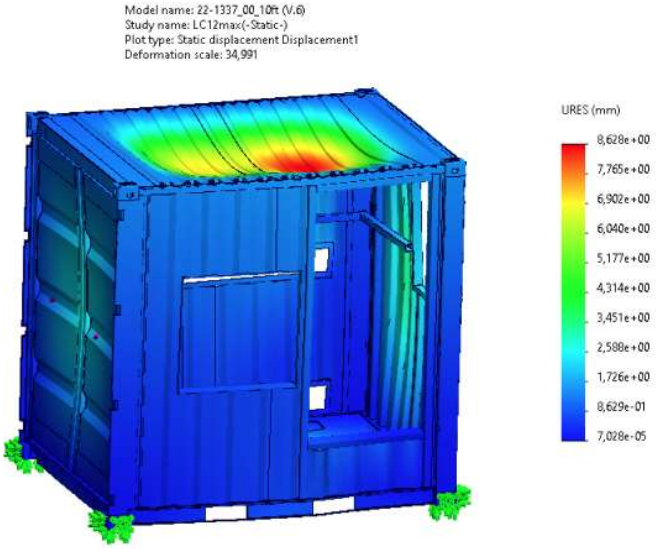


Fig 453: LC12_ MAX -Displacement plot

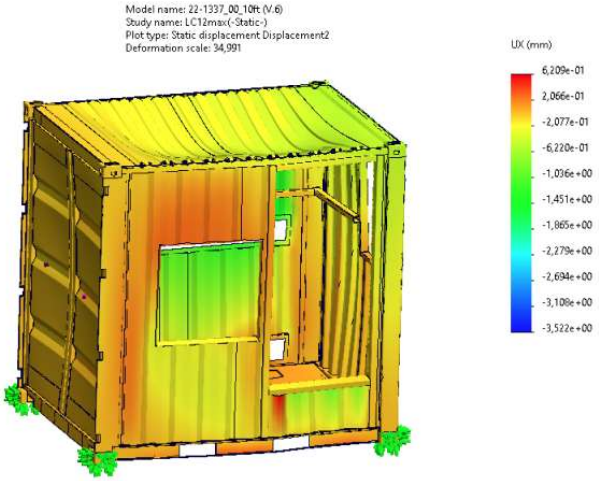


Fig 454: LC12_ MAX -Displacement plot-UX

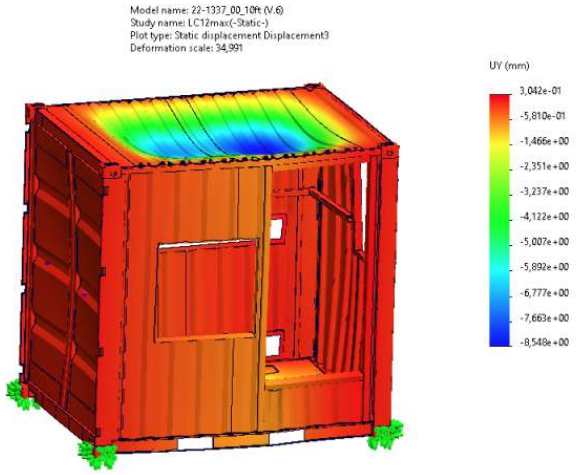


Fig 455: LC12_ MAX -Displacement plot-UY

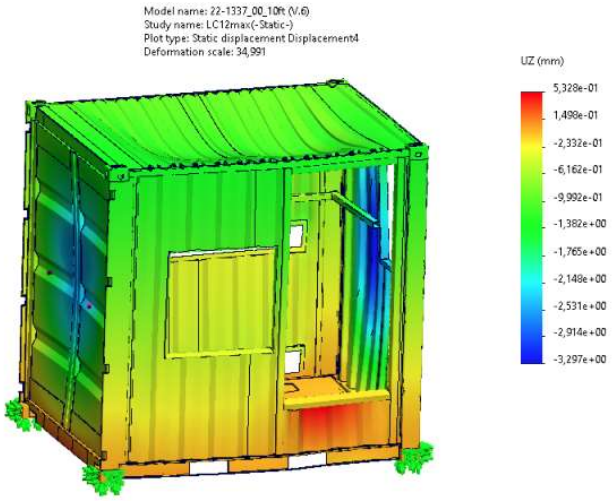


Fig 456: LC12_ MAX -Displacement plot-UZ

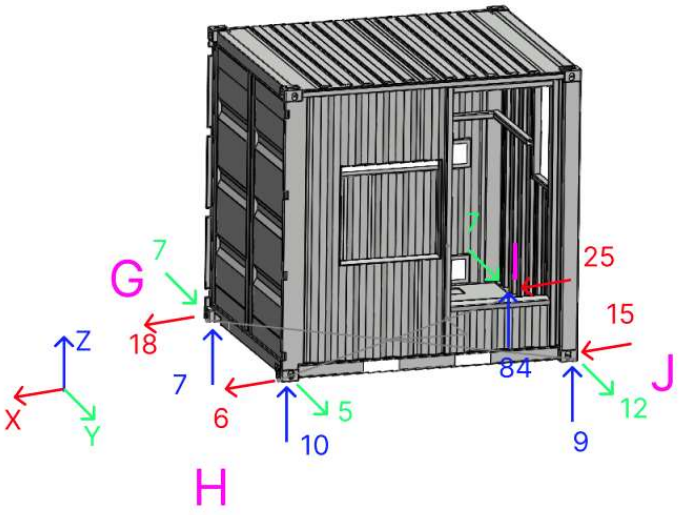


Fig 457: LC12_ MAX -Reactions

10.18.LC12-MIN

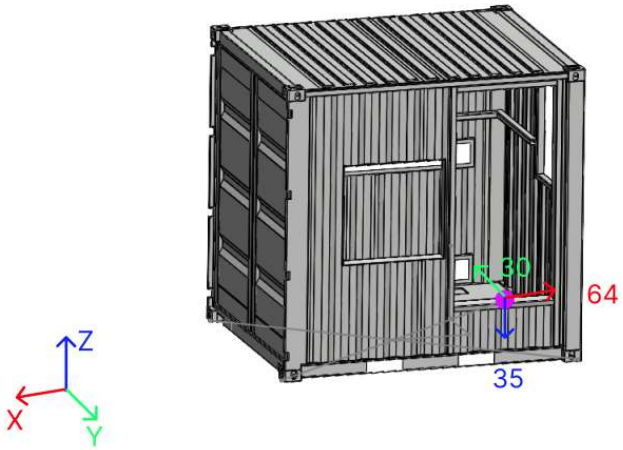


Fig 458: LC12_MIN – 10ft container – Loads

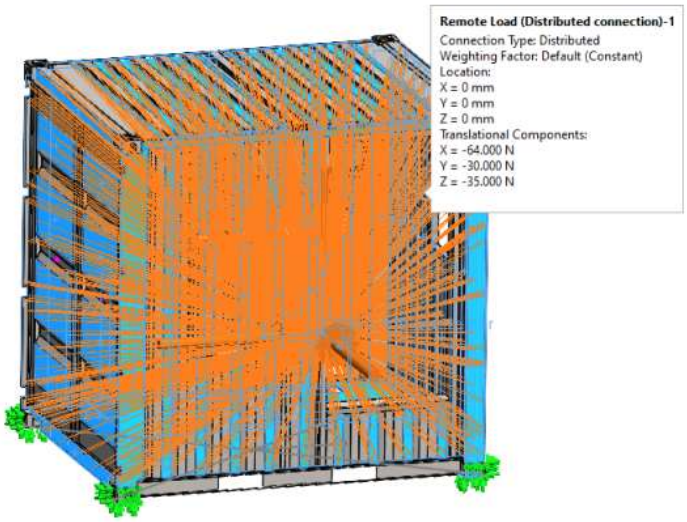


Fig 459: LC12_ MIN -Boundary conditions

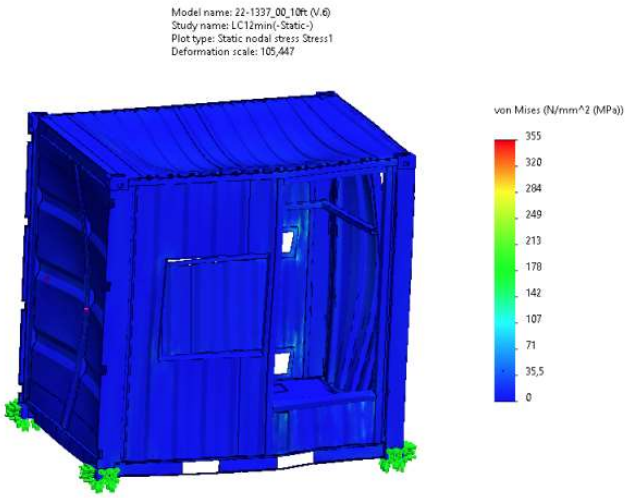


Fig 460: LC12_ MIN -Stress plot

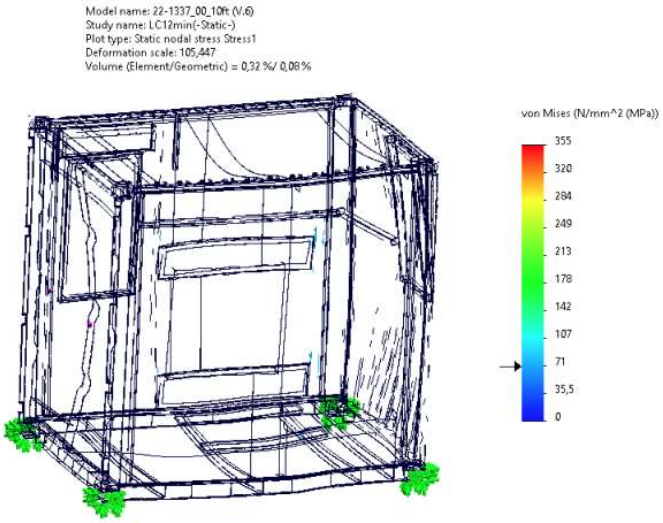


Fig 461: LC12_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

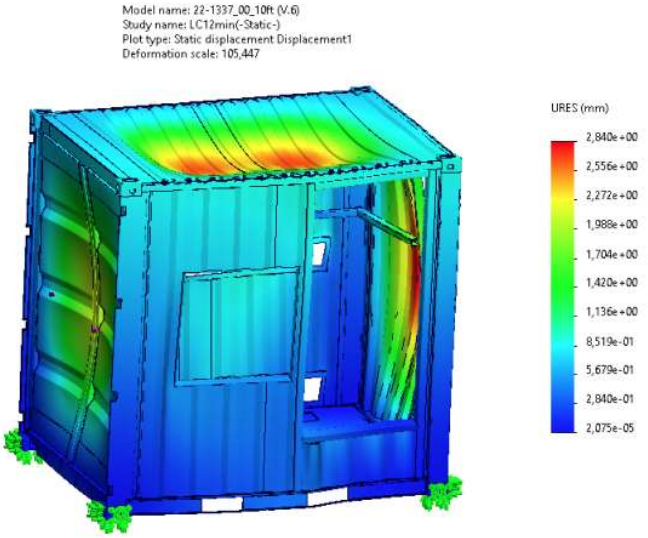


Fig 462: LC12_ MIN -Displacement plot

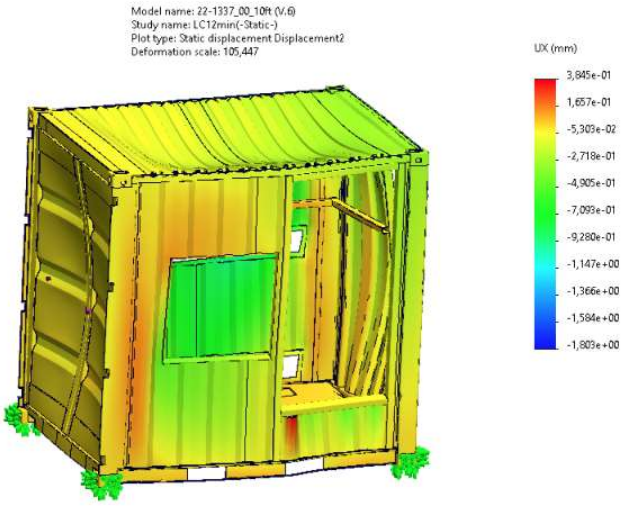


Fig 463: LC12_ MIN -Displacement plot-UX

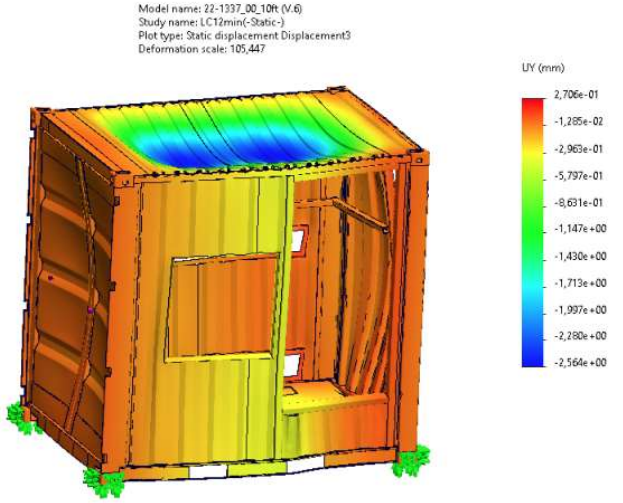


Fig 464: LC12_ MIN -Displacement plot-UY

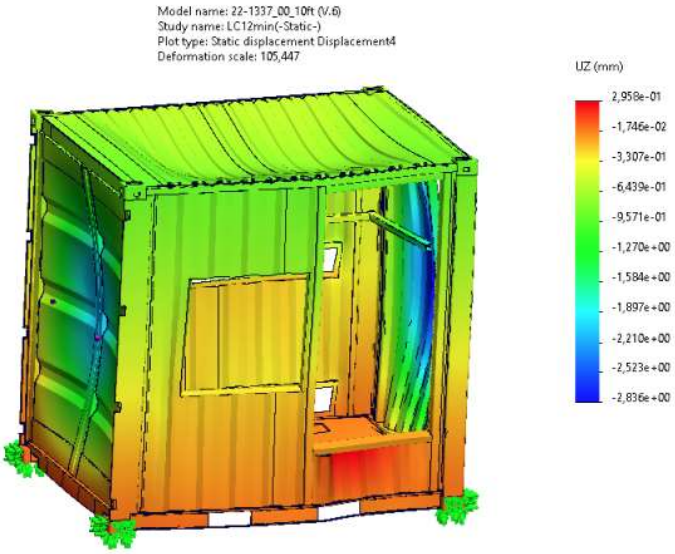


Fig 465: LC12_ MIN -Displacement plot-UZ

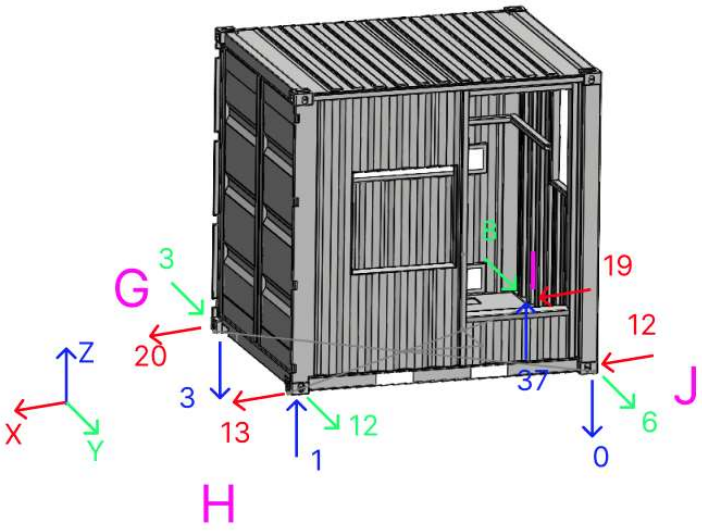


Fig 466: LC12_ MIN -Reactions

10.19.LC13-MAX

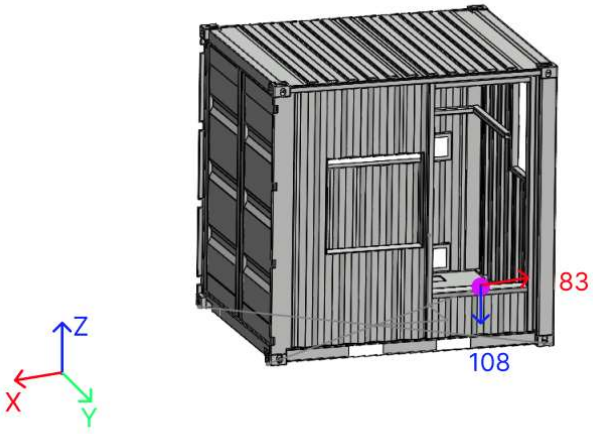


Fig 467: LC13_MAX – 10ft container – Loads

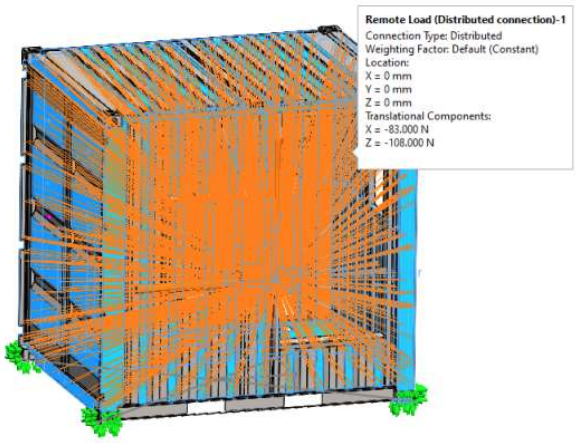


Fig 468: LC13_ MAX -Boundary conditions

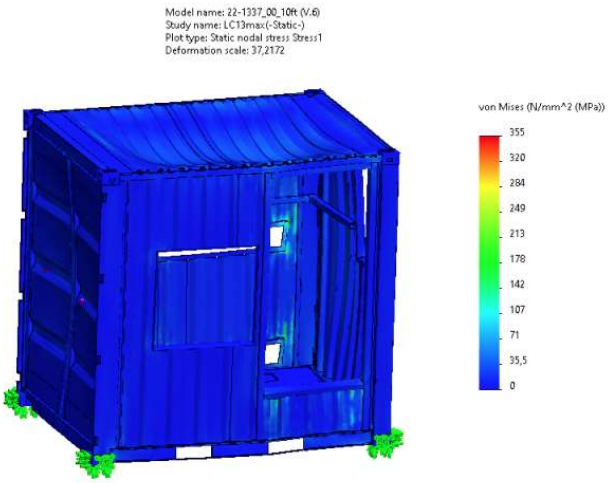


Fig 469: LC13_ MAX -Stress plot

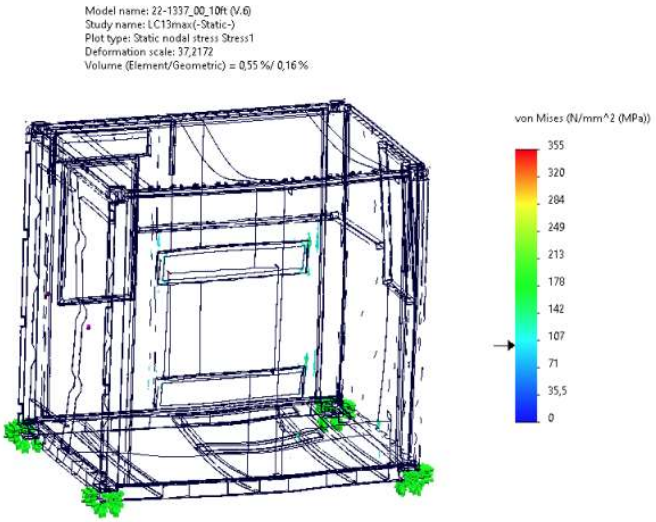


Fig 470: LC13_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

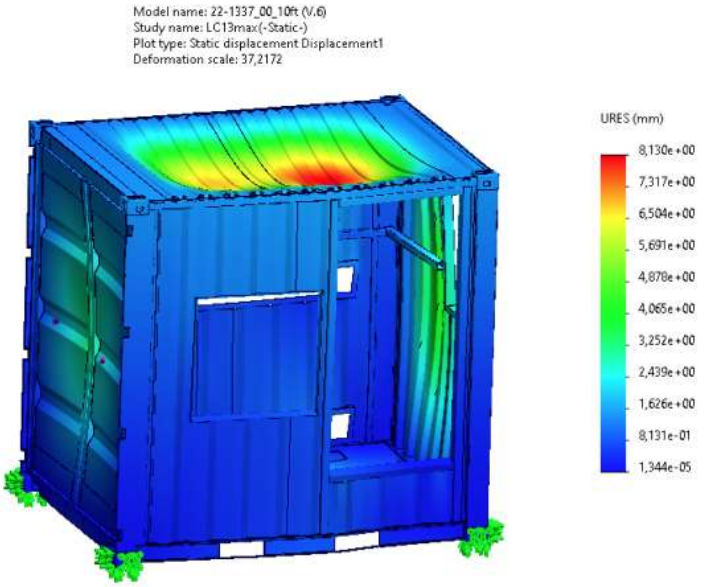


Fig 471: LC13_ MAX -Displacement plot

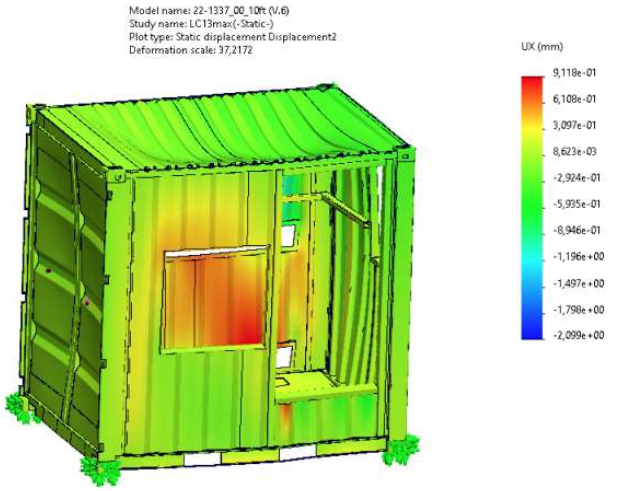


Fig 472: LC13_ MAX -Displacement plot-UX

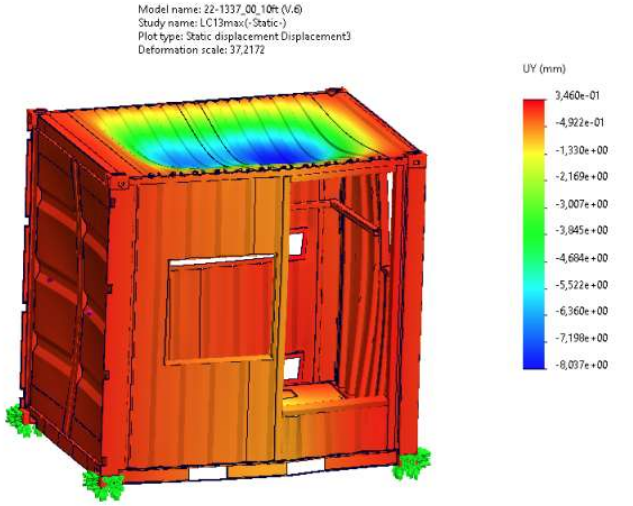


Fig 473: LC13_ MAX -Displacement plot-UY

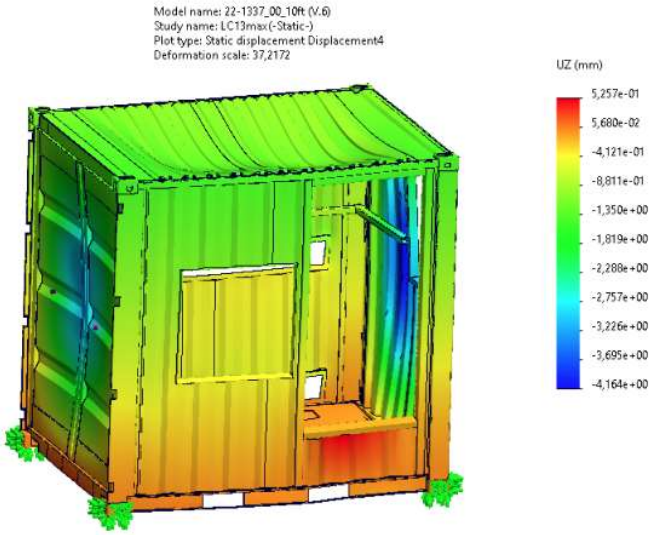


Fig 474: LC13_ MAX -Displacement plot-UZ

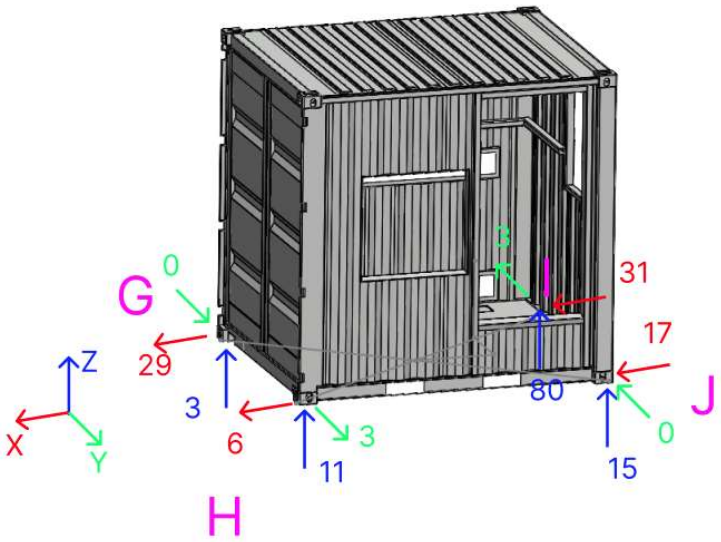


Fig 475: LC13_ MAX -Reactions

10.20.LC13-MIN

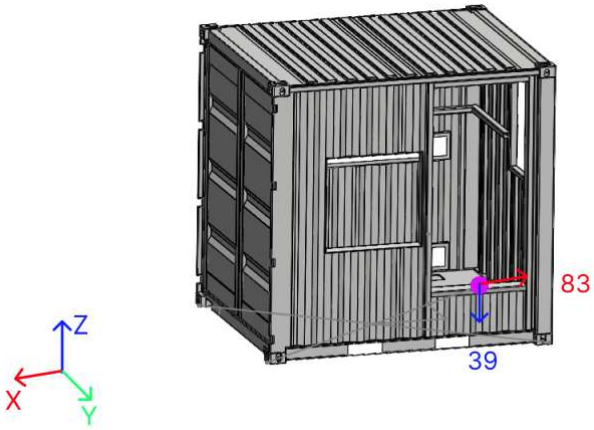


Fig 476: LC13_MIN – 10ft container – Loads

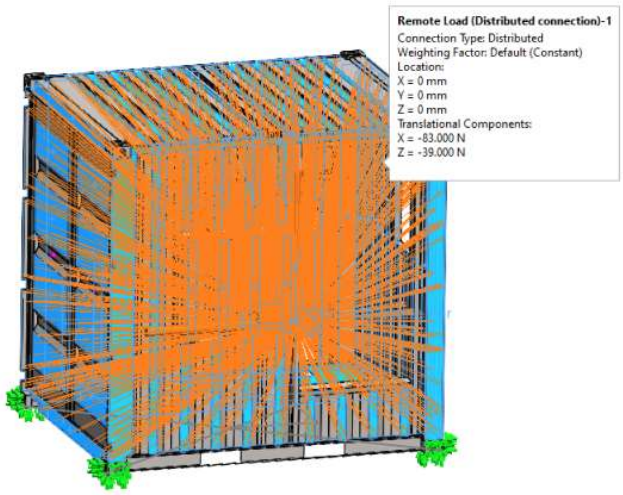


Fig 477: LC13_ MIN -Boundary conditions

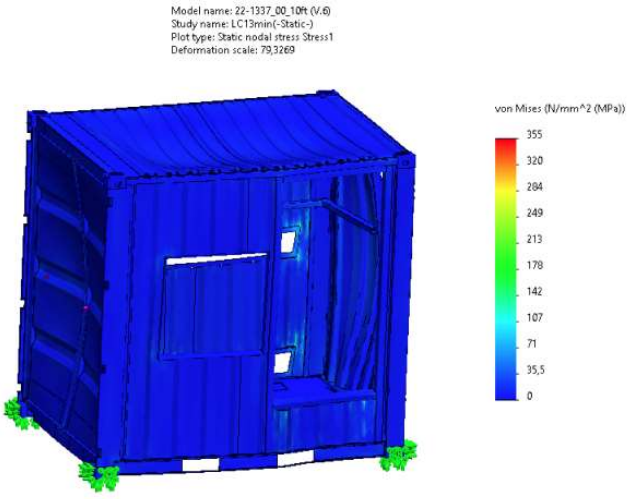


Fig 478: LC13_ MIN -Stress plot

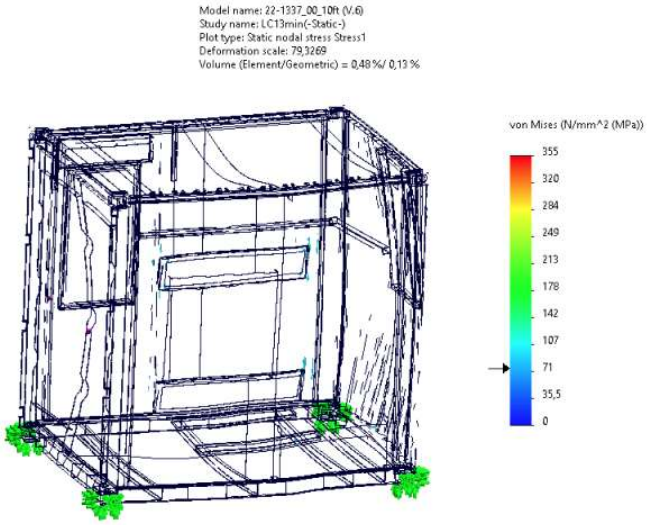


Fig 479: LC13_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

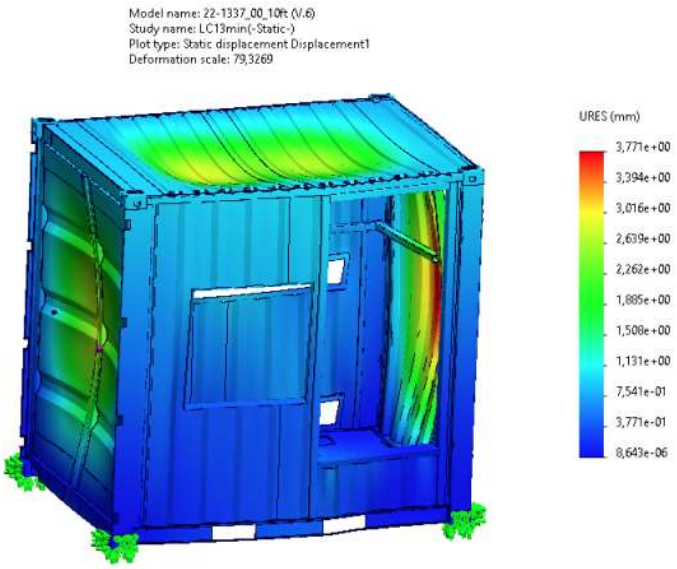


Fig 480: LC13_ MIN -Displacement plot

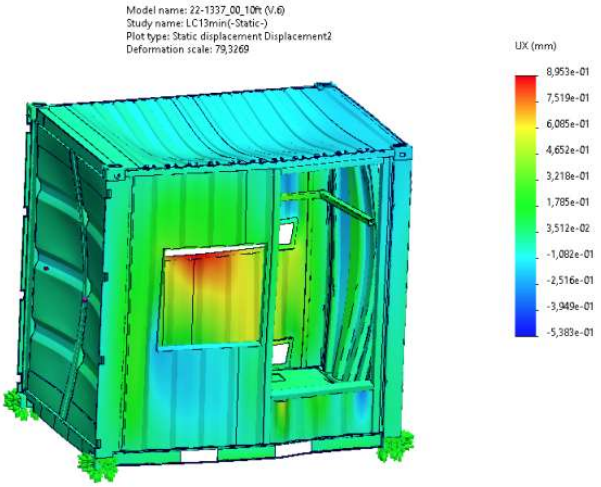


Fig 481: LC13_ MIN -Displacement plot-UX

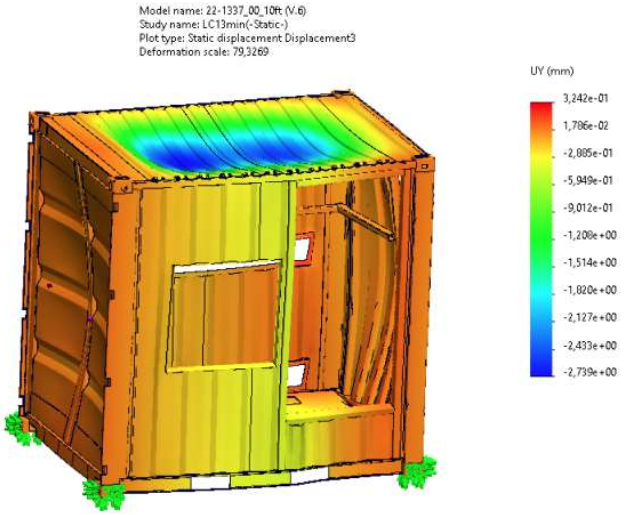


Fig 482: LC13_ MIN -Displacement plot-UY

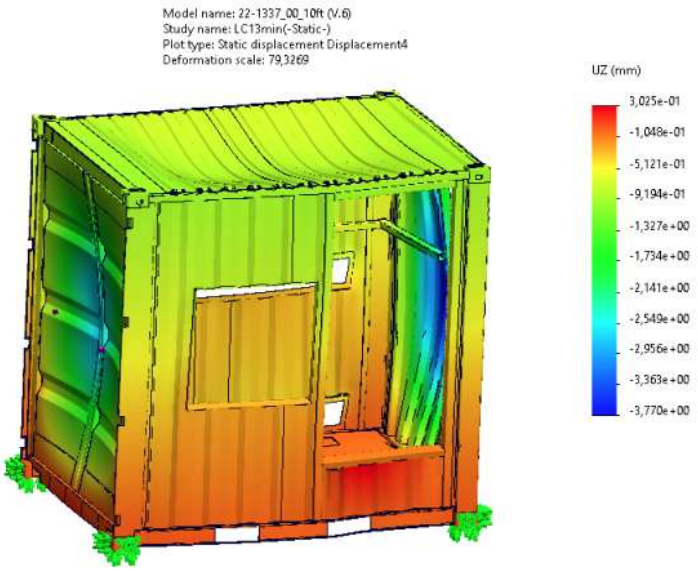


Fig 483: LC13_ MIN -Displacement plot-UZ

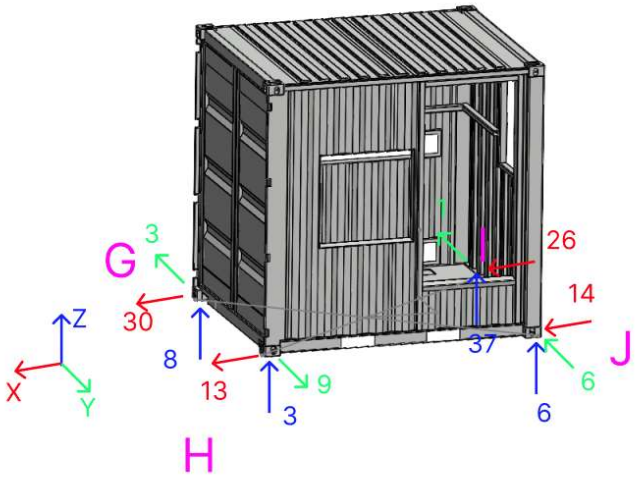


Fig 484: LC13_ MIN -Reactions

10.21.LC14-MAX

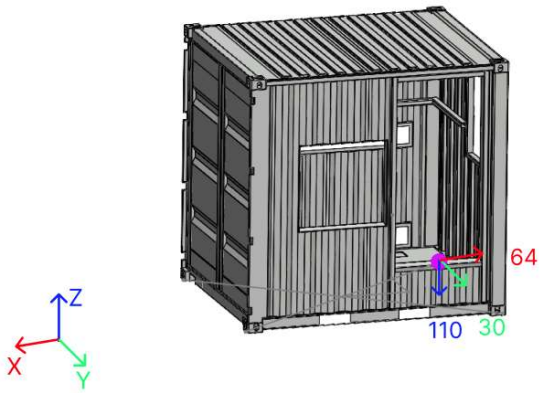


Fig 485: LC14_MAX – 10ft container – Loads

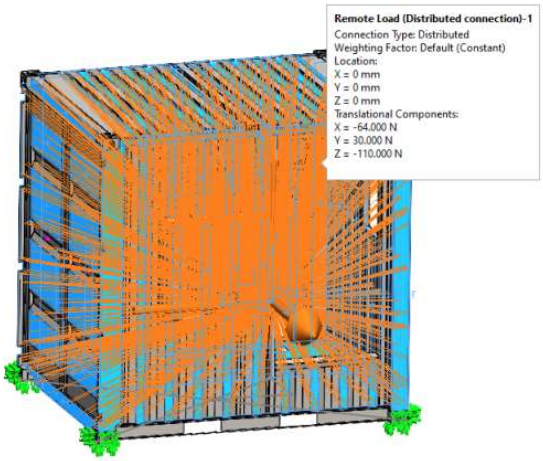


Fig 486: LC14_ MAX -Boundary conditions

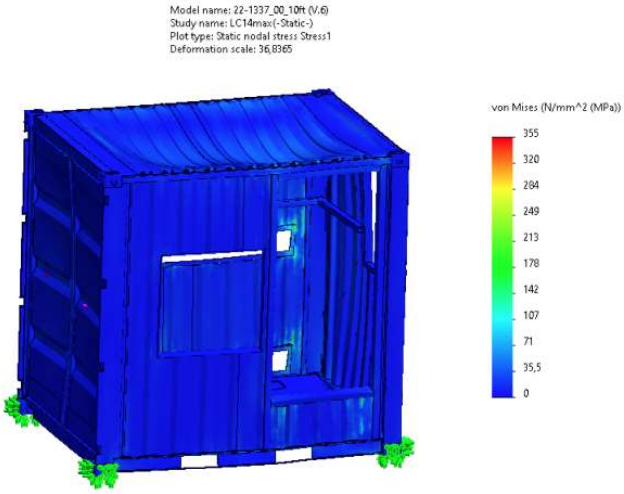


Fig 487: LC14_ MAX -Stress plot

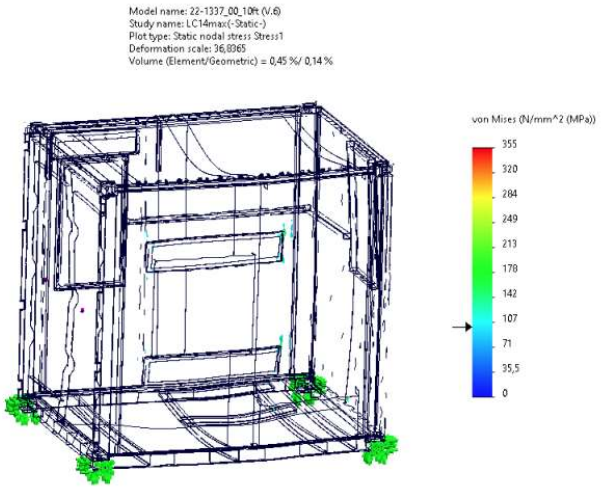


Fig 488: LC14_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

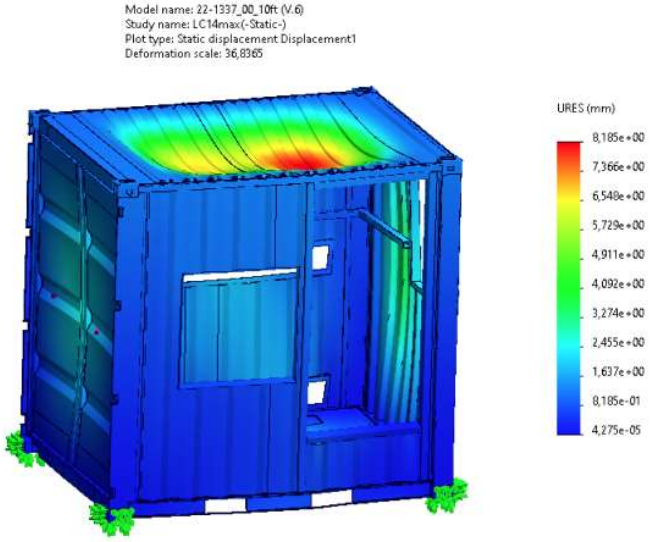


Fig 489: LC14_ MAX -Displacement plot

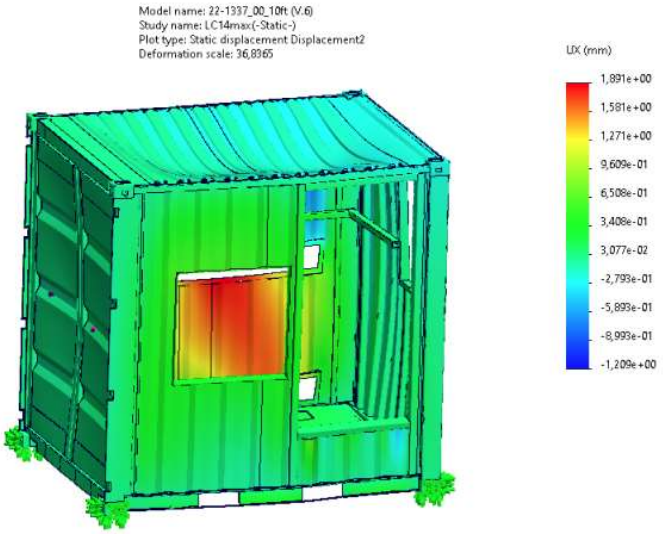


Fig 490: LC14_ MAX -Displacement plot-UX

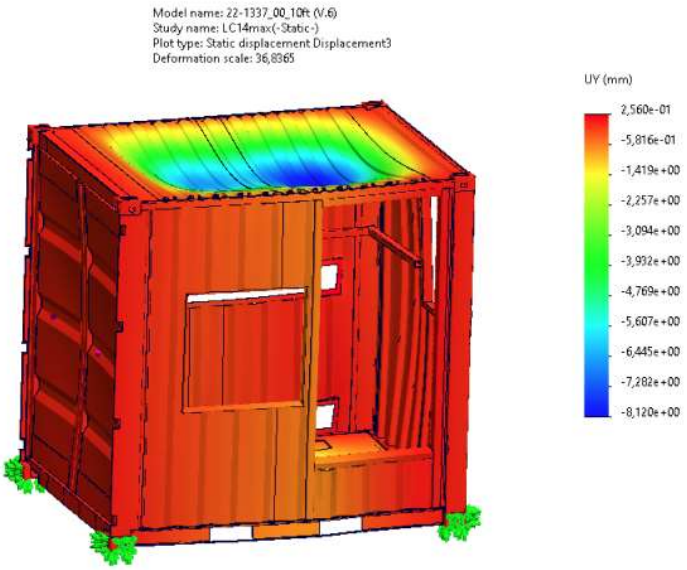


Fig 491: LC14_ MAX -Displacement plot-UY

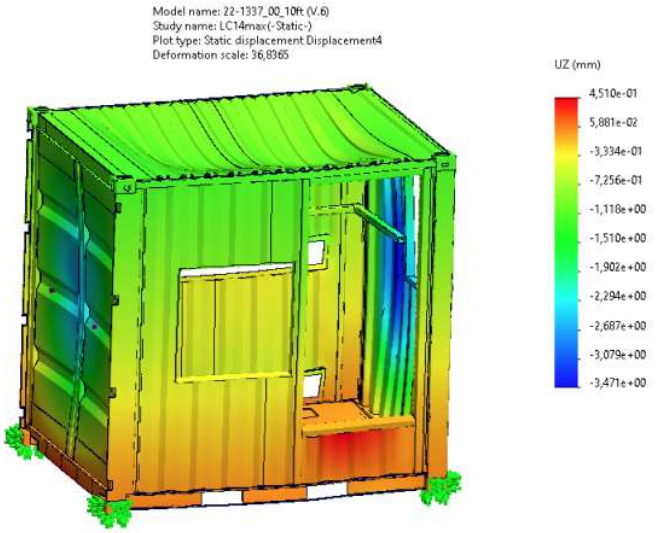


Fig 492: LC14_ MAX -Displacement plot-UZ

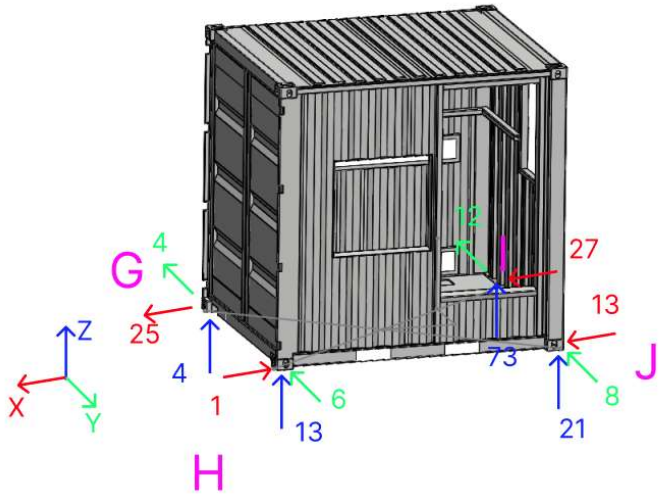


Fig 493: LC14_ MAX -Reactions

10.22.LC14-MIN

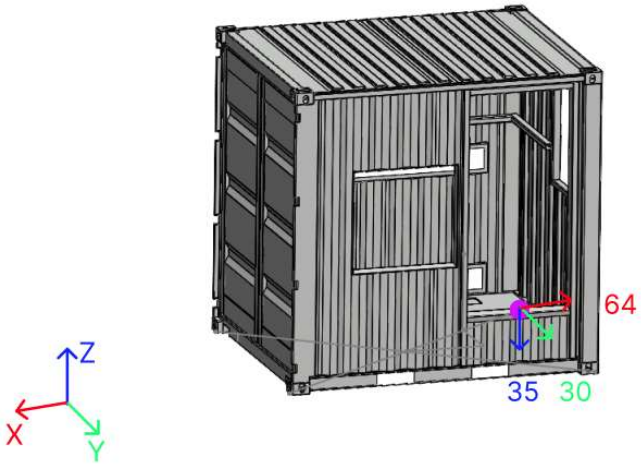


Fig 494: LC14_MIN – 10ft container – Loads

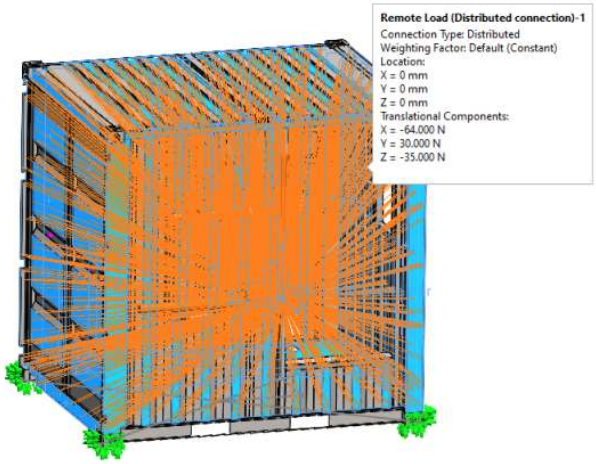


Fig 495: LC14_ MIN -Boundary conditions

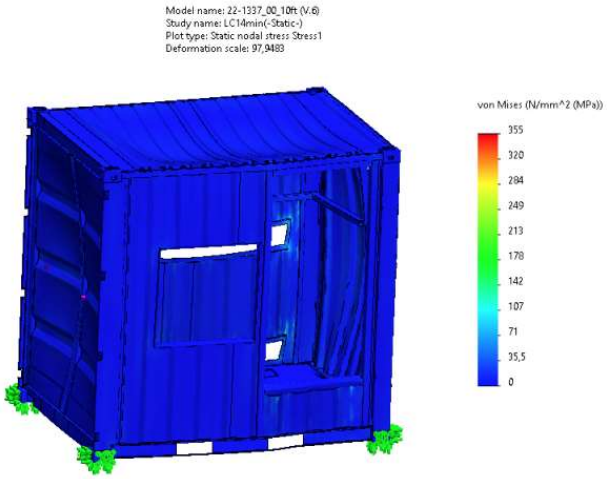


Fig 496: LC14_ MIN -Stress plot

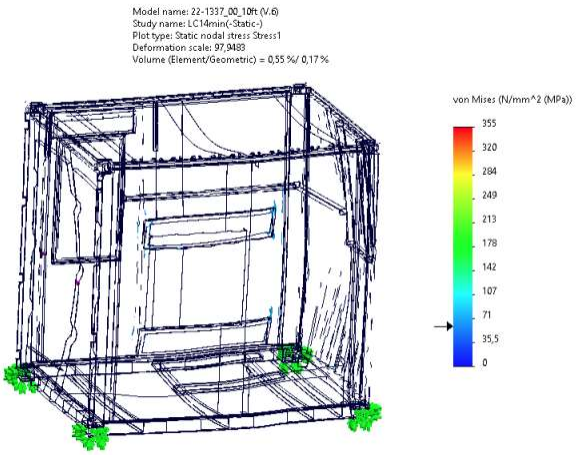


Fig 497: LC14_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

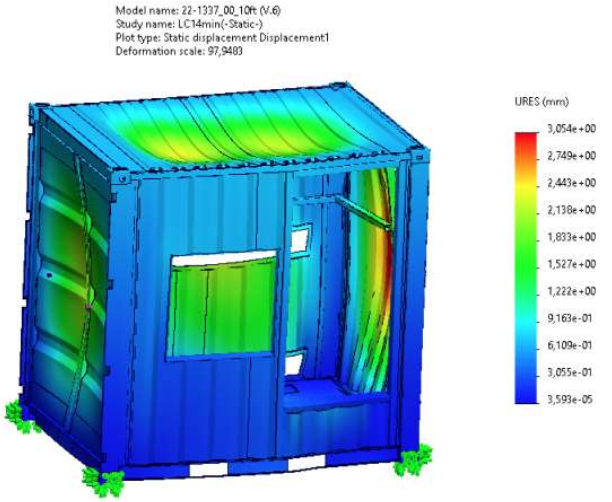


Fig 498: LC14_ MIN -Displacement plot

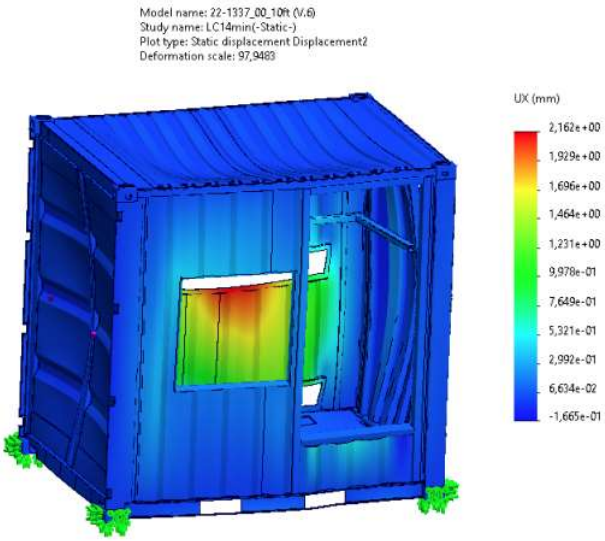


Fig 499: LC14_ MIN -Displacement plot-UX

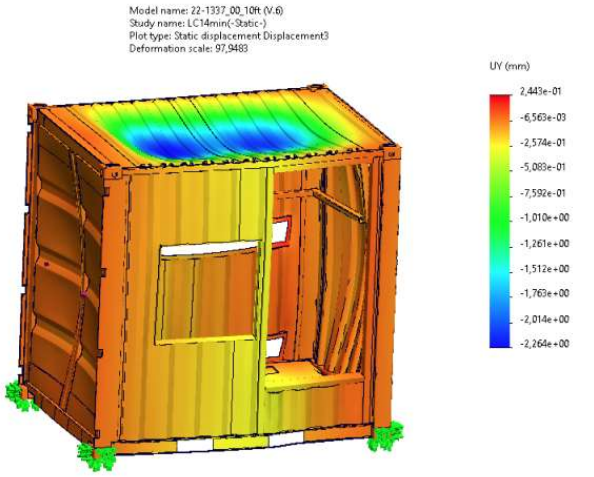


Fig 500: LC14_ MIN -Displacement plot-UY

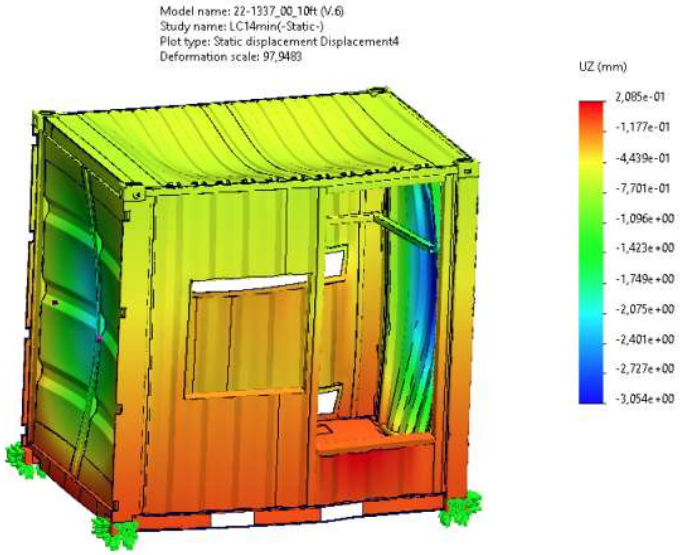


Fig 501: LC14_ MIN -Displacement plot-UZ

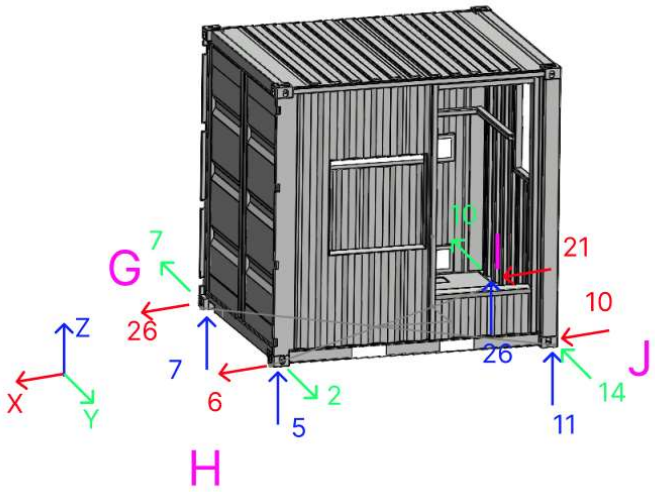


Fig 502: LC14_ MIN -Reactions

10.23.LC15-MAX

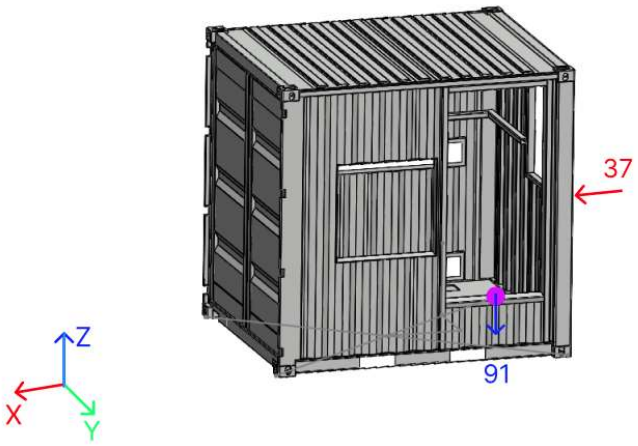


Fig 503: LC15_MAX – 10ft container – Loads

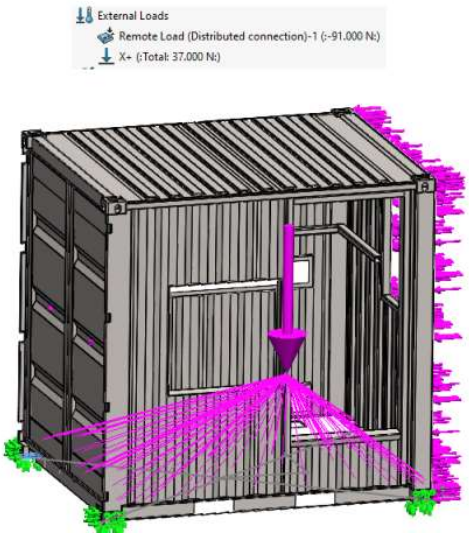


Fig 504: LC15_ MAX -Boundary conditions

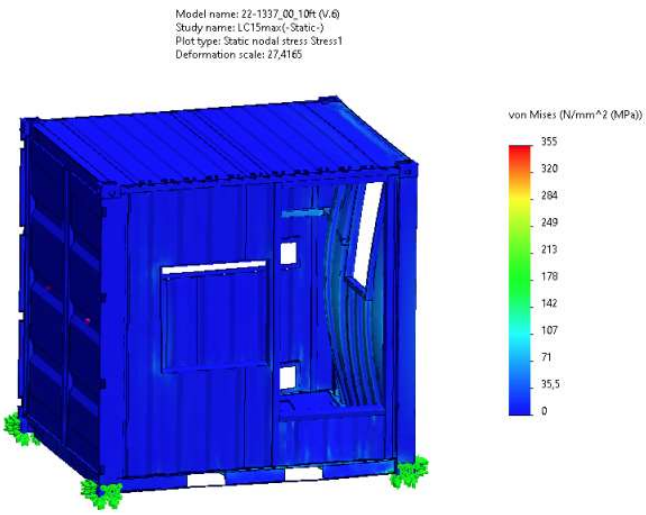


Fig 505: LC15_ MAX -Stress plot

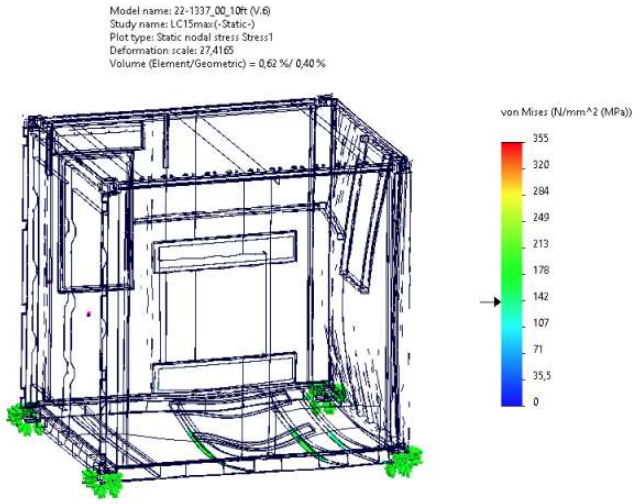


Fig 506: LC15_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

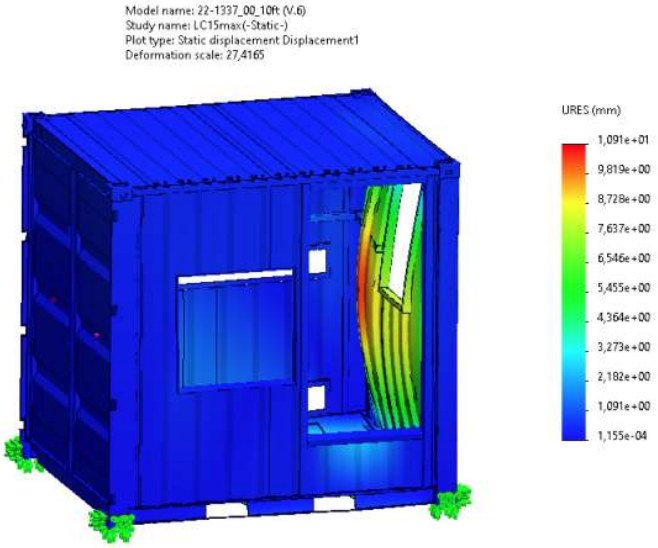


Fig 507: LC15_ MAX -Displacement plot

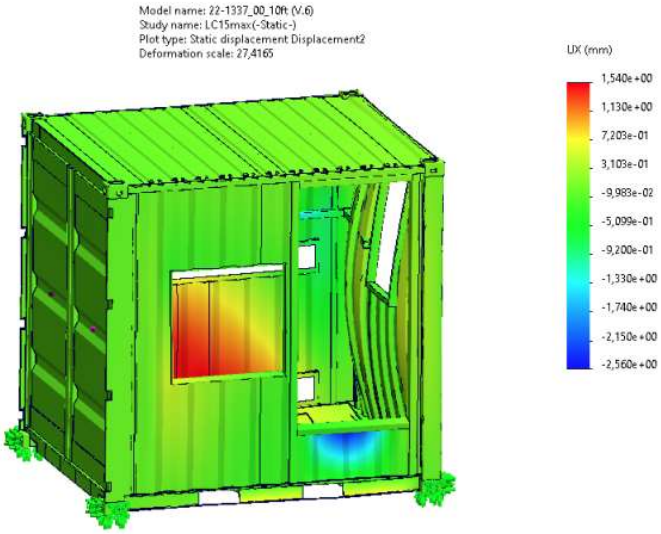


Fig 508: LC15_ MAX -Displacement plot-UX

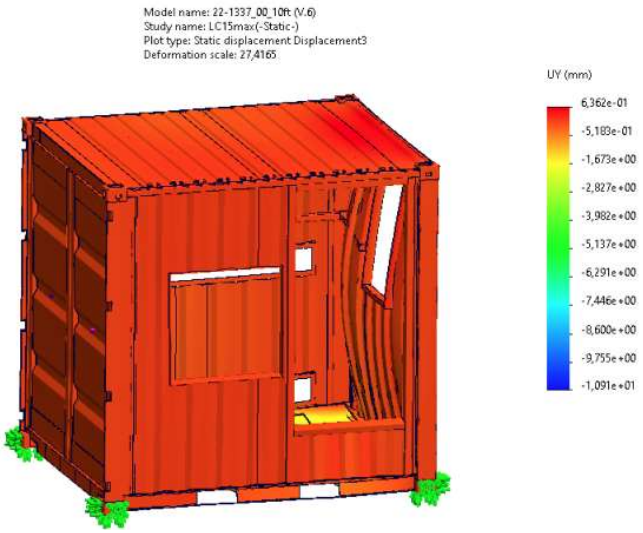


Fig 509: LC15_ MAX -Displacement plot-UY

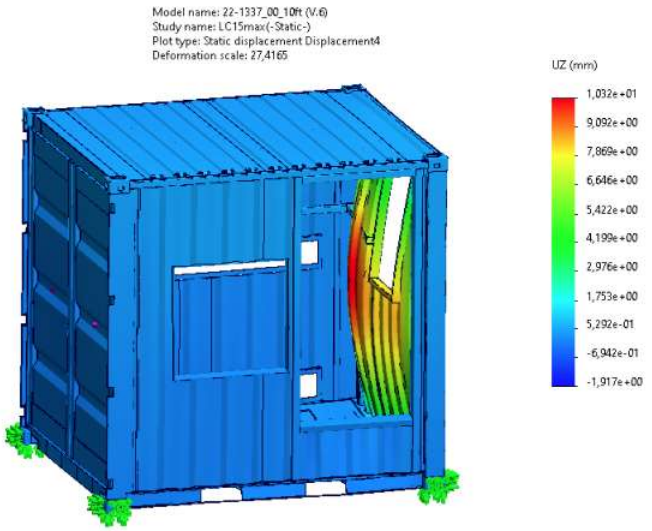


Fig 510: LC15_ MAX -Displacement plot-UZ

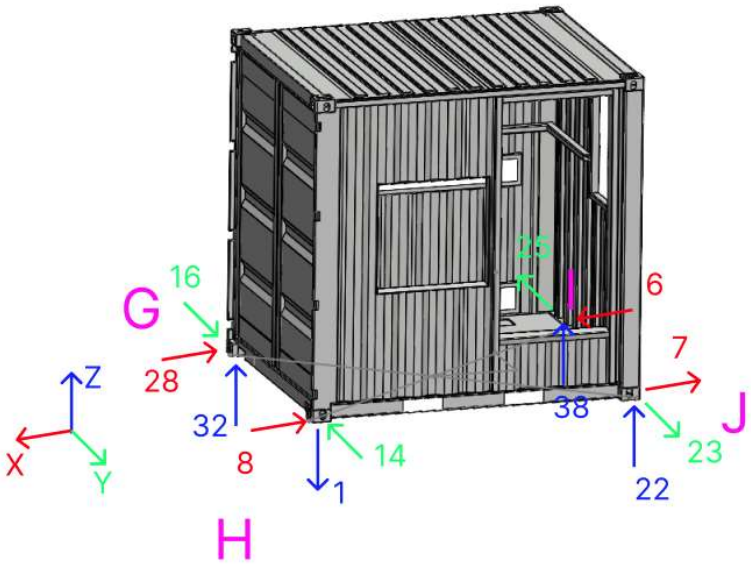


Fig 511: LC15_ MAX -Reactions

10.24.LC15-MIN

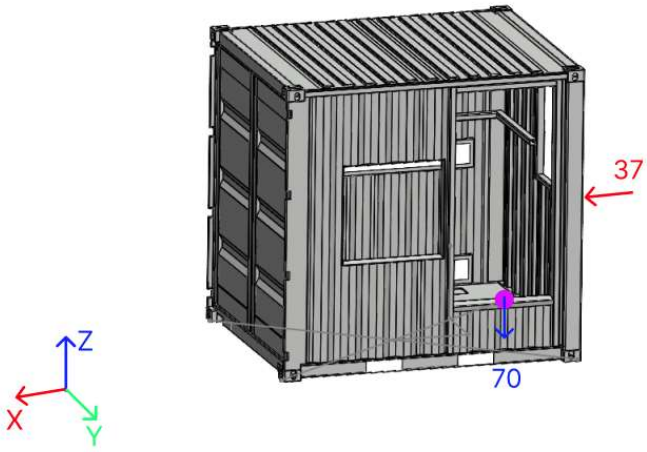


Fig 512: LC15_MIN – 10ft container – Loads

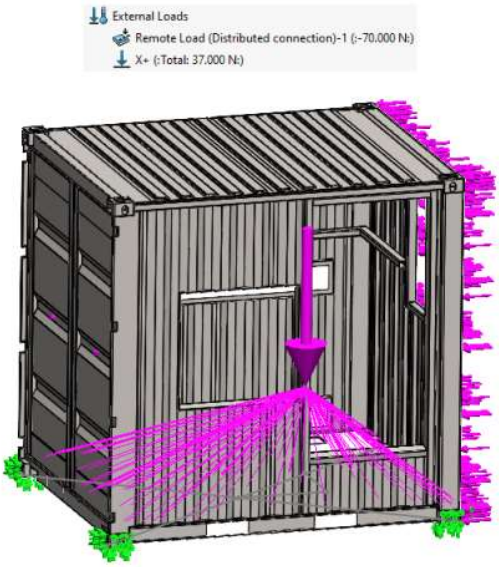


Fig 513: LC15_ MIN -Boundary conditions

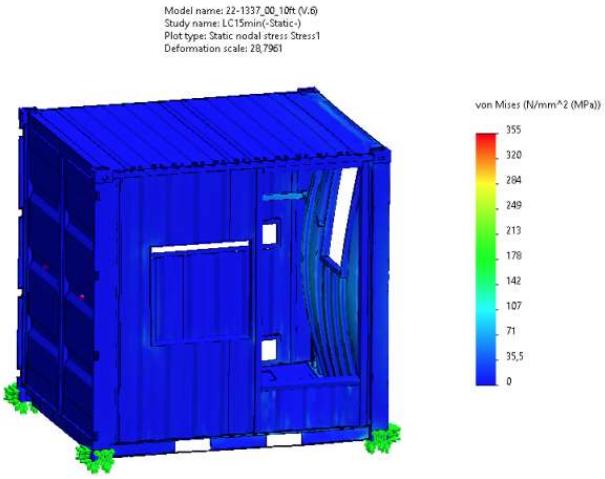


Fig 514: LC15_ MIN -Stress plot

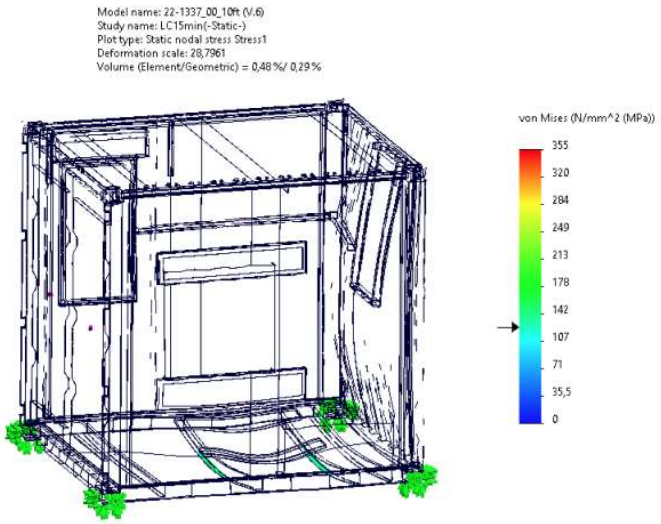


Fig 515: LC15_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

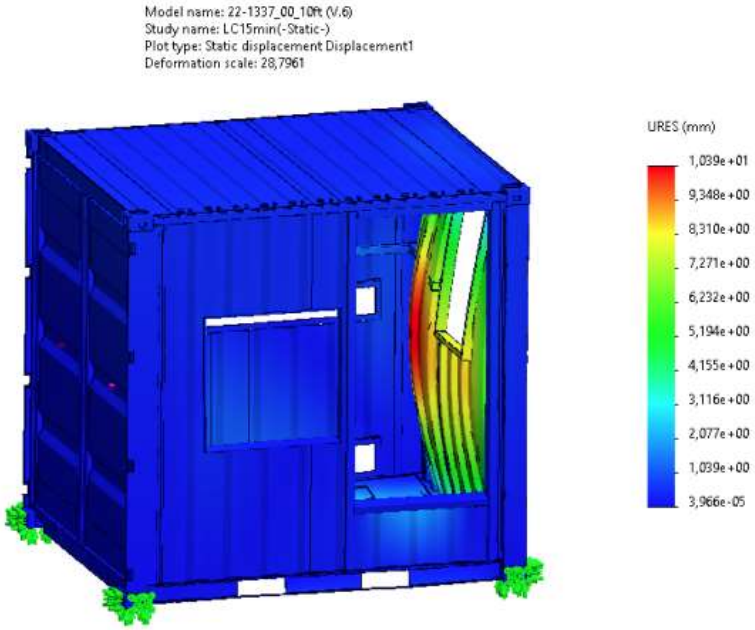


Fig 516: LC15_ MIN -Displacement plot

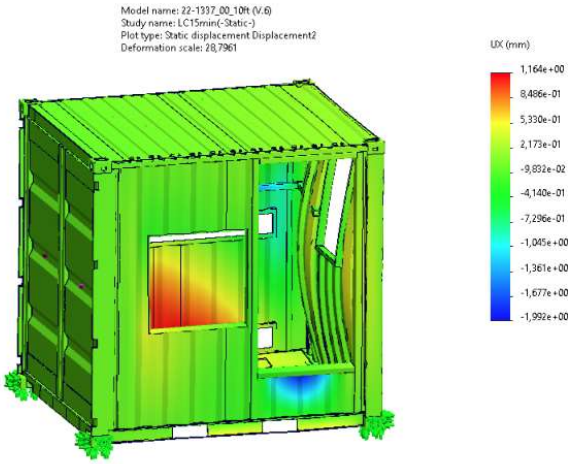


Fig 517: LC15_ MIN -Displacement plot-UX

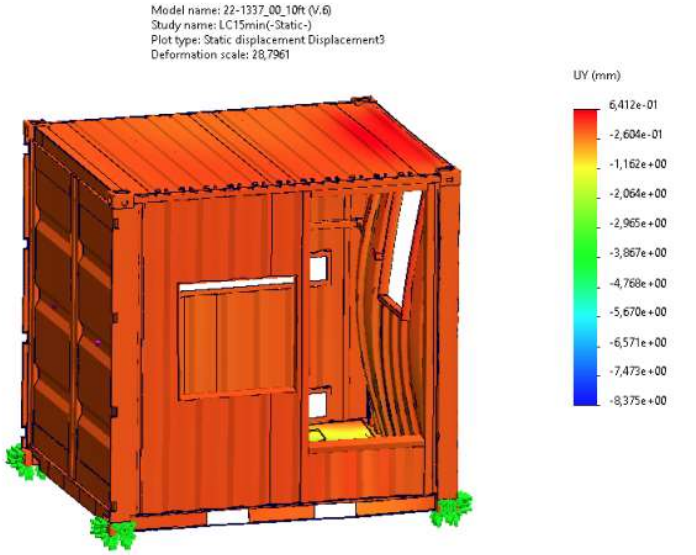


Fig 518: LC15_ MIN -Displacement plot-UY

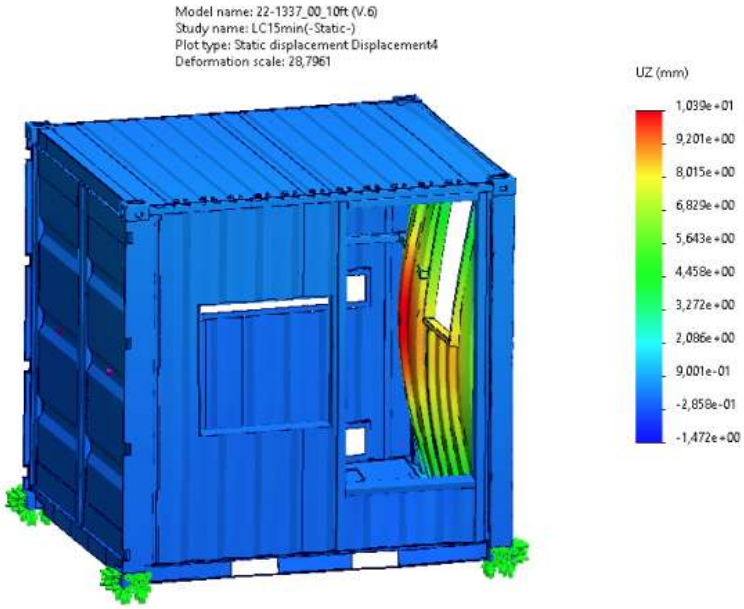


Fig 519: LC15_ MIN -Displacement plot-UZ

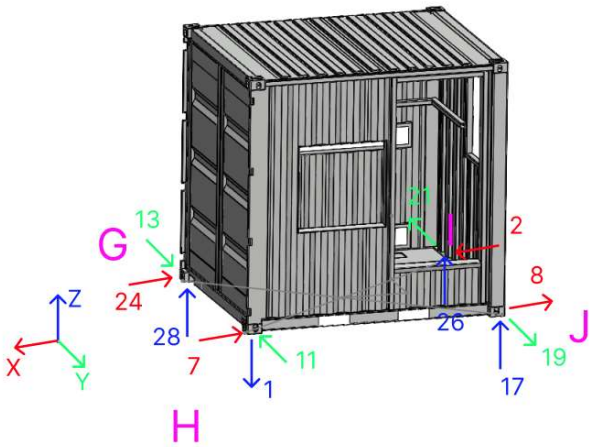


Fig 520: LC15_ MIN -Reactions

10.25.LC16-MAX

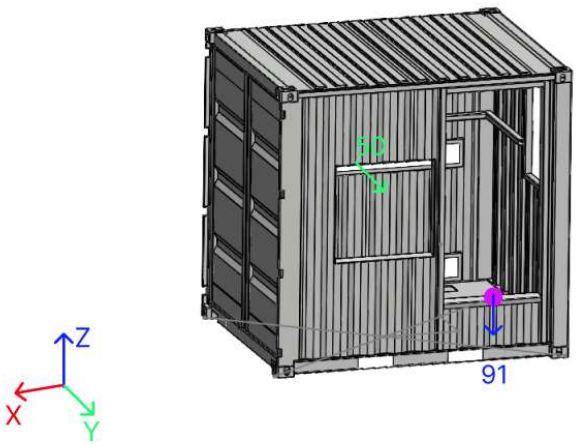


Fig 521: LC16_MAX – 10ft container – Loads

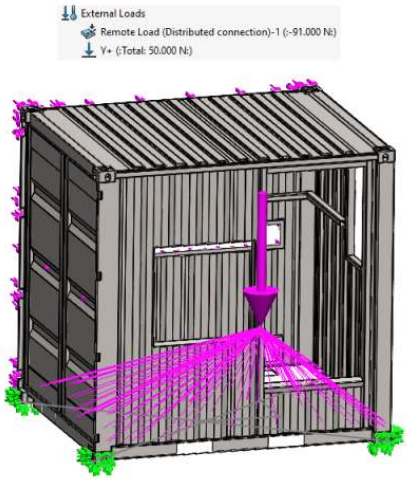


Fig 522: LC16_ MAX -Boundary conditions

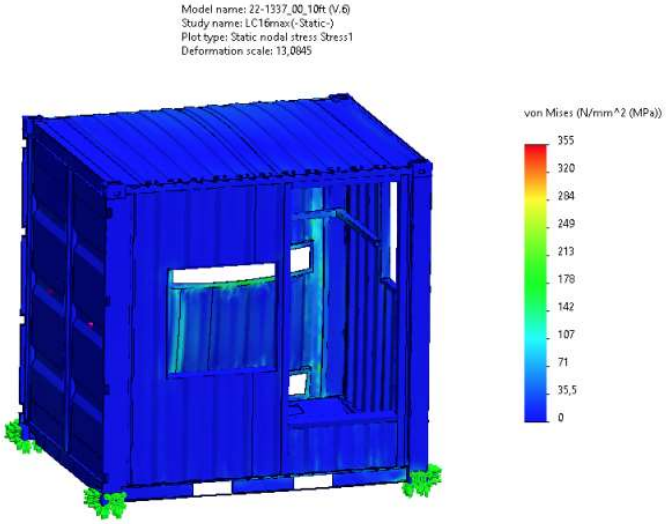


Fig 523: LC16_ MAX -Stress plot

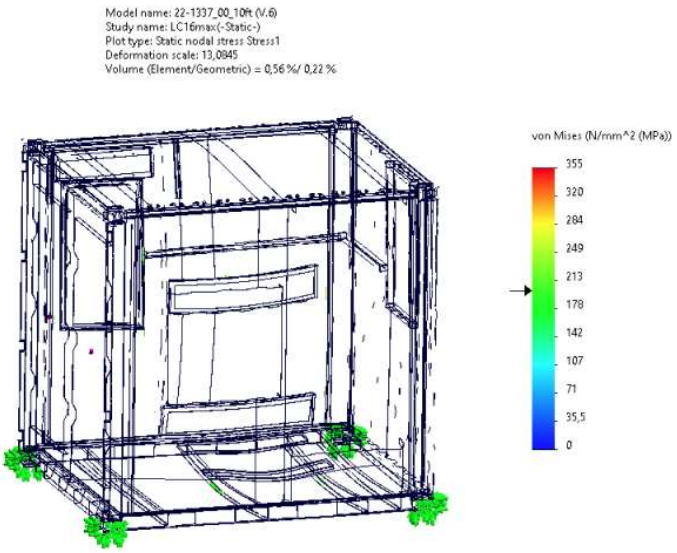


Fig 524: LC16_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

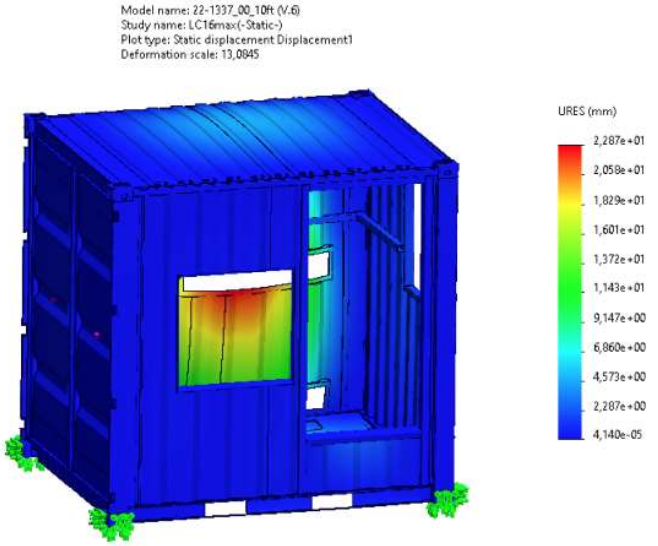


Fig 525: LC16_ MAX -Displacement plot

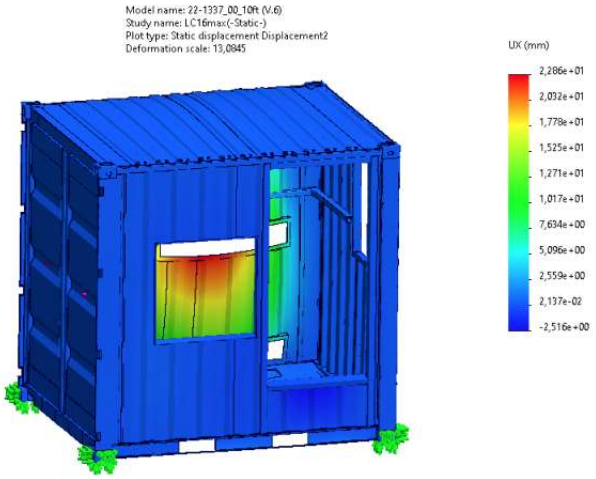


Fig 526: LC16_ MAX -Displacement plot-UX

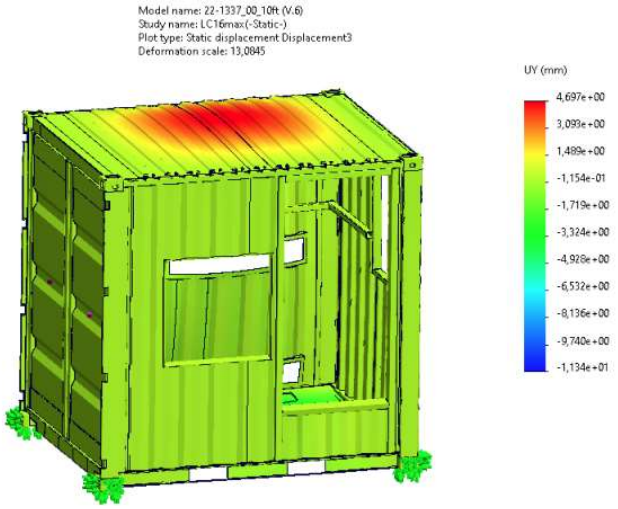


Fig 527: LC16_ MAX -Displacement plot-UY

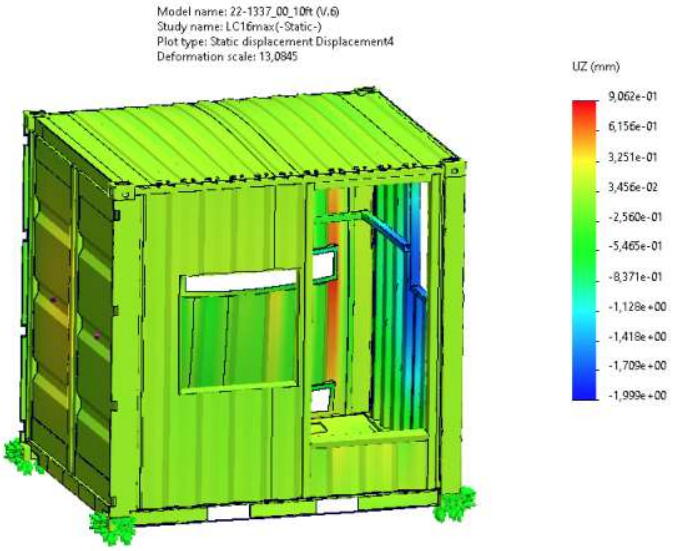


Fig 528: LC16_ MAX -Displacement plot-UZ

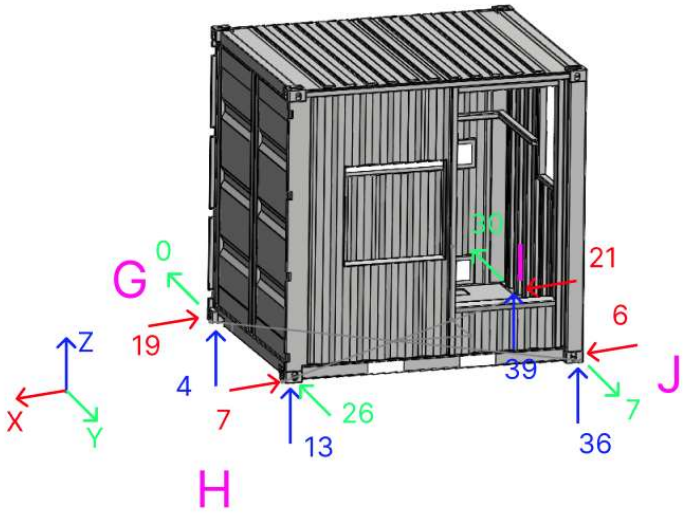


Fig 529: LC16_ MAX -Reactions

10.26.LC16-MIN

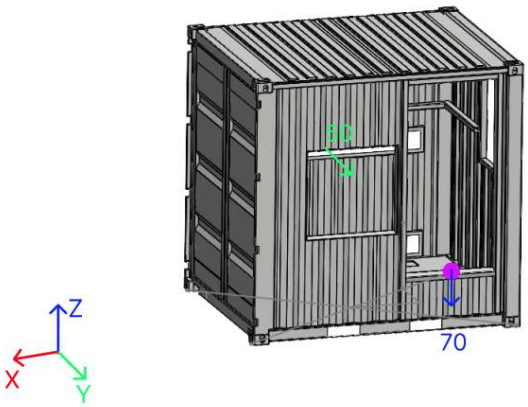


Fig 530: LC16_MIN – 10ft container – Loads

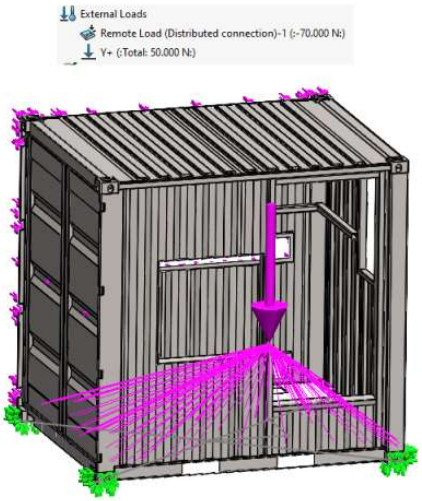


Fig 531: LC16_ MIN -Boundary conditions

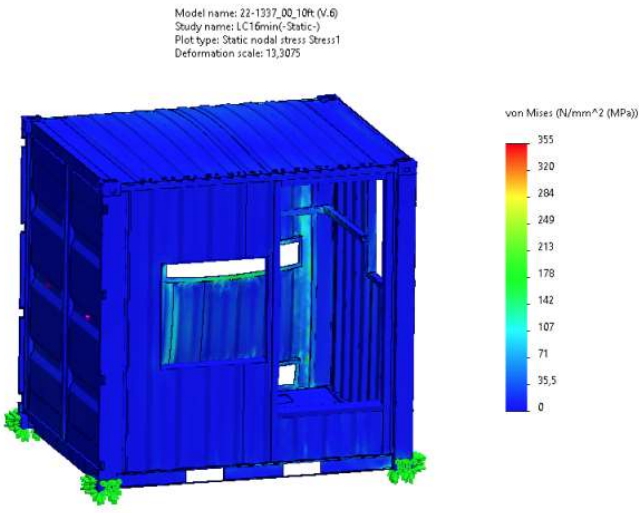


Fig 532: LC16_ MIN -Stress plot

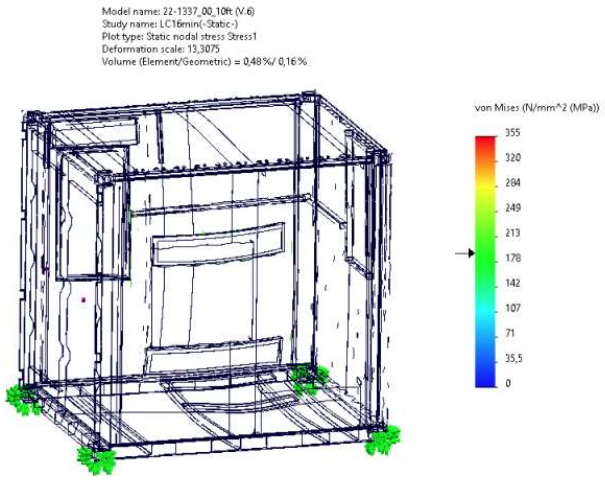


Fig 533: LC16_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

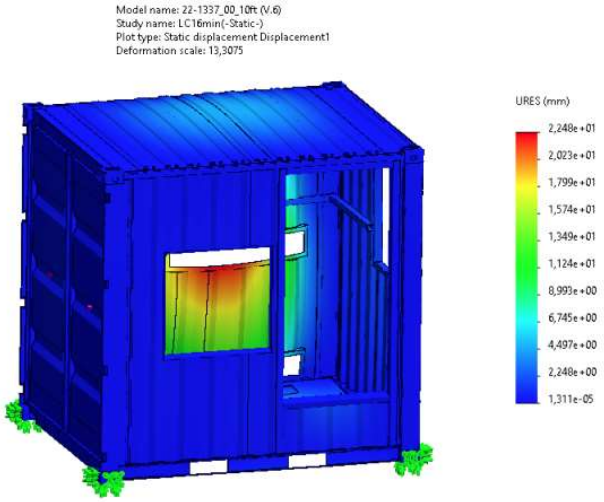


Fig 534: LC16_ MIN -Displacement plot

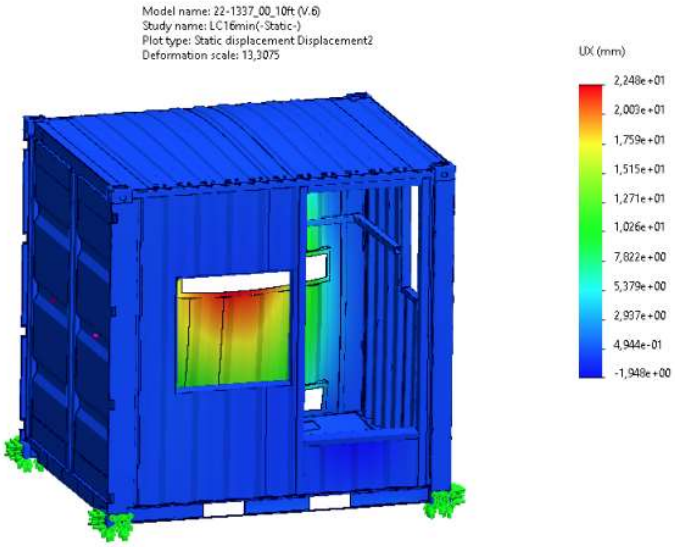


Fig 535: LC16_ MIN -Displacement plot-UX

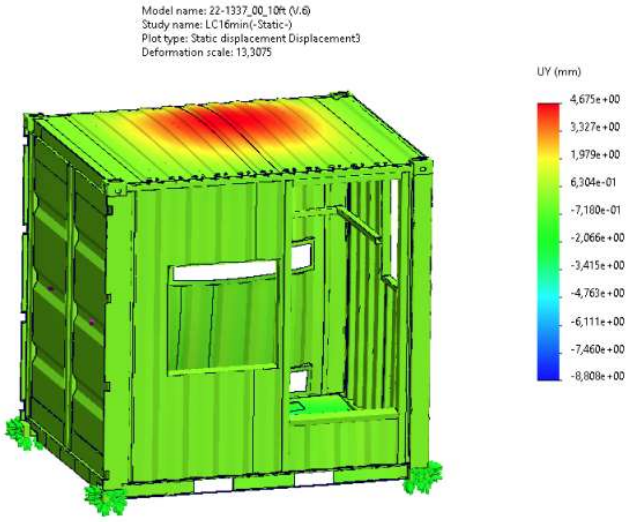


Fig 536: LC16_ MIN -Displacement plot-UY

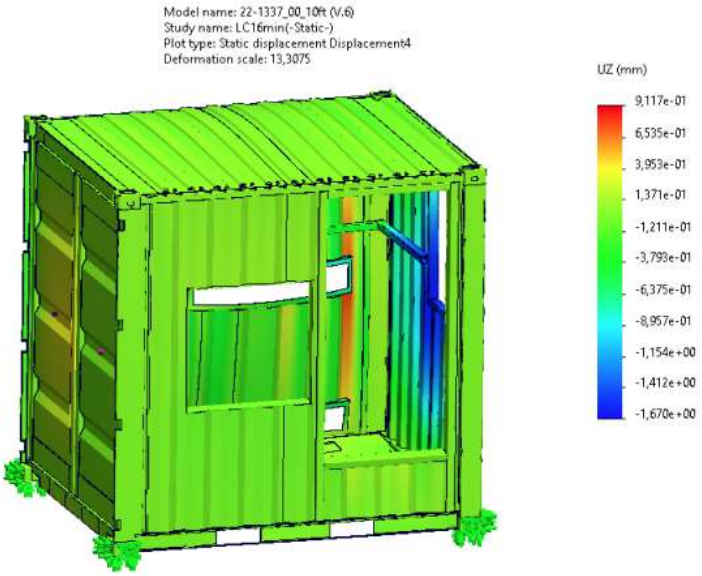


Fig 537: LC16_ MIN -Displacement plot-UZ

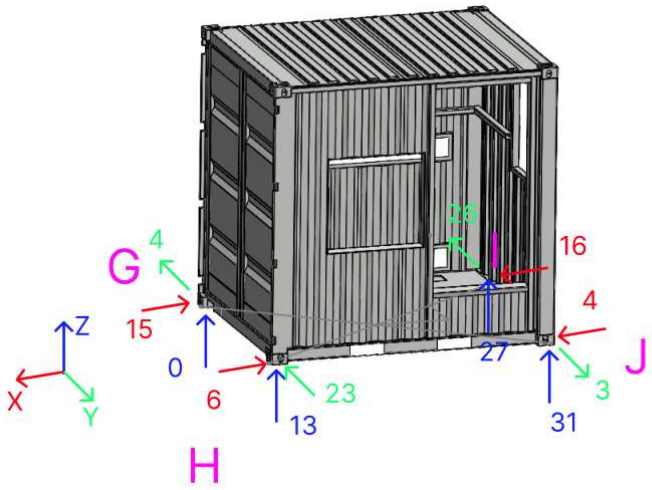


Fig 538: LC16_ MIN -Reactions

10.27.LC17-MAX

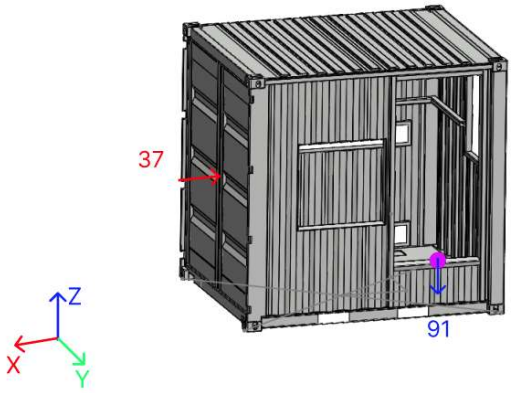


Fig 539: LC17_MAX – 10ft container – Loads



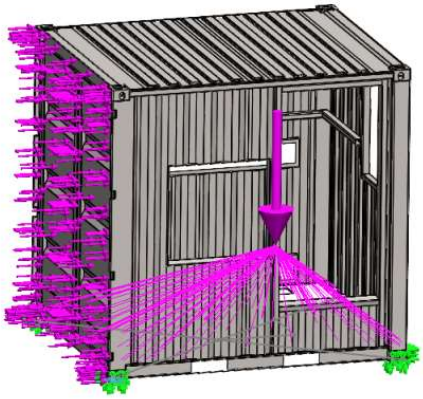


Fig 540: LC17_ MAX -Boundary conditions

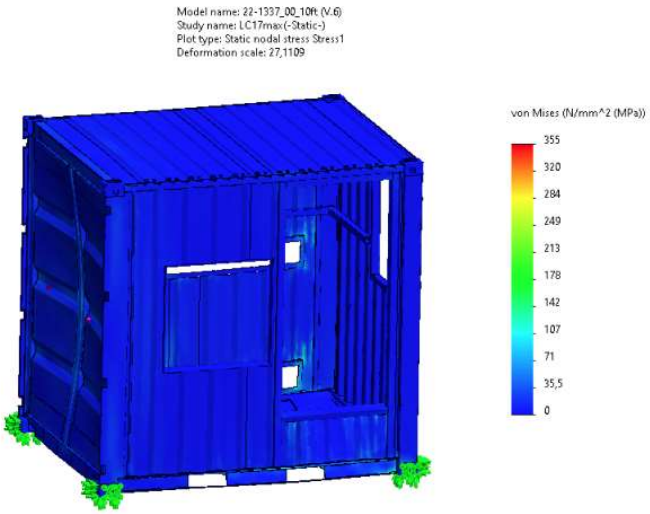


Fig 541: LC17_ MAX -Stress plot

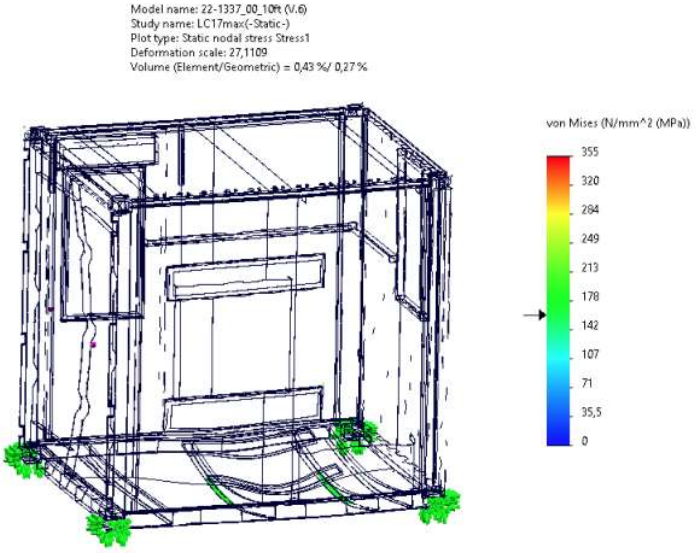


Fig 542: LC17_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

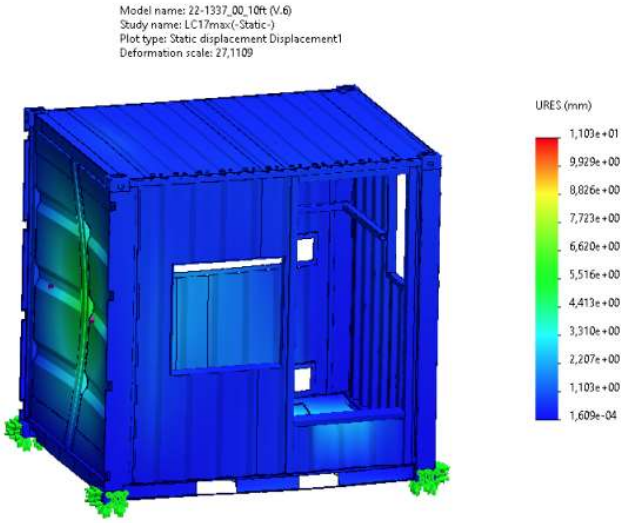


Fig 543: LC17_ MAX -Displacement plot

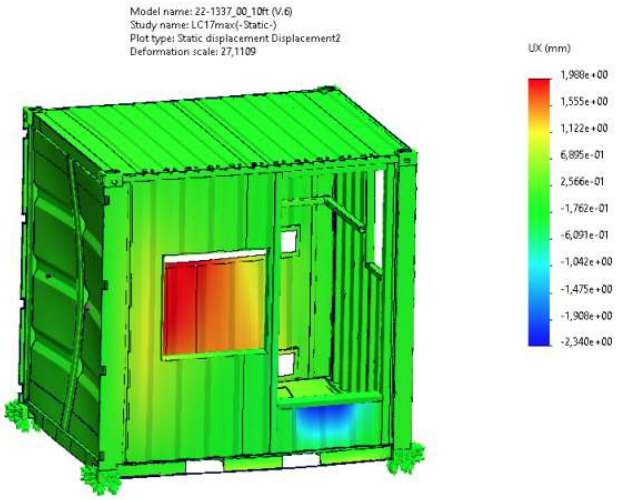


Fig 544: LC17_ MAX -Displacement plot-UX

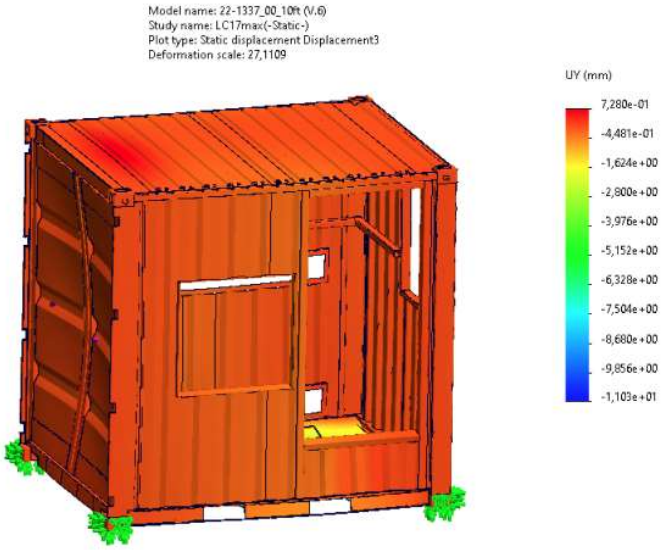


Fig 545: LC17_ MAX -Displacement plot-UY

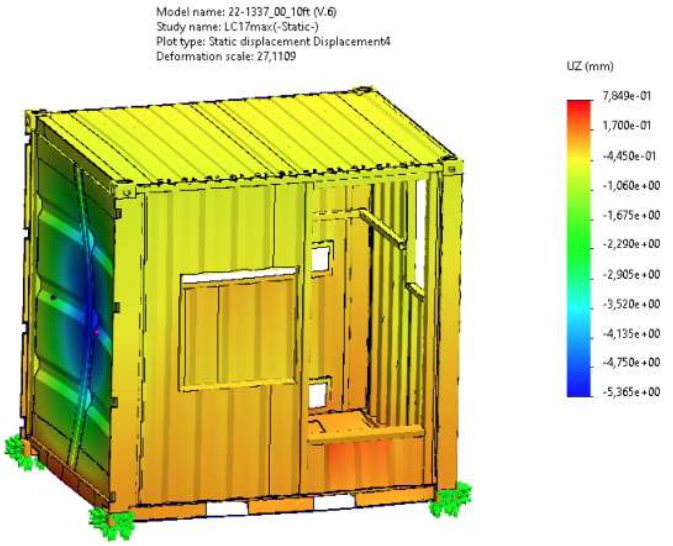


Fig 546: LC17_ MAX -Displacement plot-UZ

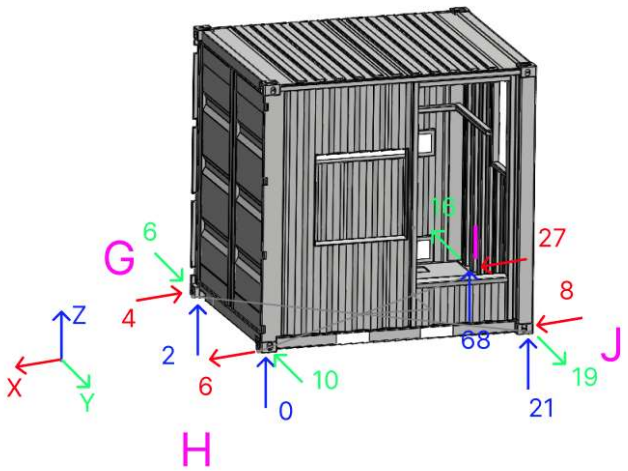


Fig 547: LC17_ MAX -Reactions

10.28.LC17-MIN

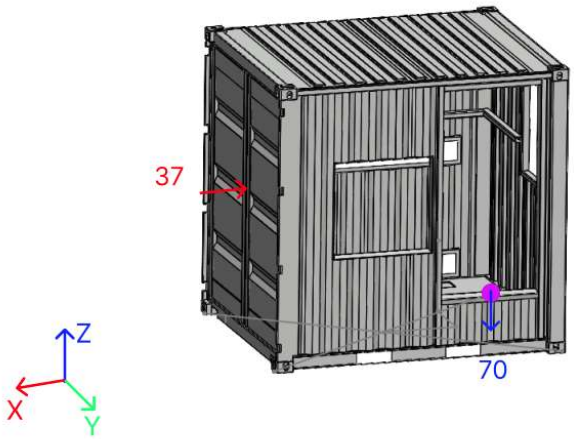


Fig 548: LC17_MIN – 10ft container – Loads

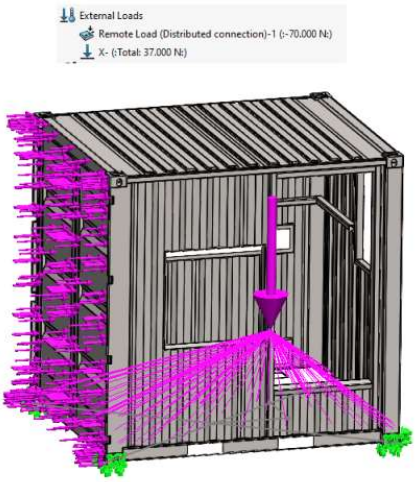


Fig 549: LC17_ MIN -Boundary conditions

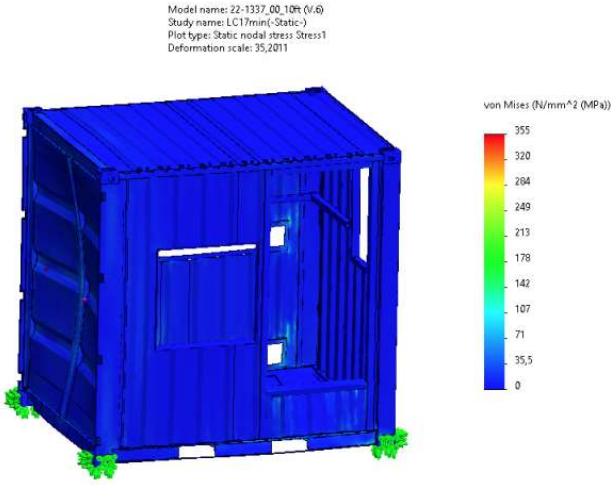


Fig 550: LC17_ MIN -Stress plot

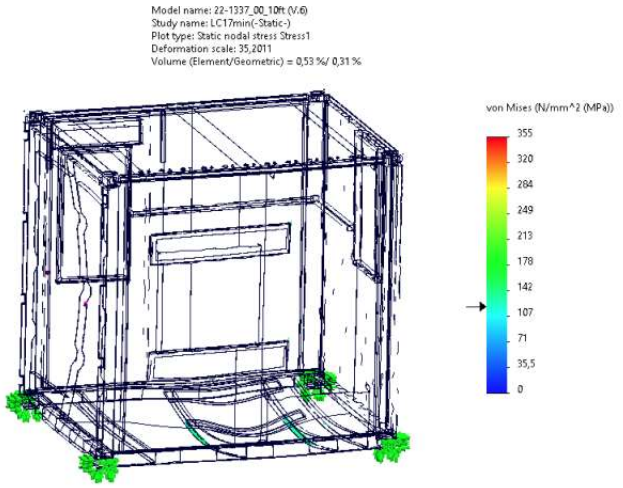


Fig 551: LC17_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

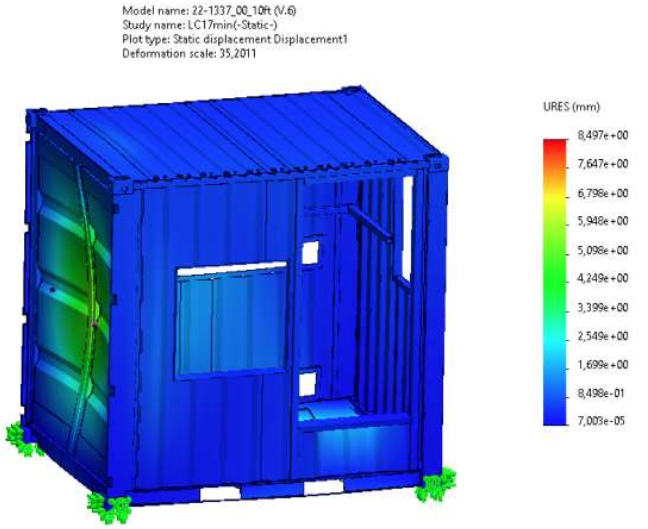


Fig 552: LC17_ MIN -Displacement plot

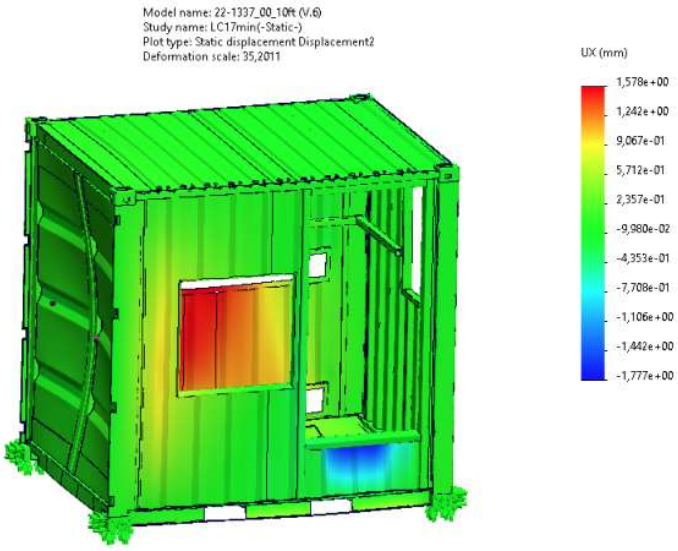


Fig 553: LC17_ MIN -Displacement plot-UX

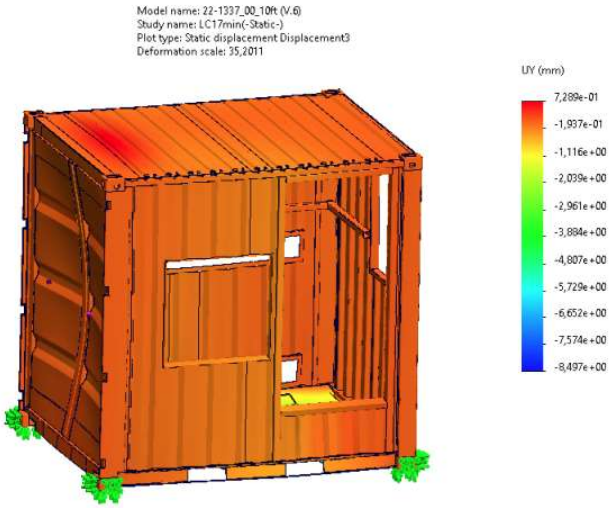


Fig 554: LC17_ MIN -Displacement plot-UY

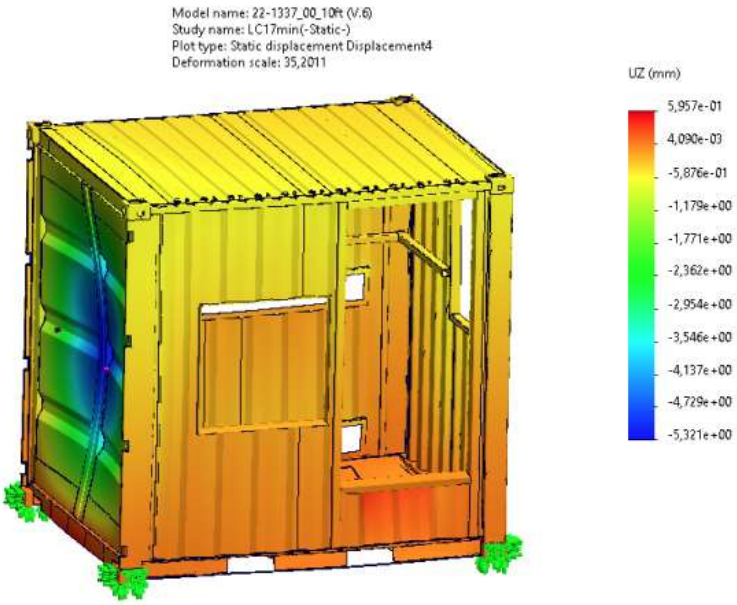


Fig 555: LC17_ MIN -Displacement plot-UZ

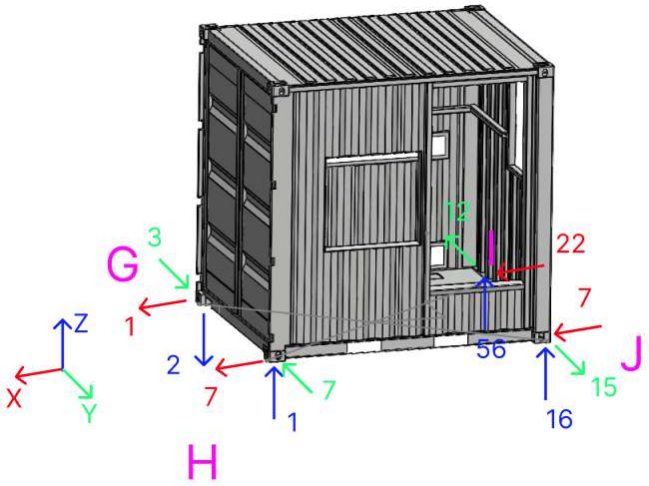


Fig 556: LC17_ MIN -Reactions

10.29.LC18-MAX

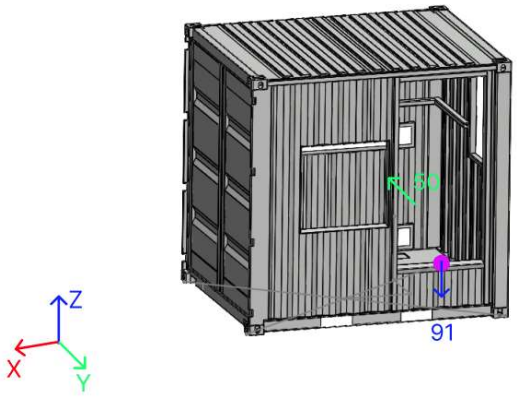


Fig 557: LC18_MAX – 10ft container – Loads

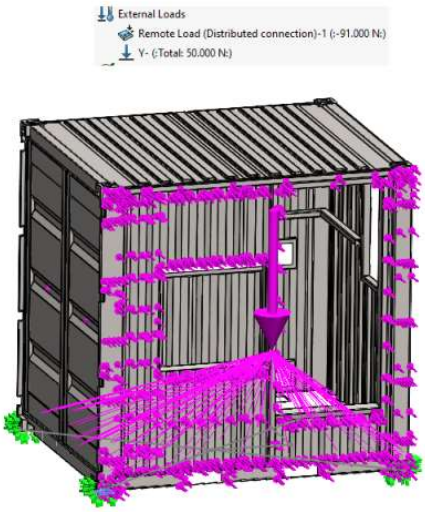


Fig 558: LC18_ MAX -Boundary conditions

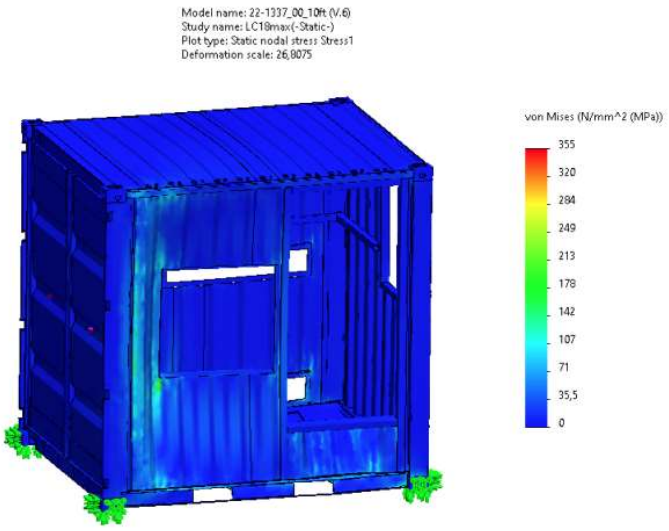


Fig 559: LC18_ MAX -Stress plot

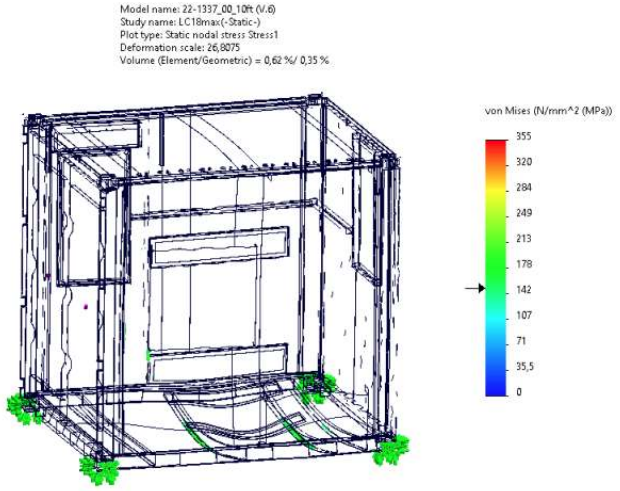


Fig 560: LC18_ MAX -Stress plot (the biggest stress in 0,5% of element volume)

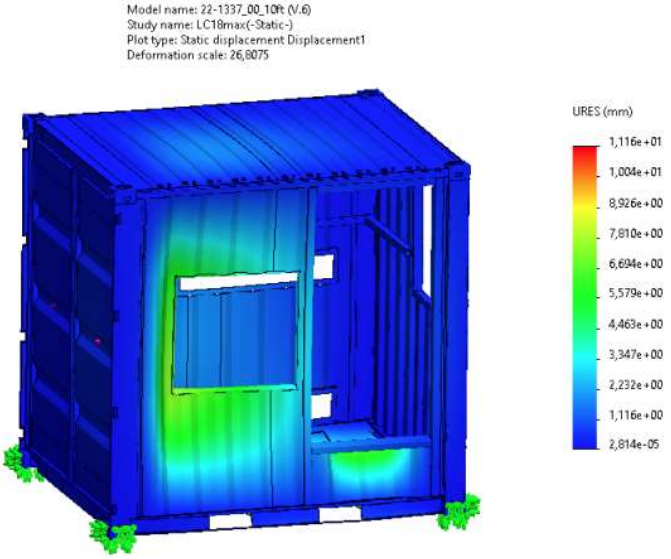


Fig 561: LC18_ MAX -Displacement plot

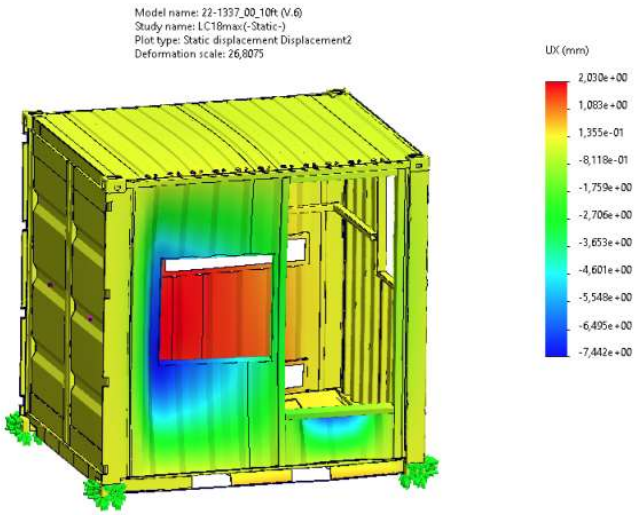


Fig 562: LC18_ MAX -Displacement plot-UX

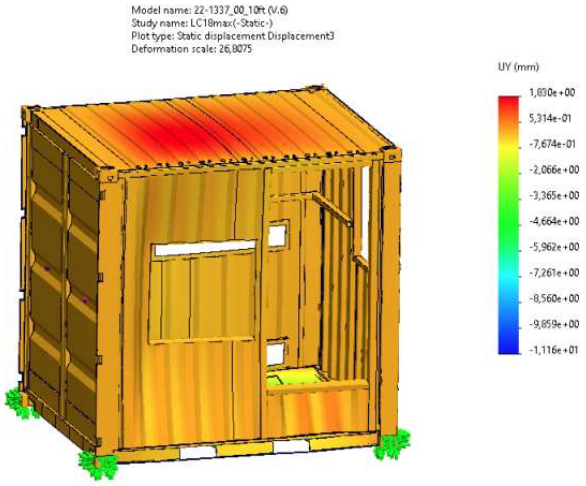


Fig 563: LC18_ MAX -Displacement plot-UY

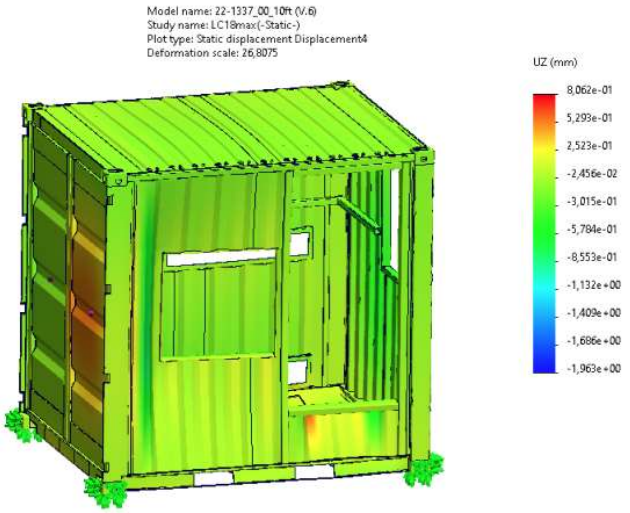


Fig 564: LC18_ MAX -Displacement plot-UZ

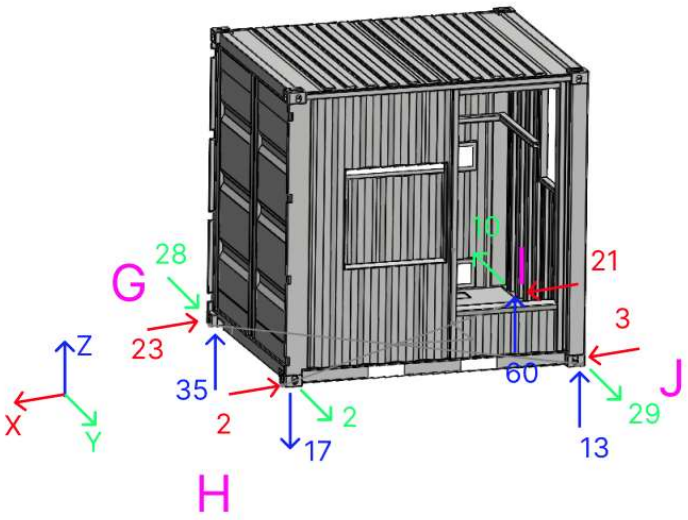


Fig 565: LC18_ MAX -Reactions

10.30.LC18-MIN

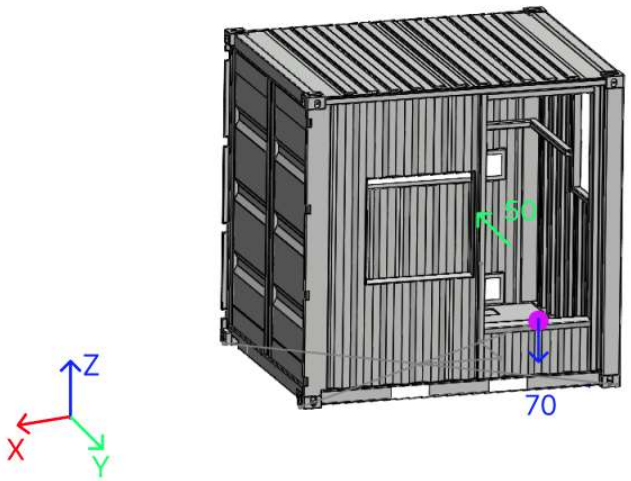


Fig 566: LC18_MIN – 10ft container – Loads

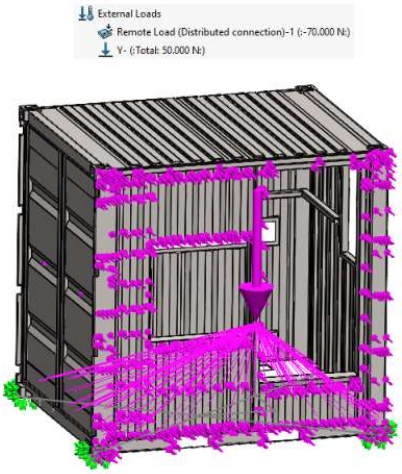


Fig 567: LC18_ MIN -Boundary conditions

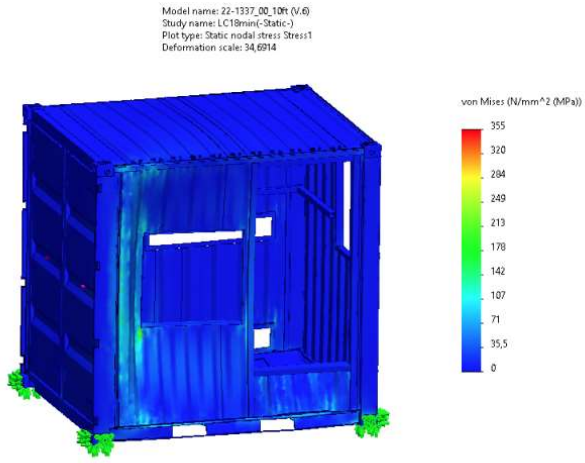


Fig 568: LC18_ MIN -Stress plot

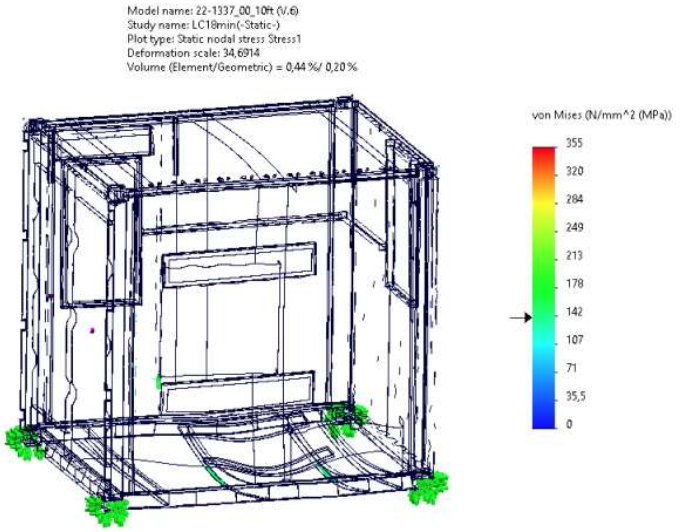


Fig 569: LC18_ MIN -Stress plot (the biggest stress in 0,5% of element volume)

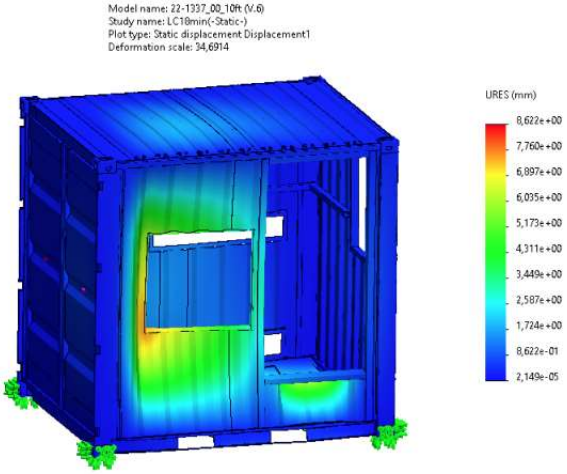


Fig 570: LC18_ MIN -Displacement plot

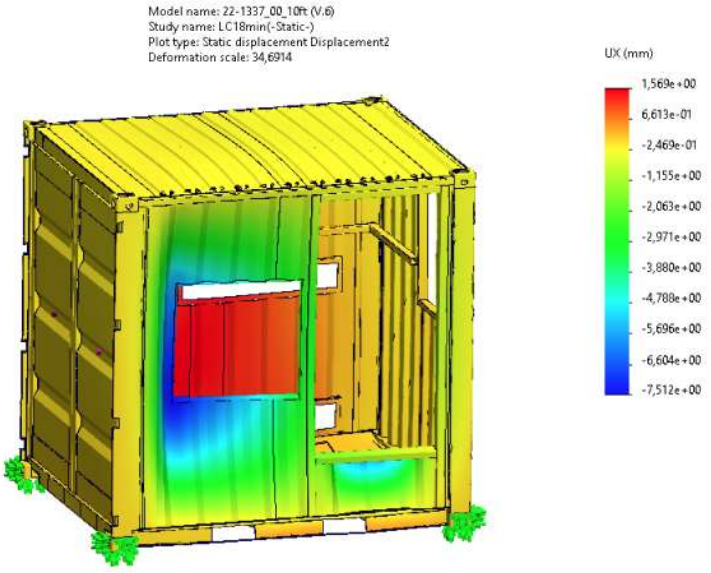


Fig 571: LC18_ MIN -Displacement plot-UX

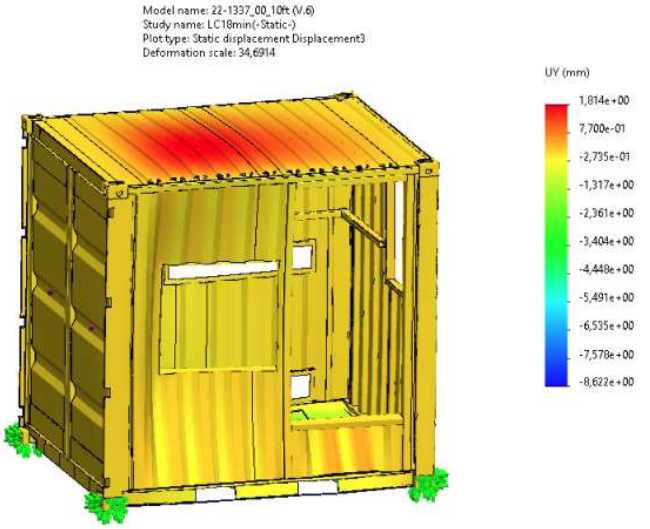


Fig 572: LC18_ MIN -Displacement plot-UY

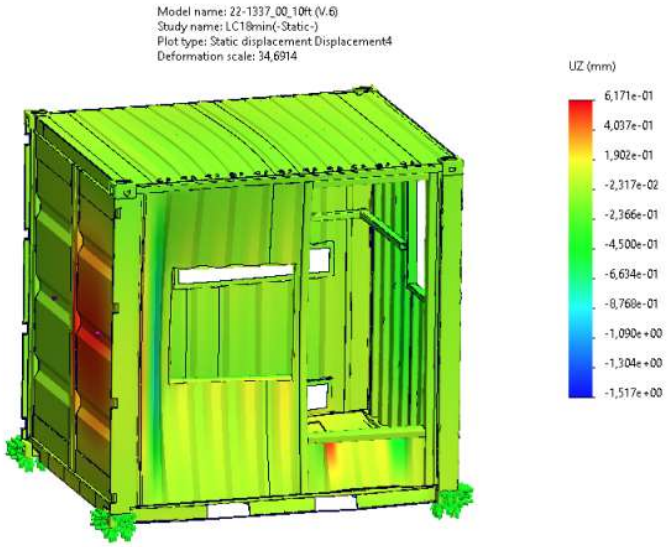


Fig 573: LC18_ MIN -Displacement plot-UZ

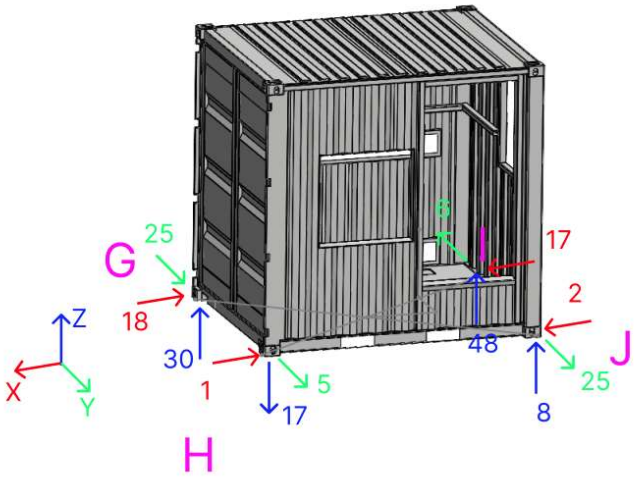


Fig 574: LC18_ MIN -Reactions

11. Summary

In tables below are listed all reaction forces from 40ft High Cube container and 10ft High Cube container which may occur during transport on sea type barge, in destination place or during lifting offshore the containers with all equipment inside them.

It is good to remember that reaction below 40ft container are caused by 40ft container and 40ft flatbed with coolers and other equipment which is placed on 40ft container, wherus 10ft container reactions are caused only by 10ft container with equipment inside them.

It is prohibited to lift 40ft container with 40ft platform together.

Structural calculations of 40ft flatbed can be found in document :"Cross_Wind – Flatbed 40ft – calculations report rev_1.pdf".

40ft container							
Ultimate Limit State: LC5 - lifting of the 40ft container with full equipment							
LC5 - Lifting offshore vertically by 4 bottom ISO 1161 corners (only 40ft container), [SF=2,34]				LC5 - Lifting offshore vertically by 4 top ISO 1161 corners (only 40ft container), [SF=2,34]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-	-	126	A	-	-	125
B	-	-	133	B	-	-	134
C	-	-	-	C	-	-	-
D	-	-	-	D	-	-	-
E	-	-	133	E	-	-	134
F	-	-	128	F	-	-	128

Fig 575: Offshore lifting of the 40ft container with equipment inside – LC5

40ft flatbed + 40ft container (CROSSWIND)							
Ultimate Limit State: LC15-LC18 - destination place (Offshore)							
40ft container + 40ft flatbed (max self-weight) LC15 MAX- Destination place - Offshore Wind X+				40ft container + 40ft flatbed (min self-weight) LC15 MIN - Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-67	2	58	A	-61	3	48
B	-69	-4	99	B	-63	-4	83
C	-	-	84	C	-	-	63
D	-	-	102	D	-	-	78
E	1	10	71	E	-7	6	51
F	-23	-8	20	F	-27	-4	9
40ft container + 40ft flatbed (max self-weight) LC16 MAX- Destination place - Offshore Wind Y+				40ft container + 40ft flatbed (min self-weight) LC16 MIN - Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	65	-95	-260	A	71	-95	-275
B	-115	-82	362	B	-108	-81	347
C	-	-	103	C	-	-	92
D	-	-	105	D	-	-	80
E	-4	-65	-38	E	-12	-69	-61
F	53	-95	158	F	50	-92	149
40ft container + 40ft flatbed (max self-weight) LC17 MAX- Destination place - Offshore Wind X-				40ft container + 40ft flatbed (min self-weight) LC17 MIN - Destination place - Offshore Wind X-			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	16	-7	26	A	21	-6	17
B	13	6	39	B	19	6	21
C	-	-	97	C	-	-	76
D	-	-	102	D	-	-	78
E	69	24	91	E	61	20	72
F	60	-24	78	F	56	-20	66
40ft container + 40ft flatbed (max self-weight) LC18 MAX- Destination place - Offshore Wind Y-				40ft container + 40ft flatbed (min self-weight) LC18 MIN - Destination place - Offshore Wind Y-			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-117	90	332	A	-111	91	323
B	60	83	-237	B	67	83	-257
C	-	-	98	C	-	-	76
D	-	-	119	D	-	-	106
E	73	98	189	E	65	94	172
F	-17	66	-72	F	-21	69	-88

Fig 576: Open sea – LC15-LC18 - 40ft container reactions in destination place

40ft flatbed + 40ft container (CROSSWIND)							
Ultimate Limit State: LC7-LC14 - sea transport on barge							
40ft container + 40ft flatbed (max self-weight) LC7 MAX: Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]				40ft container + 40ft flatbed (min self-weight) LC7 MIN: Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	39	-75	-158	A	65	-72	-217
B	-103	-63	300	B	-76	-63	234
C	-	-	113	C	-	-	53
D	-	-	130	D	-	-	24
E	11	-42	27	E	-24	-60	-70
F	53	-83	138	F	35	-67	93
40ft container + 40ft flatbed (max self-weight) LC8 MAX: Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]				40ft container + 40ft flatbed (min self-weight) LC8 MIN: Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-64	-39	-60	A	-42	-37	-98
B	-153	-49	263	B	-131	-50	207
C	-	-	101	C	-	-	34
D	-	-	127	D	-	-	41
E	-45	-33	30	E	-74	-48	-42
F	-37	-44	85	F	-52	-30	21
40ft container + 40ft flatbed (max self-weight) LC9 MAX: Sea transport on the barge Beam sea, X+ [Roll case 1]				40ft container + 40ft flatbed (min self-weight) LC9 MIN: Sea transport on the barge Beam sea, X+ [Roll case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-130	9	80	A	-111	10	48
B	-131	-12	141	B	-111	-13	90
C	-	-	99	C	-	-	31
D	-	-	124	D	-	-	47
E	-44	2	70	E	-70	-11	-10
F	-78	2	-4	F	-92	13	-41
40ft container + 40ft flatbed (max self-weight) LC10 MAX: Sea transport on the barge Quatering sea, stern down, X+ Y- [Quatering 2]				40ft container + 40ft flatbed (min self-weight) LC10 MIN: Sea transport on the barge Quatering sea, stern down, X+ Y- [Quatering 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-154	51	206	A	-132	53	172
B	-67	31	-6	B	-44	31	-65
C	-	-	105	C	-	-	30
D	-	-	126	D	-	-	49
E	-4	46	127	E	-32	32	61
F	-74	37	-39	F	-90	49	-82
40ft container + 40ft flatbed (max self-weight) LC11 MAX: Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]				40ft container + 40ft flatbed (mix self-weight) LC11 MIN: Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-104	68	265	A	-79	71	225
B	33	65	-126	B	61	64	-164
C	-	-	118	C	-	-	23
D	-	-	130	D	-	-	59
E	77	85	178	E	43	67	101
F	-6	43	-13	F	-26	59	-79
40ft container + 40ft flatbed (max self-weight) LC12 MAX: Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]				40ft container + 40ft flatbed (min self-weight) LC12 MIN: Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	0	33	161	A	22	35	129
B	88	51	-101	B	111	51	-166
C	-	-	118	C	-	-	41
D	-	-	120	D	-	-	51
E	129	75	164	E	101	61	99
F	81	6	60	F	66	19	10
40ft container + 40ft flatbed (max self-weight) LC13 MAX: Sea transport on the barge Beam sea, X- [Roll case 2]				40ft container + 40ft flatbed (min self-weight) LC13 MIN: Sea transport on the barge Beam sea, X- [Roll case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	69	-14	19	A	88	-13	-13
B	66	14	9	B	87	13	-31
C	-	-	115	C	-	-	47
D	-	-	117	D	-	-	40
E	126	39	120	E	100	25	60
F	122	-38	120	F	107	-27	83
40ft container + 40ft flatbed (max self-weight) LC14 MAX: Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]				40ft container + 40ft flatbed (min self-weight) LC14 MIN: Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	92	-57	-108	A	113	-55	-150
B	1	-29	170	B	24	-30	116
C	-	-	113	C	-	-	53
D	-	-	120	D	-	-	35
E	88	-5	70	E	59	-20	-5
F	119	-74	154	F	104	-61	116

Fig 577: Ultimate Limit State – LC7-LC14 – Sea transport on barge – 40ft container reactions

10ft container							
Ultimate Limit State: LC5 - lifting of the 10ft container with full equipment							
LC5 - Lifting offshore vertically by 4 bottom ISO 1161 corners, [SF=2,34]				LC5 - Lifting offshore vertically by 4 top ISO 1161 corners, [SF=2,34]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-	-	25	G	-	-	25
H	-	-	17	H	-	-	16
I	-	-	100	I	-	-	99
J	-	-	22	J	-	-	23

Fig 578: Offshore lifting of the 10ft container with equipment inside – LC5

10ft container (CROSSWIND)							
Ultimate Limit State: LC15-LC18 - destination place (Offshore)							
10ft container (max self-weight) LC15 MAX- Destination place - Offshore Wind X+				10ft container (min self-weight) LC15 MIN - Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-28	16	32	G	-24	13	28
H	-8	-14	-1	H	-7	-11	-1
I	6	-25	38	I	2	-21	26
J	-7	23	22	J	-8	19	17
10ft container (max self-weight) LC16 MAX- Destination place - Offshore Wind Y+				10ft container (min self-weight) LC16 MIN - Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-19	0	4	G	-15	-4	0
H	-7	-26	13	H	-6	-23	13
I	21	-30	39	I	16	-26	27
J	6	7	36	J	4	3	31
10ft container (max self-weight) LC17 MAX- Destination place - Offshore Wind X-				10ft container (min self-weight) LC17 MIN - Destination place - Offshore Wind X-			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-4	6	2	G	1	3	-2
H	6	-10	0	H	7	-7	1
I	27	-16	68	I	22	-12	56
J	8	19	21	J	7	15	16
10ft container (max self-weight) LC18 MAX- Destination place - Offshore Wind Y-				10ft container (min self-weight) LC18 MIN - Destination place - Offshore Wind Y-			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-23	28	35	G	-18	25	30
H	-2	2	-17	H	-1	5	-17
I	21	-10	60	I	17	-6	48
J	3	29	13	J	2	25	8

Fig 579: Open sea – LC15-LC18 - 10ft container reactions in destination place

10ft container (CROSSWIND)							
Ultimate Limit State: LC7-LC14 - sea transport on barge							
10ft container (max self-weight) LC7 MAX: Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]				10ft container (min self-weight) LC7 MIN: Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	3	-3	14	G	5	-7	1
H	-17	-19	15	H	-8	-11	5
I	11	-18	63	I	4	-16	7
J	2	-7	24	J	-1	-14	12
10ft container (max self-weight) LC8 MAX: Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]				10ft container (min self-weight) LC8 MIN: Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-23	3	24	G	-21	0	13
H	-27	-26	14	H	-20	-19	6
I	-7	-12	52	I	-13	-10	6
J	-7	5	19	J	-10	-1	10
10ft container (max self-weight) LC9 MAX: Sea transport on the barge Beam sea, X+ [Roll case 1]				10ft container (min self-weight) LC9 MIN: Sea transport on the barge Beam sea, X+ [Roll case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-33	10	29	G	-32	6	19
H	-27	-23	13	H	-21	-17	5
I	-13	-3	54	I	-19	-1	11
J	-9	16	13	J	-12	11	4
10ft container (max self-weight) LC10 MAX: Sea transport on the barge Quatering sea, stern down, X+ Y- [Quatering 2]				10ft container (min self-weight) LC10 MIN: Sea transport on the barge Quatering sea, stern down, X+ Y- [Quatering 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-29	14	28	G	-28	11	17
H	-21	-15	11	H	-13	-8	3
I	-9	7	63	I	-15	9	17
J	-5	25	8	J	-8	20	-2
10ft container (max self-weight) LC11 MAX: Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]				10ft container (mix self-weight) LC11 MIN: Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-8	14	19	G	-6	10	7
H	-6	-2	10	H	3	6	0
I	8	12	80	I	0	14	24
J	5	24	6	J	2	18	-6
10ft container (max self-weight) LC12 MAX: Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]				10ft container (min self-weight) LC12 MIN: Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	18	7	7	G	20	3	-3
H	6	5	10	H	13	12	1
I	25	7	84	I	19	8	37
J	15	12	9	J	12	6	0
10ft container (max self-weight) LC13 MAX: Sea transport on the barge Beam sea, X- [Roll case 2]				10ft container (min self-weight) LC13 MIN: Sea transport on the barge Beam sea, X- [Roll case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	29	0	3	G	30	-3	8
H	6	3	11	H	13	9	3
I	31	-3	80	I	26	-1	37
J	17	0	15	J	14	-6	6
10ft container (max self-weight) LC14 MAX: Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]				10ft container (min self-weight) LC14 MIN: Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	25	-4	4	G	26	-7	7
H	-1	-6	13	H	6	2	5
I	27	-12	73	I	21	-10	26
J	13	-8	21	J	10	-14	11

Fig 580: Ultimate Limit State – LC7-LC14 – Sea transport on barge – 10ft container reactions

It was assumed that containers are made of steel S355 or better.
It was assumed that 40ft flatbed is made of steel S355J2.
It was assumed that container floors are made of glued wood of class GL20c or better.

Due to the many cutouts in the containers and modifications to their shape, the loads are transferred in a non-obvious way, because the container is significantly weakened in some places and much more stiffened in others. The calculations showed that the containers after all modifications can be used to the scope presented in this document without the risk of damage or too large deformations (only elastic deformation).

Sub Subsection B99-002

Structural Calculations (Flatbed)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

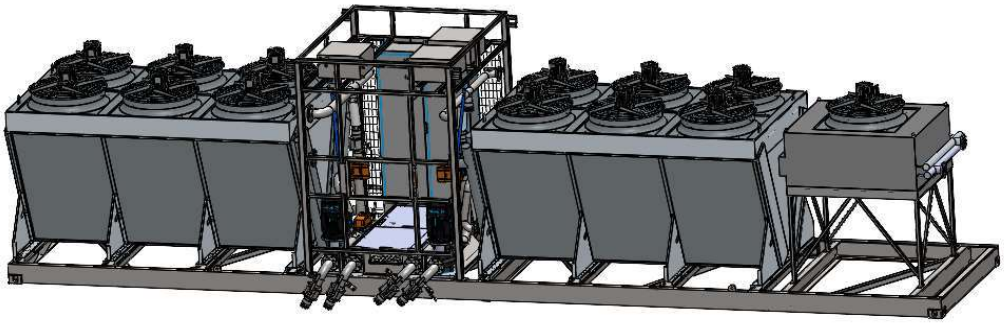
Revision history		
Rev.	**Date.**	**Description**
001	10/24/2023	First Issue
002	10/3/2025	Document name updated to include "Flatbed"

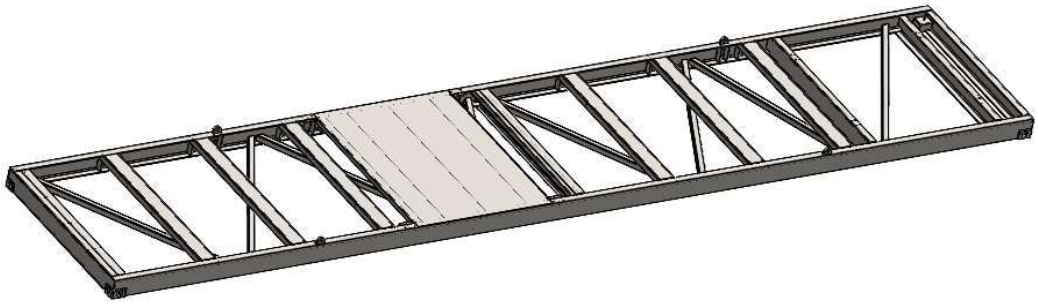
Document Title:	**BLPH Project - Structural Calculations (Flatbed)**
Document Number:	K559-2254-CWIWP4202202-B99-002
Revision:	Rev002
Sequence Number:	002
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Customer:	CrossWind C.V., Rotterdam, The Netherlands

40ft Flatbed Structure
CrossWind

STRUCTURAL CALCULATIONS

Ballard Power Systems Europe A/S
9500 Hobro, Majsmarken 1
DENMARK





Calculation and report made by:	GBO
Resp. engineer	Konrad Kaczmarek, M. Sc., EUR ING (reg. no 34497)
Date:	25/10/2023
Revision:	1

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1. Abbreviations, symbols and definitions

The most important abbreviations and definitions are listed in that point of the document as they can differ in different standards.

Platform container – a container having only the base and the floor, whose width and length correspond to the dimensions of a general-purpose container, fitted with the top and bottom corner fittings

R - rating, i. e. maximum gross mass of the container including permanent equipment and its cargo, in kg, but excluding the lifting set

T - tare mass, i. e. the mass of the empty container including any permanent equipment but excluding cargo and lifting set, in kg

P - payload, i. e. the maximum permissible mass of cargo which may be safely transported by the container, in kg

P = R – T

L - external length of the container

W - external width of the container

H - external height of the container

S - distance between the centers of apertures in corner fittings on the length of the container

P - distance between the centers of apertures in corner fittings on the breadth of the container

D - diagonals of the container measured between the centers of apertures in corner fittings (D1, D2, D3, D4, D5, D6)

K1 - difference between D1 and D2 or D3 and D4 (K1=|D1-D2| or K1=|D3-D4|)

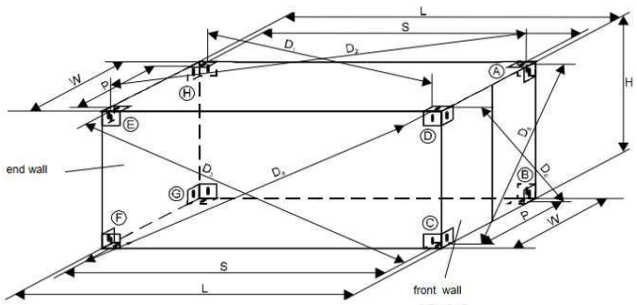
K2 - difference between D5 and D6 (i. e. K2=|D5-D6|)

2. Introduction

Designed structure is container type 1AX :
L=12192 (+0)(-10) [mm]
W=2438 (+0)(-5) [mm]
H<2438 (+0)(-5) [mm]

Designed structure is intended to be placed on sea type barge near the coast of Netherlands, and for transport by truck and transport by barge. 40ft flatbed can be also lifted onshore and offshore in accordance to the lifting guidelines.

Dimensions between ISO 1161 Corners (with assumed tolerances in cubes and dimensions tolerances of athe structure)
P=2260 (+3)(-5) [mm]
S=11989 (+3)(-10) [mm]



3. European standards and regulations

1.) EN 12195-1	Load restraining on road vehicle - safety - part 1 - calculation of securing forces
2.) EN 13155	Cranes - Safety - Non-fixed load lifting attachments
3.) ISO 1161	Series 1 freight containers – Corner and intermediate fittings - Specifications
4.) EN 1990	Basis of structural design
5.) EN 1993-1-1	Design of steel structures; General rules and rules for buildings
6.) EN 1993-1-8	Design of steel structures - Part 1-8: Design of joints
7.) DNVGL-ST-N001	Marine operations and marine warranty
8.) EN 13001-1	Cranes - General design - Part 1: General principles and requirements
9.) EN 13001-1	Cranes - General design - Part 3-1: Limit states and proof of competence of steel structures

Additional documents:

10.) Polski Rejestr Statków, Rules for the Construction of Containers, Gdańsk, 2014

11.) CW-BALL-TQ-0007 - Transportation forces (Guidelines provided by CrossWind)

4. Geometry assumptions:

4.1. Bottom and top corner fittings

Bottom and top corner fittings should be made in accordance to ISO 1611

4.2. Bottom corner fittings placement:

In accordance to “Polski Rejestr Statków, Rules for the Construction of Containers, Gdańsk, 2014” the bottom of profiles should be above bottom corner fitting as below:

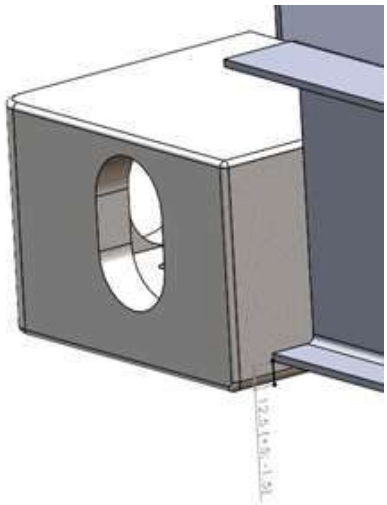


Fig 2: Distance between lowest surface of structure in regards to lowest surface of corner fitting (12,5 [+5][-1,5] mm)

Assumed distance between bottom surfaces: 15mm

4.3. Geometry of transported High Temperature Coolers

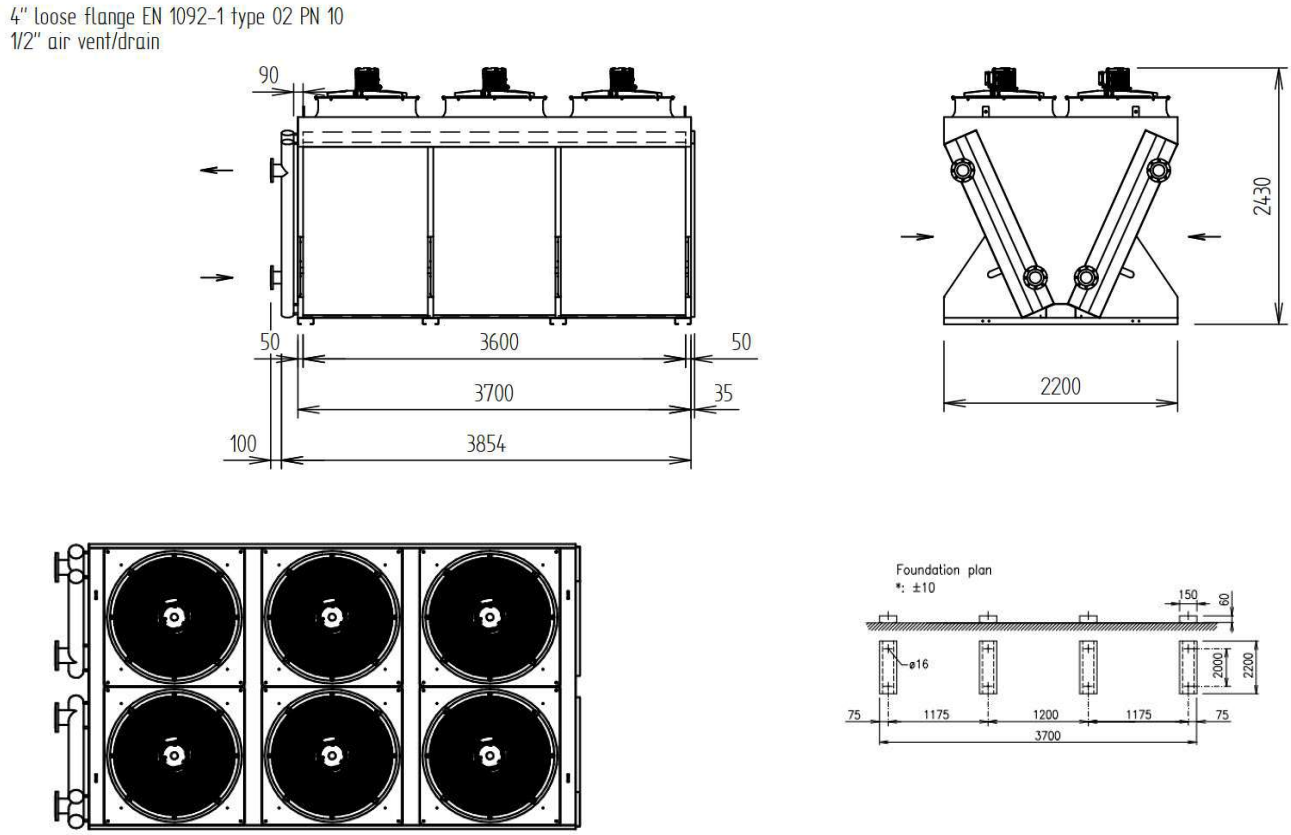


Fig 3: Geometry of High Temperature Cooler

Assumed dimensions:

Length: 3,989m $L_{HT} := 3,989\ m$

Width: 2,2m $W_{HT} := 2,2\ m$

Height: 2,43m $H_{HT} := 2,43\ m$

Mass of the dry HT Cooler provided by manufacturer - Evapco:

$m_{HT,dry} := 2181\ kg$

Total weight of coolant in the two HT Coolers and in pipes connected to coolers is equal to 1000kg. Therefore half of this weight is added to each of the cooler. (362l of coolant in the cooler).

$$m_{coolant,HT} := \frac{1000}{2}\ kg = 500\ kg$$

$$m_{HT,wet} := m_{HT,dry} + m_{coolant,HT} = 2681\ kg$$

$$COG_{HT} := \frac{2}{3} \cdot H_{HT} = 1,62\ m$$

4.4. Geometry of transported Low Temperature Cooler:

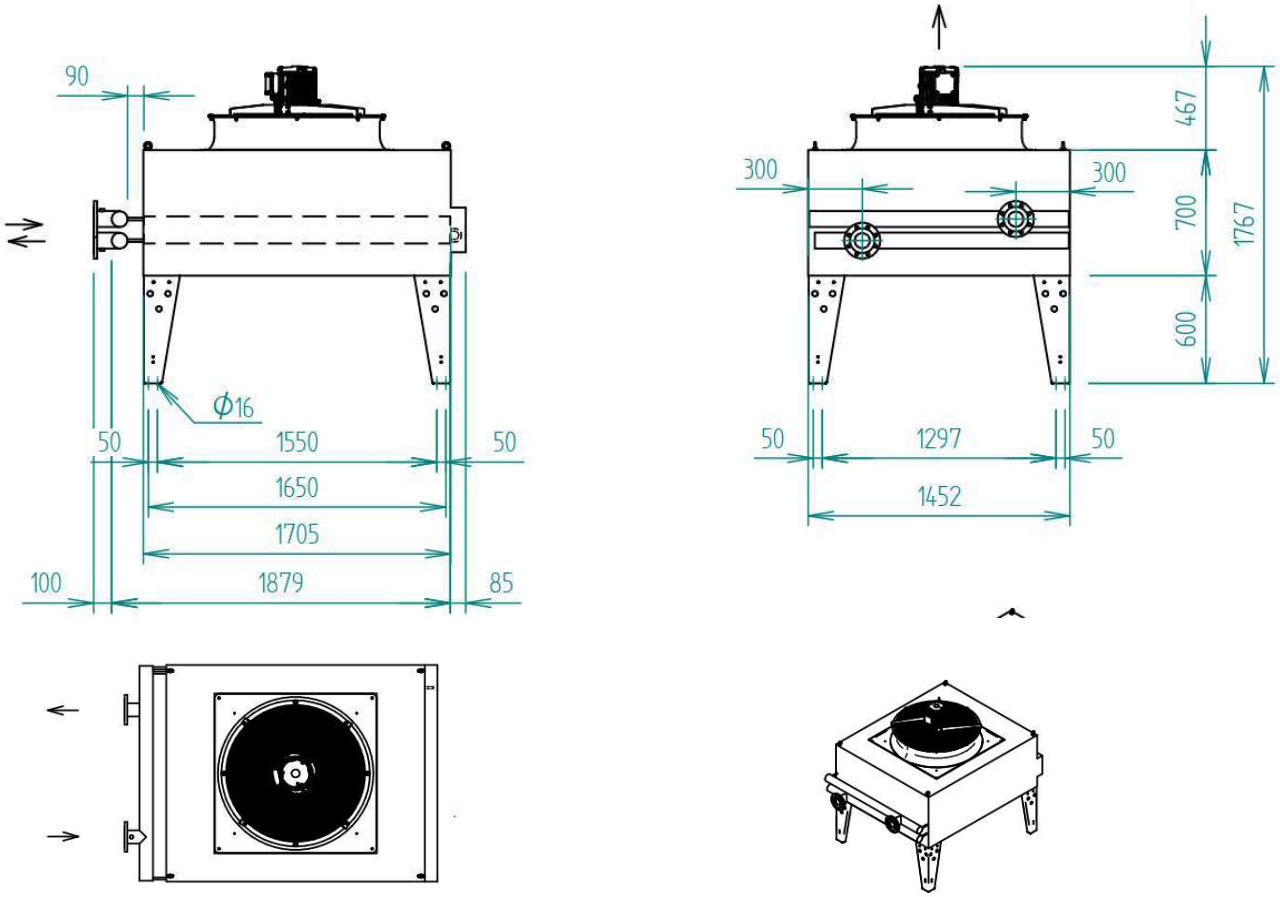


Fig 4: Geometry of Low Temperature Cooler

Height is considered together with the supporting frame below LT Cooler:

Dimensions of LT support frame:

$L_{sLT} := 1,705\ m$

$W_{sLT} := 1,452\ m$

$H_{sLT} := 1,262\ m$

Assumed dimensions:
Length: 1,705m
Width: 1,452m
Height: 1,962m

$L_{LT} := 1,705\ m$

$W_{LT} := 1,452\ m$

$H_{LT} := 0,885\ m + H_{sLT} = 2,147\ m$

Mass of the dry LT Cooler provided by manufacturer - Evapco:

$m_{LT,dry} := 335\ kg$

Total weight of coolant in the LT Cooler and all pipes is equal to 100kg, so the half of that weight has been assumed in the cooler. (52l of coolant in the cooler).

$m_{coolant,LT} := 100\ kg$

$m_{LT,wet} := m_{LT,dry} + m_{coolant,LT} = 435\ kg$

$COG_{LT} := H_{sLT} + \frac{1}{2} \cdot 700\ mm = 1,612\ m$

5. Design conditions and safety factors

$SHL := 10\ t$ (Static Hook Load)

$DAF_{onshore} := 1,10$

$DAF_{inshore} := 1,07 + 0,05 \cdot \sqrt{\frac{100\ t}{SHL}} = 1,23$ [DNVGL-ST-N001, Table 16-1]

$DAF_{offshore} := 1 + 0,25 \cdot \sqrt{\frac{100\ t}{SHL}} = 1,79$

Description	Symbol	Value	Reference
Load safety factors for supported structure (road transport)	*SF*	1,6	*DNVGL-ST-N001*
Partial factor for resistance of structural members (road transport and offshore lifting)	γ_m	1,15	*DNVGL-ST-N001*
Partial factor for resistance of joints (bolts and welds) (road transport and offshore lifting)	γ_{mw}	1,30	*DNVGL-ST-N001*
Lifting with lifting sets – DAF (Dynamic Amplification Factor)- (lifting offshore)	*DAF*	1,8	*DNVGL-ST-N001 (Table 16.1)*
Lifting with lifting sets (lifting onshore)	*SF*	2	*EN 13155*
Partial factor for resistance of structural members (lifting)	γ_m	1	*EN 13155*
Partial factor for resistance of joints (bolts and welds) (lifting)	γ_{mw}	1,1	*EN 13155*
Load safety factors for supported structure (in destination place)	*SF*	1,35/1,5	*EN 1990-1-1*
Partial factor for resistance of structural members (in destination place)	γ_m γ_{M0}, γ_{M1}	1	*EN 1993-1-1*
Partial factor for resistance of joints (bolts and welds) (in destination place)	γ_{mw} γ_{M2}	1,25	*EN 1993-1-1*

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6. Material properties and stress limits in appropriate load cases

Load cases			Load safety factors			Material partial safety factors				
	Description	Standard	Load safety factor		Dynamic safety factor	Material characteristic strength [MPa]	Partial factor for resistance of structural members	Partial factor for resistance of bolts and welds	Design strength of members	Design strength of welds
LC1	Road transport - braking	DNVGL-ST-N001	1,6			355	1,15	1,3	309	273
LC2	Road transport - accelerating	DNVGL-ST-N001	1,6				1,15	1,3	309	273
LC3	Road transport - turning	DNVGL-ST-N001	1,6				1,15	1,3	309	273
LC4	Road transport - uneven surface	DNVGL-ST-N001	1,6				1,15	1,3	309	273
LC5	Offshore lifting	DNVGL-ST-N001	LRFD Table 5.8		1,8		1,15	1,3	309	273
LC6	Onshore lifting	EN 13155	2				1	1,1-welds 1,25-bolts	355	323
				ULS-a	ULS-b					
LC7-1	Sea transport on the barque LC7-1 - Head sea, bow down, from Y+ [Pitch case 1]	DNVGL-ST-N001	LRFD Table 5.8 G-pernament loads Q-variable functional loads D-deformation loads E-environmental loads (wind, waves, storm, surge, tide, ice) A-accidental loads	G			1,15	1,3	309	273
LC8-2	Sea transport on the barque LC8-2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	DNVGL-ST-N001		1,3	1		1,15	1,3	309	273
LC9-3	Sea transport on the barque LC9-3 - Beam Sea, from X+ [Roll case 1]	DNVGL-ST-N001		Q			1,15	1,3	309	273
LC10-4	Sea transport on the barque LC10-4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	DNVGL-ST-N001		1,3	1		1,15	1,3	309	273
LC11-5	Sea transport on the barque LC11-5 - Head Sea, stern down, from Y- [Pitch case 2]	DNVGL-ST-N001		D			1,15	1,3	309	273
LC12-6	Sea transport on the barque LC12-6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	DNVGL-ST-N001		1	1		1,15	1,3	309	273
LC13-7	Sea transport on the barque LC13-7 - Beam Sea, from X- [Roll case 2]	DNVGL-ST-N001		E			1,15	1,3	309	273
LC14-8	Sea transport on the barque LC14-8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	DNVGL-ST-N001		0,7	1,3		1,15	1,3	309	273
LC15	Destination place (offshore) X+	DNVGL-ST-N001		A			1,15	1,3	309	273
LC16	Destination place (offshore} Y+	DNVGL-ST-N001		-	-		1,15	1,3	309	273

7. Calculations of basic wind velocity in destination place

7.1 First guidelines from customer

In-place Wind Loads:

Table 3.6 - Omni-Directional Extreme Values at 125 m MSL [9]

Averaging Time	Return period (years)						
	1	2	5	10	50	100	1,000
1hr	31.8	33.4	35.1	36.4	39.1	40.1	43.4
10min	33.7	35.5	37.4	38.8	41.7	42.9	46.5
3s	39.4	41.6	44.1	45.9	49.7	51.1	56.0

To adjust wind speeds to any specified averaging time or elevation, the following equations are to be used [8]:

$U(z, t) = U(z) * [1 - 0.41 * Iu(z) * \ln(t/t_0)]$

$U(z) =$ 1-hour mean wind speed given by:

$U(z) = U_0 * [1 + C * \ln(z/z_t)]$

$C = 0.0573 * (1 + 0.15 * U_0)^{1/2}$

$Iu = 0.06 * [1 + 0.043 * U_0] * (z/z_t)^{-0.22}$

$U_0 =$ 1-hour average at the reference elevation, z_t

$z_t =$ 10 m above sea level.

Directional exceedance data for wind is presented in Figure 3.6. The wind predominantly blows from the south-west.

Fig 5: Obtained guidelines of calculation procedure of wind actions

<u>In accordance to Eurokode 1991-1-4 - Wind actions:</u>

v_{b0} - fundamental basic wind velocity is the 10 minute mean wind velocity with an annual risk of being exceeded of 0,02 (which corrseponds with 50 years return period), irrespective of wind direction at a height of 10m above flat open country terrain.

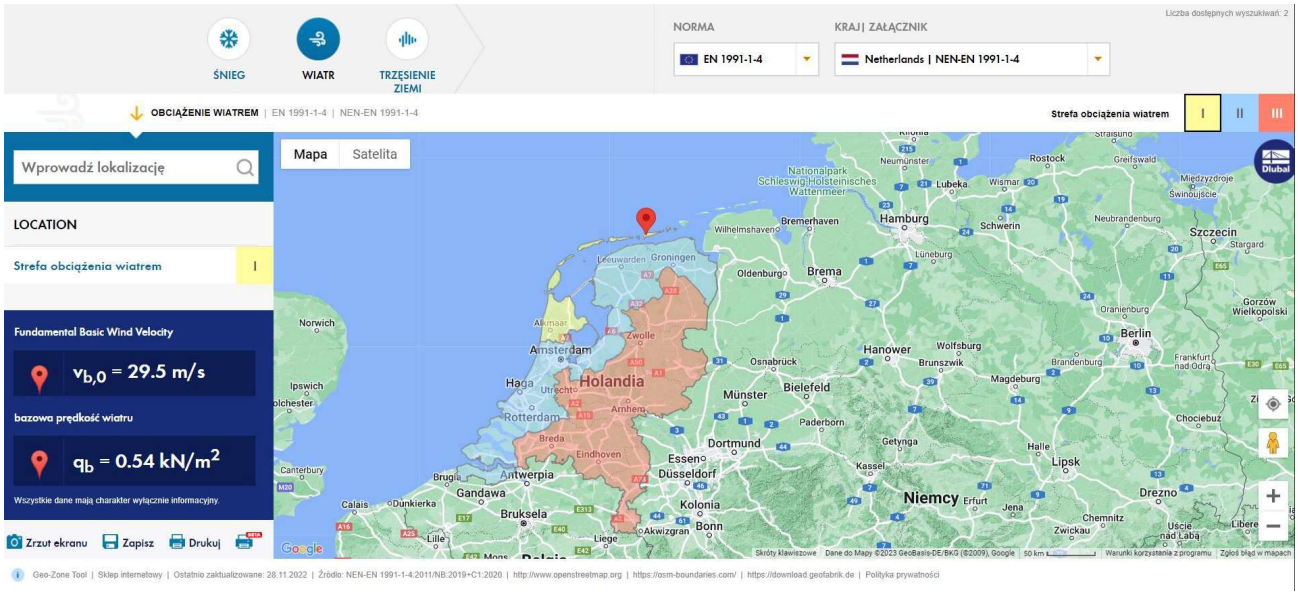


Fig 6: Wind actions according to EC1991-1-4 (Dlubal software website)

In accordance to Netherlands Eurocode 1991-1-4, North part of Netherlands is in zone 1, with fundamental basic wind velocity equals 29,5m/s.

In accordance to the above table 3.6 Omni Directional Extreme values at 125m for averaging time 10 minutes and return period 50 years, U(z) = 41,7m/s.

I am looking for fundamental basic wind velocity (averaging time 10 minuts, return period 50 years at reference elevation 10 meters):

Assumed: $v_{b,0} := 31,0 \ \frac{m}{s}$

$z := 125 \ m$

$z_r := 10 \ m$

Calculations:

$C := 0,0573 \cdot \sqrt{1 + 0,15 \cdot v_{b,0} \ \frac{s}{m}} = 0,1362$

Mean wind velocity (z=125m, averaging time 10 minutes, return period 50 years):

$v_m := v_{b,0} \cdot \left(1 + C \cdot \ln\left(\frac{z}{z_r}\right)\right) = 41,7 \ \frac{m}{s}$ U(z) = 41,7m/s

As shown above, for obtained guideliness the basic wind velocity (h=10m, 10minutes, 50years) is equal to:

$v_{b,0} := 31 \ \frac{m}{s}$

Obtained value is very similar to the value from the Netherlands Eurocode for wind (29,5), but a little bit bigger what is reasonable as the value of wind were measured on open sea.

7.2 Second guidelines from customer

Description	Unit	Value
Ambient Conditions		
Ambient Temperature (min/nom/max) – hourly @ +10m	°C	-8.4 / 10.5 / 25
Atmospheric Pressure (nominal) – hourly @ +10m	mbar	1013.7
Specific Humidity (min/nom/max) – hourly @ +10m	X 10^{-3}	4.2 / 6.5 / 9.5
Wind Conditions		
Annual average wind speed (at 100 m)	m/s	9.56
Extreme Wind Speed for 1-Year Recurrence Period (at 100 m)	m/s	33.1
Extreme Wind Speed for 50-Year Recurrence Period (at 100 m)	m/s	41.0
Marine Conditions		
Sea Water Temperature (min/max)	°C	1.3 / 20.2
Average Sea Water Density	Kg/m	1025
Highest Astronomical Tide (HAT)	m	2.2 (LAT)
Lowest Astronomical Tide (HAT)	m	0 (LAT)
Extreme High-Water Level for 50 -Year Recurrence Period	m	12.3 (LAT
Extreme High-Water Level for 1-Year Recurrence Period	m	9.1 (LAT)
Extreme Low-Water Level for 1-Year Recurrence Period	m	-0.5 (LAT)
Extreme Low-Water Level for 50-Year Recurrence Period	m	

Fig 7: Second guidelines from client regarding the wind speed

Extreme wind speed for 50-year recurrence period at 100m:

$$v_{b,max,50y,100m} := 41\ \frac{m}{s}$$

I am looking for fundamental basic wind velocity (averaging time 10 minuts, return period 50 years at reference elevation 10 meters):

Assumed:

$$v_{b,0} := 31,2\ \frac{m}{s}$$

$$z := 100\ m$$

$$z_r := 10\ m$$

Calculations:

$$C := 0,0573 \cdot \sqrt{1 + 0,15 \cdot v_{b,0}\ \frac{s}{m}} = 0,1366$$

Mean wind velocity (z=100m, averaging time 10 minutes, return period 50 years):

$$v_m := v_{b,0} \cdot \left(1 + C \cdot \ln\left(\frac{z}{z_r}\right)\right) = 41\ \frac{m}{s}$$

U(z) = 41,0m/s

Fundamental basic wind velocity	vb0 [m/s2]
1. Calculated in acc. to 1st guidelines	31
2. From EC1991-1-4 for Norht part of Netherlands	29,5
3. Calculated in acc. to 2nd guidelines	31,2

Fig 8: Comparison of obtained basic wind velocities

8. Pre-processing

8.1. Assumptions

It has been assumed that cooling machines, pumps and other equipment are supported by the 40ft flatbed container. Platform can be transported by truck, lifted by crane and transported on sea type barge and placed in destination place on open sea on barge

8.2. Loads definition

8.2.1. Road transport

The acceleration coefficients to use when designing a support structure for coolers.

Accelerations for road transport. Acc. given as fraction of standard gravity (g_0 = 9.81 m/s²)						
GCS	Road	Securing in	Longitudinal a_x		Transverse a_y	Vertical a_z
			Forward	Rearward		
		Longitudinal direction	0.8	0.5	-	1.0 / 1.2
		Transverse direction	-	-	0.5	1.0 / 1.2

$a_{xb} := 0,8\ g_e = 7,85\ \frac{m}{s^2}$ (longitudinal, breaking)

$a_{xa} := 0,5\ g_e = 4,9\ \frac{m}{s^2}$ (longitudinal, acceleration)

$a_y := 0,5\ g_e = 4,9\ \frac{m}{s^2}$ (transverse, turning)

$a_z := 1\ g_e = 9,81\ \frac{m}{s^2}$ (vertical, gravity)

$a_{z2} := 1,2\ g_e = 11,77\ \frac{m}{s^2}$ (vertical, bigger gravity)

8.2.2. Accelerations during transport on barge

Customer provided guidelines of wind during transport on barge in document "Vendor Design Data Rev B.pdf" which describe it as below:

Default motion criteria for unrestricted world-wide tows, provided in DNV-ST-N001 [23], shall be used. The LRFD design criteria are presented in Table 4.2.

Table 4.2 – Topside Transport Barge Motions [23]

Acceleration / Wind Force	Roll Case	Quartering Case	Pitch Case
Ay at waterline	0.50 g	0.40 g	0
Ay increase for each metre (z) above waterline	0.017 g/m	0.013 g/m	0
Ax at waterline	0	0.15 g	0.25 g
Ax incr. each metre (z) above waterline	0	0.005 g/m	0.007 g/m
Az at centre (C) barge	0.20 g	0.15 g	0.10 g
Az incr. each metre (y, d or x respectively) from C	0.017 g/m	0.012 g/m	0.007 g/m
Wind Pressure	1.0 kN/m²	1.0 kN/m²	1.0 kN/m²

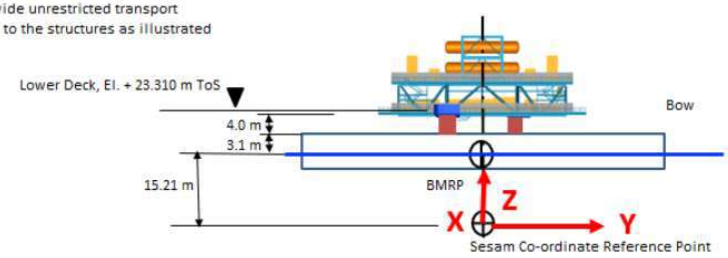
Notes:

1. x = distance from barge mid ship.
2. y = distance from barge centreline.
3. d = distance used for calculating az in quartering seas, $d = \sqrt{(y^2 + 0.5x^2)}$.
4. z = height above waterline.
5. ay = transverse acceleration parallel with barge deck.
6. ax = longitudinal acceleration parallel with barge deck.

Transport Analysis

Ref. 1: - In the absence of barge motions analysis, the topsides is considered to be transported on a North Sea type barge, defined by DNVGL to have a minimum size of 300' x 90' x 20', or larger. DNVGL simplified worldwide unrestricted transport motion criteria for this type of barge will be used to determine transport accelerations applied to the structures as illustrated below. Design methodology for LRFD.

Acceleration / Wind Force	Roll Case	Quartering	Pitch Case
Ay at waterline	0.50 g	0.40 g	0
Ay increase for each metre (z) above waterline	0.017 g/m	0.013 g/m	0
Ax at waterline	0	0.15 g	0.25 g
Ax incr. each metre (z) above waterline	0	0.005 g/m	0.007 g/m
Az at centre (C) barge	0.20 g	0.15 g	0.10 g
Az incr. each metre (y, d or x respectively) from C	0.017 g/m	0.012 g/m	0.007 g/m
Wind Pressure	1.0 kN/m²	1.0 kN/m²	1.0 kN/m²



Gravity assumed to be vertical (adjusted in the heave value) = 9.807 m/sec²

THE ABOVE ACCELERATIONS ARE CONVERTED TO PROVIDE ACCELERATIONS FOR SESAM ANALYSIS AT MRP

Description	Linear Acceleration Amplitude, (m/Sec²)				Angular Acceleration Amplitude, (Rad/Sec²)		
	Surge, Y	Sway, X	Max.	Min. Heave,	Roll, RotY	Pitch, RotX	Yaw, RotZ
Head Sea, Bow Down	2.45	0.00	10.79	8.83	0.0000	-0.0686	0.0000
Quartering Sea, Stbd Bow Down	1.47	3.92	11.28	8.34	0.1275	-0.0490	0.0000
Beam Sea, Stbd Down	0.00	4.90	11.77	7.85	0.1667	0.0000	0.0000
Quartering Sea, Stbd Stern Down	-1.47	3.92	11.28	8.34	0.1275	0.0490	0.0000
Head Sea, Stern Down	-2.45	0.00	10.79	8.83	0.0000	0.0686	0.0000
Quartering Sea, Port Stern Down	-1.47	-3.92	11.28	8.34	-0.1275	0.0490	0.0000
Beam Sea, Port Down	0.00	-4.90	11.77	7.85	-0.1667	0.0000	0.0000
Quartering Sea, Port Bow Down	1.47	-3.92	11.28	8.34	-0.1275	-0.0490	0.0000

Notes:
1) - Accelerations applied at the Barge Motions Reference Point (BMRP)
2) - Both +ve and -ve heave to be considered.

Using the Sesam co-ordinates shown above, the most onerous location of the centre of a hydrogen storage tank is:

- X = 4.0 m, (4 m off the barge centre)
- Y = 0.0 m, (at the barge centre)
- Z = 23.0 m, (above the barge water plane area)

For all other equipment, a generic centre location may be considered at:

- X = 8.0 m, (8 m off the barge centre)
- Y = 19.0 m, (19.0 m towards bow / stern)
- Z = 18.0 m, (above the barge water plane area)

Fig 9: Acceleration values during transport on barge (Vendor Design Data Rev B.pdf)

Figure 4.2 – Barge Transport Arrangement

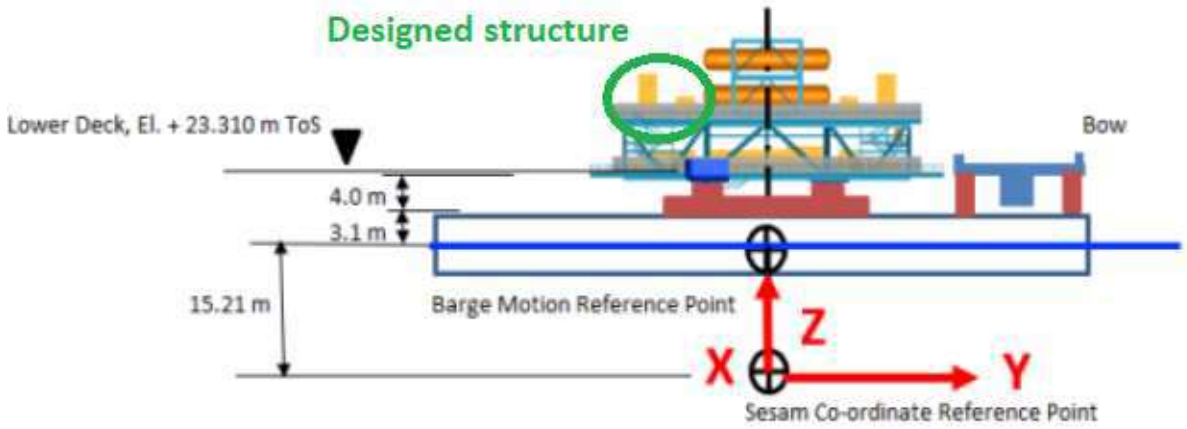


Fig 10: Designed structure on barge

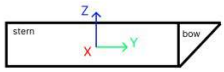
Calculation of acceleration of analyzed 40ft container with 40ft flatbed at localization X=8m; Y=19m; Z=18m						
	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
Main data: X=8m Y=19m Z=h=18m g=9,807m/s2	LC1	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	3,69		12,09	7,52
	LC2	LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	2,35	6,22	13,61	6,00
	LC3	LC3 - Beam Sea, from X+ [Roll case 1]		7,90	13,10	6,51
	LC4	LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	-2,35	6,22	13,61	6,00
	LC5	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-3,69		12,09	7,52
	LC6	LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	-2,35	-6,22	13,61	6,00
	LC7	LC7 - Beam Sea, from X- Roll case 2]		-7,90	13,10	6,51
	LC8	LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	2,35	-6,22	13,61	6,00

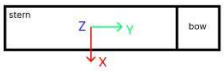
Fig 11: Calculated of accelerations on barge in according to guidelines (Vendor Design Data Rev B.pdf)

Great Back Office

Side view of barge

Top view of barge

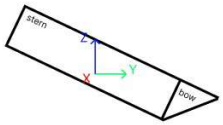




LC7 - Head sea, bow down, from Y+ [Pitch case 1]

Side view of barge

Top view of barge

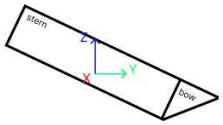




LC8 - Quatering Sea, bow down, from X+Y+ [Quatering 1]

Side view of barge

Top view of barge

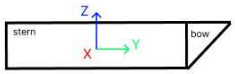


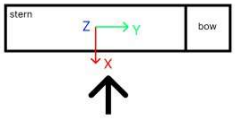


LC9 - Beam Sea, from X+ [Roll case 1]

Side view of barge

Top view of barge

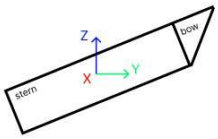


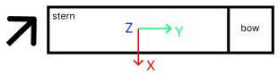


LC10 - Quatering Sea, stern down, from X+Y- [Quatering 2]

Side view of barge

Top view of barge

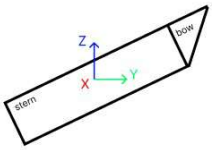


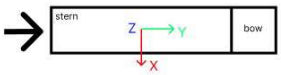


LC11 - Head Sea, stern down, from Y- [Pitch case 2]

Side view of barge

Top view of barge

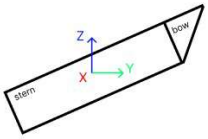


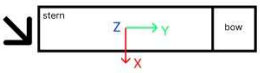


LC12 - Quatering Sea, stern down, from X-Y- [Quatering 3]

Side view of barge

Top view of barge

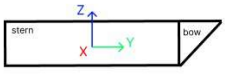


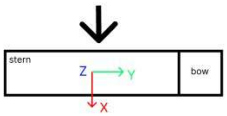


LC13 - Beam Sea, from X- [Roll case 2]

Side view of barge

Top view of barge

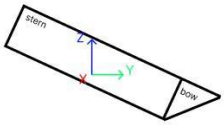




LC14 - Quatering Sea, bow down, from X-Y+ [Quatering 4]

Side view of barge

Top view of barge





8.2.3. Wind on destination place acting on HT coolers

40ft platform will be placed on 40ft container on sea type barque.
When the barge is at its destination (at sea near the coast of the Netherlands), the platform will be on the upper deck in a 40-foot container at a height of 30.31 m above sea level (according to the client's instructions)

Assumed Terrain category: 0 (Sea, coastal area eposed to the open sea)

Fundamental value of the basic wind velocity has been calculated in regards to obtained guidelines.

Basic wind velocity:

Fundamental value of the basic wind velocity: $v_{b,0} := 31,2 \frac{m}{s}$

Directional factor: $c_{dir} := 1$

Seasonal factor: $c_{season} := 1$

Basic wind velocity: $v_b := c_{dir} \cdot c_{season} \cdot v_{b,0} = 31,2 \frac{m}{s}$ (eq:4.1-EC1991-1-4)

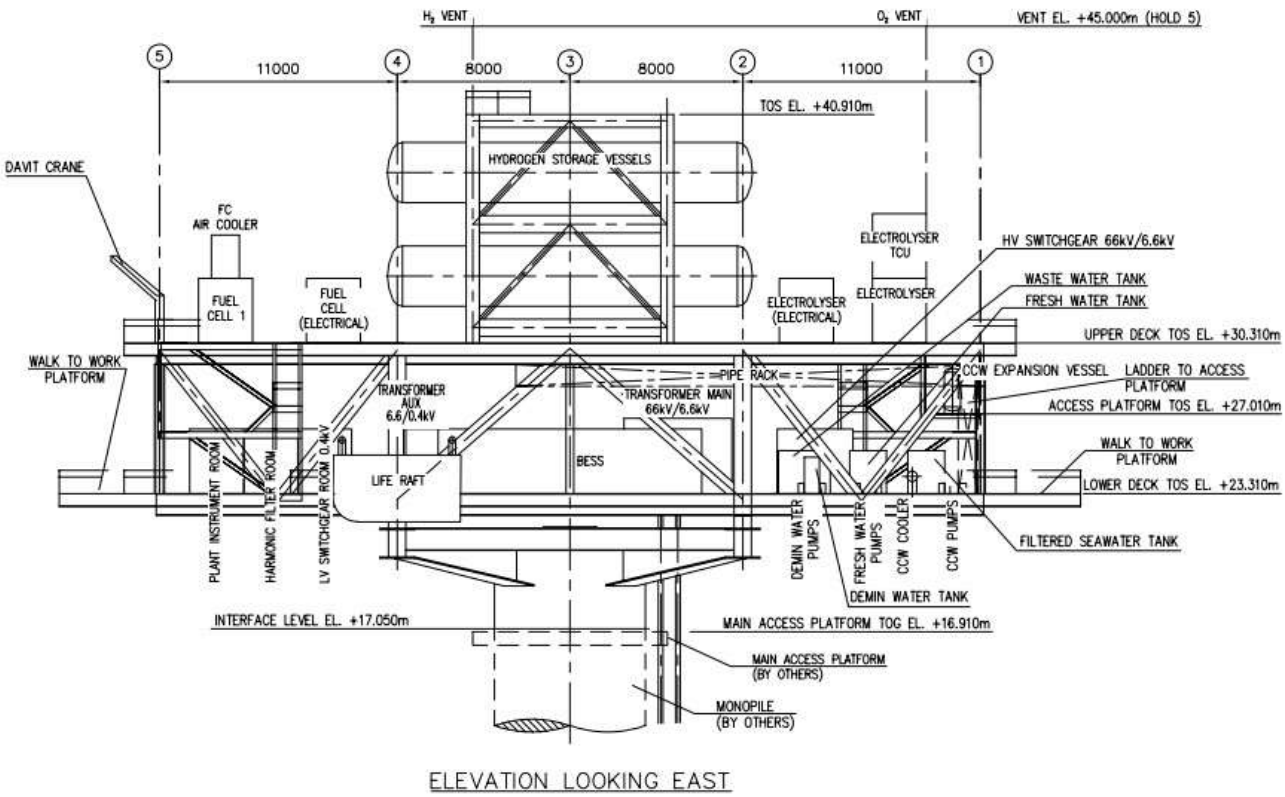


Fig 13: Guidelines from client - destination place of the designed structure

Maximum height at destination place:

$z := 30,31\ m + 2,896\ m + 30\ mm + 3,5\ m = 36,74\ m$

Mean wind velocity:

$z_{0,II} := 0,05\ \text{m}$

$z_0 := 0,003\ \text{m}$

$z_{min} := 1\ \text{m}$

$z = 36,736\ \text{m}$

Orography factor:

$c_0 := 1$

Table 4.1 — Terrain categories and terrain parameters

	Terrain category	z_0 m	z_{min} m
0	Sea or coastal area exposed to the open sea	0,003	1
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	0,01	1
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0,05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0,3	5
IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1,0	10
NOTE: The terrain categories are illustrated in A.1.			

Terrain factor: $k_r := 0,19 \cdot \left(\frac{z_0}{z_{0,II}}\right)^{0,07} = 0,156$ (eq:4.5-EC1991-1-4)

Roughness factor: $c_r := k_r \cdot \ln\left(\frac{z}{z_0}\right) = 1,4687$ (eq:4.4-EC1991-1-4)

Mean wind velocity: $v_m := c_r \cdot c_0 \cdot v_b = 45,825\ \frac{\text{m}}{\text{s}}$ (eq:4.3-EC1991-1-4)

Wind turbulence:

Turbulence factor: $k_I := 1$

Standard deviation of the turbulence: $\sigma_v := k_r \cdot v_b \cdot k_I = 4,8683\ \frac{\text{m}}{\text{s}}$ (eq:4.7-EC1991-1-4)

Turbulence intensity: $I_v := \frac{\sigma_v}{v_m} = 0,1062$ (eq:4.7-EC1991-1-4)

Peak velocity pressure:

Air density: $\rho := 1,25\ \frac{\text{kg}}{\text{m}^3}$

Peak velocity pressure: $q_p := \left(1 + I_v\right) \cdot \frac{1}{2} \cdot \rho \cdot v_m^{\ 2} = 1,4519\ \text{kPa}$

Reference mean (basic) velocity pressure: (eq:4.7-EC1991-1-4)

$q_b := \frac{1}{2} \cdot \rho \cdot v_b^{\ 2} = 0,6084\ \text{kPa}$ (eq:4.10-EC1991-1-4)

Exposure factor: $c_e := \frac{q_p}{q_b} = 2,3864$ (eq:4.9-EC1991-1-4)

Structural factor: $c_s := 1$ $c_d := 1$ $c_s \cdot c_d = 1$

Consideration of wind acting on whole structure as on a structural element with rectangular section:

Rounded corners effect factor: $\psi_r := 1$ (fig. 7.24-EC1991-1-4)

Solidity ratio: $\varphi := 1$ (eq:7.28-EC1991-1-4)

Effective slenderness:

$$\lambda_{big} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{L_{HT}}{H_{HT}} \\ 70 \end{array}\right]\right) = 3,28$$

(table:7.16-EC1991-1-4)

$$\lambda_{small} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{H_{HT}}{W_{HT}} \\ 70 \end{array}\right]\right) = 2,21$$

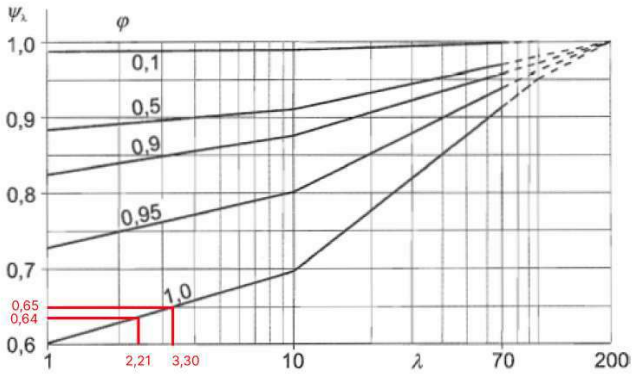


Figure 7.36 — Indicative values of the end-effect factor ψ_λ as a function of solidity ratio φ versus slenderness λ

Fig . 14: End effect factor from the figure 7.36 - EC1991-1-4

As slenderness in both directions is similar one value for two direction has been assumed:

End effect factor: $\psi_\lambda := 0,66$

$d_{small} := L_{HT} = 3,989\ \text{m}$

$b_{small} := H_{HT} = 2,43\ \text{m}$

$$\frac{d_{small}}{b_{small}} = 1,64$$

$d_{big} := W_{HT} = 2,2\ \text{m}$

$b_{big} := H_{HT} = 2,43\ \text{m}$

$$\frac{d_{big}}{b_{big}} = 0,91$$

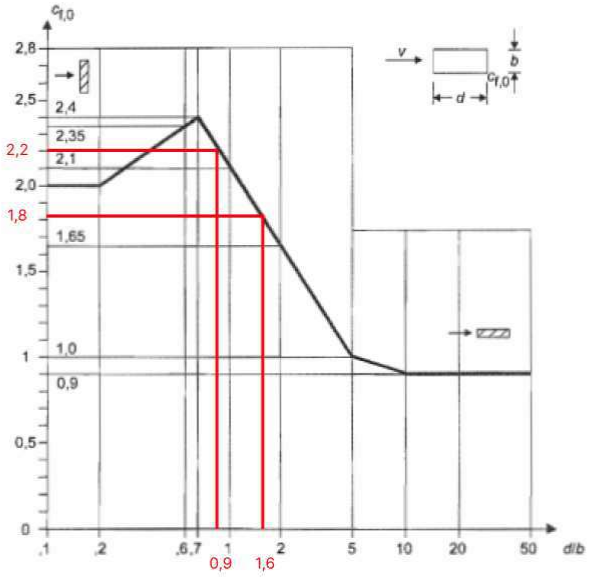


Figure 7.23 — Force coefficients $c_{f,0}$ of rectangular sections with sharp corners and without free end flow

Fig. 15: Force coefficient from the figure 7.23 - EC1991-1-4

$c_{f,0,small} := 1,8$ $c_{f,0,big} := 2,2$

Force acting on small side of the HT Cooler:

$A_{HT,small} := W_{HT} \cdot H_{HT} = 5,35\ m^2$

$W_{HT,s} := c_s \cdot c_d \cdot c_{f,0,small} \cdot q_p \cdot A_{HT,small} = 13,97\ kN$

Force acting on big side of the HT Cooler:

$A_{HT,big} := L_{HT} \cdot H_{HT} = 9,69\ m^2$

$W_{HT,b} := c_s \cdot c_d \cdot c_{f,0,big} \cdot q_p \cdot A_{HT,big} = 30,96\ kN$

8.2.4. Wind on destination place acting on LT cooler with below supporting structure.

Dimensions of LT support structure:

$L_{sLT} = 1,7\ m$

$W_{sLT} = 1,45\ m$

$H_{sLT} = 1,26\ m$

Dimensions of LT cooler with below supporting structure:

$L_{LT} = 1,7\ m$

$W_{LT} = 1,45\ m$

$H_{LT} = 2,15\ m$

Consideration of wind acting on whole structure as on a structural element with rectangular section:

Rounded corners effect factor: $\psi_r := 1$ (fig. 7.24-EC1991-1-4)

Solidity ratio: $\varphi := 1$ (eq:7.28-EC1991-1-4)

Effective slenderness:

$$\lambda_{big} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{H_{LT}}{L_{LT}} \\ 70 \end{array}\right]\right) = 2,52$$

(table:7.16-EC1991-1-4)

$$\lambda_{small} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{H_{LT}}{W_{LT}} \\ 70 \end{array}\right]\right) = 2,96$$

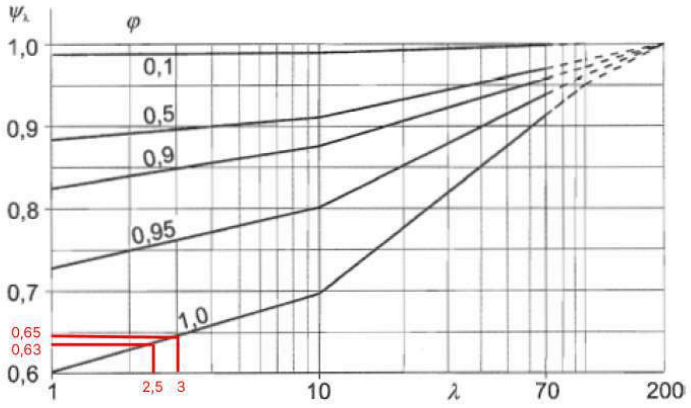


Figure 7.36 — Indicative values of the end-effect factor ψ_λ as a function of solidity ratio φ versus slenderness λ

Fig . 16: End effect factor from the figure 7.36 - EC1991-1-4

As slenderness in both directions is similar one value for two direction has been assumed:

End effect factor: $\psi_\lambda := 0,66$

$d_{small} := L_{LT} = 1,7\ m$

$b_{small} := H_{LT} = 2,15\ m$

$$\frac{d_{small}}{b_{small}} = 0,79$$

$d_{big} := W_{LT} = 1,45\ m$

$b_{big} := H_{LT} = 2,15\ m$

$\frac{d_{big}}{b_{big}} = 0,68$

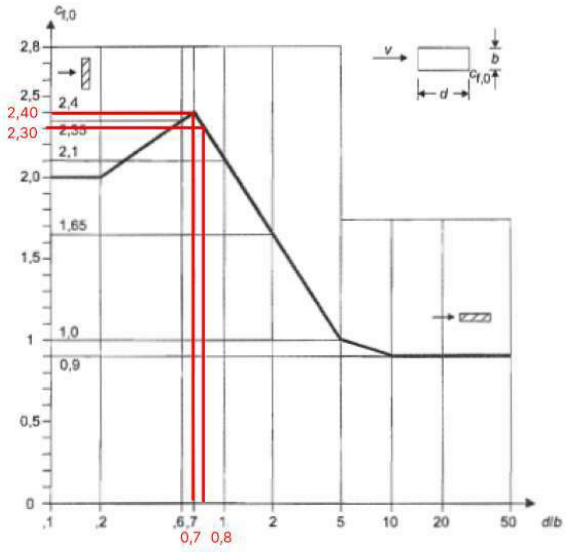


Figure 7.23 — Force coefficients $c_{f,0}$ of rectangular sections with sharp corners and without free end flow

Fig. 17: Force coefficient from the figure 7.23 - EC1991-1-4

$c_{f,0,small} := 2,30$ $c_{f,0,big} := 2,4$

Force acting on small side of the LT Cooler and LT supporting structure:

$A_{LT,small} := W_{LT} \cdot H_{LT} = 3,1174\ m^2$

$W_{LT,s} := c_s \cdot c_d \cdot c_{f,0,small} \cdot q_p \cdot A_{LT,small} = 10,41\ kN$

Force acting on big side of the LT Cooler and LT supporting structure:

$A_{LT,big} := L_{LT} \cdot H_{LT} = 3,6606\ m^2$

$W_{LT,b} := c_s \cdot c_d \cdot c_{f,0,big} \cdot q_p \cdot A_{LT,big} = 12,76\ kN$

8.2.5. Wind on destination place acting on HT work platform.

Dimensions of the HT workplatform

$L_{wp} := 1,95\ \mathrm{m}$

$W_{wp} := 2,4\ \mathrm{m}$

$H_{wp} := 2,83\ \mathrm{m}$

Consideration of wind acting on whole structure as on a structural element with rectangular section:

Rounded corners effect factor: $\psi_r := 1$ (fig. 7.24-EC1991-1-4)

Solidity ratio: $\varphi := 1$ (eq:7.28-EC1991-1-4)

Effective slenderness:

$$\lambda_{big} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{H_{wp}}{L_{wp}} \\ 70 \end{array}\right]\right) = 2,9$$

(table:7.16-EC1991-1-4)

$$\lambda_{small} := \min\left(\left[\begin{array}{c} 2 \cdot \frac{H_{wp}}{W_{wp}} \\ 70 \end{array}\right]\right) = 2,36$$

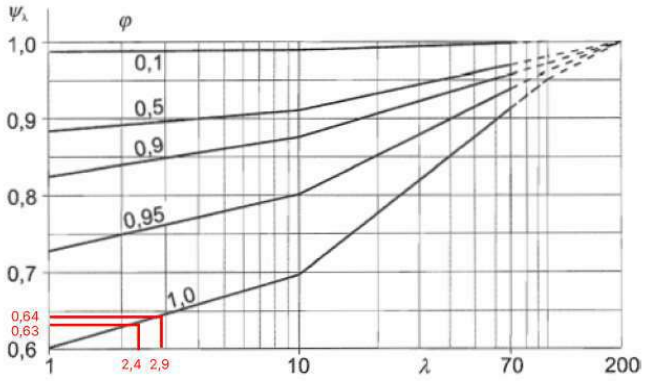


Figure 7.36 — Indicative values of the end-effect factor ψ_λ as a function of solidity ratio φ versus slenderness λ

Fig . 18: End effect factor from the figure 7.36 - EC1991-1-4

As slenderness in both directions is similar one value for two direction has been assumed:

End effect factor: $\psi_\lambda := 0,64$

$d_{small} := L_{wp} = 1,95\ \mathrm{m}$

$b_{small} := H_{wp} = 2,83\ \mathrm{m}$

$$\frac{d_{small}}{b_{small}} = 0,69$$

$d_{big} := W_{wp} = 2,4\ \mathrm{m}$

$b_{big} := H_{wp} = 2,83\ \mathrm{m}$

$$\frac{d_{big}}{b_{big}} = 0,85$$

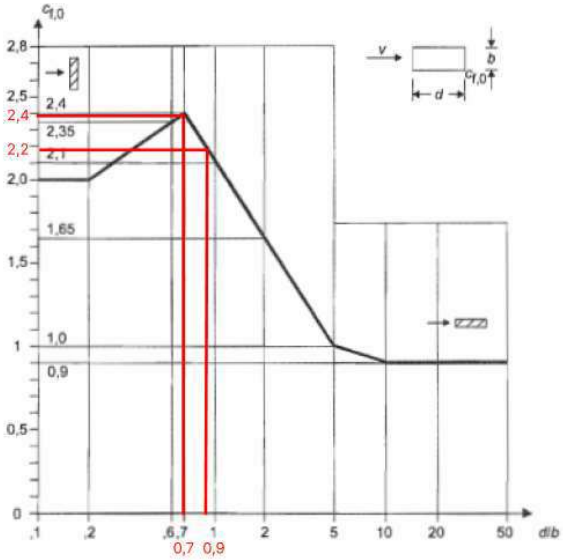


Figure 7.23 — Force coefficients $c_{f,0}$ of rectangular sections with sharp corners and without free end flow

Fig. 19: Force coefficient from the figure 7.23 - EC1991-1-4

$c_{f,0,small} := 2,40$ $c_{f,0,big} := 2,2$

Force acting on small side of the HT workplatform:

$A_{wp,small} := W_{wp} \cdot H_{wp} = 6,792\ m^2$

$W_{wp,s} := c_s \cdot c_d \cdot c_{f,0,small} \cdot q_p \cdot A_{wp,small} = 23,67\ kN$

Force acting on small side of the HT workplatform above HT coolers:

$A_{wp,small,above} := 0,85\ m \cdot W_{wp} = 2,04\ m^2$

$W_{wp,s,above} := \frac{A_{wp,small,above}}{A_{wp,small}} \cdot W_{wp,s} = 7,11\ kN$

Force acting on big side of the HT workplatform:

$A_{wp,big} := L_{wp} \cdot H_{wp} = 5,5185\ m^2$

$q_p = 1,45\ kPa$

$W_{wp,b} := c_s \cdot c_d \cdot c_{f,0,big} \cdot q_p \cdot A_{wp,big} = 17,63\ kN$

The wind load acting on the small side of the HTworkplatform is much smaller, as in almost all surface is covered by HT Coolers.

8.2.6. Wind on destination place acting on 40ft flatbed

Dimensions of the HT workplatform

$L_{40ft,fb} := 12,192\ m$

$W_{40ft,fb} := 2,438\ m$

$H_{40ft,fb} := 0,255\ m$

Consideration of wind acting on whole structure as on a structural element with rectangular section:

Rounded corners effect factor: $\psi_r := 1$ (fig. 7.24-EC1991-1-4)

Solidity ratio: $\varphi := 1$ (eq:7.28-EC1991-1-4)

Effective slenderness:

$$\lambda_{big} := \min\left(\left\lfloor 2 \cdot \frac{L_{40ft,fb}}{H_{40ft,fb}} \right\rfloor, 70\right) = 70$$ (table:7.16-EC1991-1-4)

$$\lambda_{small} := \min\left(\left\lfloor 2 \cdot \frac{W_{40ft,fb}}{H_{40ft,fb}} \right\rfloor, 70\right) = 19,12$$

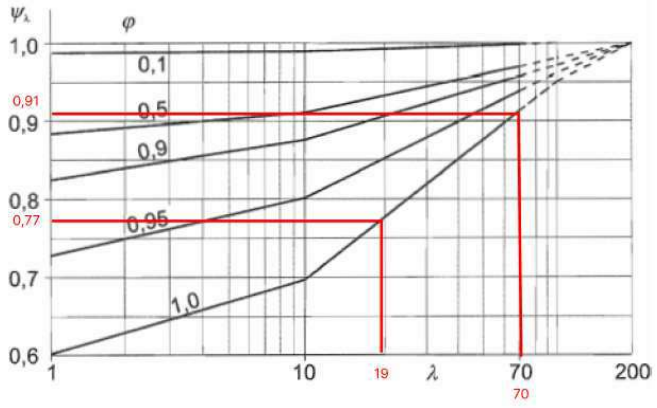


Figure 7.36 — Indicative values of the end-effect factor ψ_λ as a function of solidity ratio φ versus slenderness λ

Fig . 20: End effect factor from the figure 7.36 - EC1991-1-4

As slenderness in both directions is similar one value for two direction has been assumed:

End effect factor: $\psi_\lambda := 0,63$

$d_{small} := L_{40ft,fb} = 12,192\ m$

$b_{small} := H_{40ft,fb} = 0,255\ m$

$$\frac{d_{small}}{b_{small}} = 47,81$$

$d_{big} := W_{40ft,fb} = 2,438\ m$

$b_{big} := H_{40ft,fb} = 0,255\ m$

$$\frac{d_{big}}{b_{big}} = 9,5608$$

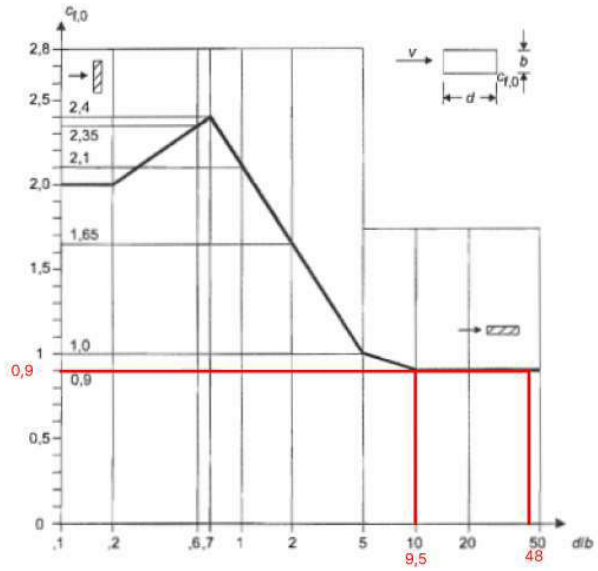


Figure 7.23 — Force coefficients $c_{f,0}$ of rectangular sections with sharp corners and without free end flow

Fig. 21: Force coefficient from the figure 7.23 - EC1991-1-4

$c_{f,0,small} := 0,9$ $c_{f,0,big} := 0,9$

Force acting on small side of the HT workplatform:

$A_{40ft,fb,small} := W_{40ft,fb} \cdot H_{40ft,fb} = 0,6217\ m^2$

$W_{40ft,fb,s} := c_s \cdot c_d \cdot c_{f,0,small} \cdot q_p \cdot A_{40ft,fb,small} = 0,8124\ kN$

Force acting on big side of the HT workplatform:

$A_{40ft,fb,small} := L_{40ft,fb} \cdot H_{40ft,fb} = 3,109\ m^2$

$W_{40ft,fb,b} := c_s \cdot c_d \cdot c_{f,0,big} \cdot q_p \cdot A_{40ft,fb,small} = 4,0625\ kN$

8.2.7. Snow on site

It was assumed that snow cannot remain on coolers or pumps, so it was not included in further calculations.

8.2.8. Wind drugin transport on barge

Wind pressure defined by customer durign transport on barge is equal to 1kN/m2.

8.3. Load combinations

8.3.1. 40ft flatbed with equipment

It has been assumed 4 main situations:
- transport by appropriate truck (LC1, LC2, LC3, LC4)
- lifting with lifting sets (LC5) [Offshore]
- lifting with lifting sets (LC6) [Onshore]
- transport on barge (LC7-LC14) (Transport LC1-LC8)
- in destination place on open sea on barge (LC15, LC16, LC17, LC18)

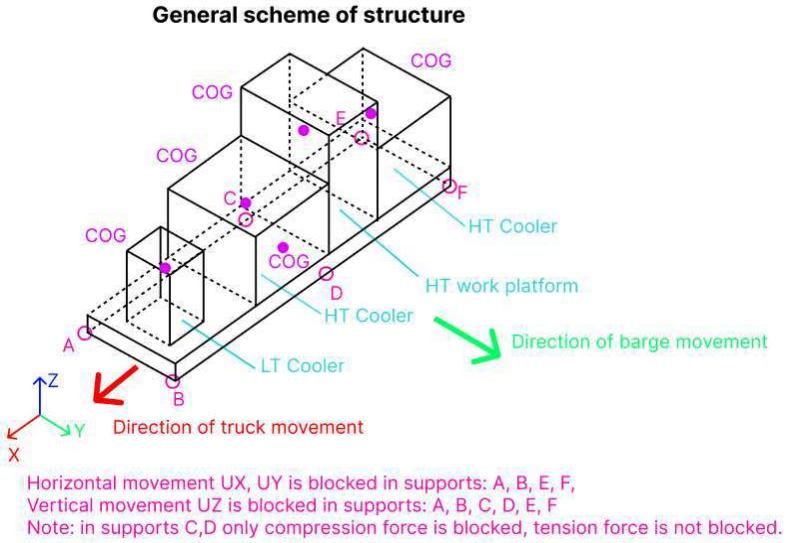


Fig. 22: Simplification of elements on barge with their centers of gravity (COG)

40ft flatbed - dimensions [mm]								
No	Item	Weight		Qty	Mass symbol	X (L)	Y (W)	Z (H)
1,1	Rad. 1050kW (HT) (wet)	2681	kg	1	m2.01.1	3989	2200	2277
1,2	Rad. 1050kW (HT) (wet)	2681	kg	1	m2.01.2	3989	2200	2277
2,1	Rad. 110kW (LT) (wet)	435	kg	1	m2.02.1	2064	1452	885
3,1	Structure below rad. 110kW (LT) (in design)	250	kg	1	m2.03.1	1720	1452	1262
4,1	Cabinet no 1	450	kg	1	m2.04.1	1200	405	2384
4,2	Cabinet no 2	450	kg	1	m2.04.2	1200	405	2384
5,1	Pump	230	kg	1	m2.05.1	380	555	930
5,2	Pump	230	kg	1	m2.05.2	380	555	930
6,1	Walkway	100	kg	1	m2.06.1	876	1903	380
7,1	Piping - HT	250	kg	1	m2.07.1	380	2000	1500
7,2	Piping - HT	250	kg	1	m2.07.2	380	2000	1500
8,1	Piping - LT	200	kg	1	m2.08.1	380	900	2000
9,1	Header tank (wet)	100	kg	1	m2.09.1	554	604	304
9,2	Header tank (wet)	100	kg	1	m2.09.2	554	604	304
9,3	Header tank (wet)	100	kg	1	m2.09.3	554	604	304
10,1	Center frame	500	kg	1	m2.10.1	2400	2330	2830
11,1	Platform	2025	kg	1	m2.12.1	12192	2437	255
12,1	Wires	300	kg	1	m2.13.1	2400	2330	2830
	Total weight:	11332						Total:

Fig. 23: Assumed masses of all components.

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Assumed load cases have been calculated automatically in Excel for each of the simplified components:

- HT Cooler
- LT Cooler with supporting strucutre
- HT workplatform
- 40ft flatbed

Data: [HT Cooler - 105KW]						
L	length	1,989	[m]			
W	width	2,2	[m]	Ax	5,35	[m]
H	height	2,43	[m]	Ay	9,69	[m]
m	mass	2681	[kg]	COG	1,62	[m]

Input by hand
Calculated automatically

Load cases			Load safety factors				Characteristic values of accelerations			Wind forces	Characteristic acceleration forces				Design acceleration forces								Characteristic wind		Design wind				Design forces (ULS)				Characteristic forces (SLS)			
	Description	Standard	Load safety factor			Dynamic safety factor	ax [m/s2]	ay [m/s2]	az [m/s2]	Fx [kN/m2]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]
LC1	Road transport - braking	DNVGL-ST-N001	1,6				7,85	0,00	9,81		21,0	-	26,3	-	33,7	-	42,1	-					-	-	-	-			33,7	-	42,1	-	21,0	-	26,3	-
LC2	Road transport - accelerating	DNVGL-ST-N001	1,6				-7,85	0,00	9,81		-21,0	-	26,3	-	-33,7	-	42,1	-					-	-	-	-			-33,7	-	42,1	-	-21,0	-	26,3	-
LC3	Road transport - turning	DNVGL-ST-N001	1,6				0,00	4,91	9,81		-	13,2	26,3	-	-	21,0	42,1	-	There is no distinction between ULS-a and ULS-b				-	-	-	-	There is no distinction between ULS-a and ULS-b		-	21,0	42,1	-	-	13,2	26,3	-
LC4	Road transport - uneven surface	DNVGL-ST-N001	1,6				0,00	0,00	11,77		-	-	31,6	-	-	-	50,5	-					-	-	-	-			-	-	50,5	-	-	-	31,6	-
LC5	Offshore lifting	DNVGL-ST-N001	LRFD		1,8						-	-	26,3	-	-	-	61,5	-					-	-	-	-			-	-	61,5	-	-	-	26,3	-
LC6	Onshore lifting	EN 13155	2								-	-	26,3	-	-	-	52,6	-					-	-	-	-			-	-	52,6	-	-	-	26,3	-
				ULS-a	ULS-b														ULS-b ULS-b values are more unvafourable in compare with ULS-a										In order to simplify max and min Fz has been take from ULS-a and ULS-b. Fx and Fy has been take from ULS-b.				In order to simplify max and min Fz has been take from SLS-a and SLS-b. Fx and Fy has been take from SLS-b.			
LC7-1	Sea transport on the barque LC7-1 - Head sea, bow down, from Y+ [Pitch case 1]	DNVGL-ST-N001	LRFD Table 5.8 G=permanent loads Q=variable functional loads D=deformation loads E=environmental loads (wind, waves, storm, surge, tide, ice) A=accidental loads	G			0,00	3,69	12,09	7,52		1,00	0,0	9,9	32,4	20,2	0,0	6,9	38,5	29,9	0,0	12,9	34,3	18,3	0,0	9,7	0,0	6,8	0,0	12,6	0,0	25,5	38,5	18,3	0,0	19,6	32,4	20,2
LC8-2	Sea transport on the barque LC8-2 - Quatering Sea, bow down, from X-Y+ [Quatering 1]	DNVGL-ST-N001		1,3	1		6,22	2,35	13,61	6,00	0,71	0,71	16,7	6,3	36,5	16,1	11,7	4,4	41,3	27,0	21,7	8,2	39,5	13,0	3,8	6,9	2,6	4,8	4,9	8,9	26,6	17,1	41,3	13,0	20,4	13,2	36,5	16,1
LC9-3	Sea transport on the barque LC9-3 - Beam Sea, from X+ [Roll case 1]	DNVGL-ST-N001		Q			7,90	0,00	13,10	6,51	1,00		21,2	0,0	35,1	17,5	14,8	0,0	40,4	28,0	27,5	0,0	37,8	14,8	5,3	0,0	3,7	0,0	6,9	0,0	34,5	0,0	40,4	14,8	26,5	0,0	35,1	17,5
LC10-4	Sea transport on the barque LC10-4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	DNVGL-ST-N001		1,3	1		6,22	-2,35	13,61	6,00	0,71	-0,71	16,7	-6,3	36,5	16,1	11,7	-4,4	41,3	27,0	21,7	-8,2	39,5	13,0	3,8	-6,9	2,6	-4,8	4,9	-8,9	26,6	-17,1	41,3	13,0	20,4	-13,2	36,5	16,1
LC13-5	Sea transport on the barque LC13-5 - Head Sea, stern down, from Y- [Pitch case 2]	DNVGL-ST-N001		D			0,00	-3,69	12,09	7,52		-1,00	0,0	-9,9	32,4	20,2	0,0	-6,9	38,5	29,9	0,0	-12,9	34,3	18,3	0,0	-9,7	0,0	-6,8	0,0	-12,6	0,0	-25,5	38,5	18,3	0,0	-19,6	32,4	20,2
LC12-6	Sea transport on the barque LC12-6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	DNVGL-ST-N001		1	1		-6,22	-2,35	13,61	6,00	-0,71	-0,71	-16,7	-6,3	36,5	16,1	-11,7	-4,4	41,3	27,0	-21,7	-8,2	39,5	13,0	-3,8	-6,9	-2,6	-4,8	-4,9	-8,9	-26,6	-17,1	41,3	13,0	-20,4	-13,2	36,5	16,1
LC13-7	Sea transport on the barque LC13-7 - Beam Sea, from X- [Roll case 2]	DNVGL-ST-N001		E			-7,90	0,00	13,10	6,51	-1,00		-21,2	0,0	35,1	17,5	-14,8	0,0	40,4	28,0	-27,5	0,0	37,8	14,8	-5,3	0,0	-3,7	0,0	-6,9	0,0	-34,5	0,0	40,4	14,8	-26,5	0,0	35,1	17,5
LC14-8	Sea transport on the barque LC14-8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	DNVGL-ST-N001		0,7	1,3		-6,22	2,35	13,61	6,00	-0,71	0,71	-16,7	6,3	36,5	16,1	-11,7	4,4	41,3	27,0	-21,7	8,2	39,5	13,0	-3,8	6,9	-2,6	4,8	-4,9	8,9	-26,6	17,1	41,3	13,0	-20,4	13,2	36,5	16,1
LC15	Destination place (offshore) X+/X-	DNVGL-ST-N001		A			1,75	0,00	9,81	9,81	depends on shape		4,7	0,0	26,3	26,3	3,3	0,0	34,2	34,2	6,1	0,0	26,3	26,3	14,0	0,0	9,8	0,0	18,2	0,0	24,3	0,0	34,2	26,3	18,7	0,0	26,3	26,3
LC16	Destination place (offshore) Y+/Y-	DNVGL-ST-N001		-	-		0,00	1,75	9,81	9,81	depends on shape		0,0	4,7	26,3	26,3	0,0	3,3	34,2	34,2	0,0	6,1	26,3	26,3	0,0	31,0	0,0	21,7	0,0	40,2	0,0	46,3	34,2	26,3	0,0	35,7	26,3	26,3

Data: [LT Cooler -110kW with supporting strucutre]						
L	length	1,72	[m]	Az	2,44	[m]
W	width	1,42	[m]	Ax	3,05	[m]
H	height	2,15	[m]	Ay	3,70	[m]
m	mass	885	[kg]	COG	1,70	[m]

Input by hand
Calculated automatically

Load cases			Load safety factors				Characteristic values of accelerations			Wind forces	Characteristic acceleration forces				Design acceleration forces								Characteristic wind		Design wind				Design forces (ULS)				Characteristic forces (SLS)			
	Description	Standard	Load safety factor			Dynamic safety factor	ax [m/s2]	ay [m/s2]	az [m/s2]	Fx [kN/m2]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]
LC1	Road transport - braking	DNVGL-ST-N001	1,6				7,85	0,00	9,81		6,9	-	8,7	-	11,1	-	13,9	-					-	-	-	-			11,1	-	13,9	-	6,9	-	8,7	-
LC2	Road transport - accelerating	DNVGL-ST-N001	1,6				-7,85	0,00	9,81		-6,9	-	8,7	-	-11,1	-	13,9	-					-	-	-	-			-11,1	-	13,9	-	-6,9	-	8,7	-
LC3	Road transport - turning	DNVGL-ST-N001	1,6				0,00	4,91	9,81		-	4,3	8,7	-	-	6,9	13,9	-	There is no distinction between ULS-a and ULS-b				-	-	-	-	There is no distinction between ULS-a and ULS-b		-	6,9	13,9	-	-	4,3	8,7	-
LC4	Road transport - uneven surface	DNVGL-ST-N001	1,6				0,00	0,00	11,77		-	-	10,4	-	-	-	16,7	-					-	-	-	-			-	-	16,7	-	-	-	10,4	-
LC5	Offshore lifting	DNVGL-ST-N001	LRFD		1,8						-	-	8,7	-	-	-	20,3	-					-	-	-	-			-	-	20,3	-	-	-	8,7	-
LC6	Onshore lifting	EN 13155	2								-	-	8,7	-	-	-	17,4	-					-	-	-	-			-	-	17,4	-	-	-	8,7	-
				ULS-a	ULS-b														ULS-b ULS-b values are more unvafourable in compare with ULS-a										In order to simplify max and min Fz has been take from ULS-a and ULS-b. Fx and Fy has been take from ULS-b.				In order to simplify max and min Fz has been take from SLS-a and SLS-b. Fx and Fy has been take from SLS-b.			
LC7-1	Sea transport on the barque LC7-1 - Head sea, bow down, from Y+ [Pitch case 1]	DNVGL-ST-N001	LRFD Table 5.8 G=permanent loads Q=variable functional loads D=deformation loads E=environmental loads (wind, waves, storm, surge, tide, ice) A=accidental loads	G			0,00	3,69	12,09	7,52		1,00	0,0	3,3	10,7	6,7	0,0	2,3	12,7	9,9	0,0	4,2	11,3	6,0	0,0	3,7	0,0	2,6	0,0	4,8	0,0	9,0	12,7	6,0	0,0	7,0	10,7	6,7
LC8-2	Sea transport on the barque LC8-2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	DNVGL-ST-N001		1,3	1		6,22	2,35	13,61	6,00	0,71	0,71	5,5	2,1	12,0	5,3	3,9	1,5	13,6	8,9	7,2	2,7	13,1	4,3	2,2	2,6	1,5	1,8	2,8	3,4	10,0	6,1	13,6	4,3	7,7	4,7	12,0	5,3
LC9-3	Sea transport on the barque LC9-3 - Beam Sea, from X+ [Roll case 1]	DNVGL-ST-N001		Q			7,90	0,00	13,10	6,51	1,00		7,0	0,0	11,6	5,8	4,9	0,0	13,3	9,2	9,1	0,0	12,5	4,9	3,1	0,0	2,1	0,0	4,0	0,0	13,1	0,0	13,3	4,9	10,0	0,0	11,6	5,8
LC10-4	Sea transport on the barque LC10-4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	DNVGL-ST-N001		1,3	1		6,22	-2,35	13,61	6,00	0,71	-0,71	5,5	-2,1	12,0	5,3	3,9	-1,5	13,6	8,9	7,2	-2,7	13,1	4,3	2,2	-2,6	1,5	-1,8	2,8	-3,4	10,0	-6,1	13,6	4,3	7,7	-4,7	12,0	5,3
LC11-5	Sea transport on the barque LC11-5 - Head Sea, stern down, from Y- [Pitch case 2]	DNVGL-ST-N001		D			0,00	-3,69	12,09	7,52		-1,00	0,0	-3,3	10,7	6,7	0,0	-2,3	12,7	9,9	0,0	-4,2	11,3	6,0	0,0	-3,7	0,0	-2,6	0,0	-4,8	0,0	-9,0	12,7	6,0	0,0	-7,0	10,7	6,7
LC12-6	Sea transport on the barque LC12-6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	DNVGL-ST-N001		1	1		-6,22	-2,35	13,61	6,00	-0,71	-0,71	-5,5	-2,1	12,0	5,3	-3,9	-1,5	13,6	8,9	-7,2	-2,7	13,1	4,3	-2,2	-2,6	-1,5	-1,8	-2,8	-3,4	-10,0	-6,1	13,6	4,3	-7,7	-4,7	12,0	5,3
LC13-7	Sea transport on the barque LC13-7 - Beam Sea, from X- [Roll case 2]	DNVGL-ST-N001		E			-7,90	0,00	13,10	6,51	-1,00		-7,0	0,0	11,6	5,8	-4,9	0,0	13,3	9,2	-9,1	0,0	12,5	4,9	-3,1	0,0	-2,1	0,0	-4,0	0,0	-13,1	0,0	13,3	4,9	-10,0	0,0	11,6	5,8
LC14-8	Sea transport on the barque LC14-8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	DNVGL-ST-N001		0,7	1,3		-6,22	2,35	13,61	6,00	-0,71	0,71	-5,5	2,1	12,0	5,3	-3,9	1,5	13,6	8,9	-7,2	2,7	13,1	4,3	-2,2	2,6	-1,5	1,8	-2,8	3,4	-10,0	6,1	13,6	4,3	-7,7	4,7	12,0	5,3
LC15	Destination place (offshore) X+/X-	DNVGL-ST-N001		A			1,75	0,00	9,81	9,81	depends on shape		1,5	0,0	8,7	8,7	1,1	0,0	11,3	11,3	2,0	0,0	8,7	8,7	10,4	0,0	7,3	0,0	13,5	0,0	15,5	0,0	11,3	8,7	11,9	0,0	8,7	8,7
LC16	Destination place (offshore) Y+/Y-	DNVGL-ST-N001		-	-		0,00	1,75	9,81	9,81	depends on shape		0,0	1,5	8,7	8,7	0,0	1,1	11,3	11,3	0,0	2,0	8,7	8,7	0,0	12,7	0,0	8,9	0,0	16,5	0,0	18,5	11,3	8,7	0,0	14,2	8,7	8,7

Data: [HT work platform] (Without cover)						
L	length	1,95	[m]	Az	4,54	[m]
W	width	2,33	[m]	Ax	6,59	[m]
H	height	2,83	[m]	Ay	5,52	[m]
m	mass	3060	[kg]	COG	1,89	[m]

Ax is calculated only above HT Coolers (h=0,85m), Total height of HT work platform is 2,83m
Input by hand
Calculated automatically

Load cases			Load safety factors				Characteristic values of accelerations			Wind forces	Characteristic acceleration forces				Design acceleration forces								Characteristic wind		Design wind				Design forces (ULS)				Characteristic forces (SLS)			
	Description	Standard	Load safety factor			Dynamic safety factor	ax [m/s2]	ay [m/s2]	az [m/s2]	Fx [kN/m2]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]
LC1	Road transport - braking	DNVGL-ST-N001	1,6				7,85	0,00	9,81		24,0	-	30,0	-	38,4	-	48,0	-					-	-	-	-			38,4	-	48,0	-	24,0	-	30,0	-
LC2	Road transport - accelerating	DNVGL-ST-N001	1,6				-7,85	0,00	9,81		-24,0	-	30,0	-	-38,4	-	48,0	-					-	-	-	-			-38,4	-	48,0	-	-24,0	-	30,0	-
LC3	Road transport - turning	DNVGL-ST-N001	1,6				0,00	4,91	9,81		-	15,0	30,0	-	-	24,0	48,0	-	There is no distinction between ULS-a and ULS-b				-	-	-	-	There is no distinction between ULS-a and ULS-b		-	24,0	48,0	-	-	15,0	30,0	-
LC4	Road transport - uneven surface	DNVGL-ST-N001	1,6				0,00	0,00	11,77		-	-	36,0	-	-	-	57,6	-					-	-	-	-			-	-	57,6	-	-	-	36,0	-
LC5	Offshore lifting	DNVGL-ST-N001	LRFD		1,8						-	-	30,0	-	-	-	70,2	-					-	-	-	-			-	-	70,2	-	-	-	30,0	-
LC6	Onshore lifting	EN 13155	2								-	-	30,0	-	-	-	60,0	-					-	-	-	-			-	-	60,0	-	-	-	30,0	-
				ULS-a	ULS-b														ULS-b										In order to simplify max and min Fz has				In order to simplify max and min Fz has			
LC7-1	Sea transport on the barque LC7-1 - Head sea, bow down, from Y+ [Pitch case 1]	DNVGL-ST-N001	LRFD Table 5.8 G=permanent loads Q=variable functional loads D=deformation loads E=environmental loads (wind, waves, storm, surge, tide, ice) A=accidental loads	G			0,00	3,69	12,09	7,52		1,00	0,0	11,3	37,0	23,0	0,0	7,9	43,9	34,1	0,0	14,7	39,1	20,9	0,0	5,5	0,0	3,9	0,0	7,2	0,0	21,8	43,9	20,9	0,0	16,8	37,0	23,0
LC8-2	Sea transport on the barque LC8-2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	DNVGL-ST-N001		1,3	1		6,22	2,35	13,61	6,00	0,71	0,71	19,0	7,2	41,6	18,4	13,3	5,0	47,2	30,9	24,7	9,4	45,1	14,9	4,7	3,9	3,3	2,7	6,1	5,1	30,8	14,4	47,2	14,9	23,7	11,1	41,6	18,4
LC9-3	Sea transport on the barque LC9-3 - Beam Sea, from X+ [Roll case 1]	DNVGL-ST-N001		Q			7,90	0,00	13,10	6,51	1,00		24,2	0,0	40,1	19,9	16,9	0,0	46,1	32,0	31,4	0,0	43,1	16,9	6,6	0,0	4,6	0,0	8,6	0,0	40,0	0,0	46,1	16,9	30,8	0,0	40,1	19,9
LC10-4	Sea transport on the barque LC10-4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	DNVGL-ST-N001		1,3	1		6,22	-2,35	13,61	6,00	0,71	-0,71	19,0	-7,2	41,6	18,4	13,3	-5,0	47,2	30,9	24,7	-9,4	45,1	14,9	4,7	-3,9	3,3	-2,7	6,1	-5,1	30,8	-14,4	47,2	14,9	23,7	-11,1	41,6	18,4
LC11-5	Sea transport on the barque LC11-5 - Head Sea, stern down, from Y- [Pitch case 2]	DNVGL-ST-N001		D			0,00	-3,69	12,09	7,52		-1,00	0,0	-11,3	37,0	23,0	0,0	-7,9	43,9	34,1	0,0	-14,7	39,1	20,9	0,0	-5,5	0,0	-3,9	0,0	-7,2	0,0	-21,8	43,9	20,9	0,0	-16,8	37,0	23,0
LC12-6	Sea transport on the barque LC12-6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	DNVGL-ST-N001		1	1		-6,22	-2,35	13,61	6,00	-0,71	-0,71	-19,0	-7,2	41,6	18,4	-13,3	-5,0	47,2	30,9	-24,7	-9,4	45,1	14,9	-4,7	-3,9	-3,3	-2,7	-6,1	-5,1	-30,8	-14,4	47,2	14,9	-23,7	-11,1	41,6	18,4
LC13-7	Sea transport on the barque LC13-7 - Beam Sea, from X- [Roll case 2]	DNVGL-ST-N001		E			-7,90	0,00	13,10	6,51	-1,00		-24,2	0,0	40,1	19,9	-16,9	0,0	46,1	32,0	-31,4	0,0	43,1	16,9	-6,6	0,0	-4,6	0,0	-8,6	0,0	-40,0	0,0	46,1	16,9	-30,8	0,0	40,1	19,9
LC14-8	Sea transport on the barque LC14-8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	DNVGL-ST-N001		0,7	1,3		-6,22	2,35	13,61	6,00	-0,71	0,71	-19,0	7,2	41,6	18,4	-13,3	5,0	47,2	30,9	-24,7	9,4	45,1	14,9	-4,7	3,9	-3,3	2,7	-6,1	5,1	-30,8	14,4	47,2	14,9	-23,7	11,1	41,6	18,4
LC15	Destination place (offshore) X+/X-	DNVGL-ST-N001		A			1,75	0,00	9,81	9,81	depends on shape		5,4	0,0	30,0	30,0	3,7	0,0	39,0	39,0	7,0	0,0	30,0	30,0	7,2	0,0	5,0	0,0	9,4	0,0	16,3	0,0	39,0	30,0	12,6	0,0	30,0	30,0
LC16	Destination place (offshore) Y+/Y-	DNVGL-ST-N001		-	-		0,00	1,75	9,81	9,81	depends on shape		0,0	5,4	30,0	30,0	0,0	3,7	39,0	39,0	0,0	7,0	30,0	30,0	0,0	17,7	0,0	12,4	0,0	23,0	0,0	30,0	39,0	30,0	0,0	23,1	30,0	30,0

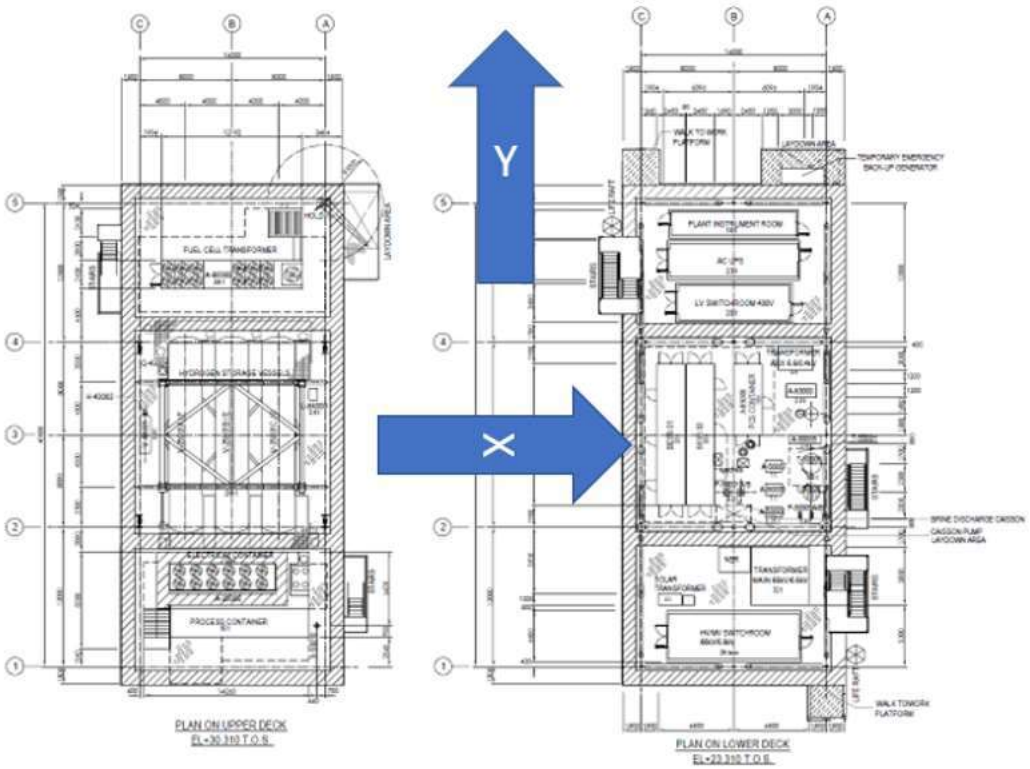
Data: [40ft flatbed]						
L	length	12,192	[m]	Az	29,71	[m]
W	width	2,437	[m]	Ax	0,62	[m]
H	height	0,255	[m]	Ay	3,11	[m]
m	mass	1765	[kg]	COG	0,13	[m]

Input by hand
Calculated automatically

Load cases			Load safety factors				Characteristic values of accelerations			Wind forces	Characteristic acceleration forces				Design acceleration forces								Characteristic wind		Design wind				Design forces (ULS)				Characteristic forces (SLS)			
	Description	Standard	Load safety factor			Dynamic safety factor	ax [m/s2]	ay [m/s2]	az [m/s2]	Fx [kN/m2]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]	Fx [kN]	Fy [kN]	Fz (max) [kN]	Fz (min) [kN]
LC1	Road transport - braking	DNVGL-ST-N001	1,6				7,85	0,00	9,81		13,9	-	17,3	-	22,2	-	27,7	-					-	-	-	-			22,2	-	27,7	-	13,9	-	17,3	-
LC2	Road transport - accelerating	DNVGL-ST-N001	1,6				-7,85	0,00	9,81		-13,9	-	17,3	-	-22,2	-	27,7	-					-	-	-	-			-22,2	-	27,7	-	-13,9	-	17,3	-
LC3	Road transport - turning	DNVGL-ST-N001	1,6				0,00	4,91	9,81		-	8,7	17,3	-	-	13,9	27,7	-	There is no distinction between ULS-a and ULS-b				-	-	-	-	There is no distinction between ULS-a and ULS-b		-	13,9	27,7	-	-	8,7	17,3	-
LC4	Road transport - uneven surface	DNVGL-ST-N001	1,6				0,00	0,00	11,77		-	-	20,8	-	-	-	33,2	-					-	-	-	-			-	-	33,2	-	-	-	20,8	-
LC5	Offshore lifting	DNVGL-ST-N001	LRFD		1,8						-	-	17,3	-	-	-	40,5	-					-	-	-	-			-	-	40,5	-	-	-	17,3	-
LC6	Onshore lifting	EN 13155	2								-	-	17,3	-	-	-	34,6	-					-	-	-	-			-	-	34,6	-	-	-	17,3	-
				ULS-a	ULS-b														ULS-b										In order to simplify max and min Fz has				In order to simplify max and min Fz has			
LC7-1	Sea transport on the barque LC7-1 - Head sea, bow down, from Y+ [Pitch case 1]	DNVGL-ST-N001	LRFD Table 5.8 G=permanent loads Q=variable functional loads D=deformation loads E=environmental loads (wind, waves, storm, surge, tide, ice) A=accidental loads	G			0,00	3,69	12,09	7,52		1,00	0,0	6,5	21,3	13,3	0,0	4,6	25,3	19,7	0,0	8,5	22,6	12,1	0,0	3,1	0,0	2,2	0,0	4,0	0,0	12,5	25,3	12,1	0,0	9,6	21,3	13,3
LC8-2	Sea transport on the barque LC8-2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	DNVGL-ST-N001		1,3	1		6,22	2,35	13,61	6,00	0,71	0,71	11,0	4,2	24,0	10,6	7,7	2,9	27,2	17,8	14,3	5,4	26,0	8,6	0,4	2,2	0,3	1,5	0,6	2,9	14,8	8,3	27,2	8,6	11,4	6,4	24,0	10,6
LC9-3	Sea transport on the barque LC9-3 - Beam Sea, from X+ [Roll case 1]	DNVGL-ST-N001		Q			7,90	0,00	13,10	6,51	1,00		14,0	0,0	23,1	11,5	9,8	0,0	26,6	18,4	18,1	0,0	24,9	9,7	0,6	0,0	0,4	0,0	0,8	0,0	18,9	0,0	26,6	9,7	14,6	0,0	23,1	11,5
LC10-4	Sea transport on the barque LC10-4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	DNVGL-ST-N001		1,3	1		6,22	-2,35	13,61	6,00	0,71	-0,71	11,0	-4,2	24,0	10,6	7,7	-2,9	27,2	17,8	14,3	-5,4	26,0	8,6	0,4	-2,2	0,3	-1,5	0,6	-2,9	14,8	-8,3	27,2	8,6	11,4	-6,4	24,0	10,6
LC11-5	Sea transport on the barque LC11-5 - Head Sea, stern down, from Y- [Pitch case 2]	DNVGL-ST-N001		D			0,00	-3,69	12,09	7,52		-1,00	0,0	-6,5	21,3	13,3	0,0	-4,6	25,3	19,7	0,0	-8,5	22,6	12,1	0,0	-3,1	0,0	-2,2	0,0	-4,0	0,0	-12,5	25,3	12,1	0,0	-9,6	21,3	13,3
LC12-6	Sea transport on the barque LC12-6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	DNVGL-ST-N001		1	1		-6,22	-2,35	13,61	6,00	-0,71	-0,71	-11,0	-4,2	24,0	10,6	-7,7	-2,9	27,2	17,8	-14,3	-5,4	26,0	8,6	-0,4	-2,2	-0,3	-1,5	-0,6	-2,9	-14,8	-8,3	27,2	8,6	-11,4	-6,4	24,0	10,6
LC13-7	Sea transport on the barque LC13-7 - Beam Sea, from X- [Roll case 2]	DNVGL-ST-N001		E			-7,90	0,00	13,10	6,51	-1,00		-14,0	0,0	23,1	11,5

8.3.2. Additional guidelines during transport

Customer provided additional guidelines in document:
"CW-BALL-TQ-0007 - Transportation forces (Guidelines provided by CrossWind) "
which states as below:



Option 1 Orientation specific transportation criteria			
	X (Roll)	**Y (Pitch)**	Z (incl. gravity)
Lower deck - roll	**+ / - 0.60 G**		**1G + / - 0.30 G**
Loadcase 1	-0.60 G in X		1.3 G Vertical
Loadcase 2	-0 .60 G in X		0.7 G vertical
Loadcase 3	+0.60 G in X		1.3 G Vertical
Loadcase 4	+0.60 G in X		0.7 G vertical
Lower deck - pitch		**+ / - 0.35G**	**1 G + / - 0.50 G**
Loadcase 5		-0.35 G in X	1.5 G Vertical
Loadcase 6		-0.35 G in X	0.5 G vertical
Loadcase 7		+0.35 G in X	1.5 G Vertical
Loadcase 8		+0.35 G in X	0.5 G vertical
Upper deck – roll	**+ / - 0.70 G**		**1G + / - 0.30 G**
Loadcase 1	-0.70 G in X		1.3 G Vertical
Loadcase 2	-0 .70 G in X		0.7 G vertical
Loadcase 3	+0.70 G in X		1.3 G Vertical
Loadcase 4	+0.70 G in X		0.7 G vertical
Upper deck -pitch		**+ / - 0.40 G**	**1G + / - 0.50 G**
Loadcase 5		-0.40 G in Y	1.5 G Vertical
Loadcase 6		-0.40 G in Y	0.5 G vertical
Loadcase 7		+0.40 G in Y	1.5 G Vertical
Loadcase 8		+0.40 G in Y	0.5 G vertical

Option 2 Generic transportation criteria irrespective of orientation on layout			
	X or Y		Z (incl gravity)
Lower deck criteria	**+ / - 0.60 G**		**1 G + / - 0.50 G**
Loadcase 1	-0.60 G in X		1.5 G vertical
Loadcase 2	-0.60 G in X		0.5 G vertical
Loadcase 3	+0.60 G in X		1.5 G vertical
Loadcase 4	+0.60 G in X		0.5 G vertical
Loadcase 5	-0.60 G in Y		1.5 G vertical
Loadcase 6	-0.60 G in Y		0.5 G vertical
Loadcase 7	+0.60 G in Y		1.5 G vertical
Loadcase 8	+0.60 G in Y		0.5 G vertical
Upper deck deck criteria	**+ / - 0.70 G**		**1 G + / - 0.50 G**
Loadcase 1	-0.70 G in X		1.5 G vertical
Loadcase 2	-0.70 G in X		0.5 G vertical
Loadcase 3	+0.70 G in X		1.5 G vertical
Loadcase 4	+0.70 G in X		0.5 G vertical
Loadcase 5	-0.70 G in Y		1.5 G vertical
Loadcase 6	-0.70 G in Y		0.5 G vertical
Loadcase 7	+0.70 G in Y		1.5 G vertical
Loadcase 8	+0.70 G in Y		0.5 G vertical

Fig. 24: Additional guidelines - 2 options

According to the above it was decided to use Option 1, as we know how the flatbed will be placed on barge and Option 2 is too conservative.
Comparison of Option 1 and Option 2 with DNV-ST-N001 has been made and it is presented below:

DNV-ST-N001 - Old calculations

Calculation of acceleration of analyzed 40ft container with 40ft flatbed at localization X=8m; Y=19m; Z=18m						
	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
Main data: X=8m Y=19m Z=h=18m g=9,807m/s2	LC1	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	3,69		12,09	7,52
	LC2	LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]	2,35	6,22	13,61	6,00
	LC3	LC3 - Beam Sea, from X+ [Roll case 1]		7,90	13,10	6,51
	LC4	LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]	-2,35	6,22	13,61	6,00
	LC5	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-3,69		12,09	7,52
	LC6	LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]	-2,35	-6,22	13,61	6,00
	LC7	LC7 - Beam Sea, from X- Roll case 2]		-7,90	13,10	6,51
	LC8	LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]	2,35	-6,22	13,61	6,00

1st option - New Italian guidelines

Calculation of acceleration of analyzed 40ft container with 40ft flatbed according to Italian guidelines 2024.01.22 - OPTION 1						
	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
Main data: Upper deck g=9,807m/s2	O1 LC1&LC2	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	3,92 (6,2%)		14,71	4,90
		LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]			(21,5%)	(35%)
	O1 LC3&LC4	LC3 - Beam Sea, from X+ [Roll case 1]	(10,3%)	6,86	12,75	6,86
		LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]			(2,7%)	(5,4%)
	O1 LC5&LC6	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-3,92 (6,2%)		14,71	4,90
		LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]			(21,5%)	(35%)
	O1 LC7&LC8	LC7 - Beam Sea, from X- Roll case 2]	(10,3%)	-6,86	12,75	6,86
		LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]			(2,7%)	(5,4%)

2nd option - New Italian guidelines

Calculation of acceleration of analyzed 40ft container with 40ft flatbed according to Italian guidelines 2024.01.22 - OPTION 2						
	Description		Linear Acceleration Amplitude (m/s2)			
			Surge, Y (a_x)	Sway, X (a_y)	Max. Heave (a_z)	Min. Heave (a_z)
LC7 / Main data: Upper deck g=9,807m/s2 / LC9 / LC11 / LC13	O2 LC1&LC2	LC1 - Head sea, bow down, from Y+ [Pitch case 1]	6,86 (86%)		14,71	4,90
		LC2 - Quatering Sea, bow down, from X+Y+ [Quatering 1]			(21,5%)	(35%)
	O2 LC3&LC4	LC3 - Beam Sea, from X+ [Roll case 1]	(10,3%)	6,86	14,71	4,90
		LC4 - Quatering Sea, stern down, from X+Y- [Quatering 2]			(12,2%)	(7,5%)
	O2 LC5&LC6	LC5 - Head Sea, stern down, from Y- [Pitch case 2]	-6,86 (86%)		14,71	4,90
		LC6 - Quatering Sea, stern down, from X-Y- [Quatering 3]			(21,5%)	(35%)
	O2 LC7&LC8	LC7 - Beam Sea, from X- Roll case 2]	(10,3%)	-6,86	14,71	4,90
		LC8 - Quatering Sea, bow down, from X-Y+ [Quatering 4]			(12,2%)	(7,5%)

Fig. 25: Acceleration comparison

Provided new guidelines gives more unfavourite accelerations then DNV-ST-N001.
The new guidelines map some of the load cases required by DNV, so strength calculations will be made in accordance with DNV and in accordance with the new guidelines - 1st option (taking into account those that give a more adverse load effect - LC7, LC11).

8.3.3. Force application in particular load cases:

LC1: Road transport (onshore) - braking

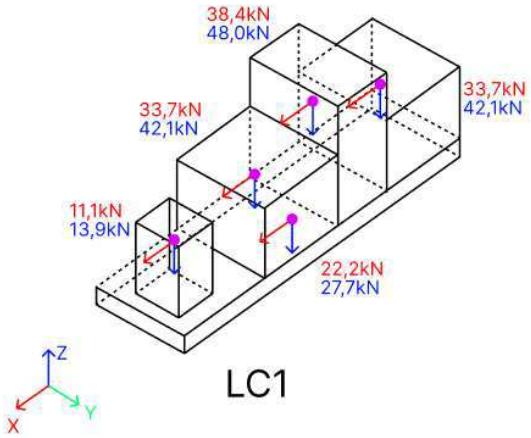


Fig 26: Load case no 1

LC2: Road transport (onshore) - accelerating

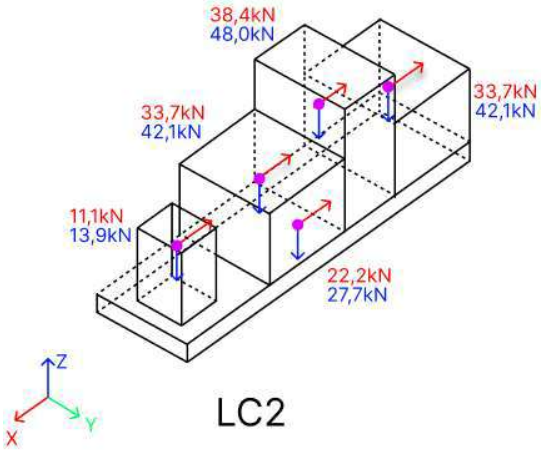
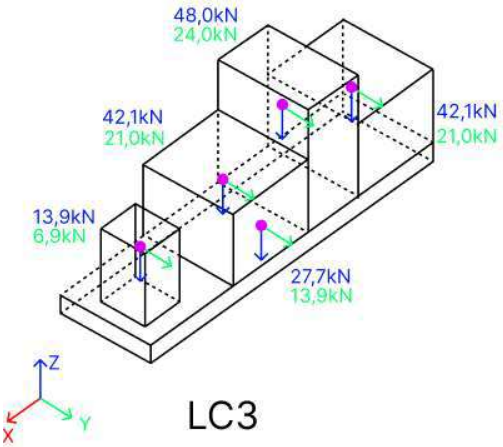


Fig 27: Load case no 2

LC3: Road transport (onshore) - turning



LC4: Road transport (onshore) - uneven surface

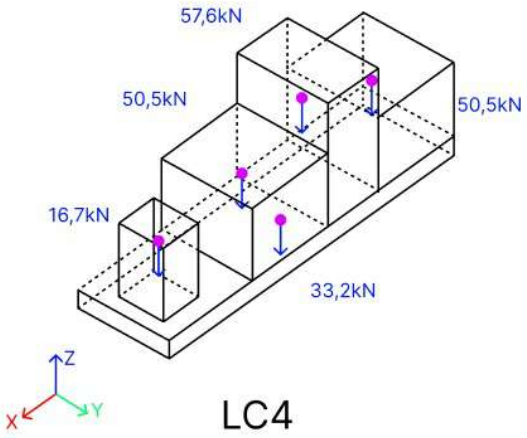


Fig 29: Load case no 4

LC5: Offshore lifting

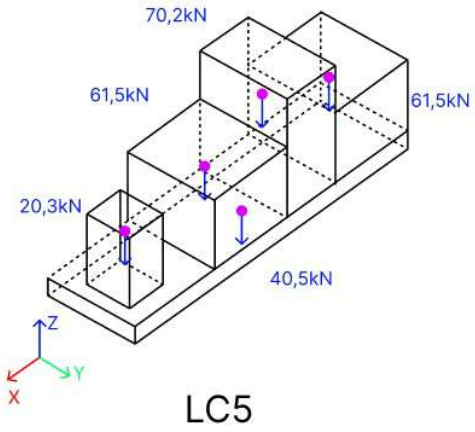


Fig 30: Load case no 5

LC6: Onshore lifting

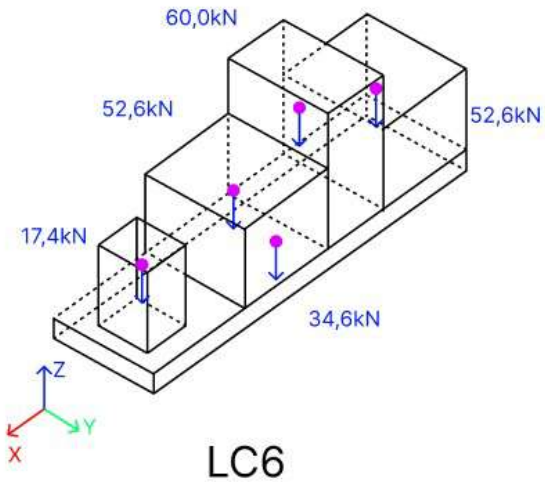


Fig 31: Load case no 6

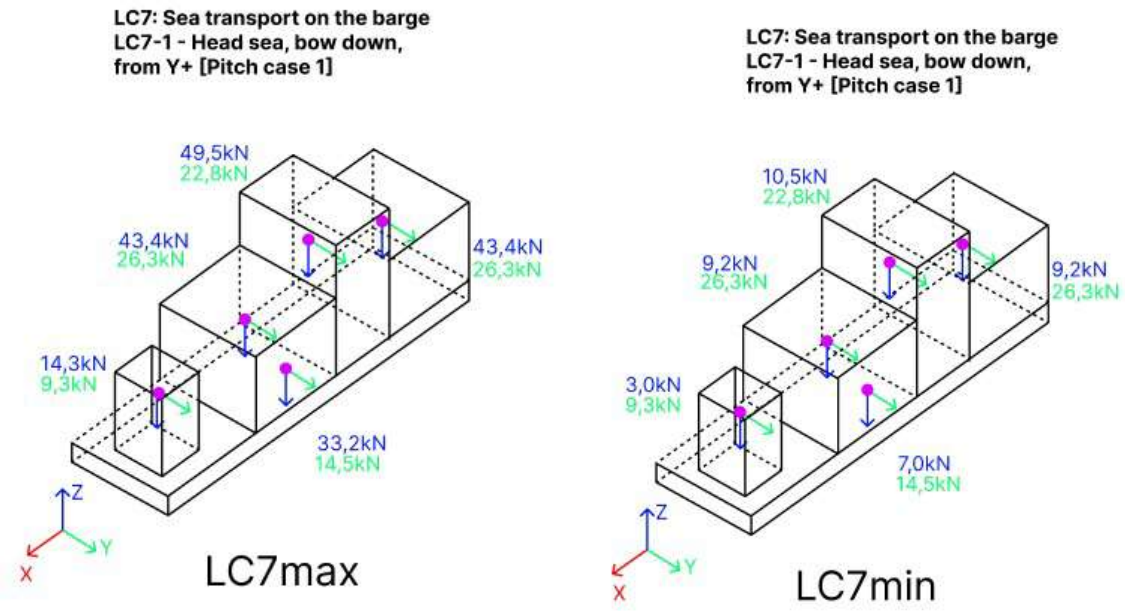


Fig 32: Load case no 7

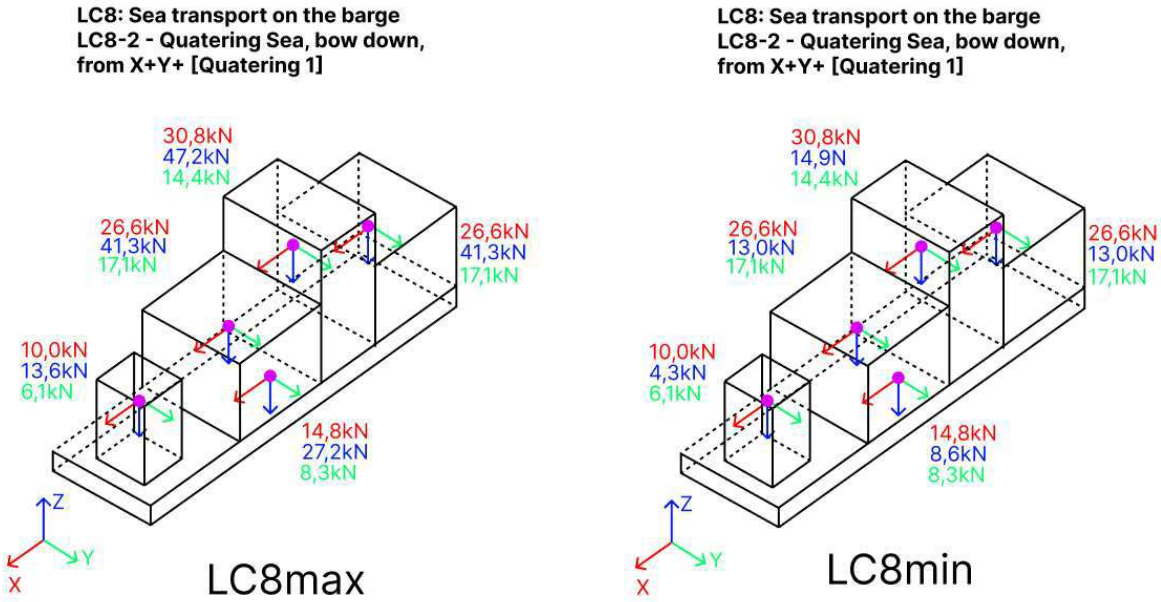


Fig 33: Load case no 8

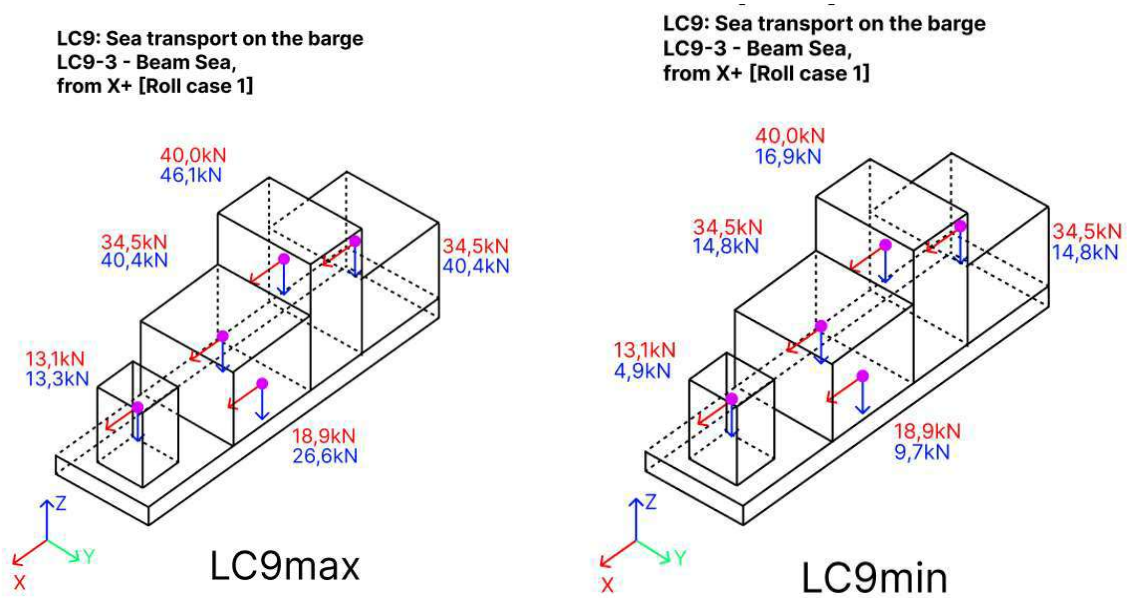


Fig 34: Load case no 9

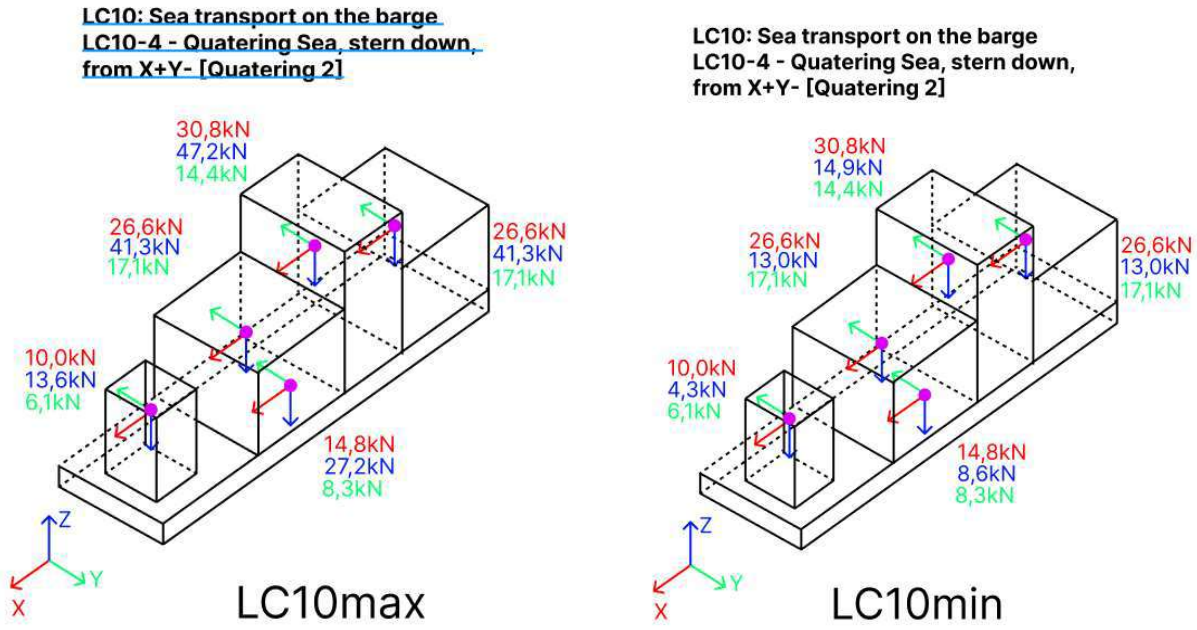


Fig 35: Load case no 10

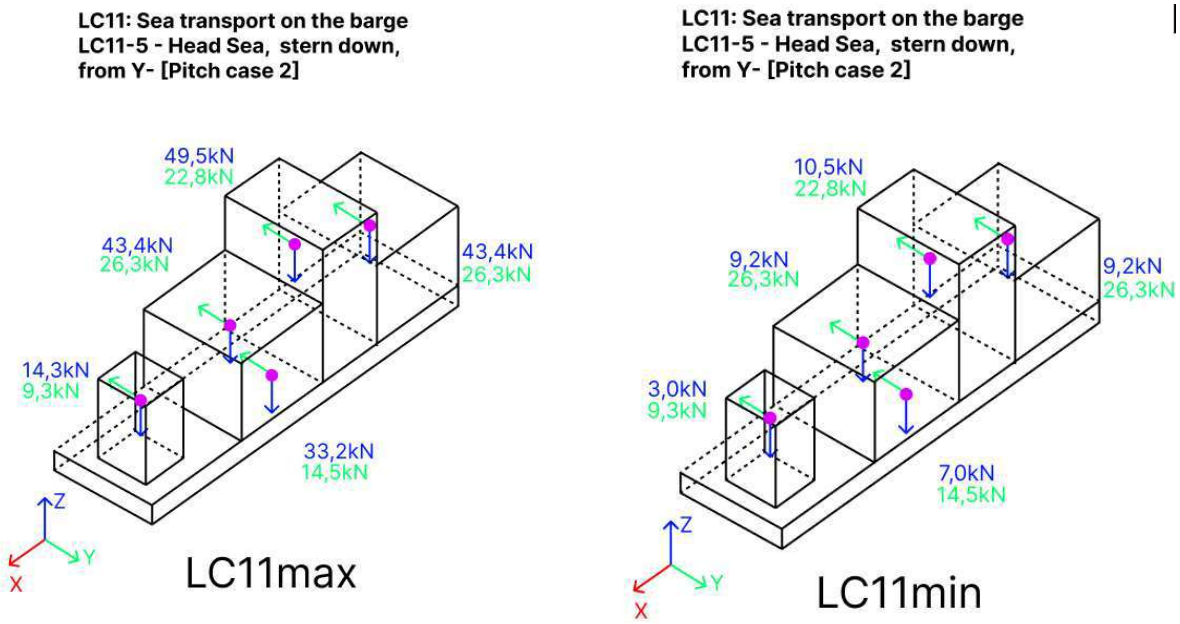


Fig 36: Load case no 11

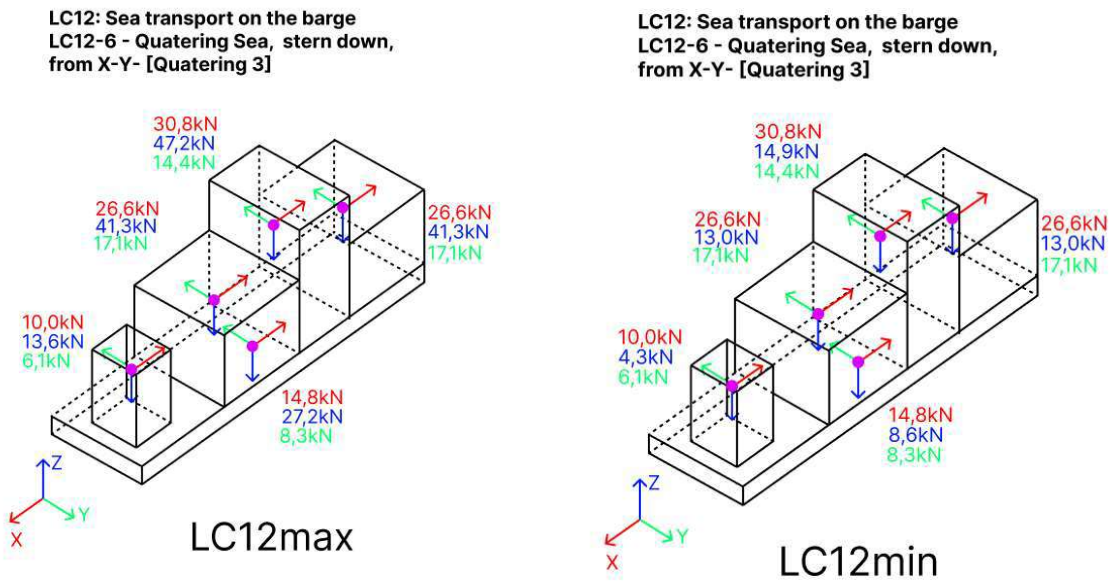


Fig 37: Load case no 12

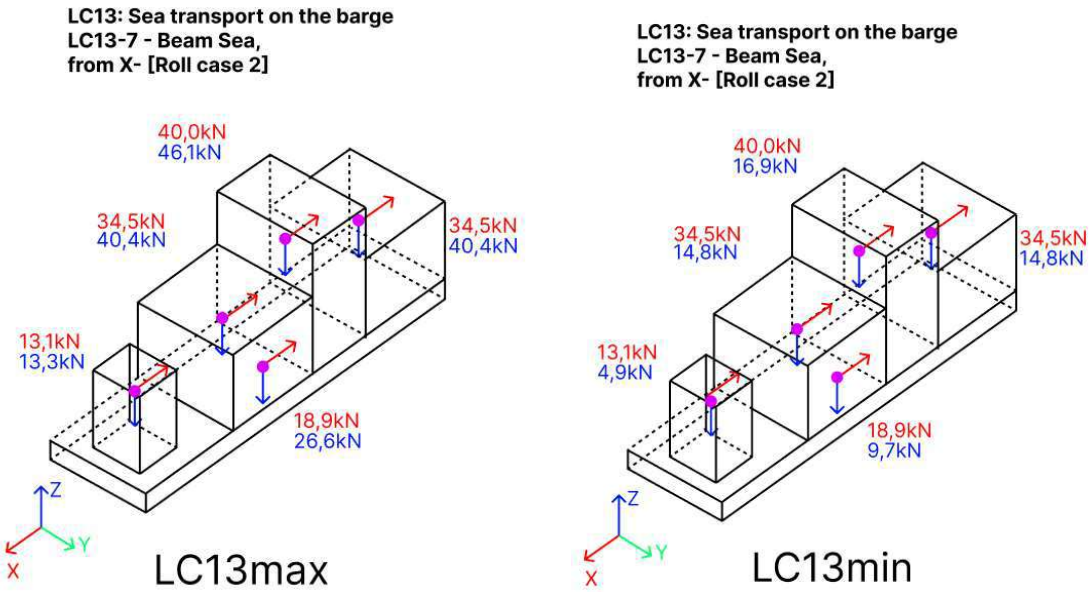


Fig 38: Load case no 13

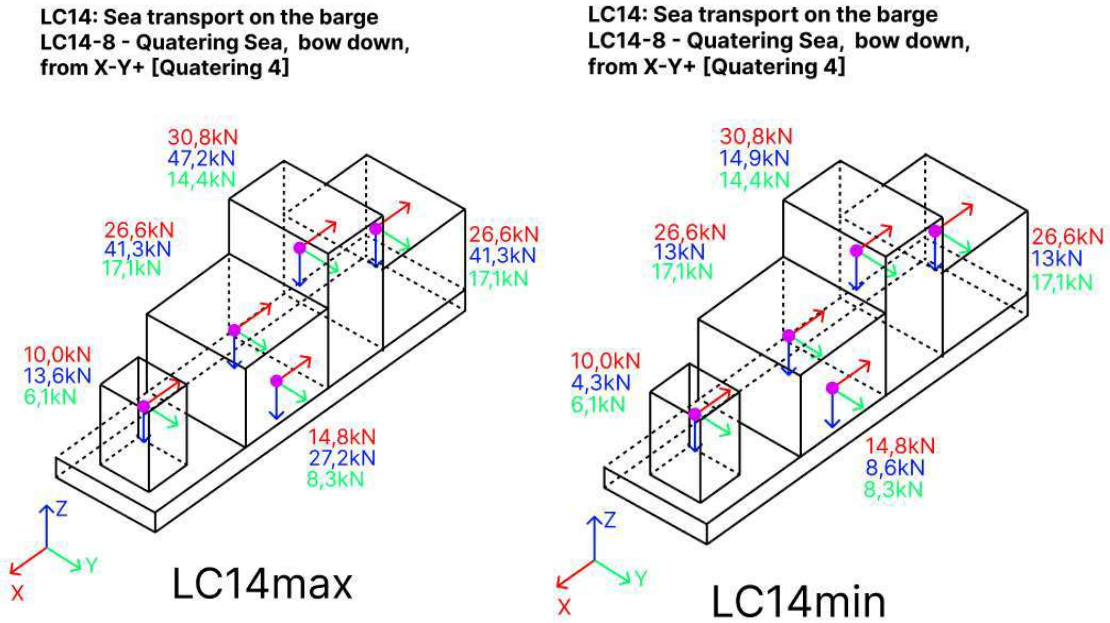
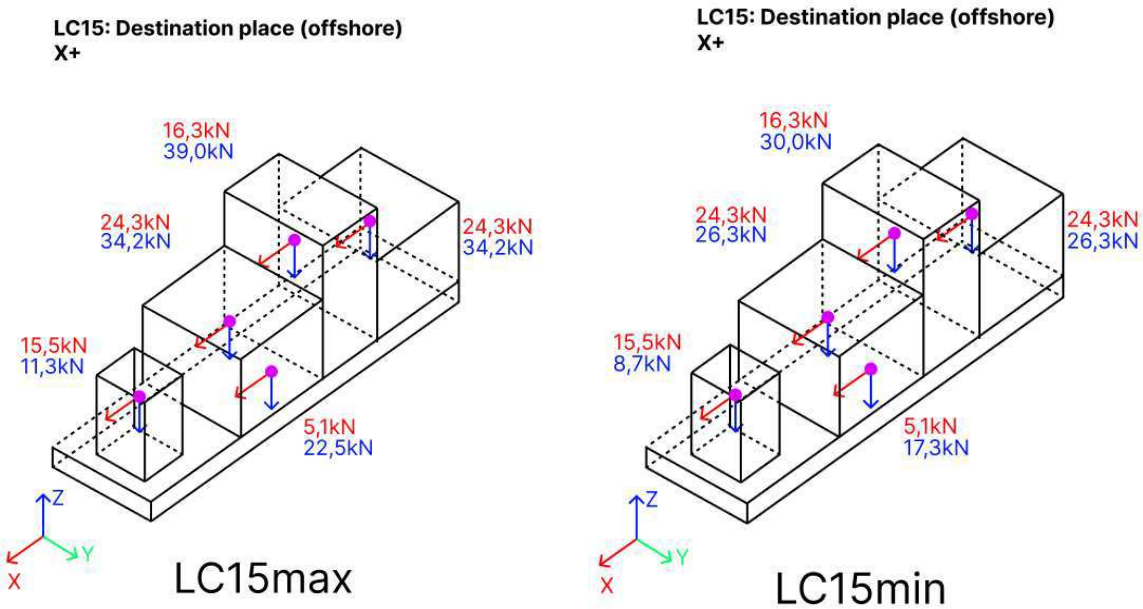


Fig 39: Load case no 14



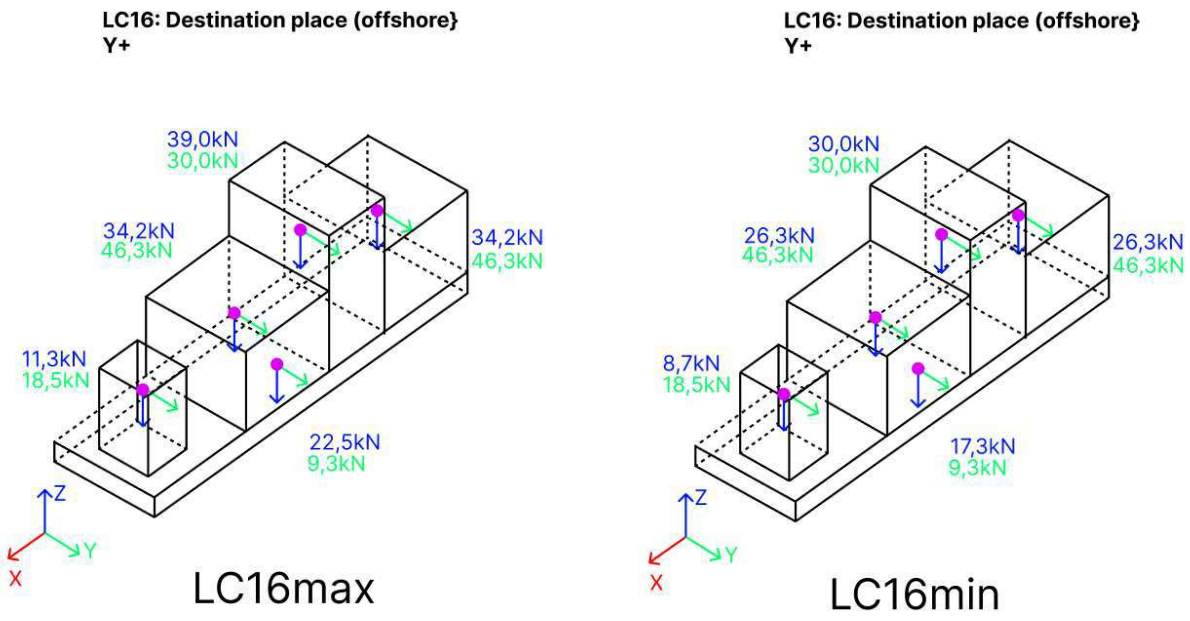


Fig 41: Load case no 16

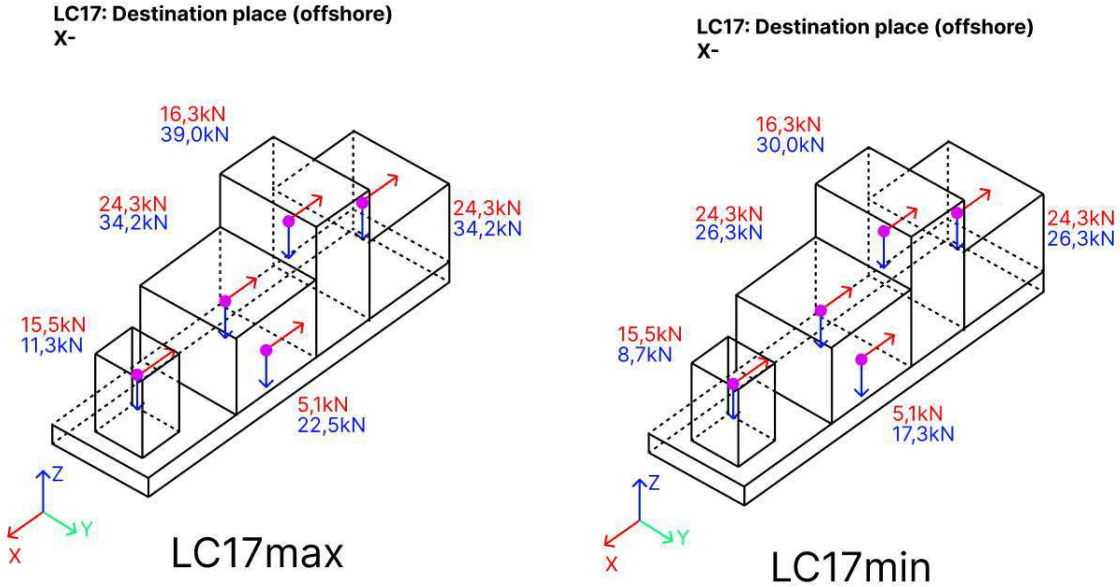


Fig 42: Load case no 17

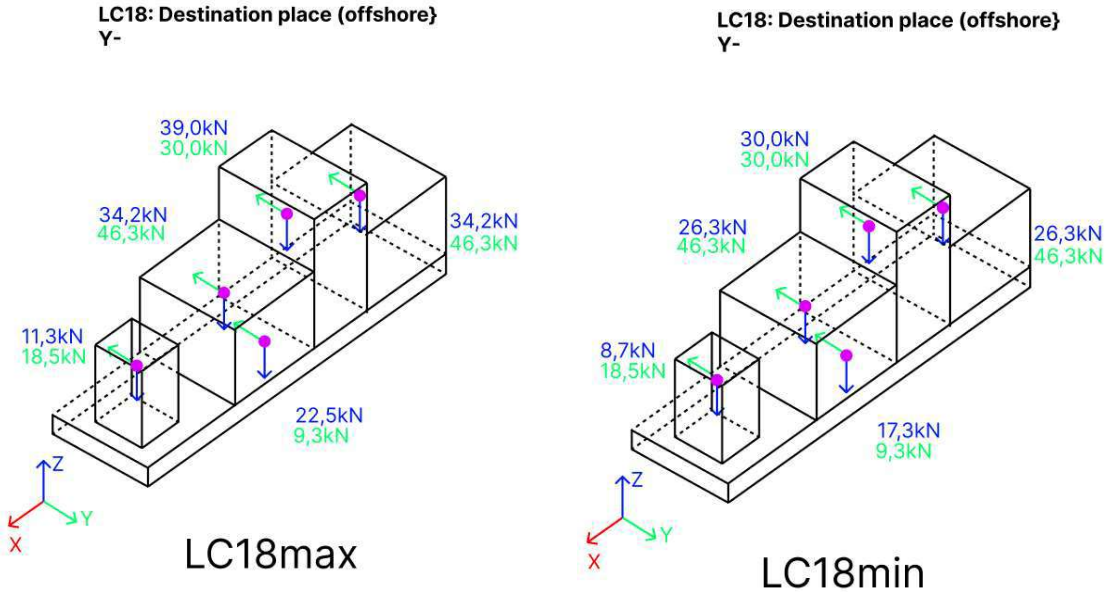


Fig 43: Load case no 18

8.4. Contact conditions

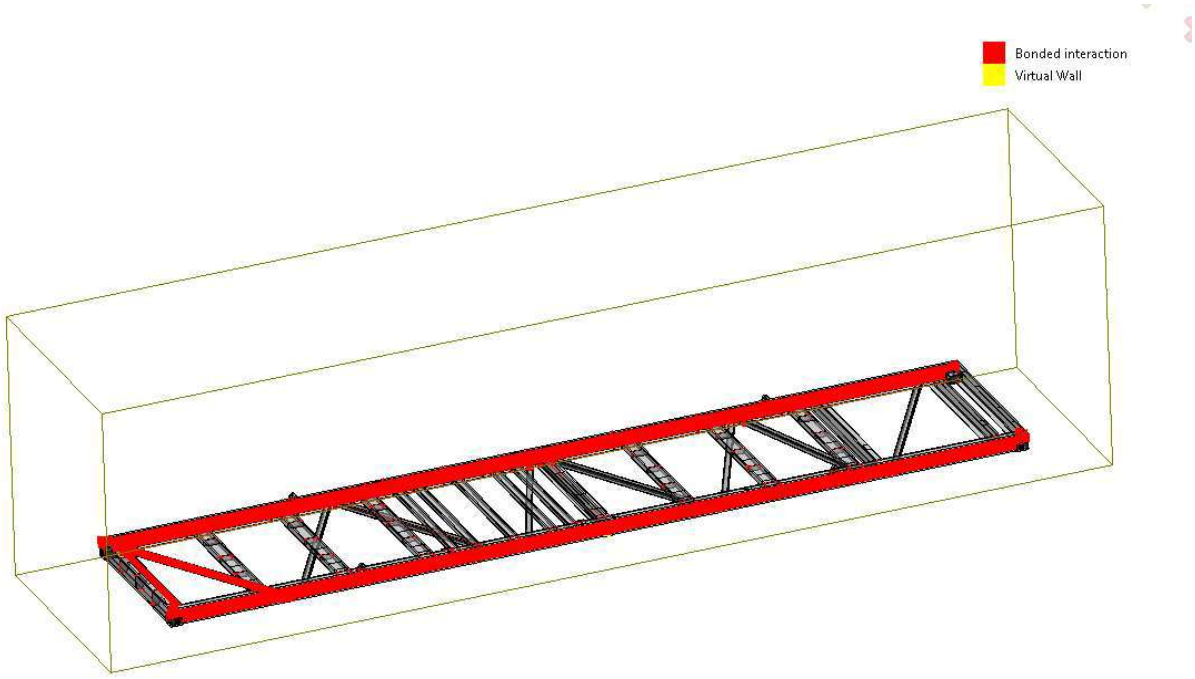


Fig 44: Global bonded contact defined and virtual wall support in the middle

8.5. Boundary conditions

8.5.1. Transport and in-place cases - LC1, LC2, LC3, LC4, LC7-LC18

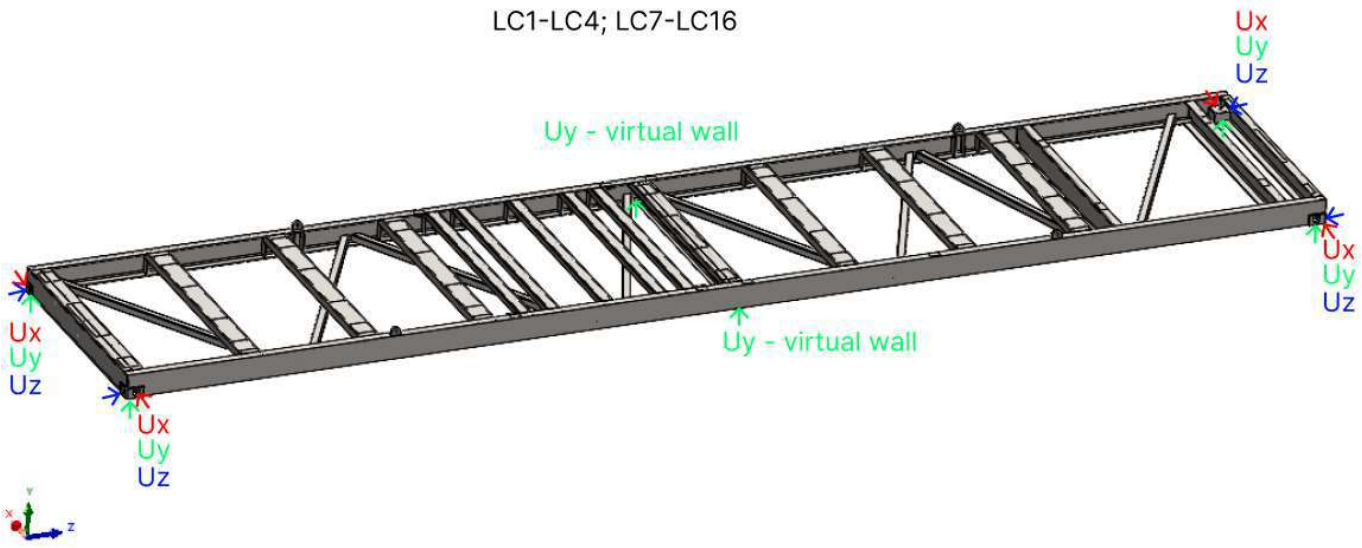


Fig 45: Boundary conditions - transport cases

It has been assumed, that during transport the flatbed is suporrted vertically at the ends (ISO corners) and in the middle (supporting plate) [UY].

Additionally flatbed during transport is supported for horizontal direction (along the truck and perpendicular to the truck) at both ends at 4 ISO corners by locks [UX, UZ]. Modeled as simple supported beam in both direction, so UZ is blocked on the left only and UX in the front

8.5.2. Lifting case - LC5 and LC6

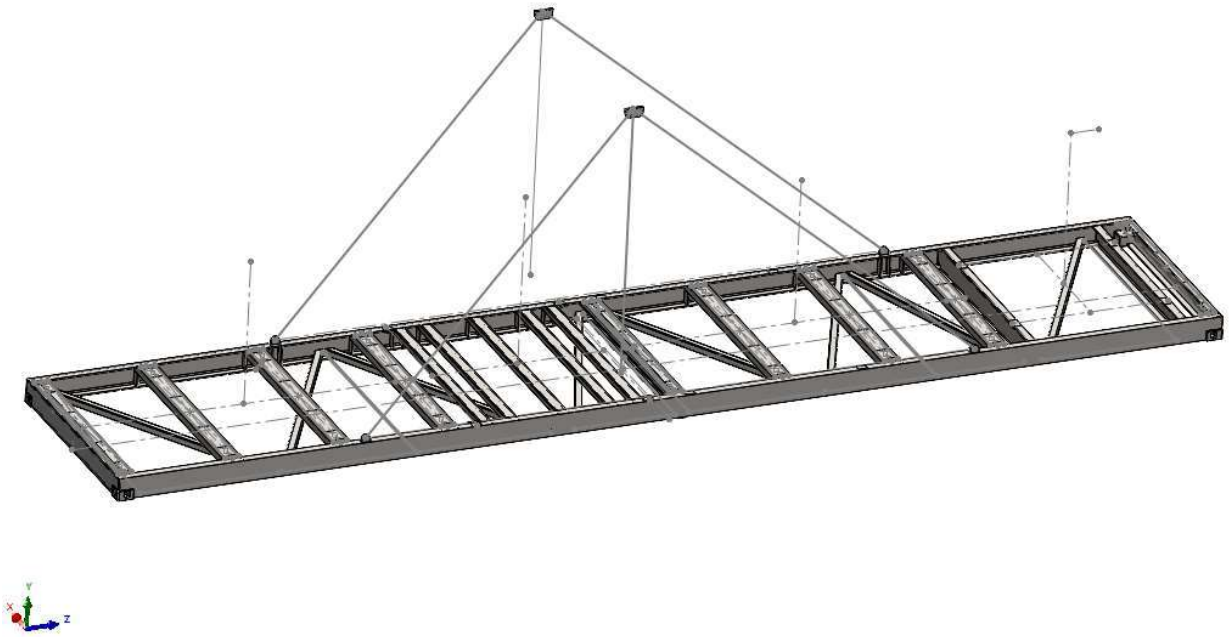


Fig 46: Boundary conditions - lifting cases

Lifting case - COG of the whole platform with equipment below lifting yoke.
Platform can be also lifted by vertical lifting ropes in places where are designed padeyes.

9. Results - Ultimate Limit State

9.1. LC1 - transport

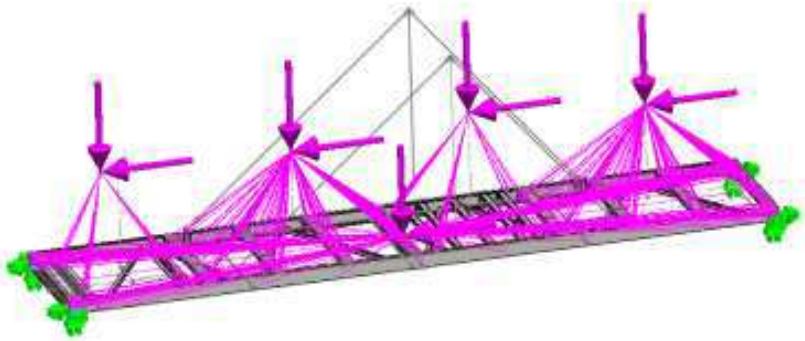


Fig 47: LC1 - ULS - Loads definition

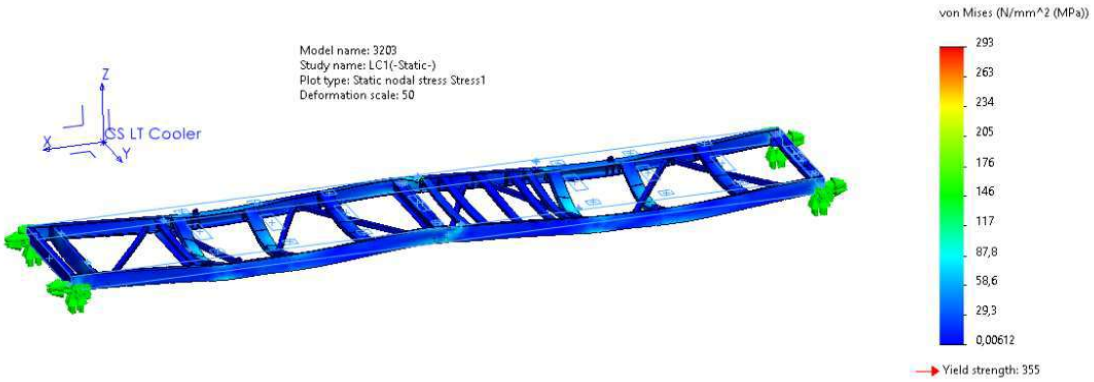


Fig 48: LC1 - ULS - Stress plot (Von Mises stress)

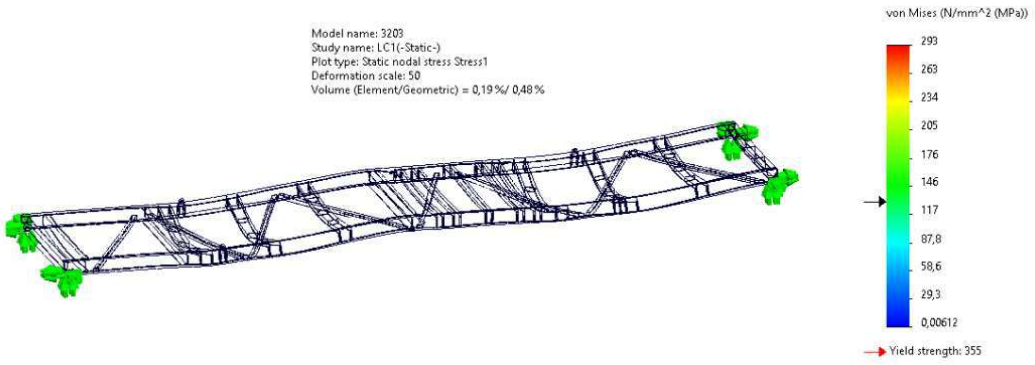


Fig 49: LC1 - ULS - Stress above 0,5% of geometry

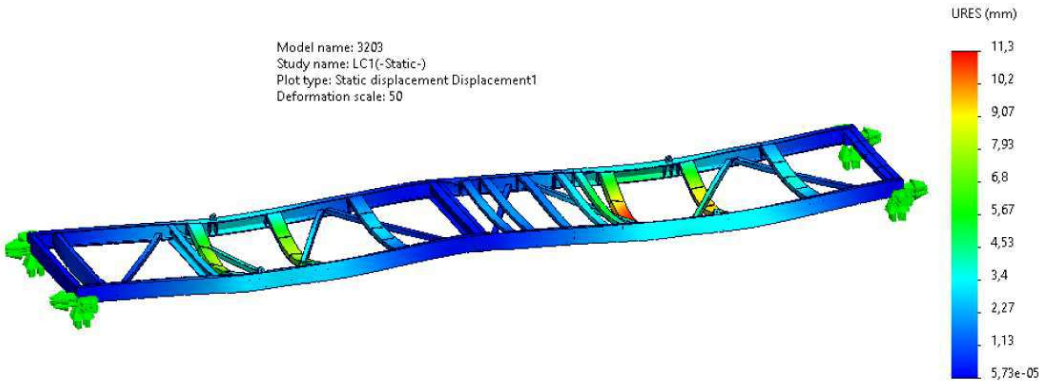


Fig 50: LC1 - ULS - Maximum deflection

9.2. LC2 - transport

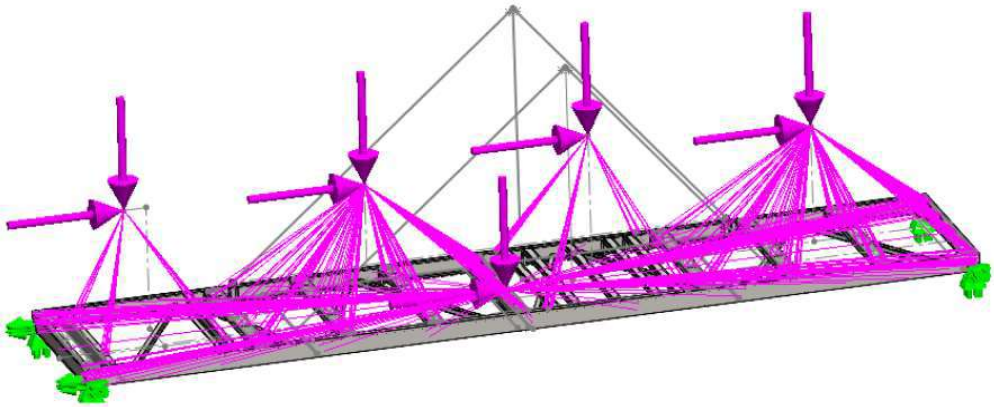


Fig 51: LC2 - ULS - Loads definition



Fig 52: LC2 - ULS - Stress plot (Von Mises stress)

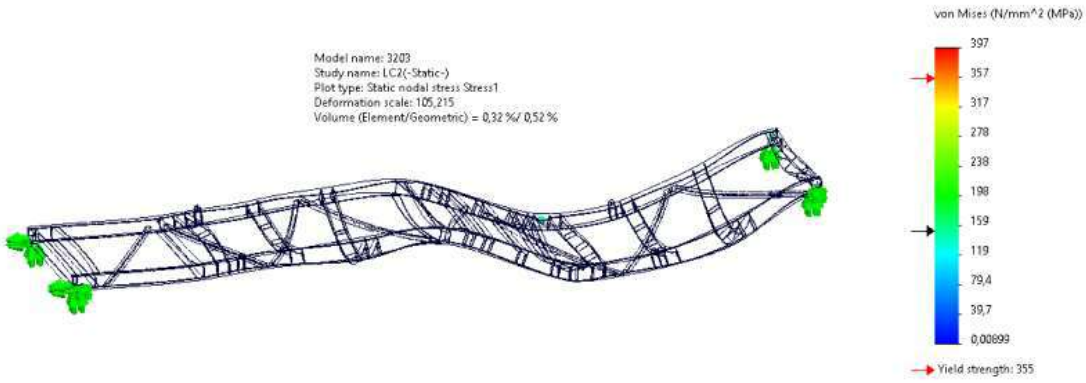
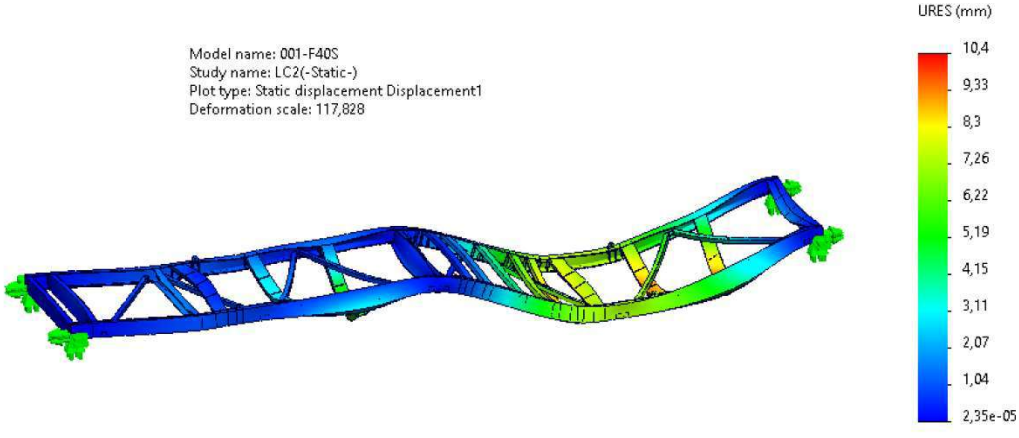


Fig 53: LC2 - ULS - Stress above 0,5% of geometry



9.3. LC3 - transport

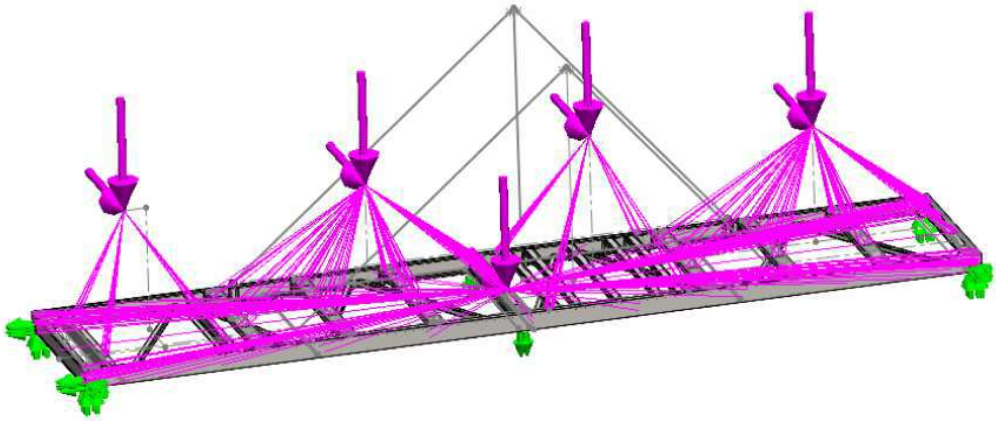


Fig 55: LC3 - ULS - Loads definition

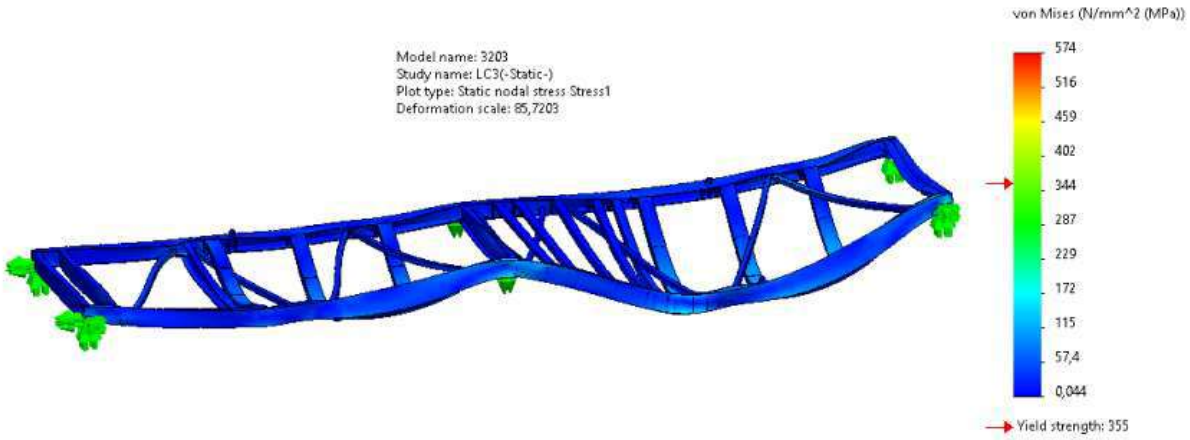


Fig 56: LC3 - ULS - Stress plot (Von Mises stress)

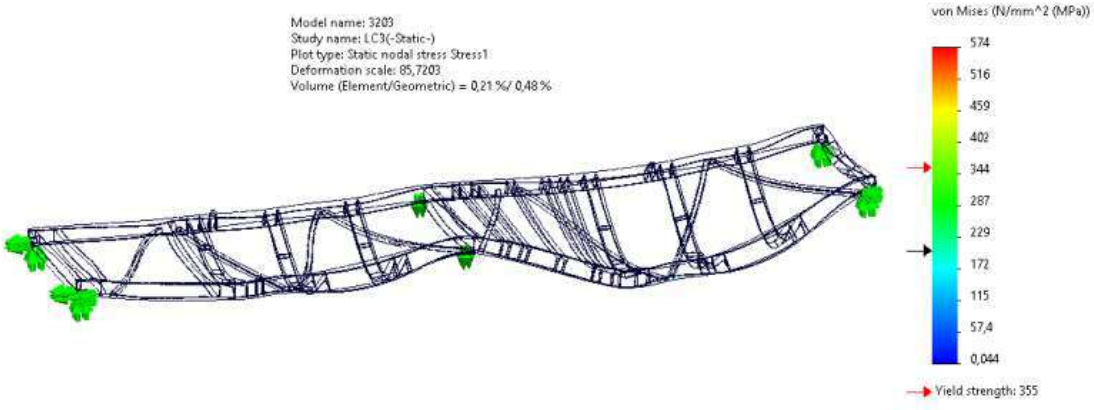


Fig 57: LC3 - ULS - Stress above 0,5% of geometry

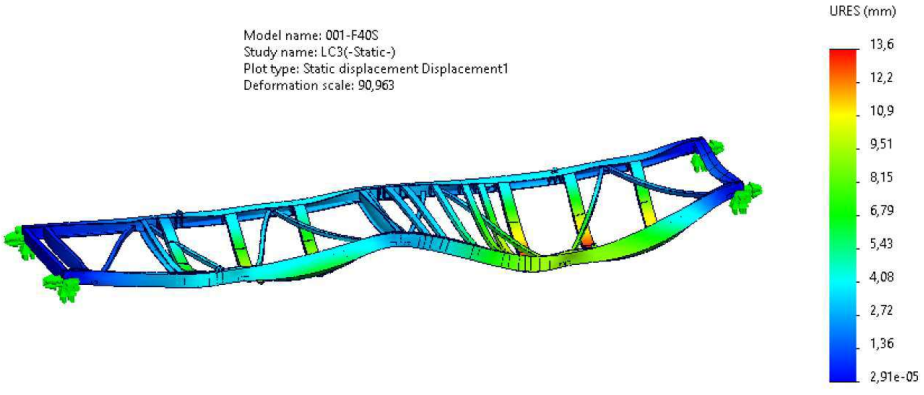


Fig 58: LC3 - ULS - Maximum deflection

9.4. LC4 - transport

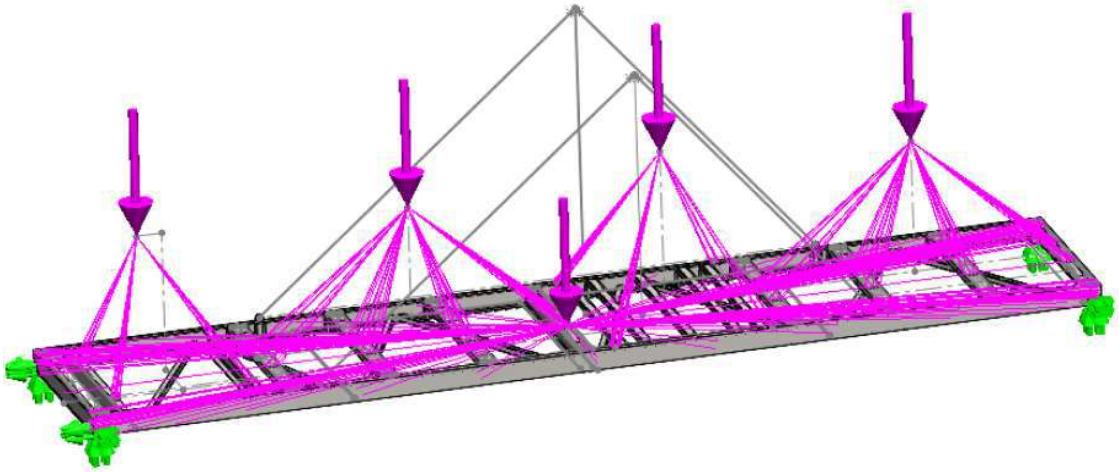


Fig 59: LC4 - ULS - Loads definition

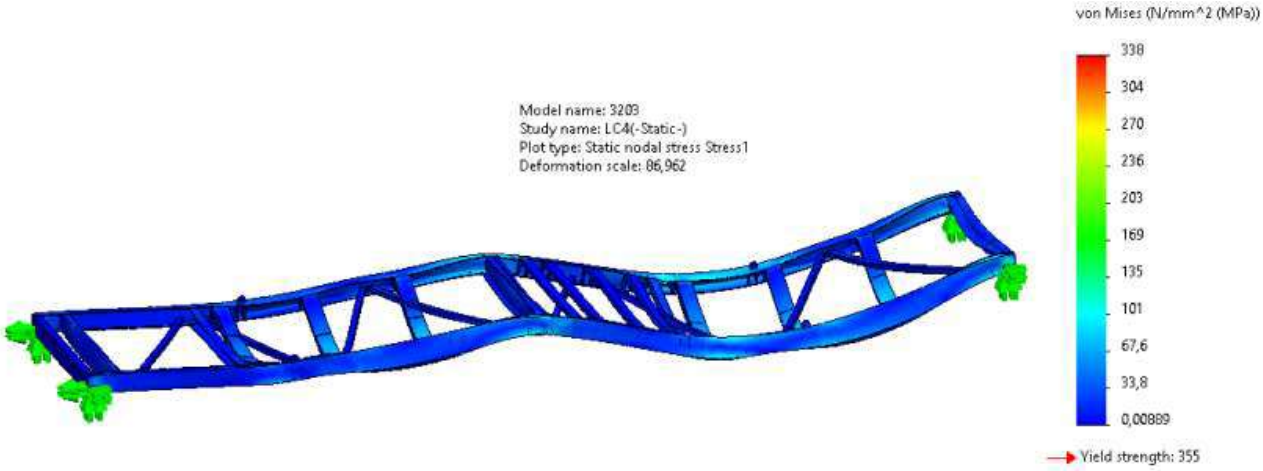


Fig 60: LC4 - ULS - Stress plot (Von Mises stress)

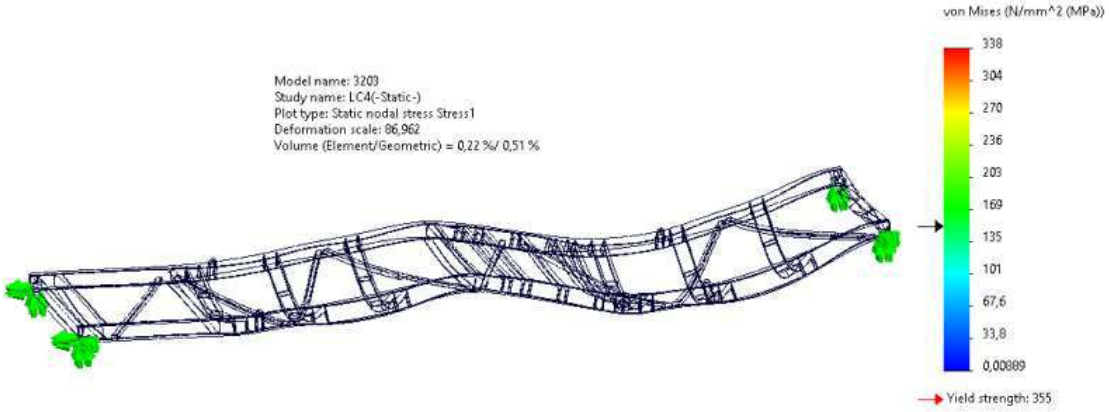
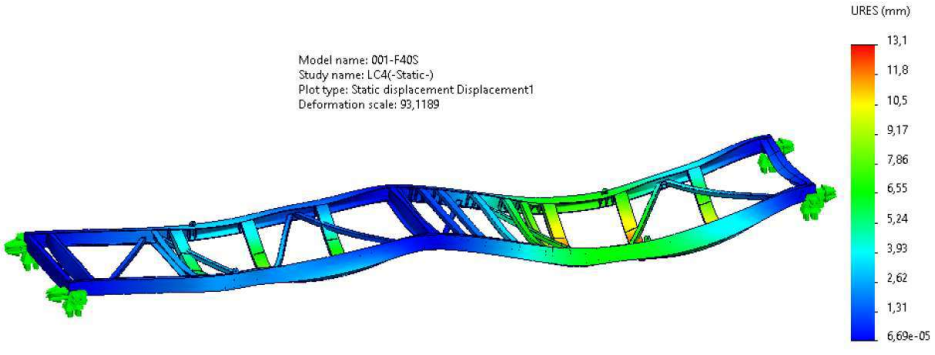


Fig 61: LC4 - ULS - Stress above 0,5% of geometry



9.5. LC5 - Lifting offshore

In accordance to DNVGL-ST-N001 (LRFD Table 5.8) for steel S355:
- maximum admissible stress for members (t<16mm): (355/1,15)=309MPa
- maximum admissible stress for welds (355MPa /1,3) = 273MPa

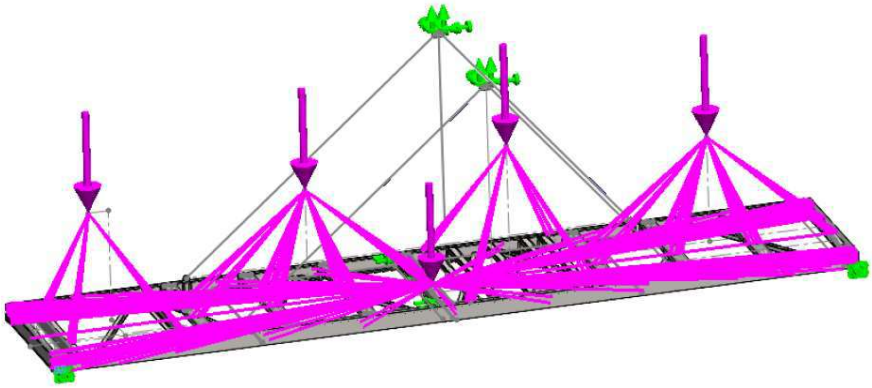


Fig 63: LC5 - ULS - Loads definition

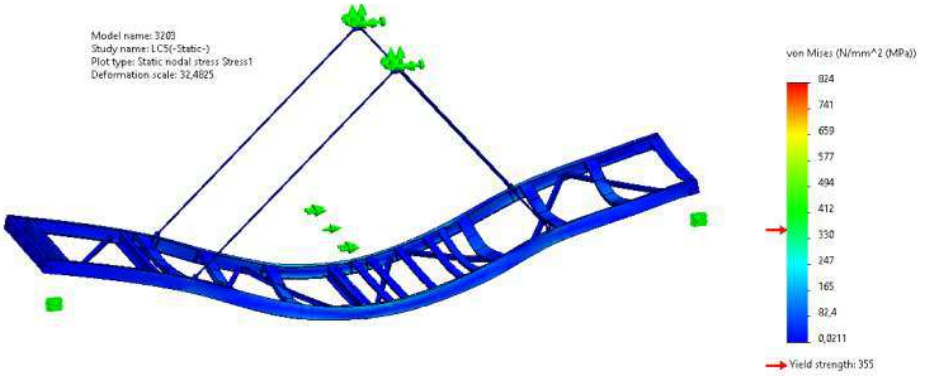


Fig 64: LC5 - ULS - Stress plot (Von Mises stress)

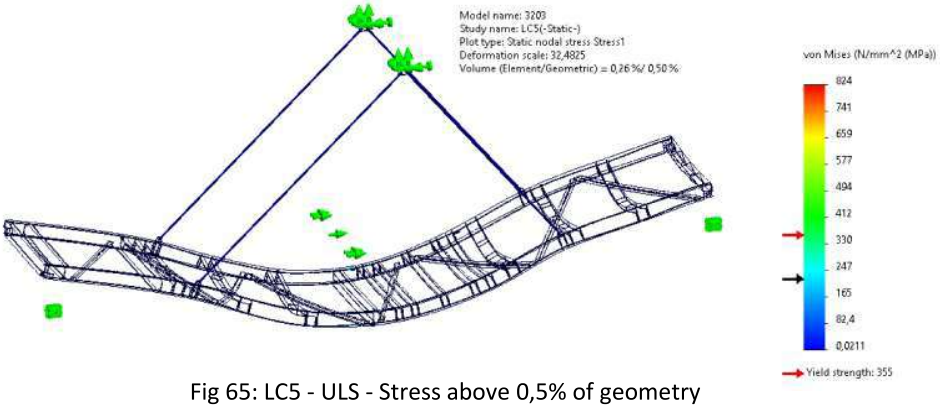


Fig 65: LC5 - ULS - Stress above 0,5% of geometry

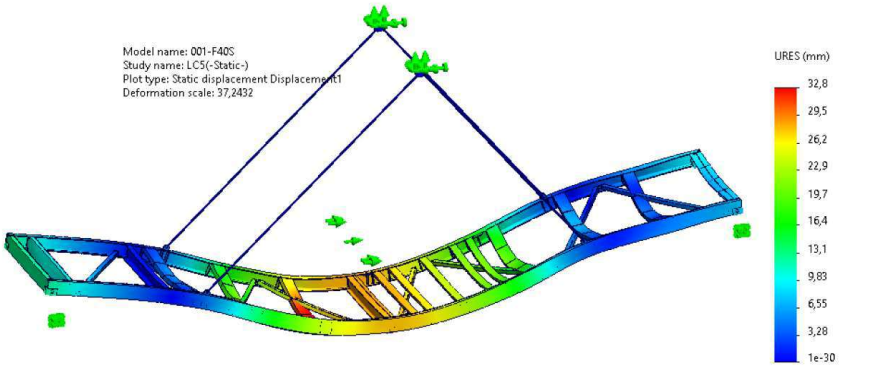


Fig 66: LC5 - ULS - Maximum deflection

Loads with Safety facotry = 2,34 (1,8x1,3xWLL) gives maximum main beam deflection of 28,8mm

Loads without safety factors (WLL+G) gives maximum main beam deflection of 14,7mm

9.6. LC6 - Lifting onshore

In accordance to EN13155 for steel S355:
- maximum admissible stress for members (t<16mm): 355MPa
- maximum admissible stress for welds ((355MPa * 1)/1,1) = 323MPa

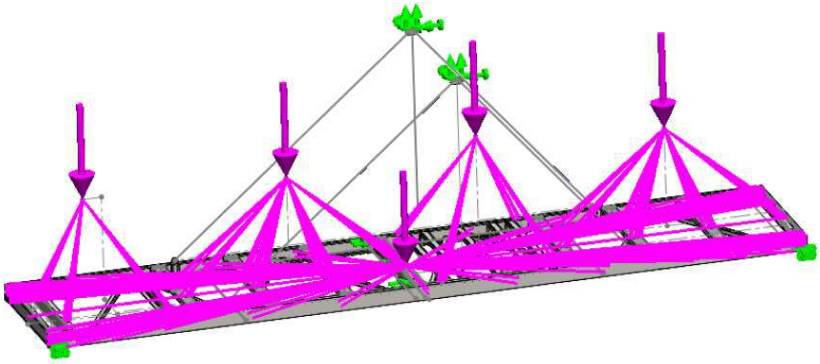


Fig 67: LC6 - ULS - Loads definition

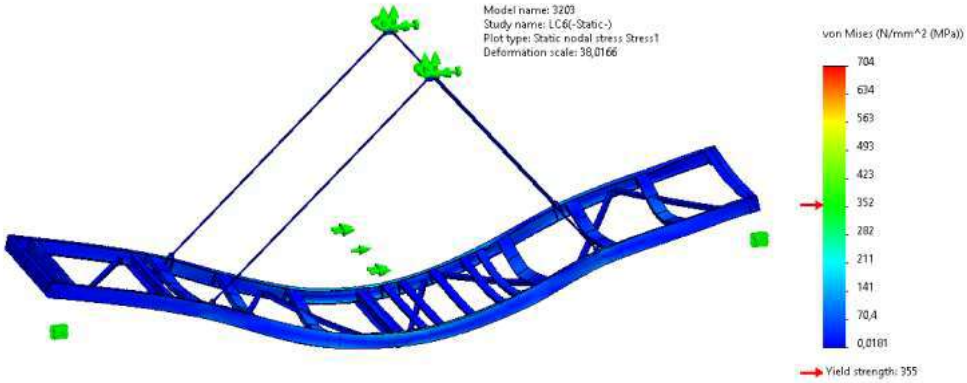


Fig 68: LC6 - ULS - Stress plot (Von Mises stress)

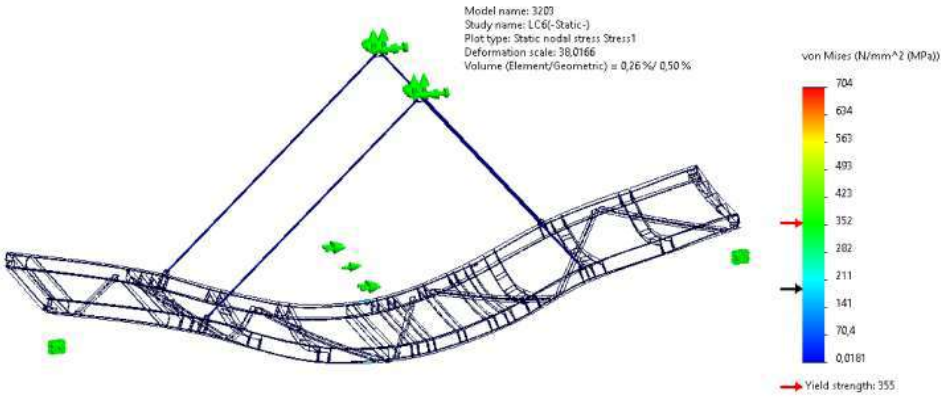


Fig 69: LC6 - ULS - Stress above 0,5% of geometry

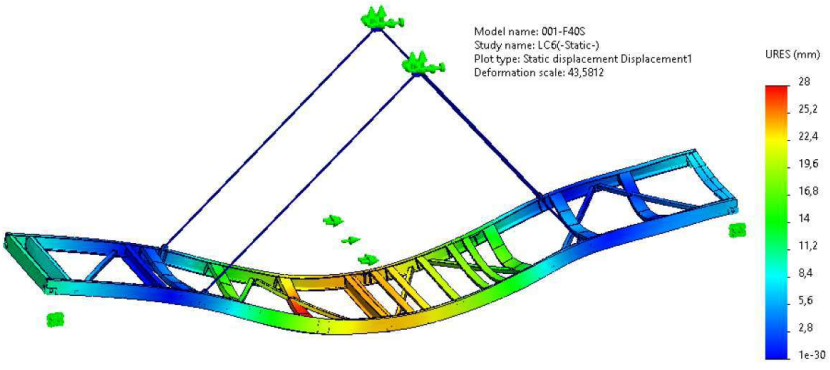


Fig 70: LC6 - ULS - Maximum deflection

Loads with Safety facotry = 2 (2xWLL+G) gives maximum main beam deflection of 26,1mm

Loads without safety factors (WLL+G), gives maximum main beam deflection of 12,4mm

9.7. LC7 - Sea transport on the barge [Pitch case 1] Y+

9.7.1. LC7 - Max - Sea transport on the barge [Pitch case 1] Y+

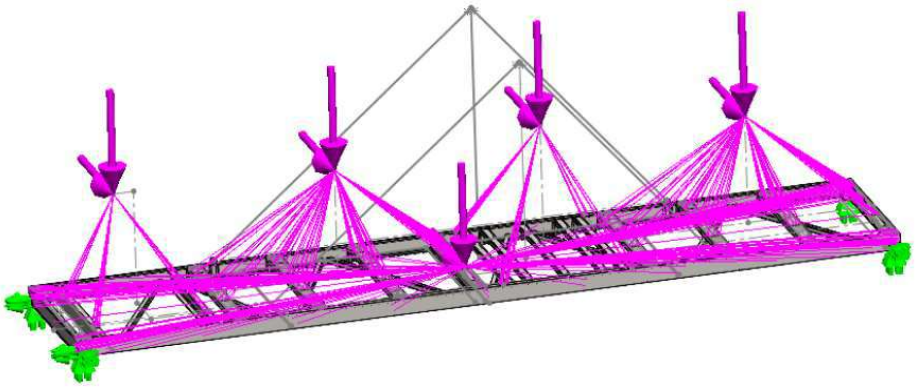


Fig 71: LC7 - ULS - MAX - Loads definition

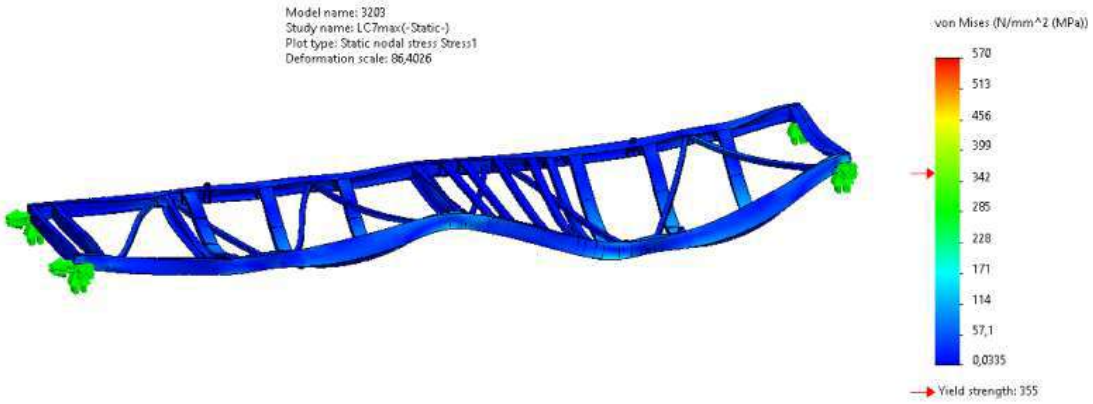


Fig 72: LC7 - ULS - MAX - Stress plot (Von Mises stress)

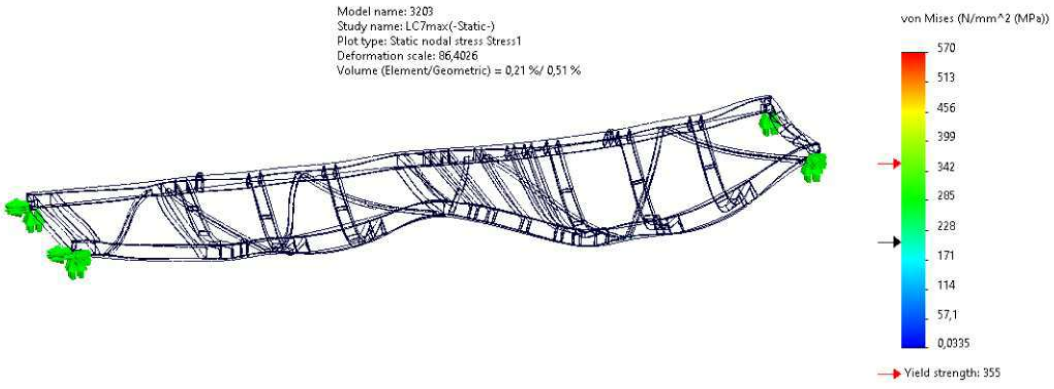


Fig 73: LC7 - ULS - MAX - Stress above 0,5% of geometry

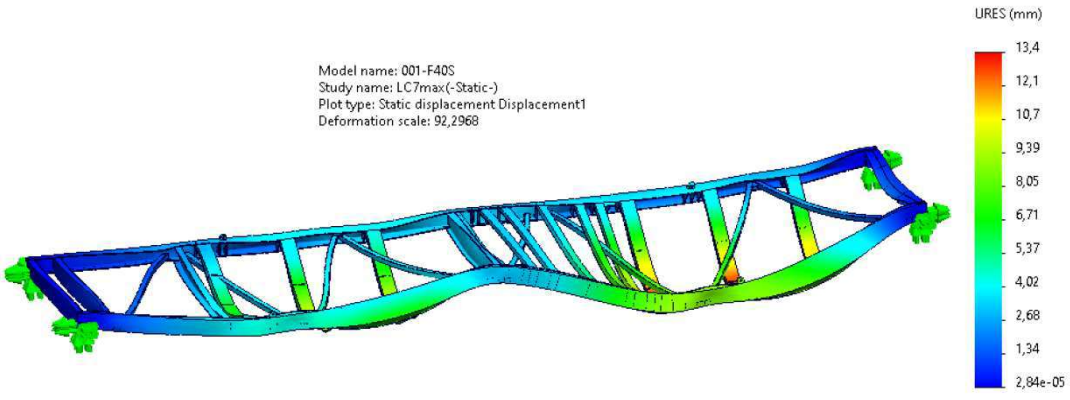


Fig 74: LC7 - ULS - MAX - Maximum deflection

9.7.2. LC7 - Min - Sea transport on the barge [Pitch case 1] Y+

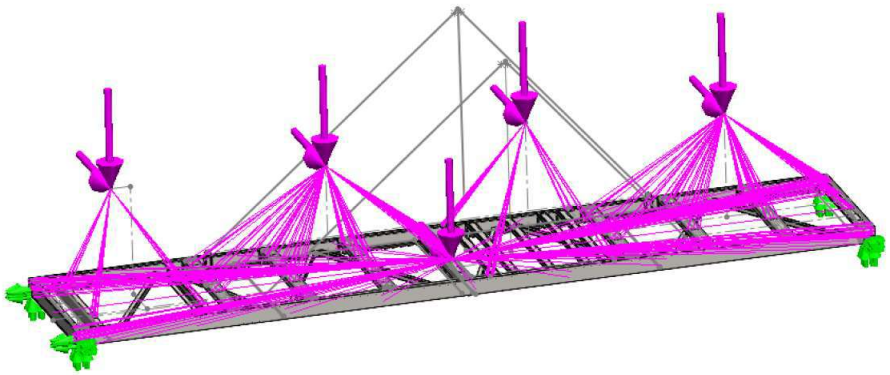


Fig 75: LC7 - ULS - MIN - Loads definition

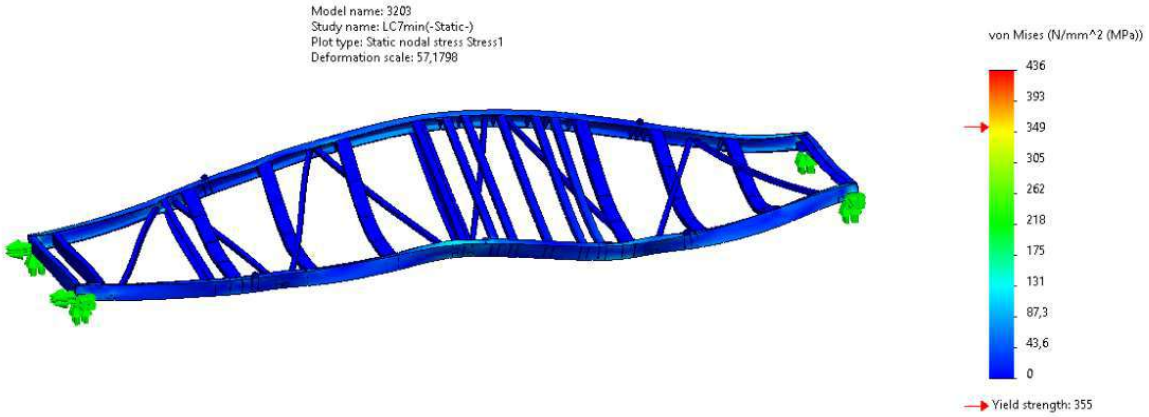


Fig 76: LC7 - ULS - MIN - Stress plot (Von Mises stress)

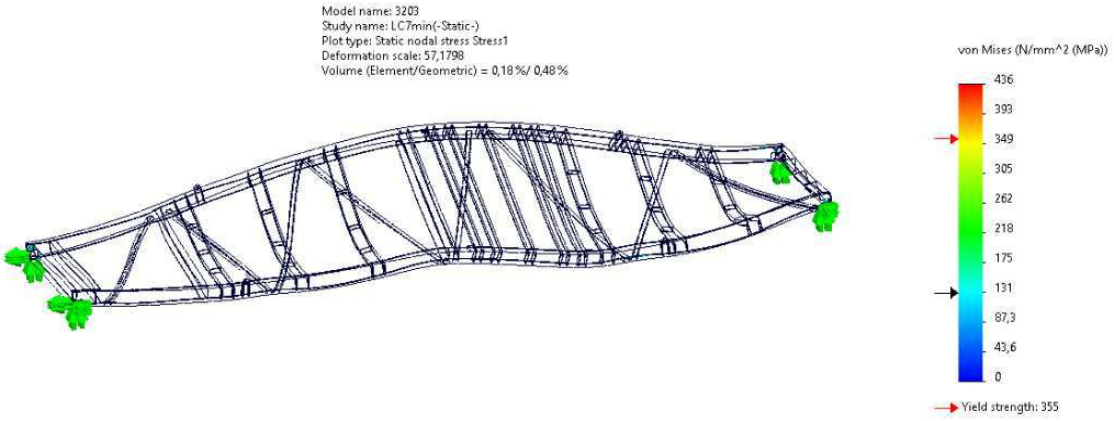


Fig 77: LC7 - ULS - MIN - Stress above 0,5% of geometry

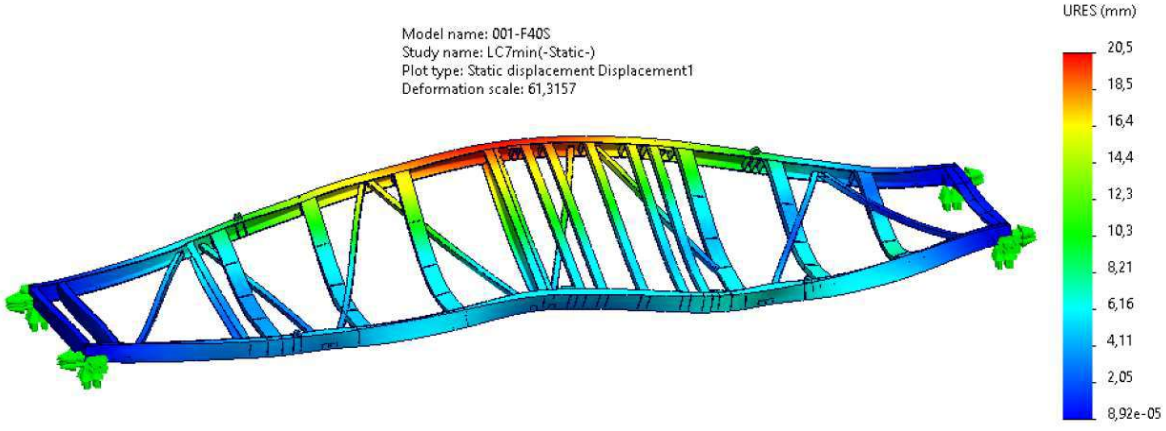


Fig 78: LC7 - ULS - MIN - Maximum deflection

9.8. LC8 - Sea transport on the barge [Quatering 1] X+Y+

9.8.1. LC8 - Max - Sea transport on the barge [Quatering 1] X+Y+

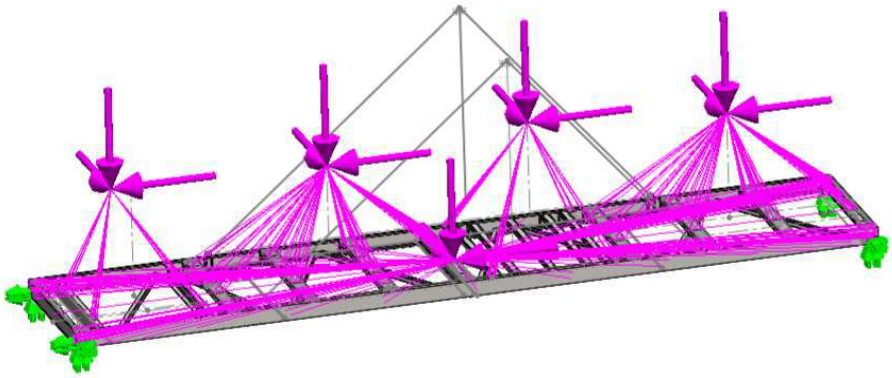


Fig 79: LC8 - ULS - MAX - Loads definition

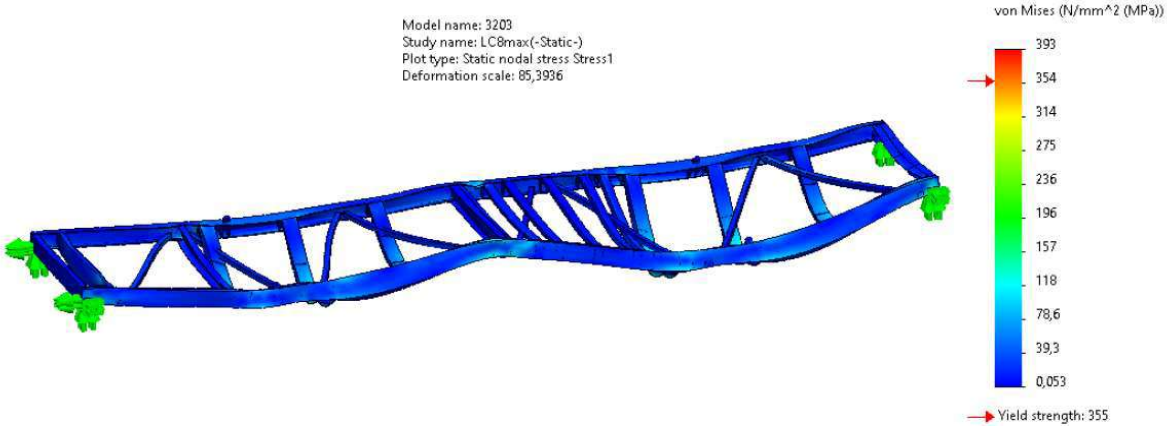


Fig 80: LC8 - ULS - MAX - Stress plot (Von Mises stress)

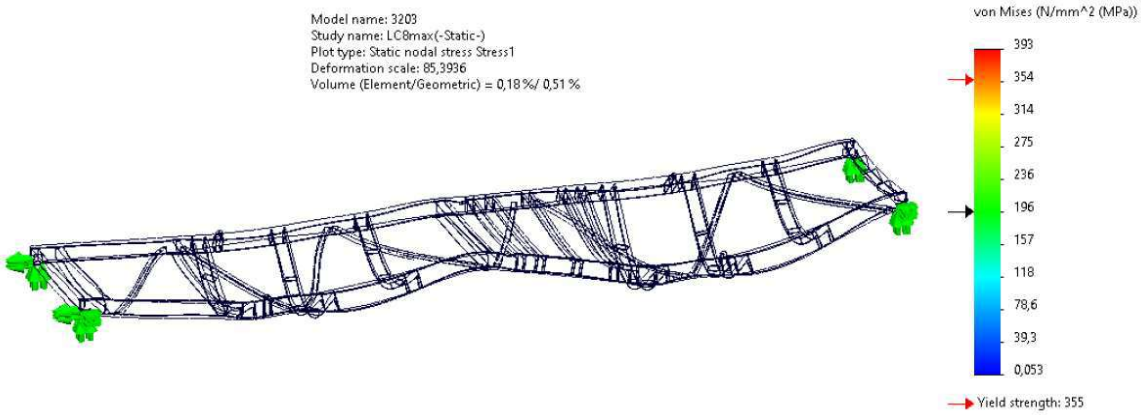


Fig 81: LC8 - ULS - MAX - Stress above 0,5% of geometry

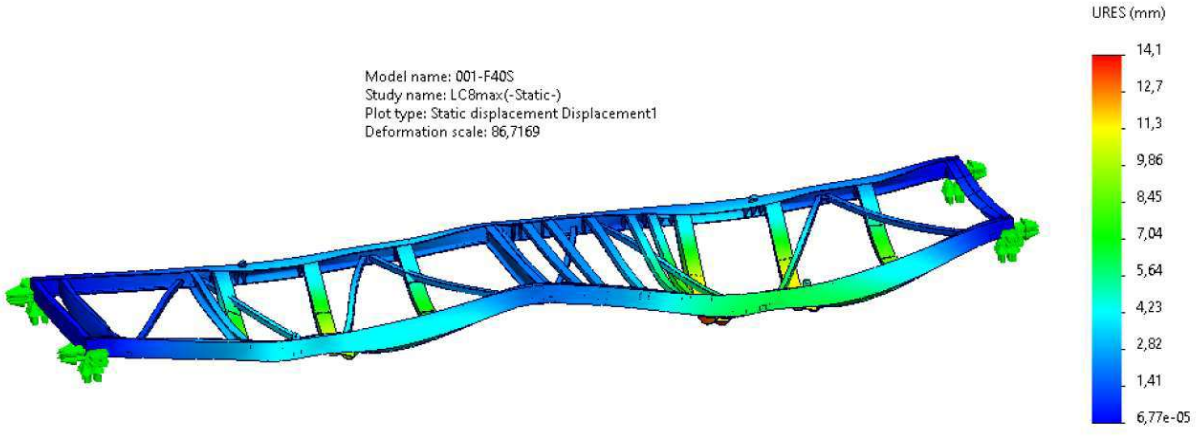


Fig 82: LC8 - ULS - MAX - Maximum deflection

9.8.2. LC8 - Min - Sea transport on the barge [Quatering 1] X+Y+

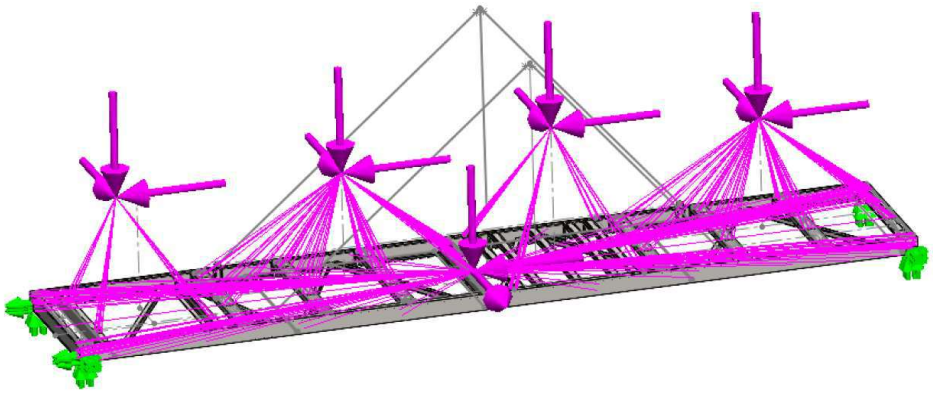


Fig 83: LC8 - ULS - MIN - Loads definition

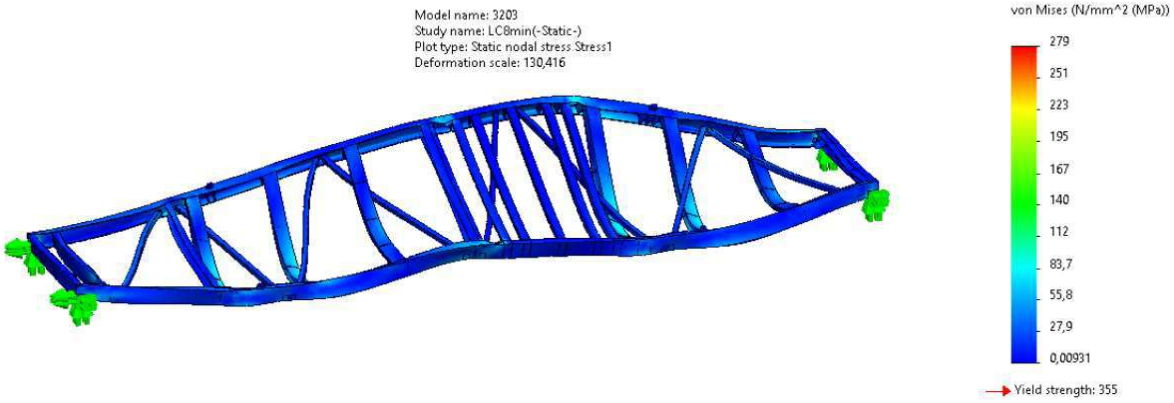


Fig 84: LC8 - ULS - MIN - Stress plot (Von Mises stress)

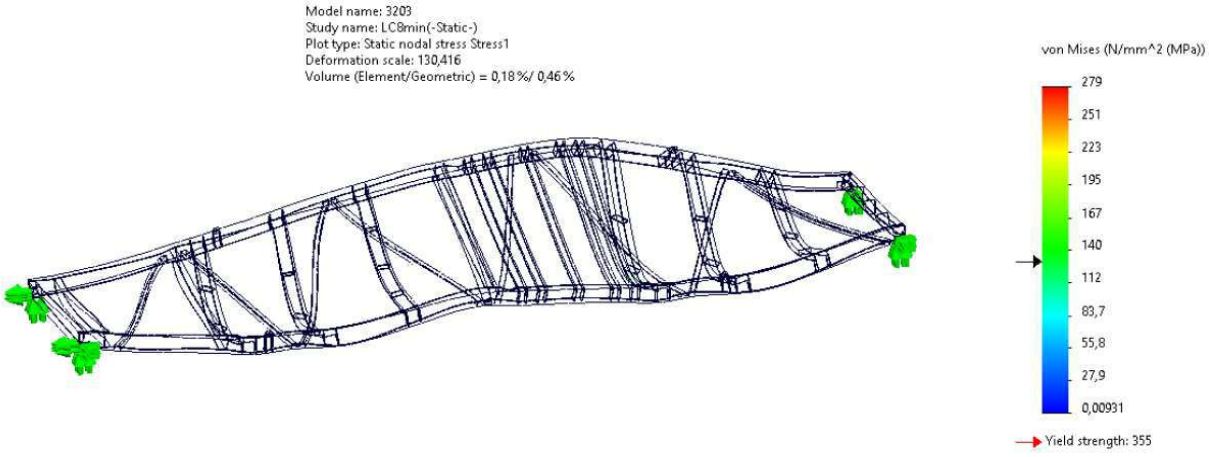


Fig 85: LC8 - ULS - MIN - Stress above 0,5% of geometry

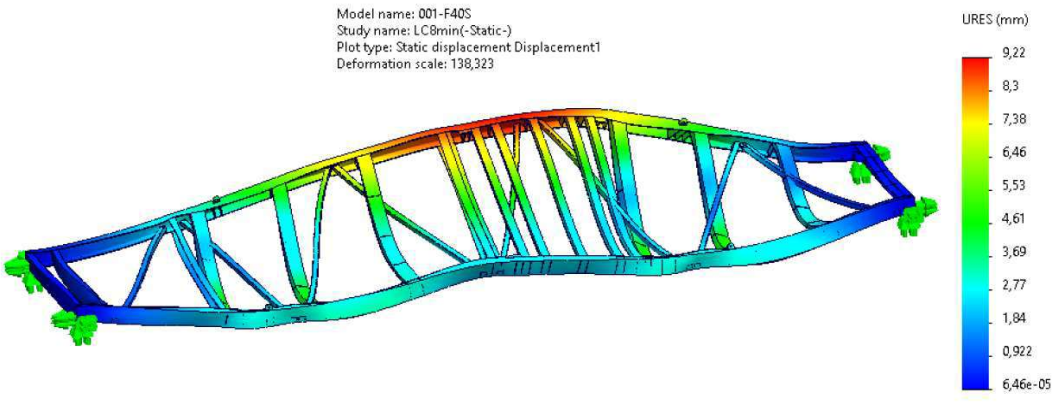


Fig 86: LC8 - ULS - MIN - Maximum deflection

9.9. LC9 - Sea transport on the barge [Roll case 1] X+

9.9.1. LC9 - Max - Sea transport on the barge [Roll case1] X+

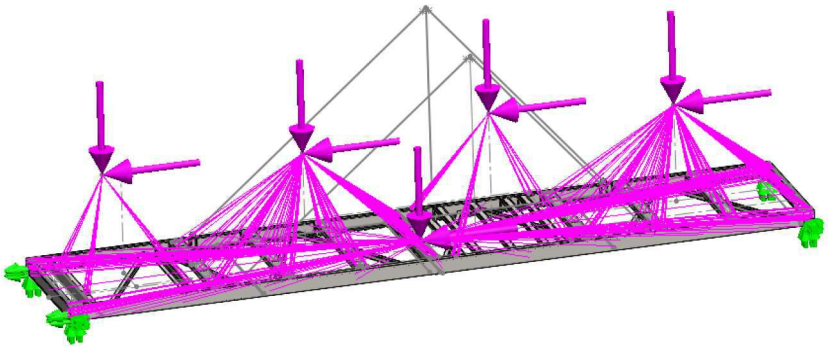


Fig 87: LC9 - ULS - MAX - Loads definition

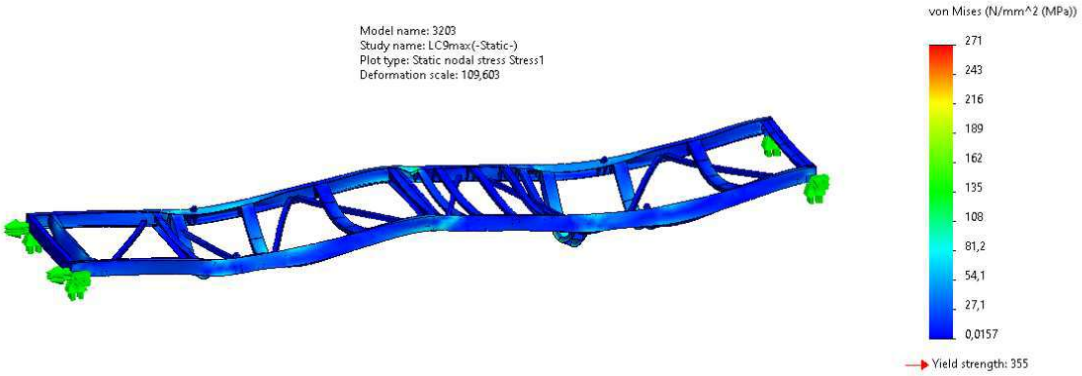


Fig 88: LC9 - ULS - MAX - Stress plot (Von Mises stress)

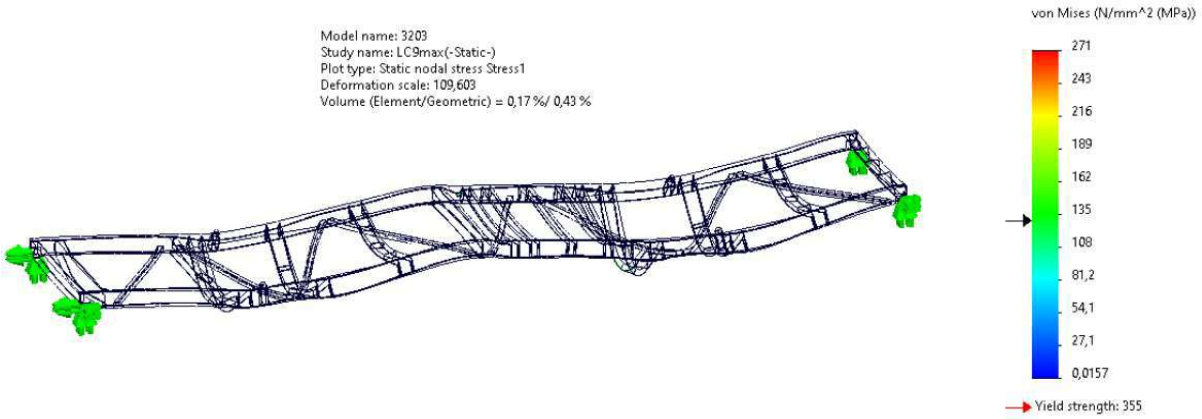


Fig 89: LC9 - ULS - MAX - Stress above 0,5% of geometry

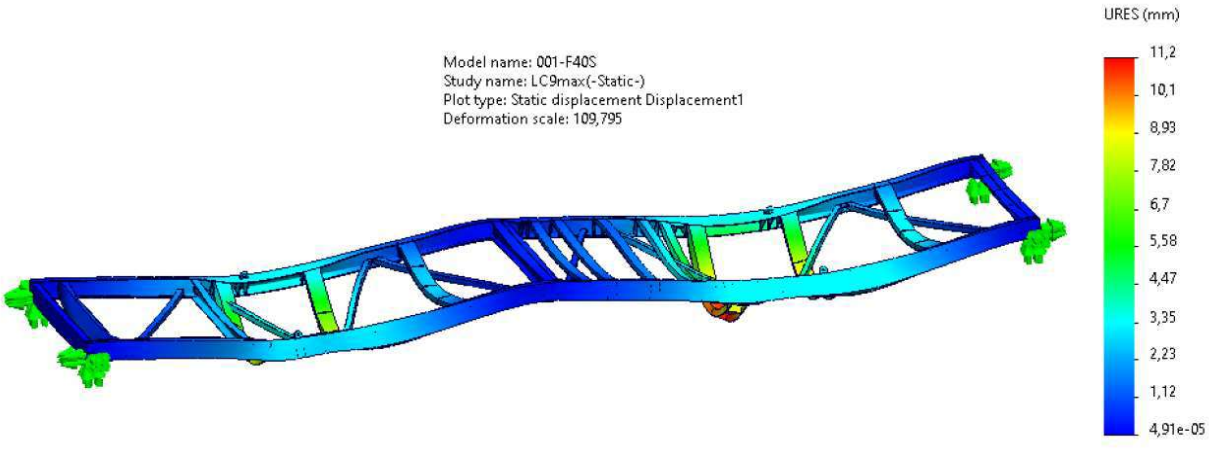


Fig 90: LC9 - ULS - MAX - Maximum deflection

9.9.2. LC9 - Min - Sea transport on the barge [Roll case 1] X+

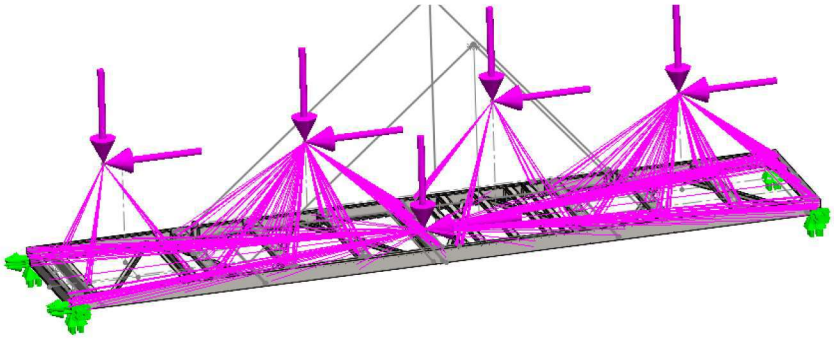


Fig 91: LC9 - ULS - MIN - Loads definition

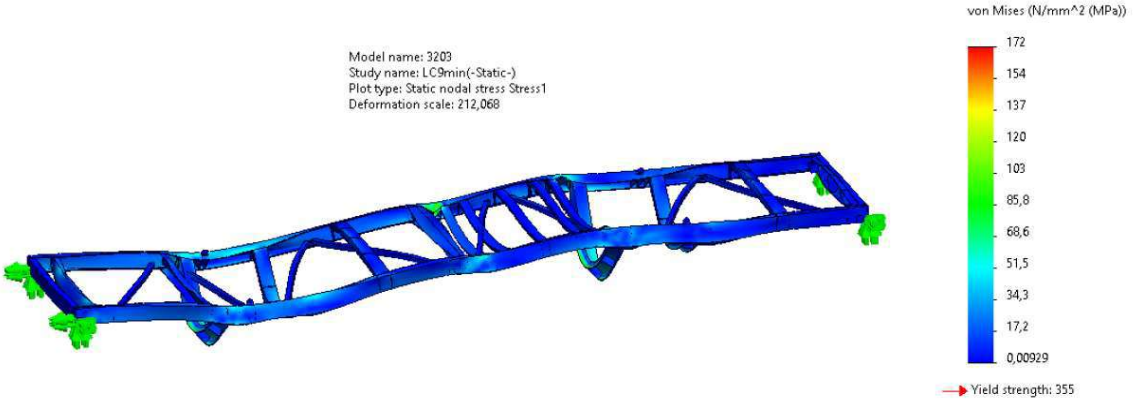


Fig 92: LC9 - ULS - MIN - Stress plot (Von Mises stress)

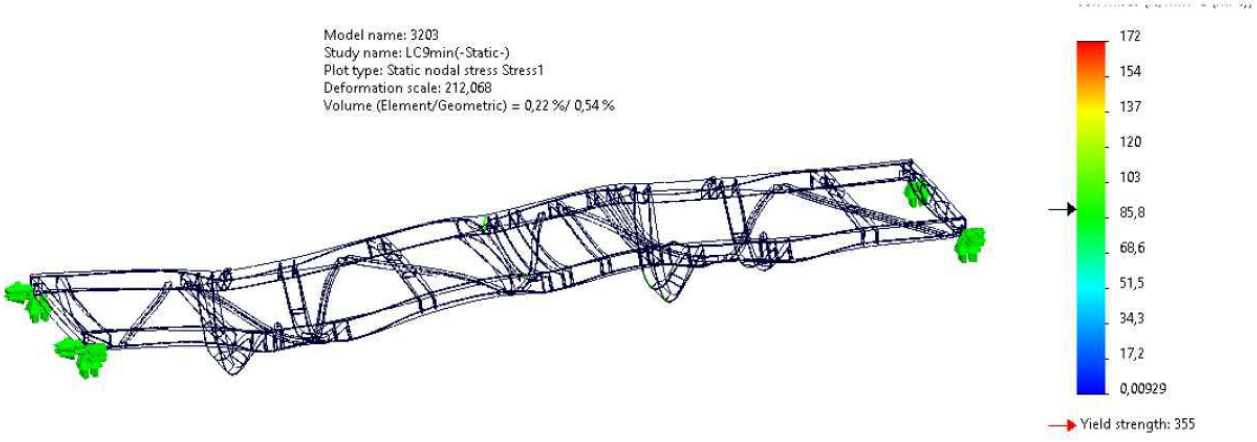
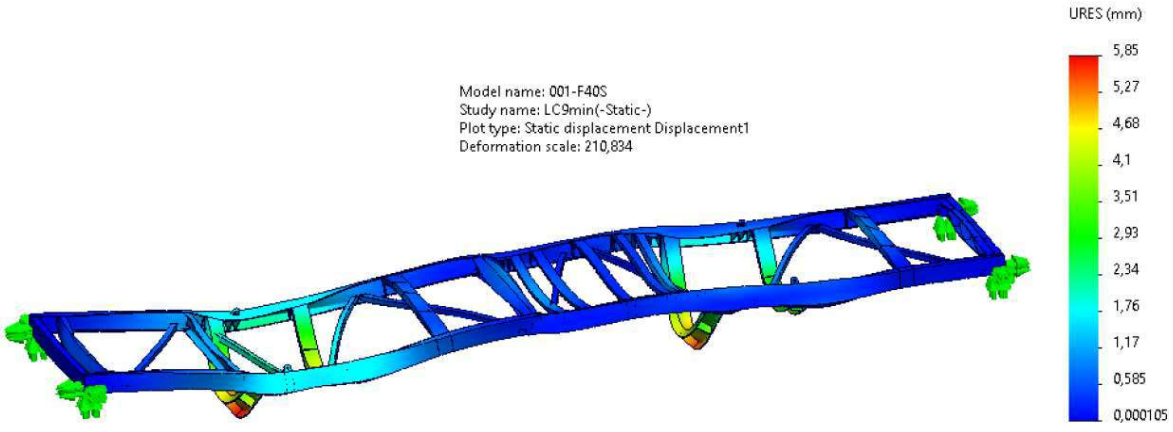


Fig 93: LC9 - ULS - MIN - Stress above 0,5% of geometry



9.10. LC10 - Sea transport on the barge [Quatering 2] X+Y-

9.10.1. LC10 - Max - Sea transport on the barge [Quatering 2] X+Y-

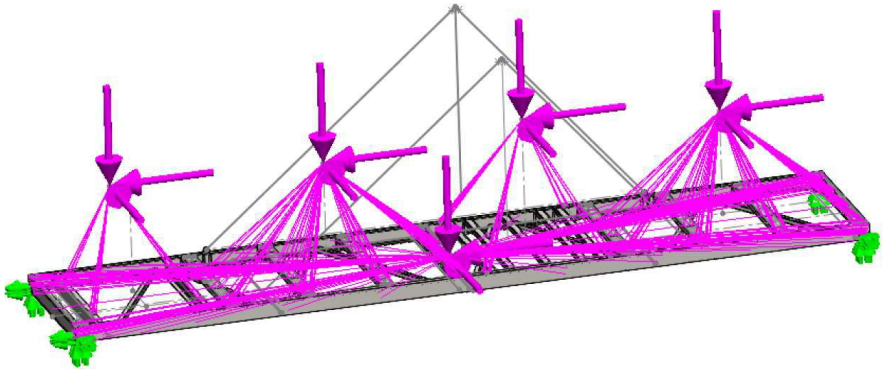


Fig 95: LC10 - ULS - MAX - Loads definition

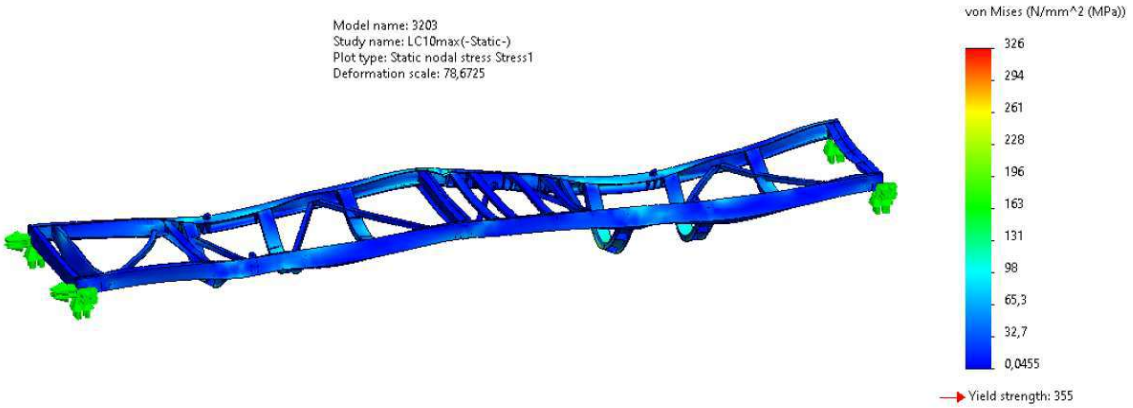


Fig 96: LC10 - ULS - MAX - Stress plot (Von Mises stress)

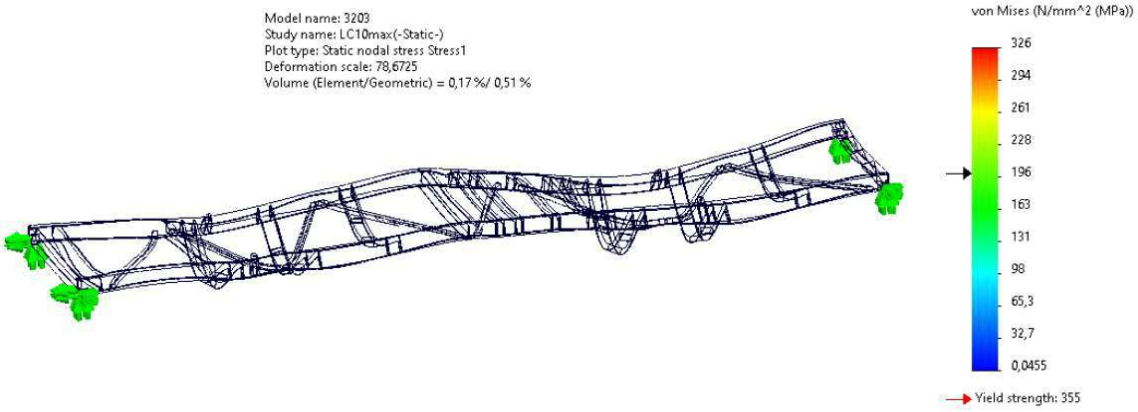


Fig 97: LC10 - ULS - MAX - Stress above 0,5% of geometry

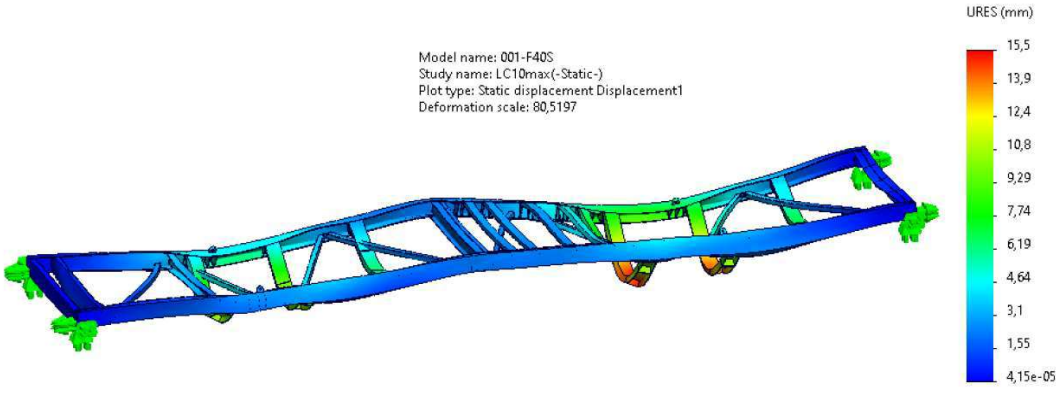


Fig 98: LC10 - ULS - MAX - Maximum deflection

9.10.2. LC10 - Min - Sea transport on the barge [Quatering 2] X+Y-

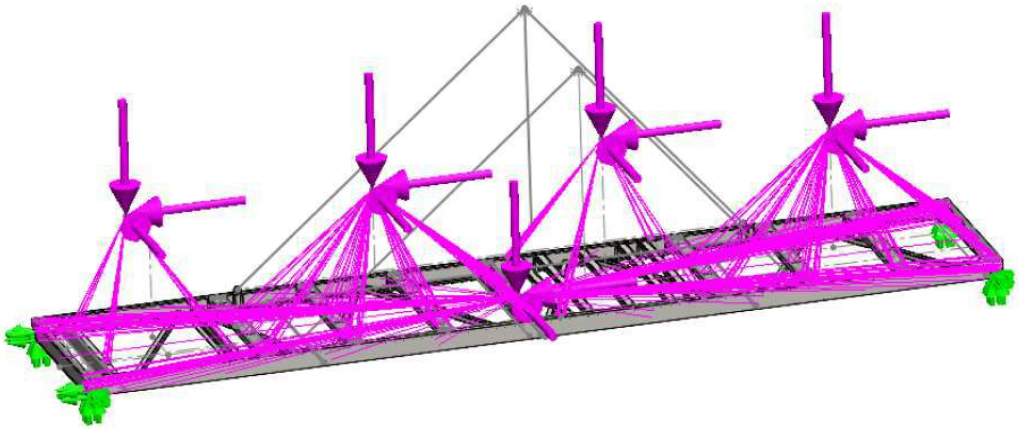


Fig 99: LC10 - ULS - MIN - Loads definition

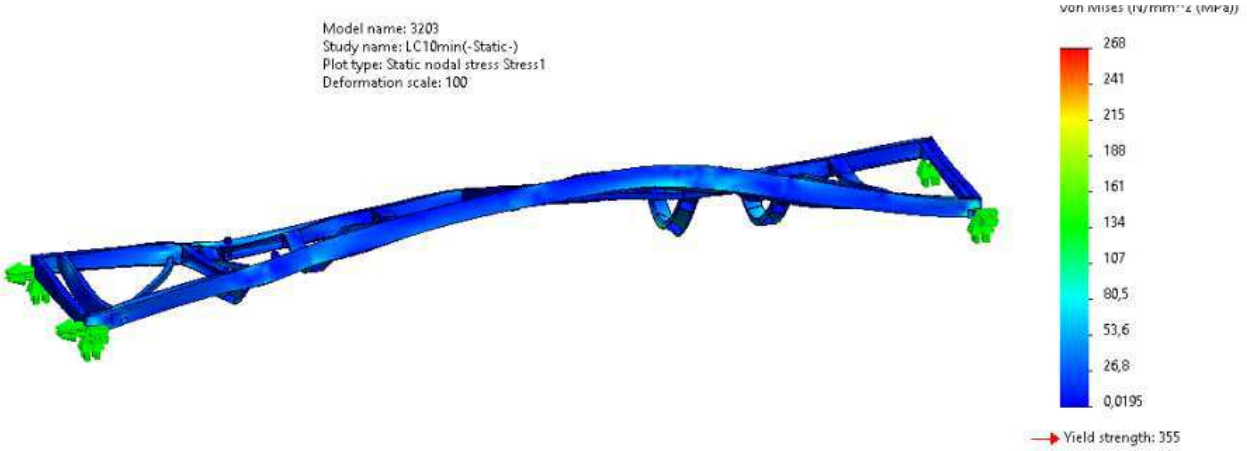


Fig 100: LC10 - ULS - MIN - Stress plot (Von Mises stress)

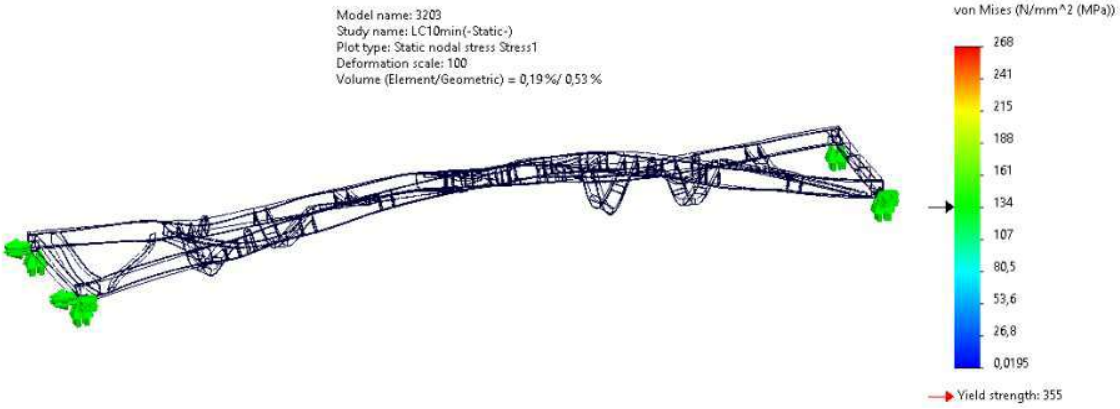


Fig 101: LC10 - ULS - MIN - Stress above 0,5% of geometry

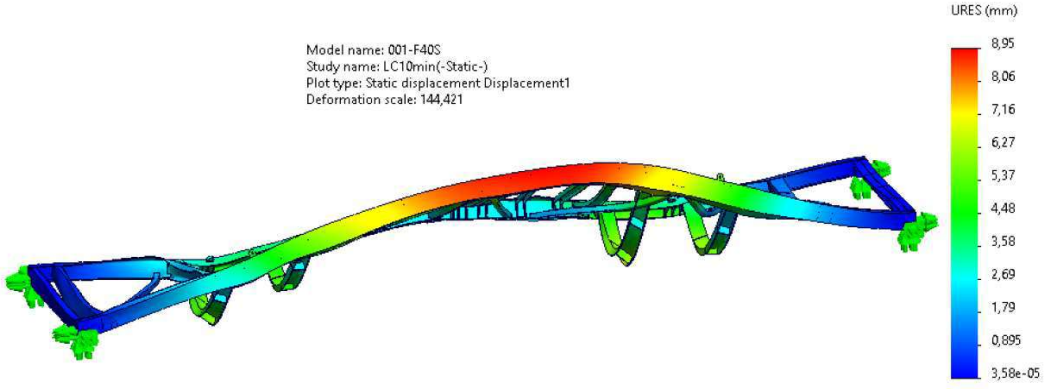


Fig 102: LC10 - ULS - MIN - Maximum deflection

9.11. LC11 - Sea transport on the barge [Pitch case 2] Y-

9.11.1. LC11 - Max - Sea transport on the barge [Pitch case 2] Y-

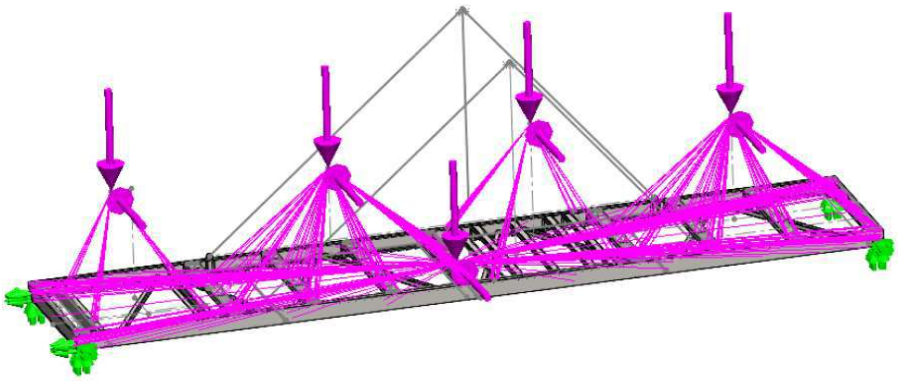


Fig 103: LC11 - ULS - MAX - Loads definition

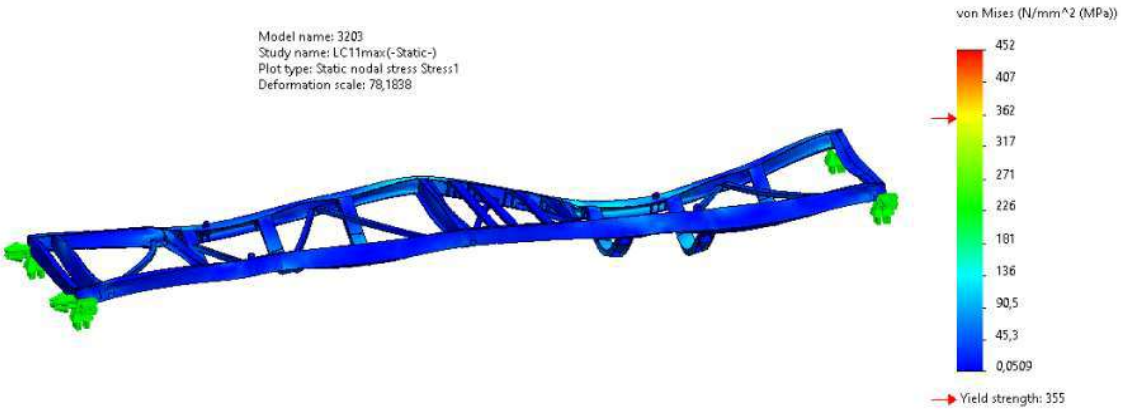


Fig 104: LC11 - ULS - MAX - Stress plot (Von Mises stress)

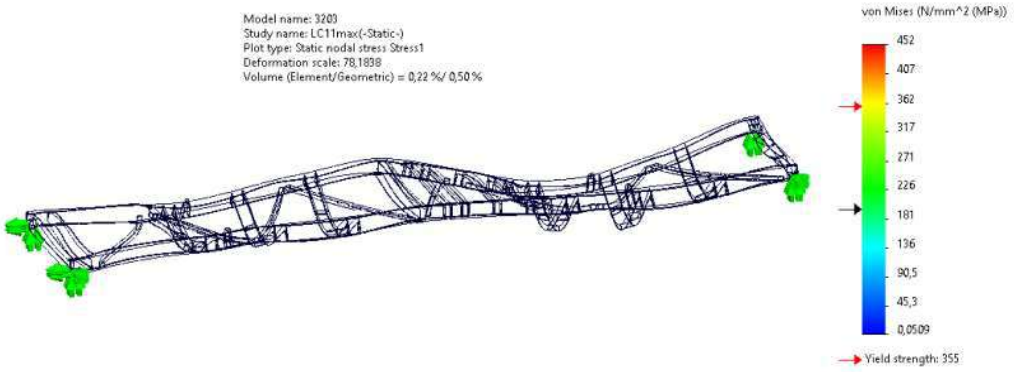
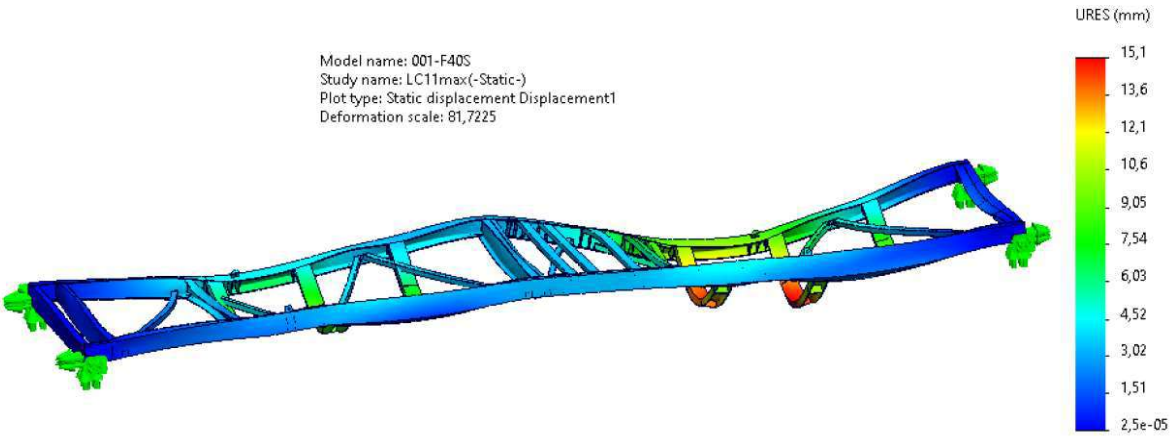


Fig 105: LC11 - ULS - MAX - Stress above 0,5% of geometry



9.11.2. LC11 - Min - Sea transport on the barge [Pitch case 2] Y-

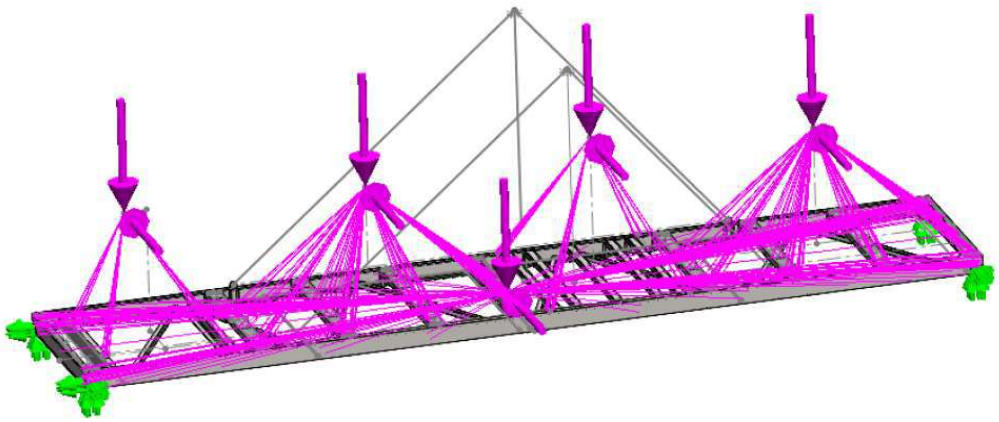


Fig 107: LC11 - ULS - MIN - Loads definition

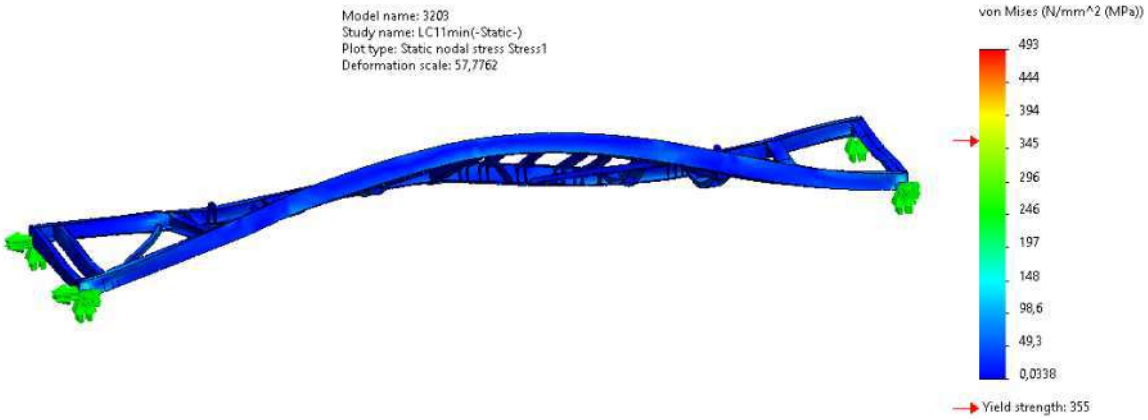


Fig 108: LC11 - ULS - MIN - Stress plot (Von Mises stress)

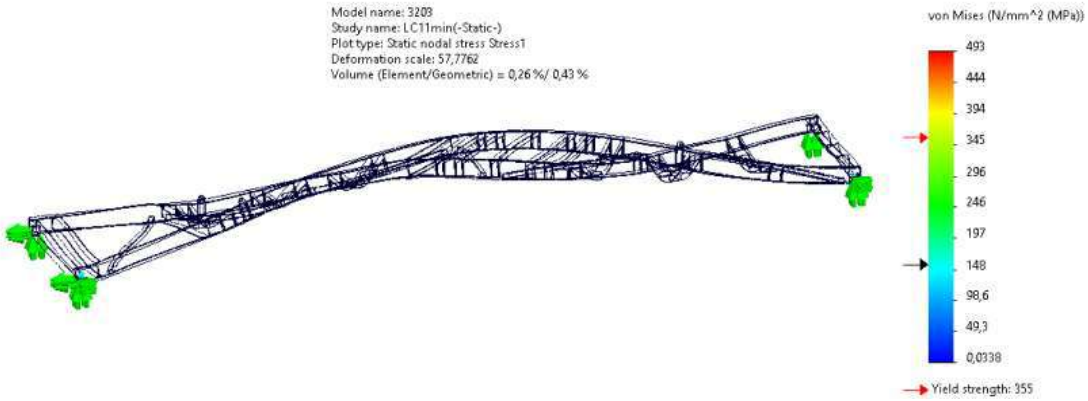
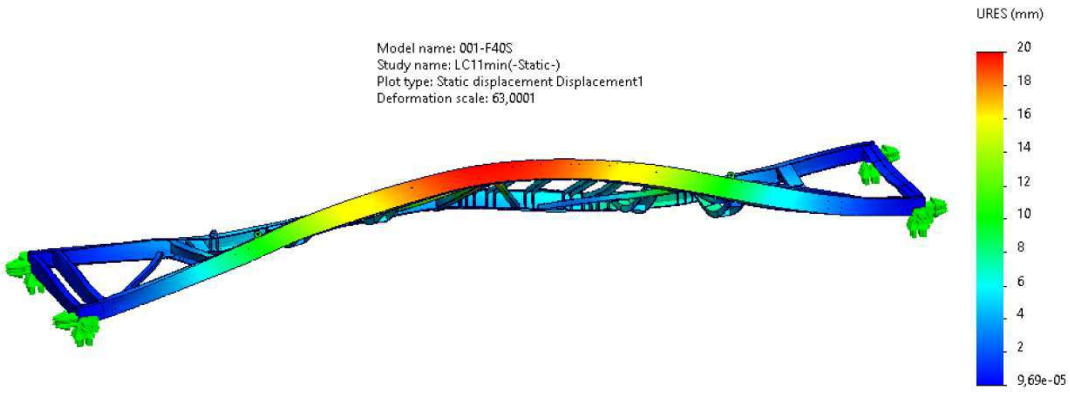


Fig 109: LC11 - ULS - MIN - Stress above 0,5% of geometry



9.12. LC12 - Sea transport on the barge [Quatering 3] X-Y-

9.12.1. LC12 - Max - Sea transport on the barge [Quatering 3] X-Y-

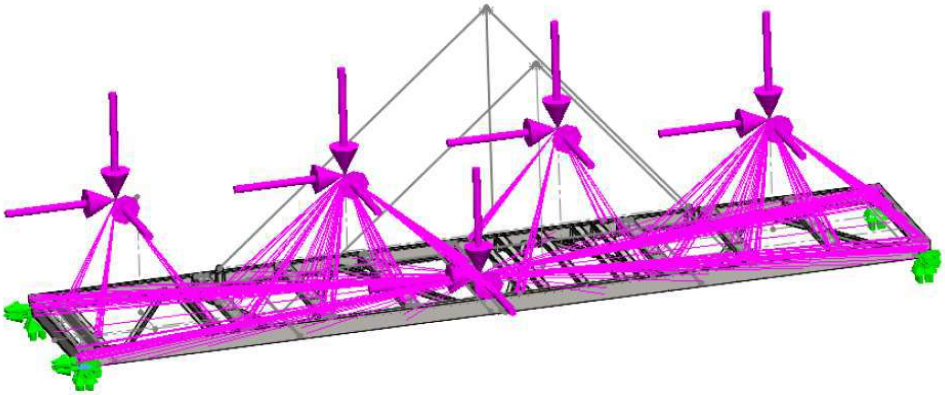


Fig 111: LC12 - ULS - MAX - Loads definition

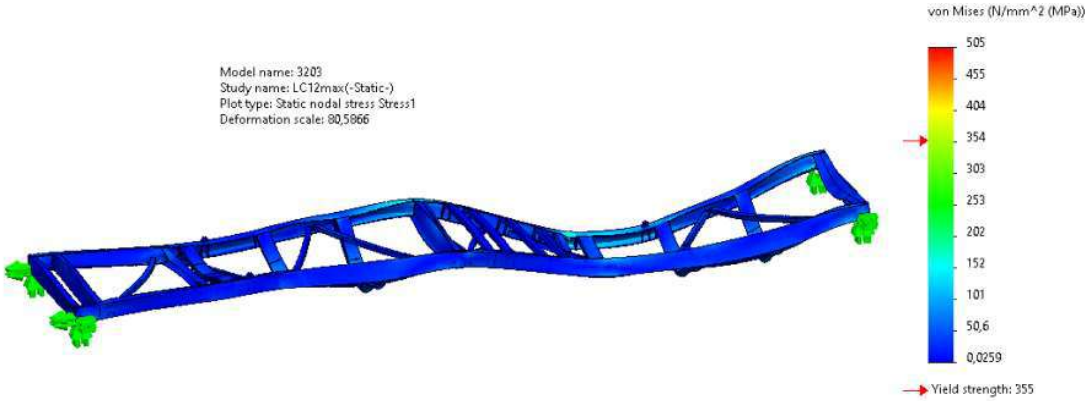


Fig 112: LC12 - ULS - MAX - Stress plot (Von Mises stress)

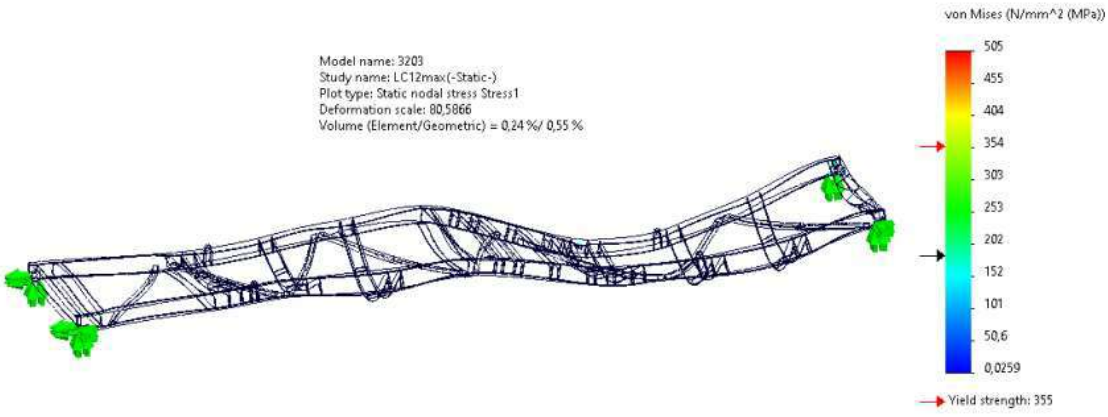


Fig 113: LC12 - ULS - MAX - Stress above 0,5% of geometry

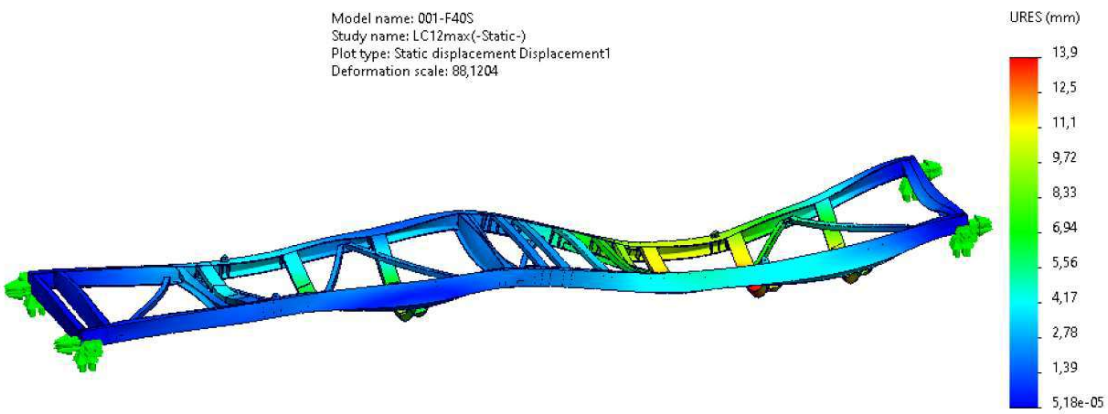


Fig 114: LC12 - ULS - MAX - Maximum deflection

9.12.2. LC12 - Min - Sea transport on the barge [Quatering 3] X-Y-

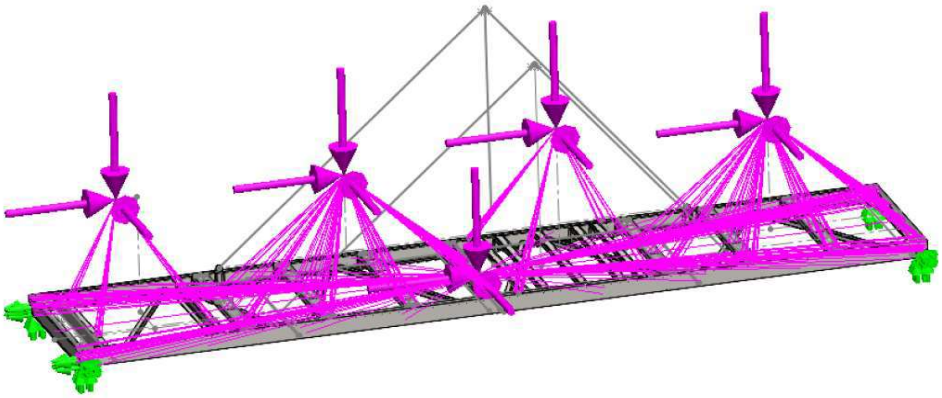


Fig 115: LC12 - ULS - MIN - Loads definition

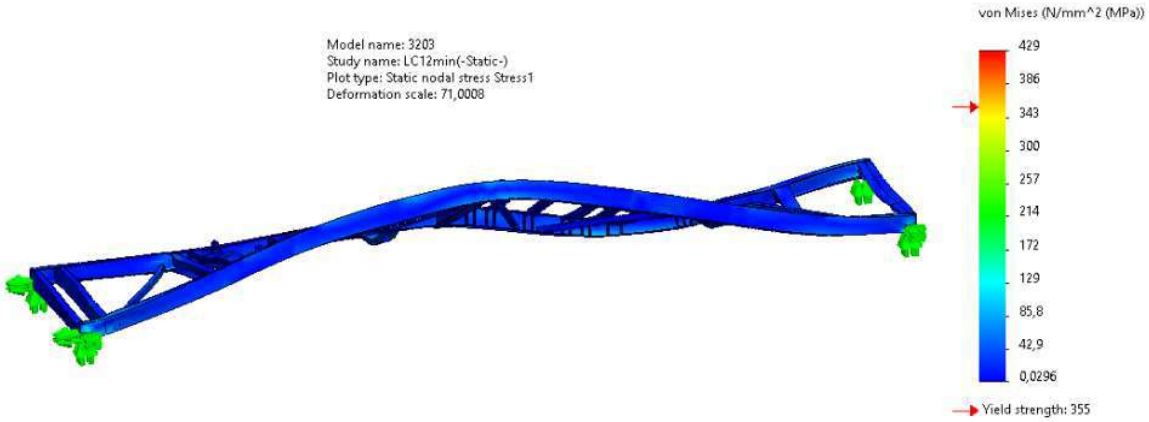


Fig 116: LC12 - ULS - MIN - Stress plot (Von Mises stress)

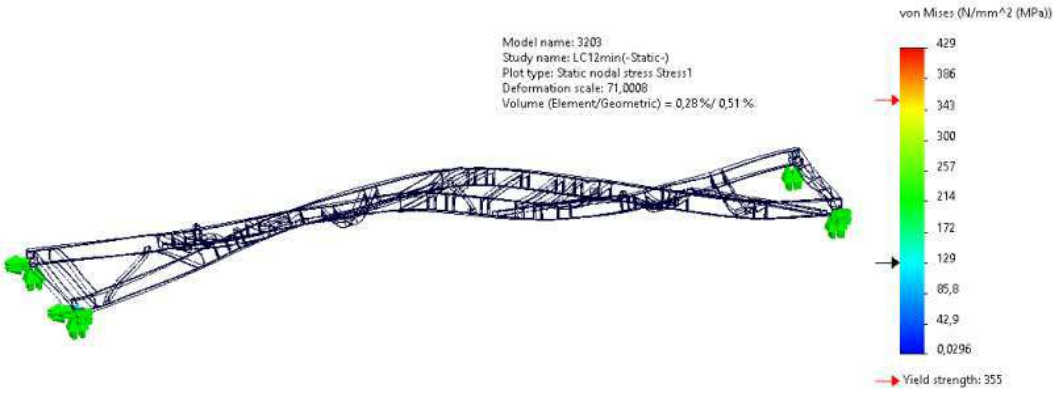
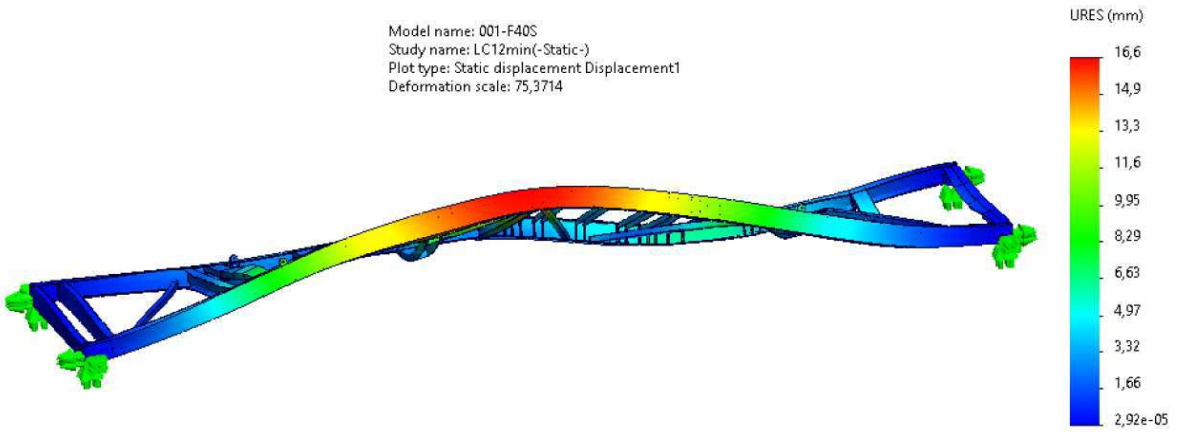


Fig 117: LC12 - ULS - MIN - Stress above 0,5% of geometry



9.13. LC13 - Sea transport on the barge [Roll case 2] X-

9.13.1. LC13 - Max - Sea transport on the barge [Roll case 2] X-

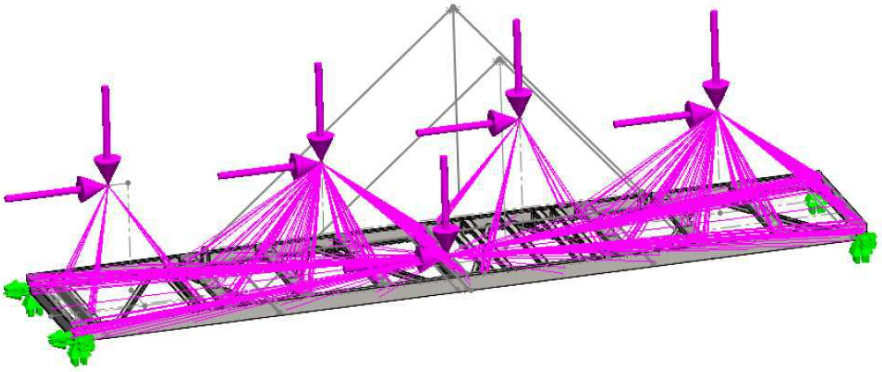


Fig 119: LC13 - ULS - MAX - Loads definition

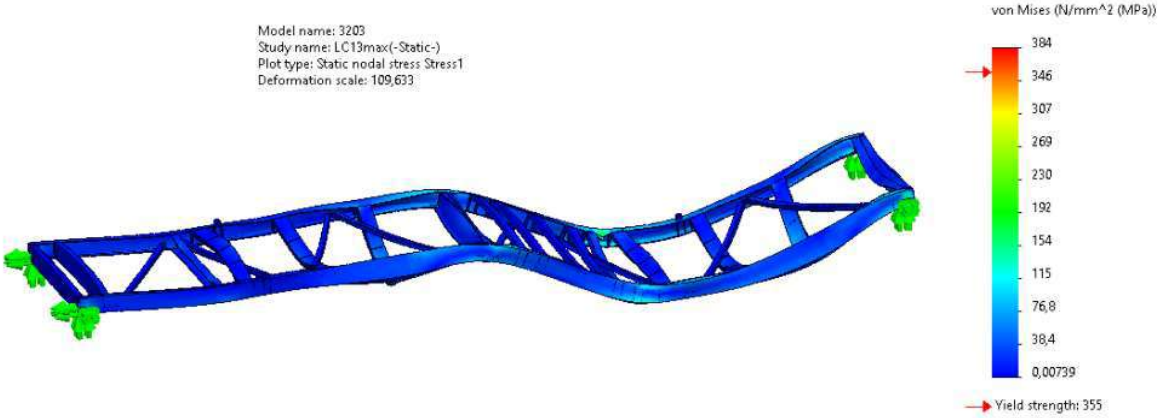


Fig 120: LC13 - ULS - MAX - Stress plot (Von Mises stress)

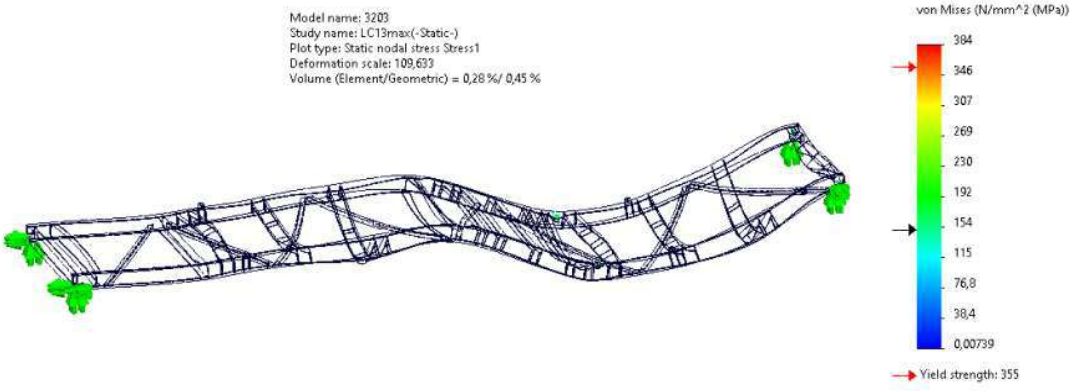


Fig 121: LC13 - ULS - MAX - Stress above 0,5% of geometry

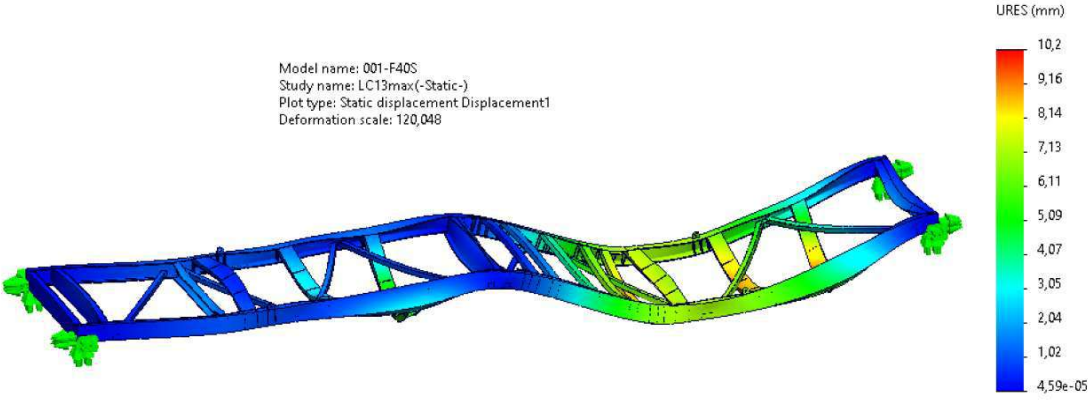


Fig 122: LC13 - ULS - MAX - Maximum deflection

9.13.2. LC13 - Min - Sea transport on the barge [Roll case 2] X-

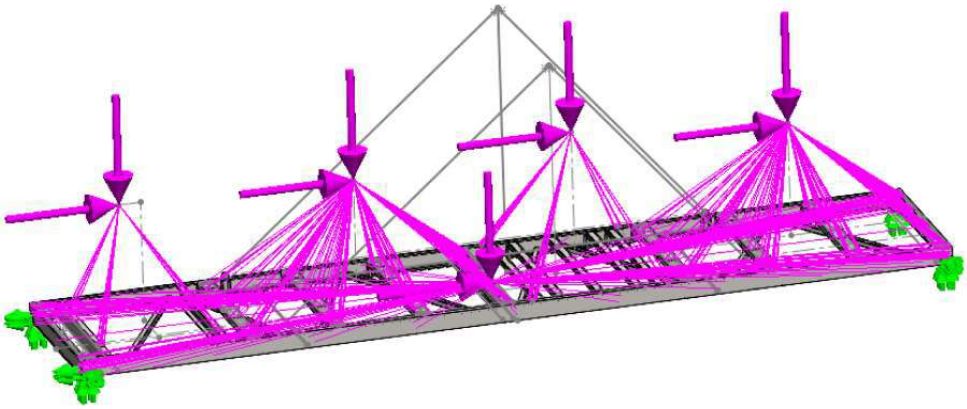


Fig 123: LC13 - ULS - MIN - Loads definition

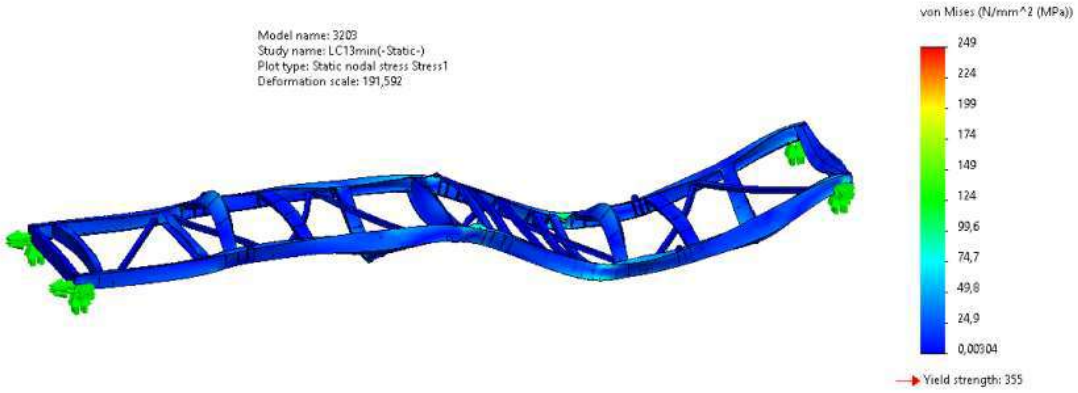


Fig 124: LC13 - ULS - MIN - Stress plot (Von Mises stress)

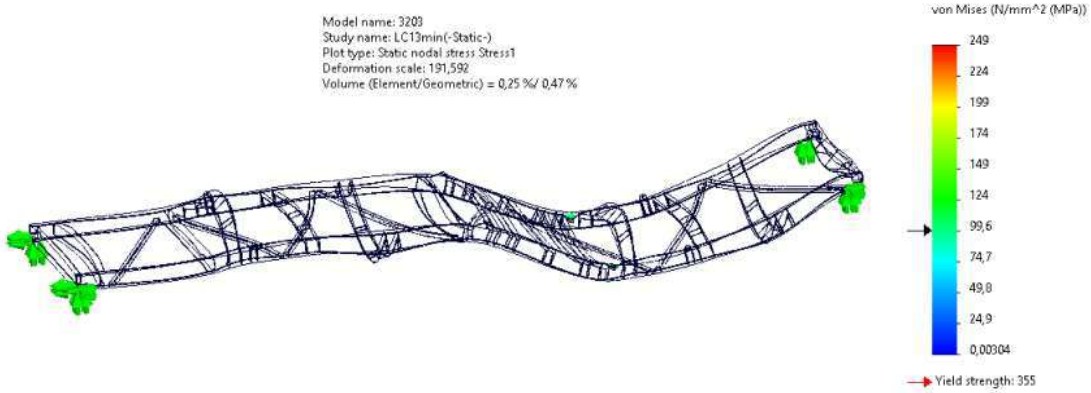
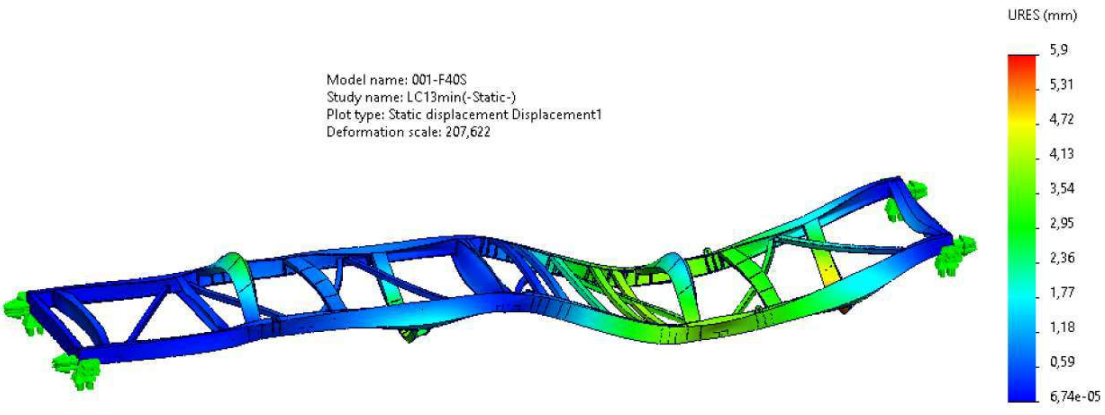


Fig 125: LC13 - ULS - MIN - Stress above 0,5% of geometry



9.14. LC14 - Sea transport on the barge [Quatering 4] X-Y+

9.14.1. LC14 - Max - Sea transport on the barge [Quatering 4] X-Y+

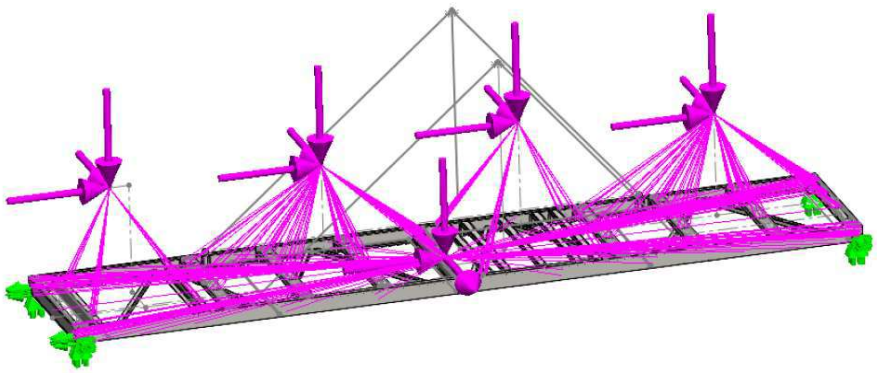


Fig 127: LC14 - ULS - MAX - Loads definition

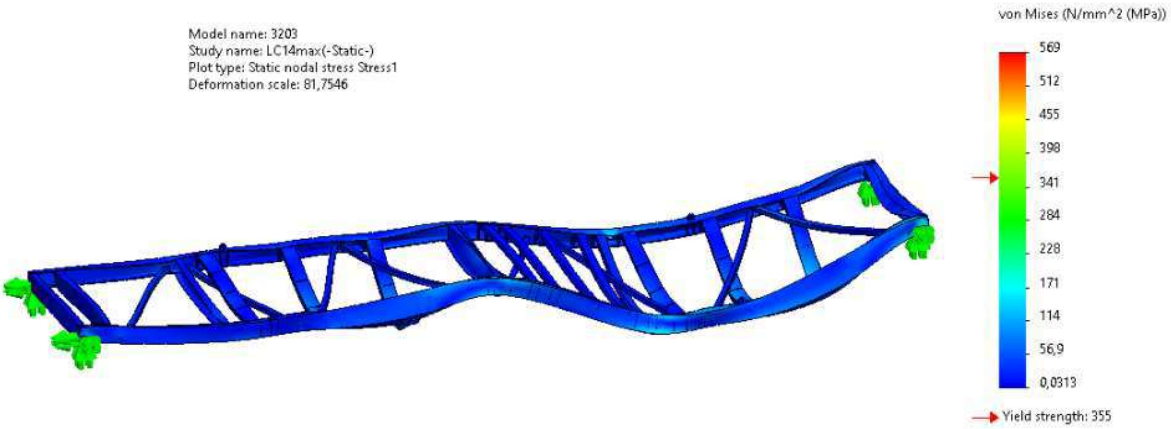


Fig 128: LC14 - ULS - MAX - Stress plot (Von Mises stress)

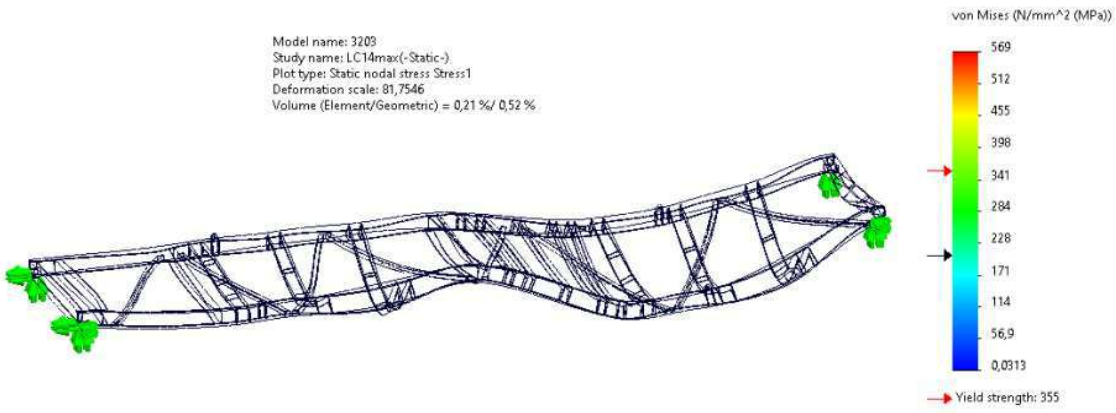


Fig 129: LC14 - ULS - MAX - Stress above 0,5% of geometry

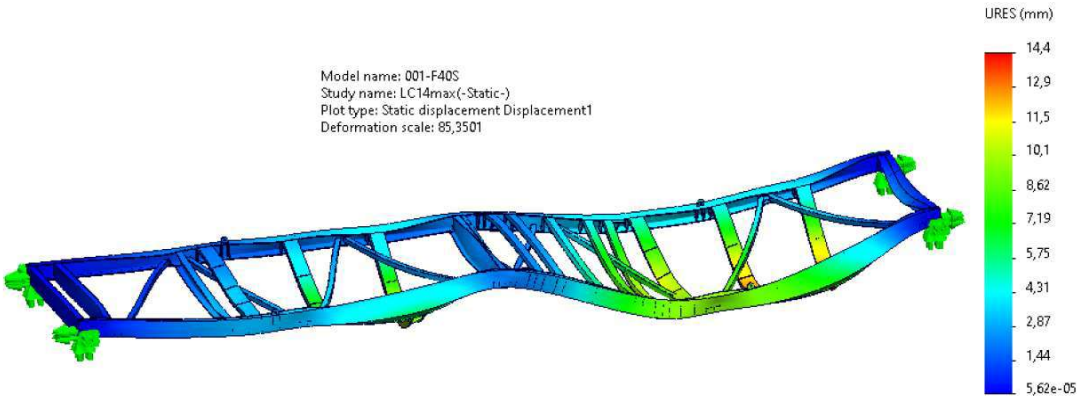


Fig 130: LC14 - ULS - MAX - Maximum deflection

9.14.2. LC14 - Min - Sea transport on the barge [Quatering 4] X-Y+

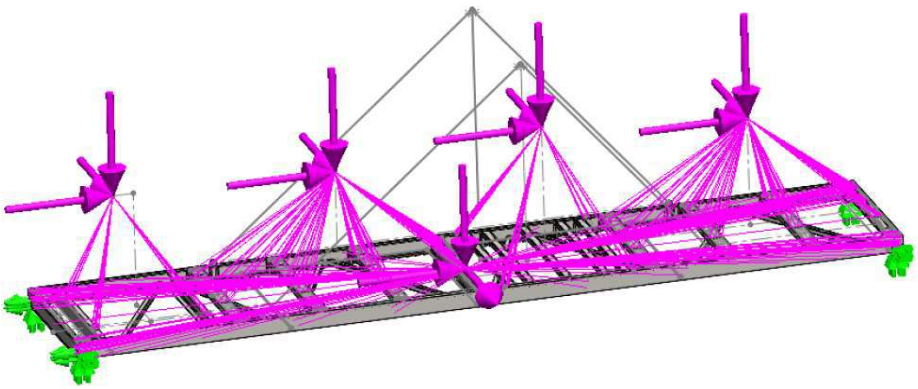


Fig 131: LC14 - ULS - MIN - Loads definition

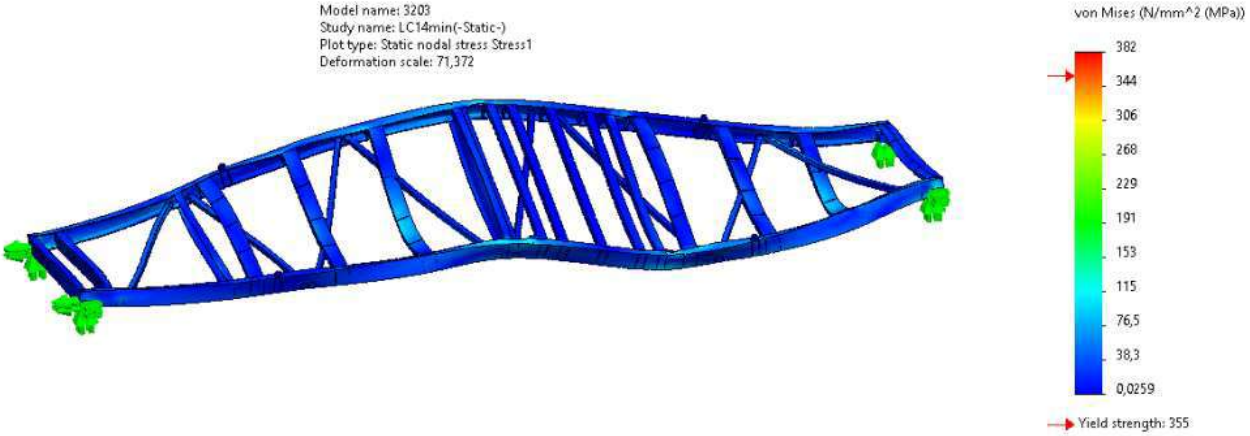


Fig 132: LC14 - ULS - MIN - Stress plot (Von Mises stress)

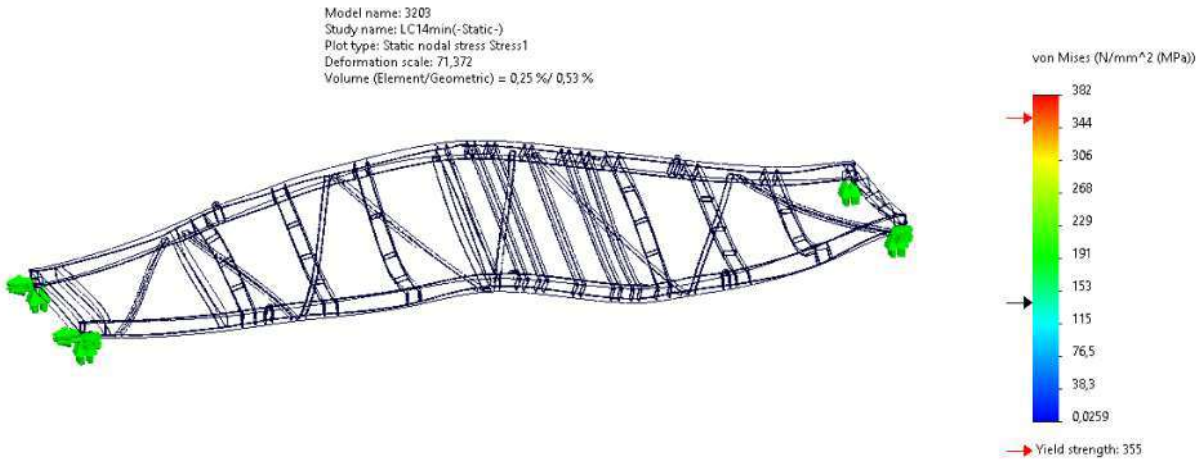
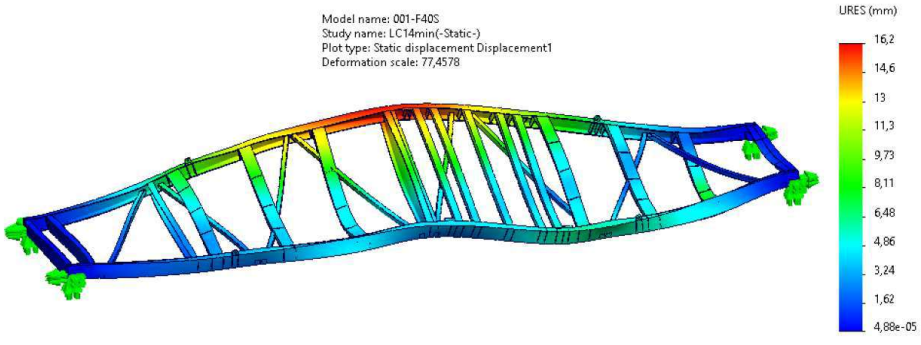


Fig 133: LC14 - ULS - MIN - Stress above 0,5% of geometry



9.15. LC15 - In destination place on barge + wind X+

9.15.1. LC15 - Max - In destination place on barge + wind X+

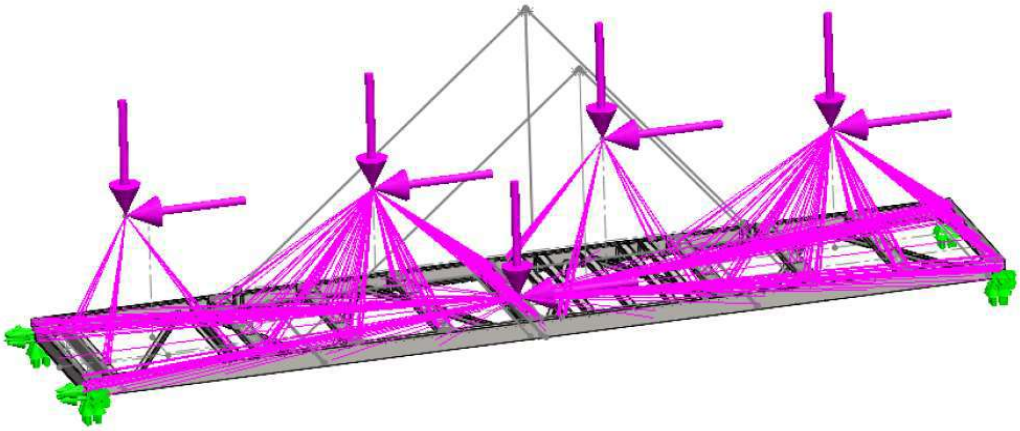


Fig 135: LC15 - ULS - MAX - Loads definition

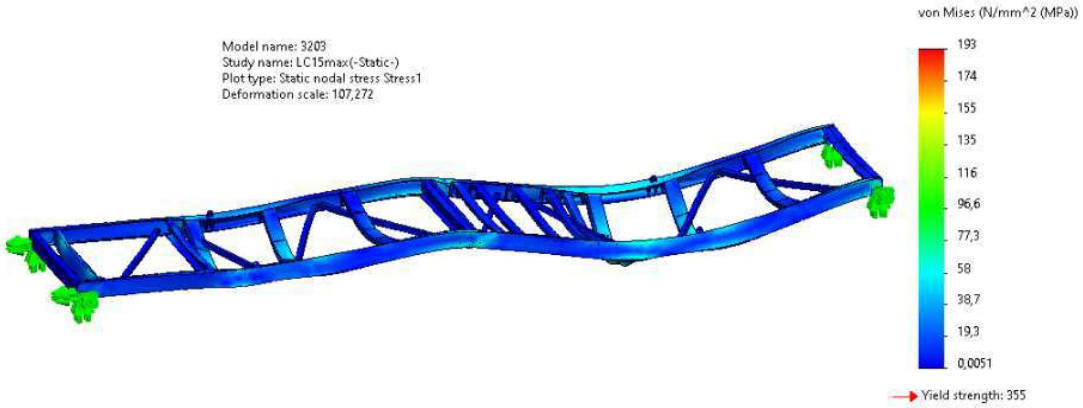


Fig 136: LC15 - ULS - MAX - Stress plot (Von Mises stress)

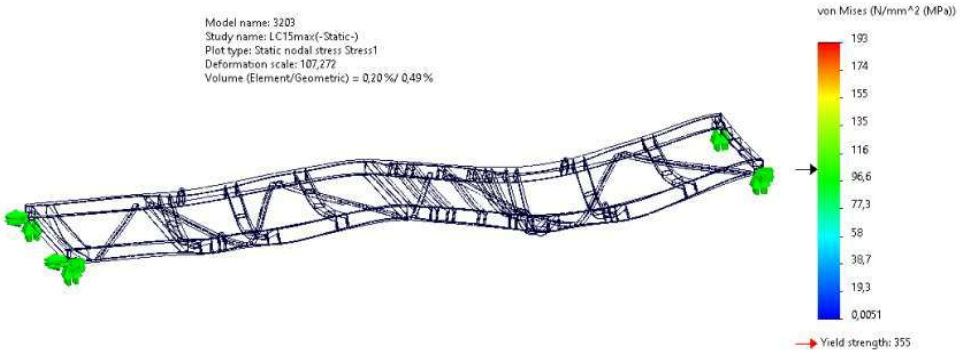
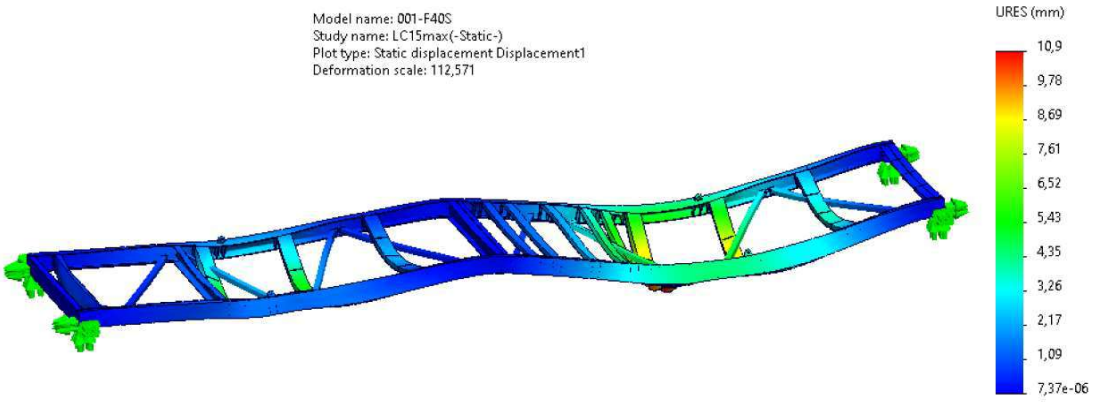


Fig 137: LC15 - ULS - MAX - Stress above 0,5% of geometry



9.15.2. LC15 - Min - In destination place on barge + wind X+

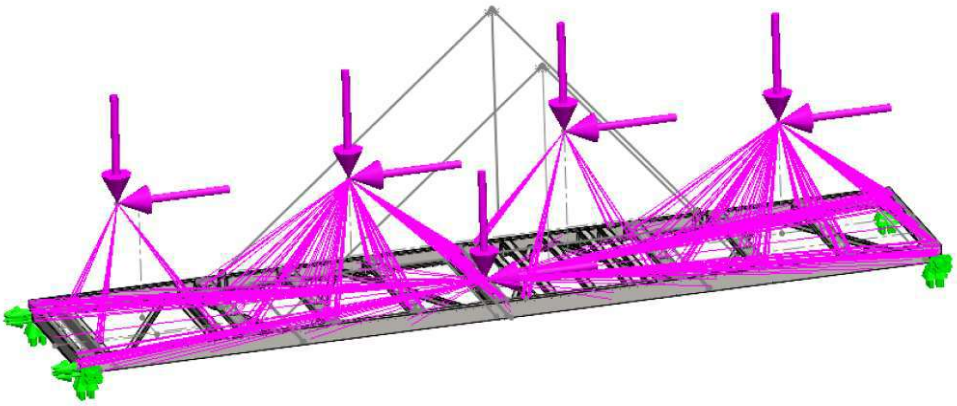


Fig 139: LC15 - ULS - MIN - Loads definition

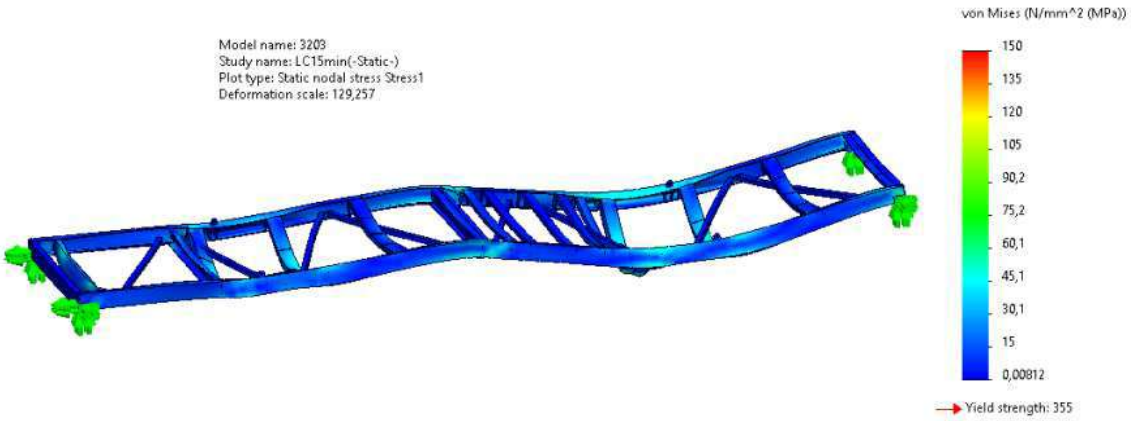


Fig 140: LC15 - ULS - MIN - Stress plot (Von Mises stress)

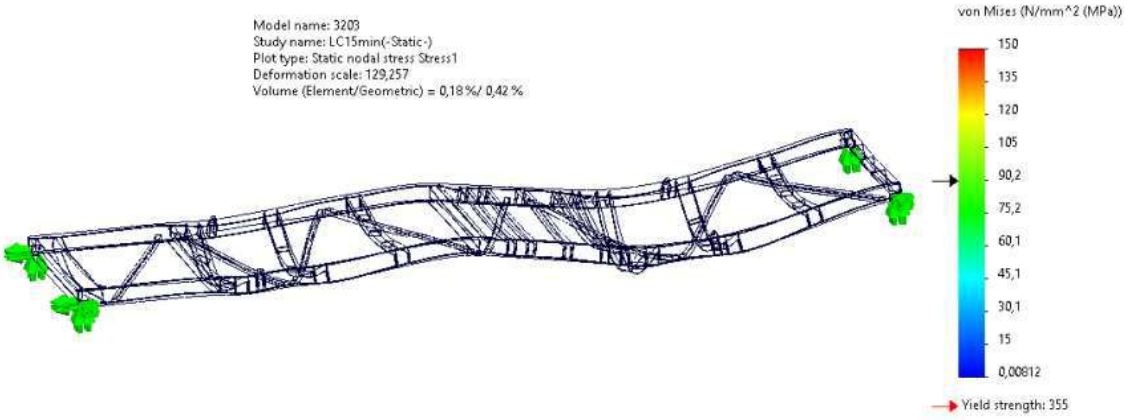
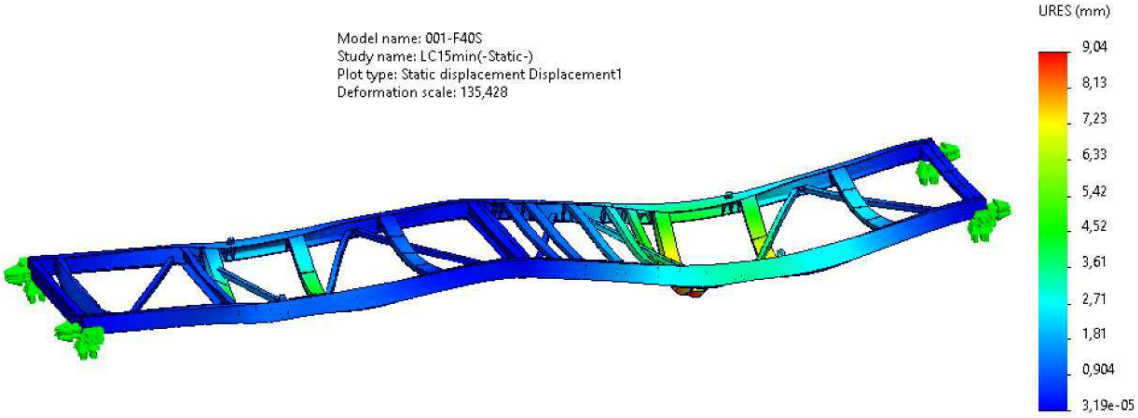


Fig 141: LC15 - ULS - MIN - Stress above 0,5% of geometry



9.16. LC16 - In destination place on barge + wind Y+

9.16.1. LC16 - Max - In destination place on barge + wind Y+

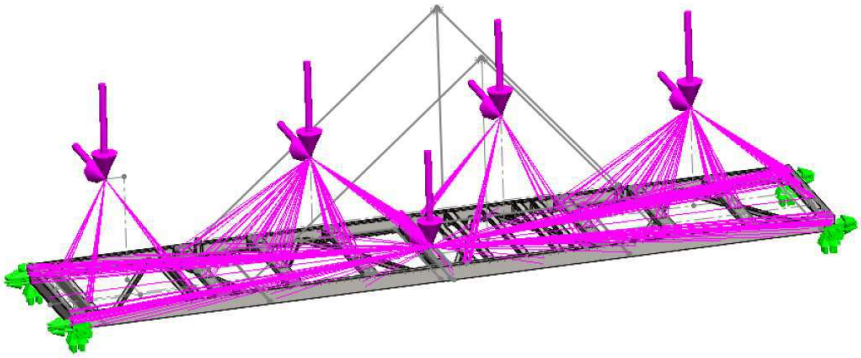


Fig 143: LC16 - ULS - MAX - Loads definition

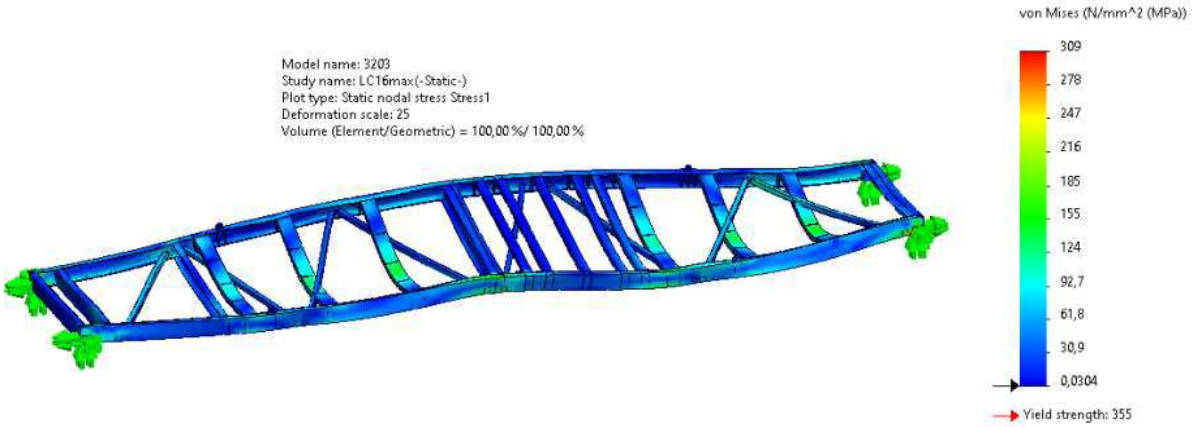


Fig 144: LC16 - ULS - MAX - Stress plot (Von Mises stress)

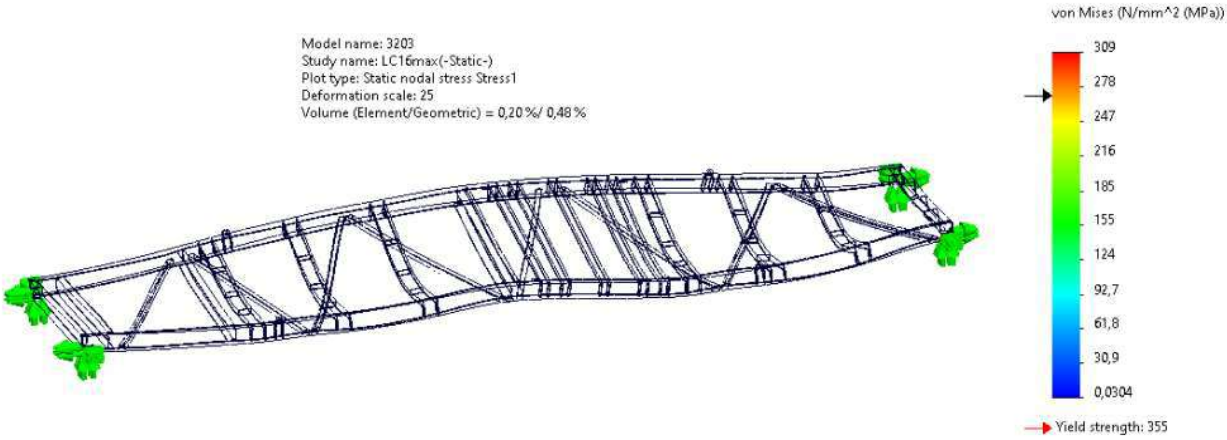
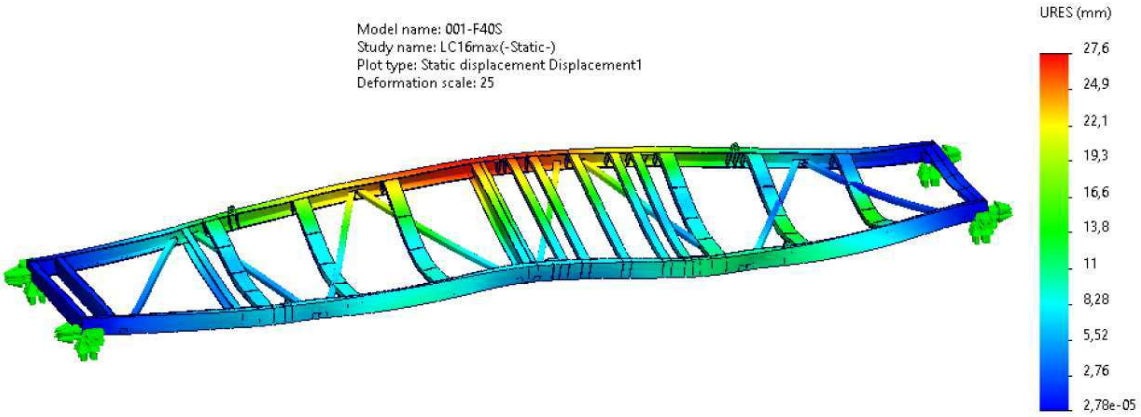


Fig 145: LC16 - ULS - MAX - Stress above 0,5% of geometry



9.16.2. LC16 - Min - In destination place on barge + wind Y+

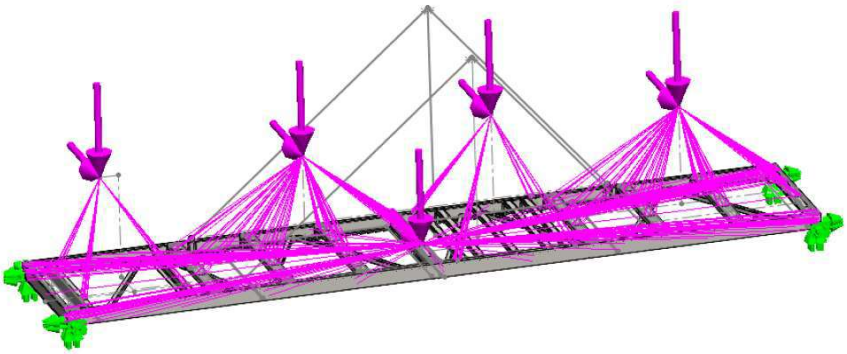


Fig 147: LC16 - ULS - MIN - Loads definition

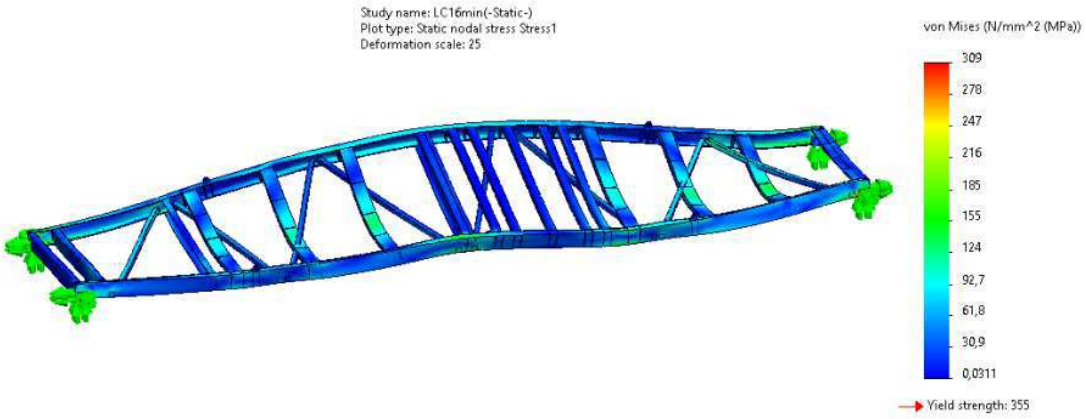


Fig 148: LC16 - ULS - MIN - Stress plot (Von Mises stress)

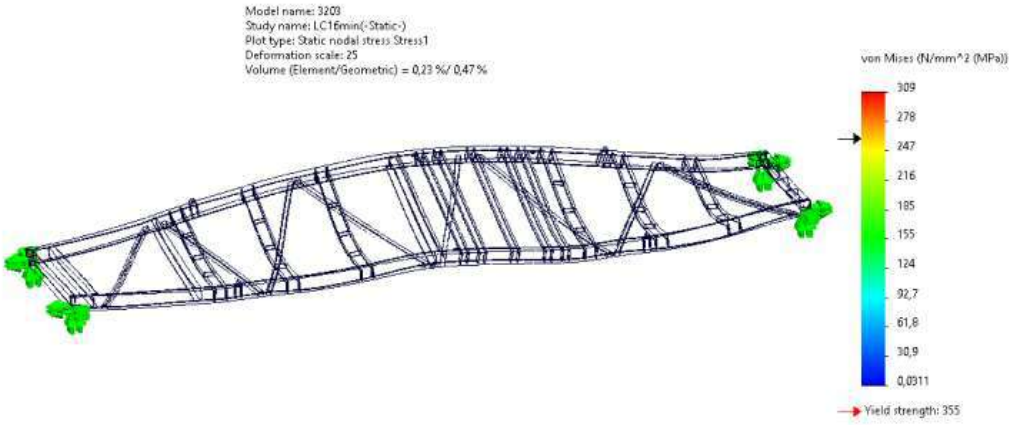
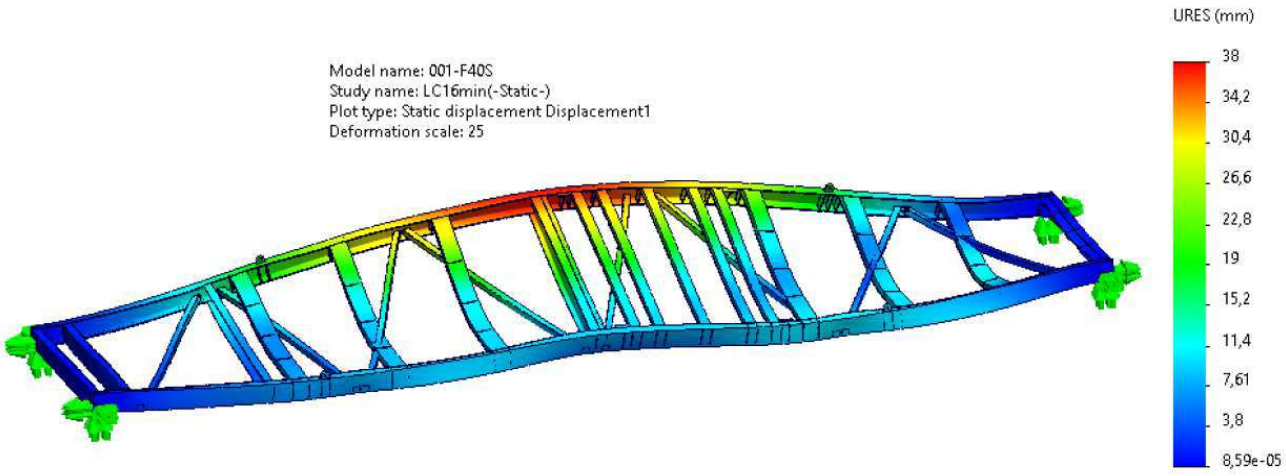


Fig 149: LC16 - ULS - MIN - Stress above 0,5% of geometry



9.17. LC17 - In destination place on barge + wind X-

9.17.1. LC17 - Max - In destination place on barge + wind X+

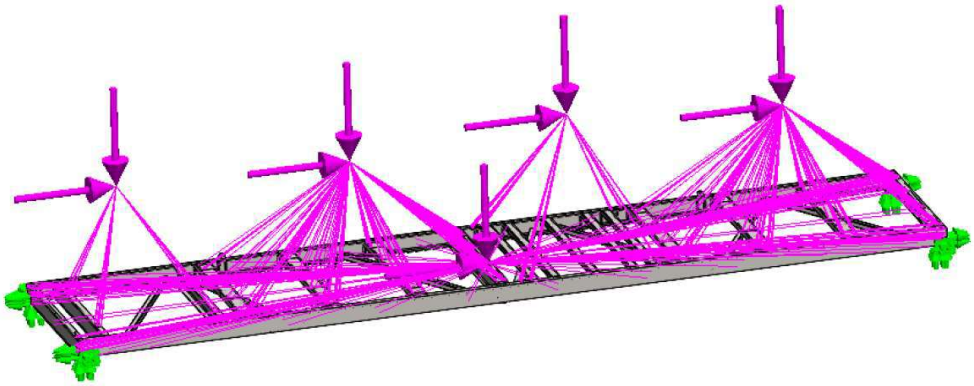


Fig 151: LC17 - ULS - MAX - Loads definition

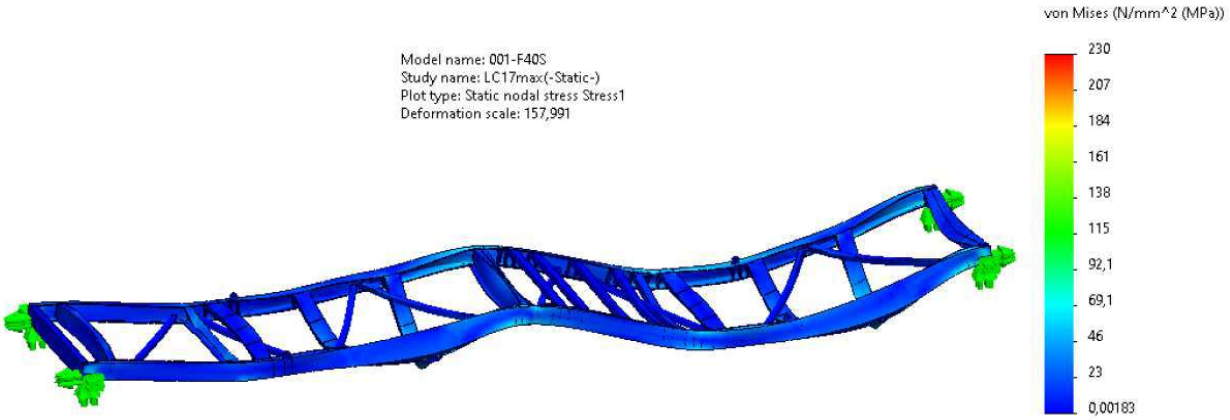


Fig 152: LC17 - ULS - MAX - Stress plot (Von Mises stress)

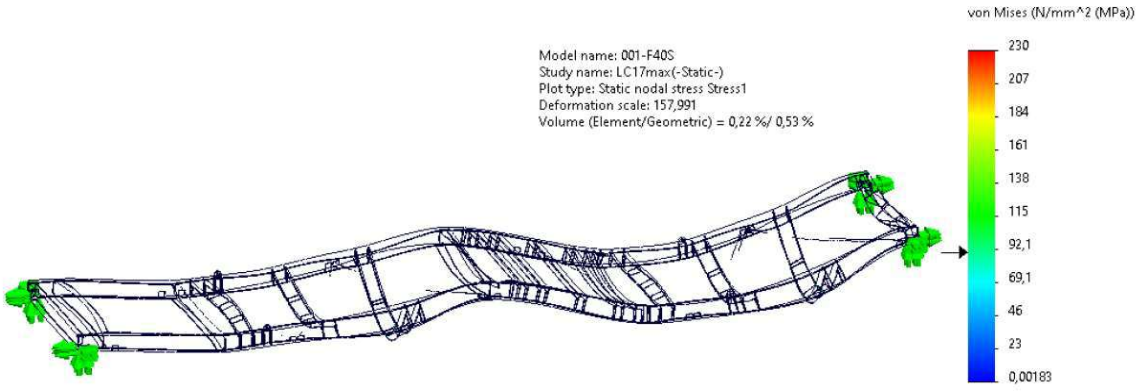


Fig 153: LC17 - ULS - MAX - Stress above 0,5% of geometry

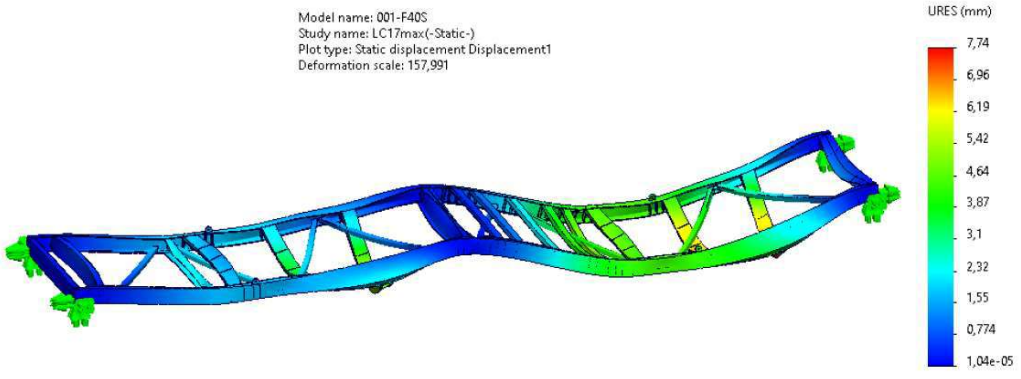


Fig 154: LC16 - ULS - MAX - Maximum deflection

9.17.2. LC17 - Min - In destination place on barge + wind X-

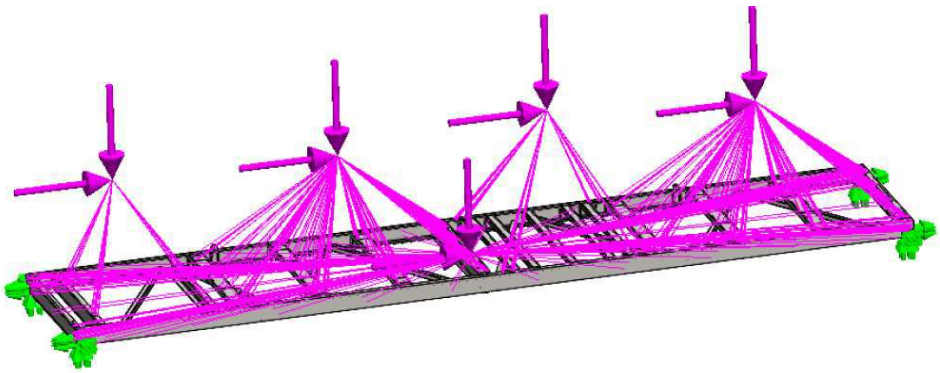


Fig 155: LC17 - ULS - MIN - Loads definition

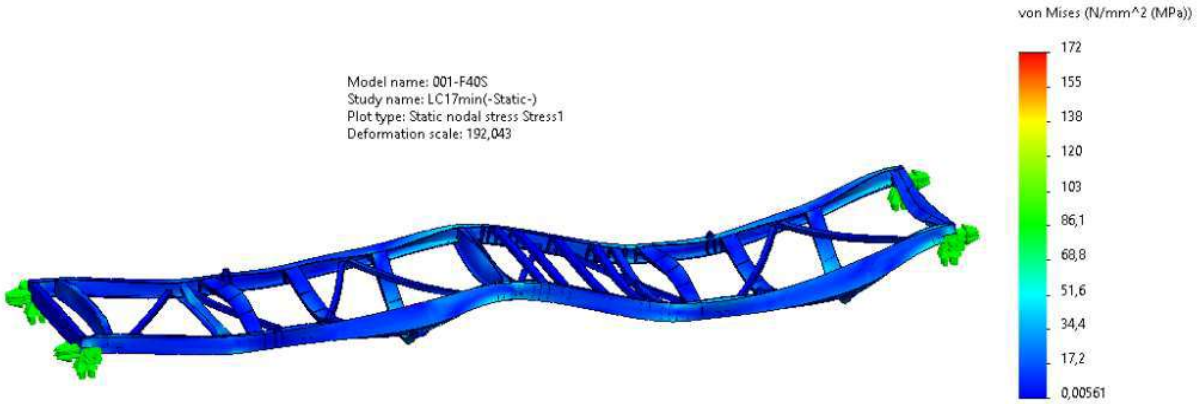


Fig 156: LC17 - ULS - MIN - Stress plot (Von Mises stress)

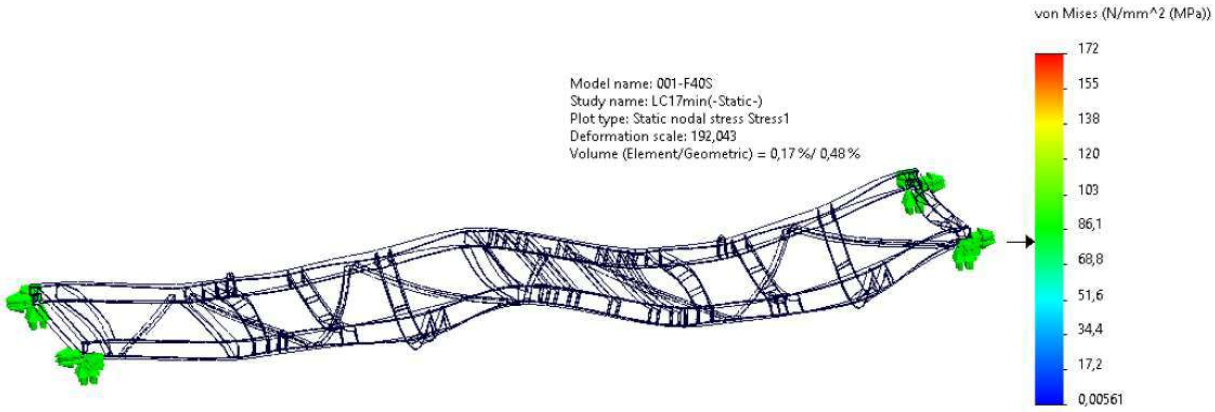
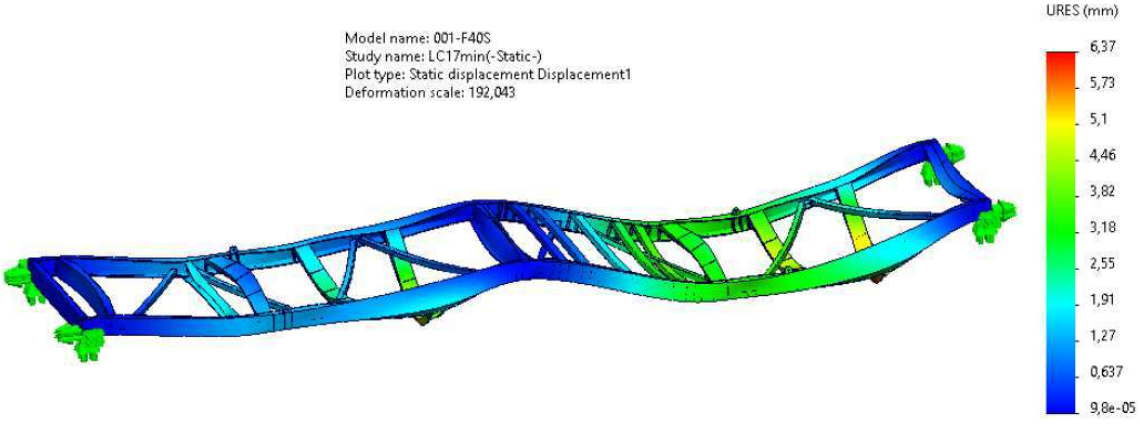


Fig 157: LC17 - ULS - MIN - Stress above 0,5% of geometry



9.18. LC18 - In destination place on barge + wind Y-

9.18.1. LC18 - Max - In destination place on barge + wind Y-

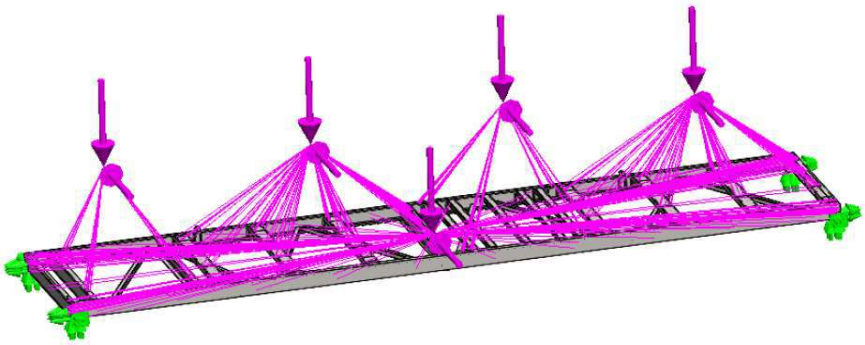


Fig 159: LC18 - ULS - MAX - Loads definition

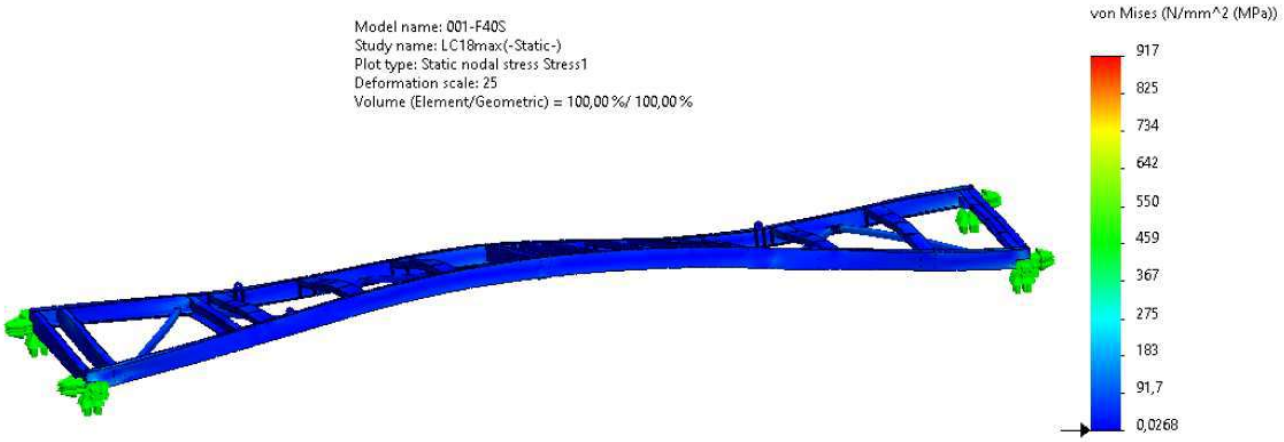


Fig 160: LC18 - ULS - MAX - Stress plot (Von Mises stress)

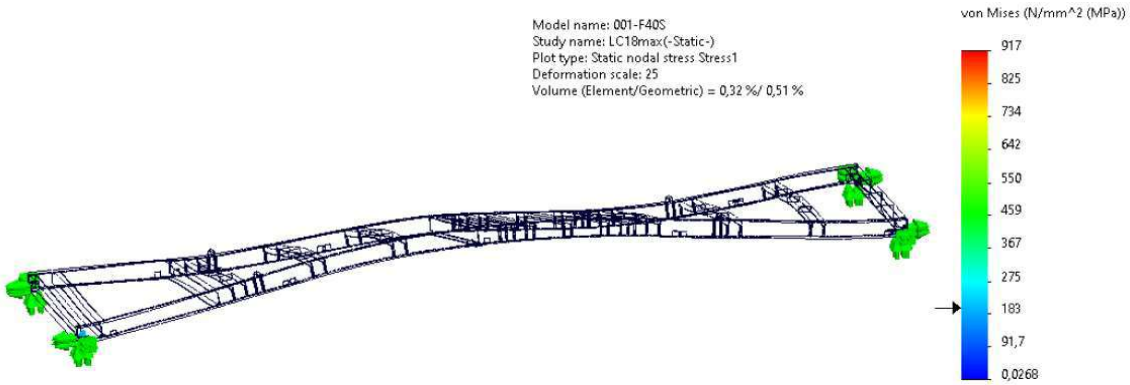


Fig 161: LC18 - ULS - MAX - Stress above 0,5% of geometry

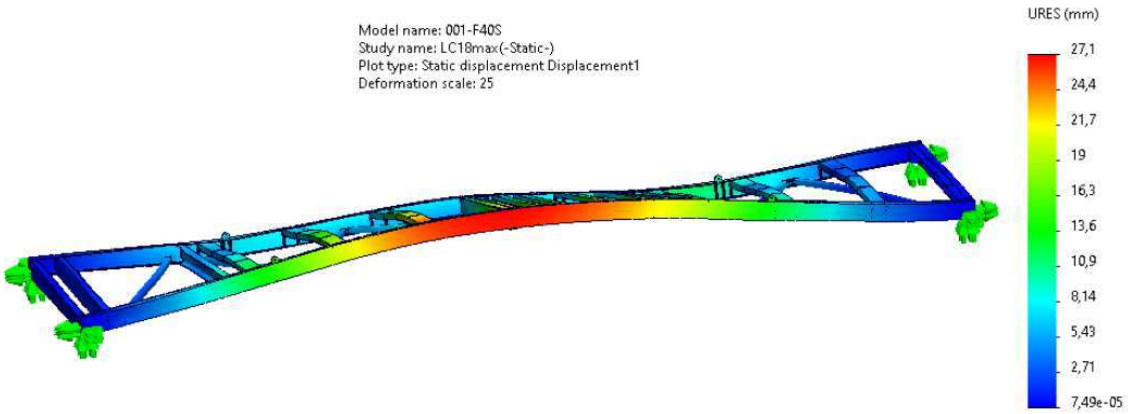


Fig 162: LC18 - ULS - MAX - Maximum deflection

9.18.2. LC18 - Min - In destination place on barge + wind Y-

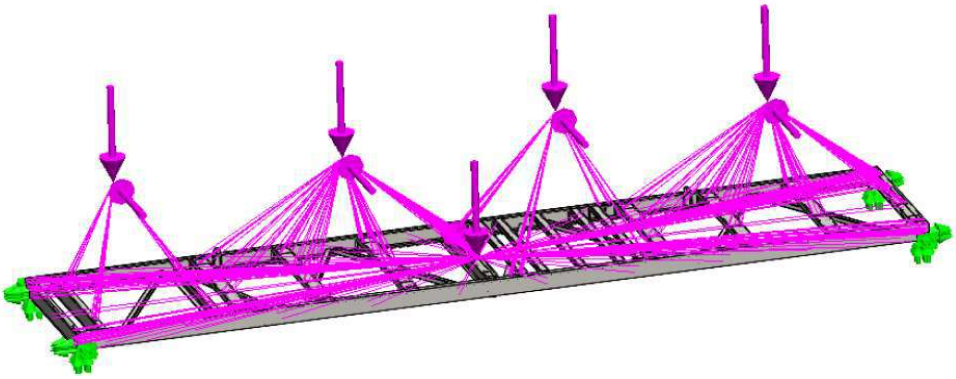


Fig 163: LC18 - ULS - MIN - Loads definition

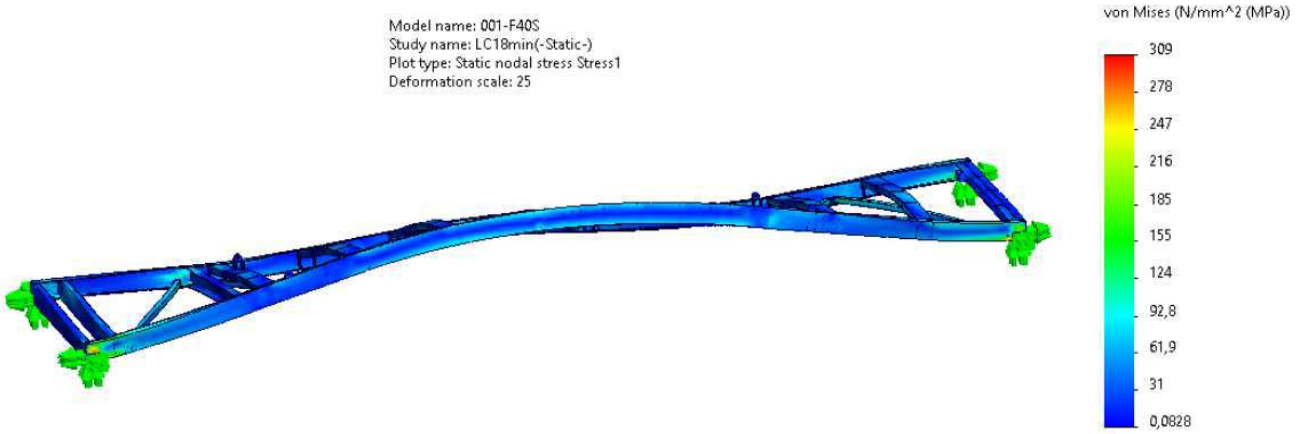


Fig 164: LC18 - ULS - MIN - Stress plot (Von Mises stress)

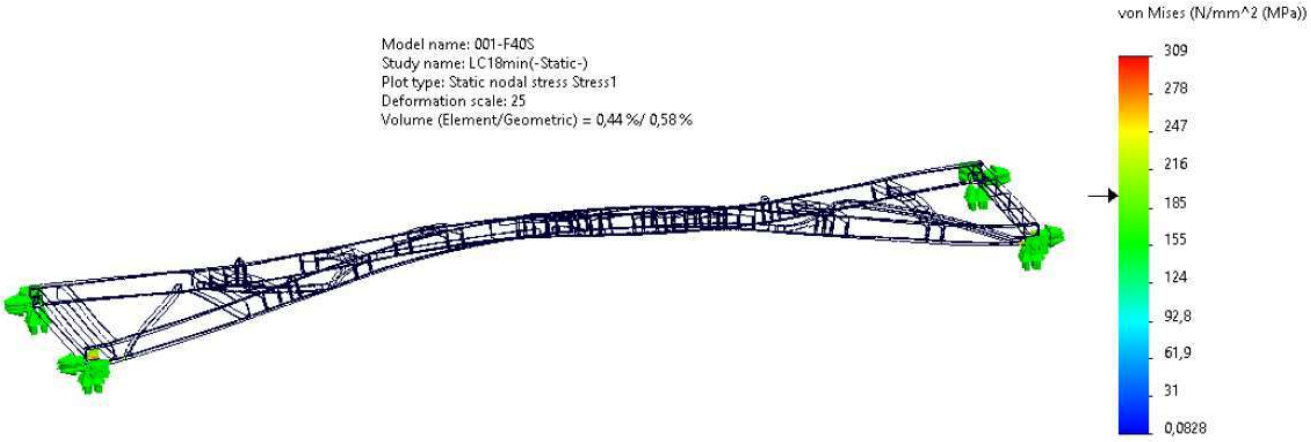
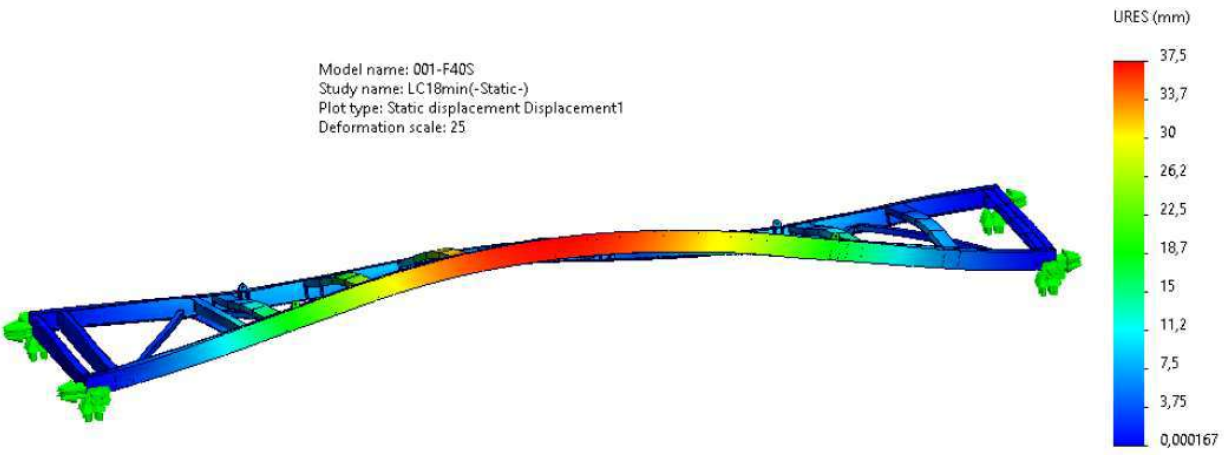


Fig 165: LC18 - ULS - MIN - Stress above 0,5% of geometry



10. Reactions - Ultimate Limit State

10.1. LC1

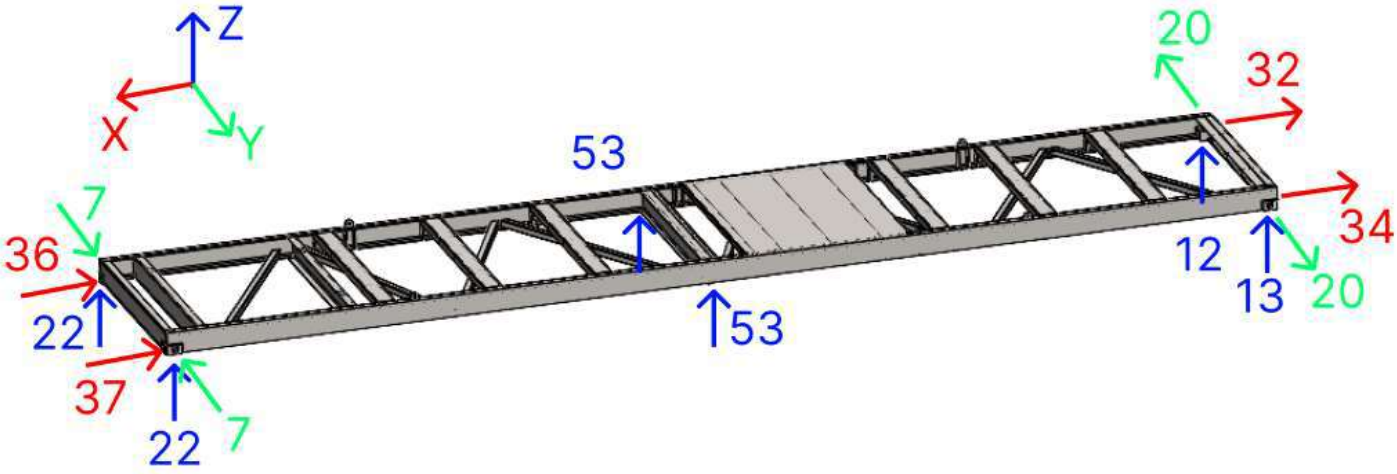


Fig 167: LC1 - ULS - Reactions

10.2. LC2

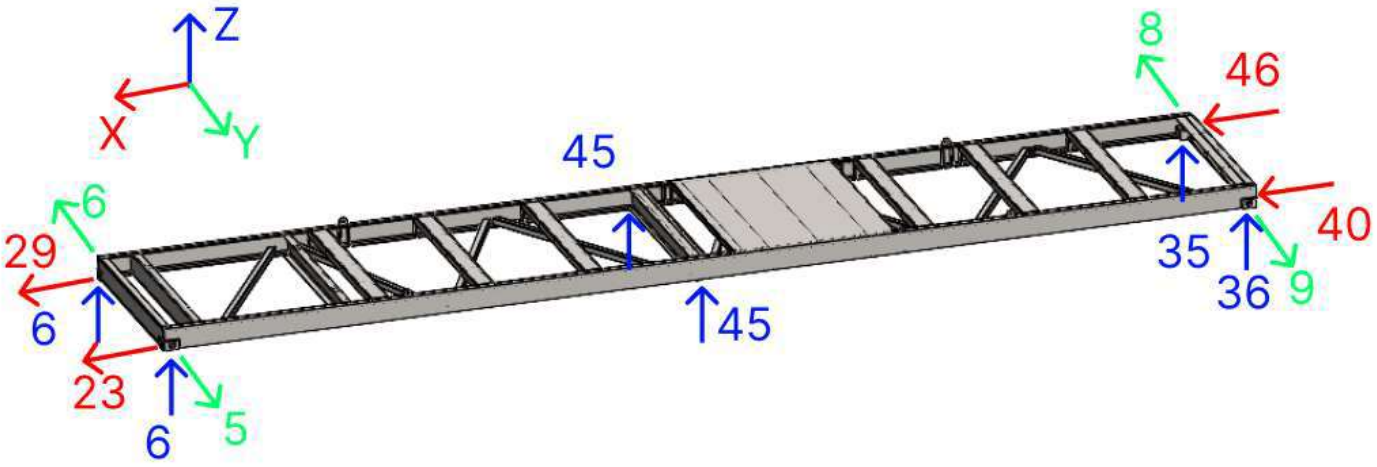
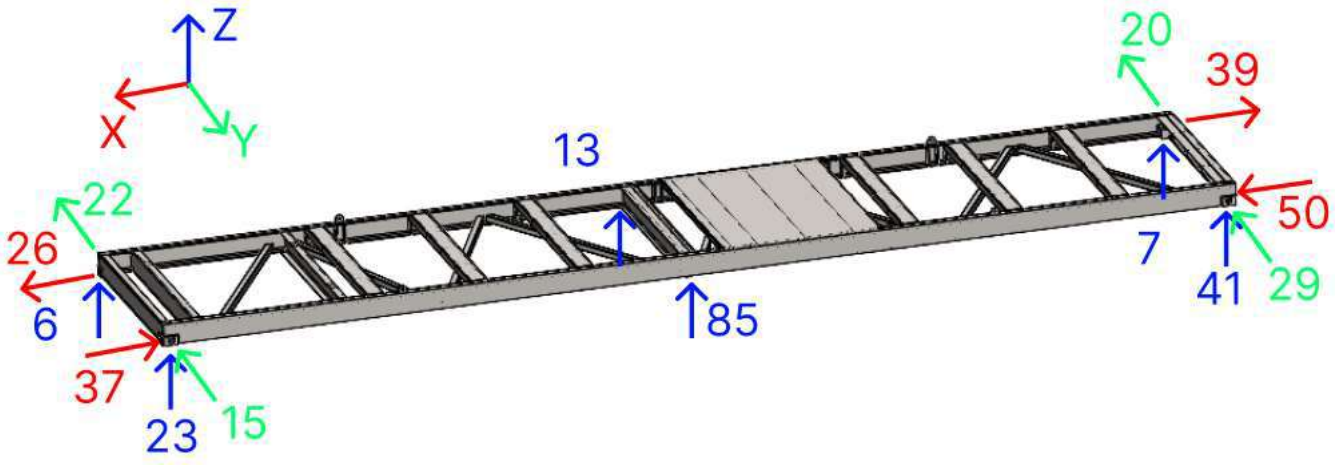


Fig 168: LC2 - ULS - Reactions

10.3. LC3



10.4. LC4

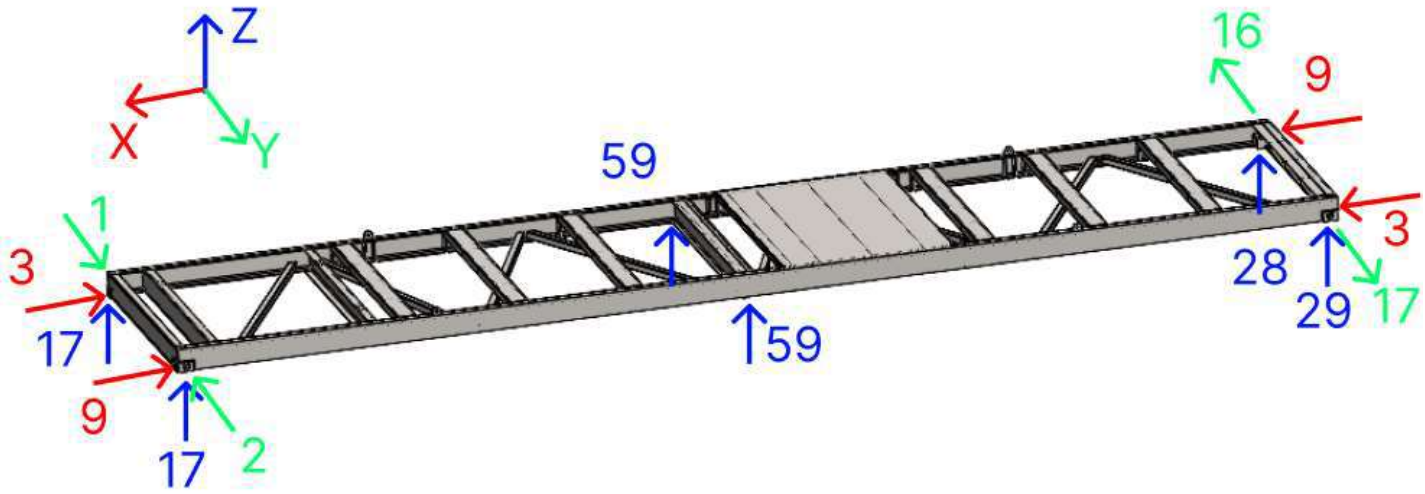


Fig 170: LC4 - ULS - Reactions

10.5. LC5

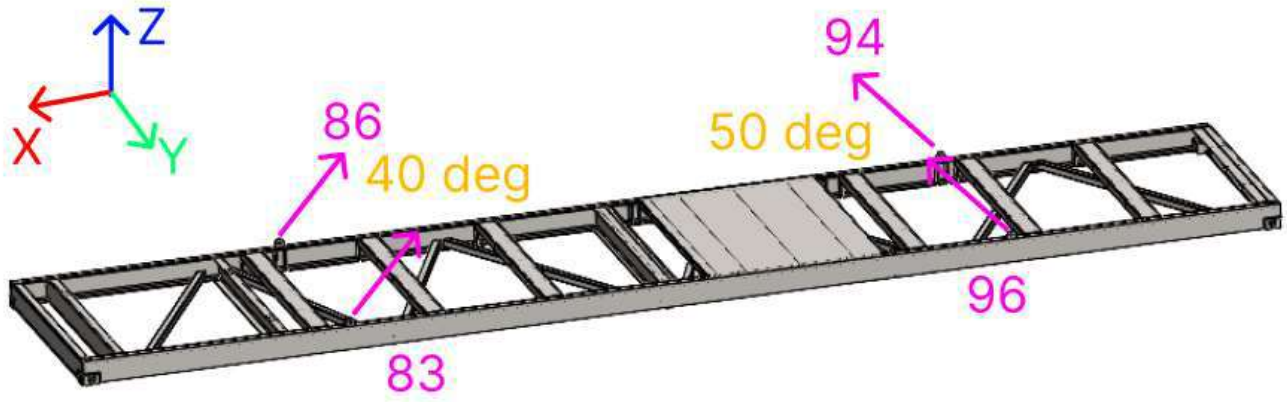


Fig 171: LC5 - ULS - Reactions

10.6. LC6

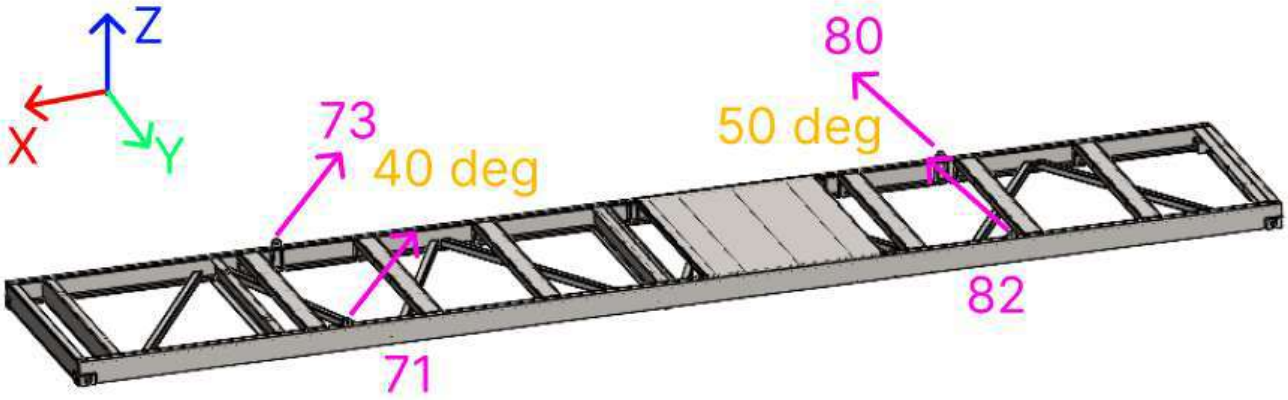


Fig 172: LC6 - ULS - Reactions

10.7. LC7

10.7.1. LC7-MAX

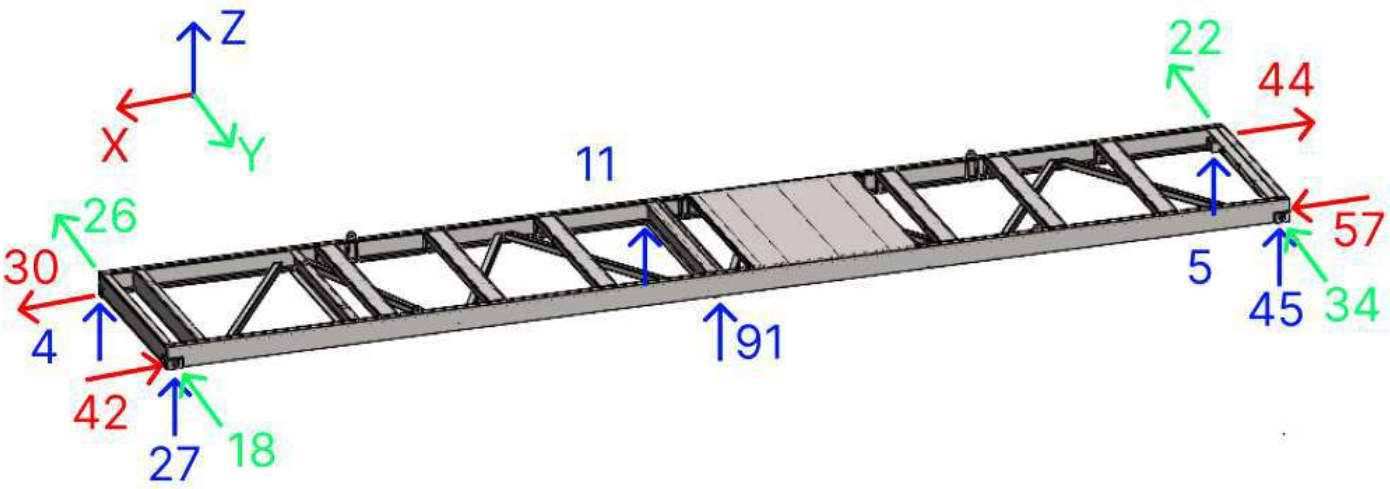


Fig 173: LC7-MAX - ULS - Reactions

10.7.2. LC7-MIN

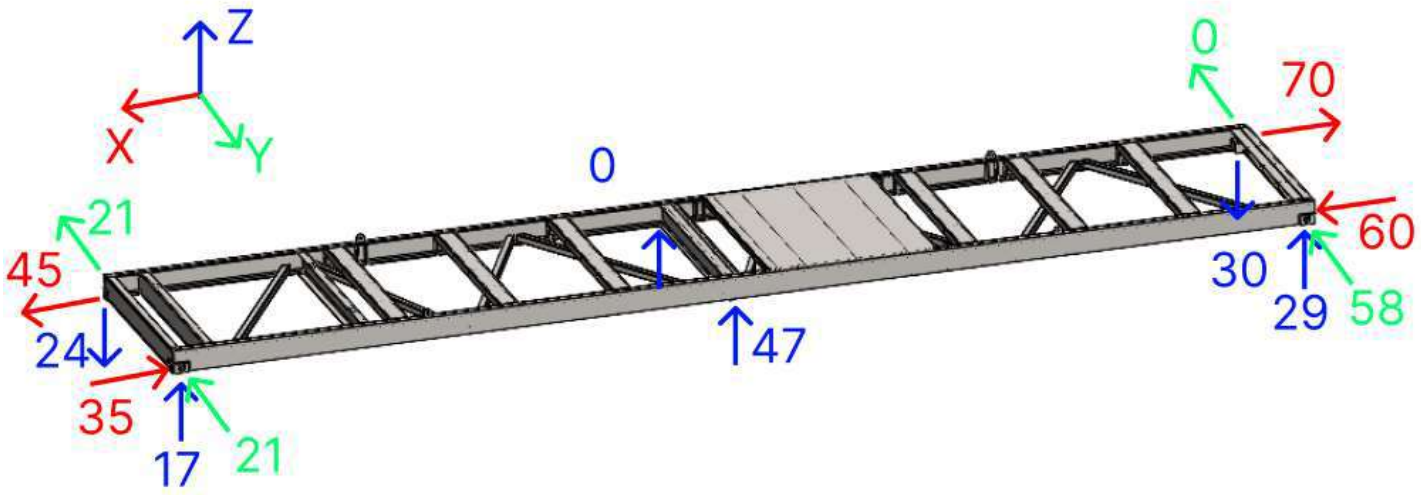


Fig 174: LC7-MIN - ULS - Reactions

10.8. LC8

10.8.1. LC8-MAX

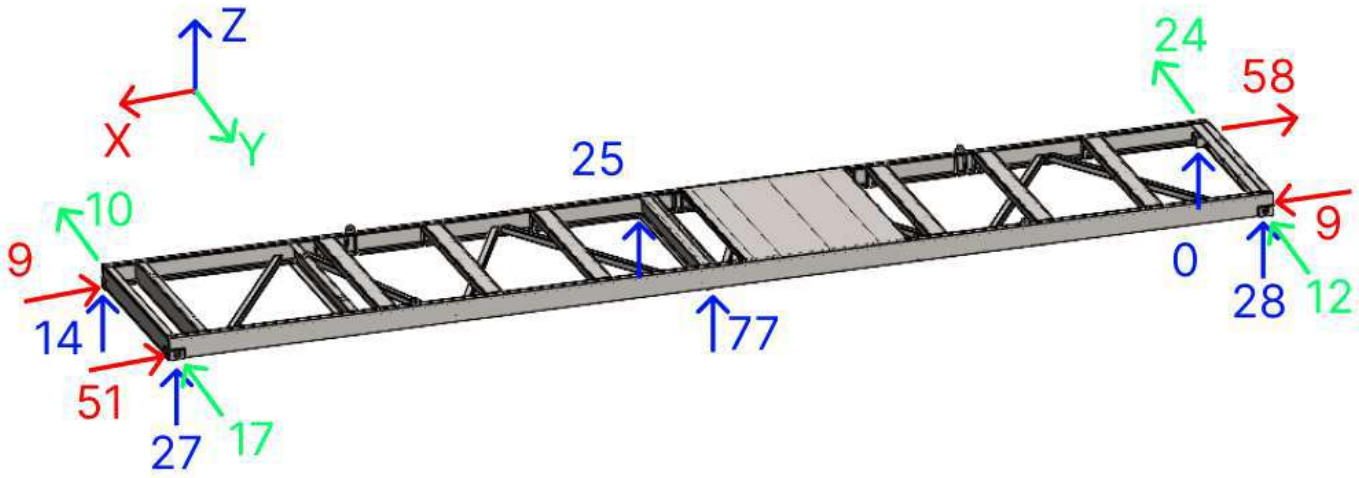


Fig 175: LC8-MAX - ULS - Reactions

10.8.2. LC8-MIN

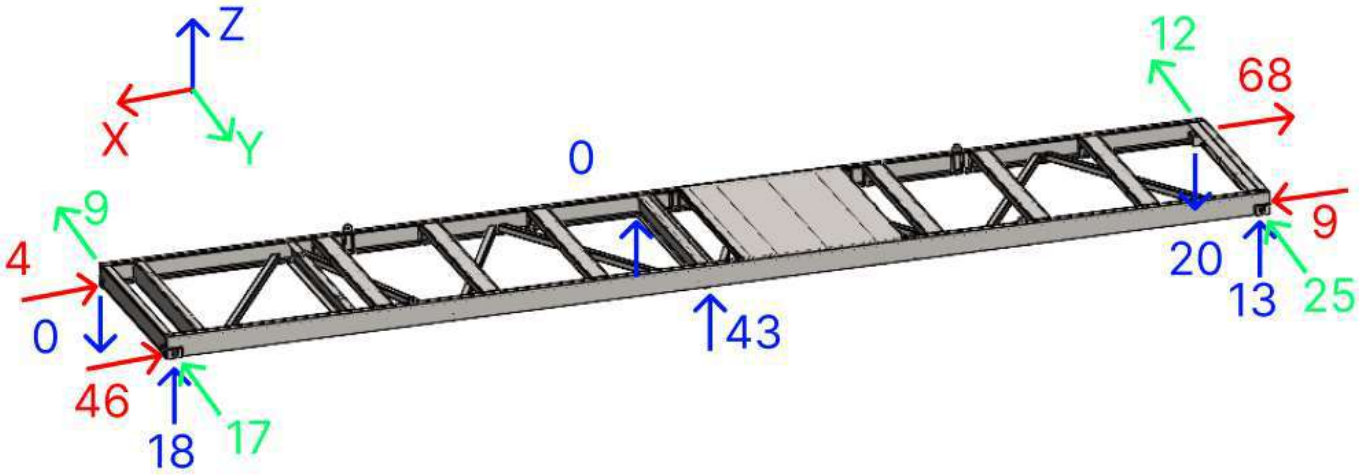


Fig 176: LC8-MIN - ULS - Reactions

10.9. LC9

10.9.1. LC9-MAX

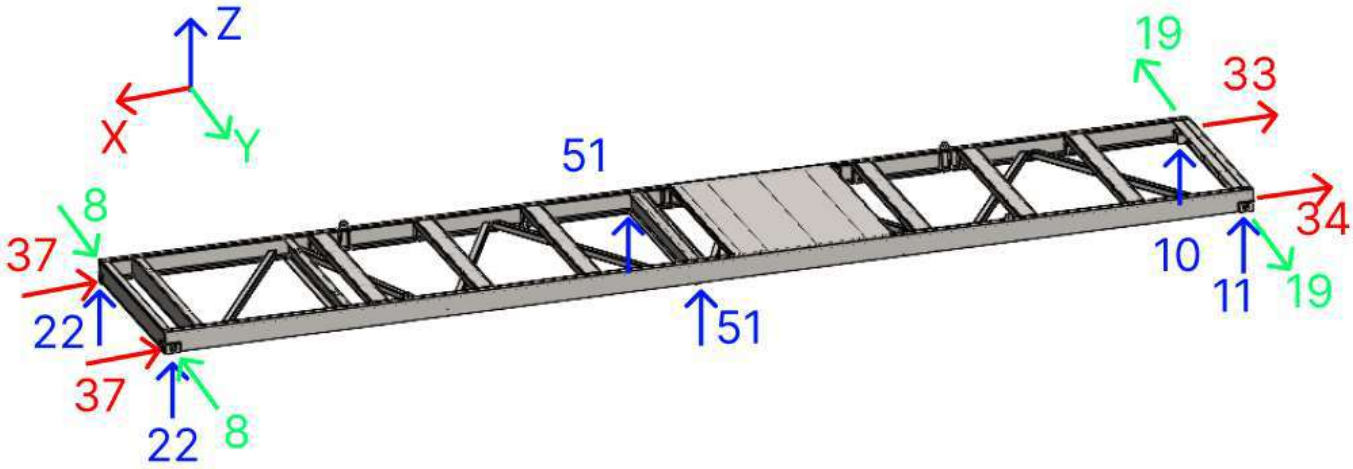


Fig 177: LC9-MAX - ULS - Reactions

10.9.2. LC9-MIN

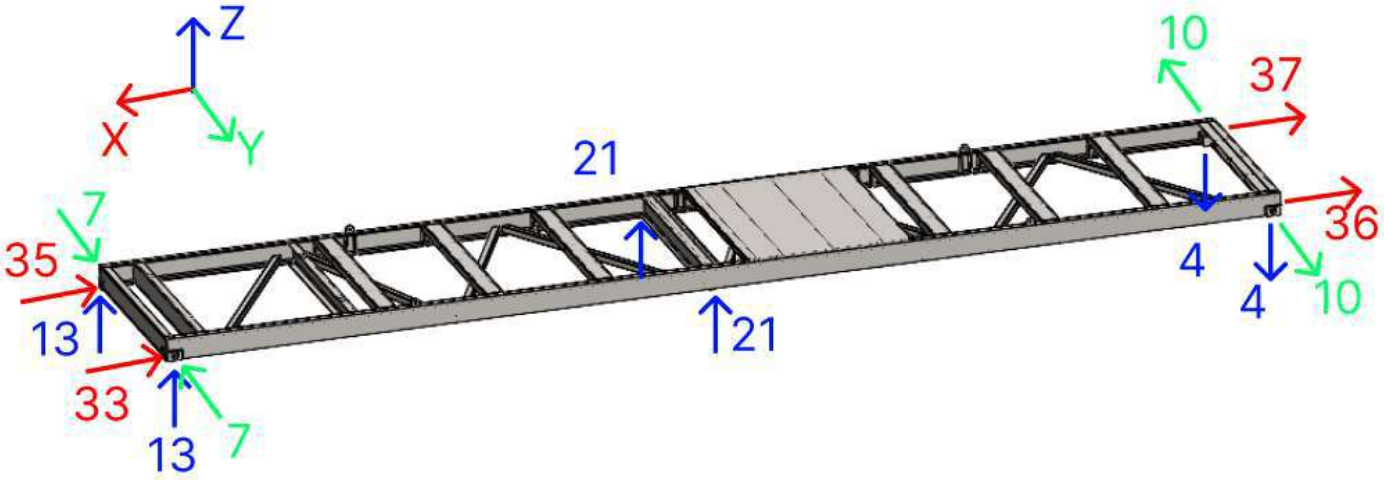


Fig 178: LC9-MIN - ULS - Reactions

10.10. LC10

10.10.1. LC10-MAX

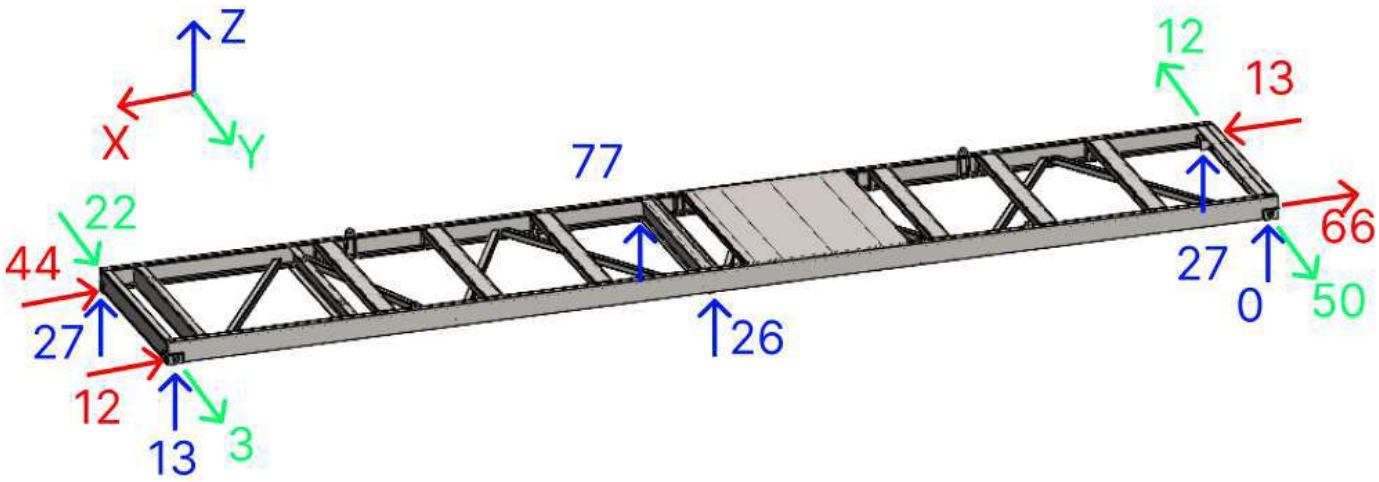


Fig 179: LC10-MAX - ULS - Reactions

10.10.2. LC10-MIN

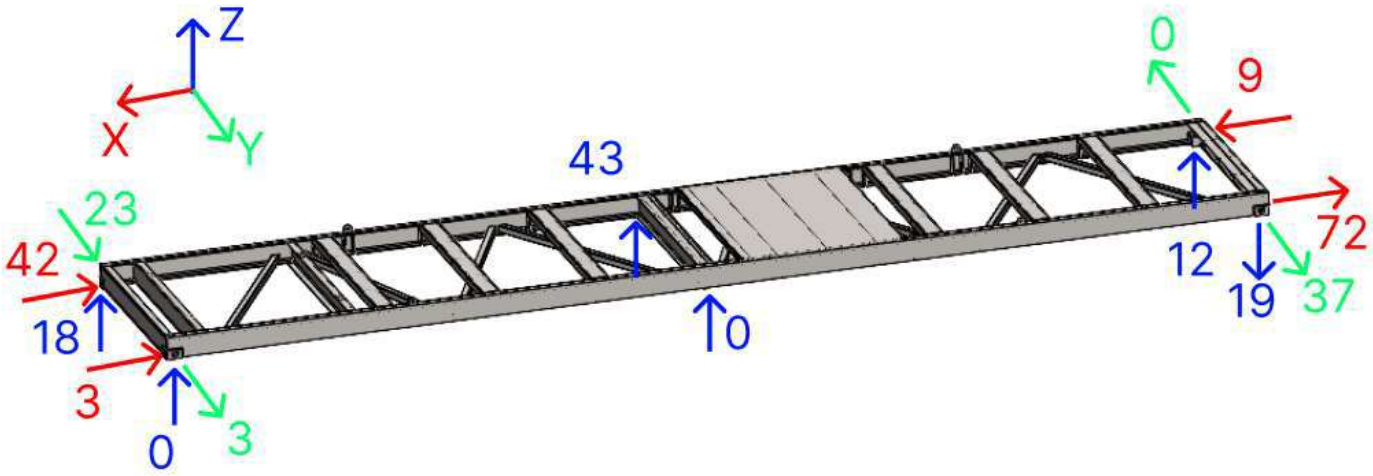


Fig 180: LC10-MIN - ULS - Reactions

10.11. LC11

10.11.1. LC11-MAX

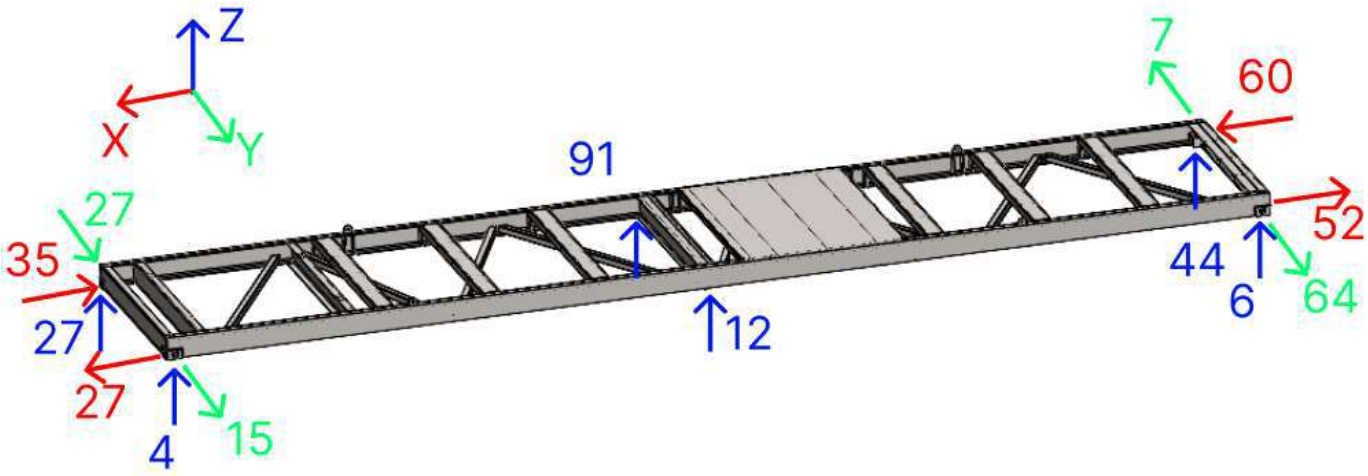


Fig 181: LC11-MAX - ULS - Reactions

10.11.2. LC11-MIN

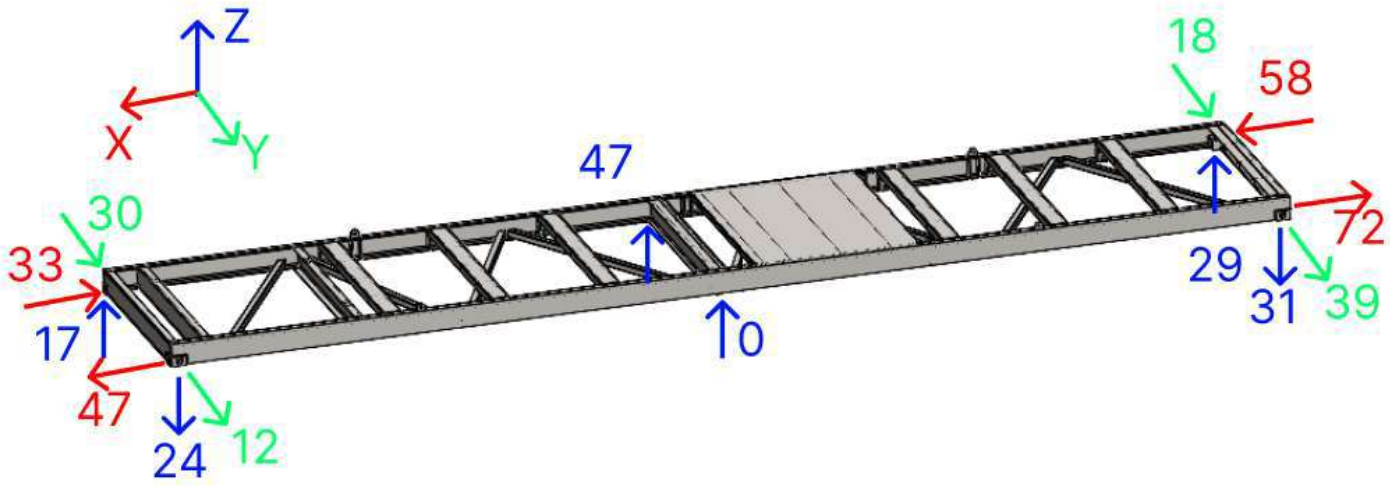


Fig 182: LC11-MIN - ULS - Reactions

10.12. LC12

10.12.1. LC12-MAX

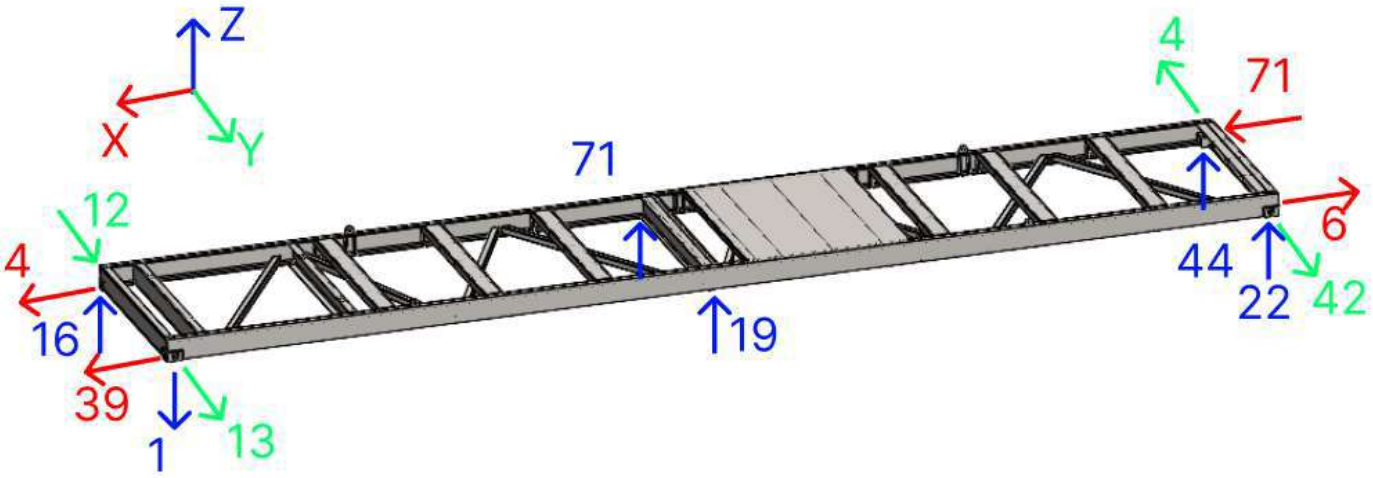


Fig 183: LC12-MAX - ULS - Reactions

10.12.2. LC12-MIN

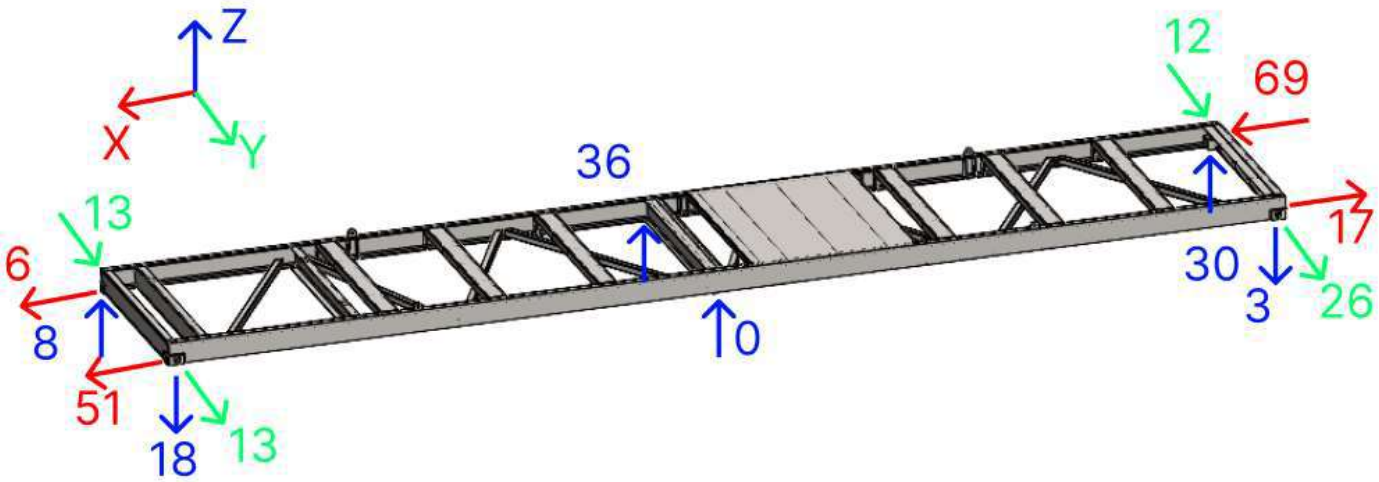


Fig 184: LC12-MIN - ULS - Reactions

10.13. LC13

10.13.1. LC13-MAX

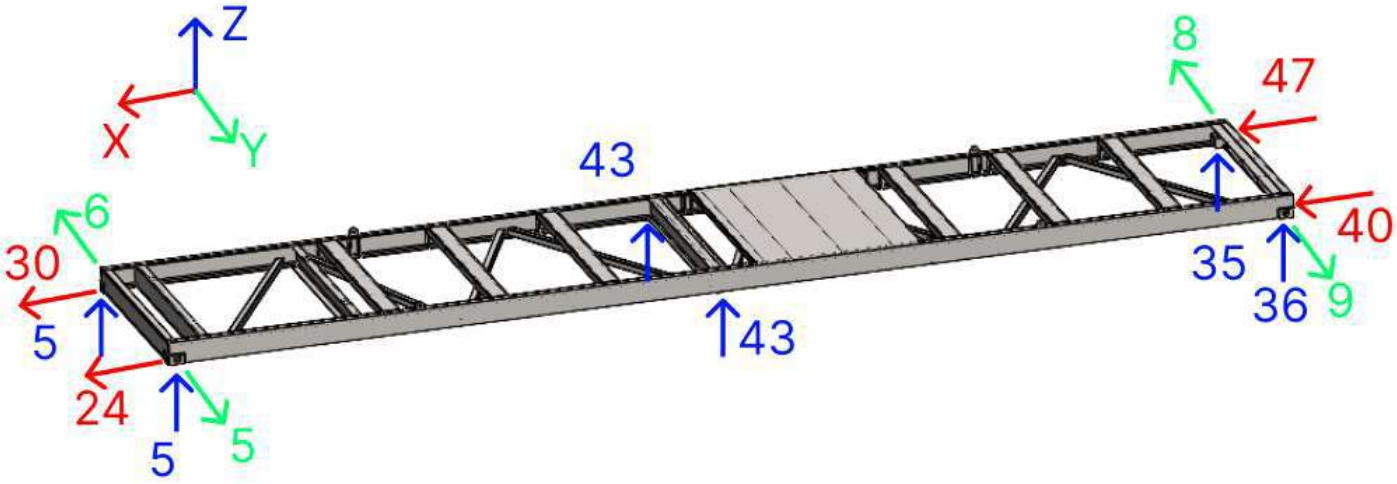


Fig 185: LC13-MAX - ULS - Reactions

10.13.2. LC13-MIN

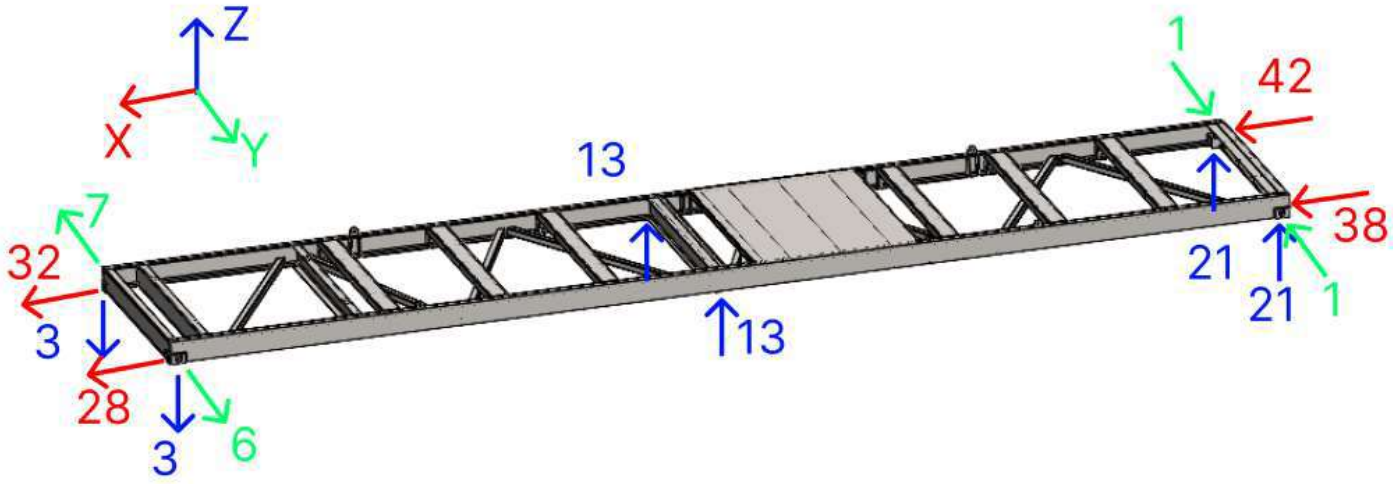


Fig 186: LC13-MIN - ULS - Reactions

10.14. LC14

10.14.1. LC14-MAX

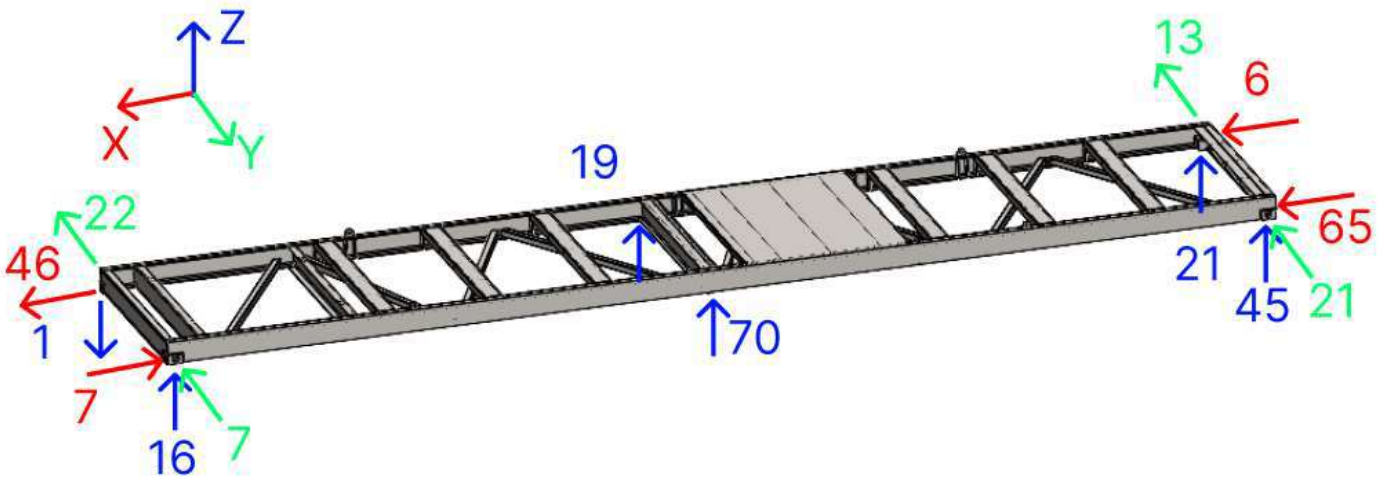


Fig 187: LC14-MAX - ULS - Reactions

10.14.2. LC14-MIN

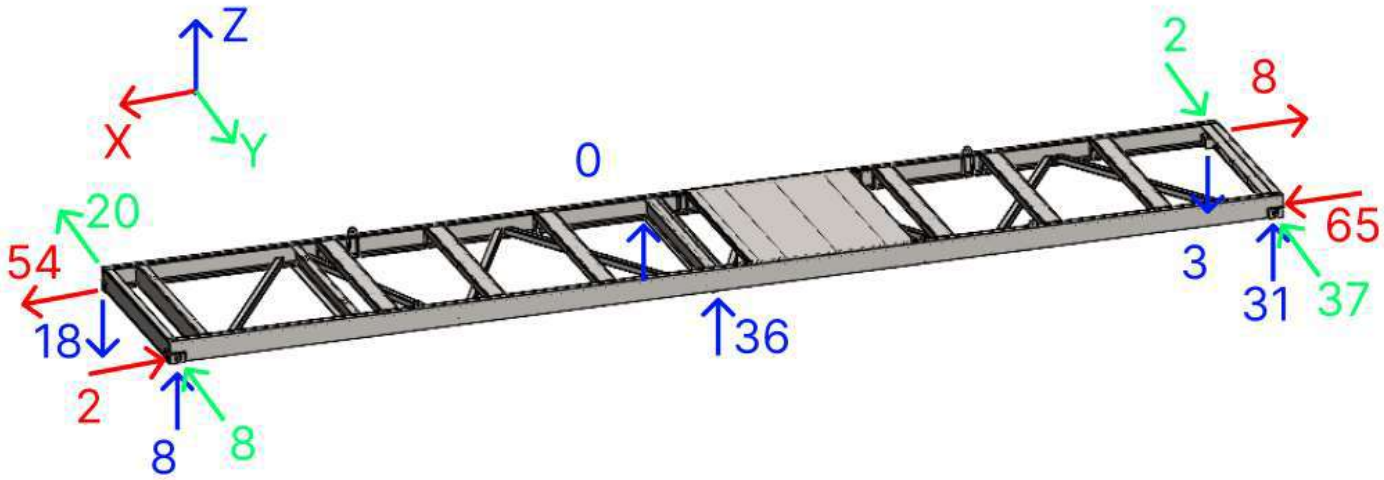


Fig 188: LC14-MIN - ULS - Reactions

10.15. LC15

10.15.1. LC15-MAX

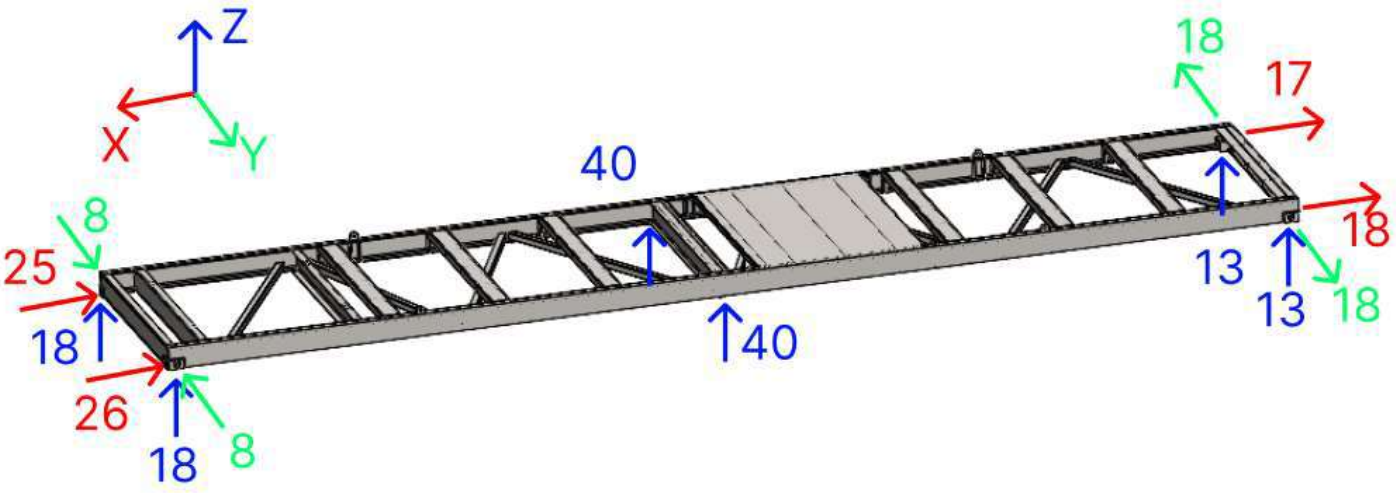


Fig 189: LC15-MAX - ULS - Reactions

10.15.2. LC15-MIN

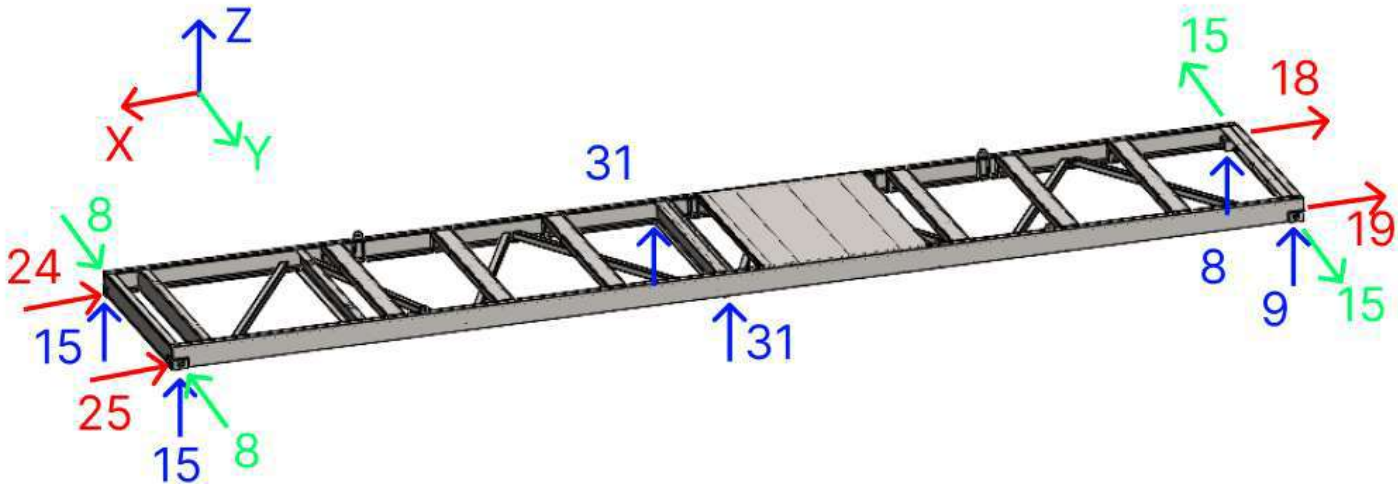


Fig 190: LC15-MIN - ULS - Reactions

10.16. LC16

10.16.1. LC16-MAX

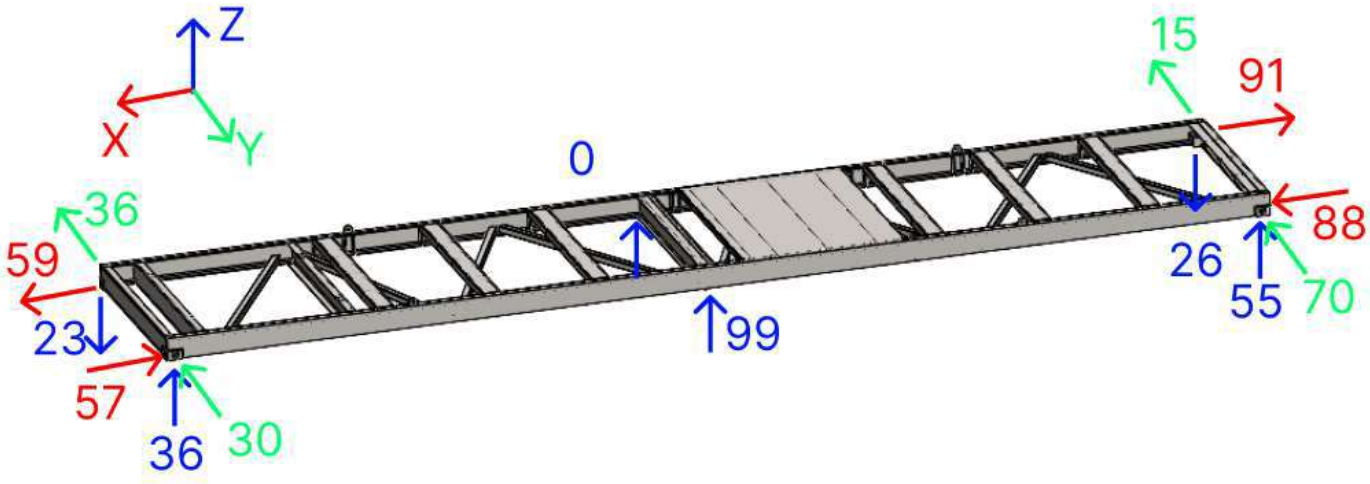


Fig 191: LC16-MAX - ULS - Reactions

10.16.2. LC16-MIN

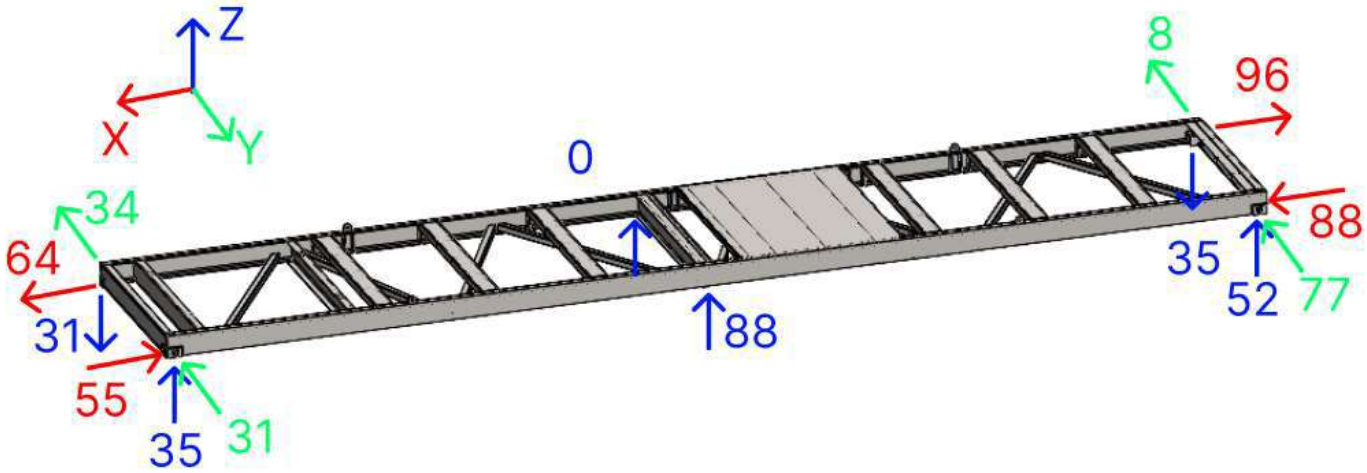


Fig 192: LC16-MIN - ULS - Reactions

10.17. LC17

10.17.1. LC17-MAX

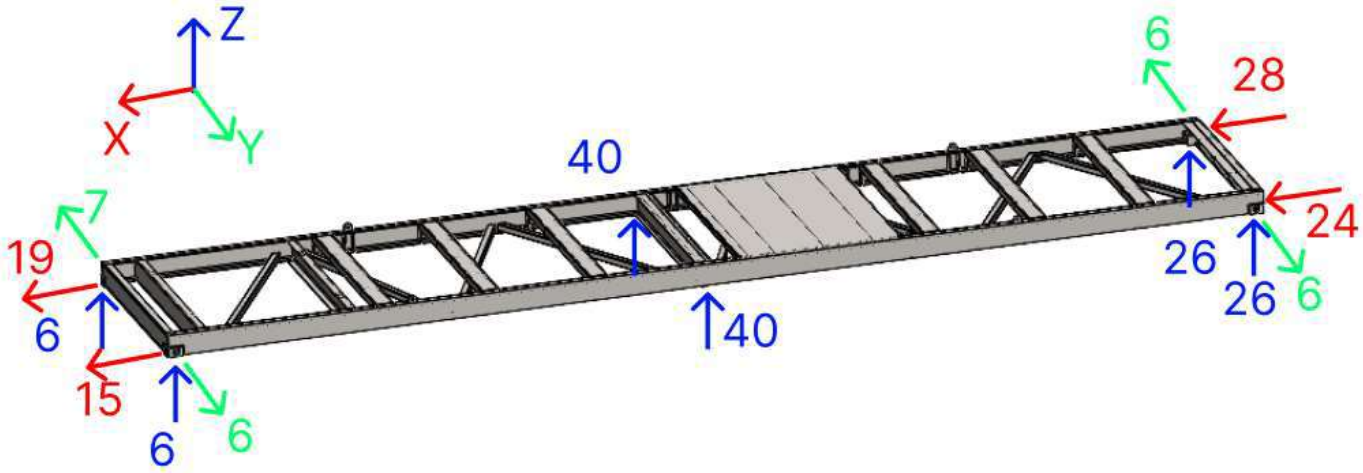


Fig 193: LC17-MAX - ULS - Reactions

10.17.2. LC17-MIN

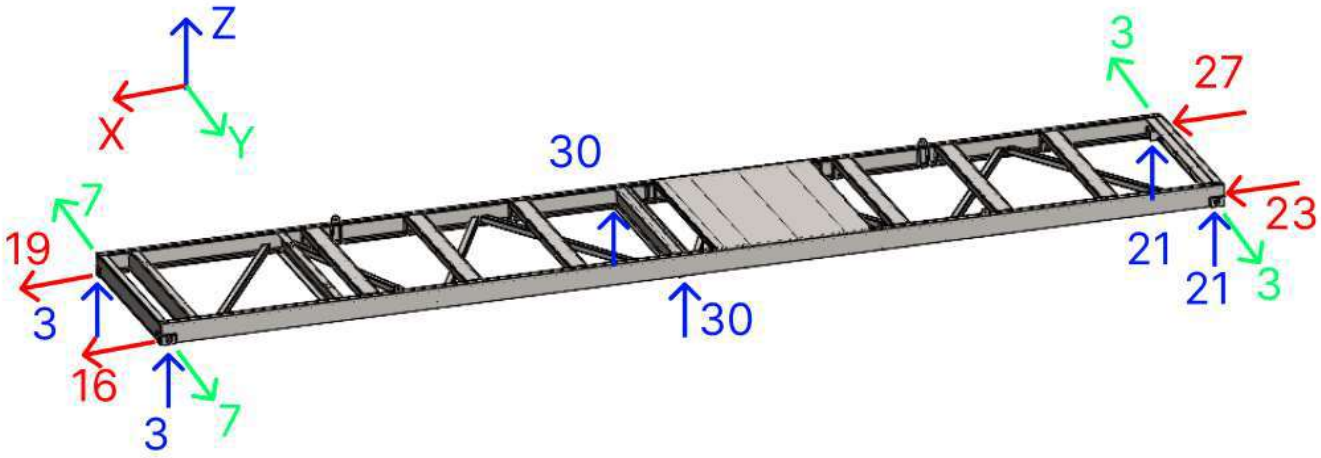


Fig 194: LC16-MIN - ULS - Reactions

10.18. LC18

10.18.1. LC18-MAX

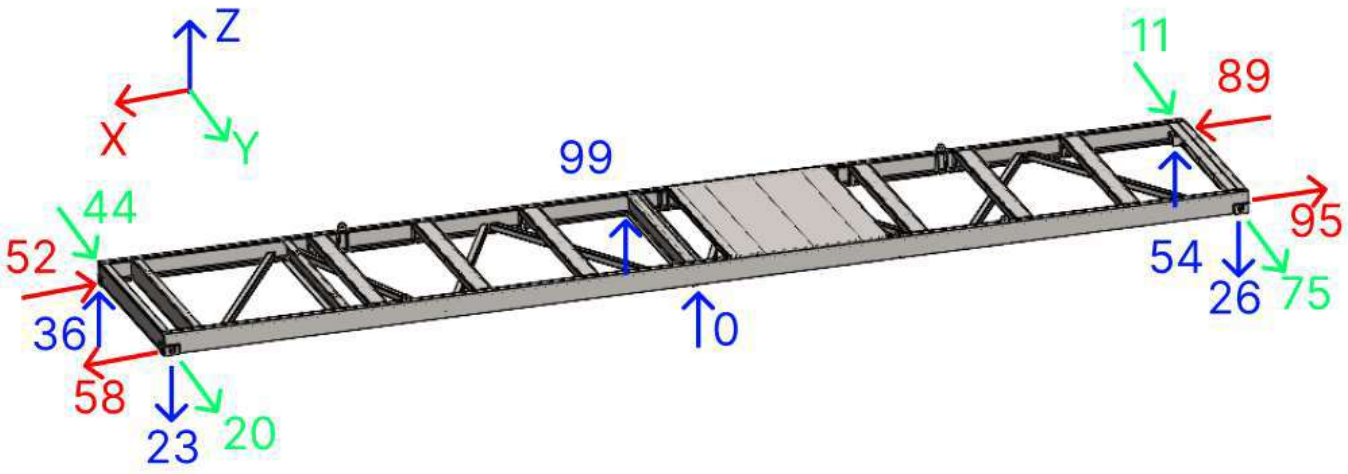


Fig 195: LC18-MAX - ULS - Reactions

10.18.2. LC18-MIN

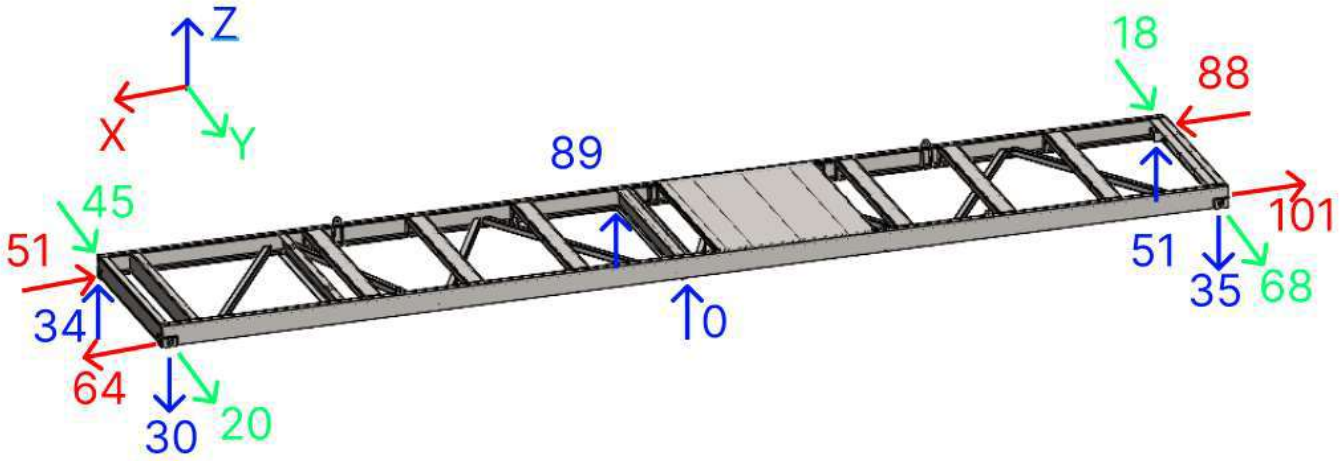


Fig 196: LC18-MIN - ULS - Reactions

11. Selection of shackles:

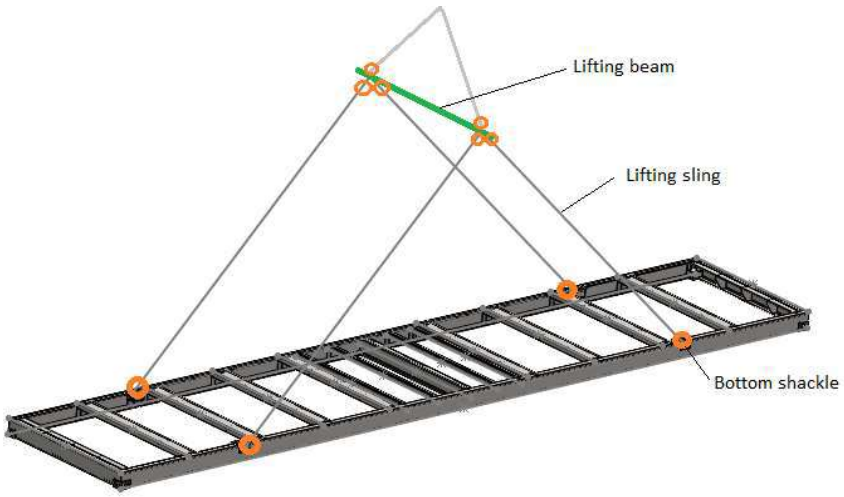


Fig 197: Schematic lifting scenario

40ft flatbed - dimensions [mm]								
No	Item	Weight		Qty	Mass symbol	X (L)	Y (W)	Z (H)
1,1	Rad. 1050kW (HT) (wet)	2681	kg	1	m2.01.1	3989	2200	2277
1,2	Rad. 1050kW (HT) (wet)	2681	kg	1	m2.01.2	3989	2200	2277
2,1	Rad. 110kW (LT) (wet)	435	kg	1	m2.02.1	2064	1452	885
3,1	Structure below rad. 110kW (LT) (in design)	250	kg	1	m2.03.1	1720	1452	1262
4,1	Cabinet no 1	450	kg	1	m2.04.1	1200	405	2384
4,2	Cabinet no 2	450	kg	1	m2.04.2	1200	405	2384
5,1	Pump	230	kg	1	m2.05.1	380	555	930
5,2	Pump	230	kg	1	m2.05.2	380	555	930
6,1	Walkway	100	kg	1	m2.06.1	876	1903	380
7,1	Piping - HT	250	kg	1	m2.07.1	380	2000	1500
7,2	Piping - HT	250	kg	1	m2.07.2	380	2000	1500
8,1	Piping - LT	200	kg	1	m2.08.1	380	900	2000
9,1	Header tank (wet)	100	kg	1	m2.09.1	554	604	304
9,2	Header tank (wet)	100	kg	1	m2.09.2	554	604	304
9,3	Header tank (wet)	100	kg	1	m2.09.3	554	604	304
10,1	Center frame	500	kg	1	m2.10.1	2400	2330	2830
11,1	Platform	2025	kg	1	m2.12.1	12192	2437	255
12,1	Wires	300	kg	1	m2.13.1	2400	2330	2830
	Total weight:	11332						Total:

11.1. Selection of 4 bottom shackles:

CARTEX product: 11.31GPGHBB22
(Bow Shackles with Screw Collar Pin G-4161)

Safety factor assumed by manufacturer: 6:1

WLL of the product: 6,5 tones

Weight of the product: 1,5kg

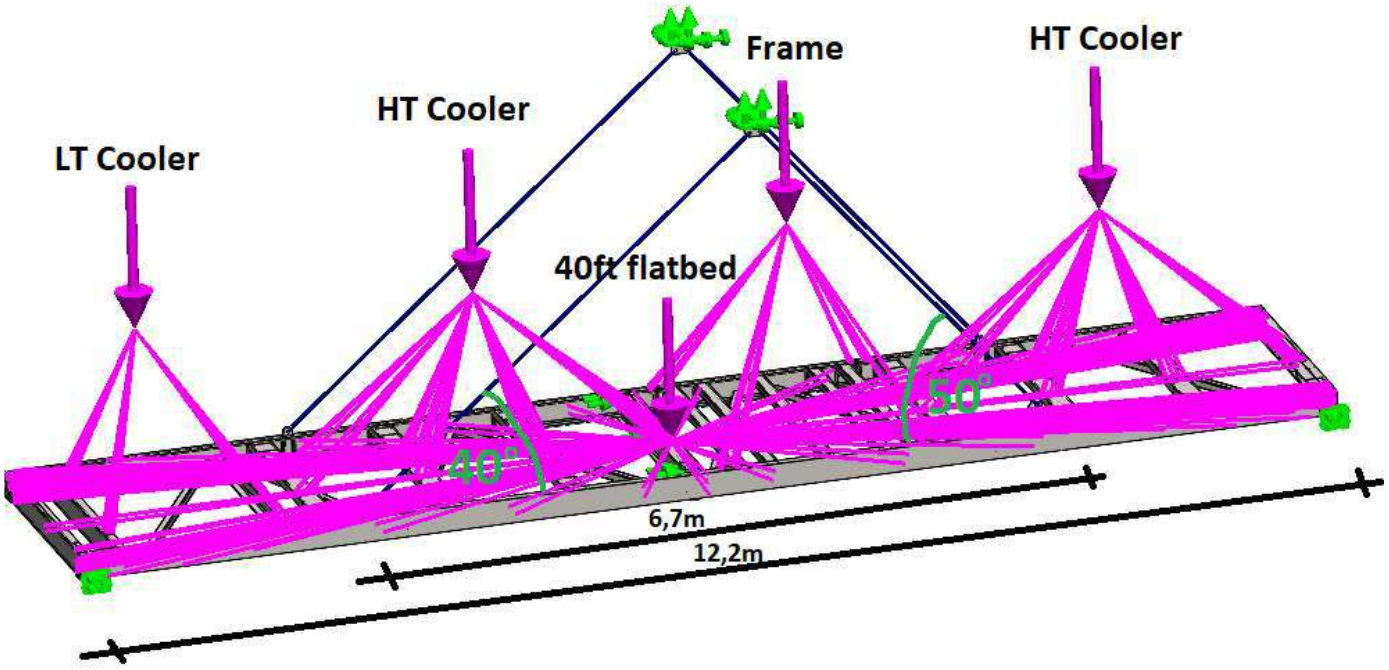


Fig 198: Schematic drawing of slings and bottom shackles

Characteristic load: $S_{WLL} := 9297\ \text{kg} \cdot 10\ \frac{\text{m}}{\text{s}^2} = 92,97\ \text{kN}$

Self weight of the flatbed: $S_{DL} := 2025\ \text{kg} \cdot 10\ \frac{\text{m}}{\text{s}^2} = 20,25\ \text{kN}$

Assumed total characteristic load: $S_{total} := S_{DL} + S_{WLL} = 113,22\ \text{kN}$

Work Life Load of one shackle: $WLL_{S1} := 6,5\ \text{t} \cdot 10\ \frac{\text{m}}{\text{s}^2} = 65\ \text{kN}$

Assumed angle between structural ropes: $\alpha := 90,0\ \text{deg}$

Angle on side of LT Cooler: $\alpha_1 := 40,0\ \text{deg}$

Angle on side of HT Cooler: $\alpha_2 := 50,0\ \text{deg}$

Reaction force in one sling on side of LT Cooler (40 degrees):

$F_{w1} := 37\ \text{kN}$

Reaction force in one sling on side of HT Cooler (50 degrees):

$F_{w2} := 43\ \text{kN}$

Horizontal reaction force on side of LT Cooler: $F_{h1} := F_{w1} \cdot \cos\left(\alpha_1\right) = 28,3\ \text{kN}$

Horizontal reaction force on side of HT Cooler: $F_{h2} := F_{w2} \cdot \cos\left(\alpha_2\right) = 27,6\ \text{kN}$

The horizontal forces are almost equal so the platform is in equilibrium.

Vertical force for one sheckle on side of LT Cooler: $F_{y1} := F_{w1} \cdot \sin\left(\alpha_1\right) = 23,8\ \text{kN}$

Vertical force for one sheckle on side of HT Cooler: $F_{y2} := F_{w2} \cdot \sin\left(\alpha_2\right) = 32,9\ \text{kN}$

$S_{total} = 113,22\ \text{kN}$

$F_{y1} \cdot 2 + F_{y2} \cdot 2 = 113,45\ \text{kN}$

Strength check:

$F_{w1} < WLL_{S1} = 1$ $\qquad \frac{F_{w1}}{WLL_{S1}} = 0,5692$ $\qquad \frac{F_{w2}}{WLL_{S1}} = 0,6615$

Resultant force for one shackle < WLL of one shackle

11.2. Geometry of the pin attachment

CARTEX product: 11.31GPGHBB22
(Bow Shackles with Screw Collar Pin G-4161)

Safety factor assumed by manufacturer: 6:1

WLL of the product: 6,5 tones

Weight of the product: 1,5kg

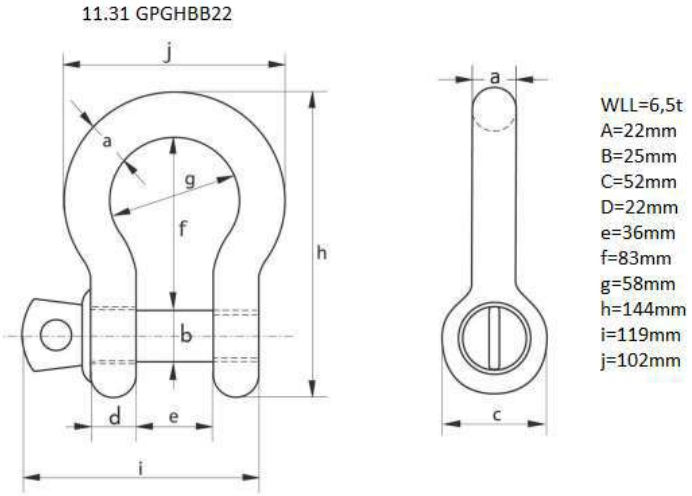


Fig. 199:Geometry of the selected bow shackle with screw collar pin G-4161

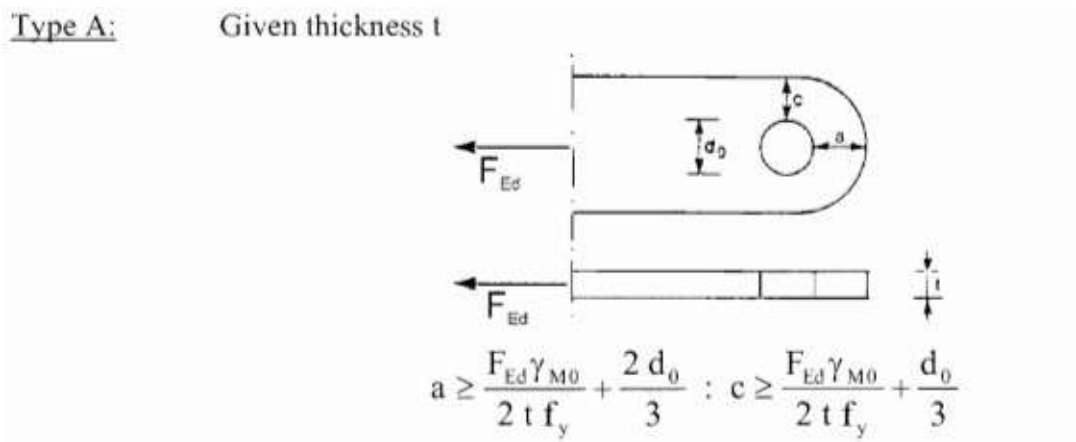


Fig. 200:Geometry of attachment for given thickness [EN 1993-1-8: Table 3.9]

Limit design stresses in structural members (acc. to EN-13155, A.1.2, Table A.1):

- for structural members: steel S355 $f_y := 345\ MPa$

16mm ≤ t ≤ 40mm $f_u := 450\ MPa$ [EN13155; A.1.1]

$\alpha_1 = 40\ deg$ $\alpha_2 = 50\ deg$ $F_{w1} = 37\ kN$ $F_{w2} = 43\ kN$

$S_{total} = 1,13 \cdot 10^{5}\ N$ $\gamma_{M0} := 1$ (partial safety factor)

$f_{y10} := 345\ MPa$ (reduced because of the thickness)

$t_{10} := 30\ mm$ (thickness of the element)

$d_{0,10} := 27\ mm$ (diameter of the hole)

Total design load (SF=2): $F_{lift,Ed} := 2 \cdot F_{w2} = 86\ kN$

Assumed angle between structural ropes: $\alpha_1 := 90,0\ deg$

Vertical force for one sheckle (SF=2): $F_{y2,Ed} := F_{lift,Ed} \cdot \sin\left(\alpha_2\right) = 65,88\ kN$

Horizontal force for one sheckle (SF=2): $F_{x2,Ed} := F_{lift,Ed} \cdot \cos\left(\alpha_2\right) = 55,28\ kN$

Check of calculations (SF=2): $\sqrt{F_{x2,Ed}^{2} + F_{y2,Ed}^{2}} = 86\ kN$

$$a \geq \frac{F_{lift,Ed} \cdot \gamma_{M0}}{2 \cdot t_{10} \cdot f_{y10}} + \frac{2 \cdot d_{0,10}}{3} = 22,1546\ mm$$

$$c \geq \frac{F_{lift,Ed} \cdot \gamma_{M0}}{2 \cdot t_{10} \cdot f_{y10}} + \frac{d_{0,10}}{3} = 13,1546\ mm$$

Therefore, below values have been assumed:

$a_{10} := 25\ mm$

$c_{10} := 25\ mm$

11.3. Ultimate Limit State of pad eye - hand calculations

As the sheckle has been assumed from catalogue, the bending resistance of the pin and shear resistance of the pin can be omitted. Safety factor assumed by producent (1:6 or 1:5) is very save assumption. However resistance of structural pad eye should be taken into account.

Pin material - assumed stronger than connected parts material.

Connected parts material: S355 $f_{y10} = 345\ MPa$ $f_{u10} := 450\ MPa$

1.) Limit design bending moment for pin: not considered

2.) Limit design shear force for the pin: not considered

3.) Limit design bearing force for pin and connected parts:

$t_{10} = 30\ mm$ $\gamma_m := 1,1$

$\gamma_{spb} := 0,9$ $\gamma_{Rp} := \gamma_m \cdot \gamma_{spb} = 0,99$

$a_b := 1$ $d_{10} := 25\ mm$

$$F_{bRd,10} := \frac{a_b \cdot d_{10} \cdot t_{10} \cdot f_{y10}}{\gamma_{Rp}} = 261,3636\ kN$$ [EN13001-3-1; p.5.2.4.3]

4.) Limit design shear force for connected parts:

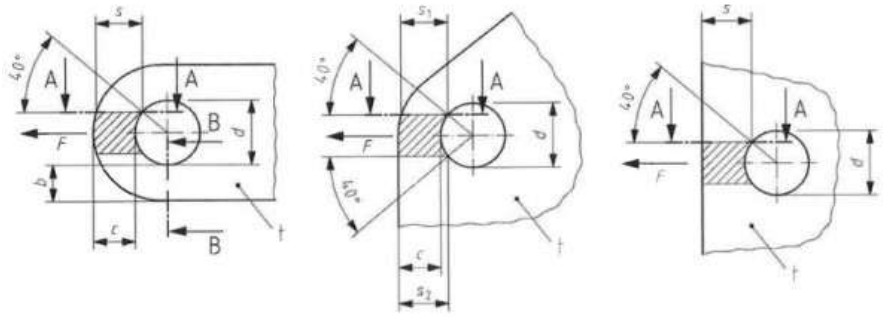


Fig. 201: Shear area in accordance to EN-13001-3-1, p. 5.2.4.4

$s_{10} := 28,7\ mm$

$t_{10} = 30\ mm$

$A_{s10} := 2 \cdot s_{10} \cdot t_{10} = 1722\ mm^2$

$$F_{vs,Rd,10} := \frac{A_{s10} \cdot f_{y10}}{\gamma_m \cdot \sqrt{3}} = 311,8164\ kN$$ [EN13001-3-1; p.5.2.4.4]

5.) Limit design tensile force for connected parts:

$c_{10} = 25\ mm$

$d_{10} = 25\ mm$

$s_{10} = 28,7\ mm$

$b_{10} := 25\ mm$

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$0{,}5 \le \frac{b_{10}}{d_{10}} = 1 \le 1 \qquad 1 \le \frac{c_{10}}{b_{10}} = 1 \le 2$

requirments met so k-factor shall be taken from fig. 7; EN13001-3-1

$k := 3{,}4$

$\gamma_{spt} := \frac{0{,}95}{\sqrt{k}} \cdot \frac{1{,}38 \cdot f_{y10}}{f_{u10}} = 0{,}5451$

$F_{vt,Rd,10} := \frac{2 \cdot b_{10} \cdot t_{10} \cdot f_{y10}}{k \cdot \gamma_m \cdot \gamma_{spt}} = 253{,}8452\ \text{kN}$ [EN13001-3-1; p.5.2.4.5]

6.) Limit resistance force for connected part (pad eye):

$F_{10,Rd} := \min\left(\begin{bmatrix} F_{bRd,10} \\ F_{vs,Rd,10} \\ F_{vt,Rd,10} \end{bmatrix}\right) = 253{,}8452\ \text{kN}$

$F_{lift,Ed} = 86\ \text{kN}$

Utilization factor:

$\frac{F_{lift,Ed}}{F_{10,Rd}} = 33{,}88\ \%$

11.4. Fillet welds between beams and padeyes for shackles

$\beta_{w,S355} := 0{,}9 \qquad \gamma_{M2} := 1{,}35 \qquad \alpha_1 = 90\ \text{deg}$

$a_{fw2} := 5\ \text{mm}$ $\qquad F_{lift,Ed} = 86\ \text{kN}$

$X_{10} := 101\ \text{t}$ $\qquad F_{x2,Ed} = 55{,}2797\ \text{kN}$

$l_{fw2,short} := 30\ \text{mm}$ $\qquad F_{y2,Ed} = 65{,}8798\ \text{kN}$

$l_{fw2,long} := 100\ \text{mm}$

$A_{fw2,short} := 2 \cdot a_{fw2} \cdot l_{fw2,short} = 300\ \text{mm}^2$

$A_{fw2,long} := 2 \cdot a_{fw2} \cdot l_{fw2,long} = 1000\ \text{mm}^2$

$A_{fw2} := A_{fw2,short} + A_{fw2,long} = 1300\ \text{mm}^2$

$\sigma_{fw2} := \frac{F_{y2,Ed}}{A_{fw2}} = 50{,}6768\ \text{MPa}$

$\sigma_{fw2,perp} := \frac{\sigma_{fw2}}{\sqrt{2}} = 35{,}8339\ \text{MPa}$ (vertical force in all welds)

$\tau_{fw2,perp} := \sigma_{fw2,perp} = 35{,}8339\ \text{MPa}$

$\tau_{fw2,par} := \frac{F_{x2,Ed}}{A} = 55{,}2797\ \text{MPa}$ (horizontal force only in longer weld)

$$\sqrt{\sigma_{fw2,perp}^{2} + 3 \cdot \left(\tau_{fw2,perp}^{2} + \tau_{fw2,par}^{2} \right)} = 119,5986 \text{ MPa}$$

$$\frac{f_u}{\beta_{w,S355} \cdot \gamma_{M2}} = 370,3704 \text{ MPa} \qquad \frac{0,9 \cdot f_u}{\gamma_{M2}} = 300 \text{ MPa}$$

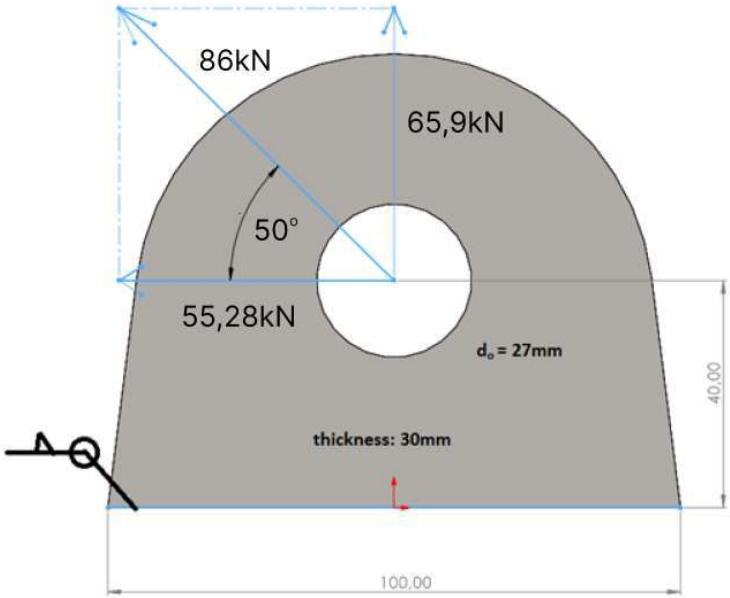


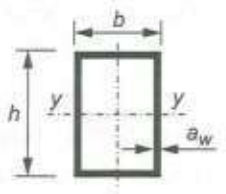
Fig. 202: Geometry of the structural attachment and applied forces

with bending moment:

$$e_{pin} := 40 \text{ mm}$$

$$M_{fw1} := F_{x2,Ed} \cdot e_{pin} = 2,21 \text{ kN m}$$

$$x_{fw1} := \frac{l_{fw2,long}}{2} + \frac{a_{fw2}}{2} = 52,5 \text{ mm}$$



$A_w = a_w 2(h+b)$ | $I_y = a_w \frac{h^3 + 3bh^2}{6}$ | $I_0 = a_w \frac{(h+b)^3}{6}$

$$I_{z,fw2} := a_{fw2} \cdot \frac{\left(l_{fw2,long} \right)^3 + 3 \cdot l_{fw2,short} \cdot \left(l_{fw2,long} \right)^2}{6} = 158,3333 \text{ cm}^4$$

$$\sigma = \frac{F_{Ed}}{A_w} + \frac{M_{y,Ed}}{I_y} z$$

$$\sigma_{fw2,M} := \frac{M_{fw1}}{I_{z,fw2}} \cdot x_{fw1} = 73,3184 \text{ MPa}$$

$$\sigma_{fw2,total} := \sigma_{fw2} + \sigma_{fw2,M} = 123,9952 \text{ MPa}$$

$$\sigma_{fw2,perp,total} := \frac{\sigma_{fw2,total}}{\sqrt{2}} = 87,6778 \text{ MPa}$$ (vertical force in all welds)

$$\tau_{fw2,perp,total} := \sigma_{fw2,perp,total} = 87,6778\ \text{MPa}$$

$$\tau_{fw2,par} := \frac{F_{x2,Ed}}{A_{fw2,long}} = 55,2797\ \text{MPa}$$ (horizontal force only in longer weld)

$$\sqrt{\sigma_{fw2,perp,total}^{2} + 3 \cdot \left(\tau_{fw2,perp,total}^{2} + \tau_{fw2,par}^{2} \right)} = 199,7928\ \text{MPa}$$

$$\frac{f_u}{\beta_{w,S355} \cdot \gamma_{M2}} = 370,3704\ \text{MPa} \qquad \frac{0,9 \cdot f_u}{\gamma_{M2}} = 300\ \text{MPa}$$

Utilization factor:

$$\frac{199,09\ \text{MPa}}{300\ \text{MPa}} = 66,36\ \%$$

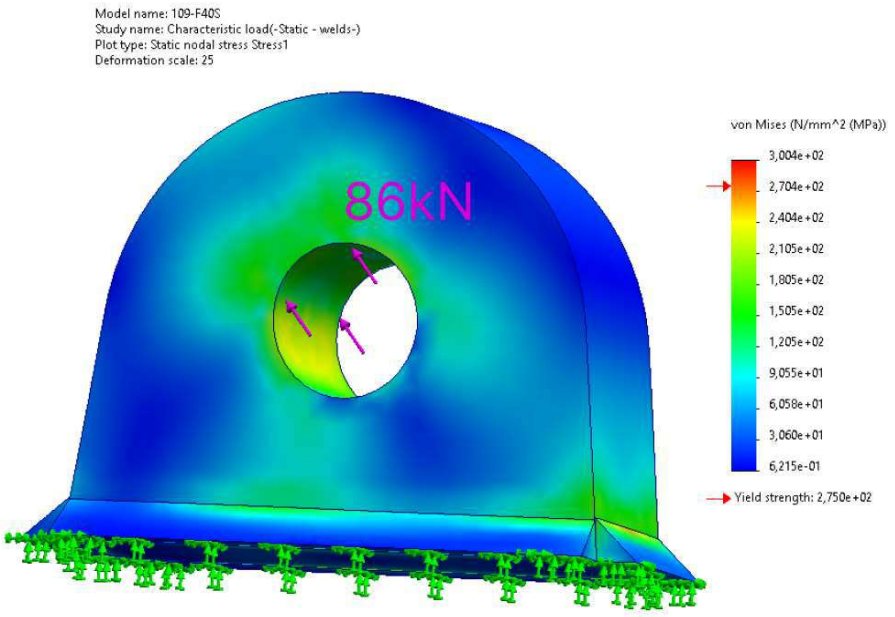


Fig. 203: Additional check of stress in ULS in welds around the pad-eye

12. Serviceability limit state

In accordance to “Polski Rejestr Statków, Rules for the Construction of Containers, Gdańsk, 2014” point 3.3 .1 states:
“In containers subjected to static and/or dynamic tests with the load distributed uniformly by a gravity force equivalent to a mass of 1.8 R, no part of the base structure is to protrude by more than 6 mm below the lower surface of the bottom corner fittings.”

As shown on figure no 2, the lowest surface of the bottom corner fitting is 15mm below the lowest base structure surface.
It has been assumed that during operation tha maximum deflection of the main beams can not be bigger then 15mm for characteristic loads (LC1 to LC4 and LC7 to LC16), so the structure will be only supported in assumed places (at ends on ISO corners, and in the middle where is designed additional support).

As shown in previous pictures in this paper, for Ultimate Limit State, the deflection in main beams downwards is never bigger then 15mm.
In case of upwards deflection of main beams the biggest deflection occurs for LC16min load case:
As the beam has length of L=12200mm, it has been assumed that the biggest deflection should be lower then L/300=12200/300=40mm and this requirement is met.

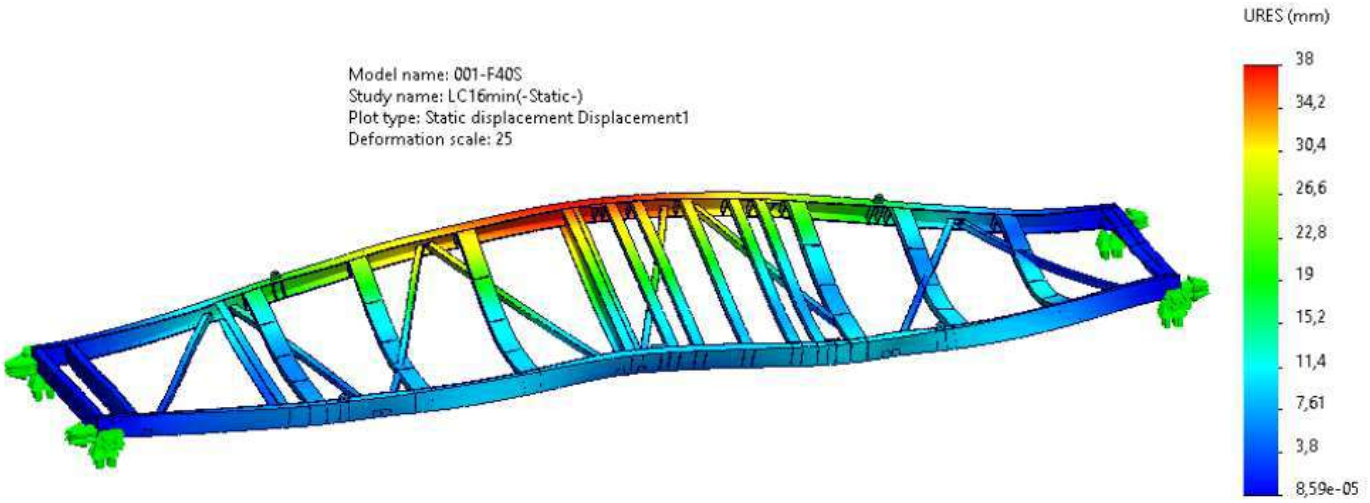


Fig. 204: The biggest upward deflection of main beams for LC16min

13. Summary and conclusion

Designed 40ft flatbed of steel S355 is strong enough to carry the design load during transport by semi-trailer on road, during transport on barge and during lifting by lifting sets. It is also suitbale for placing it on the top of 40ft custom made container solution which provide middle vertical support for flatbed (point 7.6 Boundary conditions).

The structure does not experience excessive stresses or deformations in any load case.

Transportation phase:

During transport appropriate semi-trailer has to be chosen which provides middle vertical support for the designed flatbed:



Fig 205: Example of INAPPROPRIATE semi-trailer which does not support flatbed vertically in the middle (red circles)



Fig 206: Example of APPROPRIATE semi-trailer which has locks for ISO cubes in corners and supports designed flatbed in the middle vertically.

Lifting phase:

Bow shackle with screw collar pin G-4161: 11.31GPGHBB22 (CARTEX product) has been assumed for lifting

Safety factor assumed by manufacturer: 6:1
WLL of the product: 6,5 tones
Weight of the product: 1,5kg

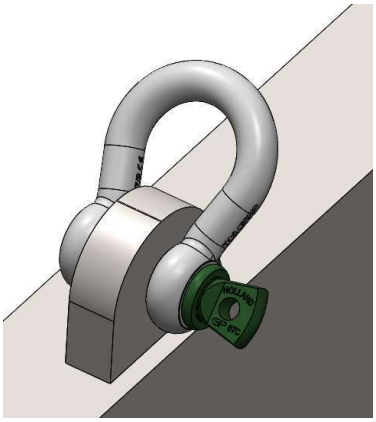


Fig 207: 11.31GPGHBB22 (CARTEX product) - with designed pad-eye

Flatbed can be lifted in two different ways:

First scenario:

- required one container lifting beam (2368mm - distance between green slings at lifting beam)

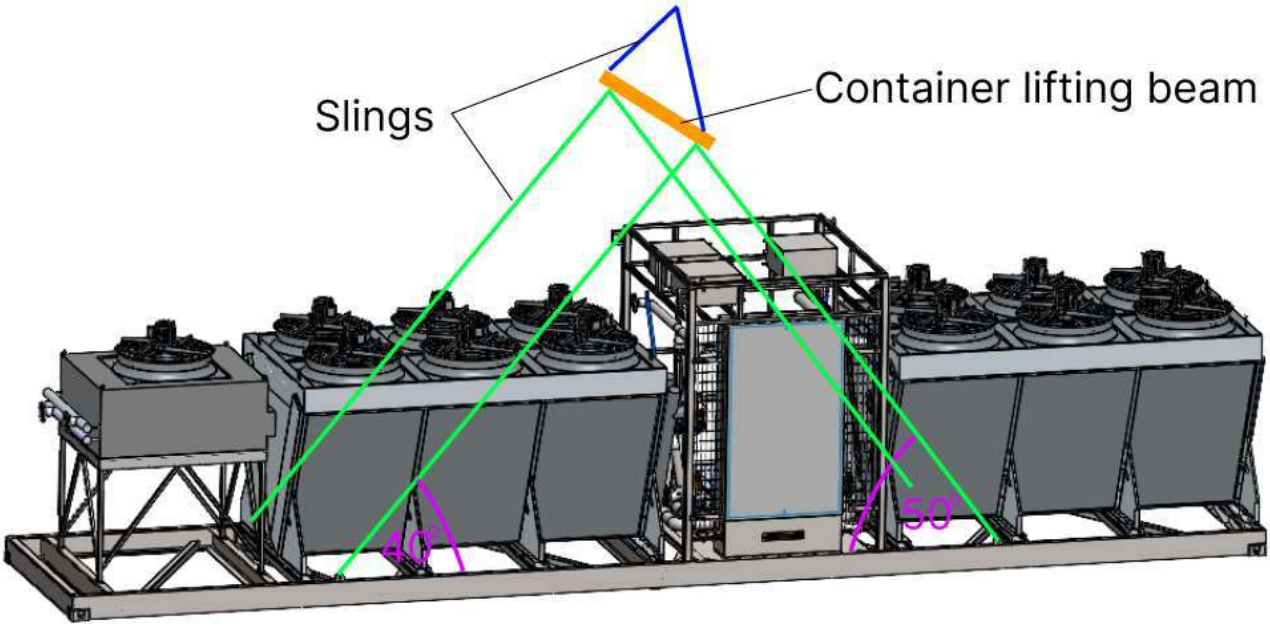


Fig 208: First lifting scenario (40 and 50 degrees)

Second scenario:

- required two container lifting beams no 1: (2368mm - distance between green slings at lifting beam)
- required one container lifting beam no 2: (6692mm - distance between blue slings at lifting beam)

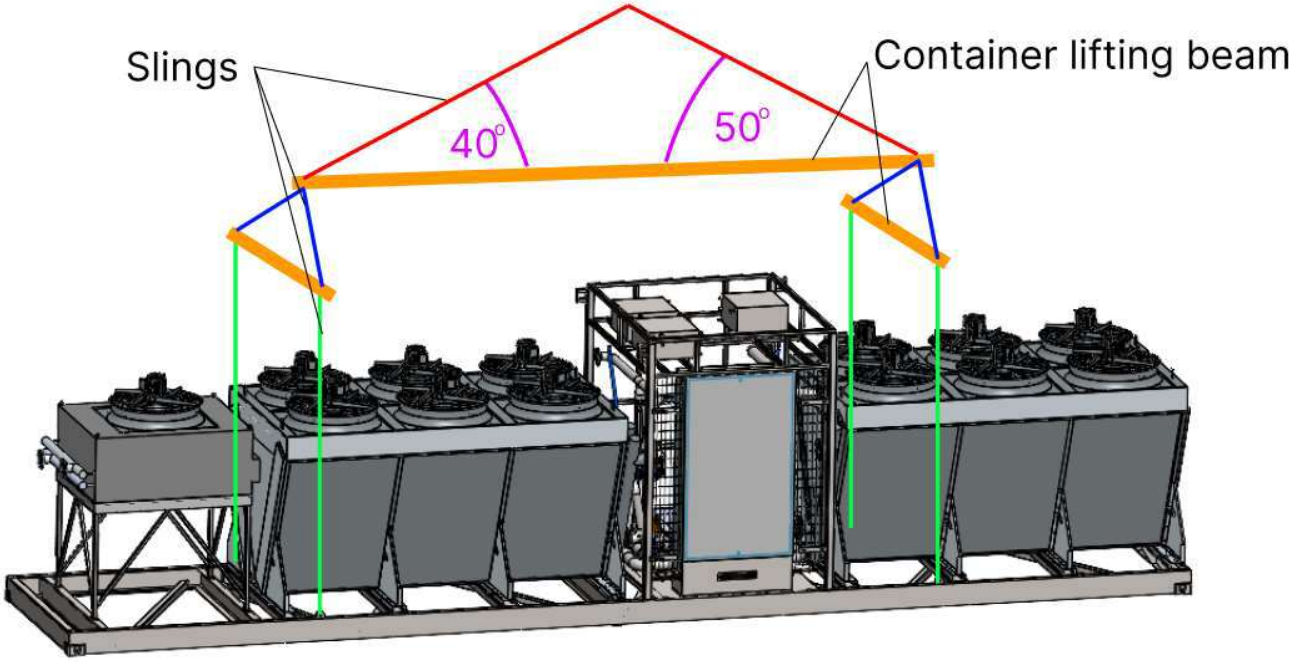


Fig 209: Second lifting scenario - vertical lifting

Destination place phase:

Flatbed has been designed in such a way that will have six points of supports at destination place:

At corners has to be locked by standarised ISO Locks:



Fig 210: Standarised ISO twist lock - example

Great Back Office

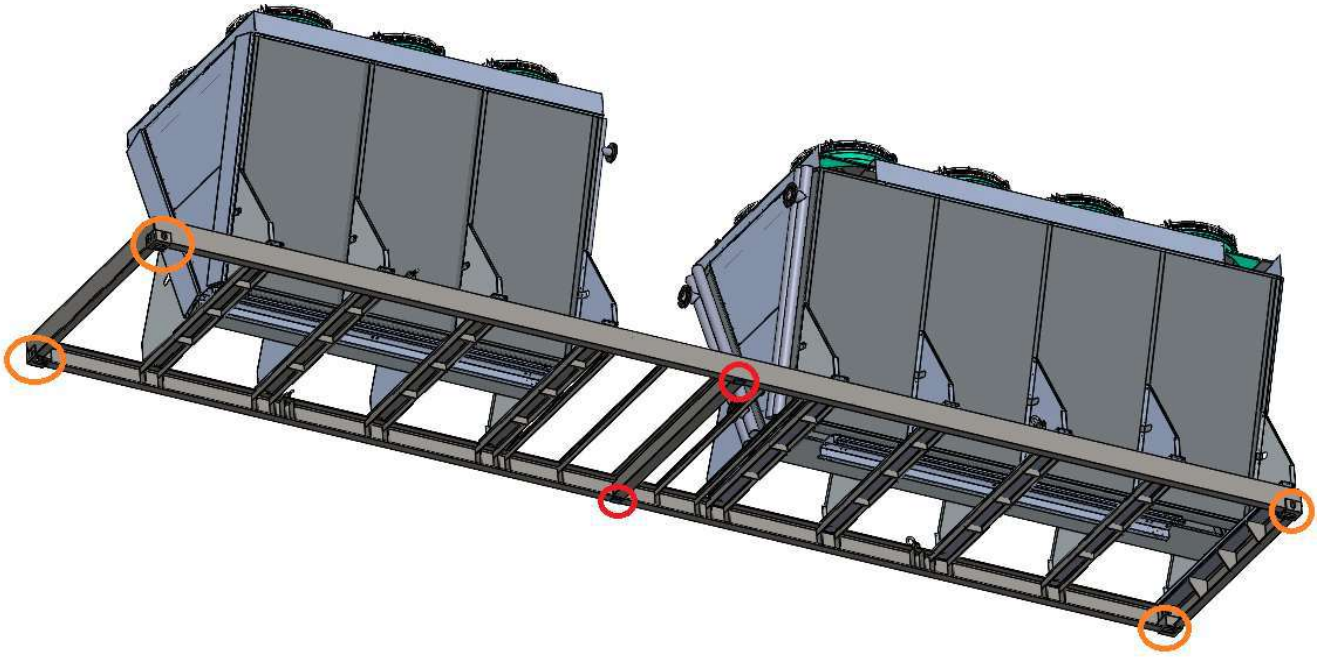


Fig 211: 40ft flatbed - bottom view

Orange circles shows bottom ISO 1161 corners
Red circles shows additional supporting plates.
Bottom level of ISO corners and additional supporting plates is the same for whole platform.

Note:
Supporting plates are not exactly in the middle of the flatbed:
- flatbed total length: 12192mm
- distance between left end to the middle of supporting plate: 6232mm
- distance betwee right end to the middle of supporting plate: 5960mm

Sub Subsection B99-003

Container fire resistance

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	10/24/2023	First Issue
002	10/3/2025	Document name corrected

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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	B99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	B99 – Ballard Container Fire Resistance
Full Title	B99 – Ballard Container Fire Resistance
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	First Release	KHE	January 24, 2025

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THIS DOCUMENT IS VALID ONLY AT TIME OF PRINTING.
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1.0 Purpose

The purpose of this document is to provide Material Safety Data Sheet, for the insulation material installed in the Ballard Fuel Cell container to provide passive fire protection. The container deliver for the Crosswind project is in accordance with standard container solution from Ballar Power systems and do not fulfill requirements for Offshore installation as stated in the contract (As a minimum, the Fuel Cell container shall provide 2 hours fire rating). The Ballard Container delivered do not have fire rating.

2.0 Overview of Material Data Sheets

The complete list of insulation material used in the 1MW fuel cell container (MEGABLOCK) is shown below.

Manufacturer	Type	Name	Description / Use	Sub-assembly
TRIMOTERM	Insulation	Insulation	Installed inside the container to create fire protection as well as creating protection for low temperature.	Container Solution

COMPANY PROFILE



Trimo is a one of the leading European companies developing original and complete building envelope solutions in the areas of fire-proof façades and roofs .

Located in Trebnje, Slovenia, Trimo sells products and services under its own brand cross more than 100 countries worldwide and has a sales network in almost 30 countries. We are a reliable, trustworthy global supplier of innovative, flexible, energy-efficient and environmentally friendly architectural building solutions.

Our customers are at the heart of our operations as we deeply understand their needs and provide them with the highest level of service and product quality. The list of outstanding and reputable partners such as Airbus, London Heathrow, Nestle, Philips, DHL, Porsche, IKEA, Prologis, Mercedes Benz, Coca Cola and many others is a true reflection of our passion, responsibility and committment to our work.

ISO 9001 ISO 14001 ISO 45001 BUREAU VERITAS Certification

Mitglied des: IFBS Industrieverband für Bausysteme im Metalleichtbau

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For information about the delivery of panels see Trimo's General conditions (https://www.trimo-group.com/en/general-conditions-of-sales).

ID_TDRTS-SVEN

Published by: TRIMO d.o.o., EN 11/2024

Ballard Container

PROFILE TYPES



S (standard) profile



V profile



V2 profile



V6 profile

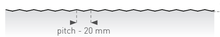


G (smooth) profile

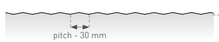
M (micro-lined) profile



M2 (micro-lined) profile



M3 (micro-lined) profile



M8 (micro-lined) profile



Trapezoid profile



Trimoterm FTV profile type	A	B
S (standard) profile	•	•
V profile (V, V2, V6*)	•	•
G (smooth) profile	•	•
Micro-lined profile (M, M3)	•	
Micro-lined profile (M2)		•
Micro-lined profile (M8)	•	•

* Available with 1.200 mm module width only.

Trimoterm FTV HL profile type	A	B
S (standard) profile	•	•
V profile (V, V2, V6*)	•	•
G (smooth) profile	•	•
Micro-lined profile (M, M3)	•	
Micro-lined profile (M2)		•
Micro-lined profile (M8)	•	•

* Available with 1.200 mm module width only.

Trimoterm SNV profile type	A	B
Trapezoid	•	
S (standard) profile		•
V profile (V, V2)		•
G (smooth) profile		•
Micro-lined profile (M2)		•

NOTES: The internal and external Trimoterm profiles seen in this document present the main range of profile options. Some combinations are mutually exclusive depending on the type of profile and product. For the approval of the requested profile combination please contact Trimo's technical support team. The arrangement of V profile (and all others) typically starts on the middle (centred) of panel steel sheet prior to forming stage. Module end, grove and the distance from the panel edge depends on Trimoterm panel module and may vary. Any other V profile arrangements are declared as non-standard and a subject of individual order. The arrangement of S profile typically starts on the middle (centred) of the Trimoterm panel module. Module end and the distance from the panel edge depends on Trimoterm panel module and may vary. Smooth profile (G) - to ensure an optimal smooth surface for building façades external side of the panel 0,7 mm steel sheet thickness must be used in lieu of standard 0,55 mm.

COLOURS



NOTES: Colours may slightly deviate due to different monitors and prints compared to original colours.

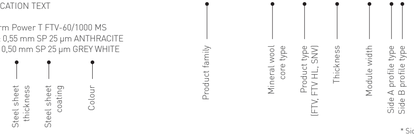
Trimo can send you a metal swatch upon request. Colour range does not in any case define delivery terms or any other terms of specific skin colour.

Colour range presented shows only a fraction of most usable colours within the variety of colours available.

PANEL MARKING

SPECIFICATION TEXT

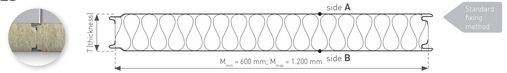
Trimoterm Power T FTV-60/1000 MS
external: 0,55 mm SP 25 µm ANTHRACITE
internal: 0,50 mm SP 25 µm GREY WHITE



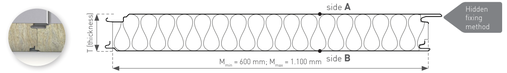
* Side A usually presents the external side of a panel.

PRODUCT TYPES

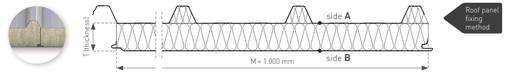
Trimoterm FTV
Horizontal and vertical panel orientation



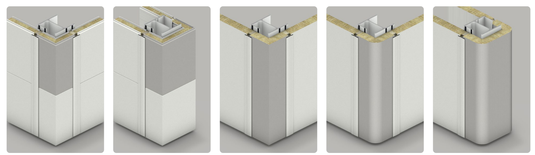
Trimoterm FTV HL
Horizontal and vertical panel orientation



Trimoterm SNV
Panel laying according to roof inclination



CORNER ELEMENTS



L-corner
Horizontal
Transversal sharp-edged corner element

U-corner
Horizontal
Double transversal sharp-edged corner element

L-corner
Vertical
Longitudinal sharp-edged corner element

Rounded L-corner
Vertical
Longitudinal curved corner element

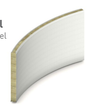
Rounded U-corner
Vertical
Double longitudinal curved corner element

SEGMENTED PANELS

Horizontal
Convex panel



Horizontal
Concave panel

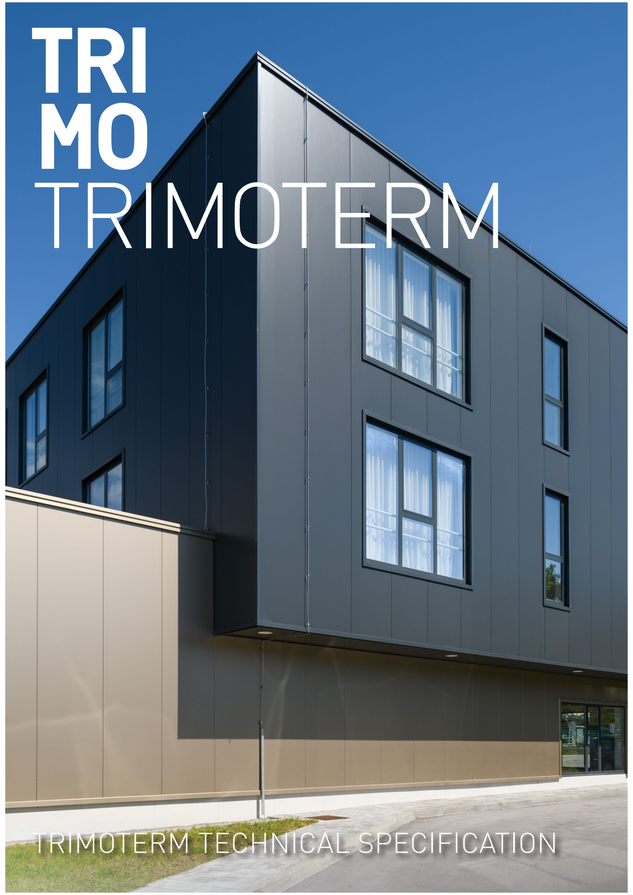


Vertical
Convex panel



Vertical
Concave panel





| PRODUCT FAMILY, PRODUCT TYPE | RENDER | CORE TYPE | MAX. ACHIAVABLE FIRE RESISTANCE (EN 14509)** | | | | | | | | | | | U THERMAL TRANSMITTANCE [W/m²K]*** | | | | | | | | | | | AIRBORNE SOUND INSULATION Rw (C;Ctr) dB (EN 14509) | | | | | | | | | | | WATER PERMEABILITY (EN 14509) | | | | | | | | | | | WEIGHT (Fe 0,55/0,5) [kg/m²] | | | | | | | | | | | REACTION TO FIRE (EN 13501-1) | COMBUSTIBILITY OF MATERIAL CORE (EN 13501-1) | WIDTH (mm) | LENGTH (m) |
|---|---|---

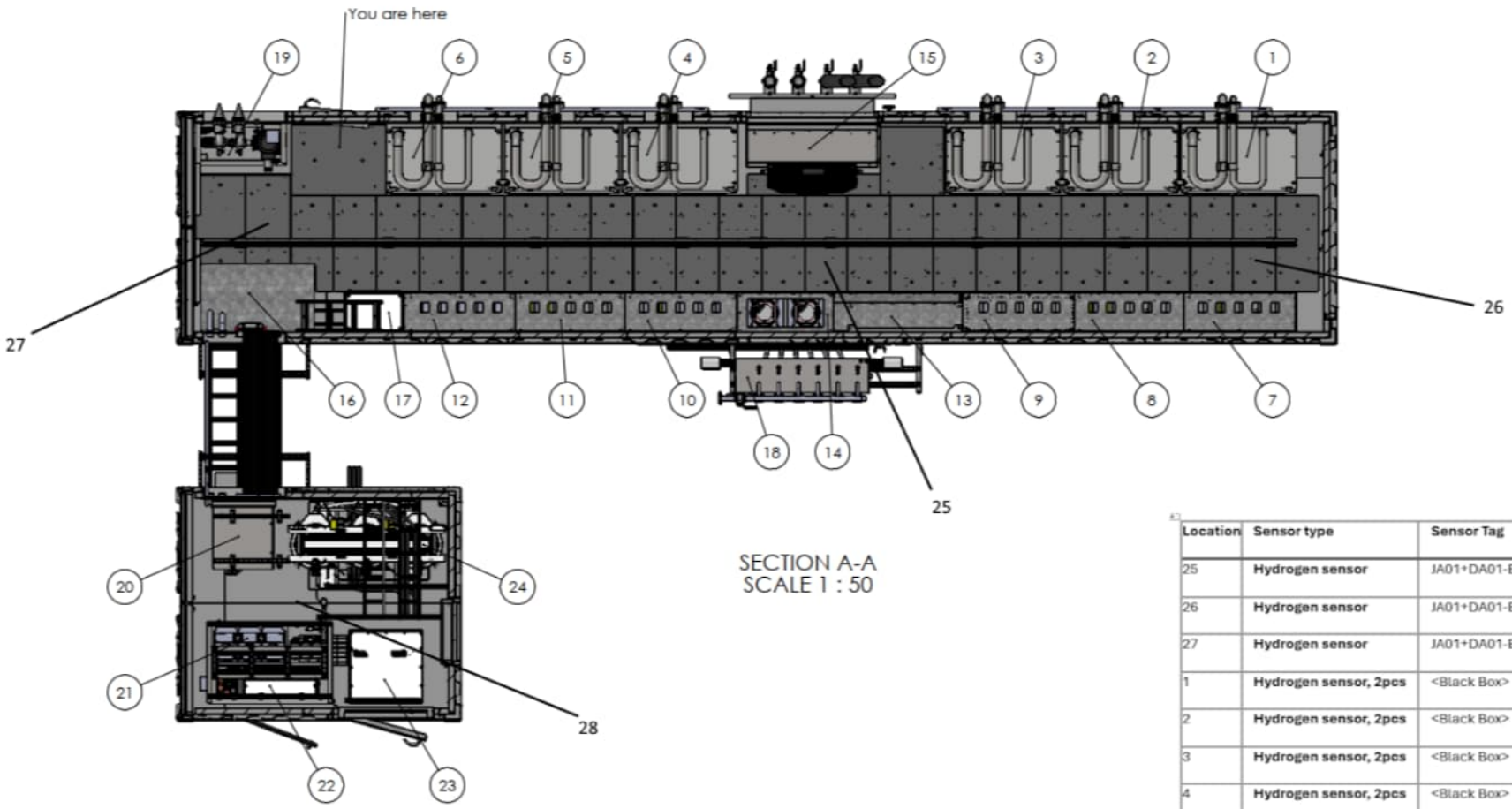
Sub Subsection B99-004

Smoke and Fire detection

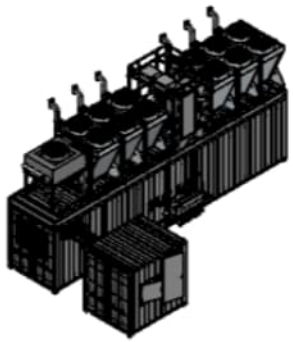
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Denmark

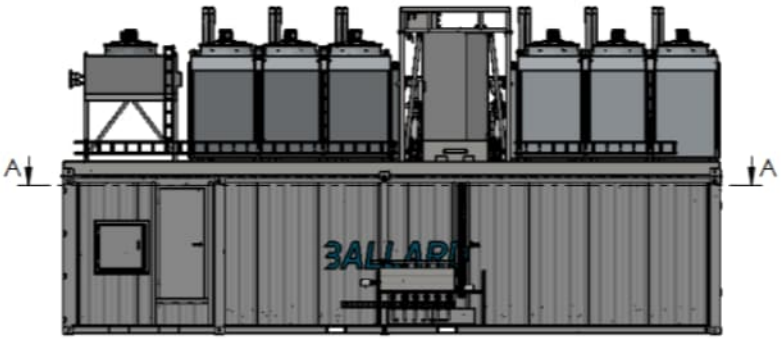
Revision history		
Rev.	**Date.**	**Description**
001	1/5/2025	First Issue
002	13/05/2025	document number corrected
003	3/10/2025	document number corrected

Document Title:	**BLPH Project - Smoke and Fire detection**
Document Number:	K559-2254-CWIWP4202202-B99-004
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	B99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands



SECTION A-A
SCALE 1 : 50





Location	Sensor type	Sensor Tag	Type
25	**Hydrogen sensor**	JA01+DA01-BQ01	Dräger Polytron 8200 CAT
26	**Hydrogen sensor**	JA01+DA01-BQ02	Dräger Polytron 8200 CAT
27	**Hydrogen sensor**	JA01+DA01-BQ03	Dräger Polytron 8200 CAT
1	**Hydrogen sensor, 2pcs**	<Black Box>	Nisha FIS FH2-HY04
2	**Hydrogen sensor, 2pcs**	<Black Box>	Nisha FIS FH2-HY04
3	**Hydrogen sensor, 2pcs**	<Black Box>	Nisha FIS FH2-HY04
4	**Hydrogen sensor, 2pcs**	<Black Box>	Nisha FIS FH2-HY04
5	**Hydrogen sensor, 2pcs**	<Black Box>	Nisha FIS FH2-HY04
6	**Hydrogen sensor, 2pcs**	<Black Box>	Nisha FIS FH2-HY04
25	**Smoke Detector**	JA01+DA01-BQ04	Apollo Orbis ORB-OP-42001-MAR
26	**Smoke Detector**	JA01+DA01-BQ05	Apollo Orbis ORB-OP-42001-MAR
27	**Smoke Detector**	JA01+DA01-BQ06	Apollo Orbis ORB-OP-42001-MAR
1	**Smoke Detector**	<Black Box>	Apollo Orbis ORB-OP-42001-MAR
2	**Smoke Detector**	<Black Box>	Apollo Orbis ORB-OP-42001-MAR
3	**Smoke Detector**	<Black Box>	Apollo Orbis ORB-OP-42001-MAR
4	**Smoke Detector**	<Black Box>	Apollo Orbis ORB-OP-42001-MAR
5	**Smoke Detector**	<Black Box>	Apollo Orbis ORB-OP-42001-MAR
6	**Smoke Detector**	<Black Box>	Apollo Orbis ORB-OP-42001-MAR
28	**Smoke Detector**	JA01+DA03-BQ01	Apollo Orbis ORB-OP-42001-MAR

Section C

System Diagrams

Sub Section C01

Instrument and Electrical Logic Diagrams

Ballard Power Systems Europe A/S
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	2/24/2023	First Issue
002	9/9/2025	General updates
003	10/6/2025	Appendix A updated to latest version

Document Title:	**BLPH Project - Instrument/Electrical Logic Diagrams**
Document Number:	K559-2254-CWIWP4202202-C01-001
Revision:	Rev003
Sequence Number:	001
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	C01 – Blackbox Instrument and Electrical Logic Diagrams
Full Title	Instrument and Electrical Logic Diagrams for Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	PBL	February 2023
2.0	General Updates	RKN	September 2025

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No table of figures entries found.

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1.0 Purpose

The purpose of this document is to provide a preliminary instrument and electrical logic diagram package for the 1MW Fuel Cell Container ("Megablock") provided by Ballard Power Systems Europe for the Crosswind project. This document considers the fuel cell container a black box, and process instrument and electrical logic inside the container is not described. The logic for interfaces with the supporting platform is described, with focus on the hydrogen system.

This document is meant to accompany the process and instrumentation diagrams for same and refers to these extensively.

2.0 References

Table 1: Reference Documents

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-EL-PHI-002	Electrical System Description & Design Philosophy	KBR
K559-2254-CWIWP4202202-C08-001Rev004	Control Philosophy & Block Logic Diagrams	Ballard
K559-2254-CWIWP4202202-C02-001Rev002	Fuel Cell Container, PFD	Ballard
K559-2254-CWIWP4202202-B99-002	Fire and Gas detection	Ballard
K559-2254-CWIWP4202202-B99-003	Container fire resistance	Ballard
Appendix A	Fuel Cell Container, P&ID (Hydrogen)	Ballard
Appendix B	Instrument Logic Diagram – Hydrogen Supply System	Ballard

3.0 Hydrogen Supply

This section describes the hydrogen supply connection and the logic regarding the usage of the connection.

3.1 Process flow diagram

On the process flow diagram (K559-2254-CWIWP4202202-C02-001Rev002), the hydrogen connection is shown with the tag "=HA01+DA02-XM01", which breaks down into the function, location and element detailed in Table 2.

Table 2: Hydrogen Supply Connection Tag details

Segment	Segment type	Segment Description
=HA01	Function	Hydrogen Supply System
+DA02	Location	Container #1, Outside
-XM01	Element	H2 Supply Connection

3.2 Piping and Instrumentation Diagram

On the hydrogen excerpt of the piping and instrumentation diagram ("Appendix A"), and the Instrument Logic Diagram – Hydrogen Supply System

Table 3: Hydrogen Solenoid Valve Tags and Logic

Valve	Description	Logic
=HA01+DA02-QM20	H2 Supply Shutoff Solenoid 1/2	Safety Status OK *AND* (Main State = Startup *OR* Run)
=HA01+DA02-QM22	H2 Supply Shutoff Solenoid 2/2	Safety Status OK *AND* (Main State = Startup *OR* Run)
=HA01+DA02-QM01	FCwave #1 Shut-off Valve	Safety Status OK *AND* (Main State = Startup *OR* Run) *AND* FCwave #1 H2 Enable
=HA01+DA02-QM02	FCwave #2 Shut-off Valve	Safety Status OK *AND* (Main State = Startup *OR* Run) *AND* FCwave #2 H2 Enable
=HA01+DA02-QM03	FCwave #3 Shut-off Valve	Safety Status OK *AND* (Main State = Startup *OR* Run) *AND* FCwave #3 H2 Enable

=HA01+DA02-QM04	FCwave #4 Shut-off Valve	Safety Status OK *AND* (Main State = Startup *OR* Run) *AND* FCwave #4 H2 Enable
=HA01+DA02-QM05	FCwave #5 Shut-off Valve	Safety Status OK *AND* (Main State = Startup *OR* Run) *AND* FCwave #5 H2 Enable
=HA01+DA02-QM06	FCwave #6 Shut-off Valve	Safety Status OK *AND* (Main State = Startup *OR* Run) *AND* FCwave #6 H2 Enable

3.3 Logic comments

The Control Philosophy & Block Logic Diagrams document, K559-2254-CWIWP4202202-C08-001, has been submitted and contains further details on control strategies.

The logic for the solenoid valves is broken down into the following elements:

- Safety Status OK:
  - Override from the container safety system, implemented via safety-rated relay
  - Enabled when safety system is in a satisfactory state and disabled when some element has tripped the safety system.
- Main State = Startup OR Run:
  - Control of the solenoid valves from the container control system.
  - Valves are normally closed, and opened when the fuel cell container is instructed to begin startup sequence from the Baseload Power Hub Central Control System. Remains open while one or more modules are operating.
- FCwave H2 Enable signal:
  - Each FCwave module controls its individual valve in front of the module, permitting gas flow only to modules actively enabling their local gas supply valve. The signal from the module is controlled by the fuel cell module process controller with override in place from the module safety system.

4.0 Coolant Systems

The control of the coolant systems (HT and LT Temperature Systems) are controlled internally to the skid and not exposed to the Baseload Power Hub Central Control System. The coolant system is not described further in this document.

5.0 Ventilation

The control of the ventilation systems (Container ventilation, Process Air supply, H2 Enclosure Ventilation) are controlled internally to the skid and not exposed to the Baseload Power Hub Central Control System. The ventilation systems is not described further in this document.

6.0 Process Drain

The process drain is a passive system inside the container, with gravity-driven drainage of the process drains and process air exhausts.

The Baseload Power Hub can expect water present in the drain when the fuel cell container is commanded to startup and run, and for a minor amount to be present during the after-run of the process system after shutdown of the fuel cell modules.

7.0 Fire and Gas

The fire and gas detection strategy is outlined in document K559-2254-CWIWP4202202-B99-002. Details on container fire resistance and material selection are available in document K559-2254-CWIWP4202202-B99-003.

APPENDIX A

H2 Supply P&ID

Hydrogen Supply System - Fuel Cells 1-6

=RE01
Fuel Cell System 1

+GB01
FCwave 1

-XM01
20mm
H2 Supply Inlet

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB02
FCwave 2

-XM01
20mm
H2 Supply Inlet

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB03
FCwave 3

-XM01
20mm
H2 Supply Inlet

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

=RE02
Fuel Cell System 2

+GB04
FCwave 4

-XM01
20mm
H2 Supply Inlet

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB05
FCwave 5

-XM01
20mm
H2 Supply Inlet

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB06
FCwave 6

-XM01
20mm
H2 Supply Inlet

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

=HA01+DA02
Hydorgen Supply System, Container #1 Outside

-XT01
Wall pass-through

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM2.1

=HA01+DA02-QM2.1
DN20
Shut-off Valve

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM1.1

=HA01+DA02-QM1.1
DN20
Shut-off Valve

-XT02
Wall pass-through

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM2.2

=HA01+DA02-QM2.2
DN20
Shut-off Valve

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM1.2

=HA01+DA02-QM1.2
DN20
Shut-off Valve

-XT03
Wall pass-through

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM2.3

=HA01+DA02-QM2.3
DN20
Shut-off Valve

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM1.3

=HA01+DA02-QM1.3
DN20
Shut-off Valve

-XT04
Wall pass-through

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM2.4

=HA01+DA02-QM2.4
DN20
Shut-off Valve

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM1.4

=HA01+DA02-QM1.4
DN20
Shut-off Valve

-XT05
Wall pass-through

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM2.5

=HA01+DA02-QM2.5
DN20
Shut-off Valve

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM1.5

=HA01+DA02-QM1.5
DN20
Shut-off Valve

-XT06
Wall pass-through

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM2.6

=HA01+DA02-QM2.6
DN20
Shut-off Valve

Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

YV
QM1.6

=HA01+DA02-QM1.6
DN20
Shut-off Valve

-BL01
SI = 11 mm
Ex Point Liquid Detection

BT01
PT1000 =60...150 °C
Liquid Temperature Sensor

-CM01
SS316, Volume 146L
Hydrogen Heater Vessel

-EA01
3x400V, 9kW, Ex
Heating Element 1

-EA02
3x400V, 9kW, Ex
Heating Element 2

-WP01
DN25, 3000m
Tube Coil

-WP02
DN25, 3000m
Tube Coil

-WP03
DN25, 3000m
Tube Coil

-WP04
DN25, 3000m
Tube Coil

-WP05
DN25, 3000m
Tube Coil

-WP06
DN25, 3000m
Tube Coil

Hydrogen
3,5-6,5 barg
<0,4 - 80°C
<4,9 g/s

H
=HA01+DA02-QM01
DN25
Isolation Valve, Lockable

Hydrogen
3,5-6,5 barg
<0,4 - 80°C
<4,9 g/s

H
=HA01+DA02-QM02
DN25
Isolation Valve, Lockable

Hydrogen
3,5-6,5 barg
<0,4 - 80°C
<4,9 g/s

H
=HA01+DA02-QM03
DN25
Isolation Valve, Lockable

Hydrogen
3,5-6,5 barg
<0,4 - 80°C
<4,9 g/s

H
=HA01+DA02-QM04
DN25
Isolation Valve, Lockable

Hydrogen
3,5-6,5 barg
<0,4 - 80°C
<4,9 g/s

H
=HA01+DA02-QM05
DN25
Isolation Valve, Lockable

Hydrogen
3,5-6,5 barg
<0,4 - 80°C
<4,9 g/s

H
=HA01+DA02-QM06
DN25
Isolation Valve, Lockable

=HKN70
Baseload Power Hub, Hydrogen Supply

0,9 - 29,4 g/s
45 K - 85°C
3,5-6,5 barg
Hydrogen

-XM01
DN32, EN1759-1, RF face
H2 Supply Connection
Flange Fitting

PT
BT01

=HA01+DA02-BP01
0...10 barg
Hydrogen Inlet
Pressure Transmitter

Hydrogen
3,5 - 6,5 barg
<0,4 - 80°C
0,9 - 29,4 g/s

H
=HA01+DA02-QM00
DN32
Manual shutoff valve
Lockable

Hydrogen
3,5 - 6,5 barg
<0,4 - 80°C
0,9 - 29,4 g/s

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
= | +	+ | & 802

Design:	PBL
Review:	RBS
Approval:	JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	
15-Sep-25	

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DRAWING	K559-2254-CWIWP4202202-C03-001			REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS				
SHEET TYPE/DESC	Hydrogen Supply System				
ALL SHEETS ARE THE SAME REVISION STATUS		SIZE A1	LANGUAGE EN	SHEET/TOTAL	4 / 16

FRM5103653/0B

APPENDIX B

Logic Diagram for H2 Supply

0	1	2	3	4	5	6	7	8

=RE01
Fuel Cell System 1

+GB01
FCwave 1

-XM01
20mm
H2 Supply Inlet

+GB02
FCwave 2

-XM01
20mm
H2 Supply Inlet

+GB03
FCwave 3

-XM01
20mm
H2 Supply Inlet

=RE02
Fuel Cell System 2

+GB04
FCwave 4

-XM01
20mm
H2 Supply Inlet

+GB05
FCwave 5

-XM01
20mm
H2 Supply Inlet

+GB06
FCwave 6

-XM01
20mm
H2 Supply Inlet

=HA01+DA02
Hydrogen Supply System, Container #1 Outside

-QM01
3/4"
Shut-off Valve

-QM02
3/4"
Shut-off Valve

-QM03
3/4"
Shut-off Valve

-QM04
3/4"
Shut-off Valve

-QM05
3/4"
Shut-off Valve

-QM06
3/4"
Shut-off Valve

0,9 - 24,5 g/s
0-80°C
3,5 - 6,5 barg
Hydrogen

-XM01
Ø 32mm
H2 Supply Connection

-QM20
Ø 32mm
H2 Supply Shutoff Solenoid 1/2

-QM22
Ø 32mm
H2 Supply Shutoff Solenoid 1/2

AND

AND

AND

AND

AND

AND

AND

Safety Status OK

Main state = Startup OR Run

FCwave #1 H2 Enable

FCwave #2 H2 Enable

FCwave #3 H2 Enable

FCwave #4 H2 Enable

FCwave #5 H2 Enable

FCwave #6 H2 Enable

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	--.P05
EPLAN Project Pages	46
=	++ | + | & B02

REVISION INFORMATION
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24-Feb-23

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DRAWING	601456B-C01	REVISION	--.P05
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Instrument Logic Diagram - Hydrogen Supply System		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 7

Sub Section C02

PFD

Ballard Power Systems Europe A/S
Majsmarken 1
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Revision history		
Rev.	**Date.**	**Description**
001	1/20/2023	First Issue
002	2/17/2023	Modified according to comments
003	8/26/2025	Modified according to comments

KBR
ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

ACCEPTED	(Code 1) ____
ACCEPTED WITH COMMENTS	(Code 2) ____
NOT ACCEPTED	(Code 3) ____
NOT REVIEWED	(Code 4) ____

ACCEPTANCE DOES NOT RELIEVE SUPPLIER FROM FURNISHING MATERIAL IN CONFORMANCE WITH ORDER. REFER TO SDR-1 FOR FULL DEFINITION OF ACCEPTANCE CONDITIONS.

DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - Process Flow Diagrams (PFD) & Heat/Mass Balances**
Document Number:	K559-2254-CWIWP4202202-C02-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-C02-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BLPH Scope

Ballard Scope

BLPH Scope

=HA01+DA02-XM01
H2 Supply Connection
DN32

0,9 - 29,4 g/s
0-80°C
3,5 - 6,5 barg
Hydrogen

+DA01
40ft ISO Container

<30080 Nm³/h
Ambient temperature (25°C max)
Ambient pressure
Air

6 separate exhausts
<3900 Nm³/h total
50-80°C
<50mbarg
Oxygen depleted, trace hydrogen
Air

6 separate exhausts
720 Nm³/h total
5-45°C
<50mbarg
Air

<24560 Nm³/h
10-45°C
<50mbarg
Air

+DA03
10ft ISO Container

-X09
Ventilation Intake

-X05
Process Air Exhaust

-X06
H2E Ventilation Exhaust

-X08
Container Ventilation Exhaust

-X07
Hydrogen Supply Inlet

20kW
480V@60Hz
400V@50Hz
3P+N+PE

-X11
AUX Power Supply

-TA30
3
3
1200kVA

=HKN70-XB02
6,6kV MV Power

-X01
HT Coolant Loop #1
Inlet

-X04
HT Cooling Loop #1
Outlet

-X02
HT Coolant Loop #2
Inlet

-X03
HT Cooling Loop #2
Outlet

-X12
LT Coolant Loop
Inlet

-X13
LT Cooling Loop
Outlet

-X10
Process Water Drain

=JB01+DA02-HQ01
Process Water Exhaust

<10 Nm³/h
25-65°C
<50mbarg
Ventilation

<100 m³/h
10-40 °C
50/50 Water/Glycol
Coolant

<100 m³/h
10-40 °C
50/50 Water/Glycol
Coolant

<30,0 m³/h
10-40°C
50/50 Water/Glycol
LT Coolant

=HE01+DA02-GP19
15kW
HT1 Coolant Pump

=HE01+DA02-EG01
1050kW, V-type
HT Cooling Tower

=HE02+DA02-GP29
15kW
HT2 Coolant Pump

=HE02+DA02-EG01
1050kW, V-type
HT Cooling Tower

=HE03+DA04-EG01
100kW, V-type
LT Cooling Tower

<13,2 l/min
50-80°C
DI Water
Water

=JB01+DA02-XM01
1" ASME B 16.5
Process Water Drain

=HKN70-XM02
Proess Water Drain

See function and location references in document C03 (P&ID document)

DRAFT

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	11
EPLAN Project Pages	628
=	++ | + | & B01

REVISION INFORMATION
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09-Sep-25

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DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Process Flow Diagram		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 1

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Sub Section C03

P&IDs

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	1/27/2023	First Issue
002	3/3/2023	Modified according to comments
003	5/17/2023	Updated according to comments
004	3/8/2024	Updated according to comments
005	10/16/2024	Updated according to comments and with changed water separator
006	11/20/2024	Updated according to comments
007	9/15/2025	Updated, as build

Document Title:	**BLPH Project - P&IDs**
Document Number:	K559-2254-CWIWP4202202-C03-001
Revision:	Rev007
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-C03-001Rev007
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

0	1	2	3	4	5	6	7	8

Process And Instrumentation Diagrams

Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS

Table of Contents

Higher-Level Function	Mounting Location	Page	Page Description	Last Modified Date
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		2	Structure Identifier Overview	15-Sep-25
		3	Symbol List	15-Sep-25
		4	Hydrogen Supply System	15-Sep-25
		5	Hydrogen Supply System - BOM	15-Sep-25
		6	Process Exhaust and Drain	15-Sep-25
		7	HT1 Coolant System - Fuel Cells	15-Sep-25
		8	HT2 Coolant System - Fuel Cells	15-Sep-25
		9	LT Coolant System - Overview	15-Sep-25
		10	LT Coolant System - Fuel Cells	15-Sep-25
		11	LT Coolant System - Power Converters 1/2	15-Sep-25
		12	LT Coolant System - Power Converters 2/2	15-Sep-25
		13	LT Coolant System - BOM	15-Sep-25
		13.a	LT Coolant System - BOM	15-Sep-25
		14	Ventilation Air System - 40ft Container	15-Sep-25
		15	Ventilation Air System - 10ft Container	15-Sep-25

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	574		
=	++	+	& B02

Design:	PBL
Review:	RBS
Approval:	JTA

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15-Sep-25

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DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	P&ID Introduction		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 15

Structure Identifier Overview

Functional Designation

Which function is associated with the components?

Structure identifier overview

Full designation	Labeling	Structure description
=AA01	Function designation	Container Interconnection
=BA01	Function designation	Power Conversion Block 1
=BA02	Function designation	Power Conversion Block 2
=BA20	Function designation	Power Conversion BOP
=BA30	Function designation	Power Conversion Output
=HA01	Function designation	Hydrogen Supply System
=HE01	Function designation	High Temperature Cooling Circuit #1
=HE02	Function designation	High Temperature Cooling System #2
=HE03	Function designation	Low Temperature Cooling Circuit
=JA01	Function designation	Container Ventilation System
=JA02	Function designation	Process Exhaust System
=JA03	Function designation	H2 Enclosure Ventilation
=JB01	Function designation	Condensate Drainage System
=LA01	Function designation	Container Control System
=LB02	Function designation	Container Safety System
=RE01	Function designation	Fuel Cell System 1
=RE02	Function designation	Fuel Cell System 2
=HKN70	Function designation	Baseload Power Hub
=EXT	Function designation	External Connection
=JB02	Function designation	Condensate Drainage System
=LA01.LA01	Function designation	

Location Designation

Where is the component located?

Structure identifier overview

Full designation	Labeling	Structure description
+DA01	Location designation	Container #1 Inside
+DA02	Location designation	Container #1 Outside
+DA03	Location designation	Container #2 Inside
+DA04	Location designation	Container #2 Outside
+GB01	Location designation	FCwave Module #1
+GB02	Location designation	FCwave Module #2
+GB03	Location designation	FCwave Module #3
+GB04	Location designation	FCwave Module #4
+GB05	Location designation	FCwave Module #5
+GB06	Location designation	FCwave Module #6
+UC01	Location designation	DCDC Cabinet #1
+UC02	Location designation	DCDC Cabinet #2
+UC03	Location designation	DCDC Cabinet #3
+UC04	Location designation	DCDC Cabinet #4
+UC05	Location designation	DCDC Cabinet #5
+UC06	Location designation	DCDC Cabinet #6
+UC07	Location designation	Ventilation Cabinet
+UC10	Location designation	DCAC Cabinet Output
+UC20	Location designation	Control Cabinet (40ft)
+UC30	Location designation	Coolant Skid Control Cabinet
+UC31	Location designation	Control Cabinet (10ft)
+UC40	Location designation	Coolant Power Distribution
+UC41	Location designation	HT+LT VFD Cabinet
+UC42	Location designation	EX Barrier Box
+UC50	Location designation	AC Power Distribution
+WZ10	Location designation	Container Interconnect Frame
+H2SS	Location designation	Hydrogen Supply (Ext)
+UC30.UC20	Location designation	

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
= ++ + & B02	

Design: PBL
Review: RBS
Approval: JTA

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15-Sep-25

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DRAWING	K559-2254-CWIWP4202202-C03-001	REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Structure Identifier Overview		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 15

Symbol List

Process Engineering

Threaded Connection
Dissimilar male and female part
=+-XM00

Valve, Hand-actuated
Typically quarter-turn, lockable in both positions
=+-QM00

Wall-passthough
Penetration through enclosure or container
-XT01

Valve, solenoid-actuated
Electromagnetic shutoff valve, normally closed type
-QM00

Pipe fixed point
Eg pipe end or welding connection
-XM00

Valve, check
One-way flow control valve for gas for fluid
-RM00

Liquid cooling element
Cooling path of liquid cooled power electronics
-TA00

Cooling Tower, with fans
Suction type
=+-EG00

Pump, centrifugal, with motor
Suction type
-GP00

Hose, Flexible
-WP00

Exhaust, to free air
With weather shield
-WM00

Valve, Shut-off, Motorized, Modulating
Motorized Control Valve, gradual between 0-100%
-QN00

Vessel or tank
With volume indicated
=+-CL00
Volume XL

Flow restrictor or orifice
For limiting gas or fluid flow rate
-QN00

Reducer, concentric
With indication of size
-XM00

Ventilation and Heating

Heater, with fans
Space heating element, electric
-EB00

Damper, lamellar
For ventilation purposes
-QM00

Actuator, motor, modulating
For dampers or valves
=+-QM00.MA00

Fan, axial flow
With motor
-GQ00

Fan, radial flow
With motor
-GQ00

Sensor, Room
Sensor for sensing conditions in open space
-BT00

Sensor, Process
Sensor with process connection
-BT00

Filter, for air
Cooling path of liquid cooled power electronics
-FS00

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
= | ++ | + | & B02	

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION
DESCRIPTION
DATE
15-Sep-25

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DRAWING	K559-2254-CWIWP4202202-C03-001	REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Symbol List		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1	LANGUAGE EN	SHEET/TOTAL 3 / 16

FRMS103653/0B

Hydrogen Supply System - Fuel Cells 1-6

=RE01
Fuel Cell System 1

+GB01
FCwave 1

-XM01
20mm
H2 Supply Inlet

-WP_H2927
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB02
FCwave 2

-XM01
20mm
H2 Supply Inlet

-WP_H2926
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB03
FCwave 3

-XM01
20mm
H2 Supply Inlet

-WP_H2925
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

=RE02
Fuel Cell System 2

+GB04
FCwave 4

-XM01
20mm
H2 Supply Inlet

-WP_H2924
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB05
FCwave 5

-XM01
20mm
H2 Supply Inlet

-WP_H2923
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

+GB06
FCwave 6

-XM01
20mm
H2 Supply Inlet

-WP_H2922
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

=HA01+DA02
Hydorgen Supply System, Container #1 Outside

-XT01
Wall pass-through

-WP_H2917
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM2.1

=HA01+DA02-QM2.1
DN20
Shut-off Valve

-WP_H2907
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM1.1

=HA01+DA02-QM1.1
DN20
Shut-off Valve

-XT02
Wall pass-through

-WP_H2916
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM2.2

=HA01+DA02-QM2.2
DN20
Shut-off Valve

-WP_H2906
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM1.2

=HA01+DA02-QM1.2
DN20
Shut-off Valve

-XT03
Wall pass-through

-WP_H2915
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM2.3

=HA01+DA02-QM2.3
DN20
Shut-off Valve

-WP_H2905
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM1.3

=HA01+DA02-QM1.3
DN20
Shut-off Valve

-XT04
Wall pass-through

-WP_H2914
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM2.4

=HA01+DA02-QM2.4
DN20
Shut-off Valve

-WP_H2904
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM1.4

=HA01+DA02-QM1.4
DN20
Shut-off Valve

-XT05
Wall pass-through

-WP_H2913
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM2.5

=HA01+DA02-QM2.5
DN20
Shut-off Valve

-WP_H2903
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM1.5

=HA01+DA02-QM1.5
DN20
Shut-off Valve

-XT06
Wall pass-through

-WP_H2912
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM2.6

=HA01+DA02-QM2.6
DN20
Shut-off Valve

-WP_H2902
Hydrogen
3,5-6,5 barg
12 - 80°C
<4,9 g/s

Y V
QM1.6

=HA01+DA02-QM1.6
DN20
Shut-off Valve

-BL01
SI = 11 mm
Ex Point Liquid Detection

BT01
PT1000 -40...150 °C
Liquid Temperature Sensor

-CM01
SS316, Volume 146L
Hydrogen Heater Vessel

-EA01
3x400V, 9kW, Ex
Heating Element 1

-EA02
3x400V, 9kW, Ex
Heating Element 2

-WP01
DN25, 3000m
Tube Coil

-WP02
DN25, 3000m
Tube Coil

-WP03
DN25, 3000m
Tube Coil

-WP04
DN25, 3000m
Tube Coil

-WP05
DN25, 3000m
Tube Coil

-WP06
DN25, 3000m
Tube Coil

-WP_H2947
Hydrogen
3,5-6,5 barg
-6,4 - 80°C
<4,9 g/s

H

=HA01+DA02-QM01
DN25
Isolation Valve, Lockable

-WP_H2946
Hydrogen
3,5-6,5 barg
-6,4 - 80°C
<4,9 g/s

H

=HA01+DA02-QM02
DN25
Isolation Valve, Lockable

-WP_H2945
Hydrogen
3,5-6,5 barg
-6,4 - 80°C
<4,9 g/s

H

=HA01+DA02-QM03
DN25
Isolation Valve, Lockable

-WP_H2944
Hydrogen
3,5-6,5 barg
-6,4 - 80°C
<4,9 g/s

H

=HA01+DA02-QM04
DN25
Isolation Valve, Lockable

-WP_H2943
Hydrogen
3,5-6,5 barg
-6,4 - 80°C
<4,9 g/s

H

=HA01+DA02-QM05
DN25
Isolation Valve, Lockable

-WP_H2942
Hydrogen
3,5-6,5 barg
-6,4 - 80°C
<4,9 g/s

H

=HA01+DA02-QM06
DN25
Isolation Valve, Lockable

=HKN70
Baseload Power Hub, Hydrogen Supply

0,9 - 29,4 g/s
-6,4 - 25°C
4,5 - 6,5 barg
Hydrogen

-XM01
DN32, EN1759-1, RF face
H2 Supply Connection
Flange Fitting

P T
BT01

=HA01+DA02-BP01
0...10 barg
Hydrogen Inlet
Pressure Transmitter

-WP_H2900
Hydrogen
3,5 - 6,5 barg
-6,4 - 80°C
0,9 - 29,4 g/s

H

=HA01+DA02-QM00
DN32
Manual shutoff valve
Lockable

-WP_H2901
Hydrogen
3,5 - 6,5 barg
-6,4 - 80°C
0,9 - 29,4 g/s

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	+ + + & B02

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	15-Sep-25

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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Hydrogen Supply System
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 · LANGUAGE EN · SHEET/TOTAL 4 / 16

FRMS103653/0B

Hydrogen Supply System - Fuel Cells 1-6

Bill of Materials / Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
-AC01-WG01	2	meter	ÖLFLEX CLASSIC 110 CH 18G0,75	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035051
-BL01	1	Piece	Electronic level sensor; Operating voltage 18...30 DC V; ATEX; M12 Connector; Gold-plated contacts	IFM Electronic AS	LMACE-A12E-QSKG-LI/S/3D/3G	LMT01A
-BL01-WG01	1	piece	Cable: 25 m, PUR, Halogen-free, black, 4 x 0,34 mm² Connector: 1 x M12, angled; coding: A	IFM Electronic AS	ADOGH040VAT002SH04/3G/2D	EVC14A
-BL01-XG01	0					
-BP01	1	Piece	Pressure Transducer, 0-10 barg, 4-20mA, ATEX, -25 to 85°C Ta, M12 Connector, 10..30 VDC, 2-wire, G1/2 Process Connection, FPM Seal	HUBA Controls AG	Pressure Transducer 520 Series	520930S04M801
-BP01-WG01	1	piece	Cable: 10 m, PUR, Halogen-free, blue, 4 x 0,34 mm² Connector: 1 x M12, straight; coding: A	IFM Electronic AS	ADOGH040MSN0010H04/1G/1D	ENC03A
-BP01-XG01	0					
-BT01	1	Piece	PT1000 Sensor Element, Ø10mm x 160mm, 4 wire connection, EN60751 Class A	IFM Electronic AS	TT-100KBBD10-...../US/	TT1050
-BT01-WG01	1	piece	Cable: 10 m, PUR, Halogen-free, blue, 4 x 0,34 mm² Connector: 1 x M12, straight; coding: A	IFM Electronic AS	ADOGH040MSN0010H04/1G/1D	ENC03A
-BT01-XG01	0					
-CM01	1	piece	Hydrogen Heater System, Water bath heat exchanger, SS316L, Volume 146L	Ballard Power Systems Europe		
-CM01-EA01	1	piece	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	JEVI Heating Elements AS	D-8640	340386
-CM01-EA01	1	Piece	Cable gland, ATEX Group II, grounding ring for amour, tightening guide, M20	Hawke International	ICG 653 UNIV Os M20	653UOsM20
-CM01-EA02	1	piece	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	JEVI Heating Elements AS	D-8640	340386
-CM01-EA02	1	Piece	Cable gland, ATEX Group II, grounding ring for amour, tightening guide, M20	Hawke International	ICG 653 UNIV Os M20	653UOsM20
-CM01-WP01	1		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall, Stainless Steel 316L	Ballard Power Systems Europe		
-CM01-WP02	1		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall, Stainless Steel 316L	Ballard Power Systems Europe		
-CM01-WP03	1		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall, Stainless Steel 316L	Ballard Power Systems Europe		
-CM01-WP04	1		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall, Stainless Steel 316L	Ballard Power Systems Europe		
-CM01-WP05	1		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall, Stainless Steel 316L	Ballard Power Systems Europe		
-CM01-WP06	1		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall, Stainless Steel 316L	Ballard Power Systems Europe		
-EA01-WD01	1	meter	Screened control cable, 4G2,5mm2, LSZH	Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123342
-EA02-WD01	1	meter	Screened control cable, 4G2,5mm2, LSZH	Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123342
-QM00	1	Piece	3-piece premium quater-turn ball valve, full bore, Stainless steel, DN32, CF8M, ATEX, Weld-ends, lockable	Armatec DVCAS	1311 Full Bore	131150032
-QM1.1	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM1.1	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM1.1	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20
-QM1.1-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
-QM1.2	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM1.2	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM1.2	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20
-QM1.2-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
-QM1.3	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM1.3	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM1.3	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20
-QM1.3-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
-QM1.4	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM1.4	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM1.4	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20
-QM1.4-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
-QM1.5	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM1.5	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM1.5	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20
-QM1.5-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
-QM1.6	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM1.6	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM1.6	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20
-QM1.6-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
-QM01	1	Piece	Quater-turn ball valve, lockable, size 25mm, 25mm Hy-Lok Tube Fitting ends	Hy-Lok Corporation	110 Series Ball Valves	BVH-25M
-QM2.1	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM2.1	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM2.1	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20
-QM2.1-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
-QM2.2	1	Piece	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	Emerson ASCO	NF X E210D488E 24/DC	NF X E210D488E 24/DC
-QM2.2	1	Piece	Eaton's Crouse-Hinds series Redapt AD-U adaptor End1 size: 1/2", NPT, Male End2 size: M20, Metric, Female	Eaton	AD-U	ADU102904
-QM2.2	1	Piece	501/421 Cable gland, ATEX Group II, M20, Unplated brass	Hawke International	501/421/O M20	421OM20

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	++ | + | & B02

FRM5103653/0B

Design:	PBL
Review:	RBS
Approval:	JTA

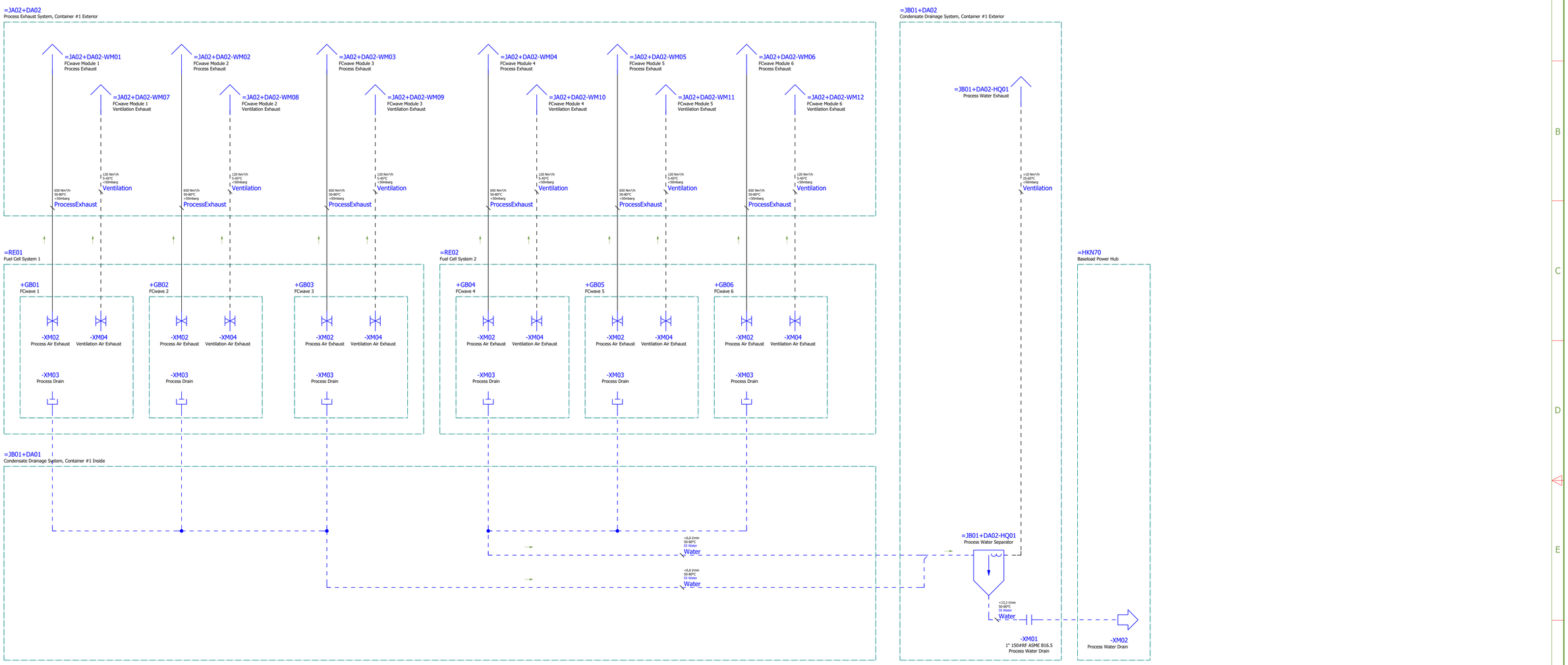
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DESCRIPTION	
DATE	
15-Sep-25	

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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Hydrogen Supply System - BOM
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 5 / 16

Process Exhaust, Ventilation Exhaust, Process Water Drain - Fuel Cells 1-6



Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=JB01+DA02-HQ01	0					
=JB01+DA02-HQ01	1		Ventilation Exhaust, Megablock, 2", Stainless 316	Ballard Power Systems Europe		7001554
=JA02+DA02-WM01	1		Process Exhaust for FCwave, Megablock, 3" Stainless 316	Ballard Power Systems Europe		7001553
=JA02+DA02-WM02	1		Process Exhaust for FCwave, Megablock, 3" Stainless 316	Ballard Power Systems Europe		7001553
=JA02+DA02-WM03	1		Process Exhaust for FCwave, Megablock, 3" Stainless 316	Ballard Power Systems Europe		7001553
=JA02+DA02-WM04	1		Process Exhaust for FCwave, Megablock, 3" Stainless 316	Ballard Power Systems Europe		7001553
=JA02+DA02-WM05	1		Process Exhaust for FCwave, Megablock, 3" Stainless 316	Ballard Power Systems Europe		7001553
=JA02+DA02-WM06	1		Process Exhaust for FCwave, Megablock, 3" Stainless 316	Ballard Power Systems Europe		7001553
=JA02+DA02-WM07	1		Ventilation Exhaust, Megablock, 2", Stainless 316	Ballard Power Systems Europe		7001554
=JA02+DA02-WM08	1		Ventilation Exhaust, Megablock, 2", Stainless 316	Ballard Power Systems Europe		7001554
=JA02+DA02-WM09	1		Ventilation Exhaust, Megablock, 2", Stainless 316	Ballard Power Systems Europe		7001554
=JA02+DA02-WM10	1		Ventilation Exhaust, Megablock, 2", Stainless 316	Ballard Power Systems Europe		7001554
=JA02+DA02-WM11	1		Ventilation Exhaust, Megablock, 2", Stainless 316	Ballard Power Systems Europe		7001554
=JA02+DA02-WM12	1		Ventilation Exhaust, Megablock, 2", Stainless 316	Ballard Power Systems Europe		7001554
=JB01+DA02-XM01	1		Pipe End, Ø60.3mm, Material 1.4301	Ballard Power Systems Europe		5500231B-2891

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
= | 1+ | + | & B02	

Design:	PBL
Review:	RBS
Approval:	JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	15-Sep-25

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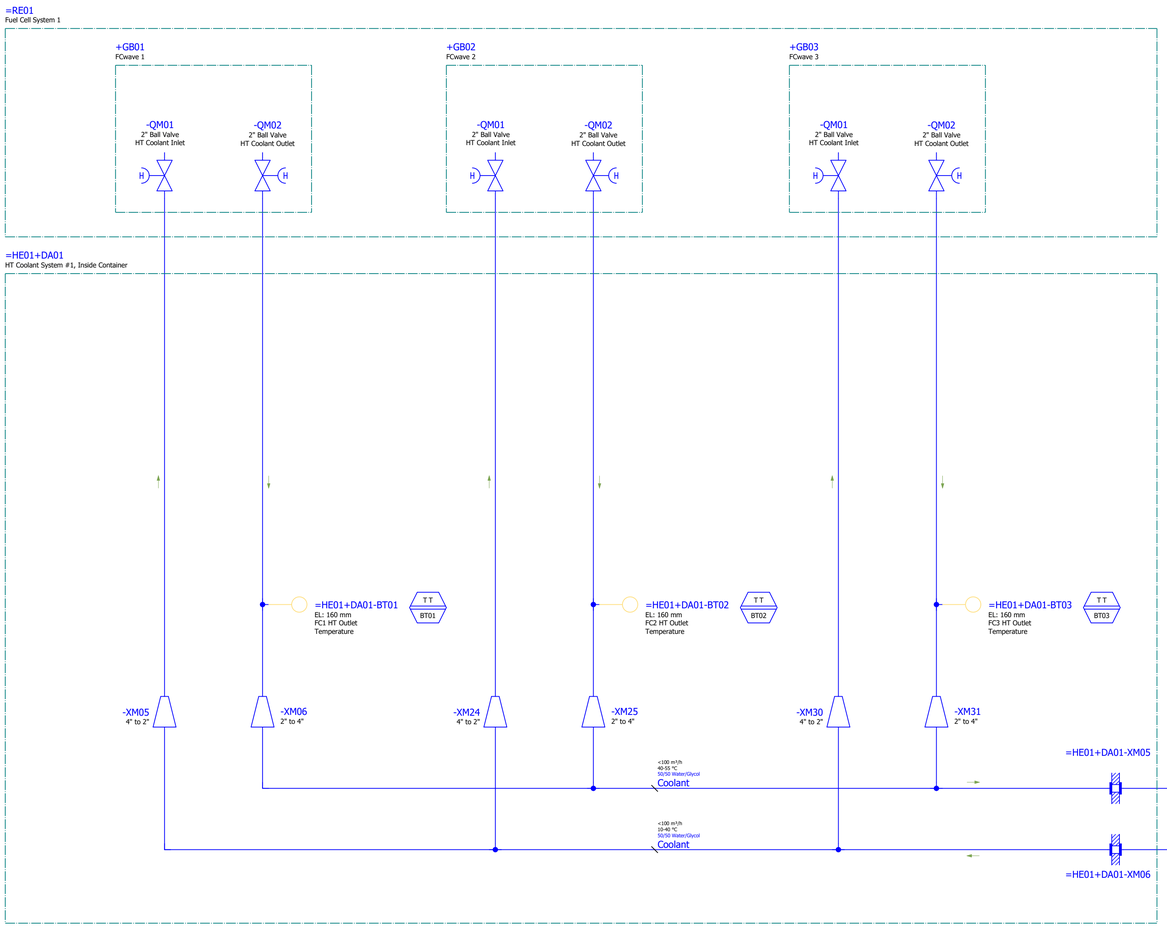
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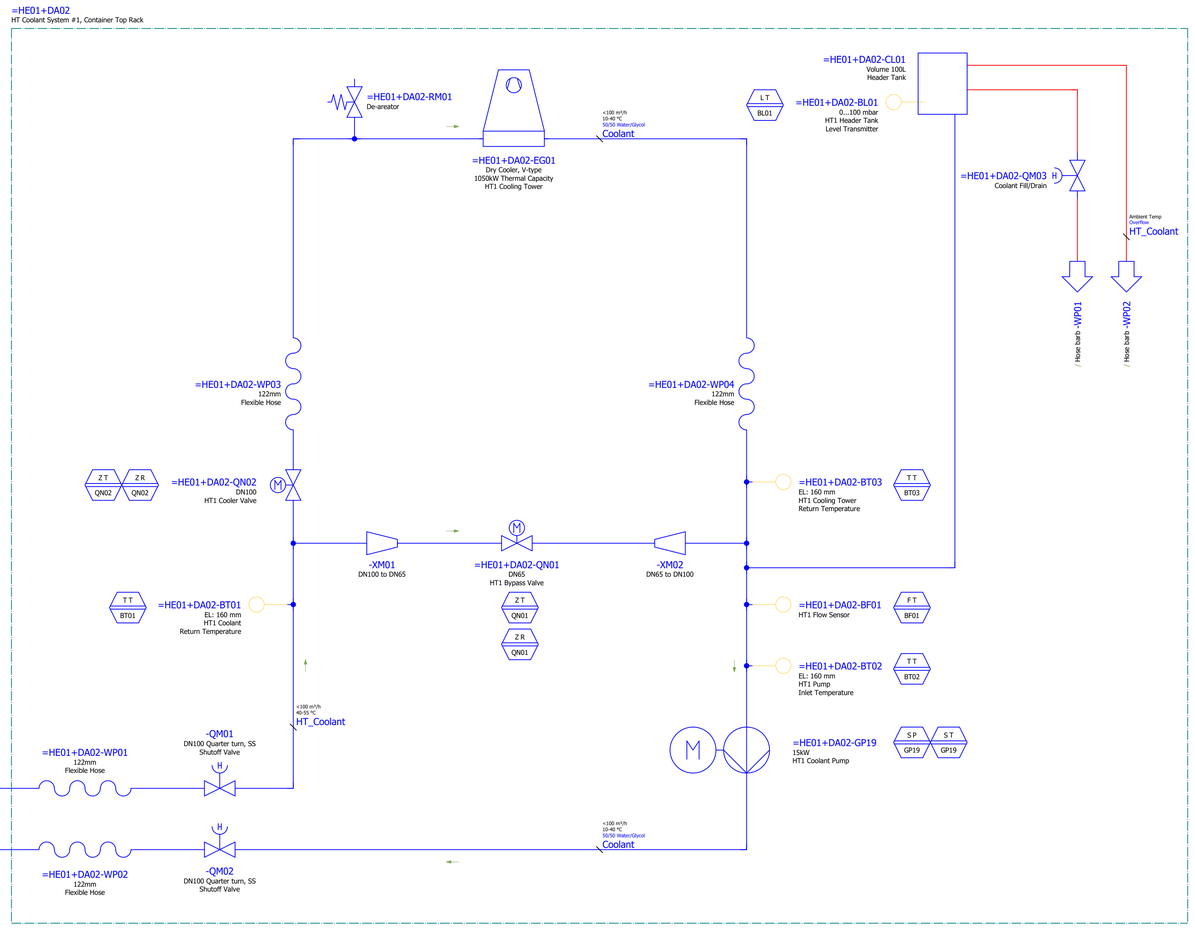
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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Process Exhaust and Drain
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 6 / 16

FRMS1036S3/08

High Temperature Cooling System - Fuel Cells 1-3





Coolant type: proviflow Neo 50/50 %vol ethylene glycol

Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=HE01+DA02-BF01	1	Piece	Flow sensor	IFM Electronic AS	SAEXXXXB50KG/US-100	SA4104
=HE01+DA02-BL01	1	Piece	Pressure transmitter with ceramic measuring cell, DC, analogue signal	IFM Electronic AS	PA-,10BRBG14-A-ZVG/US/ /V	PA3589
=HE01+DA01-BT01	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE01+DA01-BT02	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE01+DA01-BT03	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE01+DA02-BT01	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE01+DA02-BT02	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE01+DA02-BT03	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE01+DA02-CL01	1		Header Tank, Volume 100L, AISI 304	Ballard Power Systems Europe	5500231B-3002	5500231B-3002
=HE01+DA02-EG01	1		Dry Cooler, 1050kW, With Ventilators (Offshore)	EVAPCO Europe A/S	VA091 Series Drycooler	VA091EWHHD-682-IHD-120-2,3-Sp
=HE01+DA02-GP19	1		Centrifugal pump, with electric motor, single-stage close coupled in line.	Grundfos AS	TP 100-310/2 X-F-A-BQQE-OW1	92886729
=HE01+DA02-QM01	1		Ball Valve, Stainless Steel, DN100, Weld Flange	Armatec DVCAS	DVC Type 1311	1311510100
=HE01+DA02-QM02	1		Ball Valve, Stainless Steel, DN100, Weld Flange	Armatec DVCAS	DVC Type 1311	1311510100
=HE01+DA02-QM03	0					
=HE01+DA02-QN01	1	piece	Valve act. 24...230V, 160 Nm, bus, IP66	Belimo Holding AG	PRCA-BAC-S2-T	PRCA-BAC-S2-T
=HE01+DA02-QN02	1	piece	Valve act. 24...230V, 160 Nm, bus, IP66	Belimo Holding AG	PRCA-BAC-S2-T	PRCA-BAC-S2-T
=HE01+DA02-RM01	1		De-aerator, For coolant containing 50%vol glycol, 21.3mm BSPT thread external	Sanistål	Flexvent 1/2"	
=HE01+DA02-WP01	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122
=HE01+DA02-WP02	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122
=HE01+DA02-WP03	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122
=HE01+DA02-WP04	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	++ + & B02

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION
DESCRIPTION
DATE
15-Sep-25

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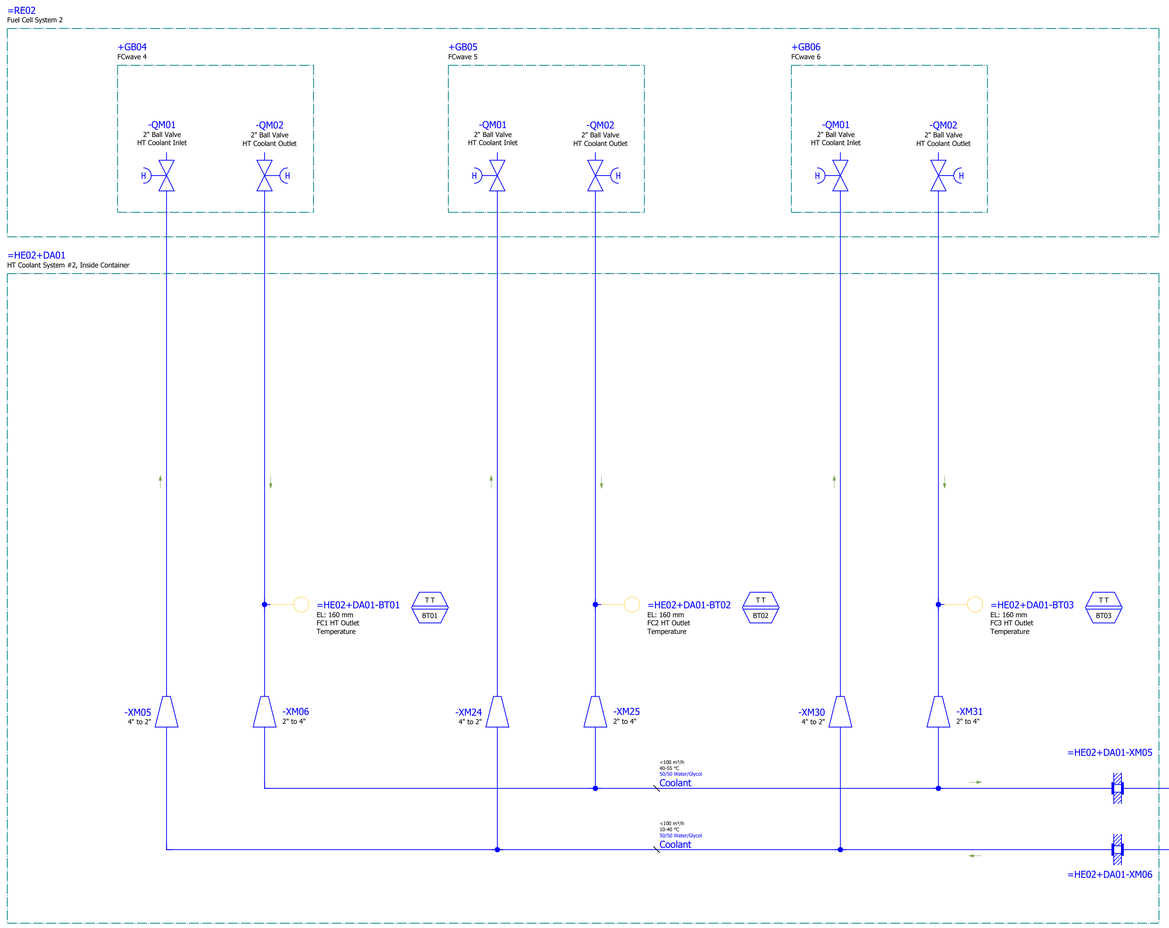
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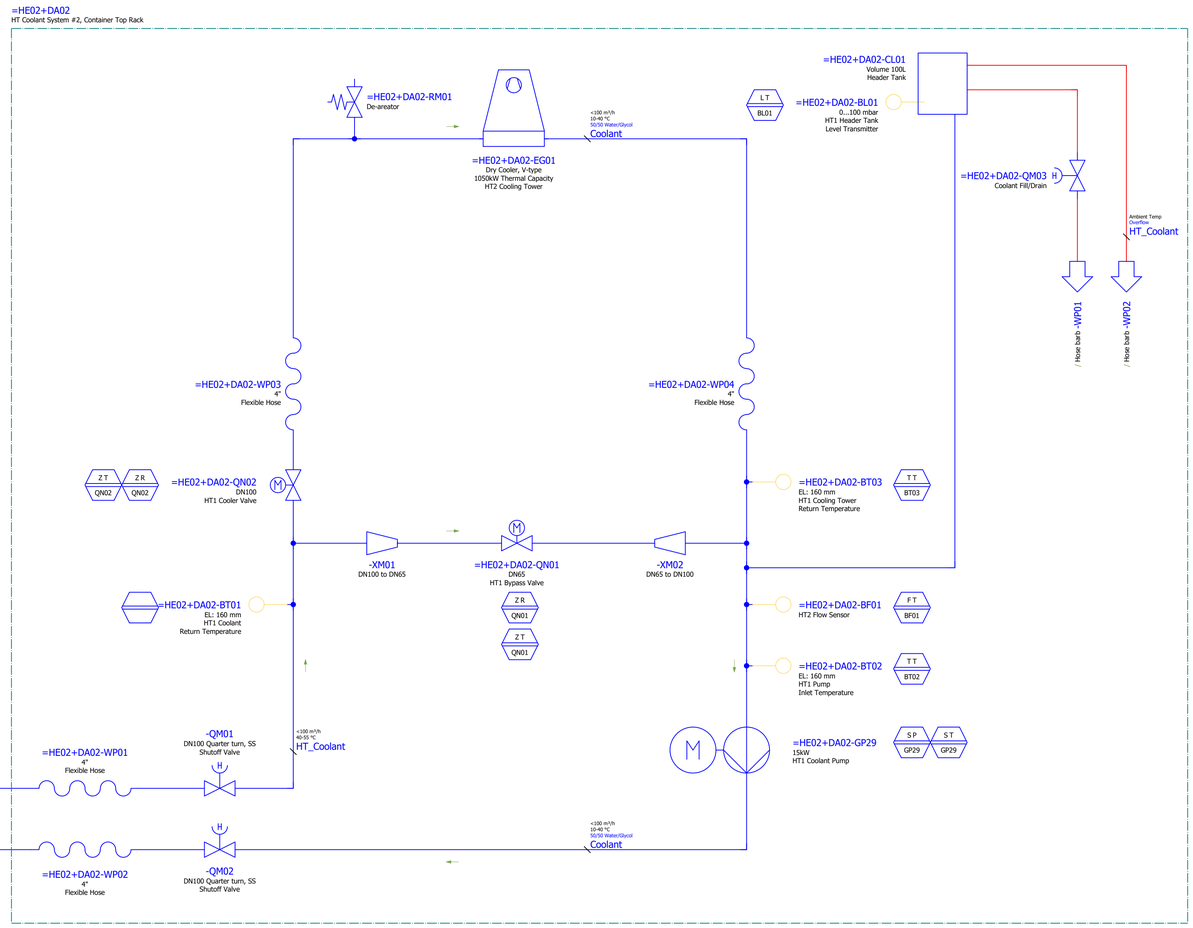
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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	HT1 Coolant System - Fuel Cells
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 LANGUAGE EN SHEET/TOTAL 7 / 16

FRMS103653/0B

High Temperature Cooling System - Fuel Cells 4-6





Coolant type: proviflow Neo 50/50 %vol ethylene glycol

Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=HE02+DA02-BF01	1	Piece	Flow sensor	IFM Electronic AS	SAEXXXXB50KG/US-100	SA4104
=HE02+DA02-BL01	1	Piece	Pressure transmitter with ceramic measuring cell, DC, analogue signal	IFM Electronic AS	PA-,10BRBG14-A-ZVG/US/ /V	PA3589
=HE02+DA01-BT01	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE02+DA01-BT02	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE02+DA01-BT03	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE02+DA02-BT01	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE02+DA02-BT02	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE02+DA02-BT03	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE02+DA02-CL01	1		Header Tank, Volume 100L, AISI 304	Ballard Power Systems Europe	5500231B-3002	5500231B-3002
=HE02+DA02-EG01	1		Dry Cooler, 1050kW, With Ventilators (Offshore)	EVAPCO Europe A/S	VA091 Series Drycooler	VA091EWHHD-682-IHD-120-2,3-Sp
=HE02+DA02-GP29	1		Centrifugal pump, with electric motor, single-stage close coupled in line.	Grundfos AS	TP 100-310/2 X-F-A-BQQE-OW1	92886729
=HE02+DA02-QM01	1		Ball Valve, Stainless Steel, DN100, Weld Flange	Armatec DVCAS	DVC Type 1311	1311510100
=HE02+DA02-QM02	1		Ball Valve, Stainless Steel, DN100, Weld Flange	Armatec DVCAS	DVC Type 1311	1311510100
=HE02+DA02-QM03	0					
=HE02+DA02-QN01	1	piece	Valve act. 24...230V, 160 Nm, bus, IP66	Belimo Holding AG	PRCA-BAC-S2-T	PRCA-BAC-S2-T
=HE02+DA02-QN02	1	piece	Valve act. 24...230V, 160 Nm, bus, IP66	Belimo Holding AG	PRCA-BAC-S2-T	PRCA-BAC-S2-T
=HE02+DA02-RM01	1		De-aerator, For coolant containing 50%vol glycol, 21.3mm BSPT thread external	Sanistål	Flexvent 1/2"	
=HE02+DA02-WP01	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122
=HE02+DA02-WP02	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122
=HE02+DA02-WP03	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122
=HE02+DA02-WP04	1		Coolant Hose, 110x122mm, EPDM, 4barg	Radiacord	5.002.000.01604	NW110-122

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	++ + & B02

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION
DESCRIPTION
DATE
15-Sep-25

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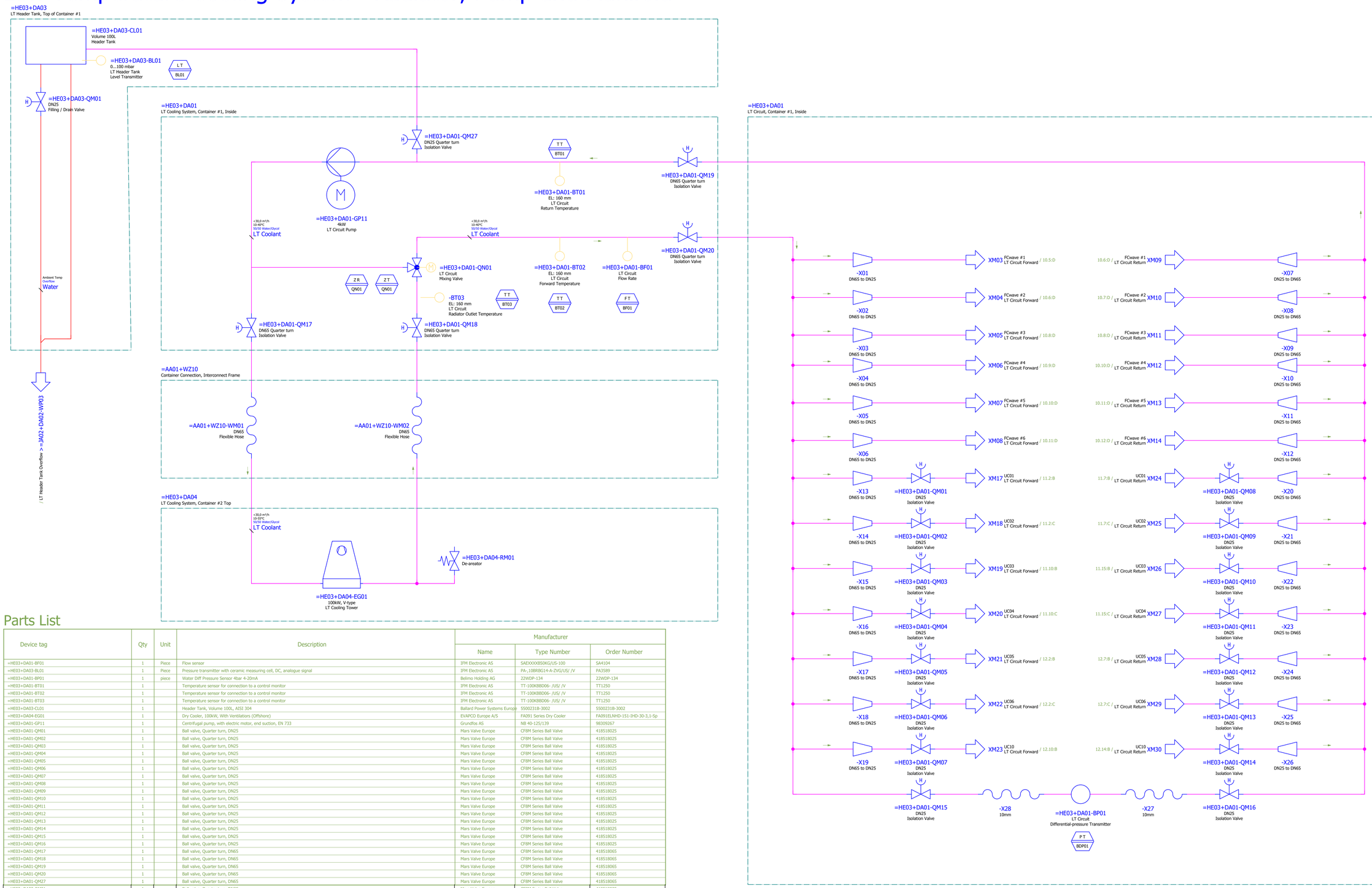
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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	HT2 Coolant System - Fuel Cells
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 LANGUAGE EN SHEET/TOTAL 8 / 16

FRMS103653/0B

Low Temperature Cooling System - Radiator, Pump and Manifold



Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=HE03+DA01-BF01	1	Piece	Flow sensor	IFM Electronic AS	SAEXXXXBS0KG/US-100	SA4104
=HE03+DA03-BL01	1	Piece	Pressure transmitter with ceramic measuring cell, DC, analogue signal	IFM Electronic AS	PA-,108RBG14-A-ZVG/US/ /V	PA3589
=HE03+DA01-BP01	1	piece	Water Diff Pressure Sensor 4bar 4-20mA	Belimo Holding AG	22WDP-134	22WDP-134
=HE03+DA01-BT01	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE03+DA01-BT02	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE03+DA01-BT03	1		Temperature sensor for connection to a control monitor	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250
=HE03+DA03-CL01	1		Header Tank, Volume 100L, AISI 304	Ballard Power Systems Europe	S500231B-3002	S500231B-3002
=HE03+DA04-EG01	1		Dry Cooler, 100kW, With Ventilators (Offshore)	EVAPCO Europe A/S	FA091 Series Dry Cooler	FA091ELNHD-151-IHD-30-3,1-Sp
=HE03+DA01-GP11	1		Centrifugal pump, with electric motor, end suction, EN 733	Grundfos AS	NB 40-125/139	98309267
=HE03+DA01-QM01	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM02	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM03	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM04	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM05	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM06	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM07	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM08	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM09	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM10	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM11	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM12	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM13	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM14	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM15	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM16	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QM17	1		Ball valve, Quarter turn, DN65	Mars Valve Europe	CF8M Series Ball Valve	418S18065
=HE03+DA01-QM18	1		Ball valve, Quarter turn, DN65	Mars Valve Europe	CF8M Series Ball Valve	418S18065
=HE03+DA01-QM19	1		Ball valve, Quarter turn, DN65	Mars Valve Europe	CF8M Series Ball Valve	418S18065
=HE03+DA01-QM20	1		Ball valve, Quarter turn, DN65	Mars Valve Europe	CF8M Series Ball Valve	418S18065
=HE03+DA01-QM27	1		Ball valve, Quarter turn, DN65	Mars Valve Europe	CF8M Series Ball Valve	418S18065
=HE03+DA03-QM01	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S18025
=HE03+DA01-QN01	1		3-way flow control valve, Stainless steel, Internal thread, DN50, PN25	Belimo Holding AG	H3S Series Globe Valve	H3S05-P
=HE03+DA01-QN01.MA01	1		Actuator, for globe valves, modulating, 1500N force	Belimo Holding AG	SVC Series Modulaing Actuators	SVC24A-SR-TPC
=HE03+DA04-RM01	1		De-aerator, Stainless, For coolant containing 50% glycol, 3/8"	Brdr AO Johansen	Aeromat Series	
=HE03+DA01-X27	1		Polyamide Flexible Tubing, Ø10x8,0	Parker Hannifin		100P1000
=HE03+DA01-X28	1		Polyamide Flexible Tubing, Ø10x8,0	Parker Hannifin		100P1000

Coolant type: proviflow Neo 50/50 %vol ethylene glycol

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	++ | + | & B02

Design:	PBL
Review:	RBS
Approval:	JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	15-Sep-25

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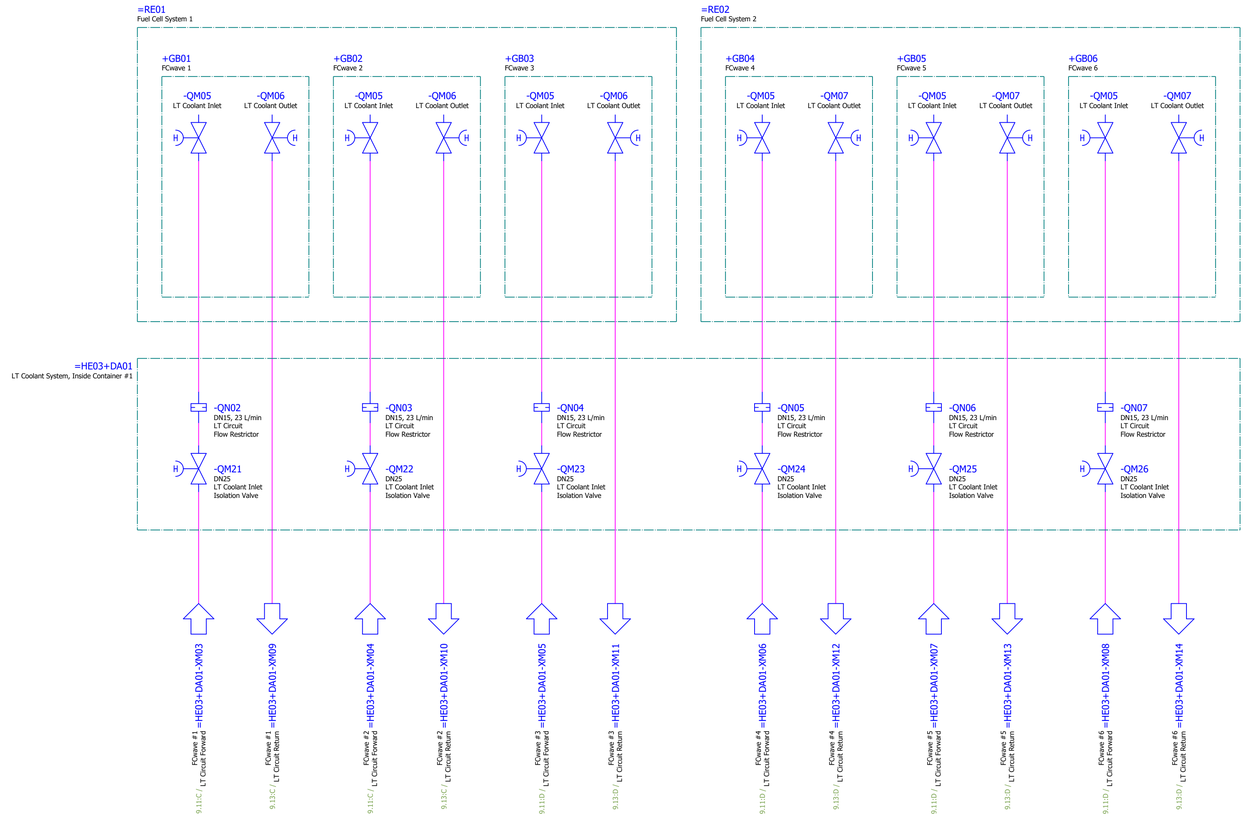
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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	LT Coolant System - Overview
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 9 / 16

FRMS103653/0B

Low Temperature Cooling System - Fuel Cell Connections



Coolant type: proviflow Neo 50/50 %vol ethylene glycol

Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=HE03+DA01-QM21	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S1802S
=HE03+DA01-QM22	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S1802S
=HE03+DA01-QM23	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S1802S
=HE03+DA01-QM24	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S1802S
=HE03+DA01-QM25	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S1802S
=HE03+DA01-QM26	1		Ball valve, Quarter turn, DN25	Mars Valve Europe	CF8M Series Ball Valve	418S1802S
=HE03+DA01-QN02	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=HE03+DA01-QN03	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=HE03+DA01-QN04	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=HE03+DA01-QN05	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=HE03+DA01-QN06	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=HE03+DA01-QN07	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	++ | + | & B02

Design:	PBL
Review:	RBS
Approval:	JTA

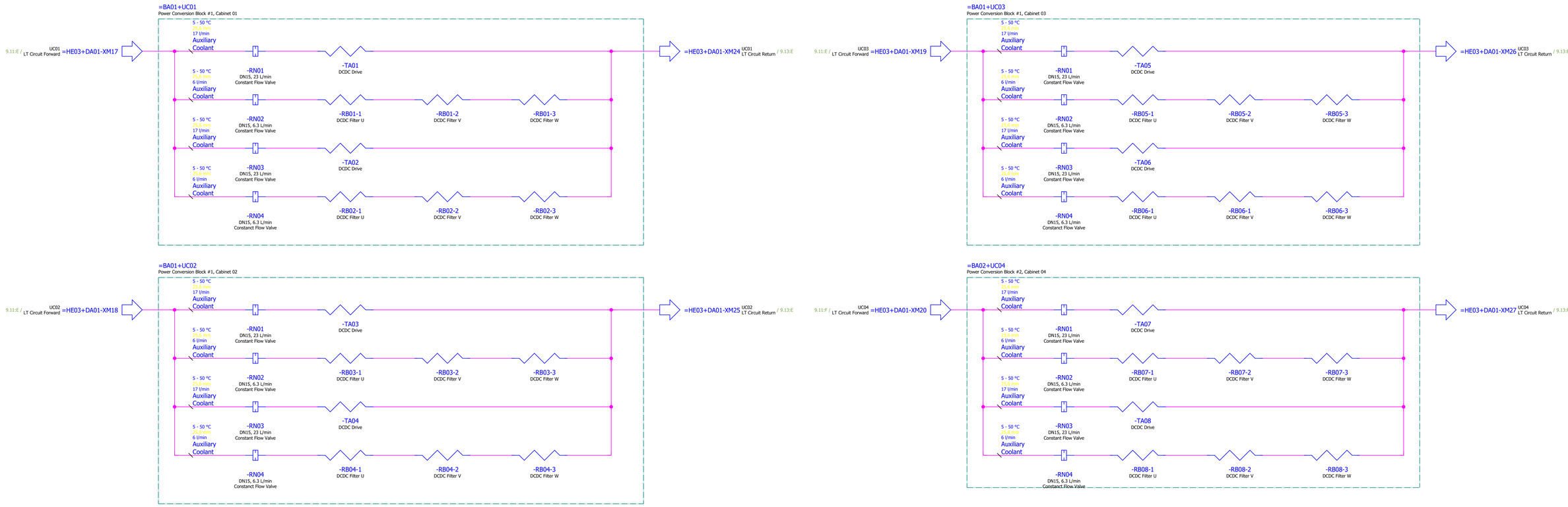
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DRAWING	K559-2254-CWIWP202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	LT Coolant System - Fuel Cells
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 10 / 16

Low Temperature Cooling System - Power Converter Connections 1/2



Coolant type: proviflow Neo 50/50 %vol ethylene glycol

Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=BA01+UC01-RB01-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC01-RB01-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC01-RB01-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC01-RB02-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC01-RB02-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC01-RB02-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC02-RB03-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC02-RB03-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC02-RB03-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC02-RB04-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC02-RB04-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC02-RB04-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC03-RB05-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC03-RB05-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC03-RB05-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC03-RB06-1	2		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC03-RB06-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA01+UC01-RN01	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA01+UC01-RN02	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA01+UC01-RN03	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA01+UC01-RN04	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA01+UC02-RN01	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA01+UC02-RN02	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA01+UC02-RN03	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA01+UC02-RN04	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA01+UC03-RN01	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA01+UC03-RN02	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA01+UC03-RN03	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA01+UC03-RN04	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA01+UC01-TA01	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA01+UC01-TA02	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA01+UC02-TA03	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA01+UC02-TA04	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA01+UC03-TA05	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
- ++	+ & B02

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	15-Sep-25

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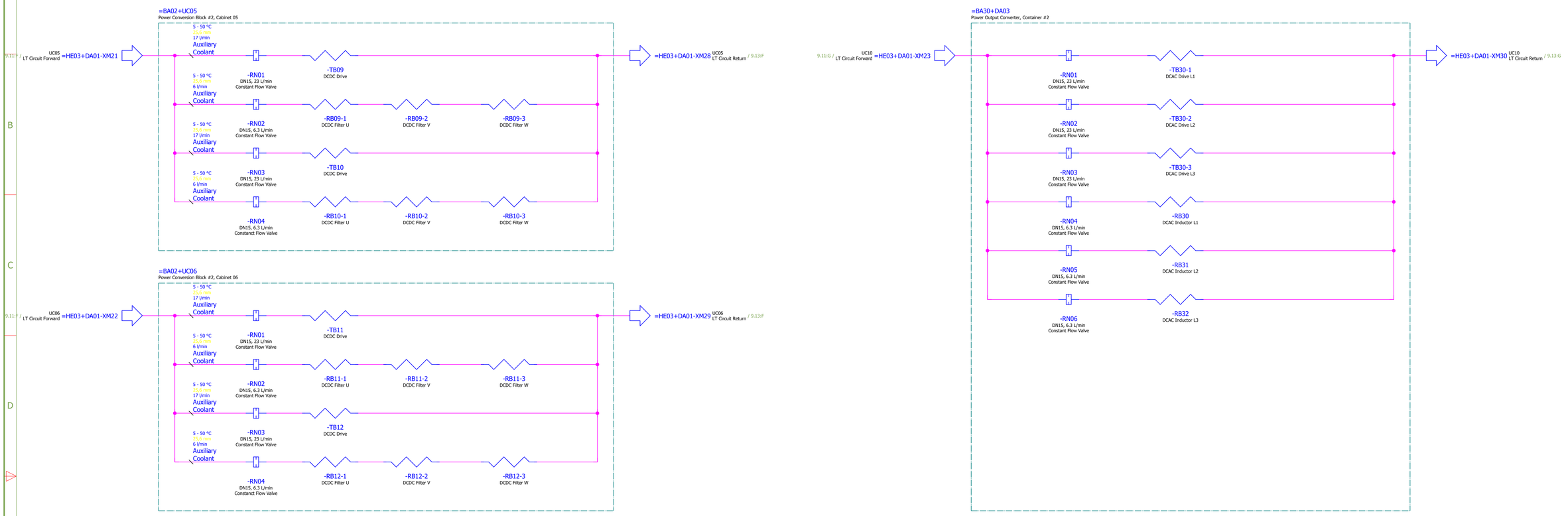
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DRAWING	K559-2254-CW1WP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	LT Coolant System - Power Converters 1/2
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 · LANGUAGE EN · SHEET/TOTAL 11 / 16

FRM510365 3/08

Low Temperature Cooling System - Power Converter Connections 2/2



Coolant type: proviflow Neo 50/50 %vol ethylene glycol

Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=BA02+UC05-RB09-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC05-RB09-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC05-RB09-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC05-RB10-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC05-RB10-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC05-RB10-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC06-RB11-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC06-RB11-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC06-RB11-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC06-RB12-1	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC06-RB12-2	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA02+UC06-RB12-3	1		Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V	QA Trafotek Oy	181B5969	
=BA30+DA03-RB30	1		Heat exchanger, Frame CH64 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FW64905
=BA30+DA03-RB31	1		Heat exchanger, Frame CH64 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FW64905
=BA30+DA03-RB32	1		Heat exchanger, Frame CH64 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FW64905
=BA02+UC05-RN01	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA02+UC05-RN02	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA02+UC05-RN03	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA02+UC05-RN04	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA02+UC06-RN01	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA02+UC06-RN02	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA02+UC06-RN03	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA02+UC06-RN04	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA30+DA03-RN01	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP
=BA30+DA03-RN02	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA30+DA03-RN03	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA30+DA03-RN04	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA30+DA03-RN05	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA30+DA03-RN06	1		Valve, Constant Flow, DN15, 6,3 L/min	Bertfeld Teknik AB		117115P63LP
=BA02+UC05-TB09	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA02+UC05-TB10	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA02+UC06-TB11	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA02+UC06-TB12	1		Heat exchanger, Frame FR8 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FR08901
=BA30+DA03-TB30-1	1		Heat exchanger, Frame CH64 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FW64905
=BA30+DA03-TB30-2	1		Heat exchanger, Frame CH64 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FW64905
=BA30+DA03-TB30-3	1		Heat exchanger, Frame CH64 for NXP series	Danfoss	FR8 Chassis Heat Exchanger	FW64905

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
-	++ | + | & B02

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	15-Sep-25

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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	LT Coolant System - Power Converters 2/2
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 12 / 16

FRM510365 3/0B

0	1	2	3	4	5	6	7	8

Bill of Materials / Parts List

Device tag	Qty	Unit	Description	Manufacturer			
				Name	Type Number	Order Number	
-BF01	1	Piece	Flow sensor, Connector: 1 x M12; coding: A; Contacts: gold-plated	IFM Electronic AS	SAEXXXXB50KG/US-100	SA4104	
-BF01-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BF01-XD01	0						
-BF01-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BF01-XG01	0						
-BL01-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BL01-XG01	0						
-BL01	1	Piece	Pressure transmitter with ceramic measuring cell, DC, analogue signal	IFM Electronic AS	PA-,10BRBG14-A-ZVG/US/ /V	PA3589	
-BP01	1	piece	Differential Pressure Sensor Water 0...4 bar AC/DC 24 V, Output signal 0...10 V	Belimo Holding AG	22WDP-134	22WDP-134	
-BP01-WG01	1	meter	ÖLFLEX CLASSIC 110 CH 3G1	Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056	
-BP01-XD01	0						
-BP02	0						
-BP02-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BP02-XG01	0						
-BP03-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BP03-XG01	0						
-BP04	0						
-BP04-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BP04-XG01	0						
-BP05	0						
-BP05-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BP05-XG01	0						
-BP06	0						
-BP06-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BP06-XG01	0						
-BP07	0						
-BP07-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BP07-XG01	0						
-BT01	1		PT1000 Sensor Element, Length 160mm to M12, A code connector. 3/4 wire measurement	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250	
-BT02	1		PT1000 Sensor Element, Length 160mm to M12, A code connector. 3/4 wire measurement	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250	
-BT03	1		PT1000 Sensor Element, Length 160mm to M12, A code connector. 3/4 wire measurement	IFM Electronic AS	TT-100KBBD06- /US/ /V	TT1250	
-BT04-XG01	0						
-BT05-XG01	0						
-BT05-WG01	1	Piece	Connecting cable with socket; 4x0,34mm2, AC/DC < 50 V; 10 m M12 to open end; LSZH	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540	
-BT05-XG01	0						
-CL01	1		Header Tank, Volume 100L, AISI 304	Ballard Power Systems Europe	5500231B-3002	5500231B-3002	
-EG01	1		Dry Cooler, 100kW, With Ventilatiors (Offshore), Tube 316, Fins AlMg/316, Frame 316	EVAPCO Europe A/S	FA091 Series Dry Cooler	FA091ELNHD-151-IHD-30-3,1-Sp	
-GP11	1		Centrifugal pump, with electric motor, end suction, EN 733, Motor: 4kW, 3x380-415D, 50Hz	Grundfos AS	NB 40-125/139	98309267	
-GP11-WG01	1	m	ÖLFLEX CLASSIC 110 Control Line	Lapp Group	ÖLFLEX CLASSIC 110	1119 203	
-GP11-WG01	0						
-GP11.WD01	1	meter	Screened control cable, 4G2,5mm2, LSZH	Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123342	
-GP11.WD02	1	meter	Screened control cable, 4G2,5mm2, LSZH	Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123342	
-GP11.WG02	1	meter		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059	
-GQ31	1		Three-phase asynchronous motor, 4 pole pairs, 4,0kW	Fabrika A/S	Fabrika CX B14 TEAO	CXB14-4	
-GQ31-WD01	1	meter	ÖLFLEX CLASSIC 135 CH BK 0,6/1 kV 4G2,5	Lapp Group	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	1123478	
-QM01	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM02	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM03	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM04	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM05	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM06	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM07	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM08	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM09	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM10	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM11	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
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REVISION INFORMATION
DESCRIPTION
DATE
15-Sep-25

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DRAWING		REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	LT Coolant System - BOM		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 13 / 15

0	1	2	3	4	5	6	7	8

Bill of Materials / Parts List

Device tag	Qty	Unit	Description	Manufacturer			
				Name	Type Number	Order Number	
-QM12	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM13	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM14	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM15	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM16	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM17	1		Ball valve, Quarter turn, DN65, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518065	
-QM18	1		Ball valve, Quarter turn, DN65, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518065	
-QM19	1		Ball valve, Quarter turn, DN65, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518065	
-QM20	1		Ball valve, Quarter turn, DN65, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518065	
-QM21	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM22	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM23	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM24	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM25	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM26	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QM27	1		Ball valve, Quarter turn, DN65, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518065	
-QM01	1		Ball valve, Quarter turn, DN25, Material body, valve AISI304, gasket and sealing ring PTFE	Mars Valve Europe	CF8M Series Ball Valve	418518025	
-QN01	1		3-way flow control valve, Stainless steel, Internal thread, DN50, PN25	Belimo Holding AG	H3S Series Globe Valve	H350S-P	
-QN01.MA01	1		Actuator, for globe valves, modulating, 1500N force	Belimo Holding AG	SVC Series Modulaing Actuators	SVC24A-SR-TPC	
-QN01.WG01	1	meter		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059	
-QN01.WG02	1	meter		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059	
-QN02	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP	
-QN03	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP	
-QN04	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP	
-QN05	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP	
-QN06	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP	
-QN07	1		Valve, Constant Flow, DN15, 23 L/min	Bertfeld Teknik AB		117115P230LP	
-RM01	1		De-aerator, Stainless, For coolant containing 50% glycol, 3/8"	Brdr AO Johansen	Aeromat Series		
-TA11	2	PIECES	Safe Torque off & ATEX board for VACON® NXP 2DI,1RO(NO/NC), 1RO(NO), 1TI Slot B	Danfoss	OPT-AF	OPT-AF-V	
-TA11	2	pieces	VFD , Input voltage: 3x 380-500 VAC, Output Power: 4 kW	Danfoss	NXP00095-A5H1SSV	NXP00095-A5H1SSV	
-TA11	0						
-TA11	2	pieces	Vacon NX, Ethernet option board with two RJ-45 connectors SLOT: D, E	Danfoss	OPT-E9	OPT-E9-V	
-TF01	1		Signal Converter Voltage/Current, Input 0-10V or (0)4-20mA, Output (0)4-20mA	Belimo Holding AG	Z-UIC	Z-UIC	
-X27	1		Polyamide Flexible Tubing, Ø10x8,0 - OD 10mm, ID 8mm, 50barg, -40 to 100°C	Parker Hannifin		100P1000	
-X28	1		Polyamide Flexible Tubing, Ø10x8,0 - OD 10mm, ID 8mm, 50barg, -40 to 100°C	Parker Hannifin		100P1000	

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	++ | + | & B02

REVISION INFORMATION
DESCRIPTION
DATE
15-Sep-25

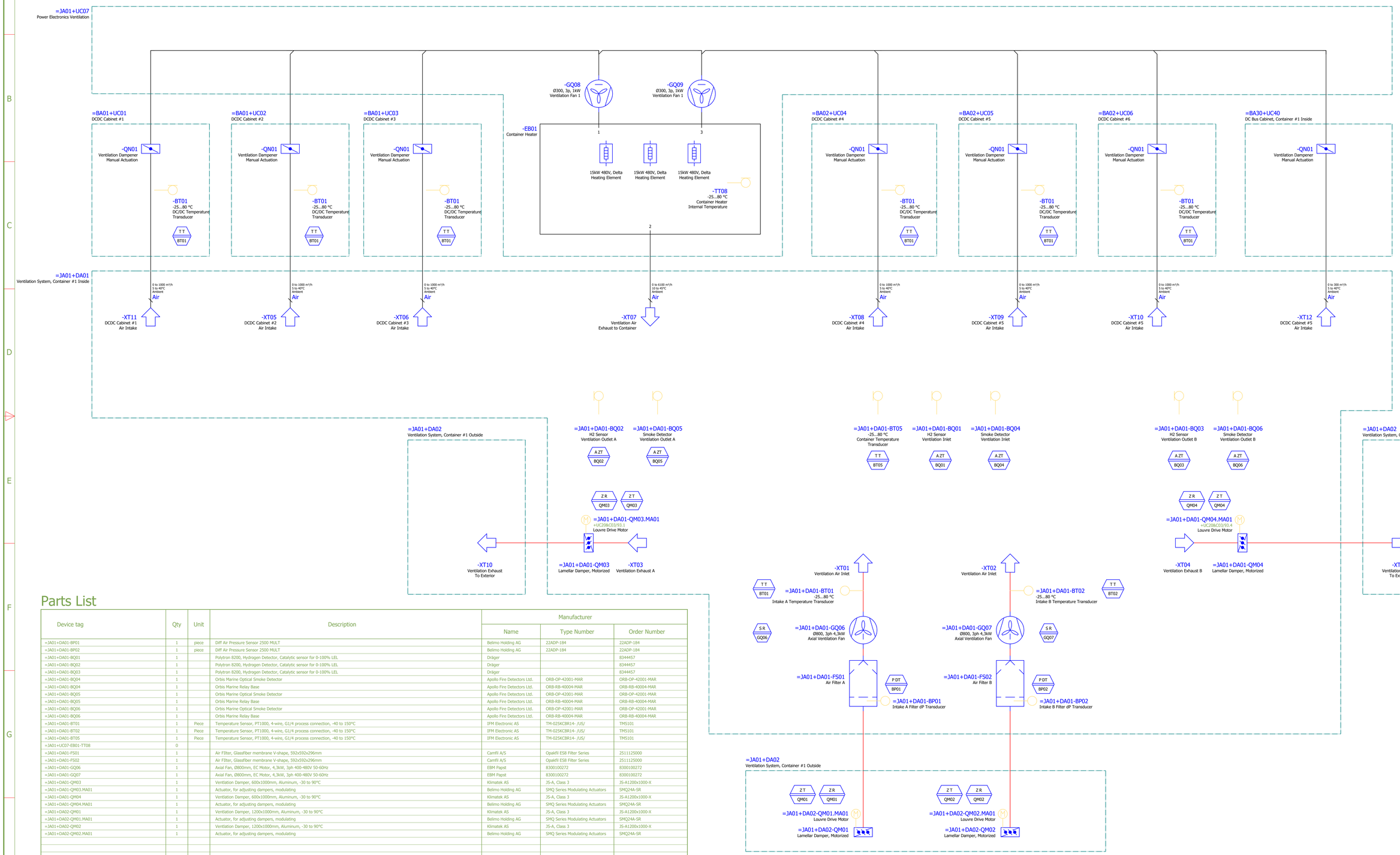
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DRAWING		REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	LT Coolant System - BOM		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 13.a / 15

Ventilation Air System - 40ft Container



Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=JA01+DA01-BP01	1	piece	Diff Air Pressure Sensor 2500 MULT	Belimo Holding AG	22ADP-184	22ADP-184
=JA01+DA01-BP02	1	piece	Diff Air Pressure Sensor 2500 MULT	Belimo Holding AG	22ADP-184	22ADP-184
=JA01+DA01-BQ01	1		Polytron 8200, Hydrogen Detector, Catalytic sensor for 0-100% LEL	Dräger		8344457
=JA01+DA01-BQ02	1		Polytron 8200, Hydrogen Detector, Catalytic sensor for 0-100% LEL	Dräger		8344457
=JA01+DA01-BQ03	1		Polytron 8200, Hydrogen Detector, Catalytic sensor for 0-100% LEL	Dräger		8344457
=JA01+DA01-BQ04	1		Orbis Marine Optical Smoke Detector	Apollo Fire Detectors Ltd.	ORB-OP-42001-MAR	ORB-OP-42001-MAR
=JA01+DA01-BQ04	1		Orbis Marine Relay Base	Apollo Fire Detectors Ltd.	ORB-RB-40004-MAR	ORB-RB-40004-MAR
=JA01+DA01-BQ05	1		Orbis Marine Optical Smoke Detector	Apollo Fire Detectors Ltd.	ORB-OP-42001-MAR	ORB-OP-42001-MAR
=JA01+DA01-BQ05	1		Orbis Marine Relay Base	Apollo Fire Detectors Ltd.	ORB-RB-40004-MAR	ORB-RB-40004-MAR
=JA01+DA01-BQ06	1		Orbis Marine Optical Smoke Detector	Apollo Fire Detectors Ltd.	ORB-OP-42001-MAR	ORB-OP-42001-MAR
=JA01+DA01-BQ06	1		Orbis Marine Relay Base	Apollo Fire Detectors Ltd.	ORB-RB-40004-MAR	ORB-RB-40004-MAR
=JA01+DA01-BT01	1	Piece	Temperature Sensor, PT1000, 4-wire, G1/4 process connection, -40 to 150°C	IFM Electronic AS	TM-025KCBR14- /US/	TM5101
=JA01+DA01-BT02	1	Piece	Temperature Sensor, PT1000, 4-wire, G1/4 process connection, -40 to 150°C	IFM Electronic AS	TM-025KCBR14- /US/	TM5101
=JA01+DA01-BT05	1	Piece	Temperature Sensor, PT1000, 4-wire, G1/4 process connection, -40 to 150°C	IFM Electronic AS	TM-025KCBR14- /US/	TM5101
=JA01+UC07-EB01-TT08	0					
=JA01+DA01-FS01	1		Air Filter, Glassfiber membrane V-shape, 592x592x296mm	Camfil A/S	Opakfil ES8 Filter Series	2511125000
=JA01+DA01-FS02	1		Air Filter, Glassfiber membrane V-shape, 592x592x296mm	Camfil A/S	Opakfil ES8 Filter Series	2511125000
=JA01+DA01-GQ06	1		Axial Fan, Ø800mm, EC Motor, 4,3kW, 3ph 400-480V 50-60Hz	EBM Papst	8300100272	8300100272
=JA01+DA01-GQ07	1		Axial Fan, Ø800mm, EC Motor, 4,3kW, 3ph 400-480V 50-60Hz	EBM Papst	8300100272	8300100272
=JA01+DA01-QM03	1		Ventilation Damper, 600x1000mm, Aluminum, -30 to 90°C	Klimatek AS	JS-A, Class 3	JS-A1200x1000-X
=JA01+DA01-QM03.MA01	1		Actuator, for adjusting dampers, modulating	Belimo Holding AG	SMQ Series Modulating Actuators	SMQ24A-SR
=JA01+DA01-QM04	1		Ventilation Damper, 600x1000mm, Aluminum, -30 to 90°C	Klimatek AS	JS-A, Class 3	JS-A1200x1000-X
=JA01+DA01-QM04.MA01	1		Actuator, for adjusting dampers, modulating	Belimo Holding AG	SMQ Series Modulating Actuators	SMQ24A-SR
=JA01+DA02-QM01	1		Ventilation Damper, 1200x1000mm, Aluminum, -30 to 90°C	Klimatek AS	JS-A, Class 3	JS-A1200x1000-X
=JA01+DA02-QM01.MA01	1		Actuator, for adjusting dampers, modulating	Belimo Holding AG	SMQ Series Modulating Actuators	SMQ24A-SR
=JA01+DA02-QM02	1		Ventilation Damper, 1200x1000mm, Aluminum, -30 to 90°C	Klimatek AS	JS-A, Class 3	JS-A1200x1000-X
=JA01+DA02-QM02.MA01	1		Actuator, for adjusting dampers, modulating	Belimo Holding AG	SMQ Series Modulating Actuators	SMQ24A-SR

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	++ | + | & B02

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	15-Sep-25

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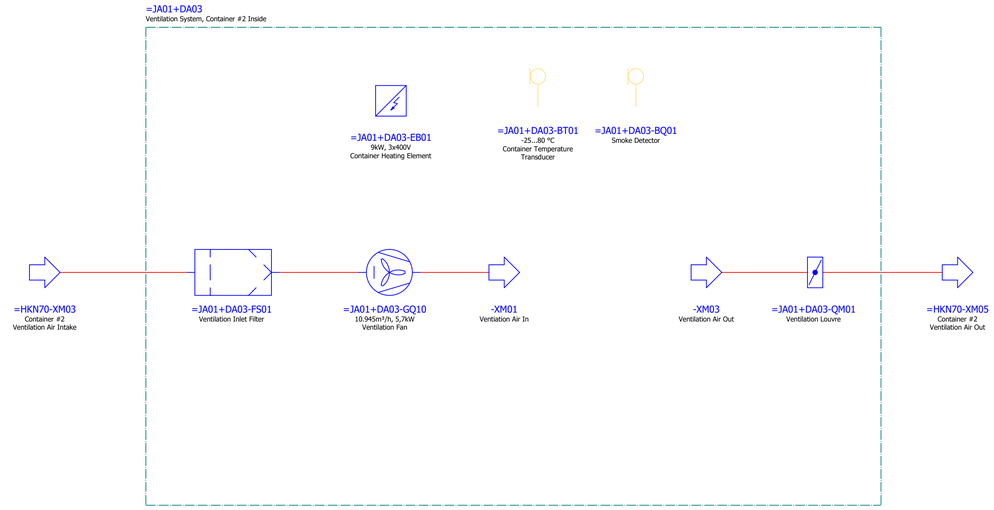
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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Ventilation Air System - 40ft Container
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 14 / 16

FRMS103653/08

Ventilation Air System - 10ft Container



Parts List

Device tag	Qty	Unit	Description	Manufacturer		
				Name	Type Number	Order Number
=JA01+DA03-BQ01	1		Orbis Marine Optical Smoke Detector	Apollo Fire Detectors Ltd.	ORB-OP-42001-MAR	ORB-OP-42001-MAR
=JA01+DA03-BQ01	1		Orbis Marine Relay Base	Apollo Fire Detectors Ltd.	ORB-RB-40004-MAR	ORB-RB-40004-MAR
=JA01+DA03-BT01	1	Piece	Temperature Sensor, PT1000, 4-wire, G1/4 process connection, -40 to 150°C	IFM Electronic AS	TM-025KCBR14- /US/	TM5101
=JA01+DA03-EB01	1		Placeholder			
=JA01+DA03-FS01	0					
=JA01+DA03-GQ10	1		Ventilation Fan, Radial, EC Motor, 3ph, 400-480V, 5.7kW	EBM Papst		
=JA01+DA03-QM01	0					

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	574
=	+ +
+	& B02

Design: PBL
Review: RBS
Approval: JTA

REVISION INFORMATION	
DESCRIPTION	
DATE	15-Sep-25

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DRAWING	K559-2254-CWIWP4202202-C03-001
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Ventilation Air System - 10ft Container
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 · LANGUAGE EN · SHEET/TOTAL 15 / 16

FRMS103653/0B

Sub Section C04

Bill of Materials

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	3/3/2023	First Issue
002	5/17/2023	Updated according to comments
003	9/9/2025	Updated with M-bom and E-bom

KBR
ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

ACCEPTED	(Code 1) ____
ACCEPTED WITH COMMENTS	(Code 2) ____
NOT ACCEPTED	(Code 3) ____
NOT REVIEWED	(Code 4)

ACCEPTANCE DOES NOT RELIEVE SUPPLIER FROM FURNISHING MATERIAL IN CONFORMANCE WITH ORDER. REFER TO SDR-1 FOR FULL DEFINITION OF ACCEPTANCE CONDITIONS.

DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - Bill of Materials**
Document Number:	K559-2254-CWIWP4202202-C04-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-C04-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C04
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Sub Subsection of C04

Bill of Materials

Electrical BOM extracted from

“EPLAN Electric P8®”

Project Bill of Materials / Parts List

Project: 601456B
Filename: K559-2254-CWIWP4202202-C04-001
Revision: 3

Full DT	Function Code (=)	Function Code Description	Location Code (+)	Location Description	Device Tag (-)	Manufacturer and Item	Manufacturer Part Number	Description
'=BA01+UC01-BT01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=BA01+UC01-BT01-WG01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=BA01+UC01-RB01-1	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RB01-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC01-RB01-2	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RB01-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC01-RB01-3	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RB01-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC01-RB02-1	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RB02-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC01-RB02-2	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RB02-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC01-RB02-3	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RB02-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC01-RN01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RN01	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA01+UC01-RN02	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RN02	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA01+UC01-RN03	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RN03	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA01+UC01-RN04	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-RN04	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA01+UC01-TA01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA01	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA01+UC01-TA01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA01	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA01+UC01-TA01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA01	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA01+UC01-TA01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA01	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA01+UC01-TA01-WG01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA01-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=BA01+UC01-TA01-WG02	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA01-WG02	LAPP.11139521	Unitronic FD CP 2x2x0.5	ÖLFLEX CLASSIC 130 H 4X1,5;
'=BA01+UC01-TA02	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA02	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA01+UC01-TA02	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA02	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA01+UC01-TA02	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA02	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA01+UC01-TA02	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA02	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA01+UC01-TA02-SlotD	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-TA02-SlotD	DAN.OPT-E9		#VALUE!
'=BA01+UC01-WD01	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC01-WD02	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC01-WD03	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-WD03	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA01+UC01-XG103A	'=BA01	Power Conversion Block 1;	'+UC01	DCDC Cabinet #1;	'-XG103A	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=BA01+UC02-BT01	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=BA01+UC02-BT01-WG01	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=BA01+UC02-RB03-1	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RB03-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC02-RB03-2	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RB03-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC02-RB03-3	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RB03-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC02-RB04-1	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RB04-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC02-RB04-2	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RB04-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC02-RB04-3	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RB04-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC02-RN01	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RN01	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA01+UC02-RN02	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RN02	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA01+UC02-RN03	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RN03	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA01+UC02-RN04	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-RN04	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA01+UC02-TA01-WG01	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA01-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=BA01+UC02-TA01-WG02	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA01-WG02	LAPP.11139521	Unitronic FD CP 2x2x0.5	ÖLFLEX CLASSIC 130 H 4X1,5;
'=BA01+UC02-TA02-SlotD	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA02-SlotD	DAN.OPT-E9		#VALUE!
'=BA01+UC02-TA03	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA03	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA01+UC02-TA03	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA03	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA01+UC02-TA03	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA03	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA01+UC02-TA03	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA03	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA01+UC02-TA04	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA04	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA01+UC02-TA04	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA04	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA01+UC02-TA04	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA04	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA01+UC02-TA04	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-TA04	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA01+UC02-WD01	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC02-WD02	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC02-WD03	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-WD03	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA01+UC02-XG103A	'=BA01	Power Conversion Block 1;	'+UC02	DCDC Cabinet #2;	'-XG103A	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=BA01+UC03-BT01	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=BA01+UC03-BT01-WG01	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=BA01+UC03-RB05-1	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RB05-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC03-RB05-2	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RB05-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC03-RB05-3	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RB05-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC03-RB06-1	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RB06-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC03-RB06-1	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RB06-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC03-RB06-3	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RB06-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA01+UC03-RN01	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RN01	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA01+UC03-RN02	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RN02	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA01+UC03-RN03	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RN03	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA01+UC03-RN04	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-RN04	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA01+UC03-TA01-WG01	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA01-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=BA01+UC03-TA01-WG02	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA01-WG02	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=BA01+UC03-TA02-SlotD	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA02-SlotD	DAN.OPT-E9		#VALUE!
'=BA01+UC03-TA05	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA05	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA01+UC03-TA05	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA05	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA01+UC03-TA05	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA05	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA01+UC03-TA05	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA05	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA01+UC03-TA06	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA06	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA01+UC03-TA06	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA06	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA01+UC03-TA06	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-TA06	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA01+UC03-WD01	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;

'=BA01+UC03-WD02	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC03-WD03	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-WD03	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA01+UC03-XG103A	'=BA01	Power Conversion Block 1;	'+UC03	DCDC Cabinet #3;	'-XG103A	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=BA01+UC04-TA01-WG01	'=BA01	Power Conversion Block 1;	'+UC04	DCDC Cabinet #4;	'-TA01-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=BA01+UC04-TA01-WG02	'=BA01	Power Conversion Block 1;	'+UC04	DCDC Cabinet #4;	'-TA01-WG02	LAPP.11139521	Unitronic FD CP 2x2x0.5	ÖLFLEX CLASSIC 130 H 4X1,5;
'=BA01+UC04-TA02-SlotD	'=BA01	Power Conversion Block 1;	'+UC04	DCDC Cabinet #4;	'-TA02-SlotD	DAN.OPT-E9		#VALUE!
'=BA01+UC04-WD01	'=BA01	Power Conversion Block 1;	'+UC04	DCDC Cabinet #4;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC04-WD02	'=BA01	Power Conversion Block 1;	'+UC04	DCDC Cabinet #4;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC04-WD03	'=BA01	Power Conversion Block 1;	'+UC04	DCDC Cabinet #4;	'-WD03	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA01+UC04-XG103A	'=BA01	Power Conversion Block 1;	'+UC04	DCDC Cabinet #4;	'-XG103A	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=BA01+UC05-TA01-WG01	'=BA01	Power Conversion Block 1;	'+UC05	DCDC Cabinet #5;	'-TA01-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=BA01+UC05-TA01-WG02	'=BA01	Power Conversion Block 1;	'+UC05	DCDC Cabinet #5;	'-TA01-WG02	LAPP.11139521	Unitronic FD CP 2x2x0.5	ÖLFLEX CLASSIC 130 H 4X1,5;
'=BA01+UC05-TA02-SlotD	'=BA01	Power Conversion Block 1;	'+UC05	DCDC Cabinet #5;	'-TA02-SlotD	DAN.OPT-E9		#VALUE!
'=BA01+UC05-WD01	'=BA01	Power Conversion Block 1;	'+UC05	DCDC Cabinet #5;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC05-WD02	'=BA01	Power Conversion Block 1;	'+UC05	DCDC Cabinet #5;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC05-WD03	'=BA01	Power Conversion Block 1;	'+UC05	DCDC Cabinet #5;	'-WD03	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA01+UC05-XG103A	'=BA01	Power Conversion Block 1;	'+UC05	DCDC Cabinet #5;	'-XG103A	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=BA01+UC06-TA01-WG01	'=BA01	Power Conversion Block 1;	'+UC06	DCDC Cabinet #6;	'-TA01-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=BA01+UC06-TA01-WG02	'=BA01	Power Conversion Block 1;	'+UC06	DCDC Cabinet #6;	'-TA01-WG02	LAPP.11139521	Unitronic FD CP 2x2x0.5	ÖLFLEX CLASSIC 130 H 4X1,5;
'=BA01+UC06-TA02-SlotD	'=BA01	Power Conversion Block 1;	'+UC06	DCDC Cabinet #6;	'-TA02-SlotD	DAN.OPT-E9		#VALUE!
'=BA01+UC06-WD01	'=BA01	Power Conversion Block 1;	'+UC06	DCDC Cabinet #6;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC06-WD02	'=BA01	Power Conversion Block 1;	'+UC06	DCDC Cabinet #6;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=BA01+UC06-WD03	'=BA01	Power Conversion Block 1;	'+UC06	DCDC Cabinet #6;	'-WD03	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA01+UC06-XG103A	'=BA01	Power Conversion Block 1;	'+UC06	DCDC Cabinet #6;	'-XG103A	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=BA02+UC04-BT01	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=BA02+UC04-BT01-WG01	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=BA02+UC04-RB07-1	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RB07-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC04-RB07-2	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RB07-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC04-RB07-3	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RB07-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC04-RB08-1	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RB08-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC04-RB08-2	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RB08-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC04-RB08-3	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RB08-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC04-RN01	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RN01	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA02+UC04-RN02	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RN02	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA02+UC04-RN03	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RN03	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA02+UC04-RN04	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-RN04	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA02+UC04-TA07	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA07	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA02+UC04-TA07	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA07	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA02+UC04-TA07	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA07	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA02+UC04-TA07	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA07	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA02+UC04-TA08	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA08	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA02+UC04-TA08	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA08	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA02+UC04-TA08	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA08	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA02+UC04-TA08	'=BA02	Power Conversion Block 2;	'+UC04	DCDC Cabinet #4;	'-TA08	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA02+UC05-BT01	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=BA02+UC05-BT01-WG01	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=BA02+UC05-RB09-1	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RB09-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC05-RB09-2	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RB09-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC05-RB09-3	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RB09-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC05-RB10-1	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RB10-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC05-RB10-2	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RB10-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC05-RB10-3	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RB10-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC05-RN01	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RN01	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA02+UC05-RN02	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RN02	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA02+UC05-RN03	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RN03	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA02+UC05-RN04	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-RN04	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA02+UC05-TA09	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TA09	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA02+UC05-TA09	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TA09	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA02+UC05-TA09	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TA09	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA02+UC05-TA10	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TA10	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA02+UC05-TA10	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TA10	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA02+UC05-TA10	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TA10	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA02+UC05-TB09	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TB09	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA02+UC05-TB10	'=BA02	Power Conversion Block 2;	'+UC05	DCDC Cabinet #5;	'-TB10	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA02+UC06-BT01	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=BA02+UC06-BT01-WG01	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=BA02+UC06-RB11-1	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RB11-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC06-RB11-2	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RB11-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC06-RB11-3	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RB11-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC06-RB12-1	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RB12-1	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC06-RB12-2	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RB12-2	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC06-RB12-3	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RB12-3	DNF.181B5969-HE	181B5969	Heat Exchanger, for liquid cooled DC inductors, 168A, 1050V;
'=BA02+UC06-RN01	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RN01	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA02+UC06-RN02	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RN02	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA02+UC06-RN03	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RN03	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA02+UC06-RN04	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-RN04	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA02+UC06-TA11	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TA11	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA02+UC06-TA11	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TA11	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA02+UC06-TA11	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TA11	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA02+UC06-TA12	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TA12	DNF.NXP_0168 5 A0N0NWV	NXP_0168 5 A0N0NWV	{{NXP, 168 A, IP00, Source: ~50-800 VDC, DC-link: 513-800 VDC}};
'=BA02+UC06-TA12	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TA12	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA02+UC06-TA12	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TA12	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA02+UC06-TB11	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TB11	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;

'=BA02+UC06-TB12	'=BA02	Power Conversion Block 2;	'+UC06	DCDC Cabinet #6;	'-TB12	DNF.NXP-FR8	FR8 Chassis Heat Exhanger	Heat exchanger, Frame FR8 for NXP series;
'=BA20+DA01-TA03	'=BA20	Power Conversion BOP;	'+DA01	Container #1 Inside;	'-TA03	DT.40859-1	40859	Isolation transformer, 3x460V 50/60Hz to 3x400-480V, 160kVA;
'=BA20+DA03-WG01	'=BA20	Power Conversion BOP;	'+DA03	Container #2 Inside;	'-WG01	LAPP.1123217	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=BA20+UC30-WD01	'=BA20	Power Conversion BOP;	'+UC30	Coolant Skid Control Cat	'-WD01	LAPP.1026561	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X70;
'=BA20+UC30-WD02	'=BA20	Power Conversion BOP;	'+UC30	Coolant Skid Control Cat	'-WD02	LAPP.1026561	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X70;
'=BA20+UC30-WD03	'=BA20	Power Conversion BOP;	'+UC30	Coolant Skid Control Cat	'-WD03	LAPP.1026561	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X70;
'=BA20+UC30-WD04	'=BA20	Power Conversion BOP;	'+UC30	Coolant Skid Control Cat	'-WD04	LAPP.1026561	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X70;
'=BA20+UC30-WD05	'=BA20	Power Conversion BOP;	'+UC30	Coolant Skid Control Cat	'-WD05	LAPP.1026561	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X70;
'=BA20+UC31-T1-WG01	'=BA20	Power Conversion BOP;	'+UC31	Control Cabinet (10ft);	'-T1-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA20+UC31-T02-WG01	'=BA20	Power Conversion BOP;	'+UC31	Control Cabinet (10ft);	'-T02-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA20+UC31-T03-WG01	'=BA20	Power Conversion BOP;	'+UC31	Control Cabinet (10ft);	'-T03-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA20+UC31-WD01	'=BA20	Power Conversion BOP;	'+UC31	Control Cabinet (10ft);	'-WD01	LAPP.1123489	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Připojovací a ovládací kabely;
'=BA20+UC50-BC01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-BC01	WAGO.855-305/075-201	855-305/075-201	Zásuvný transformátor proudu;
'=BA20+UC50-BC02	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-BC02	WAGO.855-805/2000-1001	855-805/2000-1001	Zásuvný transformátor proudu;
'=BA20+UC50-BC03	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-BC03	WAGO.855-305/075-201	855-305/075-201	Zásuvný transformátor proudu;
'=BA20+UC50-FA01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FA01	ABB.OVRT23N40320PTSU	OVR DIN Rail SPD	Surge Protection Device, 3p+N for 277Vac L-N voltage systems 50/60Hz;
'=BA20+UC50-FA01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FA01	ABB.2CTB802346R2500		#VALUE!
'=BA20+UC50-FC01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC01	ABB.1SDA075465R1	XT4L 250 Ekip LSI In=250A 4p F F UL/CSA	XT4L 250 Ekip LSI In=250A 4p F F UL/CSA;
'=BA20+UC50-FC02	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC02	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-FC02	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC02	ABB.2CDS254001R0634	S204-C63	Miniature Circuit Breaker - S200 - 4P - C - 63 A;
'=BA20+UC50-FC03	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC03	ABB.2CDS254001R0635	S204-B63	Miniature Circuit Breaker - S200 - 4P - B - 63 A;
'=BA20+UC50-FC03	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC03	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-FC04	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC04	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-FC04	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC04	ETN.FAZ-B63/3N	FAZ-B63/3N	Leitungsschutzschalter, 63 A, 3p+N, Charakteristik: B;
'=BA20+UC50-FC04	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC04	ABB.1SDA075369R1	XT4N 250 Ekip LS/I In=250A 4p F F UL/CSA	Circuit Breaker, 3P+N, 250A, UL/CSA;
'=BA20+UC50-FC05	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC05	ABB.2CDS254001R0325	S204-B32	Miniature Circuit Breaker - S200 - 4P - B - 32 A;
'=BA20+UC50-FC05	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC05	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-FC06	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC06	ABB.2CDS254001R0024	S204-C2	Miniature Circuit Breaker - S200 - 4P - C - 2 A;
'=BA20+UC50-FC10	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC10	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-FC10	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC10	ABB.2CDS254001R0024	S204-C2	Miniature Circuit Breaker - S200 - 4P - C - 2 A;
'=BA20+UC50-FC11	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC11	ABB.2CDS254001R0024	S204-C2	Miniature Circuit Breaker - S200 - 4P - C - 2 A;
'=BA20+UC50-FC11	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC11	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-FC12	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC12	ABB.2CDS254001R0634	S204-C63	Miniature Circuit Breaker - S200 - 4P - C - 63 A;
'=BA20+UC50-FC13	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC13	ABB.2CDS252001R0024	S202-C2	Miniature Circuit Breaker - S200 - 2P - C - 2 A;
'=BA20+UC50-FC13	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC13	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-FC14	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC14	ABB.2CDS252001R0024	S202-C2	Miniature Circuit Breaker - S200 - 2P - C - 2 A;
'=BA20+UC50-FC14	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-FC14	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=BA20+UC50-KE01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-KE01	WEI.2682150000	IE-SW-EL16-16TX	Netzwerk-Switch (unmanaged);
'=BA20+UC50-KF01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-KF01	PXC.2903334	RIF-1-RPT-LDP-24DC/2X21	Relaismodul;
'=BA20+UC50-KF02	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-KF02	PXC.2903334	RIF-1-RPT-LDP-24DC/2X21	Relaismodul;
'=BA20+UC50-QA01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-QA01	ABB.1SFL527263R1422	AF205B-40-22-14	AF205B-40-22-14 Contactor;
'=BA20+UC50-QA01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-QA01	ABB.1SFL527263R1422	AF205B-40-22-14	AF205B-40-22-14 Contactor;
'=BA20+UC50-QA02	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-QA02	ABB.1SBL297201R1400	AF38-40-00-14	AF38-40-00-14 250-500V50/60HZ-DC Contactor;
'=BA20+UC50-QA02	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-QA02	ABB.1SBL297201R1400	AF38-40-00-14	AF38-40-00-14 250-500V50/60HZ-DC Contactor;
'=BA20+UC50-SG01	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-SG01	ABB.1SCA105365R1001	OT63F4N2	Lasttrennsch. 4-pol. 63A m. Knebelgriff Trägerplat.- und DIN-Schienenmontage;
'=BA20+UC50-X01:1	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X01:1	WEI.1521850000	A2C 2.5	Průchozí svorka řadová;
'=BA20+UC50-X01:2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X01:2	WEI.1521850000	A2C 2.5	Průchozí svorka řadová;
'=BA20+UC50-X01:3	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X01:3	WEI.1521850000	A2C 2.5	Průchozí svorka řadová;
'=BA20+UC50-X10:1	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:1	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:9	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:9	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:2	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:4	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:6	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:8	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:8	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:10	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:10	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:12	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:12	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:14	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:14	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X10:16	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X10:16	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X11:1	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X11:1	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X11:2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X11:2	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X11:4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X11:4	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X11:6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X11:6	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X11:8	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X11:8	WEI.2469370000	A2T 1.5	Průchozí svorka řadová;
'=BA20+UC50-X200:1	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:1	WEI.2675320000	AAP11 6 LO DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:-1	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-1	WEI.2675300000	AAP11 6 LO DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:2.2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:2.2	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:-2.2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-2.2	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:2.4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:2.4	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:-2.4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-2.4	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:2.6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:2.6	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:-2.6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-2.6	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:3.2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:3.2	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:-3.2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-3.2	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:-4.2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-4.2	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:3.4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:3.4	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:-3.4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-3.4	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:-4.4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-4.4	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:3.6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:3.6	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:-3.6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-3.6	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:-4.6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:-4.6	WEI.2675360000	AAP11 1.5 LI DL BL	Průchozí svorka řadová;
'=BA20+UC50-X200:4.2	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:4.2	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:4.4	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:4.4	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;
'=BA20+UC50-X200:4.6	'=BA20	Power Conversion BOP;	'+UC50	AC Power Distribution;	'-X200:4.6	WEI.2675340000	AAP11 1.5 LI DL RD	Průchozí svorka řadová;

'=BA30+DA03-FC29	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC29	SIBA.2073332.800	SQB3 Series	Fuse, 900VDC 800A, DIN 110, Class aR;
'=BA30+DA03-FC29	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC29	MRS.SIDIN1101250A	L 091941	Fuse Holder, DIN 110, 1250V 1250A DC;
'=BA30+DA03-FC30	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC30	ABB.1SDA072385R1	E2.2N 2000 Ekip Touch LSI 3p WMP	Circuit Breaker, Drawout part, E2.2N 2000 Ekip Touch LSI 3p WMP;
'=BA30+DA03-FC30-WG01	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC30-WG01	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA30+DA03-FC30-WG02	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC30-WG02	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA30+DA03-FC30-WG02	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC30-WG02	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA30+DA03-FC30-WG03	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC30-WG03	LAPP.2170886	Profinet 2pair cabling Cat.5/5e PVC flexible	Profinet 2pair cabling Cat.5/5e PVC flexible 4X22AWG;
'=BA30+DA03-FC31	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC31	SE.C25N4	C25N4	BASIC FRAME NSX250N 50kA AC 4P 250A;
'=BA30+DA03-FC31	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC31	SE.LV431541	LV431541	Motor-mechanism - MT250 - SDE adaptor - 208..277 V 60Hz / 220..240 V 50/60Hz;
'=BA30+DA03-FC32	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC32	SIBA.2073332.800	SQB3 Series	Fuse, 900VDC 800A, DIN 110, Class aR;
'=BA30+DA03-FC32	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC32	MRS.SIDIN1101250A	L 091941	Fuse Holder, DIN 110, 1250V 1250A DC;
'=BA30+DA03-FC40	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC40	ABB.1SAM340010R1008	MS132-4.0KT	MS132-4.0KT Circuit Breaker for Primary Transformer Protection;
'=BA30+DA03-FC40	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-FC40	ABB.1SAM201902R1001	HK1-11	HK1-11 Auxiliary Contact;
'=BA30+DA03-RB30	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RB30	DNF.984-960	SIN-0840-5-0-P	Sinusiodal Filter, 3ph 500V, 50-70Hz, 840A @@ 40°C;
'=BA30+DA03-RB30	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RB30	DNF.NXP-CH64	FR8 Chassis Heat Exhanger	Heat exchanger, Frame CH64 for NXP series;
'=BA30+DA03-RB31	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RB31	DNF.984-960	SIN-0840-5-0-P	Sinusiodal Filter, 3ph 500V, 50-70Hz, 840A @@ 40°C;
'=BA30+DA03-RB31	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RB31	DNF.NXP-CH64	FR8 Chassis Heat Exhanger	Heat exchanger, Frame CH64 for NXP series;
'=BA30+DA03-RB32	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RB32	DNF.NXP-CH64	FR8 Chassis Heat Exhanger	Heat exchanger, Frame CH64 for NXP series;
'=BA30+DA03-RN01	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RN01	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=BA30+DA03-RN02	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RN02	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA30+DA03-RN03	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RN03	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA30+DA03-RN04	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RN04	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA30+DA03-RN05	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RN05	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA30+DA03-RN06	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-RN06	BERT.117115P63LP		Valve, Constant Flow, DN15, 6.3 L/min;
'=BA30+DA03-TA31	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TA31	TRF.PP00067		#VALUE!
'=BA30+DA03-TA40	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TA40	BLO.TT3 2,5-4-4	TT3 2,5-4-4	Trenntransformator;
'=BA30+DA03-TB30	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=BA30+DA03-TB30	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30	DNF.NXA_1640 5 A0T02WF	NXA_1640 5 A0T02WF	Active Front End, 1640A, 3x400-500Vac;
'=BA30+DA03-TB30-1	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-1	DNF.NXP-CH64	FR8 Chassis Heat Exhanger	Heat exchanger, Frame CH64 for NXP series;
'=BA30+DA03-TB30-2	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-2	DNF.NXP-CH64	FR8 Chassis Heat Exhanger	Heat exchanger, Frame CH64 for NXP series;
'=BA30+DA03-TB30-3	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-3	DNF.NXP-CH64	FR8 Chassis Heat Exhanger	Heat exchanger, Frame CH64 for NXP series;
'=BA30+DA03-TB30-A1	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-A1	DAN.OPT-A1		Vacon NX, Control Board;
'=BA30+DA03-TB30-AF	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-AF	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=BA30+DA03-TB30-D7	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-D7	DAN.OPT-D7	OPT-D7	Vacon NX, Line voltage measurement board;
'=BA30+DA03-TB30-WD01	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-WD01	LAPP.1123067	ÖLFLEX® CLASSIC 130 H	ÖLFLEX CLASSIC 130 H 3G1;
'=BA30+DA03-TB30-WD03	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-WD03	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=BA30+DA03-TB30-WG01	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-WG01	LAPP.11139521	Unitronic FD CP 2x2x0.5	ÖLFLEX CLASSIC 130 H 4X1,5;
'=BA30+DA03-TB30-WG02	'=BA30	Power Conversion Output;	'+DA03	Container #2 Inside;	'-TB30-WG02	LAPP.2170886	Profinet 2pair cabling Cat.5/5e PVC flexible	Profinet 2pair cabling Cat.5/5e PVC flexible 4X22AWG;
'=BA30+UC31-FC30	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-FC30	ABB.1SDA077802R1	E2.2N-A 2000 Ekip Touch LSI 4p WMP	E2.2N-A 2000 Ekip Touch LSI 4p WMP;
'=BA30+UC31-FC41	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-FC41	SIBA.5106305.2DC	5106305	Fuse Holder, 2-pole, for 10x38 fuses, 1000VDC, 30A;
'=BA30+UC31-FC41	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-FC41	SIBA.5106305.2DC	5106305	Fuse Holder, 2-pole, for 10x38 fuses, 1000VDC, 30A;
'=BA30+UC31-FC42	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-FC42	SIBA.5106305.2DC	5106305	Fuse Holder, 2-pole, for 10x38 fuses, 1000VDC, 30A;
'=BA30+UC31-FC42	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-FC42	SIBA.5106305.2DC	5106305	Fuse Holder, 2-pole, for 10x38 fuses, 1000VDC, 30A;
'=BA30+UC31-RA40.1	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-RA40.1	TE.CJP1000J3R3J	Chassis Mount CJP	Resistor, Aluminium Housing, 3.3Ω, 1000W, 5%;
'=BA30+UC31-RA40.2	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-RA40.2	TE.CJP1000J3R3J	Chassis Mount CJP	Resistor, Aluminium Housing, 3.3Ω, 1000W, 5%;
'=BA30+UC31-RA40.3	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-RA40.3	TE.CJP1000J3R3J	Chassis Mount CJP	Resistor, Aluminium Housing, 3.3Ω, 1000W, 5%;
'=BA30+UC31-RA40.4	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-RA40.4	TE.CJP1000J3R3J	Chassis Mount CJP	Resistor, Aluminium Housing, 3.3Ω, 1000W, 5%;
'=BA30+UC31-T1	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-T1	WAGO.855-805/2000-1001	855-805/2000-1001	Zásuvný transformátor proudu;
'=BA30+UC31-T2	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-T2	WAGO.855-805/2000-1001	855-805/2000-1001	Zásuvný transformátor proudu;
'=BA30+UC31-T3	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-T3	WAGO.855-805/2000-1001	855-805/2000-1001	Zásuvný transformátor proudu;
'=BA30+UC31-TA40	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-TA40	BLO.TT3 2,5-4-4	TT3 2,5-4-4	Trenntransformator;
'=BA30+UC31-TA40-WD01	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-TA40-WD01	LAPP.1123428	ÖLFLEX® CLASSIC 130 H BK 0,6/1 kV	Připojovací a ovládací kabely;
'=BA30+UC31-TB40-WD01	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-TB40-WD01	LAPP.1123428	ÖLFLEX® CLASSIC 130 H BK 0,6/1 kV	Připojovací a ovládací kabely;
'=BA30+UC31-WD02	'=BA30	Power Conversion Output;	'+UC31	Control Cabinet (10ft);	'-WD02	LAPP.1123428	ÖLFLEX® CLASSIC 130 H BK 0,6/1 kV	Připojovací a ovládací kabely;
'=HA01+DA02-AC01-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-AC01-WG01	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-AC01-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-AC01-WG01	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-BL01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-BL01	IFM.LMT01A	LMACE-A12E-QSKG-1/US/3D/3G	Füllstandsensor zur Grenzstanderfassung für den Ex-Bereich;
'=HA01+DA02-BL01-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-BL01-WG01	IFM.EVC14A	ADOGH040VAT0025H04/3G/2D	Connecting cable with socket;
'=HA01+DA02-BP01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-BP01	HUBA.520930S04M801	Pressure Transducer 520 Series	Pressure Transducer, 0-10 barg, 4-20mA, ATEX, -25 to 85°C Ta;
'=HA01+DA02-BP01-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-BP01-WG01	IFM.ENC03A	ADOGH040MSN0010H04/1G/1D	Connecting cable with socket;
'=HA01+DA02-BT01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-BT01	IFM.TT1050	TT-100KBBD10-...../US/	Temperature probe sensor;
'=HA01+DA02-BT01-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-BT01-WG01	IFM.ENC03A	ADOGH040MSN0010H04/1G/1D	Connecting cable with socket;
'=HA01+DA02-CM01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01	BPSE.7001Placeholder		Hydrogen Heater System, Water bath heat exchanger, SS316L, Volume 146L;
'=HA01+DA02-CM01-EA01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-EA01	JEVI.24014	D-8640	Immersion Heater, 3x400V, 9kW, ATEX;
'=HA01+DA02-CM01-EA01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-EA01	HWK.3913703	ICG 653 UNIV Os M20	Cable gland, ATEX Group II, grounding ring for amour, tightening guide, Resin/compound barrier with
'=HA01+DA02-CM01-EA02	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-EA02	JEVI.24014	D-8640	Immersion Heater, 3x400V, 9kW, ATEX;
'=HA01+DA02-CM01-EA02	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-EA02	HWK.3913703	ICG 653 UNIV Os M20	Cable gland, ATEX Group II, grounding ring for amour, tightening guide, Resin/compound barrier with
'=HA01+DA02-CM01-WP01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-WP01	BPSE.7000Placeholder		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall;
'=HA01+DA02-CM01-WP02	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-WP02	BPSE.7000Placeholder		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall;
'=HA01+DA02-CM01-WP03	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-WP03	BPSE.7000Placeholder		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall;
'=HA01+DA02-CM01-WP04	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-WP04	BPSE.7000Placeholder		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall;
'=HA01+DA02-CM01-WP05	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-WP05	BPSE.7000Placeholder		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall;
'=HA01+DA02-CM01-WP06	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-CM01-WP06	BPSE.7000Placeholder		Pipe coil, for H2 heater system. DN25 seamless pipe, 2mm wall;
'=HA01+DA02-EA01-WD01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-EA01-WD01	LAPP.1123342	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=HA01+DA02-EA02-WD01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-EA02-WD01	LAPP.1123342	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM00	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM00	ARMA.1311_CF8M	1311 Full Bore	3-piece premium quater-turn ball valve, full bore, Stainless steel, DN32;
'=HA01+DA02-QM1.1	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.1	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM1.1	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.1	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM1.1	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.1	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM1.1-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.1-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM1.2	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.2	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM1.2	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.2	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM1.2	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.2	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;

'=HA01+DA02-QM1.2-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.2-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM1.3	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.3	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM1.3	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.3	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM1.3	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.3	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM1.3-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.3-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM1.4	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.4	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM1.4	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.4	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM1.4	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.4	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM1.4-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.4-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM1.5	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.5	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM1.5	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.5	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM1.5	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.5	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM1.5-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.5-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM1.6	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.6	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM1.6	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.6	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM1.6	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.6	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM1.6-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM1.6-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM01	HYLOK.BVH-25M	110 Series Ball Valves	Quater-turn ball valve, lockable, size 25mm;
'=HA01+DA02-QM2.1	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.1	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM2.1	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.1	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM2.1	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.1	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM2.1-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.1-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM2.2	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.2	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM2.2	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.2	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM2.2	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.2	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM2.2-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.2-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM2.3	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.3	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM2.3	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.3	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM2.3	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.3	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM2.3-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.3-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM2.4	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.4	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM2.4	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.4	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM2.4	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.4	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM2.4-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.4-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM2.5	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.5	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM2.5	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.5	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM2.5	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.5	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM2.5-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.5-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM2.6	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.6	ASCO.NFX8210C488E	NF X E210D488E 24/DC	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen;
'=HA01+DA02-QM2.6	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.6	ETN.ADU102904	AD-U	Eaton's Crouse-Hinds series Redapt AD-U adaptor;
'=HA01+DA02-QM2.6	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.6	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-QM2.6-WG01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM2.6-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HA01+DA02-QM02	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM02	HYLOK.BVH-25M	110 Series Ball Valves	Quater-turn ball valve, lockable, size 25mm;
'=HA01+DA02-QM03	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM03	HYLOK.BVH-25M	110 Series Ball Valves	Quater-turn ball valve, lockable, size 25mm;
'=HA01+DA02-QM04	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM04	HYLOK.BVH-25M	110 Series Ball Valves	Quater-turn ball valve, lockable, size 25mm;
'=HA01+DA02-QM05	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM05	HYLOK.BVH-25M	110 Series Ball Valves	Quater-turn ball valve, lockable, size 25mm;
'=HA01+DA02-QM06	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-QM06	HYLOK.BVH-25M	110 Series Ball Valves	Quater-turn ball valve, lockable, size 25mm;
'=HA01+DA02-XM01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XM01	NEO.ASME-B16.5	ASME-B16.5-DN32-SS316	Flange , ASME B16.5 DN32, Stainless Steel 316;
'=HA01+DA02-XT01	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT01	RXT.EXRSB0500002121	RS 50 B Ex AISI316/AISI316	Cable/pipe transit device, Kit, EX;
'=HA01+DA02-XT02	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT02	RXT.EXRSB0500002121	RS 50 B Ex AISI316/AISI316	Cable/pipe transit device, Kit, EX;
'=HA01+DA02-XT03	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT03	RXT.EXRSB0500002121	RS 50 B Ex AISI316/AISI316	Cable/pipe transit device, Kit, EX;
'=HA01+DA02-XT04	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT04	RXT.EXRSB0500002121	RS 50 B Ex AISI316/AISI316	Cable/pipe transit device, Kit, EX;
'=HA01+DA02-XT05	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT05	RXT.EXRSB0500002121	RS 50 B Ex AISI316/AISI316	Cable/pipe transit device, Kit, EX;
'=HA01+DA02-XT06	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT06	RXT.EXRSB0500002121	RS 50 B Ex AISI316/AISI316	Cable/pipe transit device, Kit, EX;
'=HA01+DA02-XT07	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT07	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-XT07	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT07	ETN.RDU100604		Eaton's Crouse-Hinds series Redapt RD-U reducer;
'=HA01+DA02-XT08	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT08	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-XT08	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT08	ETN.RDU100604		Eaton's Crouse-Hinds series Redapt RD-U reducer;
'=HA01+DA02-XT08	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT08	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-XT08	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT08	ETN.RDU100604		Eaton's Crouse-Hinds series Redapt RD-U reducer;
'=HA01+DA02-XT10	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT10	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-XT10	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT10	ETN.RDU100604		Eaton's Crouse-Hinds series Redapt RD-U reducer;
'=HA01+DA02-XT11	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT11	HWK.3913698	501/421/O M20	Cable gland, ATEX Group II, M20;
'=HA01+DA02-XT11	'=HA01	Hydrogen Supply System;	'+DA02	Container #1 Outside;	'-XT11	ETN.RDU100604		Eaton's Crouse-Hinds series Redapt RD-U reducer;
'=HE01+DA01-BT01	'=HE01	High Temperature Cooling Circuit #1;	'+DA01	Container #1 Inside;	'-BT01	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE01+DA01-BT01-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA01	Container #1 Inside;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE01+DA01-BT02	'=HE01	High Temperature Cooling Circuit #1;	'+DA01	Container #1 Inside;	'-BT02	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE01+DA01-BT02-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA01	Container #1 Inside;	'-BT02-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE01+DA01-BT03	'=HE01	High Temperature Cooling Circuit #1;	'+DA01	Container #1 Inside;	'-BT03	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE01+DA01-BT03-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA01	Container #1 Inside;	'-BT03-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE01+DA02-BF01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BF01	IFM.SA4104	SAEXXXXB50KG/US-100	Strömungssensor;
'=HE01+DA02-BF01-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BF01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE01+DA02-BL01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BL01	IFM.PA3589	PA-,10BRBG14-A-ZVG/US/ /V	Drucktransmitter mit keramischer Messzelle, DC, Analogsignal;
'=HE01+DA02-BL01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BL01	IFM.E30016	PROGRESSIVE RING FITTING	Schneidringverschraubung;
'=HE01+DA02-BL01-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BL01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE01+DA02-BT01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BT01	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE01+DA02-BT02	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BT02	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE01+DA02-BT03	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BT03	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE01+DA02-BT05-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BT05-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE01+DA02-BT06-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-BT06-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE01+DA02-CL01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-CL01	BPSE.3002	5500231B-3002	Header Tank, Volume 100L, AISI 304;
'=HE01+DA02-EG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-EG01	EVP.VA091EWHHD-682-IHD-120-2,3-Sp	VA091 Series Drycooler	Dry Cooler, 1050kW, With Ventilators (Offshore);
'=HE01+DA02-GP19	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GP19	GNF.92886729	TP 100-310/2 X-F-A-BQQE-OW1	Centrifugal pump, with electric motor, single-stage close coupled in line.;

'=HE01+DA02-GP19-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GP19-WD01	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=HE01+DA02-GQ11	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ11	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE01+DA02-GQ11-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ11-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+DA02-GQ12	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ12	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE01+DA02-GQ12-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ12-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+DA02-GQ13	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ13	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE01+DA02-GQ13-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ13-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+DA02-GQ14	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ14	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE01+DA02-GQ14-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ14-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+DA02-GQ15	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ15	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE01+DA02-GQ15-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ15-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+DA02-GQ16	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ16	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE01+DA02-GQ16-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-GQ16-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+DA02-QM01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-QM01	ARMA.1311-DN100	DVC Type 1311	Ball Valve, Stainless Steel, DN100, Weld Flange;
'=HE01+DA02-QM02	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-QM02	ARMA.1311-DN100	DVC Type 1311	Ball Valve, Stainless Steel, DN100, Weld Flange;
'=HE01+DA02-QN01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-QN01	BLM.PRCA-BAC-S2-T	PRCA-BAC-S2-T	Ventilantr. 24...230V, 160 Nm, Bus, IP66;
'=HE01+DA02-QN01-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-QN01-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE01+DA02-QN02	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-QN02	BLM.PRCA-BAC-S2-T	PRCA-BAC-S2-T	Ventilantr. 24...230V, 160 Nm, Bus, IP66;
'=HE01+DA02-QN02-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-QN02-WG01	LAPP.10035060	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE01+DA02-RM01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-RM01	SANI.447155004	Flexvent 1/2"	De-aerator, For coolant containing 50% glycol, 21.3mm BSPT thread external;
'=HE01+DA02-WP01	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-WP01	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE01+DA02-WP02	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-WP02	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE01+DA02-WP03	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-WP03	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE01+DA02-WP04	'=HE01	High Temperature Cooling Circuit #1;	'+DA02	Container #1 Outside;	'-WP04	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE01+UC30-BT02	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-BT02	RIT.3110000	SK.3110000	Thermostat;
'=HE01+UC30-EA02	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-EA02	RIT.3105390	SK.3105390	Schaltschrank-Heizung;
'=HE01+UC30-EA03	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-EA03	RIT_N.2500300	SZ.2500300	Systemleuchte LED;
'=HE01+UC30-FC01	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC01	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC02	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC02	ABB.2CDS272001R0065	S202M-B6	Miniature Circuit Breaker - S200M - 2P - B - 6 A;
'=HE01+UC30-FC03	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC03	ETN.FAZ-B2/1N	FAZ-B2/1N	Leitungsschutzschalter, 2 A, 1p+N, Charakteristik: B;
'=HE01+UC30-FC11	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC11	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC12	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC12	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC13	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC13	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC14	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC14	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC15	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC15	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC16	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC16	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC19	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC19	ABB.2CDS273001R0255	S203M-B25	Miniature Circuit Breaker - S200M - 3P - B - 25 A;
'=HE01+UC30-FC21	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC21	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC22	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC22	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC23	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC23	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC24	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC24	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC25	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC25	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC26	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC26	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC29	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC29	ETN.FAZ-B25/3	FAZ-B25/3	Leitungsschutzschalter, 25 A, 3p, Charakteristik: B;
'=HE01+UC30-FC31	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC31	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC30-FC40	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC40	ABB.2CDS253001R0135	S203-B13	Miniature Circuit Breaker - S200 - 3P - B - 13 A;
'=HE01+UC30-FC41	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC41	ETN.FAZ-B20/3	FAZ-B20/3	Leitungsschutzschalter, 20 A, 3p, Charakteristik: B;
'=HE01+UC30-FC42	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-FC42	ETN.FAZ-B20/3	FAZ-B20/3	Leitungsschutzschalter, 20 A, 3p, Charakteristik: B;
'=HE01+UC30-QA41	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-QA41	SE.SSM3A325BD	SSM3A325BD	Solid state relay - DIN rail mount - input 4-32Vdc, output 48-600Vac, 25A;
'=HE01+UC30-QA42	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-QA42	SE.SSM3A325BD	SSM3A325BD	Solid state relay - DIN rail mount - input 4-32Vdc, output 48-600Vac, 25A;
'=HE01+UC30-TA19	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-TA19	DNF.NXP00315-A5H1SSV	NXP00315-A5H1SSV	Frequency Converter, NXP series, 15kW, IP21, 3x 380-500 VAC;
'=HE01+UC30-TA29	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-TA29	DNF.NXP00315-A5H1SSV	NXP00315-A5H1SSV	Frequency Converter, NXP series, 15kW, IP21, 3x 380-500 VAC;
'=HE01+UC30-TB01	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-TB01	MURR.85691	85691	Emparro Schaltnetzteil 3-phasig;
'=HE01+UC30-TB01	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-TB01	MURR.85414	85414	Emparro ACCUcontrol USV-Modul;
'=HE01+UC30-TB01	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-TB01	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=HE01+UC30-TB01	'=HE01	High Temperature Cooling Circuit #1;	'+UC30	Coolant Skid Control Cat	'-TB01	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=HE01+UC40-FC01	'=HE01	High Temperature Cooling Circuit #1;	'+UC40	Coolant Power Distributi	'-FC01	A-B_N.1492-SPM3B020N	1492	Miniature Circuit Breaker;
'=HE01+UC40-SG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC40	Coolant Power Distributi	'-SG01	ABB.1SCA022755R0810	OS400J03	OS400J03 Fusible Disconnect Switch, 690VAC, 400A, 3-Pole, Lug Terminals, ;
'=HE01+UC40-T1	'=HE01	High Temperature Cooling Circuit #1;	'+UC40	Coolant Power Distributi	'-T1	ETN.HF4B-150/5A	HF4B-150/5A	Stromwandler HF4B, 150A/5A;
'=HE01+UC40-T2	'=HE01	High Temperature Cooling Circuit #1;	'+UC40	Coolant Power Distributi	'-T2	ETN.HF4B-150/5A	HF4B-150/5A	Stromwandler HF4B, 150A/5A;
'=HE01+UC40-T3	'=HE01	High Temperature Cooling Circuit #1;	'+UC40	Coolant Power Distributi	'-T3	ETN.HF4B-150/5A	HF4B-150/5A	Stromwandler HF4B, 150A/5A;
'=HE01+UC41-EA40-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-EA40-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-EA40-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-EA40-WG01	LAPP.2170267	UNITRONIC® BUS CAN UL/CSA	UNITRONIC BUS CAN UL/CSA 2X2X0,5;
'=HE01+UC41-FC11	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-FC11	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC41-FC12	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-FC12	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC41-FC13	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-FC13	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC41-FC14	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-FC14	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC41-FC15	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-FC15	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC41-FC16	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-FC16	ABB.2CDS273001R0065	S203M-B6	Miniature Circuit Breaker - S200M - 3P - B - 6 A;
'=HE01+UC41-KF41	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-KF41	WEI.2682150000	IE-SW-EL16-16TX	Netzwerk-Switch (unmanaged);
'=HE01+UC41-KF41-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-KF41-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=HE01+UC41-ME01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-ME01	RIT.1016000	AX.1016000	Kompakt-Schaltschrank AX;
'=HE01+UC41-TA11	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA11	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA11-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA11-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA11-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA11-WG01	LAPP.2170886	Profinet 2pair cabling Cat.5/5e PVC flexible	Profinet 2pair cabling Cat.5/5e PVC flexible 4X22AWG;
'=HE01+UC41-TA11-XG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA11-XG01	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA11-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA11-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA12	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA12	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA12-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA12-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA12-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA12-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA12-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA12-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA13	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA13	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA13-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA13-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;

'=HE01+UC41-TA13-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA13-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA13-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA13-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA14	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA14	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA14-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA14-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA14-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA14-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA14-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA14-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA15	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA15	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA15-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA15-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA15-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA15-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA15-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA15-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA16	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA16	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA16-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA16-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA16-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA16-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA16-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA16-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA21	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA21	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA21-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA21-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA21-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA21-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA21-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA21-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA22	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA22	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA22-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA22-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA22-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA22-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA22-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA22-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA23	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA23	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA23-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA23-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA23-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA23-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA23-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA23-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA24	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA24	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA24-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA24-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA24-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA24-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA24-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA24-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA25	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA25	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA25-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA25-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA25-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA25-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA25-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA25-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA26	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA26	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA26-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA26-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA26-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA26-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA26-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA26-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-TA31	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA31	DNF.FC102P4K0	FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX	VFD, FC102 Series, Motor 4.0kW / 5.5HP, IP55, 3x 380-480 VAC;
'=HE01+UC41-TA31-WD01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA31-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE01+UC41-TA31-WG01	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA31-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=HE01+UC41-TA31-XG02	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-TA31-XG02	SIE.6GK1901-1BB10-2AA0	6GK1901-1BB10-2AA0	IE FC RJ45 Plug 180 2x2 (1 Stueck);
'=HE01+UC41-U1	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-U1	PAN.F2X2LG6	F2X2LG6	Narrow Slotted Duct, PVC, 2 X 2 X 6';
'=HE01+UC41-U2	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-U2	PAN.F2X2LG6	F2X2LG6	Narrow Slotted Duct, PVC, 2 X 2 X 6';
'=HE01+UC41-U3	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-U3	TS 35_15	TS 35_15	Tragschiene EN 50 022 (35x15);
'=HE01+UC41-U4	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-U4	PAN.F2X2LG6	F2X2LG6	Narrow Slotted Duct, PVC, 2 X 2 X 6';
'=HE01+UC41-X01:1	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-X01:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=HE01+UC41-X01:PE	'=HE01	High Temperature Cooling Circuit #1;	'+UC41	HT+LT VFD Cabinet;	'-X01:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=HE02+DA01-BT01	'=HE02	High Temperature Cooling System #2;	'+DA01	Container #1 Inside;	'-BT01	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE02+DA01-BT02	'=HE02	High Temperature Cooling System #2;	'+DA01	Container #1 Inside;	'-BT02	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE02+DA01-BT03	'=HE02	High Temperature Cooling System #2;	'+DA01	Container #1 Inside;	'-BT03	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE02+DA01-BT04-WG01	'=HE02	High Temperature Cooling System #2;	'+DA01	Container #1 Inside;	'-BT04-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE02+DA01-BT05-WG01	'=HE02	High Temperature Cooling System #2;	'+DA01	Container #1 Inside;	'-BT05-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE02+DA01-BT06-WG01	'=HE02	High Temperature Cooling System #2;	'+DA01	Container #1 Inside;	'-BT06-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE02+DA02-BF01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BF01	IFM.SA4104	SAEXXXXB50KG/US-100	Strömungssensor;
'=HE02+DA02-BF01-WG01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BF01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE02+DA02-BL01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BL01	IFM.PA3589	PA-,10BRBG14-A-ZVG/US/ /V	Drucktransmitter mit keramischer Messzelle, DC, Analogsignal;
'=HE02+DA02-BL01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BL01	IFM.E30016	PROGRESSIVE RING FITTING	Schneidringverschraubung;
'=HE02+DA02-BL01-WG01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BL01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE02+DA02-BT01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BT01	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE02+DA02-BT02	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BT02	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE02+DA02-BT03	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BT03	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE02+DA02-BT05-WG01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BT05-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE02+DA02-BT06-WG01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-BT06-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE02+DA02-CL01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-CL01	BPSE.3002	5500231B-3002	Header Tank, Volume 100L, AISI 304;
'=HE02+DA02-EG01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-EG01	EVP.VA091EWHHD-682-IHD-120-2,3-Sp	VA091 Series Drycooler	Dry Cooler, 1050kW, With Ventilators (Offshore);
'=HE02+DA02-GP29	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GP29	GNF.92886729	TP 100-310/2 X-F-A-BQQE-OW1	Centrifugal pump, with electric motor, single-stage close coupled in line.;
'=HE02+DA02-GP29-WD01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GP29-WD01	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=HE02+DA02-GQ21	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ21	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE02+DA02-GQ21-WD01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ21-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE02+DA02-GQ22	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ22	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE02+DA02-GQ22-WD01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ22-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE02+DA02-GQ23	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ23	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE02+DA02-GQ23-WD01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ23-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE02+DA02-GQ24	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ24	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE02+DA02-GQ24-WD01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ24-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE02+DA02-GQ25	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ25	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE02+DA02-GQ25-WD01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ25-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE02+DA02-GQ26	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ26	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE02+DA02-GQ26-WD01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-GQ26-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=HE02+DA02-QM01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-QM01	ARMA.1311-DN100	DVC Type 1311	Ball Valve, Stainless Steel, DN100, Weld Flange;
'=HE02+DA02-QM02	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-QM02	ARMA.1311-DN100	DVC Type 1311	Ball Valve, Stainless Steel, DN100, Weld Flange;
'=HE02+DA02-QN01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-QN01	BLM.PRCA-BAC-S2-T	PRCA-BAC-S2-T	Ventilantr. 24...230V, 160 Nm, Bus, IP66;

'=HE02+DA02-QN01-WG01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-QN01-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE02+DA02-QN02	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-QN02	BLM.PRCA-BAC-S2-T	PRCA-BAC-S2-T	Ventilantr. 24...230V, 160 Nm, Bus, IP66;
'=HE02+DA02-QN02-WG01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-QN02-WG01	LAPP.10035060	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE02+DA02-RM01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-RM01	SANI.447155004	Flexvent 1/2"	De-aerator, For coolant containing 50% glycol, 21.3mm BSPT thread external;
'=HE02+DA02-WP01	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-WP01	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE02+DA02-WP02	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-WP02	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE02+DA02-WP03	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-WP03	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE02+DA02-WP04	'=HE02	High Temperature Cooling System #2;	'+DA02	Container #1 Outside;	'-WP04	SEE.5.002.000.01604	5.002.000.01604	Coolant Hose, 110x122mm, EPDM, 4barg;
'=HE03+DA01-BF01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BF01	IFM.SA4104	SAEXXXB50KG/US-100	Strömungssensor;
'=HE03+DA01-BF01-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BF01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA01-BP01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP01	BLM.22WDP-134	22WDP-134	Water Diff Pressure Sensor 4bar 4-20mA;
'=HE03+DA01-BP01-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP01-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE03+DA01-BP02-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP02-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA01-BP03-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP03-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA01-BP04-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP04-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA01-BP05-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP05-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA01-BP06-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP06-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA01-BP07-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BP07-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA01-BT01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BT01	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE03+DA01-BT02	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BT02	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE03+DA01-BT03	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BT03	IFM.TT1250	TT-100KBBD06- /US/ /V	Temperatursensor zum Anschluss an eine Auswerteeinheit;
'=HE03+DA01-BT04-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BT04-WG01	IFM.EVC698	ADOAH040MSS0015K04	Anschlusskabel mit Buchse;
'=HE03+DA01-BT05-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-BT05-WG01	IFM.EVC698	ADOAH040MSS0015K04	Anschlusskabel mit Buchse;
'=HE03+DA01-GP11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-GP11	GNF.98309267	NB 40-125/139	Centrifugal pump, with electric motor, end suction, EN 733;
'=HE03+DA01-GP11-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-GP11-WG01	LAPP.1119 203 (3G1,0)	ÖLFLEX CLASSIC 110	Steuerleitung, 3G1,0;
'=HE03+DA01-GP11.WD01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-GP11.WD01	LAPP.1123342	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=HE03+DA01-GP11.WD02	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-GP11.WD02	LAPP.1123342	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=HE03+DA01-GP11.WG02	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-GP11.WG02	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE03+DA01-QM01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM01	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM02	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM02	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM03	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM03	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM04	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM04	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM05	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM05	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM06	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM06	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM07	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM07	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM08	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM08	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM09	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM09	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM10	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM10	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM11	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM12	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM12	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM13	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM13	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM14	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM14	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM15	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM15	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM16	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM16	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM17	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM17	MARS.CF8M-DN65	CF8M Series Ball Valve	Ball valve, Quarter turn, DN65;
'=HE03+DA01-QM18	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM18	MARS.CF8M-DN65	CF8M Series Ball Valve	Ball valve, Quarter turn, DN65;
'=HE03+DA01-QM19	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM19	MARS.CF8M-DN65	CF8M Series Ball Valve	Ball valve, Quarter turn, DN65;
'=HE03+DA01-QM20	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM20	MARS.CF8M-DN65	CF8M Series Ball Valve	Ball valve, Quarter turn, DN65;
'=HE03+DA01-QM21	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM21	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM22	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM22	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM23	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM23	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM24	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM24	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM25	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM25	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM26	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM26	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;
'=HE03+DA01-QM27	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QM27	MARS.CF8M-DN65	CF8M Series Ball Valve	Ball valve, Quarter turn, DN65;
'=HE03+DA01-QN01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN01	BLM.H350S-P	H3S Series Globe Valve	3-way flow control valve, Stainless steel, Internal thread, DN50, PN25;
'=HE03+DA01-QN01.MA01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN01.MA01	BLM.SVC24A-SR-TPC	SVC Series Modulaing Actuators	Actuator, for globe valves, modulating, 1500N force;
'=HE03+DA01-QN01.WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN01.WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE03+DA01-QN01.WG02	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN01.WG02	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=HE03+DA01-QN02	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN02	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=HE03+DA01-QN03	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN03	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=HE03+DA01-QN04	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN04	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=HE03+DA01-QN05	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN05	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=HE03+DA01-QN06	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN06	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=HE03+DA01-QN07	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-QN07	BERT.117115P230LP		Valve, Constant Flow, DN15, 23 L/min;
'=HE03+DA01-TA11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-TA11	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=HE03+DA01-TA11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-TA11	DNF.NXP00095-A5H1SSV	NXP00095-A5H1SSV	Frequency Converter, NXP Series, 4kW, IP21, 3x 380-500 VAC;
'=HE03+DA01-TA11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-TA11	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=HE03+DA01-TA11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-TA11	DNF.NXP00095-A5H1SSV	NXP00095-A5H1SSV	Frequency Converter, NXP Series, 4kW, IP21, 3x 380-500 VAC;
'=HE03+DA01-TA11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-TA11	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=HE03+DA01-TA11	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-TA11	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=HE03+DA01-TF01	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-TF01	BLM.Z-UIC	Z-UIC	Signal Converter Voltage/Current;
'=HE03+DA01-X27	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-X27	PH.1100P1000		Polyamide Flexible Tubing, Ø10x8,0;
'=HE03+DA01-X28	'=HE03	Low Temperature Cooling Circuit;	'+DA01	Container #1 Inside;	'-X28	PH.1100P1000		Polyamide Flexible Tubing, Ø10x8,0;
'=HE03+DA02-BL01-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA02	Container #1 Outside;	'-BL01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA02-GQ31	'=HE03	Low Temperature Cooling Circuit;	'+DA02	Container #1 Outside;	'-GQ31	FBK.CXB14-4	Fabrika CX B14 TEAO	Three-phase asynchronous motor, 4 pole pairs, 4,0kW;
'=HE03+DA02-GQ31-WD01	'=HE03	Low Temperature Cooling Circuit;	'+DA02	Container #1 Outside;	'-GQ31-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 KV	Power and control cables;
'=HE03+DA03-BF01-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA03	Container #2 Inside;	'-BF01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA03-BL01	'=HE03	Low Temperature Cooling Circuit;	'+DA03	Container #2 Inside;	'-BL01	IFM.PA3589	PA-,10BRBG14-A-ZVG/US/ /V	Drucktransmitter mit keramischer Messzelle, DC, Analogsignal;
'=HE03+DA03-BL01	'=HE03	Low Temperature Cooling Circuit;	'+DA03	Container #2 Inside;	'-BL01	IFM.E30016	PROGRESSIVE RING FITTING	Schneidringverschraubung;
'=HE03+DA03-BT05-WG01	'=HE03	Low Temperature Cooling Circuit;	'+DA03	Container #2 Inside;	'-BT05-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=HE03+DA03-CL01	'=HE03	Low Temperature Cooling Circuit;	'+DA03	Container #2 Inside;	'-CL01	BPSE.3002	5500231B-3002	Header Tank, Volume 100L, AISI 304;
'=HE03+DA03-QM01	'=HE03	Low Temperature Cooling Circuit;	'+DA03	Container #2 Inside;	'-QM01	MARS.CF8M-DN25	CF8M Series Ball Valve	Ball valve, Quarter turn, DN25;

'=HE03+DA04-EG01	'=HE03	Low Temperature Cooling Circuit;	'+DA04	Container #2 Outside;	'-EG01	EVP.FA091ELNHD-151-IHD-30-3,1-Sp	FA091 Series Dry Cooler	Dry Cooler, 100kW, With Ventilatiors (Offshore);
'=HE03+DA04-RM01	'=HE03	Low Temperature Cooling Circuit;	'+DA04	Container #2 Outside;	'-RM01	AO.447060003	Aeromat Series	De-aerator, Stainless, For coolant containing 50% glycol, 3/8";
'=JA01+DA01-AC01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC01	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC02	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC03	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC03	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC04	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC04	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC05	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC05	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC06	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC06	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC06	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC06	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC07	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC07	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-AC07-RE01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC07-RE01	VISH.RS02B120R0FE70	RS02B120R0FE70	Wirewound Resistor, 120R, 1%, 3W, Axial Lead, Moisture Resistant, 250°C;
'=JA01+DA01-AC07-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC07-WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA01-AC07-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC07-WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA01-AC08	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-AC08	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA01-BL02-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BL02-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=JA01+DA01-BP01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BP01	BLM.22ADP-184	22ADP-184	Diff Luft Druck Sensor 2500 MULT;
'=JA01+DA01-BP01-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BP01-WD01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BP02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BP02	BLM.22ADP-184	22ADP-184	Diff Luft Druck Sensor 2500 MULT;
'=JA01+DA01-BP02-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BP02-WD01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BQ01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ01	DRG.8344457		Polytron 8200, Hydrogen Detector, Catalytic sensor for 0-100% LEL;
'=JA01+DA01-BQ01-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ01-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BQ02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ02	DRG.8344457		Polytron 8200, Hydrogen Detector, Catalytic sensor for 0-100% LEL;
'=JA01+DA01-BQ02-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ02-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BQ03	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ03	DRG.8344457		Polytron 8200, Hydrogen Detector, Catalytic sensor for 0-100% LEL;
'=JA01+DA01-BQ03-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ03-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BQ04	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ04	APOL.ORB-OP-42001-MAR	ORB-OP-42001-MAR	Orbis Marine Optical Smoke Detector;
'=JA01+DA01-BQ04	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ04	APOL.ORB-RB-40004-MAR	ORB-RB-40004-MAR	Orbis Marine Relay Base;
'=JA01+DA01-BQ04-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ04-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BQ05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ05	APOL.ORB-OP-42001-MAR	ORB-OP-42001-MAR	Orbis Marine Optical Smoke Detector;
'=JA01+DA01-BQ05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ05	APOL.ORB-RB-40004-MAR	ORB-RB-40004-MAR	Orbis Marine Relay Base;
'=JA01+DA01-BQ05-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ05-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BQ06	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ06	APOL.ORB-OP-42001-MAR	ORB-OP-42001-MAR	Orbis Marine Optical Smoke Detector;
'=JA01+DA01-BQ06	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ06	APOL.ORB-RB-40004-MAR	ORB-RB-40004-MAR	Orbis Marine Relay Base;
'=JA01+DA01-BQ06-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BQ06-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BT01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=JA01+DA01-BT01-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=JA01+DA01-BT02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BT02	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=JA01+DA01-BT02-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BT02-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=JA01+DA01-BT03-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BT03-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=JA01+DA01-BT05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BT05	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=JA01+DA01-BU01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BU01	SE.SLAWXCV2		Sensor, Air Quality, Temperature, RH, CO2 and VOC content;
'=JA01+DA01-BU01-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BU01-WD01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-BU01-WG02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-BU01-WG02	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA01-EA1	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA1	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA01-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA01-WD01	MURR.7000-08061-6310200		#VALUE!
'=JA01+DA01-EA02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA02	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA02-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA02-WD01	MURR.7000-08061-6310200		#VALUE!
'=JA01+DA01-EA03	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA03	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA03-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA03-WD01	MURR.7000-08061-6310200		#VALUE!
'=JA01+DA01-EA04	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA04	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA04-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA04-WD01	MURR.7000-08061-6310200		#VALUE!
'=JA01+DA01-EA05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA05	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA05	MURR.3858627		Blind Plug, M8x1 Plastic, for female threads.;
'=JA01+DA01-EA05-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA05-WD01	MURR.7000-88011-6310600		#VALUE!
'=JA01+DA01-EA06	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA06	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA06	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA06	MURR.3858627		Blind Plug, M8x1 Plastic, for female threads.;
'=JA01+DA01-EA06-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA06-WD01	MURR.7000-88011-6310600		#VALUE!
'=JA01+DA01-EA07	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA07	MURR.4000-75800-1715032	4000-75800-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA07	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA07	MURR.3858627		Blind Plug, M8x1 Plastic, for female threads.;
'=JA01+DA01-EA07-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA07-WD01	MURR.7000-88011-6310600		#VALUE!
'=JA01+DA01-EA08	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA08	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA01-EA08	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA08	MURR.3858627		Blind Plug, M8x1 Plastic, for female threads.;
'=JA01+DA01-EA08-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EA08-WD01	MURR.7000-88011-6310600		#VALUE!
'=JA01+DA01-EB01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EB01	RIT.3105390	SK.3105390	Schaltschrank-Heizung;
'=JA01+DA01-EB01.WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EB01.WD01	LAPP.00466303	ÖLFLEX® HEAT 180 MS	Připojovací a ovládací kabely;
'=JA01+DA01-EB01.WD02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EB01.WD02	LAPP.00466303	ÖLFLEX® HEAT 180 MS	Připojovací a ovládací kabely;
'=JA01+DA01-EB01.WD03	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-EB01.WD03	LAPP.00466303	ÖLFLEX® HEAT 180 MS	Připojovací a ovládací kabely;
'=JA01+DA01-FS01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-FS01	CAM.DK2511125000	Opakfil ES8 Filter Series	Air FIlter, Glassfiber membrane V-shape, 592x592x296mm;
'=JA01+DA01-FS01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-FS01	CAM.1048102	SP Frame, ES8	Air filter frame, for ES8 Series;
'=JA01+DA01-FS02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-FS02	CAM.DK2511125000	Opakfil ES8 Filter Series	Air FIlter, Glassfiber membrane V-shape, 592x592x296mm;
'=JA01+DA01-FS02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-FS02	CAM.1048102	SP Frame, ES8	Air filter frame, for ES8 Series;
'=JA01+DA01-GQ06	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ06	EBM.8300100272	8300100272	Axial Fan, Ø800mm, EC Motor, 4.3kW, 3ph 400-480V 50-60Hz;
'=JA01+DA01-GQ06-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ06-WD01	MURR.7000-P8221-P361000	MQ15 Female 0° to open cable, 10m	Cable, 600VAC, 16A, 3ph with PE, female MQ15 connector to open end, 10m;
'=JA01+DA01-GQ06-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ06-WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA01-GQ06-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ06-WG01	MURR.7000-14541-7981000	7000-14541-7981000	Konfektionierte Datenleitung;
'=JA01+DA01-GQ06-XD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ06-XD01	MURR.7000-P8081-P820015		Male Receptacle, 600VAC, 16A, 3ph, Threaded M20 connection;
'=JA01+DA01-GQ07	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ07	EBM.8300100272	8300100272	Axial Fan, Ø800mm, EC Motor, 4.3kW, 3ph 400-480V 50-60Hz;
'=JA01+DA01-GQ07-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ07-WD01	MURR.7000-P8221-P361000	MQ15 Female 0° to open cable, 10m	Cable, 600VAC, 16A, 3ph with PE, female MQ15 connector to open end, 10m;
'=JA01+DA01-GQ07-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ07-WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA01-GQ07-XD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ07-XD01	MURR.7000-P8081-P820015		Male Receptacle, 600VAC, 16A, 3ph, Threaded M20 connection;
'=JA01+DA01-GQ08-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ08-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=JA01+DA01-GQ08-WD02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ08-WD02	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;

'=JA01+DA01-GQ08-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ08-WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA01-GQ09-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ09-WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=JA01+DA01-GQ09-WD02	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ09-WD02	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=JA01+DA01-GQ09-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-GQ09-WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA01-NA05	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-NA05	MURR.3858627		Blind Plug, M8x1 Plastic, for female threads.;
'=JA01+DA01-NA07	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-NA07	MURR.3858627		Blind Plug, M8x1 Plastic, for female threads.;
'=JA01+DA01-QM01-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM01-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-QM02-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM02-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-QM03	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM03	KLI.JS-A600x1000-X	JS-A, Class 3	Ventlation Damper, 600x1000mm, Aluminum, -30 to 90°C;
'=JA01+DA01-QM03-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM03-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-QM03.MA01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM03.MA01	BLM.SMQ24A-SR	SMQ Series Modulating Actuators	Actuator, for adjusting dampers, modulating;
'=JA01+DA01-QM04	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM04	KLI.JS-A600x1000-X	JS-A, Class 3	Ventlation Damper, 600x1000mm, Aluminum, -30 to 90°C;
'=JA01+DA01-QM04-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM04-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-QM04.MA01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM04.MA01	BLM.SMQ24A-SR	SMQ Series Modulating Actuators	Actuator, for adjusting dampers, modulating;
'=JA01+DA01-QM05-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM05-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-QM05-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM05-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-QM06-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM06-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-QM06-WD01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-QM06-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA01-SG01-WG01	'=JA01	Container Ventilation System;	'+DA01	Container #1 Inside;	'-SG01-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA02-BT04-WG01	'=JA01	Container Ventilation System;	'+DA02	Container #1 Outside;	'-BT04-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=JA01+DA02-QM01	'=JA01	Container Ventilation System;	'+DA02	Container #1 Outside;	'-QM01	KLI.JS-A1200x1000-X	JS-A, Class 3	Ventlation Damper, 1200x1000mm, Aluminum, -30 to 90°C;
'=JA01+DA02-QM01.MA01	'=JA01	Container Ventilation System;	'+DA02	Container #1 Outside;	'-QM01.MA01	BLM.SMQ24A-SR	SMQ Series Modulating Actuators	Actuator, for adjusting dampers, modulating;
'=JA01+DA02-QM02	'=JA01	Container Ventilation System;	'+DA02	Container #1 Outside;	'-QM02	KLI.JS-A1200x1000-X	JS-A, Class 3	Ventlation Damper, 1200x1000mm, Aluminum, -30 to 90°C;
'=JA01+DA02-QM02.MA01	'=JA01	Container Ventilation System;	'+DA02	Container #1 Outside;	'-QM02.MA01	BLM.SMQ24A-SR	SMQ Series Modulating Actuators	Actuator, for adjusting dampers, modulating;
'=JA01+DA03-AC07	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-AC07	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA03-AC08	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-AC08	HEN.RK0207T	Enycase RK Series	Terminal Box, 93x93mm, 7 terminals 2,5mm2, IP66;
'=JA01+DA03-BP01.WG01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-BP01.WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA03-BQ01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-BQ01	APOL.ORB-OP-42001-MAR	ORB-OP-42001-MAR	Orbis Marine Optical Smoke Detector;
'=JA01+DA03-BQ01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-BQ01	APOL.ORB-RB-40004-MAR	ORB-RB-40004-MAR	Orbis Marine Relay Base;
'=JA01+DA03-BT01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-BT01	IFM.TM5101	TM-025KCBR14- /US/	Temperatursensor zum Anschluss an eine Auswerteeinheit mit maximaler Betriebsspannung von 32 V, Kon
'=JA01+DA03-BT01-WG01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=JA01+DA03-EA01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-EA01	MURR.4000-75900-1715032	4000-75900-1715032	Leuchte (nicht spezifiziert);
'=JA01+DA03-EA01-WD01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-EA01-WD01	MURR.7000-08061-6310200		#VALUE!
'=JA01+DA03-EB01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-EB01	BPSE.PLACEHOLDER		Placeholder;
'=JA01+DA03-EB02-WD01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-EB02-WD01	LAPP.10035091	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA03-EB02-WG01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-EB02-WG01	LAPP.10035056	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=JA01+DA03-GQ01.WD01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-GQ01.WD01	LAPP.1123478	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Power and control cables;
'=JA01+DA03-GQ01.WG01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-GQ01.WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA03-GQ01.WG01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-GQ01.WG01	LAPP.2170278	UNITRONIC® BUS CAN FD P	UNITRONIC BUS CAN FD P 1X2X0,5;
'=JA01+DA03-GQ10	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-GQ10	EBM.K3G500-PB33-01		Ventilation Fan, Radial, EC Motor, 3ph, 400-480V, 5.7kW;
'=JA01+DA03-QM07-WD01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-QM07-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+DA03-QM08-WD01	'=JA01	Container Ventilation System;	'+DA03	Container #2 Inside;	'-QM08-WD01	LAPP.1123270	ÖLFLEX® CLASSIC 135 CH	Připojovací a ovládací kabely;
'=JA01+UC07-BT01-WG01	'=JA01	Container Ventilation System;	'+UC07	Ventilation Cabinet;	'-BT01-WG01	IFM.EVC540	ADOGH040VAT0025H04/3G/2D	Anschlusskabel mit Buchse;
'=JA01+UC07-GQ08	'=JA01	Container Ventilation System;	'+UC07	Ventilation Cabinet;	'-GQ08	EBM.K3G280-PS10-J2	RadiPac K2G280	Ventilation Fan, Radial, EC Motor 3ph 400-480 50/60Hz, 1kW;
'=JA01+UC07-GQ09	'=JA01	Container Ventilation System;	'+UC07	Ventilation Cabinet;	'-GQ09	EBM.K3G280-PS10-J2	RadiPac K2G280	Ventilation Fan, Radial, EC Motor 3ph 400-480 50/60Hz, 1kW;
'=JA02+DA02-WM01	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM01	BPSE.7001553		Process Exhaust for FCwave, Megablock, 3" Stainless 316;
'=JA02+DA02-WM02	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM02	BPSE.7001553		Process Exhaust for FCwave, Megablock, 3" Stainless 316;
'=JA02+DA02-WM03	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM03	BPSE.7001553		Process Exhaust for FCwave, Megablock, 3" Stainless 316;
'=JA02+DA02-WM04	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM04	BPSE.7001553		Process Exhaust for FCwave, Megablock, 3" Stainless 316;
'=JA02+DA02-WM05	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM05	BPSE.7001553		Process Exhaust for FCwave, Megablock, 3" Stainless 316;
'=JA02+DA02-WM06	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM06	BPSE.7001553		Process Exhaust for FCwave, Megablock, 3" Stainless 316;
'=JA02+DA02-WM07	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM07	BPSE.7001554		Ventilation Exhaust, Megablock, 2", Stainless 316;
'=JA02+DA02-WM08	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM08	BPSE.7001554		Ventilation Exhaust, Megablock, 2", Stainless 316;
'=JA02+DA02-WM09	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM09	BPSE.7001554		Ventilation Exhaust, Megablock, 2", Stainless 316;
'=JA02+DA02-WM10	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM10	BPSE.7001554		Ventilation Exhaust, Megablock, 2", Stainless 316;
'=JA02+DA02-WM11	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM11	BPSE.7001554		Ventilation Exhaust, Megablock, 2", Stainless 316;
'=JA02+DA02-WM12	'=JA02	Process Exhaust System;	'+DA02	Container #1 Outside;	'-WM12	BPSE.7001554		Ventilation Exhaust, Megablock, 2", Stainless 316;
'=JB01+DA02-HQ01	'=JB01	Condensate Drainage System;	'+DA02	Container #1 Outside;	'-HQ01	BPSE.7001554		Ventilation Exhaust, Megablock, 2", Stainless 316;
'=JB01+DA02-XM01	'=JB01	Condensate Drainage System;	'+DA02	Container #1 Outside;	'-XM01	BPSE.2800-2891		Pipe End, Ø60.3mm, Material 1.4301;
'=LA01+DA01-CA01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-CA01	PULS.UZK24.121	UZK24.121	Batteriemodul, 24V, 12Ah;
'=LA01+DA01-CA02	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-CA02	PULS.UZK24.121	UZK24.121	Batteriemodul, 24V, 12Ah;
'=LA01+DA01-CA03	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-CA03	PULS.UZK24.121	UZK24.121	Batteriemodul, 24V, 12Ah;
'=LA01+DA01-CA30	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-CA30	PULS.UZK24.121	UZK24.121	Batteriemodul, 24V, 12Ah;
'=LA01+DA01-CA30-WD01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-CA30-WD01	LAPP.0014 103 (3G2,5)	ÖLFLEX CLASSIC 100 H	Kabel-Halogenfrei, 3G2,5;
'=LA01+DA01-CA30-WG01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-CA30-WG01	LAPP.1123067	ÖLFLEX® CLASSIC 130 H	ÖLFLEX CLASSIC 130 H 3G1;
'=LA01+DA01-RB01-WD01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-RB01-WD01	LAPP.10035089	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LA01+DA01-RB01-WG01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-RB01-WG01	LAPP.0030937	UNITRONIC®-FD CP (TP) PLUS	UNITRONIC-FD CP (TP) PLUS 2X2X0,5;
'=LA01+DA01-RB02-WD01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-RB02-WD01	LAPP.10035089	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LA01+DA01-RB02-WG01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-RB02-WG01	LAPP.0030937	UNITRONIC®-FD CP (TP) PLUS	UNITRONIC-FD CP (TP) PLUS 2X2X0,5;
'=LA01+DA01-RB03-WD01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-RB03-WD01	LAPP.10035089	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LA01+DA01-RB03-WG01	'=LA01	Container Control System;	'+DA01	Container #1 Inside;	'-RB03-WG01	LAPP.0030937	UNITRONIC®-FD CP (TP) PLUS	UNITRONIC-FD CP (TP) PLUS 2X2X0,5;
'=LA01+UC20-EA1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-EA1	RIT_N.2500300	SZ.2500300	Systemleuchte LED;
'=LA01+UC20-EA01-WD01	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-EA01-WD01	RIT.2500500	SZ.2500500	Anschlussleitung;
'=LA01+UC20-EC1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-EC1	RIT_N.3239124	SK.3239124	TopTherm Filterlüfter;
'=LA01+UC20-FB22	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FB22	ABB.2CSR246140R1164	DS203NC L C16 A30	Kombination FI-Schalter/Leitungsschutzschalter;
'=LA01+UC20-FB23	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FB23	ABB.2CSR255188R1104	DS201T C10 A30	DS201T C10 A30 RCBO;
'=LA01+UC20-FC01A	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC01A	ETN.FAZ-B6/3	FAZ-B6/3	Leitungsschutzschalter, 6 A, 3p, Charakteristik: B;
'=LA01+UC20-FC01B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC01B	ETN.FAZ-B6/3	FAZ-B6/3	Leitungsschutzschalter, 6 A, 3p, Charakteristik: B;
'=LA01+UC20-FC01C	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC01C	ETN.FAZ-B6/3	FAZ-B6/3	Leitungsschutzschalter, 6 A, 3p, Charakteristik: B;
'=LA01+UC20-FC02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC02	ETN.FAZ-B6/3	FAZ-B6/3	Leitungsschutzschalter, 6 A, 3p, Charakteristik: B;
'=LA01+UC20-FC03A	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC03A	ETN.FAZ-B6/3	FAZ-B6/3	Leitungsschutzschalter, 6 A, 3p, Charakteristik: B;
'=LA01+UC20-FC03B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC03B	ETN.FAZ-B6/3	FAZ-B6/3	Leitungsschutzschalter, 6 A, 3p, Charakteristik: B;
'=LA01+UC20-FC04	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC04	ETN.PKNM-10/1N/C/003-A-MW	PKNM-10/1N/C/003-A-MW	FI/LS, 10A, 30mA, LS-Kennline-C, 1p+N, FI-Char: A;

'=LA01+UC20-FC06	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC06	ETN.FAZ-B10/3	FAZ-B10/3	Leitungsschutzschalter, 10 A, 3p, Charakteristik: B;
'=LA01+UC20-FC07	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC07	ETN.FAZ-B10/3	FAZ-B10/3	Leitungsschutzschalter, 10 A, 3p, Charakteristik: B;
'=LA01+UC20-FC08	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC08	ETN.FAZ-B20/3	FAZ-B20/3	Leitungsschutzschalter, 20 A, 3p, Charakteristik: B;
'=LA01+UC20-FC09	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC09	ETN.FAZ-B20/3	FAZ-B20/3	Leitungsschutzschalter, 20 A, 3p, Charakteristik: B;
'=LA01+UC20-FC10	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC10	ETN.FAZ-B20/3	FAZ-B20/3	Leitungsschutzschalter, 20 A, 3p, Charakteristik: B;
'=LA01+UC20-FC10	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC10	A-B_N.1492-SP3B100	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC10	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC10	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC11	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC11	ETN.FAZ-B10/3	FAZ-B10/3	Leitungsschutzschalter, 10 A, 3p, Charakteristik: B;
'=LA01+UC20-FC12	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC12	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC13	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC13	A-B_N.1492-SP3B100	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC13	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC13	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC14	A-B_N.1492-SP3B100	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC14	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC15	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC15	A-B_N.1492-SP3B100	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC15	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC15	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC16	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC16	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC17	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC17	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC18	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC18	ABB.2CDS252001R0105	S202-B10	Miniature Circuit Breaker - S200 - 2P - B - 10 A;
'=LA01+UC20-FC18	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC18	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC19	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC19	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC20	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC20	A-B_N.1492-SP3B160-N	1492	Supplementary Protector;
'=LA01+UC20-FC20	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC20	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-FC21	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC21	A-B_N.1492-SPM2B020	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC30	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC30	A-B_N.1492-SP3B060	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC31	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC31	A-B_N.1492-SP3B060	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC32	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC32	A-B_N.1492-SP3B060	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC33	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC33	A-B_N.1492-SP3B060	1492	Miniature Circuit Breaker;
'=LA01+UC20-FC100	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC100	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-FC101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC101	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-FC102	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC102	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-FC103	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC103	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-FC104	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC104	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-FC105	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC105	MURR.9000-41012-0200000	9000-41012-0200000	Stromüberwachungsgerät;
'=LA01+UC20-FC110	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC110	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-FC111	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC111	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-FC112	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC112	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-FC113	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC113	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-FC114	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC114	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-FC115	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC115	MURR.9000-41012-0200000	9000-41012-0200000	Stromüberwachungsgerät;
'=LA01+UC20-FC120	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC120	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-FC121	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC121	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-FC122	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC122	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-FC123	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC123	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-FC124	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC124	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-FC125	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC125	MURR.9000-41012-0200000	9000-41012-0200000	Stromüberwachungsgerät;
'=LA01+UC20-FC200	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC200	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-FC210	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC210	WEI.2081880000	AMG FIM-C	Einspeiseklemme;
'=LA01+UC20-FC210.1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC210.1	WEI.2080360000	AMG ELM-6	Elektronische Lastüberwachung;
'=LA01+UC20-FC210.2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC210.2	WEI.2080360000	AMG ELM-6	Elektronische Lastüberwachung;
'=LA01+UC20-FC211	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-FC211	ABB.2CDS200912R0001	S2C-H6R	S2C-H6R Auxiliary Contact;
'=LA01+UC20-KE01-Slot2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE01-Slot2	DEIF.ACM31	ACM3.1	Alternating Current Module for the ML300 Contorller;
'=LA01+UC20-KE01-Slot3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE01-Slot3	DEIF.IOM31	IOM3.1	Input Output Module 3.1 for the ML300 Controller Series;
'=LA01+UC20-KE01-Slot4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE01-Slot4	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC20-KE01-Slot5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE01-Slot5	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC20-KE01-Slot6	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE01-Slot6	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC20-KE01-WG01	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE01-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=LA01+UC20-KE02-Slot03	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE02-Slot03	DEIF.IOM34	IOM3.4	Input Output Module 3.4 for the ML300 Controller Series;
'=LA01+UC20-KE02-Slot04	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE02-Slot04	DEIF.IOM34	IOM3.4	Input Output Module 3.4 for the ML300 Controller Series;
'=LA01+UC20-KE02-Slot05	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE02-Slot05	DEIF.IOM34	IOM3.4	Input Output Module 3.4 for the ML300 Controller Series;
'=LA01+UC20-KE02-Slot06	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE02-Slot06	DEIF.IOM34	IOM3.4	Input Output Module 3.4 for the ML300 Controller Series;
'=LA01+UC20-KE02-Slot07	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE02-Slot07	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC20-KE02-WG01	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE02-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=LA01+UC20-KE03-Slot1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE03-Slot1	DEIF.PSM32	PSM3.2	Power Supply Unit 3.2 for the ML300 Controller Series;
'=LA01+UC20-KE03-Slot2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE03-Slot2	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC20-KE03-Slot3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE03-Slot3	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC20-KE03-Slot4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE03-Slot4	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC20-KE03-Slot5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE03-Slot5	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC20-KE03-WG01	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE03-WG01	LAPP.2170931	Profinet 4pair cabling Cat.6A FRNC flexible	Profinet 4pair cabling Cat.6A FRNC flexible 4X2X23AWG;
'=LA01+UC20-KE12	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE12	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LA01+UC20-KE13	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE13	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LA01+UC20-KE14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE14	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LA01+UC20-KE15	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE15	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LA01+UC20-KE16	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE16	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LA01+UC20-KE17	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE17	SICK.1051134	FX3-ANA020002	Flexi Soft Analoges Eingangsmodul, FX3-ANA0;
'=LA01+UC20-KE18	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE18	SICK.1051134	FX3-ANA020002	Flexi Soft Analoges Eingangsmodul, FX3-ANA0;
'=LA01+UC20-KE19	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KE19	SICK.1051134	FX3-ANA020002	Flexi Soft Analoges Eingangsmodul, FX3-ANA0;
'=LA01+UC20-KF20.2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF20.2	SE.RSL1PRBU	RSL1PRBU	Interface plug-in relay - Zelio RSL - 1 C/O - 24 V DC - 6 A - with LED;
'=LA01+UC20-KF20.4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF20.4	SE.RSL1PRBU	RSL1PRBU	Interface plug-in relay - Zelio RSL - 1 C/O - 24 V DC - 6 A - with LED;
'=LA01+UC20-KF21.2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF21.2	SE.RSL1PRBU	RSL1PRBU	Interface plug-in relay - Zelio RSL - 1 C/O - 24 V DC - 6 A - with LED;
'=LA01+UC20-KF21.4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF21.4	SE.RSL1PRBU	RSL1PRBU	Interface plug-in relay - Zelio RSL - 1 C/O - 24 V DC - 6 A - with LED;
'=LA01+UC20-KF22.2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF22.2	SE.RSL1PRBU	RSL1PRBU	Interface plug-in relay - Zelio RSL - 1 C/O - 24 V DC - 6 A - with LED;
'=LA01+UC20-KF22.4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF22.4	SE.RSL1PRBU	RSL1PRBU	Interface plug-in relay - Zelio RSL - 1 C/O - 24 V DC - 6 A - with LED;
'=LA01+UC20-KF100	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF100	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;

'=LA01+UC20-KF101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF101	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF101	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF101	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF101	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF101	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF101	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF101	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF101	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC20-KF102	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF102	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC20-KF103	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF103	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC20-KF104	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF104	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC20-KF105	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF105	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC20-KF106	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF106	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC20-KF107	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF107	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC20-KF201	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF201	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF201	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF201	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF201	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF201	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF201	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF201	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-KF201	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-KF201	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC20-QA08	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QA08	SE.SSM3A325BD	SSM3A325BD	Solid state relay - DIN rail mount - input 4-32Vdc, output 48-600Vac, 25A;
'=LA01+UC20-QA09	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QA09	SE.SSM3A325BD	SSM3A325BD	Solid state relay - DIN rail mount - input 4-32Vdc, output 48-600Vac, 25A;
'=LA01+UC20-QA10	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QA10	SE.SSM3A325BD	SSM3A325BD	Solid state relay - DIN rail mount - input 4-32Vdc, output 48-600Vac, 25A;
'=LA01+UC20-QB02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QB02	SE.LC1D50ABD	LC1D50ABD	Motor Contactor, 600VAC, 3PH, 50A AC-3 & 80A AC-1 @@ <=440V,;
'=LA01+UC20-QB03	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QB03	SE.LC1D50ABD	LC1D50ABD	Motor Contactor, 600VAC, 3PH, 50A AC-3 & 80A AC-1 @@ <=440V,;
'=LA01+UC20-QB13	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QB13	SIE.3RF2440-1AC45	3RF2440-1AC45	HALBLEITERSCHUETZ 3PHASIG 3RF2;
'=LA01+UC20-QB14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QB14	SIE.3RF2440-1AC45	3RF2440-1AC45	HALBLEITERSCHUETZ 3PHASIG 3RF2;
'=LA01+UC20-QB15	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QB15	SIE.3RF2440-1AC45	3RF2440-1AC45	HALBLEITERSCHUETZ 3PHASIG 3RF2;
'=LA01+UC20-QB18	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-QB18	ABB.1SAE231111R0122	ESB25-22N-01	ESB25-22N-01 Installation Contactor 2NO/2NC, 24 V AC/DC;
'=LA01+UC20-RB01	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-RB01	PULS.UB40.241	UB40.241	DC-UPS CONTROL UNIT;
'=LA01+UC20-RB02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-RB02	PULS.UB40.241	UB40.241	DC-UPS CONTROL UNIT;
'=LA01+UC20-RB03	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-RB03	PULS.UB40.241	UB40.241	DC-UPS CONTROL UNIT;
'=LA01+UC20-RB30	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-RB30	PULS.UB20.241	UB20.241	DC-UPS Control Unit, 24V, 20A;
'=LA01+UC20-S1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-S1	STE.01141.9-00	KTS 011	Thermostat KTS 011, NO, 32-140°C;
'=LA01+UC20-SG10	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-SG10	SE.XB4BS8444	XB4BS8444	Red Ø40 Emergency stop, switching off Ø22 latching turn release 2NC;
'=LA01+UC20-SG11.P	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-SG11.P	SE.XB4BW36B5	XB4BW36B5	Blue flush complete illum pushbutton Ø22 spring return 1NO+1NC 24V;
'=LA01+UC20-TB01	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01	PULS.QT40.241	QT40.241	Stromversorgung, 3AC, Ausgang 24V 40A;
'=LA01+UC20-TB01A	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01A	MURR.85693	85693	Emparro Schaltnetzteil 3-phasig;
'=LA01+UC20-TB01A	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01A	MURR.85415	85415	Emparro ACCUcontrol USV-Modul;
'=LA01+UC20-TB01A	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01A	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-TB01A	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01A	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-TB01A	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01A	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-TB01B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01B	MURR.85693	85693	Emparro Schaltnetzteil 3-phasig;
'=LA01+UC20-TB01B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01B	MURR.85415	85415	Emparro ACCUcontrol USV-Modul;
'=LA01+UC20-TB01B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01B	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-TB01B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01B	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-TB01B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01B	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-TB01C	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01C	MURR.85693	85693	Emparro Schaltnetzteil 3-phasig;
'=LA01+UC20-TB01C	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01C	MURR.85415	85415	Emparro ACCUcontrol USV-Modul;
'=LA01+UC20-TB01C	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01C	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-TB01C	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01C	MURR.9000-41091-1102000	9000-41091-1102000	Stromüberwachungsgerät;
'=LA01+UC20-TB01C	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB01C	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-TB02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB02	PULS.QT40.241	QT40.241	Stromversorgung, 3AC, Ausgang 24V 40A;
'=LA01+UC20-TB02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB02	MURR.85691	85691	Emparro Schaltnetzteil 3-phasig;
'=LA01+UC20-TB02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB02	MURR.85414	85414	Emparro ACCUcontrol USV-Modul;
'=LA01+UC20-TB02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB02	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC20-TB02	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB02	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC20-TB03	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB03	PULS.QT40.241	QT40.241	Stromversorgung, 3AC, Ausgang 24V 40A;
'=LA01+UC20-TB30	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-TB30	PULS.QT20.241	QT20.241	Stromversorgung, 3AC, Ausgang 24V 20A;
'=LA01+UC20-WD01	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-WD01	LAPP.1123493	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	Připojovací a ovládací kabely;
'=LA01+UC20-X11:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X11:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X11:PE	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X11:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC20-X11:2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X11:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X11:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X11:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X12:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X12:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X12:PE	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X12:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC20-X12:2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X12:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X12:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X12:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X16:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X16:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X16:PE	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X16:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC20-X16:2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X16:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X16:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X16:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X17:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X17:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X17:PE	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X17:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC20-X17:2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X17:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X17:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X17:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC20-X101:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X101:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X101:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X101:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X102:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X102:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X102:2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X102:2	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X102:4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X102:4	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X103:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X103:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X103:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X103:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X103:5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X103:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;

'=LA01+UC20-X103:7	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X103:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X103:9	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X103:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X103:11	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X103:11	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X104:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X104:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X104:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X104:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X104:5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X104:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X104:7	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X104:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X104:9	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X104:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X104:11	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X104:11	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X105:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X105:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X105:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X105:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X110:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X110:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X110:2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X110:2	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X110:4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X110:4	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:13	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:13	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:7	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:9	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:11	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:11	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:14	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:15	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:15	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:17	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:17	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:19	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:19	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:21	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:21	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:25	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:25	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:23	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:23	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X120:27	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X120:27	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X121:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X121:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X121:2	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X121:2	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X121:4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X121:4	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X121:6	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X121:6	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X121:8	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X121:8	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:9	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:4	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:12	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:12	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:6	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:6	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:14	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:8	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:8	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X122:16	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X122:16	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X123:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X123:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X123:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X123:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X123:4	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X123:4	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X123:6	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X123:6	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X124:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X124:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X124:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X124:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X124:5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X124:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X124:7	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X124:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X124:9	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X124:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X124:12	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X124:12	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X125:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X125:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X125:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X125:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X125:5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X125:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:13	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:13	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:25	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:25	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:7	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:9	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:11	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:11	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:14	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:16	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:16	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:18	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:18	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:20	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:20	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:22	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:22	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:24	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:24	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X150:26	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X150:26	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:1	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:13	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:13	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:3	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:5	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:7	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:9	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:11	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:11	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:14	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:14	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:16	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:16	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:17	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:17	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:19	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:19	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:21	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:21	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC20-X160:23	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-X160:23	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;

'=LA01+UC20-XG103B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-XG103B	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=LA01+UC20-XG103B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-XG103B	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=LA01+UC20-XG103B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-XG103B	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=LA01+UC20-XG103B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-XG103B	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=LA01+UC20-XG103B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-XG103B	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=LA01+UC20-XG103B	'=LA01	Container Control System;	'+UC20	Control Cabinet (40ft);	'-XG103B	PXC.1656725	VS-08-RJ45-5-Q/IP20	RJ45-Steckverbinder;
'=LA01+UC30-14:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-14:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-14:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-14:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-14:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-14:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-14:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-14:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-CA30	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-CA30	PULS.UZK24.121	UZK24.121	Batteriemodul, 24V, 12Ah;
'=LA01+UC30-EA1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-EA1	RIT_N.2500300	SZ.2500300	Systemleuchte LED;
'=LA01+UC30-EB01	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-EB01	RIT.3105390	SK.3105390	Schaltschrank-Heizung;
'=LA01+UC30-EE120	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-EE120	SEA.26919		Antenna, Puck, For 3G/4G, Mounting on flat surface;
'=LA01+UC30-FC01	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-FC01	A-B_N.1492-SPM3B020N	1492	Miniature Circuit Breaker;
'=LA01+UC30-FC02	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-FC02	A-B_N.1492-SPM2B020	1492	Miniature Circuit Breaker;
'=LA01+UC30-FC03	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-FC03	A-B_N.1492-SPM2B100	1492	Miniature Circuit Breaker;
'=LA01+UC30-FC28	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-FC28	A-B.1492-SPM3B250	1492	Miniature Circuit Breaker;
'=LA01+UC30-FC38	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-FC38	A-B.1492-SPM3B250	1492	Miniature Circuit Breaker;
'=LA01+UC30-FC100	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-FC100	A-B_N.1492-SP3B060	1492	Miniature Circuit Breaker;
'=LA01+UC30-FC200	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-FC200	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC30-KE04-Slot2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE04-Slot2	DEIF.ACM31	ACM3.1	Alternating Current Module for the ML300 Contorller;
'=LA01+UC30-KE04-Slot3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE04-Slot3	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC30-KE04-Slot4	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE04-Slot4	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC30-KE04-Slot5	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE04-Slot5	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC30-KE04-Slot6	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE04-Slot6	DEIF.IOM34	IOM3.4	Input Output Module 3.4 for the ML300 Controller Series;
'=LA01+UC30-KE04-WG01	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE04-WG01	LAPP.2172363	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	Ethernet Patch Cable, Pre-made, 0.5m, RJ45 to RJ45, Cat 6A;
'=LA01+UC30-KE05-Slot2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE05-Slot2	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC30-KE05-WG01	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KE05-WG01	LAPP.2170931	Profinet 4pair cabling Cat.6A FRNC flexible	Profinet 4pair cabling Cat.6A FRNC flexible 4X2X23AWG;
'=LA01+UC30-KF10	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KF10	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LA01+UC30-KF110	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KF110	MOXA.EDS-316-T		Switch, Unmanaged, 16 port, DIN-rail mount;
'=LA01+UC30-KF120	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-KF120	SEA.3539-4G	SiteManager 3539-4G	Industrial Router, with 4G, 3539;
'=LA01+UC30-QA41	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-QA41	SIE.3RF2420-1AB45	3RF2420-1AB45	HALBLEITERSCHUETZ 3PHASIG 3RF2;
'=LA01+UC30-QA42	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-QA42	SIE.3RF2420-1AB45	3RF2420-1AB45	HALBLEITERSCHUETZ 3PHASIG 3RF2;
'=LA01+UC30-RB30	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-RB30	PULS.UB20.241	UB20.241	DC-UPS Control Unit, 24V, 20A;
'=LA01+UC30-S1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-S1	RIT.3118000	SK.3118000	Hygrostat;
'=LA01+UC30-SG01	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-SG01	SE.XB4BS8444	XB4BS8444	Red Ø40 Emergency stop, switching off Ø22 latching turn release 2NC;
'=LA01+UC30-T1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-T1	ETN.HF4B-150/5A	HF4B-150/5A	Stromwandler HF4B, 150A/5A;
'=LA01+UC30-T2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-T2	ETN.HF4B-150/5A	HF4B-150/5A	Stromwandler HF4B, 150A/5A;
'=LA01+UC30-T3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-T3	ETN.HF4B-150/5A	HF4B-150/5A	Stromwandler HF4B, 150A/5A;
'=LA01+UC30-TA19	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-TA19	DAN.OPT-A1		Vacon NX, Control Board;
'=LA01+UC30-TA19	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-TA19	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=LA01+UC30-TA19	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-TA19	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=LA01+UC30-TA29	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-TA29	DAN.OPT-A1		Vacon NX, Control Board;
'=LA01+UC30-TA29	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-TA29	DNF.OPT-AF	OPT-AF	Vacon NX, Option Board, Safe Torque-Off function board (STO);
'=LA01+UC30-TA29	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-TA29	DNF.OPT-E9	OPT-E9	Vacon NX, Dual Port Ethernet option board;
'=LA01+UC30-TB30	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-TB30	PULS.QT20.241	QT20.241	Stromversorgung, 3AC, Ausgang 24V 20A;
'=LA01+UC30-W1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-W1	RIT.2500500	SZ.2500500	Anschlussleitung;
'=LA01+UC30-W1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-W1	2500500		#VALUE!
'=LA01+UC30-WG01	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LA01+UC30-WG02	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LA01+UC30-X11:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X11:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X11:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X11:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X11:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X11:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X11:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X11:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X12:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X12:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X12:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X12:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X12:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X12:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X12:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X12:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X13:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X13:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X13:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X13:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X13:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X13:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X13:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X13:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X15:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X15:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X15:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X15:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X15:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X15:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X15:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X15:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X16:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X16:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X16:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X16:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X16:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X16:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X16:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X16:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X21:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X21:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X21:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X21:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X21:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X21:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X21:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X21:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X22:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X22:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X22:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X22:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X22:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X22:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X22:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X22:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X23:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X23:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X23:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X23:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X23:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X23:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X23:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X23:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;

'=LA01+UC30-X24:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X24:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X24:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X24:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X24:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X24:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X24:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X24:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X25:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X25:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X25:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X25:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X25:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X25:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X25:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X25:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X26:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X26:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X26:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X26:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X26:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X26:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X26:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X26:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X31:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X31:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X31:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X31:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X31:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X31:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X31:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X31:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X41:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X41:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X41:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X41:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X41:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X41:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X41:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X41:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X42:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X42:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X42:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X42:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X42:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X42:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X42:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X42:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X50:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X50:1	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X50:2	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X50:2	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X50:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X50:3	WEI.1608510000	ZDU 2.5	Průchozí svorka řadová;
'=LA01+UC30-X50:PE	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X50:PE	WEI.1608640000	ZPE 2.5	Řadová svorka ochranného vodiče;
'=LA01+UC30-X110:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X110:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X110:5	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X110:7	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X110:9	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X110:11	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:11	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X110:13	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:13	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X110:15	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X110:15	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X111:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X111:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X111:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X111:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X111:5	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X111:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X111:7	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X111:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:5	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:7	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:9	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:9	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:11	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:11	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:13	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:13	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X112:15	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X112:15	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X113:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X113:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X113:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X113:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X113:5	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X113:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X113:7	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X113:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X114:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X114:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X114:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X114:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X115:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X115:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X115:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X115:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X116:1	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X116:1	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X116:3	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X116:3	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X116:5	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X116:5	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC30-X116:7	'=LA01	Container Control System;	'+UC30	Coolant Skid Control Cat	'-X116:7	WEI.1791100000	ZDK 1.5	Průchozí svorka řadová;
'=LA01+UC31-BB01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-BB01	BENDER.B 9106 7010	iso685-D	Digital Ground Fault Monitor for Ungrounded AC/DC Systems;
'=LA01+UC31-CA01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-CA01	PULS.UZK24.121	UZK24.121	Batteriemodul, 24V, 12Ah;
'=LA01+UC31-CA01-WD01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-CA01-WD01	LAPP.10035089	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LA01+UC31-CA01-WG01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-CA01-WG01	LAPP.0030937	UNITRONIC®-FD CP (TP) PLUS	UNITRONIC-FD CP (TP) PLUS 2X2X0,5;
'=LA01+UC31-CA02	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-CA02	PULS.UZK24.121	UZK24.121	Batteriemodul, 24V, 12Ah;
'=LA01+UC31-CA02-WD01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-CA02-WD01	LAPP.10035089	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LA01+UC31-CA02-WG01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-CA02-WG01	LAPP.0030937	UNITRONIC®-FD CP (TP) PLUS	UNITRONIC-FD CP (TP) PLUS 2X2X0,5;
'=LA01+UC31-FC01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC01	ABB.2CDS253001R0377	S203-K6	Miniature Circuit Breaker - S200 - 3P - K - 6 A;
'=LA01+UC31-FC02	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC02	ABB.2CDS253001R0377	S203-K6	Miniature Circuit Breaker - S200 - 3P - K - 6 A;
'=LA01+UC31-FC03	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC03	ETN.FAZ-B13/3	FAZ-B13/3	Leitungsschutzschalter, 13 A, 3p, Charakteristik: B;
'=LA01+UC31-FC03	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC03	ABB.2CDS254001R0165	S204-B16	Miniature Circuit Breaker - S200 - 4P - B - 16 A;
'=LA01+UC31-FC03	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC03	ABB.2CDS253001R0135	S203-B13	Miniature Circuit Breaker - S200 - 3P - B - 13 A;
'=LA01+UC31-FC04	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC04	ETN.FAZ-B10/3	FAZ-B10/3	Leitungsschutzschalter, 10 A, 3p, Charakteristik: B;
'=LA01+UC31-FC04	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC04	ABB.2CDS253001R0105	S203-B10	Miniature Circuit Breaker - S200 - 3P - B - 10 A;
'=LA01+UC31-FC06	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC06	ABB.2CDS253103R0105	S203-B10NA	Miniature Circuit Breaker - S200 - 4P - B - 10 A;
'=LA01+UC31-FC07	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC07	ABB.2CDS251103R0065	S201-B6NA	Miniature Circuit Breaker - S200 - 2P - B - 6 A;
'=LA01+UC31-FC08	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC08	ETN.PKNM-10/1N/C/003-A-MW	PKNM-10/1N/C/003-A-MW	FI/LS, 10A, 30mA, LS-Kennline-C, 1p+N, FI-Char: A;
'=LA01+UC31-FC10	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC10	ABB.1SAM350005R1005	MS132-1.0-HKF1-11	MS132-1.0-HKF1-11 Manual Motor Starter;
'=LA01+UC31-FC11	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC11	ABB.1SAM350005R1005	MS132-1.0-HKF1-11	MS132-1.0-HKF1-11 Manual Motor Starter;
'=LA01+UC31-FC31	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC31	ABB.2CDS253001R0065	S203-B6	Miniature Circuit Breaker - S200 - 3P - B - 6 A;
'=LA01+UC31-FC32	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC32	ABB.2CDS253001R0065	S203-B6	Miniature Circuit Breaker - S200 - 3P - B - 6 A;
'=LA01+UC31-FC40	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC40	ABB.1SAM340010R1008	MS132-4.0KT	MS132-4.0KT Circuit Breaker for Primary Transformer Protection;
'=LA01+UC31-FC100	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC100	WEI.2081880000	AMG FIM-C	Einspeiseklemme;

'=LA01+UC31-FC100	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC100	WEI.2495380000	AMG EP 2010	Abschluss- und Zwischenplatte (Klemmen);
'=LA01+UC31-FC100	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC100	WEI.2460730000	ZQV 4N/50 RD	Příčná spojka/přemostění pro řadovou svorku;
'=LA01+UC31-FC101	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC101	WEI.2080650000	AMG ELM-10F	Elektronische Lastüberwachung;
'=LA01+UC31-FC101-1:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC101-1:1	WEI.2122920000	AMG PD	Potentialverteilerklemme;
'=LA01+UC31-FC101-2:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC101-2:2	WEI.2122930000	AMG MD	Potentialverteilerklemme;
'=LA01+UC31-FC102	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC102	WEI.2080480000	AMG ELM-2F	Elektronische Lastüberwachung;
'=LA01+UC31-FC102-1:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC102-1:1	WEI.2122920000	AMG PD	Potentialverteilerklemme;
'=LA01+UC31-FC102-1:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC102-1:2	WEI.2122920000	AMG PD	Potentialverteilerklemme;
'=LA01+UC31-FC103	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC103	WEI.2080480000	AMG ELM-2F	Elektronische Lastüberwachung;
'=LA01+UC31-FC103-1:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC103-1:1	WEI.2122920000	AMG PD	Potentialverteilerklemme;
'=LA01+UC31-FC103-1:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC103-1:2	WEI.2122920000	AMG PD	Potentialverteilerklemme;
'=LA01+UC31-FC103-3:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC103-3:3	WEI.2122930000	AMG MD	Potentialverteilerklemme;
'=LA01+UC31-FC103-3:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC103-3:3	WEI.2122930000	AMG MD	Potentialverteilerklemme;
'=LA01+UC31-FC103-3:4	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC103-3:4	WEI.2122930000	AMG MD	Potentialverteilerklemme;
'=LA01+UC31-FC103-3:4	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC103-3:4	WEI.2122930000	AMG MD	Potentialverteilerklemme;
'=LA01+UC31-FC104	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC104	WEI.2080480000	AMG ELM-2F	Elektronische Lastüberwachung;
'=LA01+UC31-FC104-1:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC104-1:1	WEI.2122920000	AMG PD	Potentialverteilerklemme;
'=LA01+UC31-FC104-1:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC104-1:2	WEI.2122920000	AMG PD	Potentialverteilerklemme;
'=LA01+UC31-FC104-3:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC104-3:3	WEI.2122930000	AMG MD	Potentialverteilerklemme;
'=LA01+UC31-FC104-3:4	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-FC104-3:4	WEI.2122930000	AMG MD	Potentialverteilerklemme;
'=LA01+UC31-KE06	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06	DEIF.RACK71		Multi Line 300 - 7 Module Slots;
'=LA01+UC31-KE06-Slot1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-Slot1	DEIF.PSM32	PSM3.2	Power Supply Unit 3.2 for the ML300 Controller Series;
'=LA01+UC31-KE06-Slot2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-Slot2	DEIF.ACM31	ACM3.1	Alternating Current Module for the ML300 Contorller;
'=LA01+UC31-KE06-Slot3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-Slot3	DEIF.IOM31	IOM3.1	Input Output Module 3.1 for the ML300 Controller Series;
'=LA01+UC31-KE06-Slot4	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-Slot4	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC31-KE06-Slot5	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-Slot5	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC31-KE06-Slot6	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-Slot6	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC31-KE06-Slot7	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-Slot7	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC31-KE06-WG01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE06-WG01	LAPP.2170931	Profinet 4pair cabling Cat.6A FRNC flexible	Profinet 4pair cabling Cat.6A FRNC flexible 4X2X23AWG;
'=LA01+UC31-KE20	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE20	SICK.1043784	FX3-CPU130002	Flexi Soft, Hauptmodul, FX3-CPU1;
'=LA01+UC31-KE21	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE21	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LA01+UC31-KE22	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KE22	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LA01+UC31-KF103	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KF103	WEI.2682150000	IE-SW-EL16-16TX	Netzwerk-Switch (unmanaged);
'=LA01+UC31-KF113	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-KF113	MOXA.MB3170-T	MGate MB3170-T	Gateway, Serial bus to Modbus TCP, RS 232/422/485 to TCP;
'=LA01+UC31-MA02	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-MA02	CUB.GP3x4	GP3x4	Mounting Plate, Cubic Modular System, 3x4 Units;
'=LA01+UC31-QA01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-QA01	ABB.1SBE111111R0120	ESB16-20N-01	ESB16-20N-01 Installation Contactor 2NO/0NC, 24V AC/DC;
'=LA01+UC31-QA03	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-QA03	ABB.1SBL136001R2110	AF09Z-30-10-21	Power contactor, AC switching;
'=LA01+UC31-QA03	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-QA03	SE.SSM3A325BD	SSM3A325BD	Solid state relay - DIN rail mount - input 4-32Vdc, output 48-600Vac, 25A;
'=LA01+UC31-QA40	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-QA40	ABB.1SBL297001R1100	AF38-30-00-11	AF38-30-00-11 24-60V50/60HZ 20-60VDC Contactor;
'=LA01+UC31-RB01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-RB01	WEI.1370050010	CP DC UPS 24V 20A/10A	USV Steuereinheit, 24 V DC ± 1 %, 20 A 40 °C;
'=LA01+UC31-RB02	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-RB02	WEI.1370040010	CP DC UPS 24V 40A	USV Steuereinheit;
'=LA01+UC31-TB01	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-TB01	WEI.1469540000	PRO ECO3 240W 24V 10A	Gleichstromversorgung;
'=LA01+UC31-TB02	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-TB02	WEI.1469560000	PRO ECO3 960W 24V 40A	Gleichstromversorgung;
'=LA01+UC31-TB33	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-TB33	MURR.85691	85691	Emparro Schaltnetzteil 3-phasig;
'=LA01+UC31-TB33	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-TB33	MURR.85414	85414	Emparro ACCUcontrol USV-Modul;
'=LA01+UC31-TB33	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-TB33	MURR.9000-41190-0000000	9000-41190-0000000	Stromüberwachungsgerät;
'=LA01+UC31-TB33	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-TB33	MURR.9000-41091-0101000	9000-41091-0101000	Stromüberwachungsgerät;
'=LA01+UC31-XD01:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:2	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:7	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:7	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:4	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:4	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:8	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:8	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:9	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:9	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XD01:5	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:5	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD01:6	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD01:6	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD02:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD02:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD02:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD02:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD02:5	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD02:5	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD02:5	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD02:5	WEI.2532690000	AEP 2T 2.5 3C	Uzavírací deska a mezideska pro řadovou svorku;
'=LA01+UC31-XD02:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD02:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XD03:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD03:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD03:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD03:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD03:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD03:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XD04:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD04:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD04:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD04:1	WEI.1985650000	ZQV 1.5N/2 RD	Příčná spojka/přemostění pro řadovou svorku;
'=LA01+UC31-XD04:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD04:1	WEI.1527740000	ZQV 2.5N/2 BL	Příčná spojka/přemostění pro řadovou svorku;
'=LA01+UC31-XD04:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD04:2	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD04:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD04:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD04:7	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD04:7	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD09:9	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD09:9	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD09:11	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD09:11	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD09:13	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD09:13	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:1	WEI.1985670000	ZQV 1.5N/3 RD	Příčná spojka/přemostění pro řadovou svorku;
'=LA01+UC31-XD10:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:1	WEI.1527770000	ZQV 2.5N/3 BL	Příčná spojka/přemostění pro řadovou svorku;
'=LA01+UC31-XD10:10	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:10	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:5	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:5	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:7	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:7	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XD10:12	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:12	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;

'=LA01+UC31-XD10:14	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:14	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:16	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:16	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD10:18	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD10:18	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD11:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:1	WEI.2428510000	A3T 2.5	Průchozí svorka řadová;
'=LA01+UC31-XD11:10	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:10	WEI.2428510000	A3T 2.5	Průchozí svorka řadová;
'=LA01+UC31-XD11:4	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:4	WEI.2428510000	A3T 2.5	Průchozí svorka řadová;
'=LA01+UC31-XD11:7	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:7	WEI.2428510000	A3T 2.5	Průchozí svorka řadová;
'=LA01+UC31-XD11:13	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:13	WEI.2428510000	A3T 2.5	Průchozí svorka řadová;
'=LA01+UC31-XD11:16	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:16	WEI.2428510000	A3T 2.5	Průchozí svorka řadová;
'=LA01+UC31-XD11:19	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:19	WEI.2428510000	A3T 2.5	Průchozí svorka řadová;
'=LA01+UC31-XD11:19	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD11:19	WEI.2428560000	AEP 3T 2.5	Uzavírací deska a mezideska pro řadovou svorku;
'=LA01+UC31-XD20:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:5	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:5	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:7	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:7	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:9	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:9	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:11	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:11	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:13	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:13	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:15	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:15	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:17	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:17	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:19	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:19	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:21	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:21	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:23	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:23	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:25	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:25	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:27	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:27	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:27	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:27	WEI.1985670000	ZQV 1.5N/3 RD	Příčná spojka/přemostění pro řadovou svorku;
'=LA01+UC31-XD20:27	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:27	WEI.1527770000	ZQV 2.5N/3 BL	Příčná spojka/přemostění pro řadovou svorku;
'=LA01+UC31-XD20:29	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:29	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:32	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:32	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:34	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:34	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:35	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:35	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD20:37	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD20:37	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD21:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD21:1	PXC.3062744	PTTB 4-L 1000V	Doppelstockklemme;
'=LA01+UC31-XD21:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD21:2	PXC.3062744	PTTB 4-L 1000V	Doppelstockklemme;
'=LA01+UC31-XD21:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD21:2	PXC.3030747	ATP-STTB 4	Abschluss- und Zwischenplatte für Reihenklemme;
'=LA01+UC31-XD22:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD22:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD22:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD22:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD22:5	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD22:5	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD22:7	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD22:7	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD22:9	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD22:9	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD22:11	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD22:11	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD22:13	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD22:13	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD40:1	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD40:1	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD40:2	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD40:2	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD40:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD40:3	WEI.2531290000	A2T 2.5 3C	Feed-through terminal block, 2 tier, Beige;
'=LA01+UC31-XD40:3	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD40:3	WEI.2532690000	AEP 2T 2.5 3C	Uzavírací deska a mezideska pro řadovou svorku;
'=LA01+UC31-XD40:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XD40:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XE00:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XE00:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XE00:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XE00:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XE00:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XE00:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC31-XE00:PE	'=LA01	Container Control System;	'+UC31	Control Cabinet (10ft);	'-XE00:PE	WEI.2531320000	A2T 2.5 3C PE	Mehrstock-Reihenklemme, PUSH IN, 2.5 mm², 800 V, Anzahl der Etagen: 2, grün / gelb;
'=LA01+UC41-KF41-WG16	'=LA01	Container Control System;	'+UC41	HT+LT VFD Cabinet;	'-KF41-WG16	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=LA01+UC42-TF01	'=LA01	Container Control System;	'+UC42	EX Barrier Box;	'-TF01	PR.9113B-U9	9113B-U9	Temperature/mA converter - UL913;
'=LA01+UC42-TF02	'=LA01	Container Control System;	'+UC42	EX Barrier Box;	'-TF02	PR.9113B-U9	9113B-U9	Temperature/mA converter - UL913;
'=LA01+UC50-KE07-Slot2	'=LA01	Container Control System;	'+UC50	AC Power Distribution;	'-KE07-Slot2	DEIF.ACM31	ACM3.1	Alternating Current Module for the ML300 Contorller;
'=LA01+UC50-KE07-Slot3	'=LA01	Container Control System;	'+UC50	AC Power Distribution;	'-KE07-Slot3	DEIF.IOM32	IOM3.2	Input Output Module 3.2 for the ML300 Controller Series;
'=LA01+UC50-KE07-Slot4	'=LA01	Container Control System;	'+UC50	AC Power Distribution;	'-KE07-Slot4	DEIF.IOM34	IOM3.4	Input Output Module 3.4 for the ML300 Controller Series;
'=LA01+UC50-KE07-Slot5	'=LA01	Container Control System;	'+UC50	AC Power Distribution;	'-KE07-Slot5	DEIF.IOM33	IOM3.3	Input Output Module 3.3 for the ML300 Controller Series;
'=LA01+UC50-KE07-WG01	'=LA01	Container Control System;	'+UC50	AC Power Distribution;	'-KE07-WG01	LAPP.2170931	Profinet 4pair cabling Cat.6A FRNC flexible	Profinet 4pair cabling Cat.6A FRNC flexible 4X2X23AWG;
'=LB02+DA01-SG23	'=LB02	Container Safety System;	'+DA01	Container #1 Inside;	'-SG23	SE.XALK178F	XALK178F	Yellow station - 1 red mushroom head pushbutton Ø40 turn to release 2NC;
'=LB02+DA01-SG23-WG01	'=LB02	Container Safety System;	'+DA01	Container #1 Inside;	'-SG23-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LB02+DA03-BQ07-WG01	'=LB02	Container Safety System;	'+DA03	Container #2 Inside;	'-BQ07-WG01	LAPP.10035059	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=LB02+DA03-SG03	'=LB02	Container Safety System;	'+DA03	Container #2 Inside;	'-SG03	SE.XB4BS8444	XB4BS8444	Red Ø40 Emergency stop, switching off Ø22 latching turn release 2NC;
'=LB02+DA04-S1	'=LB02	Container Safety System;	'+DA04	Container #2 Outside;	'-S1	SE.XB4BS8444	XB4BS8444	Red Ø40 Emergency stop, switching off Ø22 latching turn release 2NC;
'=LB02+UC31-KE20	'=LB02	Container Safety System;	'+UC31	Control Cabinet (10ft);	'-KE20	SICK.1043784	FX3-CPU130002	Flexi Soft, Hauptmodul, FX3-CPU1;
'=LB02+UC31-KE21	'=LB02	Container Safety System;	'+UC31	Control Cabinet (10ft);	'-KE21	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LB02+UC31-KE22	'=LB02	Container Safety System;	'+UC31	Control Cabinet (10ft);	'-KE22	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LB02+UC31-KE23	'=LB02	Container Safety System;	'+UC31	Control Cabinet (10ft);	'-KE23	SICK.1044125	FX3-XTIO84002	Flexi Soft, Erweiterungsmodul, I/O-Modul, FX3-XTIO;
'=LB02+UC31-KF30	'=LB02	Container Safety System;	'+UC31	Control Cabinet (10ft);	'-KF30	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=LB02+UC31-KF31	'=LB02	Container Safety System;	'+UC31	Control Cabinet (10ft);	'-KF31	PXC.2702382	PSR-MC82-5NO-1NC-1DO-24DC-SC	Safety Relay module, 5 NO, 1 NC, 24VDC coil;
'=RE01+GB01-GB01-WD05	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-GB01-WD05	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=RE01+GB01-GB01-WG01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-GB01-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=RE01+GB01-GB01-WG02	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-GB01-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE01+GB01-GB01-WG02	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-GB01-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE01+GB01-GB01-XG01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-GB01-XG01	LAPP.21700653	ED-IE-AXS-6A-B-20-FC	RJ45 Connector, Field-mountable, Cat 6A;
'=RE01+GB01-GB01-XG01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-GB01-XG01	LAPP.21700653	ED-IE-AXS-6A-B-20-FC	RJ45 Connector, Field-mountable, Cat 6A;
'=RE01+GB01-QM01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-QM01	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE01+GB01-QM02	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-QM02	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE01+GB01-WD01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB01-WD02	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB01-WD03	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-WD03	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB01-WD04	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-WD04	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB01-XB01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XB01	AMP.APSLD-1-R-S120-M50	APSLD-1-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 1;

'=RE01+GB01-XB02	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XB02	AMP.APSLD-1-BK-S120-M50	APSLD-1-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 1;
'=RE01+GB01-XB03	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XB03	AMP.APSLD-2-R-S120-M50	APSLD-2-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 2;
'=RE01+GB01-XB04	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XB04	AMP.APSLD-2-BK-S120-M50	APSLD-2-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 2;
'=RE01+GB01-XM01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XM01	HYLOK.CUR-25M-20M-S316	CUR-25M-20M-S316	Tube to Tube Reducing Union, Two-ferrule fitting;
'=RE01+GB01-XZ01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01	HAR.19400240514	19 40 024 0514	Gehäuse für Industriesteckverbinder;
'=RE01+GB01-XZ01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01	HAR.09140240361	Han Gelenkrahmen plus, für 6 Module A-F	Zubehör;
'=RE01+GB01-XZ01	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01	HAR.19000005086	19 00 000 5086	Kabelverschraubung (Elektroinstallation);
'=RE01+GB01-XZ01-SlotA	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01-SlotA	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE01+GB01-XZ01-SlotB	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01-SlotB	HAR.09140122632	09140122632	Modules;
'=RE01+GB01-XZ01-SlotC	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01-SlotC	HAR.09140083011	09140083011	Inserts;
'=RE01+GB01-XZ01-SlotC	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01-SlotC	HAR.09670007576	09670007576	Kontakt für Industriesteckverbinder;
'=RE01+GB01-XZ01-SlotD	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01-SlotD	HAR.09140009950	09140009950	Modules;
'=RE01+GB01-XZ01-SlotE	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01-SlotE	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE01+GB01-XZ01-SlotF	'=RE01	Fuel Cell System 1;	'+GB01	FCwave Module #1;	'-XZ01-SlotF	HAR.09140122632	09140122632	Modules;
'=RE01+GB02-GB02-WD05	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-GB02-WD05	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=RE01+GB02-GB02-WG01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-GB02-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=RE01+GB02-GB02-WG02	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-GB02-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE01+GB02-GB02-WG02	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-GB02-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE01+GB02-GB02-XG01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-GB02-XG01	LAPP.21700653	ED-IE-AXS-6A-B-20-FC	RJ45 Connector, Field-mountable, Cat 6A;
'=RE01+GB02-QM01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-QM01	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE01+GB02-QM02	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-QM02	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE01+GB02-WD01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB02-WD02	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB02-WD03	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-WD03	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB02-WD04	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-WD04	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB02-XB01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XB01	AMP.APSLD-1-R-S120-M50	APSLD-1-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 1;
'=RE01+GB02-XB02	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XB02	AMP.APSLD-1-BK-S120-M50	APSLD-1-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 1;
'=RE01+GB02-XB03	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XB03	AMP.APSLD-2-R-S120-M50	APSLD-2-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 2;
'=RE01+GB02-XB04	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XB04	AMP.APSLD-2-BK-S120-M50	APSLD-2-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 2;
'=RE01+GB02-XM01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XM01	HYLOK.CUR-25M-20M-S316	CUR-25M-20M-S316	Tube to Tube Reducing Union, Two-ferrule fitting;
'=RE01+GB02-XZ01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01	HAR.19400240514	19 40 024 0514	Gehäuse für Industriesteckverbinder;
'=RE01+GB02-XZ01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01	HAR.09140240361	Han Gelenkrahmen plus, für 6 Module A-F	Zubehör;
'=RE01+GB02-XZ01	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01	HAR.19000005086	19 00 000 5086	Kabelverschraubung (Elektroinstallation);
'=RE01+GB02-XZ01-SlotA	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01-SlotA	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE01+GB02-XZ01-SlotB	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01-SlotB	HAR.09140122632	09140122632	Modules;
'=RE01+GB02-XZ01-SlotC	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01-SlotC	HAR.09140083011	09140083011	Inserts;
'=RE01+GB02-XZ01-SlotC	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01-SlotC	HAR.09670007576	09670007576	Kontakt für Industriesteckverbinder;
'=RE01+GB02-XZ01-SlotD	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01-SlotD	HAR.09140009950	09140009950	Modules;
'=RE01+GB02-XZ01-SlotE	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01-SlotE	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE01+GB02-XZ01-SlotF	'=RE01	Fuel Cell System 1;	'+GB02	FCwave Module #2;	'-XZ01-SlotF	HAR.09140122632	09140122632	Modules;
'=RE01+GB03-GB03-WD05	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-GB03-WD05	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=RE01+GB03-GB03-WG01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-GB03-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=RE01+GB03-GB03-WG02	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-GB03-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE01+GB03-GB03-WG02	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-GB03-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE01+GB03-GB03-XG01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-GB03-XG01	LAPP.21700653	ED-IE-AXS-6A-B-20-FC	RJ45 Connector, Field-mountable, Cat 6A;
'=RE01+GB03-QM01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-QM01	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE01+GB03-QM02	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-QM02	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE01+GB03-WD01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB03-WD02	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB03-WD03	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-WD03	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB03-WD04	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-WD04	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE01+GB03-XB01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XB01	AMP.APSLD-1-R-S120-M50	APSLD-1-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 1;
'=RE01+GB03-XB02	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XB02	AMP.APSLD-1-BK-S120-M50	APSLD-1-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 1;
'=RE01+GB03-XB03	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XB03	AMP.APSLD-2-R-S120-M50	APSLD-2-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 2;
'=RE01+GB03-XB04	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XB04	AMP.APSLD-2-BK-S120-M50	APSLD-2-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 2;
'=RE01+GB03-XM01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XM01	HYLOK.CUR-25M-20M-S316	CUR-25M-20M-S316	Tube to Tube Reducing Union, Two-ferrule fitting;
'=RE01+GB03-XZ01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01	HAR.19400240514	19 40 024 0514	Gehäuse für Industriesteckverbinder;
'=RE01+GB03-XZ01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01	HAR.09140240361	Han Gelenkrahmen plus, für 6 Module A-F	Zubehör;
'=RE01+GB03-XZ01	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01	HAR.19000005086	19 00 000 5086	Kabelverschraubung (Elektroinstallation);
'=RE01+GB03-XZ01-SlotA	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01-SlotA	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE01+GB03-XZ01-SlotB	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01-SlotB	HAR.09140122632	09140122632	Modules;
'=RE01+GB03-XZ01-SlotC	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01-SlotC	HAR.09140083011	09140083011	Inserts;
'=RE01+GB03-XZ01-SlotC	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01-SlotC	HAR.09670007576	09670007576	Kontakt für Industriesteckverbinder;
'=RE01+GB03-XZ01-SlotD	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01-SlotD	HAR.09140009950	09140009950	Modules;
'=RE01+GB03-XZ01-SlotE	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01-SlotE	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE01+GB03-XZ01-SlotF	'=RE01	Fuel Cell System 1;	'+GB03	FCwave Module #3;	'-XZ01-SlotF	HAR.09140122632	09140122632	Modules;
'=RE01+GB04-GB04-XG01	'=RE01	Fuel Cell System 1;	'+GB04	FCwave Module #4;	'-GB04-XG01	LAPP.21700653	ED-IE-AXS-6A-B-20-FC	RJ45 Connector, Field-mountable, Cat 6A;
'=RE01+GB05-GB05-XG01	'=RE01	Fuel Cell System 1;	'+GB05	FCwave Module #5;	'-GB05-XG01	LAPP.21700653	ED-IE-AXS-6A-B-20-FC	RJ45 Connector, Field-mountable, Cat 6A;
'=RE02+GB04-GB04-WD05	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-GB04-WD05	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=RE02+GB04-GB04-WG01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-GB04-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=RE02+GB04-GB04-WG02	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-GB04-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE02+GB04-GB04-WG02	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-GB04-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE02+GB04-QM01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-QM01	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE02+GB04-QM02	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-QM02	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE02+GB04-WD01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB04-WD02	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB04-WD03	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-WD03	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB04-WD04	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-WD04	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB04-XB01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XB01	AMP.APSLD-1-R-S120-M50	APSLD-1-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 1;
'=RE02+GB04-XB02	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XB02	AMP.APSLD-1-BK-S120-M50	APSLD-1-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 1;
'=RE02+GB04-XB03	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XB03	AMP.APSLD-2-R-S120-M50	APSLD-2-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 2;
'=RE02+GB04-XB04	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XB04	AMP.APSLD-2-BK-S120-M50	APSLD-2-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 2;
'=RE02+GB04-XM01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XM01	HYLOK.CUR-25M-20M-S316	CUR-25M-20M-S316	Tube to Tube Reducing Union, Two-ferrule fitting;

'=RE02+GB04-XZ01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01	HAR.19400240514	19 40 024 0514	Gehäuse für Industriesteckverbinder;
'=RE02+GB04-XZ01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01	HAR.09140240361	Han Gelenkrahmen plus, für 6 Module A-F	Zubehör;
'=RE02+GB04-XZ01	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01	HAR.19000005086	19 00 000 5086	Kabelverschraubung (Elektroinstallation);
'=RE02+GB04-XZ01-SlotA	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01-SlotA	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE02+GB04-XZ01-SlotB	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01-SlotB	HAR.09140122632	09140122632	Modules;
'=RE02+GB04-XZ01-SlotC	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01-SlotC	HAR.09140083011	09140083011	Inserts;
'=RE02+GB04-XZ01-SlotC	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01-SlotC	HAR.09670007576	09670007576	Kontakt für Industriesteckverbinder;
'=RE02+GB04-XZ01-SlotD	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01-SlotD	HAR.09140009950	09140009950	Modules;
'=RE02+GB04-XZ01-SlotE	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01-SlotE	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE02+GB04-XZ01-SlotF	'=RE02	Fuel Cell System 2;	'+GB04	FCwave Module #4;	'-XZ01-SlotF	HAR.09140122632	09140122632	Modules;
'=RE02+GB05-GB05-WD05	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-GB05-WD05	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=RE02+GB05-GB05-WG01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-GB05-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=RE02+GB05-GB05-WG02	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-GB05-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE02+GB05-GB05-WG02	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-GB05-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE02+GB05-QM01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-QM01	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE02+GB05-QM02	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-QM02	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE02+GB05-WD01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB05-WD02	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB05-WD03	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-WD03	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB05-WD04	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-WD04	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB05-XB01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XB01	AMP.APSLD-1-R-S120-M50	APSLD-1-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 1;
'=RE02+GB05-XB02	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XB02	AMP.APSLD-1-BK-S120-M50	APSLD-1-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 1;
'=RE02+GB05-XB03	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XB03	AMP.APSLD-2-R-S120-M50	APSLD-2-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 2;
'=RE02+GB05-XB04	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XB04	AMP.APSLD-2-BK-S120-M50	APSLD-2-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 2;
'=RE02+GB05-XM01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XM01	HYLOK.CUR-25M-20M-S316	CUR-25M-20M-S316	Tube to Tube Reducing Union, Two-ferrule fitting;
'=RE02+GB05-XZ01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01	HAR.19400240514	19 40 024 0514	Gehäuse für Industriesteckverbinder;
'=RE02+GB05-XZ01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01	HAR.09140240361	Han Gelenkrahmen plus, für 6 Module A-F	Zubehör;
'=RE02+GB05-XZ01	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01	HAR.19000005086	19 00 000 5086	Kabelverschraubung (Elektroinstallation);
'=RE02+GB05-XZ01-SlotA	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01-SlotA	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE02+GB05-XZ01-SlotB	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01-SlotB	HAR.09140122632	09140122632	Modules;
'=RE02+GB05-XZ01-SlotC	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01-SlotC	HAR.09140083011	09140083011	Inserts;
'=RE02+GB05-XZ01-SlotC	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01-SlotC	HAR.09670007576	09670007576	Kontakt für Industriesteckverbinder;
'=RE02+GB05-XZ01-SlotD	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01-SlotD	HAR.09140009950	09140009950	Modules;
'=RE02+GB05-XZ01-SlotE	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01-SlotE	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE02+GB05-XZ01-SlotF	'=RE02	Fuel Cell System 2;	'+GB05	FCwave Module #5;	'-XZ01-SlotF	HAR.09140122632	09140122632	Modules;
'=RE02+GB06-GB06-WD05	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-GB06-WD05	LAPP.10035098	ÖLFLEX® CLASSIC 110 CH	Power and control cables;
'=RE02+GB06-GB06-WG01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-GB06-WG01	LAPP.2170483	Ethernet Cat.6A PUR	Profinet 4pair cabling Cat.6A PUR special 4X2X24AWG;
'=RE02+GB06-GB06-WG02	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-GB06-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE02+GB06-GB06-WG02	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-GB06-WG02	LAPP.10035051	ÖLFLEX® CLASSIC 110 CH	Připojovací a ovládací kabely;
'=RE02+GB06-QM01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-QM01	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE02+GB06-QM02	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-QM02	ARMA.1311-DN50	DVC Type 1311	Ball Valve, Stainless Steel, DN50, Weld Flange;
'=RE02+GB06-WD01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-WD01	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB06-WD02	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-WD02	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB06-WD03	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-WD03	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB06-WD04	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-WD04	LAPP.1026565	ÖLFLEX® FD CHAIN 90 CP	ÖLFLEX FD CHAIN 90 CP 1X120;
'=RE02+GB06-XB01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XB01	AMP.APSLD-1-R-S120-M50	APSLD-1-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 1;
'=RE02+GB06-XB02	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XB02	AMP.APSLD-1-BK-S120-M50	APSLD-1-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 1;
'=RE02+GB06-XB03	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XB03	AMP.APSLD-2-R-S120-M50	APSLD-2-R-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Red, Keying 2;
'=RE02+GB06-XB04	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XB04	AMP.APSLD-2-BK-S120-M50	APSLD-2-BK-S120-M50	Line Mount Single Pole Drain, 800A, 1kV, Black, Keying 2;
'=RE02+GB06-XM01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XM01	HYLOK.CUR-25M-20M-S316	CUR-25M-20M-S316	Tube to Tube Reducing Union, Two-ferrule fitting;
'=RE02+GB06-XZ01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01	HAR.19400240514	19 40 024 0514	Gehäuse für Industriesteckverbinder;
'=RE02+GB06-XZ01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01	HAR.09140240361	Han Gelenkrahmen plus, für 6 Module A-F	Zubehör;
'=RE02+GB06-XZ01	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01	HAR.19000005086	19 00 000 5086	Kabelverschraubung (Elektroinstallation);
'=RE02+GB06-XZ01-SlotA	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01-SlotA	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE02+GB06-XZ01-SlotB	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01-SlotB	HAR.09140122632	09140122632	Modules;
'=RE02+GB06-XZ01-SlotC	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01-SlotC	HAR.09140083011	09140083011	Inserts;
'=RE02+GB06-XZ01-SlotC	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01-SlotC	HAR.09670007576	09670007576	Kontakt für Industriesteckverbinder;
'=RE02+GB06-XZ01-SlotD	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01-SlotD	HAR.09140009950	09140009950	Modules;
'=RE02+GB06-XZ01-SlotE	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01-SlotE	HAR.09140022601	Han 40A axial module, male 2,5-8mm²	Module;
'=RE02+GB06-XZ01-SlotF	'=RE02	Fuel Cell System 2;	'+GB06	FCwave Module #6;	'-XZ01-SlotF	HAR.09140122632	09140122632	Modules;
'=HKN70+-82003-CEM-1-L1	'=HKN70	Baseload Power Hub;			'-82003-CEM-1-L1	BATT.14167	Marineflex-B	Cable, 1x70mm2, 7.2kV, Shielded, Offshore;
'=HKN70+-82003-CEM-1-L2	'=HKN70	Baseload Power Hub;			'-82003-CEM-1-L2	BATT.14167	Marineflex-B	Cable, 1x70mm2, 7.2kV, Shielded, Offshore;
'=HKN70+-82003-CEM-1-L3	'=HKN70	Baseload Power Hub;			'-82003-CEM-1-L3	BATT.14167	Marineflex-B	Cable, 1x70mm2, 7.2kV, Shielded, Offshore;

Sub Subsection of C04

Bill of Materials

Mechanical BOM extracted from

“SOLIDWORKS®”

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	DOOR-LOCKING- STANG_20FT HC^DOOR - LOCKING-BAR_HC RIGHT 2 LOCKING BARS_DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
2	BEARING BRACKET_LONG^D OOR-LOCKING - BAR_HC RIGHT 2 LOCKING BARS_DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		4
3	HANDLE_LEFT^DOOR -LOCKING-BAR_HC RIGHT 2 LOCKING BARS_DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
4	BEARING BRACKET_SHORT^D OOR-LOCKING - BAR_HC RIGHT 2 LOCKING BARS_DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
5	LOCKING- HANDEL^DOOR - LOCKING-BAR_HC RIGHT 2 LOCKING BARS_DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
6	DOOR_20FT HC^DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
7	RUBBER GASKET_20FT HC^DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
8	DOORSTOP^DOORS_ HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
9	HINGE_20FT^DOORS _HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		4
10	LOCKING- LATCH^DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
11	LOCKING- PLATE^DOORS_HC RIGHT 2 LOCKINGBARS_DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
12	DOOR-LOCKING- STANG_20FT HC^DOOR - LOCKING-BAR_HC LEFT_DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
13	BEARING BRACKET_LONG^D OOR-LOCKING - BAR_HC LEFT_DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		4
14	HANDLE_LEFT^DOOR -LOCKING-BAR_HC LEFT_DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
15	BEARING BRACKET_SHORT^D OOR-LOCKING - BAR_HC LEFT_DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
16	LOCKING- HANDEL^DOOR - LOCKING-BAR_HC LEFT_DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
17	DOOR_20FT HC- 0^DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
18	RUBBER GASKET_20FT HC-1^DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
19	HINGE_20FT^DOORS _HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		4
20	LOCKING- LATCH^DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
21	LOCKING- PLATE^DOORS_HC LEFT_DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
22	CORNERPOST- DOOR_HC^DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
23	DOORHEADER_20FT_ AS MACHINED_^DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
24	DOORSILL_STANDAR D_AS MACHINED_^DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		1
25	DOOR- KEEPER_LEFT^DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
26	DOOR- KEEPER_RIGHT^DO OR-ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
27	DOOR-KEEPER- LOCK_RIGHT^DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
28	DOOR-KEEPER- LOCK_LEFT^DOOR - ASSEM_HC CLOSED_103640_LU KKET_22-1337-100_22 - 1337-200_700236		2
29	CORNERPOST- FRONT_GOOSENECK HC^END - CLOSED_GOOSENE CK HC_103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1
30	FRONTPANEL_GOOS ENECK HC^END - CLOSED_GOOSENE CK HC_103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1
31	FRONTPANEL_GOOS ENECK HC-2^END - CLOSED_GOOSENE CK HC_103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1
32	TOP- FRONTRAIL_20FT^E ND - CLOSED_GOOSENE CK HC_103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1
33	FRONTHEADER TOP_STANDARD^E ND - CLOSED_GOOSENE CK HC_103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1
34	GOOSENECK- BOTTOM-END - RAIL_DEFAULT_AS MACHINED_^END - CLOSED_GOOSENE CK HC_103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1
35	SIDE BOTTOMRAIL_40FT^ BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		2
36	GOOSENECK- PLATE^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		1
37	GOOSENECK- BOTTOMRAIL^BOTT OM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		13
38	CROSSMEMBER_GO OSENECK LEFT^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		9
39	CROSSMEMBER_GO OSENECK RIGHT^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		9
40	GOOSENECK- BOTTOMRAIL - FLOOR^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		1
41	CROSSMEMBER_20FT ^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		21
42	FLOORPLATE_STAND ARD 2400mm^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		6
43	FLOORPLATE_40FT KORT^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		2
44	FLOORPLATE_GOOSE NECK^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		4
45	50X30-L- PROFIL_GOOSENECK RAIL_AS MACHINED_^BOTT OM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		1
46	CROSSMEMBER_BRE D TOP^BOTTOM - FRAME_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		3
47	TOP- SIDERAIL_40FT^ROO F-ASSEM_40FT_10364 0_LUKKET_22-1337 - 100_22-1337 - 200_700236		2
48	ROOFPANEL 2 mm_20FT^ROOF - ASSEM_40FT_103640 _LUKKET_22-1337 - 100_22-1337 - 200_700236		11
49	BOTTOM_CORNER_C ASTINGS_CORNER CASTINGS 40FT^103640_LUKKE T_22-1337-100_22 - 1337-200_700236		1
50	TOP CORNER CASTINGS_40FT^103 6 40_LUKKET_22-1337 - 100_22-1337 - 200_700236		1
51	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL^103640_ L UKKET_22-1337 - 100_22-1337 - 200_700236		1
52	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 3^103640_LUKKET_2 2-1337-100_22-1337 - 200_700236		7
53	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 4^103640_LUKKET_2 2-1337-100_22-1337 - 200_700236		1
54	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 5^103640_LUKKET_2 2-1337-100_22-1337 - 200_700236		1
55	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 6^103640_LUKKET_2 2-1337-100_22-1337 - 200_700236		1
56	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 7^103640_LUKKET_2 2-1337-100_22-1337 - 200_700236		1
57	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 8^103640_LUKKET_2 2-1337-100_22-1337 - 200_700236		1
58	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 9^103640_LUKKET_2 2-1337-100_22-1337 - 200_700236		1
59	SIDEPANEL 2 mm_SHORT PIECE 40FT HC^103640_LUKKET _22-1337-100_22-1337 - 200_700236		1
60	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 10^103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1
61	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 11^103640_LUKKET_ 22-1337-100_22-1337 - 200_700236		1

62	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 12^103640_LUKKET_ 2 2-1337-100_22-1337 - 200_700236		1
63	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 13^103640_LUKKET_ 2 2-1337-100_22-1337 - 200_700236		1
64	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 14^103640_LUKKET_ 2 2-1337-100_22-1337 - 200_700236		1
65	SIDEPANEL 2 mm_STANDARD HC SIDEPANEL - 15^103640_LUKKET_ 2 2-1337-100_22-1337 - 200_700236		1
66	SIDEPANEL 2 mm_SHORT PIECE 40FT HC - 16^103640_LUKKET_ 2 2-1337-100_22-1337 - 200_700236		1
67	22-1337 DØRRAMME_1_DEF AULT_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		1
68	22-1337 VENTILATIONSRAM ME_2_FORSTÆRKNIN G_DEFAULT_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		1
69	22-1337 GENNEMFØRING_1 ^ 22-1337-100_22-1337 - 200_700236		6
70	22-1337 GENNEMFØRING_6 ^ 22-1337-100_22-1337 - 200_700236		1
71	22-1337 FORSTÆRKNING SIDEVANGE^22 - 1337-100_22-1337 - 200_700236		4
72	22-1337 UNDERSTØTNING^22 - 1337-100_22-1337 - 200_700236		4
73	22-1337 DØRRAMME_2_DEF AULT_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		1
74	22-1337 GENNEMFØRING_4 ^ 22-1337-100_22-1337 - 200_700236		1
75	22-1337 GENNEMFØRING_3 ^ 22-1337-100_22-1337 - 200_700236		2
76	22-1337 114673_ JORDING_336020^2 2 -1337-100_22-1337 - 200_700236		10
77	22-1337 FORSTÆRKNING TIL SIDE 120X60 PROFIL_DEFAULT_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		1
78	22-1337 GENNEMFØRING_7 ^ 22-1337-100_22-1337 - 200_700236		1
79	22-1325 1200X600 RAMME_LODRET_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		2
80	22-1337 STÅLPROFIL_KRAN_T AG_DEFAULT_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		8
81	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		17
82	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-17^22 - 1337-100_22-1337 - 200_700236		1
83	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-18^22 - 1337-100_22-1337 - 200_700236		1
84	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-19^22 - 1337-100_22-1337 - 200_700236		1
85	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-20^22 - 1337-100_22-1337 - 200_700236		1
86	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-21^22 - 1337-100_22-1337 - 200_700236		1
87	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-22^22 - 1337-100_22-1337 - 200_700236		1
88	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-23^22 - 1337-100_22-1337 - 200_700236		1
89	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-24^22 - 1337-100_22-1337 - 200_700236		1
90	22-1337 PROFIL 50X30 TIL SIDER_DEFAULT_AS MACHINED_-25^22 - 1337-100_22-1337 - 200_700236		1
91	22-1337 VANDRET PROFIL INKL. FLADJERN_DEFAULT _AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		1
92	22-1337 VANDRET PROFIL INKL. FLADJERN_DEFAULT _AS MACHINED_ - 26^22-1337-100_22 - 1337-200_700236		1
93	22-1337 VANDRET PROFIL INKL. FLADJERN_DEFAULT _AS MACHINED_ - 27^22-1337-100_22 - 1337-200_700236		1
94	22-1337 VANDRET PROFIL INKL. FLADJERN_DEFAULT _AS MACHINED_ - 28^22-1337-100_22 - 1337-200_700236		1
95	UNISTRUT P10000 41X41_500^22-1337 - 100_22-1337 - 200_700236		9
96	UNISTRUT P10000 41X41_500-29^22 - 1337-100_22-1337 - 200_700236		1
97	UNISTRUT P10000 41X41_2434^22-1337 - 100_22-1337 - 200_700236		1
98	UNISTRUT P10000 41X41_2434-30^22 - 1337-100_22-1337 - 200_700236		1
99	UNISTRUT P10000 41X41_1235^22-1337 - 100_22-1337 - 200_700236		1
100	UNISTRUT P10000 41X41_1235-31^22 - 1337-100_22-1337 - 200_700236		1
101	22-1337 VINKEL TIL TAG 60X40X5 PROFIL_DEFAULT_AS MACHINED_^22 - 1337-100_22-1337 - 200_700236		1
102	22-1337 VINKEL TIL TAG 60X40X5 PROFIL_DEFAULT_AS MACHINED_-32^22 - 1337-100_22-1337 - 200_700236		1
103	22-1337 FTV 200 ROCKWOOL ISOLERING^22-1337 FTV 200_VÆG_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
104	22-1337 FTV 200 GLAT INDV PLADE^22-1337 FTV 200_VÆG_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
105	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET^ 2 2-1337 FTV 200_VÆG_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
106	22-1337 FTV 200 ROCKWOOL ISOLERING-33^22 - 1337 FTV 200_VÆG - 1_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
107	22-1337 FTV 200 GLAT INDV PLADE - 34^22-1337 FTV 200_VÆG-1_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
108	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 35^22-1337 FTV 200_VÆG-1_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
109	22-1337 FTV 200 ROCKWOOL ISOLERING-36^22 - 1337 FTV 200_LOFT_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
110	22-1337 FTV 200 GLAT INDV PLADE - 37^22-1337 FTV 200_LOFT_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
111	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
112	22-1337 FTV 200 ROCKWOOL ISOLERING-39^22 - 1337 FTV 200_LOFT - 1_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
113	22-1337 FTV 200 GLAT INDV PLADE - 40^22-1337 FTV 200_LOFT-1_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
114	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-1_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
115	22-1337 FTV 200 ROCKWOOL ISOLERING-41^22 - 1337 FTV 200_LOFT - 2_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
116	22-1337 FTV 200 GLAT INDV PLADE - 42^22-1337 FTV 200_LOFT-2_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
117	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-2_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
118	22-1337 FTV 200 ROCKWOOL ISOLERING-43^22 - 1337 FTV 200_LOFT - 3_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
119	22-1337 FTV 200 GLAT INDV PLADE - 44^22-1337 FTV 200_LOFT-3_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
120	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-3_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
121	22-1337 FTV 200 ROCKWOOL ISOLERING-45^22 - 1337 FTV 200_LOFT - 4_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
122	22-1337 FTV 200 GLAT INDV PLADE - 46^22-1337 FTV 200_LOFT-4_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
123	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-4_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
124	22-1337 FTV 200 ROCKWOOL ISOLERING-39^22 - 1337 FTV 200_LOFT - 5_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		2
125	22-1337 FTV 200 GLAT INDV PLADE - 47^22-1337 FTV 200_LOFT-5_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		2
126	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-5_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		2

127	22-1337 FTV 200	ROCKWOOL ISOLERING-48^22 - 1337 FTV 200_LOFT - 6_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
128	22-1337 FTV 200	GLAT INDV PLADE - 49^22-1337 FTV 200_LOFT-6_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
129	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-6_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
130	22-1337 FTV 200	ROCKWOOL ISOLERING-50^22 - 1337 FTV 200_LOFT - 7_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
131	22-1337 FTV 200	GLAT INDV PLADE - 51^22-1337 FTV 200_LOFT-7_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
132	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-7_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
133	22-1337 FTV 200	ROCKWOOL ISOLERING-52^22 - 1337 FTV 200_LOFT - 8_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
134	22-1337 FTV 200	GLAT INDV PLADE - 53^22-1337 FTV 200_LOFT-8_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
135	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 38^22-1337 FTV 200_LOFT-8_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
136	22-1337 FTV 200	ROCKWOOL ISOLERING-54^22 - 1337 FTV 200_VÆG - 2_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		7
137	22-1337 FTV 200	GLAT INDV PLADE - 55^22-1337 FTV 200_VÆG-2_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		7
138	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 56^22-1337 FTV 200_VÆG-2_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		7
139	22-1337 FTV 200	ROCKWOOL ISOLERING-57^22 - 1337 FTV 200_VÆG - 3_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
140	22-1337 FTV 200	GLAT INDV PLADE - 58^22-1337 FTV 200_VÆG-3_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
141	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 59^22-1337 FTV 200_VÆG-3_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
142	22-1337 FTV 200	ROCKWOOL ISOLERING-60^22 - 1337 FTV 200_VÆG - 4_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
143	22-1337 FTV 200	GLAT INDV PLADE - 61^22-1337 FTV 200_VÆG-4_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
144	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 62^22-1337 FTV 200_VÆG-4_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
145	22-1337 FTV 200	ROCKWOOL ISOLERING-63^22 - 1337 FTV 200_VÆG - 5_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
146	22-1337 FTV 200	GLAT INDV PLADE - 64^22-1337 FTV 200_VÆG-5_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
147	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 65^22-1337 FTV 200_VÆG-5_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
148	22-1337 FTV 200	ROCKWOOL ISOLERING-66^22 - 1337 FTV 200_VÆG - 6_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
149	22-1337 FTV 200	GLAT INDV PLADE - 67^22-1337 FTV 200_VÆG-6_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
150	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 68^22-1337 FTV 200_VÆG-6_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
151	22-1337 FTV 200	ROCKWOOL ISOLERING-69^22 - 1337 FTV 200_VÆG - 7_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
152	22-1337 FTV 200	GLAT INDV PLADE - 70^22-1337 FTV 200_VÆG-7_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
153	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 71^22-1337 FTV 200_VÆG-7_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
154	22-1337 FTV 200	ROCKWOOL ISOLERING-72^22 - 1337 FTV 200_VÆG - 8_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
155	22-1337 FTV 200	GLAT INDV PLADE - 73^22-1337 FTV 200_VÆG-8_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
156	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 74^22-1337 FTV 200_VÆG-8_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
157	22-1337 FTV 200	ROCKWOOL ISOLERING-75^22 - 1337 FTV 200_VÆG - 9_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
158	22-1337 FTV 200	GLAT INDV PLADE - 76^22-1337 FTV 200_VÆG-9_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
159	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 77^22-1337 FTV 200_VÆG-9_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
160	22-1337 FTV 200	ROCKWOOL ISOLERING-78^22 - 1337 FTV 200_VÆG - 10_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
161	22-1337 FTV 200	GLAT INDV PLADE - 79^22-1337 FTV 200_VÆG-10_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
162	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 80^22-1337 FTV 200_VÆG-10_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
163	22-1337 FTV 200	ROCKWOOL ISOLERING-81^22 - 1337 FTV 200_VÆG - 11_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
164	22-1337 FTV 200	GLAT INDV PLADE - 82^22-1337 FTV 200_VÆG-11_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
165	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 83^22-1337 FTV 200_VÆG-11_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
166	22-1337 FTV 200	ROCKWOOL ISOLERING-84^22 - 1337 FTV 200_VÆG - 12_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
167	22-1337 FTV 200	GLAT INDV PLADE - 85^22-1337 FTV 200_VÆG-12_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
168	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 86^22-1337 FTV 200_VÆG-12_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
169	22-1337 FTV 200	ROCKWOOL ISOLERING-87^22 - 1337 FTV 200_VÆG - 13_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
170	22-1337 FTV 200	GLAT INDV PLADE - 88^22-1337 FTV 200_VÆG-13_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
171	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 89^22-1337 FTV 200_VÆG-13_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
172	22-1337 FTV 200	ROCKWOOL ISOLERING-90^22 - 1337 FTV 200_VÆG - 14_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
173	22-1337 FTV 200	GLAT INDV PLADE - 91^22-1337 FTV 200_VÆG-14_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
174	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 92^22-1337 FTV 200_VÆG-14_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
175	22-1337 FTV 200	ROCKWOOL ISOLERING-93^22 - 1337 FTV 200_VÆG - 15_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
176	22-1337 FTV 200	GLAT INDV PLADE - 94^22-1337 FTV 200_VÆG-15_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
177	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 95^22-1337 FTV 200_VÆG-15_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
178	22-1337 FTV 200	ROCKWOOL ISOLERING-96^22 - 1337 FTV 200_LOFT - 9_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
179	22-1337 FTV 200	GLAT INDV PLADE - 97^22-1337 FTV 200_LOFT-9_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
180	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 98^22-1337 FTV 200_LOFT-9_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
181	22-1337 FTV 200	ROCKWOOL ISOLERING-99^22 - 1337 FTV 200_VÆG - 16_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
182	22-1337 FTV 200	GLAT INDV PLADE - 100^22-1337 FTV 200_VÆG-16_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
183	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 101^22-1337 FTV 200_VÆG-16_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
184	22-1337 FTV 200	ROCKWOOL ISOLERING-102^22 - 1337 FTV 200_VÆG - 17_22-1337 SAMLET INDRETNING_22 - 1337-200_700236		1
185	22-1337 FTV 200	GLAT INDV PLADE - 103^22-1337 FTV 200_VÆG-17_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
186	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 104^22-1337 FTV 200_VÆG-17_22 - 1337 SAMLET INDRETNING_22 - 1337-200_700236		1
187	22-1337 FTV 200	ROCKWOOL ISOLERING-105^22 - 1337 FTV 200_LÅGER_22-1337 - 200_700236		1
188	22-1337 FTV 200	GLAT INDV PLADE - 106^22-1337 FTV 200_LÅGER_22-1337 - 200_700236		1
189	22-1337 FTV 200	PROFILERET UDV PLADE_PROFILERET - 107^22-1337 FTV 200_LÅGER_22-1337 - 200_700236		1
190	22-1337 FTV 200	ROCKWOOL ISOLERING-108^22 - 1337 FTV 200_LÅGER - 1_22-1337 - 200_700236		1
191	22-1337 FTV 200	GLAT INDV PLADE - 109^22-1337 FTV 200_LÅGER-1_22 - 1337-200_700236		1

192	22-1337 FTV 200 PROFILERET UDV PLADE_PROFILERET - 110^22-1337 FTV 200_LÅGER-1_22 - 1337-200_700236		1
193	22-1337 BALLARD_DOORFR AME_2200X2100^22 - 1337 BALLARD_DOBBELT STÅLDØR _2200X2100_22-1337 - 200_700236		1
194	22-1337 BALLARD_HAMBORG HÆNGSEL^22-1337 BALLARD_DOBBELT STÅLDØR _2200X2100_22-1337 - 200_700236		4
195	22-1337 BALLARD_HAMBORG HÆNGSEL_HAN DEL^22-1337 BALLARD_DOBBELT STÅLDØR _2200X2100_22-1337 - 200_700236		4
196	22-1337 BALLARD_DØRBLAD _SPEC_1025^22-1337 BALLARD_DOBBELT STÅLDØR _2200X2100_22-1337 - 200_700236		1
197	22-1337 BALLARD_DØRBLAD _SPEC_1025-111^22 - 1337 BALLARD_DOBBELT STÅLDØR _2200X2100_22-1337 - 200_700236		1
198	22-1337 VENTILATIONSRIST TYPEV_OUT_500X11 0 0^22-1337 BALLARD_DOBBELT STÅLDØR _2200X2100_22-1337 - 200_700236		2
199	22-1337 PUSH PAD^22-1337 BALLARD_DOBBELT STÅLDØR _2200X2100_22-1337 - 200_700236		1
200	22-1337 DOORFRAME_10X2 1^22-1337 STÅLDØR 9X21 m. PUSHBAR_10X21M STD_22-1337 - 200_700236		1
201	22-1337 HAMBORG HÆNGSEL^22-1337 STÅLDØR 9X21 m. PUSHBAR_10X21M STD_22-1337 - 200_700236		2
202	22-1337 HAMBORG HÆNGSEL_HAN DEL^22-1337 STÅLDØR 9X21 m. PUSHBAR_10X21M STD_22-1337 - 200_700236		2
203	22-1337 DOORHANDLE^22 - 1337 STÅLDØR 9X21 m. PUSHBAR_10X21M STD_22-1337 - 200_700236		1
204	22-1337 DØRBLAD^22-1337 STÅLDØR 9X21 m. PUSHBAR_10X21M STD_22-1337 - 200_700236		1
205	22-1337 PUSHBAR^22-1337 STÅLDØR 9X21 m. PUSHBAR_10X21M STD_22-1337 - 200_700236		1
206	22-1337 VENTILATIONSRIST _600X1200 LODRET^22-1337 - 200_700236		2
207	22-1337 NIKO_26.000_SUPP ORT_BRACKET^22 - 1337-200_700236		8
208	22-1337 NIKO_26.000^22 - 1337-200_700236		1
209	22-1337 NIKO_26.000_CONN ECTOR^22-1337 - 200_700236		1
210	22-1337 SPJÆLD_900X1200 LODRET^22-1337 - 200_700236		2
211	22-1337 SPJÆLD_STOR TIL SIDE^22-1337 - 200_700236		2
212	UNISTRUT P3300 41X21_11950^22 - 1337-200_700236		2
213	22-1325 BELIMO MOTOR SM24A - SR^22-1337 - 200_700236		6
214	22-1337 VANDOPSAMLINGSR I STE TIL SIDE^22-1337 - 200_700236		2
215	22-1325 BALLARD-01 LOGO_0.5^700236		2
216	7002365-1		4
217	7001634	MCU CABINET WITH FRAME	1
218	3621	STOOL FOR CABINET	1
219	3622	FOOT	4
220	7002008	TOP BRACKET FOR MCU CABINET	1
221	7001777-01	PIPE CLAMP W. RUBBER - BSM M8/10 75-80mm	12
222	M10 NUT ISO 4032 A2	NUT HEX ISO 4032/DIN 934 M10 A2	30
223	7003643-150	THREADED ROD M10 STAINLESS (150mm)	5
224	FRS_25___30_M8_M1 0_42537_	PIPE CLAMP W. RUBBER M8/10 25-30mm BSI	1
225	7003643-50	THREADED ROD M10 STAINLESS (50mm)	9
226	7002319-01	PLATE FOR VACON	1
227	7002319-02	MOUNTING BRACKET	2
228	7002319-03	AMAZON LT PUMP	1
229	7002319-04	FOOD PLATE	4
230	7002319-05	MOUNTING PLATE FOR BELIMO BOX	1
231	7002319-06	PUMP FEET	1
232	DACAPO EB10105566 76.1 X 2.0 mm R 95.0 mm ELBOW 90 DEG, 4307_304L, WELDED, EN10253, 3	DACAPO EB10105566 76.1 X 2.0 mm R 95.0 m	4
233	1037	DACAPO TB06214795 2 1_2 INCH X 50mm WEL	4
234	1052	PIPE 2 Ø76,1 X 2	2
235	7003278-01	PIPE	2
236	DACAPO VB51655615 2 1_2 INCH_DN65 BALL VALVE, 3-PCS THREADED ENDS, FB, 316, F_F BSP, PN6	2 1/2" BALL VALVE - MUFFE/MUFFE	4
237	DACAPO TB27385615 2 1_2 INCH UNION M_F, CONICAL, 4408, BSP, ISO 7-1R _ ISO 228-1	2 1/2" F/M UNION I/l m FLAT GASKET PTFE,	4
238	1030	PIPE Ø76,1 X 2	1
239	DACAPO TB06214795 2 1_2 INCH X 60 mm WELDING NIPPLE, 316L, BSP, ISO 7-1	DACAPO TB06214795 2 1_2 INCH X 60mm WEL	6
240	1038	DACAPO TB04212580 1_2 INCH SOCKET, HALF,	9
241	DACAPO TB32385615 2 1_2 INCH UNION F_F PTFE, 4408, BSP, ISO 228-1	2 1/2" F/F UNION I/l m FLAT GASKET PTFE,	1
242	DACAPO TB60384274 2 1_2 INCH X 2 INCH REDUCING BUSHING, 4408, BSP, ISO 7-1R _ ISO 228-1G, OCTAGONA	2 1/2" - 2" M/F - NIPPEL/MUFFE REDUCER A	1

243	DACAPO TB11185135 2 INCH HEXAGON NIPPLE, 4308, BSP, ISO 7-1	2" HEXAGON NIPPLE A4	1
244	H350S-P	LT 3WAY VALVE	1
245	BELIMO_SV24A-SR- TPC_3	LT 3WAY VALVE - ACTUATOR	1
246	CAD_STP_Z_0249	TEMP SENSOR - PT1000 - 160mm TIP	3
247	CAD_STP_TT1250	TEMP SENSOR - PT1000 - 160mm TIP - MOUNT	3
248	ZL312323	BALL VALVE 1/2" F/m, BUTTERFLY HANDLE	4
249	1033	PIPE Ø76,1 X 2	1
250	DACAPO EB10104491 48.3 X 3.0 mm R 57.0 mm ELBOW 90 DEG, 4307_304L, WELDED, EN10253, 3	DACAPO EB10104491 48.3 X 3.0 mm R 57.0 m	1
251	DACAPO ER10084214 76.1 X 48.3 X 2.0 mm REDUCER, CONCENTRIC, 4301_4307, WELDED, L 3_D-	DACAPO ER10084214 76.1 X 48.3 X 2.0 mm	1
252	DACAPO TB06214040 1 1_2 INCH X 80 mm WELDING NIPPLE, 316L, BSP, ISO 7-1	DACAPO TB06214040 1 1_2 INCH X 80 mm WEL	1
253	1051	DACAPO TB06214215 2 INCH X 50 mm WELDING	1
254	DACAPO TB52182580 1_2 INCH PLUG, SQUARE, 4308, BSP, ISO 7-1	1/2" STAINLESS END PLUG	10
255	DACAPO TB33185135 2 INCH UNION M_F PTFE, 4308, BSP, ISO 7-1R _ ISO 228-1	2" M/F UNION I/I m FLAT GASKET PTFE, 1.4	1
256	DACAPO GT11084470 DN40 X 1 1_2 INCH G THREADED FLANGE, EN, TYPE 13B, 4301_4307, EN-1092 TYPE 13B, PN10_16_25_4	1 1/2" FLANGE, THREADED AISI 316L DN40	1
257	FLANGE GASKET DN 40 RUBBE	BUTYL GASKET FOR DN 40 FLANCE	1
258	DACAPO TB56213240 1 INCH X 80 mm HOSE TAIL, MALE, 316L, BSP, ISO 7-1	1" STAINLESS NIPPEL HOSE CONNECTOR - 25	14
259	DACAPO VB25653590 1 INCH_DN25 BALL VALVE, 2-PCS, FB, 316, F_F BSP, PN6	BALL VALVE - 1" MUFFE/MUFFE	16
260	1047	PIPE 33,7 X 2	1
261	DACAPO TB06023215 1 INCH X 40 mm WELDING NIPPLE, 304L, BSP, ISO 7-1	DACAPO TB06023215 1 INCH X 40 mm WELDING	3
262	DACAPO TB14183590 1 INCH ELBOW 90 DEG, F_F, 4308, BSP, 90 DE	1" 90° STAINLESS MUFFE/MUFFE	1
263	DACAPO TB07213240 1 INCH X 80 mm BARREL NIPPLE, 316L, BSP, ISO 7-1	1" BARREL PIPE 1.4404, 20 BAR, 80mm AISI	1
264	1042	DACAPO TB07214880 2 1_2 INCH X 200mm	1
265	1032	PIPE Ø76,1 X 2	1
266	1048	DACAPO TB01183590 1 INCH SOCKET, 4308, B	1
267	DACAPO GT12085599 DN65 X 2 1_2 INCH G 4H THREADED FLANGE, EN, TYPE 13B, 4301_4307, EN-1092 TYPE 13B, PN10_1	2 1/2" FLANGE, THREADED AISI 316L DN65	1
268	013- 01_NBNK_SS_FOD(2 0 18) - COPY^NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
269	013-02_COVER^NB 40-125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
270	013-03_FLANGER^NB 40-125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
271	013-03_FLANGER- 0^NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
272	013- 07_MOTORSTOOL_S EP^NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
273	13-08- MOTORFLANGE^NB 40-125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
274	013- 09_PH_SUPPORTS^NB 40-125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
275	SLETMIG^NB 40- 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K W(2)_NB 40 - 125_STAINLESS STEEL_F2_SUPPORT_S I EMENS_50Hz_2P_4K		1
276	7002066	FLANGE GASKET - EPDM - DN65	1
277	1041	DACAPO TB07214880 2 1_2 INCH X 200mm	1
278	1031	PIPE Ø76,1 X 2	1
279	DACAPO ER10084271 76.1 X 60.3 X 3.0 mm REDUCER, CONCENTRIC, 4301_4307, WELDED, L 3_D-	DACAPO ER10084271 76.1 X 60.3 X 3.0 mm	7
280	DACAPO TB06024215 2 INCH X 50 mm WELDING NIPPLE, 304L, BSP, ISO 7-1	DACAPO TB06024215 2 INCH X 50 mm WELDING	1
281	CAD_STP_300_0231_S A410	FLOW SENSOR – LIQUID	3
282	CAD_STP_Z_1095	FLOW SENSOR /LIQUID/MOUNT. EQUIP. G1/2"	3
283	7001566	DANFOSS NXP00095 CONVERTER	1
284	BELIMO_Z-UIC_3D	LT 3WAY VALVE - ACTUATOR - SIGNAL CONVER	1
285	7003280-01	PLATE FOR LT PUMP	1
286	7003280-03	PIPE 2 Ø76,1 X 2	2

287	DACAPO TB03213590 1 INCH SOCKE	DACAPO TB03213590 1 INCH SOCKET, 316L, B	1
288	STRAUB-FLEX-1_76.1 m	STRAUB-FLEX-1_76.1 mm	2
289	7003669-01	COBALCH MANCHET 100/125-0	2
290	HOSE CLAMP HARD Ø12	HOSE CLAMP HARD Ø120	6
291	BLÆSER 02	CONTAINER VENTILATION FAN	2
292	7002556_01	PLATE FOR FILTER BOX	2
293	4004923	NUT HEX DIN 934 M6 8 FZB	239
294	7002557_01	RAIL FOR FANE BOX 02	1
295	7002558_01	RAIL FOR FANE BOX 01	1
296	CAD_STP_600_0069_T M510	TEMP SENSOR - PT1000 - 25mm TIP - G1/4"	1
297	7002015	BLACK PLASTIC HANDLE, 137mm	8
298	7002559	VENTILATION BOX BEARING FOR FAN	2
299	7002550_01	FRONT PLATE FANE FILTER BOX BOTTOM	1
300	M12-WELD NUT	M12-WELD NUT	24
301	7002551_01	FRONT PLATE FOR FANE FILTER BOX TOP	1
302	SKINTOP MS-M 16X1_5 ART. NR. 53112010(F=4.5	SKINTOP MS-M 16X1,5 ART. NR. 53112010(F=4.5)	1
303	7002542_01	FRAME FOR FILTER 01	1
304	7002542_02	HOLDER FOR FILTER FRAME	5
305	700183	CONTAINER INTAKE FILTER - LARGE	4
306	7001812	CONTAINER INTAKE FILTER - MEDIUM	6
307	7001815	CONTAINER INTAKE FILTER - MOUNTING FRAME	4
308	7001814	CONTAINER INTAKE FILTER - MOUNTING FRAME	6
309	CABINET CUBIC 3MX10MX2M_00		1
310	3621_SHELL	STOOL FOR CABINET	1
311	3622_SHELL	FOOT	4
312	4313	PLATE FOR MOUNTING TRAFO FRAME	4
313	4650-01	CONTAINER HEATER FOOT FRAME PART 01	3
314	4650-02	CONTAINER HEATER FOOT FRAME PART 02	1
315	4650-03	CONTAINER HEATER FOOT FRAME PART 03	2
316	4650-06	CONTAINER HEATER FOOT FRAME PART 06	1
317	4650-05	CONTAINER HEATER FOOT FRAME PART 05	1
318	BN_1971_1400517_BLI ND_RIVET_NUT_M5_ UT_ROF_	BLIND RIVET NUT M5 UT/ROF 3	117
319	4602	CONTAINER HEATER VENTILATION BOX	1
320	7000835	NUT HEX DIN 934 M8 A2	26
321	4614	HEATER CLAMPING PLATE	1
322	4613	HEATER CLAMPING PLATE	1
323	4603	CONTAINER HEATER FAN BOX	1
324	4617	HEATER FAN SUPPORT PLATE	1
325	PEM FHS-M4-18 ---C	FLUSH HEAD STUD PEM FHS-M4-18	4
326	7002422	CONTAINER DCDC FAN COVER PLATE	1
327	7002424	FLOOR PLATE BRACE	1
328	7002205	DUCT HEATER 45KW	1
329	4616	HEATER CLAMPING PLATE	1
330	4619	HEATER CABLE COVER PLATE	1
331	4622	ROD FOR HEATER CABLES	5
332	7001595	VENTILATION FAN	2

333	7002430	CONTAINER DCDC FAN COVER PLATE	1
334	7002274	CABLE JUNCTION BOX	2
335	7002431	FLOOR PLATE BRACE	1
336	7003414	RUBBER GASKET 220X852MM	2
337	7003413	COVER PLATE 220X852MM	1
338	7003656	MCT BRATTBERG MULTIPLE FRAMES RGS 6+6	2
339	7003658	2 INCH SOCKET	4
340	7003460	TRANSPORT BRACKET FOR FC WAVE CABINET	1
341	7003470-01	ALU PROFILE 30 X30	2
342	7003470-02	ALU PROFILE 30 X30	4
343	7003470-03	ALU PROFILE 30 X30	4
344	7003470-04	ALU PROFILE 30 X30	1
345	7003470-05	PERFOREREDE PLATE	1
346	7003470-06	TOP PLATE FOR TRAFO	1
347	7003470-07	ALUMINIUM-CORNER-BRACKET-2028	14
348	DIN 603 M10X30		2
349	7003508-2	WIBE CABLE LADDER KHZP-300	4
350	7003505	KONSOLKLEMME 42 FZS	48
351	7003496-02	WIBE CABLE LADDER 150	1
352	7003496-03	WIBE CABLE LADDER 150	6
353	7002362-05	PIPE FOR	1
354	7002362-06	PIPE FOR	1
355	7003649	WIBE OPHÆNG TYPE ÅBEN 900 300mm FZV	4
356	7003504-5	SKINNE, 41 X 21mm, MED HULLER, STÅL GALV	2
357	7003729	2" INCH X 95 mm HOSE TAIL, MALE, 316L, BSP, ISO 7-1R (1)	4
358	7003771-1	PLATE FOR DRAIN	1
359	7003771-2	PROCESS DRAIN WATER LOCK	1
360	7003771-3	60,3X2X45MM	1
361	7003771-4	DACAPO TB03213590 1 INCH SOCKET, 316L, B	1
362	7003771-5	DACAPO TB03212580 1_2 INCH SOCKET, 316L,	1
363	7003771-6	12mm OD X 1mm WT - SEAMLESS PIPE - HY-LOK	6
364	7003771-7	DRAIN BOX BACK PLATE	1
365	7003771-8	DRAIN BOX SIDE PLATE	2
366	7003274	RUBBER GASKET	1
367	7003266-02	GW11083560	2
368	7003266-03	TB06023215	2
369	HEX PLUG	1/2" STAINLESS HEX PLUG	3
370	7003774	MOUNTING PLATE FOR VENT PIPE	2
371	4005407	M10 PLAIN WASHER ISO 7089 A2	84
372	7003738	UNISTRUT PROFILE NUT M10 P3008 SS	28
373	7003639	SELF LOCKING NUT	56
374	7000860	SCREW HEX ISO 4017/DIN 933 M10X25 A4	28
375	7003464	SUPORT BLOCK FOR 3" EXHAUST PIPE.	16
376	7002738	U-BOLT M10 FOR Ø88,9mm PIPE	28
377	7003775		2
378	7003772-2-1	EXHAUST PIPE 60,3X2	2
379	7003772-2-2	DACAPO AR10224652 3 INCH X 2 INCH 10S REDUCER, CONCENTRIC, 316_316L, WELDED, ASTM A-403 WP-W	2
380	7003772-2-3	EXHAUST PIPE 88,9X2	2
381	7003772-1-1	EXHAUST PIPE 88,9X2	2

382	7003772-1-2	EXHAUST PIPE Ø101,6X3,05	2
383	7003772-1-3	STRÆKMETAL RUSTFRI STÅL 2500X1250X2,0 mm	4
384	7003772-3	EXHAUST PIPE 60,3X2	2
385	STRAUB-FLEX-1_60.3 m	FLEXIBLE PIPE COUPLING 60,3mm	26
386	STRAUB-FLEX-1_88.9 m	FLEXIBLE PIPE COUPLING 88,9mm	28
387	SKINTOP ST-M 25X1_5 ART. NR. 53111230(F=9	SKINTOP ST-M 25X1,5 ART. NR. 53111230(F=9)	1
388	SKINTOP GMP-GL-M 25X1_5 ART. NR. 5311913	SKINTOP GMP-GL-M 25X1,5 ART. NR. 53119130	1
389	1962	FC WAVE BASE FRAME FRONT PLATE	6
390	1961	FC WAVE BASE FRAME PLATE	12
391	1963	FC WAVE BASE FRAME BACK PLATE	6
392	1973	FC WAVE BASE FRAME SUPPORT PLATE	36
393	1932	FC WAVE BASE FRAME TUNNEL PLATE	12
394	FCWAVE UNIT	FCWAVE MODULE UNIT	6
395	7001636	FC WAVE MOUNTING PLATE	6
396	601396-1548	LINE DRAIN POWER CONNECTOR - STRING A POS	6
397	7000824	LINE DRAIN POWER CONNECTOR - STRING A NEG	6
398	7000825	LINE DRAIN POWER CONNECTOR - STRING B POS	6
399	7000826	LINE DRAIN POWER CONNECTOR - STRING B NEG	6
400	601396-1503	CABLE TRAY 70X200 FZS_L=750	6
401	601396-1504	BRACKET FOR CABLE TRAY	12
402	DACAPO TB06214215 2 INCH X 50 mm WELDING NIPPLE, 316L, BSP, ISO 7-1	DACAPO TB06214215 2 INCH X 50 mm WELDING	12
403	2985	FC WAVE HYDROGEN TUBE 1	12
404	TOPPART MULTICAD	FCW INTERFACE PLUG	6
405	7001622	TRANSPORT BRACKET FOR FC WAVE CABINET	6
406	DACAPO TB58384220 2 INCH X 50.8 mm HOSE NIPPLE, FEMALE, 4408, BSP, ISO 228-1	2" STAINLESS MUFFE HOSE CONNECTOR - 50,8mm	12
407	2999-15		6
408	09400240311_100101 605MOD000	HAN 24HPR BASE PANEL SCREW LOCKING	6
409	09400009904_100101 606MOD000	HAN 24 HPR MOUNTING FRAME	6
410	09140240371_100659 802MOD000	HAN HINGED FRAME PLUS, FOR 6 MODULES	6
411	09400245411_100094 826MOD000	HAN 24 HPR COVER SCREW LOCKING	6
412	031841.XXX	UNION 1" CONICAL SEAT MALE / FEMALE	12
413	106776210	NON-DRIP NIPPLE G3/4" DN14	6
414	STRAIGHT BULKHEAD ADAPTORS - BSP - MAL	STRAIGHT BULKHEAD ADAPTOR G3/4"	6
415	STRAIGHT BULKHEAD ADAPTORS - BSP - MAL	STRAIGHT BULKHEAD ADAPTOR G1/2"	6
416	7000142	BONDED SEAL 3/4"	24
417	105771210	NON-DRIP COUPLING G1/2" DN9	6
418	106771210	NON-DRIP COUPLING G 3/4" DN14	6
419	105671050	DUST CAP FOR NON-DRIP NIPPLES DN9	6
420	106671050	DUST CAP FOR NON-DRIP NIPPLES DN14	6
421	105776210	NON-DRIP NIPPLE G1/2" DN9	6
422	BARREL NIPPLE METRI	BARREL NIPPLE, R 1" X 40 mm	12

423	418207568	BALL VALVE, TYPE 2006, ISO 7/1, 1"	12
424	7000653	NUT HEX ISO 4032/DIN 934 M10 A2	114
425	7000652	WASHER ISO 7089 M10 A2 140 HV	162
426	7000651	HEX SOCKET HEAD CAP SCREW ISO 4762 - M10 X 40 A4	6
427	7000790	TB60382384	14
428	7000791	HOSE BARP Ø17MM X 1/2"	12
429	PANEL-SOURCE-SLS	PANEL POWER CONNECTOR - STRING A POS	6
430	ANGLED TUBULAR CABLE LUGS 9	ANGLED TUBULAR CABLE LUG 90°, 95 MM², M12	24
431	TUBULAR CABLE LUG	TUBULAR CABLE LUGS 95 MM² M10	24
432	600001-1229	SILICON MEDIUM VOLTAGE CABLE, 95MM²	1902
433	7000556	HEXAGON NUT ISO 4032 M12 FZB	12
434	SST-12-17_FR	SHRINKABLE TUBING, BLACK SHRINKFLEX 19/6	7680
435	WASHER DIN 125 - A 138.8FZ		24
436	PANEL-SOURCE-SLS	PANEL POWER CONNECTOR - STRING A NEG	6
437	600001-1230	SILICON MEDIUM VOLTAGE CABLE, 95MM²	1860
438	PANEL-SOURCE-SLS	PANEL POWER CONNECTOR - STRING B POS	6
439	600001-1231	SILICON MEDIUM VOLTAGE CABLE, 95MM²	1860
440	PANEL-SOURCE-SLS	PANEL POWER CONNECTOR - STRING B NEG	6
441	600001-1232	SILICON MEDIUM VOLTAGE CABLE, 95MM²	1878
442	600001-5931	CONDENSATE DRAIN PIPE	6
443	7001802	TRANSPORT BRACKET FOR FC WAVE CABINET	4
444	7002508-01	PLATE FOR EXHAUST PIPE	6
445	7002508-02	PIPE FOR EXHAUST	6
446	7002508-03	PIPE FOR VENTALATION	6
447	7002524-01	VENTILATION Ø60,3X1,6	6
448	2034	EXHAUST 02 Ø88,9X1,6	6
449	DACAPO EB10345856 88.9 X 2.0 mm R 114.0 mm ELBOW 90 DEG, 4404_316L, WELDED, EN10253, 3	DACAPO EB10345856 88.9 X 2.0 mm R 114.0	6
450	2040	EXHAUST PIPE 01 Ø88,9X1,6	6
451	1922	DC_DC BASE FRAME PART 2	12
452	1959	DC_DC BASE FRAME PART 3	6
453	1960-1	DC_DC BASE FRAME PART 1	6
454	1982	BASE FRAME STIFNER	12
455	1983	DC DC BASE FRAME STIFNER	24
456	7001533	DC CABINET UL	6
457	7001621	MOUNTING BRACKET FOR DC/DC CABINET	12
458	MANUFOLD_DUMMY		2
459	7003318-1	VENTILATION PLATE 1 FOR DC/DC	2
460	7003445	BN 4577 1174339 BLIND RIVET NUT M5UFO40	138
461	7003319	SIDE PLATE FOR VENTILATION BOX	1
462	7003320-1	RAIL FOR CEILING	1
463	7003314	SIDE PLATE FOR VENTILATION BOX 01	1
464	7003321	VENTILATION CLOSES	6

465	7003322-1	VENTILATION PLATE 2 FOR DC/DC	2
466	7003323	SIDE PLATE FOR VENTILATION BOX	2
467	7003324-1	RAIL FOR CEILING	2
468	7003325-1	VENTILATION PLATE 3 FOR DC/DC	2
469	7003316-1	RAIL FOR CEILING	1
470	7003346	SIDE PLATE FOR VENTILATION BOX	1
471	7003326	SIDE PLATE FOR VENTILATION BOX 01	1
472	7003327-1	ANGEL FASTNING MCU	1
473	7003328-1	PLATE MCU	1
474	7003329-1	RAIL FOR CEILING 02	1
475	7003330-1	RAIL FOR CEILING	1
476	7003348	SIDE PLATE FOR VENTILATION BOX	1
477	7003331-1	RAIL FOR CEILING	1
478	7003332	SIDE PLATE FOR VENTILATION BOX 02	1
479	7003349-1	RAIL FOR CEILING	1
480	7003334	SIDE PLATE FOR VENTILATION BOX 02	1
481	7003450	RAIL FOR CEILING	2
482	7003350	SIDE PLATE FOR VENTILATION BOX	1
483	7002379-2	CONTAINER HEATER VENTILATION PLATE	1
484	7003458-2	RAIL FOR CEILING	1
485	7002513-01	PIPE D114,3X2,0 EN10217	1
486	DACAPO EB10106571 114.3 X 2.0 mm R 152.0 mm ELBOW 90 DEG, 4307_304L, WELDED, EN10253, 3	DACAPO EB10106571 114.3 X 2.0 mm R 152.0	2
487	3418	PIPE D114,3X2,0 EN10217	2
488	DACAPO AC10036630 4 INCH SCH 10S 114.30 X 3.05 mm END CAP, 304_304L, SEAMLESS, ASTM A-403 WP-	DACAPO AC10036630 4 INCH SCH 10S 114.30	4
489	3429	DACAPO EB10105071 - MILLED TO FIT	12
490	3405	THREADED WELDING MUFF, G 1/2" ISO 7/1	3
491	3439	BARREL NIPPEL 2INCH X 60 mm 316 ISO 7-1R	12
492	STRAUB-FLEX-1_114.3 m	FLEXIBLE PIPE COUPLING 114,3mm	8
493	418207572	BALL VALVE TYPE 2006, ISO7/1, 2"	12
494	DACAPO TB56214247 2 INCH X 95 mm HOSE TAIL, MALE, 316L, BSP, ISO 7-1R (1	2" STAINLESS NIPPEL HOSE CONNECTOR	12
495	7001832	2" EPDM COOLANT HOSE - ID 50mm OD 60mm	12
496	FRS_PLUS_108___116_ 79455_	PIPE CLAMP W. RUBBER-BSM M8/10 108-116mm	12
497	GPL_M_10_79666_1	PIPE CLAMP MOUNTING BRACKET M10 120X40MM	20
498	4005406	NUT HEX ISO 4032/DIN 934 M10 8 FZB	8
499	7002514-01	PIPE D114,3X2,0 EN10217	1
500	3417	PIPE D114,3X2,0 EN10217	2
501	3438	HT PIPE Ø60,3/Ø53	6
502	DACAPO TB01182580 1_2 INCH SOCKET, 4308, BSP, ISO 228 - 1	DACAPO TB01182580 1_2 INCH SOCKET, 4308,	27
503	7001939	PIPE HOLDER Ø108 -116 mm/MOUNTING BRACKE	8
504	DACAPO EB10106616 114.3 X 3.0 mm R 152.0 mm ELBOW 90 DEG, 4307_304L, WELDED, EN10253, 3	DACAPO EB10106616 114.3 X 3.0 mm R 152.0	2
505	7002515-01	PIPE 114,3X2 EN10217	1

506	DACAPO TB20182580 1_2 INCH ELBOW 90 DEG, M_F, 4308, BSP, 90 DE	1/2" 90° STAINLESS MUFFE/NIPPEL	5
507	7002516-01	PIPE 114,3X2 EN10217	1
508	1900-601396-3107	THREADED WELDING MUFF, G 1/2" ISO 7/1	1
509	7002512-01	3mm PLATE FOR PIPE	1
510	7002512-02	PIPE 01 Ø168,3X2	4
511	7003491-1	COBALCH DU CASING 4X6"	4
512	HOSE CLAMP HARD Ø16	HOSE CLAMP HARD Ø160	4
513	7003643-25	THREADED ROD M10 STAINLESS (25mm)	12
514	7001776	PIPE CLAMP W.RUBBER-BSM M8/10 58-61mm 2"	12
515	3506	LT COOLING PIPE 2"	1
516	DACAPO TB01183590 1 INCH SOCKET, 4308, BSP, ISO 228 - 1G_R30,15 CUTOU	DACAPO TB01183590 1 INCH SOCKET, 4308, B	24
517	DACAPO TB57214830 2 1_2 INCH X 105 mm HOSE TAIL, BW, 316	DACAPO TB57214830 2 1_2 INCH X 105 WELD	6
518	DACAPO TB56214830 2 1_2 INCH X 105 mm HOSE TAIL, MALE, 316L, BSP, ISO 7-1	2 1/2" STAINLESS NIPPEL HOSE CONNECTOR - 76,1mm	2
519	3426	3" EPDM COOLANT HOSE - ID 75mm OD 85mm	1
520	7001956	2 1/2" 90° STAINLESS MUFFE/MUFFE	1
521	7001959	2 1/2" STAINLESS NIPPEL PIPE 100mm	1
522	DACAPO TB03215615 2 1_2 INCH SOCKET, 316L, BSP, ISO 228 - 1G, FROM PIP	2 1/2" STAINLESS MUFFE	1
523	DACAPO TB50182580 1_2 INCH PLUG, HEXAGON, 4308, BSP, ISO 7-1	DACAPO TB50182580 1_2 INCH PLUG, HEXAGON	2
524	3516	LT COOLING PIPE 2"	1
525	DACAPO AC10035110 2 INCH SCH 10S 60.33 X 2.77 mm END CAP, 304_304L, SEAMLESS, ASTM A-403 WP-	DACAPO AC10035110 2 INCH SCH 10S Ø60.33	2
526	3525	THREADED WELDING MUFF, G 1/2" ISO 7/1	2
527	3518	3" EPDM COOLANT HOSE - ID 75mm OD 85mm	1
528	3503	LT COOLING PIPE	6
529	JGSM-PM011814E	STRAIGHT ADAPTOR 18MM-1/2" BSP	12
530	DACAPO TB60182384 1 INCH X 1_2 INCH REDUCING BUSHING, 4308, BSP, ISO 7-1R _ ISO 228-1G, HEXAGO	DACAPO TB60182384 1 INCH X 1_2 INCH REDU	12
531	DACAPO TB07212245 1_2 INCH X 100 mm BARREL NIPPLE, 316L, BSP, ISO 7-1	DACAPO TB07212245 1_2 INCH X 100 mm BARR	6
532	DACAPO TB13382580 1_2 INCH ELBOW 45 DEG, F_F, 4408, BSP, 45 DEG (1	DACAPO TB13382580 1_2 INCH ELBOW 45 DEG,	6
533	DACAPO TB06212220 1_2 INCH X 50 mm WELDING NIPPLE, 316L, BSP, ISO 7-1	DACAPO TB06212220 1_2 INCH X 50 mm WELDI	12
534	1944	LT COOLING PIPE	6
535	CONSTANT FLOW VALV	CONSTANT FLOW VALVE PVC-MF	6
536	3524	LT COOLING PIPE 2"	1
537	3425	2,5" RUBBER HOSE	1
538	DACAPO TB20385615 2 1_2 INCH ELBOW 90 DEG, M_F, 4408, BSP, 90 DE	DACAPO TB20385615 2 1_2 INCH ELBOW 90 DE	1
539	3517	2,5" RUBBER HOSE	1
540	3508	LT COOLING PIPE 2"	1
541	DACAPO TB57213240 1 INCH X 80 mm HOSE TAIL, BW, 316	DACAPO TB57213240 1 INCH X 80 mm HOSE TA	1
542	DACAPO EB10103536 33.7 X 2.0 mm R 38.0 mm ELBOW 90 DEG, 4307_304L, WELDED, EN10253, 3	DACAPO EB10103536 33.7 X 2.0 mm R 38.0 m	1
543	7003262-01	PROCESS DRAIN TANK	1
544	7003262-02	PROCESS DRAIN TANK PLATE	1
545	7003262-03	PROCESS DRAIN PLATE	1
546	TB04212580	TB04212580	11
547	DACAPO TB04213590 1 INCH SOCKET, HALF, 316L, BSP, ISO 228-1G, FROM PIPE	DACAPO TB04213590 1 INCH SOCKET, HALF, 3	1

548	7003264	BRACKET FOR DRAIN	2
549	7003263	PROCESS DRAIN TANK COVER PLATE	1
550	600001-3210	NON-RETURN VALVE RT 25 1/2"	8
551	7002029	LEVEL SENSOR - LIQUID - BINARY	1
552	7003267	RUBBER GASKET	1
553	7001772	BALL VALVE - 1/2" MUFFE/NIPPEL	7
554	DACAPO TB59382190 1_2 INCH X 19.0 mm HOSE NIPPLE, MALE, 4408, BSP, ISO 7-1	1/2" STAINLESS NIPPEL HOSE CONNECTOR 19	8
555	69333GMVA1812	UNION F/M-THREAD,FLAT SEAL Ø18 X 1/2"	6
556	7003597-01		1
557	7003600-01		1
558	7003601-01		1
559	7003603-01		1
560	7003604-01		1
561	7003605-01		1
562	7001737-01	FOOT PLATE	74
563	7001737-02	LEG	74
564	7001728	FLOOR BRACES	47
565	2363	MAIN BEAM FOR FLOOR SECTION	11
566	7001730	ALU FLOOR PLATE 5-7mm	23
567	7001731	CONNECTION BRACKET	10
568	7001732	FLOOR PLATE BRACE	61
569	7001859	GRID CABLE TRAY 300mm	6
570	7001733	STABILIZER BAR 1	25
571	7001734	STABILIZER BAR 2	13
572	7001735	CABLE TRAY FASTNER BAR	48
573	7001736	FLOOR STRUCTURE STABILIZER	12
574	7003488-01	MAIN BEAM FOR FLOOR SECTION	1
575	7003471	ALU FLOOR PLATE 5-7mm	1
576	7003441	MAIN BEAM FOR FLOOR SECTION 1	1
577	7001753-01	FLOOR BRACES	3
578	7003440	ALU FLOOR PLATE 5-7mm	1
579	7001757	MAIN BEAM FOR FLOOR SECTION	1
580	7001758-01	FLOOR BRACES	4
581	7001759	ALU FLOOR PLATE 5-7mm	1
582	7001760	MAIN BEAM FOR FLOOR SECTION	1
583	7001761-01	FLOOR BRACES	2
584	7001762	ALU FLOOR PLATE 5-7mm	1
585	7001763	MAIN BEAM FOR FLOOR SECTION	1
586	7001764-01	FLOOR BRACES	3
587	7003437	ALU FLOOR PLATE 5-7mm	1
588	7001824	CABLE TRAY BRACKET 2	2
589	7001858	GRID CABLE TRAY 120mm	1
590	7001818	CABLE TRAY BRACKET 1	2
591	7001823	CABLE TRAY FASTNER BAR	4
592	7002439-01	MAIN BEAM FOR FLOOR SECTION	1
593	2366_03	FLOOR PLATE BRACE	4
594	7002442	FLOOR PLATE BRACE	3
595	7003492-01	MAIN BEAM FOR FLOOR SECTION	1
596	7003446	ALU FLOOR PLATE 5-7mm	1
597	7003447	ALU FLOOR PLATE 5-7mm	1
598	7003053	RUBBER GASKET	6
599	7001637	HYDROGEN CONNECTION BOX	6
600	7001855	HYDROGEN BOX FILTER	6

601	7003043	HYDROGEN CONNECTION TUBE 6	1
602	HYLOK_CUA-25M- S31	HYLOK_CUA-25M-S316	6
603	7001806	FRAME FOR FILTER	6
604	SKINTOP GMP-GL-M 40X1_5 ART. NR. 5311905	SKINTOP GMP-GL-M 40X1_5	6
605	SKINTOP ST-M 40X1,5 ART_ NR_ 53111250(F=19)_KU NSTSTOF	SKINTOP ST-M 40X1,5	6
606	7003044	HYDROGEN CONNECTION TUBE 5	1
607	7003045	HYDROGEN CONNECTION TUBE 4	1
608	7001695	HYDROGEN CONNECTION TUBE 3	1
609	7001694	HYDROGEN CONNECTION TUBE 2	1
610	7001693	HYDROGEN CONNECTION TUBE 1	1
611	7001807	BRACKET FOR PIPE HOLDER 1	2
612	7001810	PIPE CLAMP 325-PP	2
613	7001808	BRACKET FOR PIPE HOLDER	6
614	7001811	PIPE CLAMP 325/25-PP	10
615	7003071_01	EXHAUST PIPE 88,9X2	12
616	7003071_04	EXHAUST PIPE Ø101,6X3,05	12
617	7003071_03	STRÆKMETAL RUSTFRI STÅL 2500X1250X2,0 mm	24
618	7003072_01	EXHAUST PIPE 60,3X2	12
619	7003072_02	EXHAUST PIPE 73,03X3,05	12
620	7003072_03	STAINLESS STEEL EXPANDED 2500X1250X2,	24
621	7002709	MOUNTING PLATE FOR EXHAUST PIPE	12
622	7002734	U-BOLT M10 FOR Ø60,3mm PIPE	24
623	7003462	SUPORT BLOCK FOR 2" EXHAUST PIPE	12
624	7002742	UNISTRUT MOUNTING RAIL WITH HOLES	12
625	7002706	UNISTRUT MOUNTING RAIL WITH HOLES 470mm	24
626	7002721	UNISTRUT L-PLANE BRACKET P1036	17
627	7002720	UNITSTRUT PLANE BRACKET P1358	15
628	7002718	UNISTRUT PROFILE NUT P3013M12	282
629	7002719	UNISTRUT U-BRACKET P1047	38
630	7003077	PIPE CLAMP W.RUBBER-BSM M8/10 88-92 mm 3	12
631	FRS_PLUS_55___61_79 447_1_	PIPE CLAMP W.RUBBER-BSM M8/10 58-61mm 2"	12
632	ISO - 4032 - M10 - D - C8FZ	HEXAGON NUT ISO 4032 - M10	24
633	ISO 4017 - M10 X 25- C8.8FZ	HEX HEAD SCREW ISO 4017 - M10 X 25 FZB	24
634	7002716	MOUNTING PLATE FOR EXHAUST PIPE	12
635	7003073	FRAME F/EXHAUST PIPE MOUNTING ON COOLER	6
636	7003081	MOUNTING PLATE FOR EXHAUST PIPE	12
637	7003085	MOUNTING PLATE FOR EXHAUST PIPE	10
638	ISO 4014 - M10 X 70 X 26-CA	HEX HEAD BOLT ISO 4014 - M10 X 70 A2	48
639	7003098	MOUNTING PLATE FOR EXHAUST PIPE	4
640	7002974-01	MAIN LONG BEAM NO 1	1
641	7002974-02	MAIN SHORT BEAM	2
642	7002974-03	STIFFENER NO 10	2
643	7002974-04	MIDDLE BEAM	1

644	7002974-05	MAIN LONG BEAM NO 2	1
645	7002974-06	SUPPORT PLATE NO 1	2
646	7002974-07	BEAM NO 1	6
647	7002974-08	STIFFENER NO 1	18
648	7002974-09	STIFFENER NO 2	24
649	7002974-10	PAD EYE	4
650	7002974-11	STIFFENER NO 3	8
651	7002974-12	FLOOR PLATE	1
652	7002974-13	BEAM NO 5	2
653	7002974-14	STIFFENER NO 4	20
654	7002974-15	SUPPORT PLATE NO 2	2
655	7002974-16	SUPPORT PLATE NO 3	2
656	7002974-17	CORNER CAST BOTTOM LEFT (BL) ISO1161	2
657	7002974-18	CORNER CAST BOTTOM RIGHT (BR) ISO1161	2
658	7002974-19	SUPPORT PLATE NO 4	1
659	7002974-20	STIFFENER NO 5	3
660	7002974-21	BEAM NO 3	1
661	7002974-22	BEAM NO 4	2
662	7002974-23	STIFFENER NO 6	2
663	7002974-24	BOTTOM TRUSS BAR NO 1	2
664	7002974-25	BOTTOM TRUSS BAR NO 2	1
665	7002974-26	BOTTOM TRUSS BAR NO 3	1
666	7002974-27	BOTTOM TRUSS BAR NO 4	1
667	7002974-28	BOTTOM TRUSS BAR NO 5	1
668	7002974-29	BOTTOM TRUSS BAR NO 6	1
669	7002974-30	BOTTOM TRUSS BAR NO 7	1
670	7002974-31	STIFFENER NO 7	1
671	7002974-32	STIFFENER NO 8	1
672	7002974-33	STIFFENER NO 9	4
673	7002974-34	BEAM NO 2	1
674	7002974-35	BEAM NO 6	2
675	7002977	HT COOLER	2
676	7002982	LT COOLER-SHELL	1
677	7002983	FRAME-WELDED FOR LT COOLER-SHELL	1
678	7002933-1	SHS60X5	4
679	7002933-2	PL10	4
680	7002933-3	PL10	2
681	7002933-4	PL8	8
682	7002933-5	PL10	4
683	7002933-6	SHS50X5	4
684	7002933-7	SHS50X5	1
685	7002933-8	PL6	4
686	7002933-9	PL10	2
687	7002933-10	PL10	2
688	7002933-11	PL6	2
689	7002933-12	PL6	2
690	7002934-1	SHS50X5	1
691	7002934-2	PL10	2
692	7002936-1	SHS50X5	1
693	7002936-2	PL10	2
694	7002936-3	PL10	2
695	7002936-4	PL10	2
696	7002936-5	PL10	2
697	7002936-6	BUSHING 13/19,8; L=50mm	8
698	7002935-1	PL10	2
699	7002937-1	SHS50X5	1
700	7002937-2	SHS50X5	2
701	7002937-3	PL10	2
702	7002937-4	PL10	2
703	7002937-5	PL10	2
704	7002938-1	SHS50X5	4
705	7002938-2	PL10	12

706	7002938-3	PL10	12
707	7002942	MOUNTING PROFILE NO 1	1
708	7002943	MOUNTING PROFILE NO 2	1
709	7002944	MOUNTING PROFILE NO 3	1
710	7002940-1	SHS50X5	2
711	7002941-1	SHS50X3	1
712	7002941-2	PL10	2
713	7002941-3	PL10	2
714	HINGE GN 127-ZD-76- 60-HB-SR (0)-		8
715	HINGE GN 127-ZD-76- 60-HB-SR (0)-		2
716	HINGE GN 127-ZD-76- 60-HB-SR (0)-		2
717	GN 840-50-ASD0-4		2
718	GN 840-50-ASD0-3		2
719	GN 840-50-ASD-2		2
720	GN 840-50-ASD-1		2
721	ISO 7380 - M4 X 16 - 16		6
722	ISO 10642 - M6 X 30 - 30		5
723	WASHER ISO 7089 - 1		20
724	ISO - 4032 - M12 - W -		17
725	ISO 4017 - M12 X 50-		1
726	WASHER ISO 7093 - 1		5
727	ISO 4017 - M12 X 90-		5
728	7002995-01	RAIL FOR WALK WAY LEFT	1
729	7002996-02	MONTING PLATE FOR RAIL	2
730	7002996-01	RAIL FOR WALK WAY RIGHT	1
731	7002994-01	GRID CABLY TRAY 400mm	1
732	7002997	ALU COVERPLATE (DOORK PLATE 5-7mm)	2
733	7002998-01	PLATE FOR WORKWAY	3
734	7002998-02	PLATE FOR RAIL	6
735	7003015	ATTACHMENT TO CABLE TRAY	4
736	7003016	ATTACHMENT TO CABLE TRAY	4
737	7003014-01	PLATE FOR BASE FRAME	1
738	7003014-02	PLATE FOR BASE FRAME	1
739	EKDS20124- 316(1)_FRAME_1.ST	EKDS20124-316(1)_FRAME	1
740	MCDSXXXX4(1)_BASE CENTER PROFILE_1.ST	MCDSXXXX4(1)_BASE CENTER PROFILE	1
741	MCDSXXXX4(1)_ROO F CENTER PROFILE_1.ST	MCDSXXXX4(1)_ROOF CENTER PROFILE	1
742	DNMKS01(1)_HINGE_ 1.ST	DNMKS01(1)_HINGE	8
743	DNSS2012R(1)_RIGHT DOOR_1.ST	DNSS2012R(1)_RIGHT DOOR	1
744	LSSDSXXXX(1)_LOCK_ 1.ST	LSSDSXXXX(1)_LOCK	1
745	LSSDS2000(1)_ESPAG NOLETTE TOP_1.ST	LSSDS2000(1)_ESPAGNOLETTE TOP	1
746	LSSDS2000(1)_ESPAG NOLETTE BOTTOM_1.ST	LSSDS2000(1)_ESPAGNOLETTE BOTTOM	1
747	DNSS2012L(1)_LEFT DOOR_1.ST	DNSS2012L(1)_LEFT DOOR	1
748	LSEL2000(1)_LEFT DOOR ESPAGNOLETTE_1.ST	LSEL2000(1)_LEFT DOOR ESPAGNOLETTE	1
749	DNMKS01(1)_ROD CATCHES_1.ST	DNMKS01(1)_ROD CATCHES	4
750	CRPKS12(1)_REAR PANEL MK, LEFT_1.ST	CRPKS12(1)_REAR PANEL MK, LEFT	1
751	CRPKS12(1)_REAR PANEL MK, RIGHT_1.ST	CRPKS12(1)_REAR PANEL MK, RIGHT	1
752	CRPKS12(1)_REAR PANEL MOUNTING KIT_1.ST	CRPKS12(1)_REAR PANEL MOUNTING KIT	6
753	CRPS2012(1)_REAR PANEL_1.ST	CRPS2012(1)_REAR PANEL	1
754	CRPKS12(1)_REAR PANEL CENTRE BRACKET_1.ST	CRPKS12(1)_REAR PANEL CENTRE BRACKET	2
755	MPA06(1)_MOUNTIN G PLATE BRACKETS 1_1.ST	MPA06(1)_MOUNTING PLATE BRACKETS 1	1
756	MP2012(1)_P1_1.STP	MP2012(1)_P1	1
757	MPA06(1)_MOUNTIN G PLATE BRACKETS 2_1.ST	MPA06(1)_MOUNTING PLATE BRACKETS 2	1

758	MPA06(1)_MOUNTIN G PLATE BRACKETS 3_1.ST	MPA06(1)_MOUNTING PLATE BRACKETS 3	1
759	MPA06(1)_MOUNTIN G PLATE BRACKETS 4_1.ST	MPA06(1)_MOUNTING PLATE BRACKETS 4	1
760	CBPS064(1)_BOTTOM PLATE_1.ST	CBPS064(1)_BOTTOM PLATE	2
761	LSSDS2000(1)_LOCK CATCH_1.ST	LSSDS2000(1)_LOCK CATCH	2
762	LSELXX16X(1)_LEFT DOOR ESPAGNOLETTE_1.ST	LSELXX16X(1)_LEFT DOOR ESPAGNOLETTE	2
763	7003018-01	PLATE FOR BASE FRAME	1
764	7003018-02	TUBE FOR BASE FRAME	1
765	7003018-03	PLATE FOR BASE FRAME	1
766	7003018-04	PLATE FOR BASE FRAME	1
767	7003022	COOLING SKID VFD CABINET - OFF SHORE VER	1
768	7002991	TOP BRACKET FOR MCU CABINET	1
769	7002915-01	PIPE Ø114,3 X 2	4
770	7002987-05	DACAPO EB10106571 114.3 X 2.0 mm R 152.0	23
771	7002987-08	DACAPO TB01183590 1 INCH SOCKET, 4308, B	11
772	7002987-10	DACAPO VB56656655 4 INCH_DN100 BALL VALV	8
773	7002987-06	DACAPO TB57215835 4 INCH X 115 mm HOSE T	17
774	7002987-04	DACAPO GW12146640 DN100_114.3 mm WELDING	21
775	7002906-02	PIPE Ø114,3 X 2	8
776	DACAPO TB11183590 1 INCH HEXAGON NIPPLE, 4308, BSP, ISO 7-1	1" STAINLESS HEXNIPPLE	19
777	FLANGE GASKET DN 100 RUBBE	EPDM FLANGE GASKET DN100	6
778	7002914-02	PIPE Ø114,3 X 2	1
779	7002914-03	PIPE Ø76,1 X 2	1
780	7002914-04	PIPE Ø114,3 X 2	1
781	7002905-05	DACAPO 1_2 INCH SOCKET - TB01182580	14
782	7002987-03	DACAPO GW10255599 DN65_76.1 mm WELDING N	5
783	7002987-07	DACAPO ET40255297 114.3 X 76.1 X 3.0 mm	5
784	7002611	PUMP, CENTRIFUGAL, 15KW,	2
785	7002918-01	PIPE Ø114,3 X 2	3
786	7002987-25	KONUS OD 129 - 114,3	4
787	7002987-23	SVEJSEKRAVE DIN 2642 PN10	4
788	7002987-24	DACAPO GL70056944 DN125_129.0 mm LAP JOI	4
789	7002987-27	DACAPO EB10106571 114.3 X 2.0 mm R 152.0	7
790	7002918-04	PIPE Ø114,3 X 2	2
791	4007975	HT 2WAY VALVE DN65	2
792	4007976	HT 2WAY VALVE DN65 – ACTUATOR	2
793	DACAPO TB22183590 1 INCH TEE F_F_F, 4308, BSP, ISO 228 - 1	DACAPO TB22183590 1 INCH TEE F_F_F, 4308	2
794	DACAPO TB59383195 1 INCH X 25.4 mm HOSE NIPPLE, MALE, 4408, BSP, ISO 7-1	1" STAINLESS NIPPEL HOSE CONNECTOR	15
795	4007977	HT 2WAY VALVE DN125	2
796	7001541	HT 2WAY VALVE DN125	2
797	7002923-01	HOST RUBBER Ø100	2
798	7002923-02	HOST RUBBER Ø100 LONG	1
799	7002920-02	PIPE Ø114,3X2	2
800	7002987-29	DACAPO EB10106571 114.3 X 2.0 mm R 152.0	4
801	7002987-20	DACAPO ET10086570 114.3 X 2.0 mm L 105 m	2
802	7002987-30	DACAPO EB10106571 114.3 X 2.0 mm R 152.0	1

803	7002912-01	PIPE Ø114,3X2	2
804	7002912-02	DACAPO ET10086570 114.3 X 2.0 mm L 105 m	1
805	7002906-01	PIPE Ø114,3 X 2	4
806	7003386-02	PIPE Ø114,3 X 2	1
807	7003386-03	PIPE Ø76,1 X 2	1
808	7003386-04	PIPE Ø114,3 X 2	1
809	7003390-05	PIPE Ø114,3 X 2	1
810	7002922-02	HOST RUBBER Ø100 LONG	1
811	7003384-01	PIPE Ø114,3X2	2
812	7003384-02	DACAPO ET10086570 114.3 X 2.0 mm L 105 m	1
813	7003384-04	PIPE Ø114,3X2	2
814	7003392-01	PIPE Ø114,3X2	1
815	3005	BUTTOM HEATER TANK	3
816	3004	TOP HEATER TANK	3
817	DACAPO TB01183590 1 INCH SOCKET, 4308, BSP, ISO 228 - 1G (1	DACAPO TB01183590 1 INCH SOCKET, 4308, B	6
818	3003	ANGLE BRACKETS	12
819	DACAPO TB20183590 1 INCH ELBOW 90 DEG, M_F, 4308, BSP, 90 DE	1" 90° STAINLESS MUFFE/NIPPEL	3
820	NORDJYSK MARINE SERVIC	1/2" 90° STAINLESS NIPPEL HOSE CONNECTOR	6
821	DACAPO TB60181709 1_2 INCH X 1_4 INCH REDUCING BUSHING, 4308, BSP, ISO 7-1R _ ISO 228-1G, HEXAGO	1/2"-1/4" STAINLESS NIPPEL/MUFFE REDUCTI	3
822	CAD_STP_500_0071	PRESSURE SENSOR - 0-100MBARG - G1/4"	3
823	7003293-01	UNISTRUT MOUNTING RAIL WITH HOLES	1
824	7003293-03	UNISTRUT MOUNTING RAIL WITH HOLES	1
825	7003293-04	UNISTRUT MOUNTING RAIL WITH HOLES 470mm	1
826	7003293-05	UNISTRUT MOUNTING RAIL WITH HOLES 470mm	1
827	7003643-70	THREADED ROD M10 STAINLESS (70mm)	7
828	7003393	PLATE FOR PIPE CLAMP	11
829	7003394	P 1008 SS (PNL10SS)	11
830	7003293-02	UNISTRUT MOUNTING RAIL WITH HOLES 470mm	3
831	7003285-01	ER10084709	2
832	7003285-02	GW12145920	2
833	7003285-03	PIPE Ø 76,2X2	1
834	7003285-04	PIPE Ø 76,2X2	1
835	7003285-05	PIPE Ø 76,2X2	1
836	7003286-06-	GW12085599	2
837	7003286-03	PIPE Ø 76,2X2	1
838	7003286-04	PIPE Ø76,2X2	1
839	7003286-05	PIPE Ø76,2X2	1
840	7003292-01	PIPE Ø76,2X2	4
841	7003292-02-01	EC11085565	4
842	7003292-02-02	GL70055599	4
843	39015_BSI_108- 116.ST		6
844	7003577	MONTAGEFLANGE GP M10 80X30 mm FLAMCO	2
845	7003495		3
846	7003679	WIBE LOFTPENDEL 2F 280mm FZV	5
847	7003496-07	WIBE CABLE LADDER 150	2
848	7003679-01	WIBE LOFTPENDEL 2F 280mm FZV	3
849	7003496-04	WIBE CABLE LADDER 150	5
850	7003025-02	UNIVERSALJOINT 22 AISI316L	13
851	7003025-01	UNIVERSALJOINT 22 AISI316L	25
852	DIN EN 24017 - M5 X 10-		75
853	7003025-03	UNIVERSALJOINT 22 AISI316L	12
854	7003033	CONTAINER TWIST LOCK	4

855	7003453	SUPPORT BLOCK FOR 40' COOLING TOWER	2
856	7003453_01	FRONT PLATE FOR SUPPORT BLOCK	2
857	3016	HEATER BOX BOTTOM REV 2	1
858	3017	HEATER BOX TOP REV2	1
859	3015	BRACKET FOR HEATER BOX	4
860	DIN2353- TUBE_CRTM^CMC - 25M-12R-S31	NOT SPECIFIED	30
861	DIN2353_TUBE_CRTM _NUT^CMC-25M - 12R-S31		30
862	BACK_FERRULE_CRT M^CMC-25M-12R - S31	NOT SPECIFIED	30
863	FRONT_FERRULE_CRT M^CMC-25M-12R - S31	NOT SPECIFIED	30
864	SVEJSEMUFFE 1 TOMME		2
865	SVEJSEMUFFE 0.5 TOMME		7
866	SVEJSEMUFFE 1.5 TOMME		2
867	7003636-01	UNISTRUT MOUNTING P 1000 T SS (400mm)	2
868	7002897	P2663T - SLOTTED CANT ARM	2
869	7002898	P2484 - 90 DEG GUSSET FITTING	2
870	COPY OF COPY OF DIN2353_TUBE_CRT M_NUT^700363		1
871	COPY OF COPY (2) OF DIN2353_TUBE_CRT M_NUT^700363		1
872	COPY OF COPY (3) OF DIN2353_TUBE_CRT M_NUT^700363		1
873	COPY OF COPY (4) OF DIN2353_TUBE_CRT M_NUT^700363		1
874	COPY OF COPY (5) OF DIN2353_TUBE_CRT M_NUT^700363		1
875	COPY OF COPY (6) OF DIN2353_TUBE_CRT M_NUT^700363		1
876	7003526	EMMERSON ASCO SOLENOID VALVE NFM 12II	12
877	7003525-8	PIPE FOR	1
878	7003525-9	PIPE FOR	1
879	7003525-16	PIPE FOR HT	1
880	7003525-17	PIPE FOR HT	1
881	7003525-15	PIPE FOR HT	1
882	7003525-7	PIPE FOR	1
883	END CAPS - DIN 2617 DN3	END CAP - DIN 2617 DN32	1
884	7003525-1	MANIFOLD PIPE	1
885	7003524-1		1
886	7003524-2		1
887	7003525-2	MANIFOLD PIPE Ø25*2	6
888	7003525-4	MANIFOLD PIPE	1
889	7003525-3	FLANGE 11/4"	1
890	7003525-5	MUFFS FOR WELDING	2
891	HYLOK_CLA-25M- S316-HEATER TANK UNI		6
892	HYLOK_BVH-16T- S316-HEATER TANK UNI		6
893	HYLOK_CPC-25M- S31		6
894	7003699	IMMERSION HEATER TYPE D-8640	2
895	7003636-02	UNISTRUT MOUNTING P 1000 T SS (400mm)	2
896	NSYPLSP1827G	PART-NSYPLSP1827G_1-DESC	1
897	CP-300 9712200474		1
898	7003636-3	GRID CABLE TRAY 54 X 300mm	1
899	7003636-4	GRID CABLE TRAY 54 X 300mm	1
900	7003092-01	50mm PIPE 114,3X2	4
901	7003092-03	DACAPO EB10106616 114.3 X 3.0 mm R 152.0	4
902	7003092-02	1580mm PIPE 114,3X2	4
903	DACAPO TB57215835 4 INCH X 115 mm HOSE TAIL, BW, 316	DACAPO TB57215835 4 INCH X 115 mm HOSE T	4
904	DACAPO TB06213275 1 INCH X 150 mm WELDING NIPPLE, 316L, BSP, ISO 7-1	DACAPO TB06213275 1 INCH X 150 mm WELDIN	4
905	7003095	1" FITTING	4
906	7003739-1750	UNISTRUT MOUNTING RAIL WITH HOLES -STAINLESS STEEL- 1750mm	1
907	7003643-100	THREADED ROD M10 STAINLESS (100mm)	4
908	7003514	GRID CABLE TRAY 54 X 300mm	2
909	7002301		1

910	7002842-01	PIC MOUNTING FRAME WELDMENT	1
911	7002842-02	PIC MOUNTING PLATE	1
912	7002842-03	PIC MOUNTING PLATE	1
913	7002842-04	PIC MOUNTING PLATE	1
914	7002842-05	PIC MOUNTING PLATE	1
915	7002842-06	PIC BASE PLATE	1
916	7002546-16	PLATE FOR MOUNTING FRAME TO CONTAINER	8
917	PEM FHS-M8-20 ---C	FLUSH HEAD STUD PEM FHS-M8-20	4
918	7002842-07	PIC MOUNTING PLATE	2
919	7002842-08	PIC MOUNTING PLATE, BUSBAR	2
920	7002842-09	PIC MOUNTING PLATE	2
921	7002842-10	PIC MOUNTING PLATE	1
922	7002851	10` CONTAINER-POWER UNIT COVER PANEL	1
923	7002543	MICROGRID CONTROL PANEL	1
924	7002865	PLATE FOR MOUNTING PIC MANIFOLD	2
925	7002643	POWER ELECTRONIC COOLING MANIFOLD	4
926	7002664	MALE CONNECTOR CAM-16-16N-S316	2
927	7002663	MALE CONNECTOR Ø25,4-R1" CMC-16-16N-S316	2
928	7002866-01	POWER ELECTRONIC COOLING PIPE	1
929	TB06023215	DACAPO TB06023215 1 INCH X 40 mm WELDING	4
930	7002653-02	POWER ELECTRONIC COOLING PIPE	2
931	7002867-01	POWER ELECTRONIC COOLING PIPE	1
932	7001773	BALL VALVE - 1" MUFFE/MUFFE	2
933	7002024	FLOW SENSOR - LIQUID	2
934	7002025	FLOW SENSOR - LIQUID - MOUNT. EQUIP G1/2	2
935	7001560	DANFOSS NXA23005 CONVERTER	1
936	7002852	10` CONTAINER-POWER UNIT COVER PANEL	3
937	7002856	10` CONTAINER-POWER UNIT COVER PANEL	1
938	7002853	10` CONTAINER-POWER UNIT COVER PANEL	1
939	7002854	10` CONTAINER-POWER UNIT COVER PANEL	1
940	7002857	10` CONTAINER-POWER UNIT COVER PANEL	1
941	7002868	CUBIC S2000HD BUSBAR	1
942	7002859	UNISTRUT MOUNTING P1000 SS (1300)	2
943	7002861	PLATE FOR MOUNTING FRAME TO CONTAINER	4
944	7001559_01	LCL FILTER CAPACITORS	1
945	7001559_02	LCL FILTER DRIVE SIDE REACTOR	3
946	TRT000000225_STEP		1
947	7003673	ISO - INSULATORS	2
948	7003674-01	BRACKET FOR INSULATOR	2
949	7003674-02	BRACKET FOR INSULATOR	4
950	7003674-03	BRACKET FOR INSULATOR	2
951	7000831	WASHER ISO 7089 M16 A2 140 HV	4
952	ISO 4015 - M16 X 55 X 38-NEPDM70FZ		2

953	ISO 4014 - M16 X 100 X 38-CA	HEX HEAD BOLT ISO 4014 - M16 X 100 A2	2
954	7002412	BRAKER CABINET	1
955	7002820-01	FRAME	1
956	7002825	UNISTRUT MOUNTING RAIL P100SS (130mm)	4
957	7002826	UNISTRUT MOUNTING RAIL P1000SS (800mm)	2
958	7002828	ANGLE BRACKET P1026 SS	8
959	7002874-01	10´ CONT. VENT. ENCLOSURE PLATE	1
960	7002777-02	20´ CONT. VENT. ENCLOSURE BUSHING	8
961	7002789	UNISTRUT ANGLED BRACKET 90 DEGREE P1036	8
962	7002790	UNISTRUT MOUNTING RAIL P1000 T SS (205)	4
963	7002791	UNISTRUT MOUNTING P 1000 T SS (800mm)	2
964	7002877-01	FRAME FOR FILTER 01	1
965	7002803-02	HOLDER FOR FILTER FRAME	3
966	7002392	PILOT TUPE FOR DP L=40mm TUBE CONNECTION	1
967	7001551	BELIMO PRESSURE DIFF. SENSOR 22ADP-184	1
968	7002278	CONTAINER VENTILATION FAN	1
969	7002788	10`-20´ CONT. FANSEALING EPDM GAS TIGHT	1
970	7002875	10´ CONT. VENT. ENCLOSURE COVER PLATE	2
971	7003411	COVER PLATE, STAINLESS STEEL, FOR CONTAINER	2
972	7003412	RUBBER GASKET 270X1367MM	2
973	7003660	COVER PLATE 220X852MM	1
974	7002859-07	UNISTRUT MOUNTING P1000 SS (1300)	2
975	4302	GRID CABLE TRAY 54 X 300mm	1
976	7003495-01		2
977	7003495-02		1
978	7003659-1	2" RUBBER HOSE	2
979	7003508-3	WIBE CABLE LADDER KHZP-300	2
980	7003504-3	C RAIL F. MOUTING	4
981	7003508-1	WIBE CABLE LADDER KHZP-300	1
982	7003509-1	WIBE CABLE LADDER KHZP-300	1
983	7003510		4
984	LT HEADERTANK PIPE		1
985	LT HEADERTANK PIPE		1
986	DACAPO TB29183590 1 INCH UNION BW_BW, CONICAL, 4308, BSP, ANSI B16.2		2
987	LT HEADERTANK HOSE		1

Sub Section C05

Piping Line List

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	5/30/2023	First Issue
002	8/11/2023	Expanded, completed list
003	9/15/2025	Updated, As build

Document Title:	**BLPH Project - Piping Line List and Speciality Item List**
Document Number:	K559-2254-CWIWP4202202-C05-001
Revision:	Rev0013
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Purchaser Job:	K559-2254
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Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Piping Class Overview and Piping Line List

Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS

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		3	P&I diagram: Piping overview : Hydrogen - Hydrogen	08-Sep-25
		4	P&I diagram: Piping overview : Water - Water	28-Mar-25
		5	P&I diagram: Piping overview : Ventilation - ProcessExhaust	28-Mar-25
		6	P&I diagram: Piping overview : HT_Coolant - HT_Coolant	15-Oct-24

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	06
EPLAN Project Pages	574
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REVISION INFORMATION
DESCRIPTION
CO???????
DATE
08-Sep-25

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DRAWING	K559-2254-CWIWP4202202-C05-001	REVISION	06
DRAWING TITLE	Piping Line List (C05-001)		
SHEET TYPE/DESC	Document C05 Introduction		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 6

Pre-planning: Pipe class overview

F49_001

Pipe class		Description	Standard	Nominal pressure level	Material
1	Customer Scope	Piping is within Customer Scope	Customer Scope	Customer Scope	AISI 316 Suggested
2	DN25-PIPE	Seamless hydraulic pipe, acid-resistant	EN 10216-5, ASTM A269/A213	166 bar dynamic, 194 static (DIN2421)	AISI 316
3	DN32-PIPE	Seamless hydraulic pipe, acid-resistant	EN 10216-5, ASTM A269/A213	166 bar dynamic, 194 static (DIN2421)	AISI 316
4	DN50-PIPE	Stainless Steel Pipe, 2mm wall thickness	EN 10216-5	2mm pipe wall thickness	AISI 304
5	DN50x1.6	60,3 x 1,6mm Pipe, Material 1.4404	EN 1092-1	n/a	1.4404 (X2XrNiMo17-12-2)
6	DN80x2.0	88.9 x 2.0 mm Pipe, Material 1.4404	EN 1092-1	n/a	1.4404 (X2XrNiMo17-12-2)
7	RadiaCord-122	Ø 122mm x 6,0mm, Flexible Coolant Hose	DIN 73411	4bar	EPDM

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P&I diagram: Piping overview

F37_001-BPSE

Piping Name	From (Source)	To (Target)	Pipe Class	Length	Substance (Contents)	Pressure	Flow	Temperature	
-HKN70_H2	=HKN70-C01	=HA01+DA02-XM01	CustomerScope		Hydrogen	4.0 - 6,5 barg	0,9 - 29,4 g/s	-8,4 - 25°C	
-WP_H2900	=HA01+DA02-XM01	=HA01+DA02-QM00	DN32-PIPE		Hydrogen	3,5 - 6,5 barg	0,9 - 29,4 g/s	-8,4 - 80°C	
-WP_H2901	=HA01+DA02-QM00	=HA01+DA02-QM04	DN32-PIPE		Hydrogen	3,5 - 6,5 barg	0,9 - 29,4 g/s	-8,4 - 80°C	
-WP_H2902	=HA01+DA02-QM2.6	=HA01+DA02-QM1.6	DN25-PIPE	220 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2903	=HA01+DA02-QM2.5	=HA01+DA02-QM1.5	DN25-PIPE	220 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2904	=HA01+DA02-QM2.4	=HA01+DA02-QM1.4	DN25-PIPE	220 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2905	=HA01+DA02-QM2.3	=HA01+DA02-QM1.3	DN25-PIPE	220 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2906	=HA01+DA02-QM2.2	=HA01+DA02-QM1.2	DN25-PIPE	220 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2907	=HA01+DA02-QM1.1	=HA01+DA02-QM2.1	DN25-PIPE	220 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2912	=HA01+DA02-QM2.6	=HA01+DA02-XT06	DN25-PIPE	5477 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2913	=HA01+DA02-QM2.5	=HA01+DA02-XT05	DN25-PIPE	4390 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2914	=HA01+DA02-QM2.4	=HA01+DA02-XT04	DN25-PIPE	3303 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2915	=HA01+DA02-QM2.3	=HA01+DA02-XT03	DN25-PIPE	3462 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2916	=HA01+DA02-QM2.2	=HA01+DA02-XT02	DN25-PIPE	4547 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2917	=HA01+DA02-QM2.1	=HA01+DA02-XT01	DN25-PIPE	5637 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2922	=HA01+DA02-XT06	=RE02+GB06-XM01	DN25-PIPE	5477 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2923	=HA01+DA02-XT05	=RE02+GB05-XM01	DN25-PIPE	4390 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2924	=HA01+DA02-XT04	=RE02+GB04-XM01	DN25-PIPE	3303 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2925	=HA01+DA02-XT03	=RE01+GB03-XM01	DN25-PIPE	3462 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2926	=HA01+DA02-XT02	=RE01+GB02-XM01	DN25-PIPE	4547 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2927	=HA01+DA02-XT01	=RE01+GB01-XM01	DN25-PIPE	5637 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	12 - 80°C	
-WP_H2942	=HA01+DA02-CM01-WP06	=HA01+DA02-QM06	DN25-PIPE	190 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	-8,4 - 80°C	
-WP_H2943	=HA01+DA02-CM01-WP05	=HA01+DA02-QM05	DN25-PIPE	190 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	-8,4 - 80°C	
-WP_H2944	=HA01+DA02-CM01-WP04	=HA01+DA02-QM04	DN25-PIPE	190 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	-8,4 - 80°C	
-WP_H2945	=HA01+DA02-CM01-WP03	=HA01+DA02-QM03	DN25-PIPE	190 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	-8,4 - 80°C	
-WP_H2946	=HA01+DA02-CM01-WP02	=HA01+DA02-QM02	DN25-PIPE	190 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	-8,4 - 80°C	
-WP_H2947	=HA01+DA02-CM01-WP01	=HA01+DA02-QM01	DN25-PIPE	190 mm	Hydrogen	3,5-6,5 barg	<4,9 g/s	-8,4 - 80°C	

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	06
EPLAN Project Pages	574
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REVISION INFORMATION
DESCRIPTION
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DRAWING	K559-2254-CWIWP4202202-C05-001	REVISION	06
DRAWING TITLE	Piping Line List (C05-001)		
SHEET TYPE/DESC	P&I diagram: Piping overview : Hydrogen - Hydrogen		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 3 / 6

P&I diagram: Piping overview

F37_001-BPSE

Piping Name	From (Source)	To (Target)	Pipe Class	Length	Substance (Contents)	Pressure	Flow	Temperature	
	+DA01-X10	=HKN70-XM02			Water		<13,2 l/min	10-50°C	
	=HKN70-XM02				Water		<6,6 l/min	50-80°C	
	=HKN70-XM02				Water		<6,6 l/min	50-80°C	
		=HKN70-XM02	DN50-PIPE		Water		<13,2 l/min	50-80°C	
					Water			Ambient Temp	

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	574		
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DRAWING	K559-2254-CWIWP4202202-C05-001	REVISION	06
DRAWING TITLE	Piping Line List (C05-001)		
SHEET TYPE/DESC	P&I diagram: Piping overview : Water - Water		

ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 4 / 6

P&I diagram: Piping overview

F37_001-BPSE

Piping Name	From (Source)	To (Target)	Pipe Class	Length	Substance (Contents)	Pressure	Flow	Temperature	
-WP_A2010	=JA02+DA02-WM07		DN50x1.6		Ventilation	<50mbarg	120 Nm³/h	5-45°C	
-WP_A2011	=JA02+DA02-WM08		DN50x1.6		Ventilation	<50mbarg	120 Nm³/h	5-45°C	
-WP_A2012	=JA02+DA02-WM09		DN50x1.6		Ventilation	<50mbarg	120 Nm³/h	5-45°C	
-WP_A2013	=JA02+DA02-WM10		DN50x1.6		Ventilation	<50mbarg	120 Nm³/h	5-45°C	
-WP_A2014		=JA02+DA02-WM11	DN50x1.6		Ventilation	<50mbarg	120 Nm³/h	5-45°C	
-WP_A2015	=JA02+DA02-WM12		DN50x1.6		Ventilation	<50mbarg	120 Nm³/h	5-45°C	
-WP_A2015	=JB01+DA02-HQ01	=JB01+DA02-HQ01	DN50x1.6		Ventilation	<50mbarg	<10 Nm³/h	25-65°C	
-WP_A2020	=JA02+DA02-WM01		DN80x2.0		ProcessExhaust	<50mbarg	650 Nm³/h	50-80°C	
-WP_A2021	=JA02+DA02-WM02		DN80x2.0		ProcessExhaust	<50mbarg	650 Nm³/h	50-80°C	
-WP_A2022	=JA02+DA02-WM03		DN80x2.0		ProcessExhaust	<50mbarg	650 Nm³/h	50-80°C	
-WP_A2023		=JA02+DA02-WM04	DN80x2.0		ProcessExhaust	<50mbarg	650 Nm³/h	50-80°C	
-WP_A2024	=JA02+DA02-WM05		DN80x2.0		ProcessExhaust	<50mbarg	650 Nm³/h	50-80°C	
-WP_A2025		=JA02+DA02-WM06	DN80x2.0		ProcessExhaust	<50mbarg	650 Nm³/h	50-80°C	

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	574		
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DRAWING	K559-2254-CWIWP4202202-C05-001	REVISION	06
DRAWING TITLE	Piping Line List (C05-001)		
SHEET TYPE/DESC	P&I diagram: Piping overview : Ventilation - ProcessExhaust		

ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	5 / 6

P&I diagram: Piping overview

F37_001-BPSE

Piping Name	From (Source)	To (Target)	Pipe Class	Length	Substance (Contents)	Pressure	Flow	Temperature	
-WP_C101		=HE01+DA02-EG01	RadiaCord-122		HT_Coolant		<100 m³/h	40-55 °C	
-WP_C102		=HE02+DA02-EG01	RadiaCord-122		HT_Coolant		<100 m³/h	40-55 °C	
Overflow					HT_Coolant			Ambient Temp	
Overflow					HT_Coolant			Ambient Temp	

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	574		
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DRAWING TITLE	Piping Line List (C05-001)		
SHEET TYPE/DESC	P&I diagram: Piping overview : HT_Coolant - HT_Coolant		

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Sub Section C06

Electrical Single Line Diagram

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Revision history		
Rev.	**Date.**	**Description**
001	2/3/2023	First Issue
002	2/17/2023	Modified according to comments
003	3/24/2023	Further detailed and expanded
004	9/18/2023	Updated and expanded
005	3/8/2024	Updated according to comments
006	4/9/2024	Exp. to include fan contactors
007	10/15/2024	Updated with changed water separator
008	9/9/2025	Updated. As build

Document Title:	**BLPH Project - Electrical Single Line Diagrams**
Document Number:	BPSE-ELE-BPH-DWG-00005
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File Name:	K559-2254-CWIWP4202202-C06-001Rev008
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C06
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Single Line Diagrams

Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS

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AC Distribution - 40ft Container

Crosswind Scope

Ballard Scope

=HKN70-XB01
3p+N+PE 400Vac
20kW

=BA20+UC50
AC Power Distribution

-XB01
AUX Supply Terminals

-SG01
63 A
Switch Disconnector

-FA01
Uc:277V
Iimp: 25 kA
Surge Arrester

-FC06
2A, B curve
MCB

AUX Customer Supply
Voltage Meas
3ph 400V
-BA01

-BC02
+UC50&CO3/10.1
+UC50&CO3/10.1
+UC50&CO3/10.1
3ph 75A
AUX Customer Supply
Current Trafo

-FC02
50A, C curve
MCCB

-FC12
63A, C Curve
MCCB

-QA02
55A
Isolation Contactor, 4 pole

3p+N 400-480V 50/60Hz

-FC10
2A, C-curve
MCCB

-FC01
250A, 3p+N
MCCB

Nanogrid Internal
Voltage Meas
3ph 400V
-BA02

-QA01
55A
Isolation Contactor, 4 pole

-FC05
32A, B-curve
MCCB

-FC04
63A, B Curve
MCCB

-FC04
160A, 3p+N
MCCB Cooling Skid
+UC30

=BA20+DA01

Transformer, dry-type
-TA03
0,46/0,4-0,48
Dyn11 160kVA

=AA01+WZ10
Container Interconnect, Between Containers

BP1 AC Supply from Transformer 250A / 4.3:B

BP2 AC Supply to Container #2 - 32A / 4.3:C

=LA01+UC20
Control System, Container #1 Inside

-QB01
63A, 3ph+N
Switch Disconnector

3p+N 400-480V 50/60Hz

-FC01A
6A, B-curve
MCCB

-FC01B
6A, B-curve
MCCB

-FC01C
6A, B-curve
MCCB

-FC02
4A, B-curve
MCCB

-FC06
10A, B-curve
MCCB

-FC07
10A, B-curve
MCCB

-FC03A
6A, B-curve
MCCB

-FC03B
6A, B-curve
MCCB

-FC04
10A, C-curve
RCD/MCB

-FC08
20A, B-curve
MCCB

-FC09
20A, B-curve
MCCB

-FC10
20A, B-curve
MCCB

-FC11
10A, B-curve
MCCB

-TB01A
24-28V/40ADC
FCwave PSU
with UPS

-TB01B
24-28V/40ADC
FCwave PSU
with UPS

-TB01C
24-28V/40ADC
FCwave PSU
with UPS

-TB02
24-28V/10ADC
Control PSU
with UPS

-QB02
50A, 24V coil
Contactor

-QB03
50A, 24V coil
Contactor

-QA08
25A
Solidstate
Contactor

-QA09
25A
Solidstate
contactor

-QA10
25A
Solidstate
contactor

-GB01A
UPS Battery
24V, XY Ah

-GB01B
UPS Battery
24V, XY Ah

-GB01C
UPS Battery
24V, XY Ah

-GB02
UPS Battery
24V, XY Ah

-XD04
1P+N+PE, 1kW
Service

=HE01+UC30
Coolant Skid Cabinet, Container #1 Outside

3p+N 400-480V 50/60Hz

-FC01
6A, B-curve
MCCB

-FC02
2A, B-curve
MCCB

-FC19
25A, B-curve
MCCB

-FC11
6A, B-curve
MCCB

-FC12
6A, B-curve
MCCB

-FC13
6A, B-curve
MCCB

-FC14
6A, B-curve
MCCB

-FC15
6A, B-curve
MCCB

-FC16
6A, B-curve
MCCB

-FC40
13A, B-curve
MCCB

-TB01
24-28V/10ADC
PSU with UPS

-BT02
5°C
Temperature Switch

-GB01
24V Backup Battery
24V, XY Ah

-EA02
0,4W
Cabinet Heater

-TA19
15kW
3x 380-500 VAC
HT Pump Drive

=HE01+UC41
HT + LT VFD Cabinet

-TA11
4.0kW
VFD

-TA12
4.0kW
VFD

-TA13
4.0kW
VFD

-TA14
4.0kW
VFD

-TA15
4.0kW
VFD

-TA16
4.0kW
VFD

-EC40
VFD Cabinet Chiller

=HE01+DA02
HT Cooling System #1, Container #1 Outside

-GP19
15kW
HT1
Coolant Pump

-GQ11
4kW
Ventilation Fan

-GQ12
4kW
Ventilation Fan

-GQ13
4kW
Ventilation Fan

-GQ14
4kW
Ventilation Fan

-GQ15
4kW
Ventilation Fan

-GQ16
4kW
Ventilation Fan

=HE01+UC30
Coolant Skid Cabinet, Container #1 Outside

3p+N 400-480V 50/60Hz

-FC41
20A, B-curve
MCCB

-FC42
20A, B-curve
MCCB

-FC03
2A, B-curve
MCCB

-FC29
25A, B-curve
MCCB

-FC21
6A, B-curve
MCCB

-FC22
6A, B-curve
MCCB

-FC23
6A, B-curve
MCCB

-FC24
6A, B-curve
MCCB

-FC25
6A, B-curve
MCCB

-FC26
6A, B-curve
MCCB

-FC31
6A, B-curve
MCCB

-QA41
25A
Solidstate
contactor

-QA42
25A
Solidstate
contactor

-EA03
Container
Lighting

-TA29
15kW
3x 380-500 VAC
HT Pump Drive

=HE01+UC41
HT + LT VFD Cabinet

-TA21
4.0kW
VFD

-TA22
4.0kW
VFD

-TA23
4.0kW
VFD

-TA24
4.0kW
VFD

-TA25
4.0kW
VFD

-TA26
4.0kW
VFD

-TA31
4.0kW
VFD

-EB01
3x480V, 3x15kW
H2 Heater

9kW
Heating Element

9kW
Heating Element

=HE02+DA02
HT Cooling System #2, Container #1 Outside

-GP29
15kW
HT2
Coolant Pump

-GQ21
4kW
Ventilation Fan

-GQ22
4kW
Ventilation Fan

-GQ23
4kW
Ventilation Fan

-GQ24
4kW
Ventilation Fan

-GQ25
4kW
Ventilation Fan

-GQ26
4kW
Ventilation Fan

=HE03+DA02
LT Coolant System Cooler, Container #1 Outside

-GQ31
4kW
Ventilation Fan

=JA01+DA01
Container Ventilation, Inside Container #1

-EA01
Container
Lighting

-GQ06
4,3 kW
Ventilation Fan

-GQ07
4,3 kW
Ventilation Fan

=JA01+UC07
Container Ventilation, Fan/Heater Assembly

-GQ08
1kW
Ventilation Fan

-GQ09
1kW
Ventilation Fan

-EB01
3x480V, 3x15kW
Container Heater

15kW
Heating Element

15kW
Heating Element

15kW
Heating Element

=HE03+DA01
LT Cooling System, Container #1 Inside

-TA11
4kW
3x380-500VAC
LT Pump Drive

-GP11
4kW
LT Circuit Pump

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	628
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REVISION INFORMATION	
DESCRIPTION	
DATE	29-Sep-25

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DRAWING	6014568 C06 Single Line Diagram
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Single Line Diagram - 40ft Container AC
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 2 / 8

FRM510365 3/0B

DC Distribution - 40ft Container

=AA01+WZ10
Container Interconnect, Between Containers

DC1 DC Bus to Container #2 / 4.3:G
DC2 DC Bus to Container #2 / 4.3:G
DC3 DC Bus to Container #2 / 4.3:G
DC4 DC Bus to Container #2 / 4.3:G
DC5 DC Bus to Container #2 / 4.3:G
DC6 DC Bus to Container #2 / 4.3:G

=BA01
Power Conversion Block #1, Container #1 Inside

+UC01
DCDC Cabinet #1, Inside Container #1

-QB01
Switch Disconnector

-FC03
215A

-TA01
DCDC Drive

-TA02
DCDC Drive

-RB01
Converter Inductor

-RB02
Converter Inductor

-FC01
315A

-FC02
315A

+UC02
DCDC Cabinet #2, Inside Container #1

-QB01
Switch Disconnector

-FC03
215A

-TA03
DCDC Drive

-TA04
DCDC Drive

-RB03
Converter Inductor

-RB04
Converter Inductor

-FC01
315A

-FC02
315A

+UC03
DCDC Cabinet #3, Inside Container #1

-QB01
Switch Disconnector

-FC03
215A

-TA05
DCDC Drive

-TA06
DCDC Drive

-RB05
Converter Inductor

-RB06
Converter Inductor

-FC01
315A

-FC02
315A

=BA02
Power Conversion Block #2, Container #1 Inside

+UC04
DCDC Cabinet #4, Inside Container #1

-QB01
Switch Disconnector

-FC03
215A

-TA07
DCDC Drive

-TA08
DCDC Drive

-RB07
Converter Inductor

-RB08
Converter Inductor

-FC01
315A

-FC02
315A

+UC05
DCDC Cabinet #5, Inside Container #1

-QB01
Switch Disconnector

-FC03
215A

-TA09
DCDC Drive

-TA10
DCDC Drive

-RB09
Converter Inductor

-RB10
Converter Inductor

-FC01
315A

-FC02
315A

+UC06
DCDC Cabinet #6, Inside Container #1

-QB01
Switch Disconnector

-FC03
215A

-TA11
DCDC Drive

-TA12
DCDC Drive

-RB11
Converter Inductor

-RB12
Converter Inductor

-FC01
315A

-FC02
315A

=RE01
Fuel Cell Block 1

+GB01
Fuel Cell Module 1

-GB01
720-350V, 0-300A
Fuel Cell Stacks

-GB02
720-350V, 0-300A
Fuel Cell Stacks

+GB02
Fuel Cell Module 2

-GB01
720-350V, 0-300A
Fuel Cell Stacks

-GB02
720-350V, 0-300A
Fuel Cell Stacks

+GB03
Fuel Cell Module 3

-GB01
720-350V, 0-300A
Fuel Cell Stacks

-GB02
720-350V, 0-300A
Fuel Cell Stacks

=RE02
Fuel Cell Block 2

+GB04
Fuel Cell Module 4

-GB01
720-350V, 0-300A
Fuel Cell Stacks

-GB02
720-350V, 0-300A
Fuel Cell Stacks

+GB05
Fuel Cell Module 5

-GB01
720-350V, 0-300A
Fuel Cell Stacks

-GB02
720-350V, 0-300A
Fuel Cell Stacks

+GB06
Fuel Cell Module 6

-GB01
720-350V, 0-300A
Fuel Cell Stacks

-GB02
720-350V, 0-300A
Fuel Cell Stacks

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	628
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DATE	29-Sep-25

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DRAWING	6014568 C06 Single Line Diagram
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Single Line Diagram - 40ft Container DC
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1	LANGUAGE EN	SHEET/TOTAL 3 / 8

FRMS103653/0B

AC/DC Distribution - 10ft Container

Crosswind Scope

Ballard Scope

=AA01+WZ10
Container Interconnect, Between Containers

=HKN70-XB02
3ph 6,6 kV

=HKN70-FC01
MV Latched Contactor

=HKN70-FC02
400A
Fuse

=BA30+DA03
Power Conversion Output, Inside Container #2

-TA30
1250kVA
400/6600V Transformer
Dry-type

-FC31
250A
250A Breaker

-FC30
2000A
2000A Breaker

-FC40
2.5..4A
Circuit Breaker
for Primary Transformer Protection

-RB30
500V, 840A
0,084mH, 203uF
LC Filter

-RB31
500V, 840A
0,084mH, 203uF
LC Filter

-TA40
0,4/0,4 kV, 2kVA
Isolation Transformer

-TB30
1640 A, 3x 400-500 VAC
Active Front End

-QA40
Precharge Contactor

-TB40
60A
Rectifier, 3ph doide bridge

-RA40
4 pcs 3,3Ω, 1000W
Resistor

-FC29
800A
Fuse

-FC32
800A
Fuse

-FC41
20A

DC Busbar System

2.15:B / 3ph AC Supply to Container #1 - 250A BP1

2.15:B / 3ph+N AC Supply from Container #1 - 32A BP2

3ph 400-480V, 50-60Hz

=LA01+UC31
Control System, Container #2 Inside

-QB01
32A, 3p+N
Switch Disconnector

3ph+N 400-480V, 50-60Hz

-FC01
4A, B-curve
MCCB

-FC03
13A, B-curve
MCCB

-FC04
10A, B-curve
MCCB

-FC07
4A, B-curve
MCCB

-FC08
10A, C-curve
RCB/MCB

-TB33
24-28V/10ADC
PSU with UPS

-GB01
UPS Battery
24V, XY Ah

-QA03
4...32 V DC/48...600 V AC
Solidstate contactor
Container Heating

-EA07
Room Lighting

-XD08
1kW
Service Outlet

=JA01+DA03
Container Ventilation System, Inside Container #2

-EB03
10kW
Container Heating

-GQ10
5,7kW
Ventilation Fan

3.15:B / DC Bus from Fuel Cells DC1

3.15:B / DC Bus from Fuel Cells DC2

3.15:B / DC Bus from Fuel Cells DC3

6x (2x120 mm2)

3.15:B / DC Bus from Fuel Cells DC4

3.15:B / DC Bus from Fuel Cells DC5

3.15:B / DC Bus from Fuel Cells DC6

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	628
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DATE	29-Sep-25

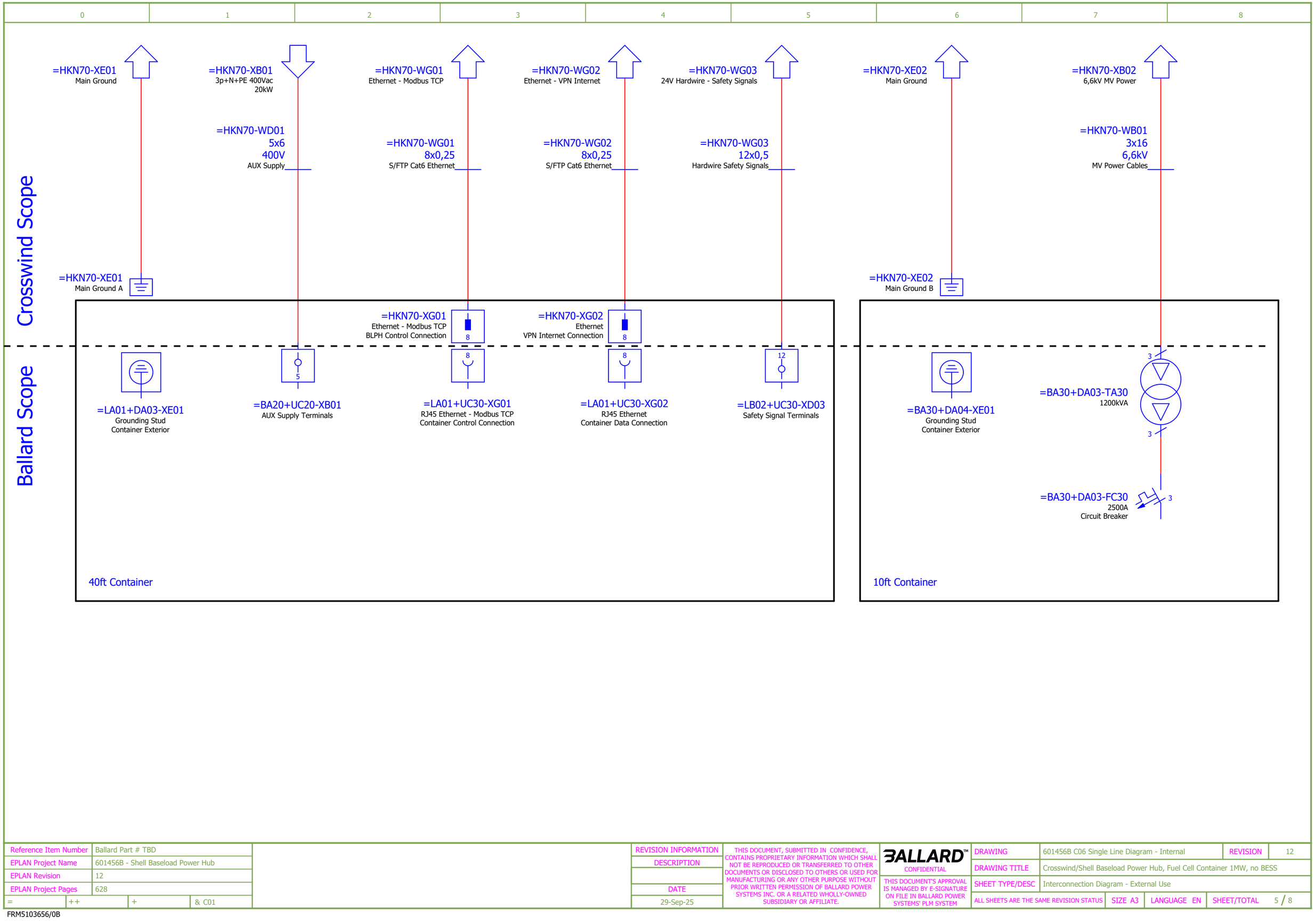
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DRAWING	6014568 C06 Single Line Diagram
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Single Line Diagram - 10ft Container
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 4 / 8

FRM5103653/0B



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	628		
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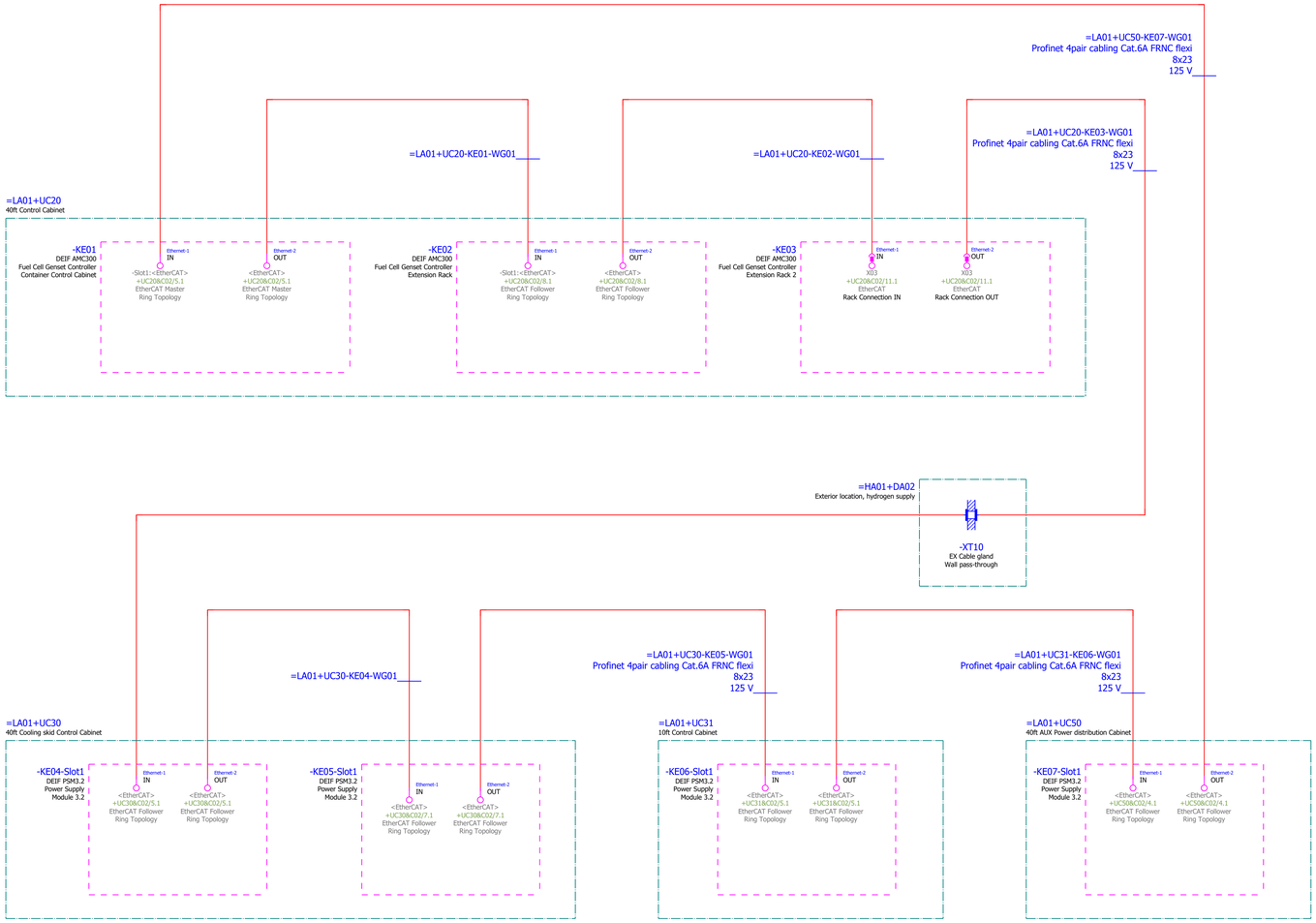
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DRAWING	601456B C06 Single Line Diagram - Internal	REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Interconnection Diagram - External Use		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 5 / 8



Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	628
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DRAWING	6014568 C06 Single Line Diagram - Internal
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Single Line Diagram -Ethercat Network,
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 | LANGUAGE EN | SHEET/TOTAL 6 / 8

=LA01+UC31
10ft Control Cabinet

-KE06
DEIF AMC300
Controller Extension Rack

Ethernet-1
IN
X03
+UC31&C02/5.1
EtherCAT
EtherCAT Follower
Ring Topology

Ethernet-2
OUT
X03
+UC31&C02/5.1
EtherCAT
EtherCAT Follower
Ring Topology

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
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- ++ + & C01	

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DRAWING	6014568 C06 Single Line Diagram - Internal
REVISION	12
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Single Line Diagram - Network, 10ft
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1 · LANGUAGE EN · SHEET/TOTAL 7 / 8

FRM5103653/08

=HE01+UC41

-TA11
VFD - HT1 Fan 1
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA12
VFD - HT1 Fan 2
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA13
VFD - HT1 Fan 3
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA14
VFD - HT1 Fan 4
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA15
VFD - HT1 Fan 4
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA16
VFD - HT1 Fan 6
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA21
VFD - HT2 Fan 1
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA22
VFD - HT2 Fan 2
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA23
VFD - HT2 Fan 3
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA24
VFD - HT2 Fan 4
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA25
VFD - HT2 Fan 5
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA26
VFD - HT2 Fan 6
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-TA31
VFD - LT Fan
4.0kW / 5.5HP, 3x 380-480 VAC
Net1
ETH01

-KF41
16 port network
VFD Cabinet Network Switch
V2+
Port 2
1
Port 3
1
Port 4
1
Port 5
1
Port 6
1
Port 7
1
Port 8
1
Port 9
1
Port 10
1
Port 11
1
Port 12
1
Port 13
1
Port 14
1
Port 15

R1.2
Port 1

=LA01+UC30
Coolant Skid Control Cabinet

-KF110
16 port
Unmanaged Switch
Port 7
7
7 Ethernet
Port 1
1
Ethernet 1
Port 4
4
4 Ethernet
Port 5
5
5 Ethernet
Port 16
16
16 Ethernet

-TA19
VFD, 15kW
HT Pump #1 Drive
1
RJ-45
OPT-E9

-TA29
VFD, 15kW
HT Pump #2 Drive
1
RJ-45
OPT-E9

-KF120
4G/LTE
WLAN Gateway
Firewall
1
ODV1

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	12
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Sub Section C07

Cause and Effects Charts

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001	3/10/2023	First Issue
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003	9/15/2025	Updated, As build

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Short Title	C07 – Cause and Effect Matrix
Full Title	Cause and effect Matrix for the primary control system for the Fuel Cell container (1MW) for Crosswind Baseload Power Hub

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	PBL	March 2023
2.0	Revision according to comments to K559-2254-CWIWP4202202-C07-001Rev001 Rework from fishbone diagram to C&E matrix	PBL	April 2023
3.0	Update to As-built documentation	PBL	Sept 2025

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1.0 Purpose

The purpose of this document is to provide a cover sheet and explanation of the cause-and-effect matrix attached to this document (Appendix 1).

This diagram illustrates the causal relationship between events that may occur, the inputs registering these events and the resulting effect this will have on the entire fuel cell system, as seen from outside the container.

All specific technical details and further description of causes and effect will be found in the referenced documents.

The reader should refer to this diagram while reading this document.

2.0 References

Table 1: Reference Documents

Document ID	Short ID	Document Title	Source
K559-2254-DM-PRO-001	n/a	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-C03-001	C03	Process and Instrumentation Diagrams	BPSE
K559-2254-CWIWP4202202-C06-001	C06	Electrical Single Line Diagram	BPSE
K559-2254-CWIWP4202202-C08-002	C08-002	FC Package Modbus Map	BPSE
K559-2254-CWIWP4202202-C08-003	C08-003	FC Package Alarm List	BPSE
K559-2254-CWIWP4202202-E06-001	E06	Computer System Documentation	BPSE

3.0 Appendix

Table 2: Appendix Documents

Document ID	Short ID	Document Title	Source
601456B-C07-A1	Appendix 1	Cause and Effect Matrix	BPSE

4.0 Safety

4.1 Introduction

The safety system of the fuel cell system container is physically separate safety rated control system, monitoring the essential safety parameters of the container.

The safety system is powered from an independent 24V supply with battery backup, with a UPS duration exceeding 30 minutes. The primary safety system is located in the control cabinet inside the 40ft container (=LB02+UC30) with a secondary connected safety controller located in the 10ft container (=LB02+UC31) with a safety rated interconnect.

4.2 Safety System Hardware

Please refer to document E06 Computer System Documentation

4.3 Tripping the Safety System

The entire fuel cell system will trip if any single of the inputs to the safety controller is outside acceptable parameters, e.g. hydrogen detection, E-Stop activation or external trip. These are further described in section

"5.0 Cause – Safety".

4.4 System Safe State

The system safe state is defined as the state where sources of energy has been disconnected (gas, electricity) and the process stopped.

- Hydrogen valves are de-energized and shut (normally closed)
- Power converters Safe Torque-Off function is activated.
    - This applies to fuel cell DCDC converters and main DCAC converter.
- Motor drives Safe Torque-Off function is activated.
    - This applies to coolant system pumps.
- Main breaker is opened.
    - Disconnect from the BLPH 6,6kV grid.
- Fuel Cell Modules emergency stop is activated.
    - Closes module internal H2 valves and opens contactors for the fuel cell module.

5.0 Cause – Safety

The section describes the causes related to the safety system.

5.1 Hydrogen Detection

The 40ft container has the following hydrogen sensors:

- 3 Sensors located inside the container, monitoring the inlet and outlet of the ventilation air.
- 2 Sensor inside each FCwave module (12 total), monitoring the hydrogen concentration in the ventilation air

5.2 Fire detection

The 40ft container has the following fire detection sensors:

- 3 smoke detectors inside the container, monitoring the inlet and outlet of the ventilation air.

- Each FCwave module contains an internal smoke detector and linear heat detector.

The 10ft container contains the following fire detection sensor:

- A smoke detector inside the container.

5.3 Emergency Stop

The hardwired emergency stop locations are:

- Control cabinet inside 40ft container
- Inside access door for the 40ft container
- On control panel door for coolant skid control panel

5.4 Physical protection

The access to the 10ft container must be safely restricted, as the container internally has IP00 rated high voltage equipment.

The container end door to the 10ft container is equipped with non-contact safety switches.

6.0 Cause – Fuel Cell Modules and Power Converters

6.1 Introduction

The 6 fuel cell modules inside the 40ft container and the power conversion equipment inside the 40ft and 10ft container may be the cause of derates or loss of production.

6.2 FCwave Internal Warning or Alarm

- The FCwave modules provides a warning when a process parameter is at the edge of allowable parameters.
- FCwave modules may perform a controlled shutdown if a process parameter exceeds allowable limits. This will reduce the maximum available power by 1/6 of the total power. The remaining 5 modules will continue operating.

6.3 DCDC Converter Trip

- Each of the 6 FCwave modules are connected to a pair of DCDC converters managing the power flow from individual modules to the common DC bus.
- If a converter trips, the connected FCwave module is also unavailable for power production. This will reduce the maximum available power by 1/6 of the total power. The remaining 5 modules will continue operating.
- This may be caused by e.g., insufficient cooling.

6.4 DCAC Converter Trip

- The power produced by the fuel cell modules is converted to AC power by a single DCAC power converter, which may also trip offline.

7.0 Cause – Coolant

7.1 Introduction

The coolant systems responsible for rejecting the heat generated by the fuel cell modules and power converters may be unable to dissipate the desired amount of heat or fail entirely

The two coolant systems are designated HT1 and HT2:

- HT1 is responsible for cooling FC1-3
- HT2 is responsible for cooling FC4-6

7.2 HT Coolant Group Derate

3 FCwave modules share a coolant system, which will reduce the power available from the modules if the cooling system is unable dissipate the heat.

- Fan failure
    - A failed fan on the HT cooler will reduce the total available cooling capacity. On days where the full cooling capacity is needed (high ambient temperatures), this may derate the cooling group and subsequently derate the available power from the modules connected to the cooling group.
- Valve failure
    - A valve may fail stuck in a given position and cause reduced cooling capacity.
- Temperature sensor failure
    - A temperature sensor may fail, hindering the control system from correctly regulating the coolant group.
- Coolant Radiator Blockage
    - The radiator fins on the radiators may be blocked by debris or damaged, hindering heat dissipation.

7.3 HT Coolant Group Loss

Some failure scenarios will prevent the coolant group from operating, and prevent the connected FCwave modules from operating, causing the power available from the container to be derated to half

- HT Pump Failure
    - If the pump driving the coolant loop fails, the coolant group is unable to dissipate any heat from the attached modules.
- Loss of coolant media
    - If a damaged or burst hose or pipe causes total loss of the coolant media, the cooling group is unable to function.
- Valve failure
    - If a valve fails stuck in certain positions, the flow of coolant through the cooler is prevented and the coolant group is unable to function.
- Fan failure
    - Fan failures may prevent correct airflow over the cooling surfaces or insufficient air flow at high ambient temperatures.

7.4 LT Coolant Group Derate

The LT coolant system provides liquid cooling to power electronics in the container and FCwave modules. If this coolant system cannot dissipate the required heat, the container will need to derate its output.

- Fan failure
    - A failed fan on the LT cooler will reduce the total available cooling capacity. On days where the full cooling capacity is needed (high ambient temperatures), this may derate the cooling group and subsequently derate the available power from the modules connected to the cooling group.

- Valve failure
    - A valve may fail stuck in a given position and cause reduced cooling capacity.
- Temperature sensor failure
    - A temperature sensor may fail, hindering the control system from correctly regulating the coolant group.
- Coolant Radiator Blockage
    - The radiator fins on the radiators may be blocked by debris or damaged, hindering heat dissipation.

7.5 LT Coolant Group Loss

Some failure scenarios will prevent the LT coolant group from operating, and prevent the fuel cell modules and power electronics from working.

- LT Pump Failure
    - If the pump driving the coolant loop fails, the coolant group is unable to dissipate any heat from the attached modules.
- Loss of coolant media
    - If a damaged or burst hose or pipe causes total loss of the coolant media, the cooling group is unable to function.
- Valve failure
    - If a valve fails stuck in certain positions, the flow of coolant through the cooler is prevented and the coolant group is unable to function.
- Fan failure
    - Fan failures may prevent correct airflow over the cooling surfaces or insufficient air flow at high ambient temperatures.

7.6 Process Water Drain Blockage

The process water drain serves as the drain for the water produced by the fuel cell modules during operation.

If this drain is blocked, the fuel cell package cannot operate. The most probable cause is a blockage in the downstream drain system.

8.0 Cause – Ventilation

8.1 Introduction

The ventilation system provides air for the container ventilation and process air for the fuel cells. The ventilation system maintains the interior of the fuel cell container at 20 Pa above ambient pressure.

If insufficient air is available, the fuel cell package will derate or shut down.

8.2 Ventilation Derate

If the ventilation system is unable to provide the full amount of air required for correct operation, the package will attempt to remain operational by derating the available power. Many ventilation derate functions are impacted by higher ambient temperatures.

- Intake damper blockage
    - The intake dampers may be blocked or stuck, preventing sufficient airflow.

- Intake ventilation failure
    - One or more of the intake ventilators may fail to operate, limiting the available air flow.
- Outlet louvre blockage
    - The ventilation outlets may be blocked, preventing egress of the ventilation air.
- Air filter blockage
    - The filters maintaining the air quality inside the container will get clogged over time, restricting the available airflow.

8.3 Ventilation Failure

Many of the causes for ventilation derate may progressively cause a ventilation failure, exacerbated by high ambient temperatures.

9.0 Cause – Integrator

9.1 Introduction

The connections to the integrator (BLPH) are required for correct operation of the fuel cell package. An exception may exist for the Aux supply connection during operation.

9.2 Integrator Aux Supply Failure

If the supply from the integrator is interrupted, one of two events will occur:

1. If the 6.6kV connection is not active, the fuel cell package is able to continue operating on battery supplies for a limited time. An alarm is raised to the BLPH control system.
2. If the 6.6kV connection is active, the fuel cell package will continue operating, supplied off the fuel cell power train. A warning is raised to the BLPH control system.

9.3 Integrator Communication Failure

If the communication is lost to the integrator (BLPH), the fuel cell package will perform a controlled shutdown and enter an idle state.

9.4 Integrator Safety Connection Failure / Trip

If the safety interlock is disabled or wires broken, the safety system is activated. This is also the case when it is intentionally triggered.

10.0 Effects - Safety

10.1 Introduction

This section describes the effects managed by the safety system, which will be caused by some of the abovementioned causes.

10.2 Fuel Cell Module Safety Trip

The fuel cell modules can be brought to a guaranteed safe state where energy sources are disconnected and the reaction is immediately stopped.

10.3 Hydrogen Valve Safety Override

The safety system has a safety-rated relay as a part of the supply to the solenoid valves, which enables the safety system to override and guarantee that the hydrogen valves are shut.

10.4 Power Converters STO

The safety system is connected to the Safe Torque-Off (STO) function on the power converters, which is a safety rated way of guaranteeing the power converters are shut down.

10.5 Motor Drives STO

The safety system is connected to the Safe Torque-Off (STO) function on the motor drives, which is a safety rated way of guaranteeing the drives are shut down.

11.0 Effects – Hydrogen Valve

11.1 Introduction

The hydrogen valves located on the outside of the container are electrically actuated, and of the normally-closed type.

11.2 Hydrogen Valves

Each of the 6 FCwave modules has a separate hydrogen string, with each string having a pair of direct acting solenoid valves in series. Each string is also fitted with a manual, lockable shutoff fitting.

12.0 Effects – FCwave Fuel Cell Modules

12.1 Introduction

This section describes the effects from the fuel cell modules, which may be derated or stopped, with a single module or multiple modules.

12.2 FCwave – Single Module Controlled Stop

Some causes may result in a single module performing its controlled stop sequence, where it signals stop of power production, ramps down and disconnects from the DC bus and H2 supply.

12.3 FCwave – Multiple Modules Controlled Stop

Some causes may result in multiple modules doing a controlled stop simultaneously. This is identical to the effect above but occurs for multiple modules.

12.4 FCwave – All Modules Controlled Stop

Some causes may result in all modules stopping. This is identical to the effect above but occurring for all modules.

12.5 FCwave – Single Module Derate

Some causes may result in a single module derating its output, until all process parameters return to normal ranges. The limited power productions is communicated to the package control system.

12.6 FCwave – Multiple Modules Derate / All Modules Derate

Some causes may result in multiple modules derating their output, e.g. high coolant temperatures.

13.0 Effects – Power Converters

13.1 Introduction

The power converters primary function is to control and condition the power from the fuel cells to match the power requested from the BLPH. The power converters require cooling to continue operating.

13.2 Power Converter Derate

Some causes limit the amount of cooling available for the power converters, which in turn limits their available performance. Inside the fuel cell package, there are both liquid and air-cooled power converters.

13.3 Power Converter Stop

The power converters may be stopped entirely if they reach a protection value or cooling is not available for them.

14.0 Effects – Integrator

14.1 Introduction

This section describes the signals and effects directly communicated to the integrator.

Please refer to documents C08-002 and C08-003 (*FC Package Modbus Map* and *FC Package Alarm List*) for details on the communication.

14.2 Information

The fuel cell package will communicate to the integrator when an internal situation occurs, which does not require action from the integrator, but would be of interest. This would be events such as warnings from the fuel cell modules or derate information due to coolant or temperature issues.

Communication method is Modbus connection.

14.3 Alarm Information

The fuel cell package will communicate to the integrator when an internal alarm has occurred, and some or all fuel cell modules are unable to function.

Communication method is Modbus connection.

14.4 Safety Trip

The fuel cell package will communicate any eventual safety system trip to the integrator.

Communication method is hardwired connections.

14.5 Power Output – Derate

If internal components are derating their performance, this is communicated to the integrator as a reduction in the total amount of power available.

Communication method is Modbus connection.

14.6 Power Output – Loss of production

If an internal fault prevents the fuel cell package from producing any power, this is communicated to the integrator.

Communication method is Modbus connection

					Safety					Hydrogen	FCwave						Power Converters		Integrator				
Control System	**Segment**	**Sensors**	**Cause**	**Effect**	**FCwave All Modules Safety Trip**	**Hydrogen Valve Safety Override**	**Power Converters STO**	**Motor Drives STO**	**Main Breaker Trip Coil**	**Hydrogen Valves Closed**	**FCwave Single Module Controlled Stop**	**FCwave Multiple Modules Controlled Stop**	**FCwave All modules Controlled Stop**	**FCwave Single Module Derate**	**FCwave Multiple Modules Derate**	**FCwave All Modules Derate**	**Power Converter Derate**	**Power Converter Stop**	**To Integrator - Information**	**To Integrator - Alarm Information**	**To Integrator - Safety Trip**	**Power Output - Derate**	**Power Output - Loss of production**
Safety	Hydrogen	=JA01+DA01+BQ01..03 =RE01+GB01..03-SAFE_H2 =RE02+GB04..06-SAFE_H2	**Hydrogen Detection**		X	X	X	X	X	X (2)											X		X
Safety	Ventilation	=JA01+DA01-BQ04..BQ06 =JA01+DA03-BQ01 =RE01+GB01..03-SAFE_FIRE =RE02+GB04..06-SAFE_FIRE	**Fire Detection**		X	X	X	X	X	X (2)											X		X
Safety	Safety	=LA01+UC20-SG01	**Emergency Stop**		X	X	X	X	X	X (2)											X		X
Safety	Container	=LB02+DA03-BG01..02	**Physcial Protection (Door Sensors)**		X	X	X	X	X	X (2)											X		X
MCU	FCM	=RE01+GB01..03-MCU =RE02+GB04..06-MCU	**FCwave Module Internal Warning**											X (5)					X				
MCU	FCM	=RE01+GB01..03-MCU =RE02+GB04..06-MCU	**FCwave Module Internal Alarm**								X									X		X	
MCU	Power Converters	=BA01+UC01-TA01..02 =BA01+UC02-TA03..04 =BA01+UC03-TA05..06 =BA02+UC04-TA07..08 =BA02+UC05-TA09..10 =BA02+UC06-TA11..12	**DCDC Converter Trip**								X							X	X			X	
MCU	Power Converters	=BA03+DA03-TB30	**DCAC Converter Trip**							X			X					X		X			X
MCU	Coolant	=HE01+DA01-<all> =HE01+DA02-<all> =HE02+DA01-<all> =HE02+DA02-<all>	**HT Coolant Group Derate**												X (4)				X			X	
MCU	Coolant	=HE01+DA01-<all> =HE01+DA02-<all> =HE02+DA01-<all> =HE02+DA02-<all>	**HT Coolant Group Loss**									X (4)								X		X	
MCU	Coolant	=HE03+DA01-<all> =HE03+DA04-<all>	**LT Coolant Group Derate**													X	X		X			X	
MCU	Coolant	=HE03+DA01-<all> =HE03+DA04-<all>	**LT Coolant Group Loss**							X			X					X		X			X
MCU	Ventilation	=JA01+DA01-QM01 =JA01+DA01-QM02 =JA01+DA01-GQ06 =JA01+DA01-GQ07	**Ventilation Derate**													X	X (1)		X			X	
MCU	Ventilation	=JA01+DA01-QM01 =JA01+DA01-QM02 =JA01+DA01-GQ06 =JA01+DA01-GQ07	**Ventilation Failure**							X			X					X (1)		X			X
MCU	Coolant	=JB01+DA01-BL01	**Process Water Tank Full / Drain blocked**							X			X							X			X
MCU	Integrator	=BA20+UC20-XB01	**Integrator Aux Supply Failure (3)**																	X	X		
MCU	Integrator	=LA01+UC30-XG01	**Integrator Communication Failure**							X			X					X		X			X
Safety	Integrator	=LB02+UC30-XD03	**Integrator Safety Connection Failure / Trip**		X	X	X	X															X
MCU	Hydrogen	=HA01+DA02-BT01	**Hydrogen Supply Outside Spec**							X			X							X			X

1: Some power converters are air cooled.
2: See also column H - Valve Override
3: While supplied from the 6.6kV connection, this is warning. If 6.6kV is not connected, this causes an Alarm.
4: HT1 Coolant system is relevant for FC 1-3, HT2 Coolant System is relevant for FC 4-6
5: Only some warnings cause derate, see C08-003

Sub Section C08-001

Contol Philosophy and Logic Block Diagrams

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Full Title	K559-2254-CWIWP4202202-C08-001 Primary state machine description for fuel cell package control system

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1.0	Initial Release	PBL	March 2023
2.0	Update according to comments	PBL	June 2023
3.0	Additional Information Added prior to Controls Workshop 17-18 Oct 2023 Changes are only in the sections “Package Power Response” at the end of the document	PBL	Oct 2023
4.0	Added sections on start-stop frequency and MV disconnect. (Minor additions)	PBL	May 2024

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Table 18: Previous States – Rampdown 19
Table 19: Next States – Shutdown 20

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Purpose

The purpose of this document is to provide an overview of the state machine for the 1MW Fuel Cell Container ("Megablock") provided by Ballard Power Systems Europe for the Crosswind project.

References

Table 1: Reference Documents

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-EL-PHI-002	Electrical System Description & Design Philosophy	KBR
K559-2254-CWIWP4202202-C03-001	Process and Instrumentation Diagrams	BPSE

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Fuel Cell Container Operating Modes

This section provides an introduction to different states of the fuel cell package control system. For each of the states, a brief description of the state is provided, with a more complete description in the following sections.

The operating mode overview is presented in Table 2: Fuel Cell Container Operating Mode Overview. This table describes the operating modes for the container, and outlines the preconditions for each operating mode (power availability, hydrogen, etc.)

Table 2: Fuel Cell Container Operating Mode Overview

Operating Mode	Brief Description	Preconditions
Off	Container fully depowered	No power supplied to container; UPS batteries depleted
Initialization	Functions to establish baseline container status, with connections to external power and communications.	After bootup 400Vac Supplied to Container
Sleep	Container minimum operational level, where control and safety system are operating, but no high power systems (>20kW) are operating. Hydrogen supply and fuel cells are inactive.	400Vac Supplied to Container Communications heartbeat from CCS
Wakeup	Container enables 24V supply to fuel cell modules and starts container ventilation system.	400Vac Supplied to Container Signal from CCS (Standby)
Standby	Waiting state for “Run” command from high level control system. Hydrogen supply and MV link disabled.	400Vac Supplied to Container Signal from CCS (Standby)
Startup	Transitional phase when CCS signals container to initiate operation. The significant part of this phase is that the container will draw a significant amount of power during startup, to energize fuel cell modules and cooling fans/pumps. After startup is complete on the fuel cells, the container transitions to “Running”. All systems operational. Hydrogen system active.	400Vac from internal microgrid Signal from CCS (Run) MV link active (10-150kW power draw, depending on # of FCwave starts concurrent) Hydrogen supply active.

Running	Operational state for the container, where the fuel cell modules are consuming hydrogen to produce electrical energy. Cooling and ventilation systems are operating to support fuel cell modules.	Signal from CCS (Run) Signal from CCS (Power request) MV link active (up to 1050kW power produced) Hydrogen supply active.
Rampdown	When signaled from CCS that operation is done, the container stops power production and performs fuel cell module shutdown procedures. Fuel cell modules shutting down. Hydrogen system transitions from active to inactive. After shutdown is complete, container proceeds to aftercooling.	Signal from CCS (Standby) MV link active (~10kW power draw) Hydrogen supply active.
Aftercooling	After fuel cell system has shut down, container performs aftercooling from the cooling system and ventilation from the container ventilation	400Vac Supplied to Container MV link active (~5kW power draw)
Shutdown	The cooling and ventilation systems shuts down. Container returns to standby.	400Vac Supplied to Container MV link transitions from active to inactive
Fault	Internal fault state. Hydrogen supply and fuel cells are inactive.	400Vac Supplied to Container Fault indication to CCS

Subsystem Activity Matrix

This section describes the matrix of container state and subsystem activity.

- Offline
  - Without power, no activity or power present
- Inactive
  - Components may be supplied with control power, but is inactive, not performing its primary functions.
- Active
  - Online and performing its function

Table 3: Subsystem Activity Matrix

Container State	Control System	Container Heating	Container Ventilation	Cooling Systems	Hydrogen system	DC Bus	Fuel Cell – Control System	Fuel Cell – Power Production
Off	Offline	Offline	Offline	Offline	Offline	Offline	Offline	Offline
Initialization	Active	Active	Inactive	Inactive	Inactive	Inactive	Offline	Offline
Sleep	Active	Active	Inactive	Inactive	Inactive	Inactive	Offline[3]	Offline
Cold Standby	Active	Active	Active	Inactive	Inactive	Inactive	Active	Inactive
Hot Standby	Active	Active	Active	Active	Inactive	Active	Active	Inactive
Startup	Active	Active	Active	Active	Active	Active	Active	Active
Running	Active	Inactive[1]	Active	Active	Active	Active	Active	Active
Rampdown	Active	Inactive[1]	Active	Active	Active	Active	Active	Active
Aftercooling	Active	Active	Active	Active	Inactive	Inactive	Active	Inactive
Shutdown	Active	Active	Active	Inactive	Inactive	Inactive	Active	Inactive
Error	Active	Active	Active	Inactive	Inactive	Inactive	Active[2]	Inactive

Notes to Table 3: Subsystem Activity Matrix

- Note 1
  - Container heating during fuel cell operation is inactive, as waste heat from fuel cells and cooling system maintain temperatures.
- Note 2
  - Fuel cell control system is not active if error state is entered from initialization or sleep state.
- Note 3
  - Fuel cell control system is unpowered to save electrical power.

State Machine Diagrams

The primary state machine is shown below in Figure 1: State Machine Diagram.

For states with a fixed duration, the current best estimate is provided.

For states with no listed duration, the transition depends on external signals.

Figure 1: State Machine Diagram

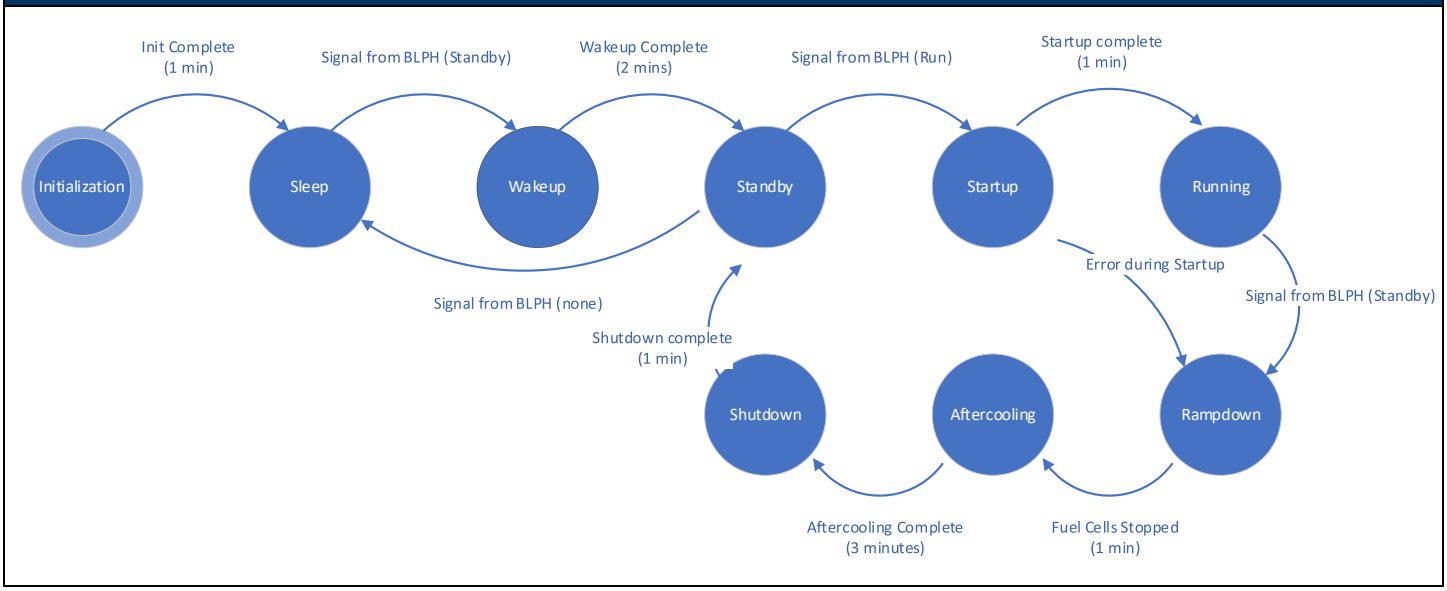


Diagram for the main state machine for the fuel cell container

State Details – Initialization

The Initialization state of the fuel cell package controller is the initial state, where the controller initializes the subsystems in the package, ensuring the container is connected to the external grid and the environment inside the container is maintained.

1.1. Possible Previous States

The state machine can enter the Initialization state from the following states:

Table 4: Previous States – Initialization

Previous State	Description	Transition Requirement
<Boot>	When the container is booted, when the controller finished initializing, the Initialization state is entered.	Controller Boot Sequence completed

1.2. Sub states and functions

The function of the Initialization state is as follows:

- External power connection management
  - The control system monitors the voltage and frequency of the AUX power connection, and if within acceptable parameters closes breaker for auxiliary supply.
- Communication management (Internal, External)
  - Waits for communication with higher-level controller.
  - Establish communication with internal components.
- Internal heating startup
  - Starts sub state machine for internal air handling (ventilation, heating)

1.3. Next State and Transition Requirements

Table 5: Next States – Initialization

Next State	Description	Transition Requirement
Sleep	When all actions completed successfully, control system transitions to sleep state	When all subtasks completed

Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

State Details - Sleep

The Sleep state of the fuel cell package controller is the state, where the controller maintains a minimum level of operation to conserve power drawn from the AUX supply. In this state, the container heating and safety systems are active, but all other systems are inactive.

The container can maintain the sleep state indefinity until activity is requested by the higher-level control system.

This state is intended as the default state for long term inactivity.

1.4. Possible Previous States

The state machine can enter the Sleep state from the following states:

Table 6: Previous States – Sleep

Previous State	Description	Transition Requirement
Initialization	When Initialization state is completed, the Sleep state is entered.	Initialization requirements completed.

1.5. Sub states and functions

The following functions are active during the sleep state:

- Communication management (Internal, External)
- Container heating system

1.1. Next State and Transition Requirements

Table 7: Next States – Sleep

Next State	Description	Transition Requirement
Standby	Transition to Standby when requested by higher-level control system	Signal from CCS (Standby)

Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

State Details – Wakeup

The Wakeup state of the fuel cell package controller is the state, where the controller has received a request from the higher-level control system to enter standby state and prepares to do so.

This requires enabling the control power to the fuel cell modules and waiting for them to reach readiness.

Furthermore, the ventilation system for the container is enabled to provide ventilation and process air for the fuel cell modules.

The container can maintain the standby state indefinity until power production is requested by the higher-level control system.

If the Standby request is disabled, the state machine returns to Sleep.

1.2. Possible Previous States

The state machine can enter the Wakeup state from the following states:

Table 8: Previous States – Wakeup

Previous State	Description	Transition Requirement
Sleep	Minimum power state	Signal from CCS (Standby)

1.3. Sub states and functions

The following functions are active during the sleep state:

- Communication management (Internal, External)
- Container heating system
- Fuel cell control systems
- Container ventilation system

1.4. Next State and Transition Requirements

Table 9: Next States – Wakeup

Next State	Description	Transition Requirement
Sleep	Reversion to Sleep if Standby request is disabled.	Signal from CCS (none)
Standby	All fuel cells control systems are online and ventilation system is active	Signal from CCS (Standby) Fuel cells control system is active. Ventilation is running.
Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

State Details – Standby

The Standby state of the fuel cell package controller is the state, where the controller has received a request from the higher-level control system to enter standby state has completed this request.

This state maintains readiness to operate the fuel cell system but does not trigger a startup unless requested by the higher-level control system.

The container can maintain the standby state indefinity until power production is requested by the higher-level control system.

If the Standby request is disabled, the state machine returns to Sleep.

1.5. Possible Previous States

The state machine can enter the Standby state from the following states:

Table 10: Previous States – Standby

Previous State	Description	Transition Requirement
Wakeup	Fuel Cell control system and ventilation startup	Signal from CCS (Standby)
Shutdown	After shutting down the fuel cells and support systems, the container returns to Standby	Shutdown sequence complete.

1.6. Sub states and functions

The following functions are active during the sleep state:

- Communication management (Internal, External)
- Container heating system
- Fuel cell control systems
- Container ventilation system

1.7. Fuel Cell Control Systems

If the previous state was Shutdown, the Fuel Cell control system is active and will remain so for 15 minutes, allowing the fuel cell modules to ventilate the hydrogen enclosure, dissipating any remaining hydrogen. Even if the Standby signal is not received from the higher-level control system, the fuel cell package control system will remain in Standby state until the timer has elapsed.

1.8. Next State and Transition Requirements

Table 11: Next States – Standby

Next State	Description	Transition Requirement
Sleep	Reversion to Sleep if Standby request is disabled. May be delayed by fuel cell module ventilation requirements.	Signal from CCS (none)
Startup	If the run command is received from the higher-level control system, the control system begins the startup sequence.	Signal from CCS (Run)
Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

State Details – Startup

The Startup state of the fuel cell package controller is the state, where the controller has received a request from the higher-level control system to begin power production and will execute the startup sequence.

If the Run request is disabled or a failed startup occurs, the state machine proceeds to Rampdown.

1.9. Possible Previous States

The state machine can enter the Startup state from the following states:

Table 12: Previous States – Startup

Previous State	Description	Transition Requirement
Standby	Container requested to begin power production	Signal from CCS (Run)

1.10. Sub states and functions

The sequence of events during the startup state is outlined below:

- Transfer of load from AUX supply to MV supply
    - If the voltage and frequency monitoring of the external grid connection is acceptable, the contactor between the AUX supply inlet and internal AC bus is opened (=BA20+UC20-AQ01) and after a delay, the breaker between the transformer and AC bus is closed (=BA30+DA03-FC31).
    - As the AUX supply is limited to 20kW, this ensures that sufficient power is available for the cooling systems and fuel cell startup.
- LT Coolant Startup
    - The cooling system for the power electronics is started, such that overheating of the power converters is prevented.
- Main breaker closing
    - The input side of the primary DC/AC (=BA30+DA03-TB30) is precharged.
    - The main breaker (=BA30+DA03-FC30) is closed.
- Main DCAC startup
    - The primary DC/AC (=BA30+DA03-TB30) is started and the internal DC bus is energized.
- High Temperature Cooling system startup
    - The pumps and fans for the process cooling system is started at low power.
- Fuel Cell module(s) are started.
    - The DCDC converters for the relevant fuel cell modules are started.
    - One or more fuel cell modules begin the module startup sequence.

1.11. Next State and Transition Requirements

Table 13: Next States – Startup

Next State	Description	Transition Requirement
Rampdown	If a failure during the startup sequence is detected, the container aborts the startup sequence and transitions to the Rampdown sequence for orderly shutdown of the container	Aborted Startup
Running	Upon completed startup sequence, the control system transitions to the running state.	Signal from CCS (Run) Signal from CCS (Power request) Startup sequence completed
Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

State Details – Running

In the running state, the fuel cell package is actively producing power, and the control system is attempting to match the requested power from the higher-level control system, which may include starting and stopping fuel cells to match the power demand.

1.12. Possible Previous States

The state machine can enter the Running state from the following states:

Table 14: Previous States – Running

Previous State	Description	Transition Requirement
Startup	Fuel Cell module startup sequence	Startup sequence completed

1.13. Sub states and functions

The following functions are active during the sleep state:

- All subsystems are active during the Running state, except the heating system.

- Hydrogen, cooling, and power systems are operating to meet requested power requirements.
- The fuel cell package controller will start or stop fuel cell modules to match the requested power demand.
- During

1.14. Next State and Transition Requirements

Table 15: Next States – Running

Next State	Description	Transition Requirement
Rampdown	If the Run request from the higher-level control system is disabled or the requested power is below the minimum possible level for more than a brief period, the fuel cell container transitions to the Rampdown state	Signal from CCS (Standby) No or low power request for more than 10 seconds
Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

Note to state transition to Rampdown:

The fuel cell modules can produce a minimum amount of power. If the requested power is below the minimum power for one fuel cell module for more than 10 seconds, the fuel cell package controller will initiate the Rampdown and shutdown of the package.

State Details – Rampdown

When the fuel cell package is done producing power, the fuel cell modules are returned to their internal standby state and the build up heat is dissipated before stopping cooling and pumps.

During this state, the internal container AC grid is still powered from the MV connection, drawing estimated 10 kW for several minutes.

1.15. Possible Previous States

The state machine can enter the Rampdown state from the following states:

Table 16: Previous States – Rampdown

Previous State	Description	Transition Requirement
Running	Fuel Cell module operation	Fuel cell modules not needed

1.16. Sub states and functions

The following functions are active during the Rampdown state:

- All active fuel cell modules will perform their shutdown sequence and return to their standby state.
- DCDC converters are stopped.
- The following systems will run for aftercooling:
  - HT Cooling system, 3 mins
  - LT cooling system, 3 mins
  - Ventilation system, 3 mins
- The above systems will operate at reduced power levels during Rampdown.

1.17. Next State and Transition Requirements

Table 17: Next States – Rampdown

Next State	Description	Transition Requirement
Shutdown	The Rampdown sequence has completed and the fuel cell package controller transitions to Shutdown	Rampdown complete (grid power is below 2%)
Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

State Details – Shutdown

After dissipating the buildup heat in the cooling systems, the fuel cell package shuts down primary and secondary cooling systems, stops power converters and disconnects from the MV connection.

The power supply is transferred to the AUX connection.

1.18. Possible Previous States

The state machine can enter the Rampdown state from the following states:

Table 18: Previous States – Rampdown

Previous State	Description	Transition Requirement
Rampdown	Aftercooling of cooling systems	State timer elapsed

1.19. Sub states and functions

The following functions are active during the Shutdown state:

- The High Temperature cooling system is shutdown.
  - Fans and pumps stopped.
- Container heating is re-established.
- Primary DCAC converter is stopped, and DC bus is discharged.
- Main AC breaker is opened.
- LT Cooling system is stopped.
- Container load transferred from MV connection to AUX connection:
  - If the voltage and frequency monitoring of the AUX grid connection is acceptable, the breaker between the transformer and AC bus is opened (=BA30+DA03-FC31). After a delay, the contactor between the AUX supply inlet and internal AC bus is closed (=BA20+UC20-AQ01)
- State transitions to Standby

1.20. Next State and Transition Requirements

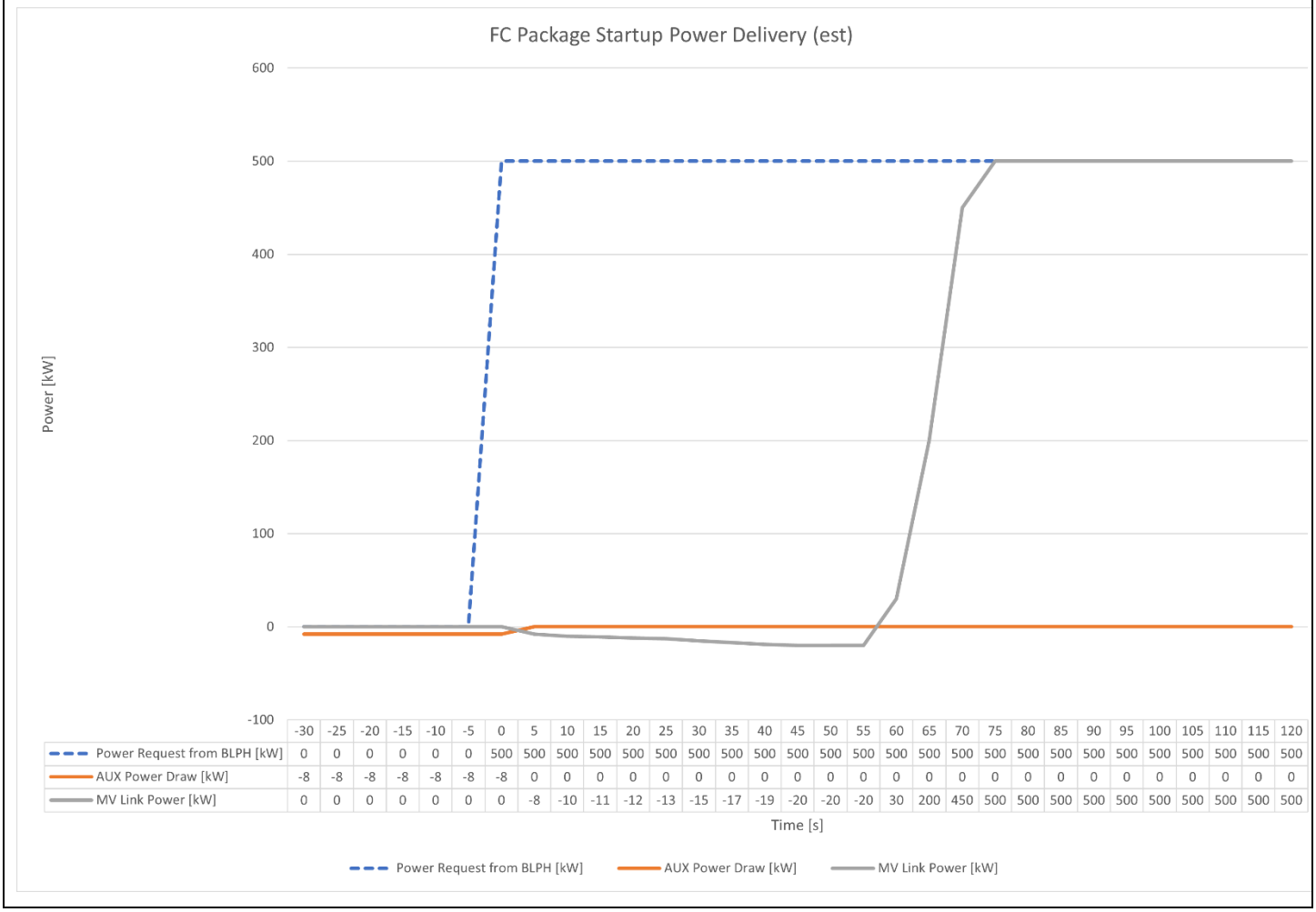
Table 19: Next States – Shutdown

Next State	Description	Transition Requirement
Standby	Shutdown sequence completed and container has disconnected from the MV connection and transitions to the AUX supply.	Shutdown sequence complete
Error State	If a process variable is outside acceptable parameters, or a fault is detected on some equipment, an error state is entered, where startup is prevented.	Process parameter outside acceptable range

Package Power Response - Startup

This section describes the power draw and subsequent power delivery from the fuel cell package during startup and when responding to a Run request and power request from the BLPH control system.

Figure 2: Startup Power Delivery



	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Power Request from BLPH [kW]	0	0	0	0	0	0	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
AUX Power Draw [kW]	-8	-8	-8	-8	-8	-8	-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MV Link Power [kW]	0	0	0	0	0	0	0	-8	-10	-11	-12	-13	-15	-17	-19	-20	-20	-20	30	200	450	500	500	500	500	500	500	500	500	500	500

Power flow during startup of the FC package – negative values denote power to the FC package. The package is requested to start at time 0 with a power request of 500kW

1.21. Timeline for Startup response

As shown in Figure 2: Startup Power Delivery, the fuel cell package does have a delay from a power request being sent from the BLPH to the requested power is being delivered.

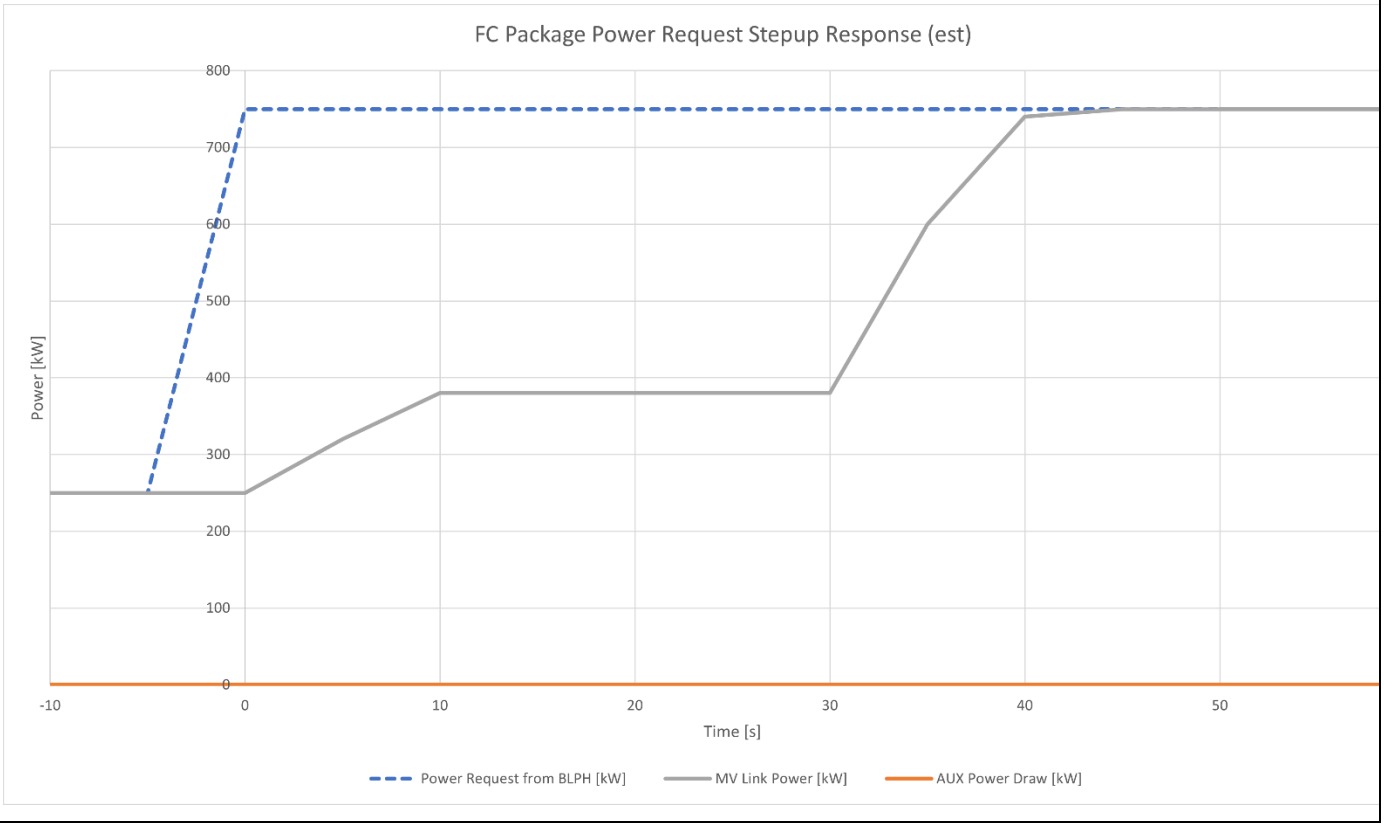
- At time zero, the BLPH requests the FC package to run and requests 500kW of power.
- Between time zero and 5, the FC package switches its AC supply from the auxiliary feed to the MV connection.
- Between time 5 and 25, the FC package starts electronics, process cooling and ventilation systems. The DC bus is precharged and the primary output drive energizes the DC bus.
- Between time 25 and 55, the fuel cell modules are started.
- Between time 55 and 65, the fuel cell modules are ready to produce power and their output is ramped up to meet the power request from BLPH.

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Package Power Response - Step-up

This section describes power delivery from the fuel cell package during a step-up in the power request from the BLPH control system.

Figure 3: Step-Up Power Delivery



Power flow during a step-up of the power request from the BLPH. The power request is increased from 250 to 750 kW

1.22. Timeline for Step-up response

As shown in Figure 3: Step-Up Power Delivery, a step-up in the power request from BLPH may cause the FC package to start additional fuel cell modules to meet the power request.

- At time -5, the FC package is producing 250kW, as requested. In this example, two fuel cell modules are running and each producing 125kW + ancillary loads and losses.
- At time 0, the power request is stepped from 250 to 750 kW.

- At time 0 to 10, the FC package ramps the two online fuel cells to their rated power (2 x 200kW) and begins startup of the remaining fuel cell modules.
- At time 10, the active fuel cells are at rated power, producing ~380kW with the auxiliary loads and converter losses.
- Between time 10 to 30, the remaining fuel cell modules are going through their start-up sequence.
- At time 30 to 40, all fuel cell modules are running, and power output is ramped to meet the request.

1.23. Power regulator overshoot

The power regulator is a PID controlled system, with the attending risk of overshoot.

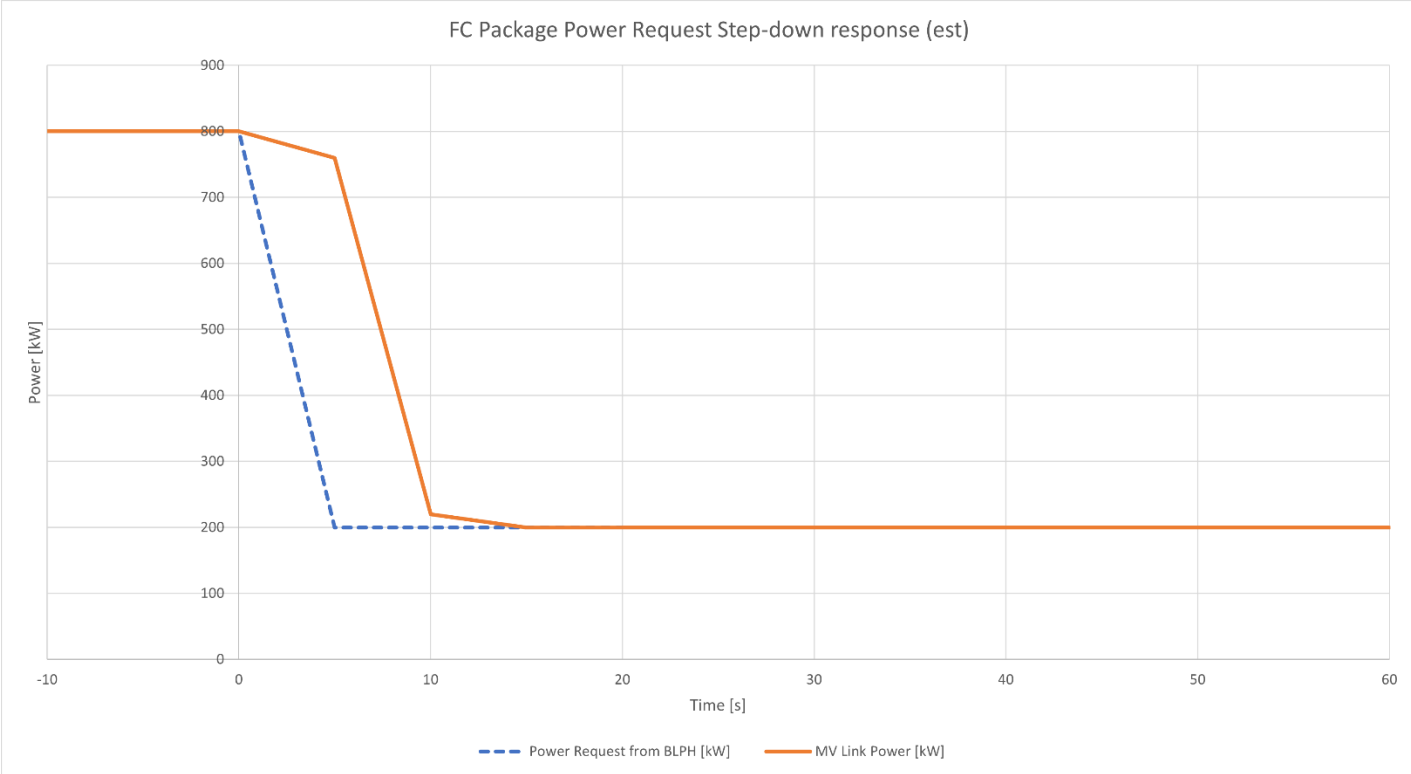
The power regulator will overshoot less than 10% of the setpoint (e.g. for a setpoint of 500kW, the overshoot will be less than 550kW peak) and have a duration less than 5 seconds.

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Package Power Response - Step-down

This section describes power delivery from the fuel cell package during a step-down in the power request from the BLPH control system.

Figure 4: Step-Down Power Delivery



Power flow during a step-down of the power request from the BLPH. The power request is decreased from 800 to 200 kW

1.24. Timeline for Step-down response

As shown in Figure 4: Step-Down Power Delivery, a step-down in the power request from BLPH will cause the FC package to adjust its power output.

- At time -5, the FC package is producing 800kW, as requested. In this example, all six fuel cell modules are running.
- At time 0, the power request is stepped from 800 to 200 kW.

- At time 0 to 10, the FC package ramps down the power produced by each fuel cells to match the power request.
- At time 15, the FC package begins shutting down 4 of the 6 fuel cell modules, allowing the two remaining fuel cell modules to handle the load.
- At time 45, the 4 modules are finished shutting down and are kept ready for restart if needed.

Integrator notes for the FC package

This section outlines guidelines for the Power Request from the BLPH, which should be known by the integrator.

- The startup duration for a fuel cell module is approx. 30 seconds.
- A running fuel cell module can ramp from minimum power to rated power in 10 seconds.
- Start-up and significant step-up in power request will be limited by the startup duration, followed by the ramp-up time.
- Ramp-down is not limited by startup duration.
- The power request should be set to the desired value, instead of incrementally increased as fuel cells come online.
    - If the power request is incrementally increased, the FC package controller may not start all required fuel cell modules, and the power output will be limited by multiple sequential startup delays.
- Ballard expects that the BESS is used for short term spikes and dips in load and the FC package is responsible for long term power delivery with minimum short-term changes in requested power.
- The fuel cell package restart limits are as follows:
    - Restart less than 6 times in an hour.
    - Restart less than 20 times in a 24-hour period.

Disconnecting the MV bus

This section describes the consequences of disconnecting the MV bus from the FC package.

1.25. Disconnecting when not in operation

When the package is not in operation (State “Sleep” or “Cold Standby”), the MV bus can freely be disconnected.

1.26. Disconnecting while operating

The MV bus cannot be disconnected while the FC package is operating.

Sub Section C08-002

FC Package Modbus Map

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
004	7/10/2025	Front page added
005	21/08/2025	Update in acordance with alarm list

KBR
ACCEPTANCE
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ACCEPTED WITH COMMENTS	(Code 2) ____
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DISCIPLINE ____ BY ____
DATE ____

Document Title:	**BLPH Project - Modbus Table for Main PLC**
Document Number:	K559-2254-CWIWP4202202-C08-002
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C08
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Customer:	CrossWind C.V., Rotterdam, The Netherlands

Crosswind BLPH FC Package - Main PLC

Discrete Inputs

Function Code FC02
Read only access

Implemented	Group	Internal - Base	Internal - Offset	Address [Decimal]	TAG	Pretty Name	Datatype	Comment
	External Control	1000	0	1000	FC30_OPN	Main LV Breaker Status is Open	BOOL	
	External Control	1000	1	1001	FC30_CLS	Main LV Breaker Status is Closed	BOOL	
	External Control	1000	2	1002				
	External Control	1000	3	1003				
	External Control	1000	4	1004				
	External Control	1000	5	1005				
	External Control	1000	6	1006	CONTROL_LOC	Control Place (Local / Remote)	BOOL	True = Remote, False = Local
	External Control	1000	7	1007	AUX_OK	Auxillary Supply Present and OK	BOOL	True = Supply OK, False = Supply not OK
	External Control	1000	8	1008				
	External Control	1000	9	1009				
	External Control	1000	10	1010				
	External Control	1000	11	1011				
	FCwave - FC1	3000	0	3000	FC1_H2_EN	FC1 Hydrogen Enable Request		
	FCwave - FC1	3000	1	3001	FC1_DECAYTESTFAIL	FC1 Pressure Decay Test Information		
	FCwave - FC1	3000	2	3002	FC1_HLOCK	FC1 Hydrogen Detection Lockout		
	FCwave - FC1	3000	3	3003	FC1_DCDCSTOP	FC1 DCDC Stop Request		
	FCwave - FC1	3000	4	3004	FC1_DCDCIMPORT	FC1 DCDC Import Request		
	FCwave - FC1	3000	5	3005	FC1_DCDCEXPORT	FC1 DCDC Export Request		
	FCwave - FC2	3030	0	3030	FC2_H2_EN	FC2 Hydrogen Enable Request		
	FCwave - FC2	3030	1	3031	FC2_DECAYTESTFAIL	FC2 Pressure Decay Test Information		
	FCwave - FC2	3030	2	3032	FC2_HLOCK	FC2 Hydrogen Detection Lockout		
	FCwave - FC2	3030	3	3033	FC2_DCDCSTOP	FC2 DCDC Stop Request		
	FCwave - FC2	3030	4	3034	FC2_DCDCIMPORT	FC2 DCDC Import Request		
	FCwave - FC2	3030	5	3035	FC2_DCDCEXPORT	FC2 DCDC Export Request		
	FCwave - FC3	3060	0	3060	FC3_H2_EN	FC3 Hydrogen Enable Request		
	FCwave - FC3	3060	1	3061	FC3_DECAYTESTFAIL	FC3 Pressure Decay Test Information		
	FCwave - FC3	3060	2	3062	FC3_HLOCK	FC3 Hydrogen Detection Lockout		
	FCwave - FC3	3060	3	3063	FC3_DCDCSTOP	FC3 DCDC Stop Request		
	FCwave - FC3	3060	4	3064	FC3_DCDCIMPORT	FC3 DCDC Import Request		
	FCwave - FC3	3060	5	3065	FC3_DCDCEXPORT	FC3 DCDC Export Request		
	FCwave - FC4	3090	0	3090	FC4_H2_EN	FC4 Hydrogen Enable Request		
	FCwave - FC4	3090	1	3091	FC4_DECAYTESTFAIL	FC4 Pressure Decay Test Information		
	FCwave - FC4	3090	2	3092	FC4_HLOCK	FC4 Hydrogen Detection Lockout		
	FCwave - FC4	3090	3	3093	FC4_DCDCSTOP	FC4 DCDC Stop Request		
	FCwave - FC4	3090	4	3094	FC4_DCDCIMPORT	FC4 DCDC Import Request		
	FCwave - FC4	3090	5	3095	FC4_DCDCEXPORT	FC4 DCDC Export Request		

FCwave - FC5	3120	0	3120 FC5_H2_EN	FC5 Hydrogen Enable Request	
FCwave - FC5	3120	1	3121 FC5_DECAYTESTFAIL	FC5 Pressure Decay Test Information	
FCwave - FC5	3120	2	3122 FC5_HLOCK	FC5 Hydrogen Detection Lockout	
FCwave - FC5	3120	3	3123 FC5_DCDCSTOP	FC5 DCDC Stop Request	
FCwave - FC5	3120	4	3124 FC5_DCDCIMPORT	FC5 DCDC Import Request	
FCwave - FC5	3120	5	3125 FC5_DCDCEXPORT	FC5 DCDC Export Request	
FCwave - FC6	3150	0	3150 FC6_H2_EN	FC6 Hydrogen Enable Request	
FCwave - FC6	3150	1	3151 FC6_DECAYTESTFAIL	FC6 Pressure Decay Test Information	
FCwave - FC6	3150	2	3152 FC6_HLOCK	FC6 Hydrogen Detection Lockout	
FCwave - FC6	3150	3	3153 FC6_DCDCSTOP	FC6 DCDC Stop Request	
FCwave - FC6	3150	4	3154 FC6_DCDCIMPORT	FC6 DCDC Import Request	
FCwave - FC6	3150	5	3155 FC6_DCDCEXPORT	FC6 DCDC Export Request	
Ventilation - 40ft			4000 JA01_EB01_1	Container Heater #1	BOOL
Ventilation - 40ft			4001 JA01_EB01_2	Container Heater #2	BOOL
Ventilation - 40ft			4002 JA01_EB01_3	Container Heater #3	BOOL
Ventilation - 40ft			4003		
Electrical - 40ft			5000	AUX Supply Contactor	BOOL
Electrical - 40ft			5001	Nanogrid Supply Contactor	BOOL
Electrical - 40ft			5002		BOOL
Electrical - 40ft			5003		BOOL
Electrical - 40ft			5004		BOOL
Electrical - 40ft			5005 JS_EA01	Container Ligthing 1/2	BOOL
Electrical - 40ft			5006 JS_EA02	Container Ligthing 2/2	BOOL
Electrical - 40ft			5007 HF01_SG100	Container Light Switch	BOOL
Electrical - 40ft			5008		BOOL
Electrical - 40ft			5009		BOOL
Electrical - 40ft			5010 UC20_RB30_RDY	PLC UPS Battery Ready	BOOL
Electrical - 40ft			5011 UC20_RB30_BAT	PLC UPS Battery Operation	BOOL
Electrical - 40ft			5012 UC20_RB30_SOH	PLC UPS Battery Low SOH	BOOL
Electrical - 40ft			5013 UC30_RB30_RDY	Coolant Skid UPS Battery Ready	BOOL
Electrical - 40ft			5014 UC30_RB30_BAT	Coolant Skid UPS Battery Operation	BOOL
Electrical - 40ft			5015 UC30_RB30_SOH	Coolant Skid UPS Battery Low SOH	BOOL
Electrical - 40ft			5016 UC20_RB01_RDY	FC1+2 24V UPS Battery Ready	BOOL
Electrical - 40ft			5017 UC20_RB01_BAT	FC1+2 24V UPS Battery Operation	BOOL
Electrical - 40ft			5018 UC20_RB01_SOH	FC1+2 24V UPS Battery Low SOH	BOOL
Electrical - 40ft			5019 UC20_RB01_DIS	FC1+2 24V UPS Battery Discharged	BOOL
Electrical - 40ft			5020 UC20_RB02_RDY	FC3+4 24V UPS Battery Ready	BOOL
Electrical - 40ft			5021 UC20_RB02_BAT	FC3+4 24V UPS Battery Operation	BOOL
Electrical - 40ft			5022 UC20_RB02_SOH	FC3+4 24V UPS Battery Low SOH	BOOL
Electrical - 40ft			5023 UC20_RB02_DIS	FC3+4 24V UPS Battery Discharged	BOOL
Electrical - 40ft			5024 UC20_RB03_RDY	FC5+6 24V UPS Battery Ready	BOOL
Electrical - 40ft			5025 UC20_RB03_BAT	FC5+6 24V UPS Battery Operation	BOOL
Electrical - 40ft			5026 UC20_RB03_SOH	FC5+6 24V UPS Battery Low SOH	BOOL
Electrical - 40ft			5027 UC20_RB03_DIS	FC5+6 24V UPS Battery Discharged	BOOL
Electrical - 40ft			5028		

Crosswind BLPH FC Package - Main PLC

HOLDING REGISTERS

Allowable Function Codes: FC03;06;16
Read and Write access, if otherwise not specified

Implemented?	Group	Internal - Base	Internal - Offset	Address [Decimal]	Bit	TAG	Pretty Name	Read	Write	Datatype	Scaling	Unit	Comment
	External Control	1000	0	1000		POWER_SP	Export Power Setpoint	TRUE	TRUE	INT16	0.1	kW	Range 0 to 1200 kW
	External Control	1000	1	1001			Control word						
					0		Wakeup			BOOL			Rising edge triggers wakeup
					1		Sleep			BOOL			Rising edge triggers go to sleep
					2		Start			BOOL			Rising edge triggers start sequence
					3		Stop			BOOL			Rising edge triggers stop sequence
					4		<Spare>			BOOL			Not used
					5		Reset			BOOL			Rising edge triggers fault clear
	External Control	1000	2	1002									
	External Control	1000	3	1003									
	External Control	1000	4	1004									
	External Control	1000	5	1005									
	External Control	1000	6	1006									
	External Control	1000	7	1007									
	External Control	1000	8	1008									
	External Control	1000	9	1009									

Crosswind BLPH FC Package - Main PLC

INPUT REGISTERS

Allowable Function Codes: FC04

Read only access

Implemented?	Group	Internal - Base	Internal - Offset	Address [Decimal]	Bit	TAG	Pretty Name	Read	Write	Datatype	Scaling	Unit	Comment	Max value
TRUE	External Control	1000	0	1000		StateMain	Main FC Package Statemachine Index	TRUE	FALSE	INT16	1	n/a	Enumeration index attached	
TRUE	External Control	1000	1	1001		FC1_Control_State	Fuel Cell Control #1 Statemachine Index	TRUE	FALSE	INT16	1	n/a	Enumeration index attached	
TRUE	External Control	1000	2	1002		FC2_Control_State	Fuel Cell Control #2 Statemachine Index	TRUE	FALSE	INT16	1	n/a	Enumeration index attached	
TRUE	External Control	1000	3	1003		FC3_Control_State	Fuel Cell Control #3 Statemachine Index	TRUE	FALSE	INT16	1	n/a	Enumeration index attached	
TRUE	External Control	1000	4	1004		FC4_Control_State	Fuel Cell Control #4 Statemachine Index	TRUE	FALSE	INT16	1	n/a	Enumeration index attached	
TRUE	External Control	1000	5	1005		FC5_Control_State	Fuel Cell Control #5 Statemachine Index	TRUE	FALSE	INT16	1	n/a	Enumeration index attached	
TRUE	External Control	1000	6	1006		FC6_Control_State	Fuel Cell Control #6 Statemachine Index	TRUE	FALSE	INT16	1	n/a	Enumeration index attached	
TRUE	External Control	1000	7	1007			<Spare>							
TRUE	External Control	1000	8	1008			<Spare>							
TRUE	External Control	1000	9	1009			<Spare>							
TRUE	External Control	1000	10	1010			<Spare>							
TRUE	External Control	1000	11	1011			<Spare>							
TRUE	External Control	1000	12	1012			<Spare>							
TRUE	External Control	1000	13	1013		P_MAX	Total Capacity of FC Package	TRUE	FALSE	INT16	1	kW	Range 0 to 1000 kW	
TRUE	External Control	1000	14	1014		P_OPTIMIZED	Fuel Efficient Power Point	TRUE	FALSE	INT16	1	kW	Range 0 to 1000 kW	
TRUE	External Control	1000	15	1015			Spare							
TRUE	External Control	1000	16	1016		FCM_RUNNING	Number of Fuel Cell Modules Producing Power	TRUE	FALSE	INT16	1	n/a	Range 0 to 6	
TRUE	External Control	1000	17	1017			<Spare>							
TRUE	External Control	1000	18	1018			<Spare>							
TRUE	External Control	1000	19	1019			<Spare>							
TRUE	External Control	1000	20	1020			FCWave 1 Power Internal	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	21	1021			FCWave 1 DCDC A Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	22	1022			FCWave 1 DCDC B Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	23	1023			FCWave 2 Power Internal	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	24	1024			FCWave 2 DCDC A Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	25	1025			FCWave 2 DCDC B Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	26	1026			FCWave 3 Power Internal	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	27	1027			FCWave 3 DCDC A Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	28	1028			FCWave 3 DCDC B Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	29	1029			FCWave 4 Power Internal	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	30	1030			FCWave 4 DCDC A Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	31	1031			FCWave 4 DCDC B Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	32	1032			FCWave 5 Power Internal	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	33	1033			FCWave 5 DCDC A Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	34	1034			FCWave 5 DCDC B Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	35	1035			FCWave 6 Power Internal	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	36	1036			FCWave 6 DCDC A Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	37	1037			FCWave 6 DCDC B Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	38	1038			Manual Power Setpoint	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	39	1039			Export AC Power	TRUE		INT16	0.1	kW	measurement before breaker	
TRUE	External Control	1000	40	1040			Nanogrid AC Power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	41	1041			Aux AC power	TRUE		INT16	0.1	kW		
TRUE	External Control	1000	42	1042			<Spare>							
TRUE	External Control	1000	43	1043			<Spare>							
TRUE	External Control	1000	44	1044			<Spare>							
TRUE	External Control	1000	45	1045			<Spare>							
TRUE	External Control	1000	46	1046			<Spare>							
TRUE	External Control	1000	47	1047			<Spare>							
TRUE	External Control	1000	48	1048			<Spare>							
TRUE	External Control	1000	49	1049			<Spare>							
TRUE	External Control	1000	50	1050			Error Code 1	TRUE		INT16	1	n/a	Active Error Code #1	
TRUE	External Control	1000	51	1051			Error Code 2	TRUE		INT16	1	n/a	Active Error Code #2	
TRUE	External Control	1000	52	1052			Error Code 3	TRUE		INT16	1	n/a	Active Error Code #3	
TRUE	External Control	1000	53	1053			Error Code 4	TRUE		INT16	1	n/a	Active Error Code #4	
TRUE	External Control	1000	54	1054			Error Code 5	TRUE		INT16	1	n/a	Active Error Code #5	
TRUE	External Control	1000	55	1055			Error Code 6	TRUE		INT16	1	n/a	Active Error Code #6	
TRUE	External Control	1000	56	1056			Error Code 7	TRUE		INT16	1	n/a	Active Error Code #7	
TRUE	External Control	1000	57	1057			Error Code 8	TRUE		INT16	1	n/a	Active Error Code #8	
TRUE	External Control	1000	58	1058			Error Code 9	TRUE		INT16	1	n/a	Active Error Code #9	
TRUE	External Control	1000	59	1059			Error Code 10	TRUE		INT16	1	n/a	Active Error Code #10	
TRUE	External Control	1000	60	1060			Error Code 11	TRUE		INT16	1	n/a	Active Error Code #11	
TRUE	External Control	1000	61	1061			Error Code 12	TRUE		INT16	1	n/a	Active Error Code #12	
TRUE	External Control	1000	62	1062			Error Code 13	TRUE		INT16	1	n/a	Active Error Code #13	
TRUE	External Control	1000	63	1063			Error Code 14	TRUE		INT16	1	n/a	Active Error Code #14	
TRUE	External Control	1000	64	1064			Error Code 15	TRUE		INT16	1	n/a	Active Error Code #15	
TRUE	External Control	1000	65	1065			Error Code 16	TRUE		INT16	1	n/a	Active Error Code #16	
TRUE	External Control	1000	66	1066			Error Code 17	TRUE		INT16	1	n/a	Active Error Code #17	
TRUE	External Control	1000	67	1067			Error Code 18	TRUE		INT16	1	n/a	Active Error Code #18	
TRUE	External Control	1000	68	1068			Error Code 19	TRUE		INT16	1	n/a	Active Error Code #19	
TRUE	External Control	1000	69	1069			Error Code 20	TRUE		INT16	1	n/a	Active Error Code #20	

TRUE	External Information	1100	0	1100		=HE01+DA02-BT01	HT1 - Coolant Return Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	1	1101		=HE01+DA02-BT02	HT1 - Pump Inlet Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	2	1102		=HE01+DA02-BF01	HT1 - Flowrate	TRUE	FALSE	INT16	0.1	m3^h	
TRUE	External Information	1100	3	1103		=HE01+DA02-GP19_RPM	HT1 - Pump RPM	TRUE	FALSE	INT16	1	rpm	
TRUE	External Information	1100	4	1104		=HE02+DA02-BT01	HT2 - Coolant Return Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	5	1105		=HE02+DA02-BT02	HT2 - Pump Inlet Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	6	1106		=HE02+DA02-BF01	HT2 - Flowrate	TRUE	FALSE	INT16	0.1	m^3/h	
TRUE	External Information	1100	7	1107		=HE02+DA02-GP29_RPM	HT2 - Pump RPM	TRUE	FALSE	INT16	1	rpm	
TRUE	External Information	1100	8	1108		=HE03+DA01-BT01	LT - Coolant Return Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	9	1109		=HE03+DA01-BT02	LT - Coolant Forward Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	10	1110		=HE03+DA01-BF03	LT - Flowrate	TRUE	FALSE	INT16	0.1	m^3/h	
TRUE	External Information	1100	11	1111		=HE03+DA01-GP11_RPM	LT - Pump RPM	TRUE	FALSE	INT16	1	rpm	
TRUE	External Information	1100	12	1112		=JA01+DA01-BT01	40ft - Ventilation Intake Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	13	1113		=JA01+DA01-BT02	40ft - Container Temperature 2	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	14	1114		=JA01+DA01-BT03	40ft - Container Temperature 3	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	15	1115		=JA01+DA01-GQ06_RPM	40ft - Ventilation Fan 1 Speed	TRUE	FALSE	INT16	1	rpm	
TRUE	External Information	1100	16	1116		=JA01+DA01-GQ07_RPM	40ft - Ventilation Fan 2 Speed	TRUE	FALSE	INT16	1	rpm	
TRUE	External Information	1100	17	1117		=JA01+DA03-BT01	10ft - Container Temperature	TRUE	FALSE	INT16	0.1	°C	
TRUE	External Information	1100	18	1118		=JA01+DA03-GQ10_RPM	10ft - Ventilation Fan Speed	TRUE	FALSE	INT16	1	rpm	
TRUE	External Information	1100	19	1119			Available Unused Power (AUP)	TRUE	FALSE	INT16	0.1	kW	
TRUE	External Information	1100	20	1120			Calculated Maximum Power (CMP)	TRUE	FALSE	INT16	0.1	kW	
TRUE	External Information	1100	21	1121			Operating state	TRUE	FALSE	INT16	1	n/a	Range 0 to 6
TRUE	Alarms	1100	40	1140	0	MainSafetyOK	Main Safety needs Reset	TRUE	FALSE	BOOL	n/a	n/a	Reset Main Safety Controller once it is safe to do so
TRUE	Alarms	1100	40	1140	1	SafetymodbusCommsDriverError	Safety Controller - Com Error	TRUE	FALSE	BOOL	n/a	n/a	Inspect network connection between Safety Controllers and main controller, and fix loose cables, replace broken cables and check network switches
TRUE	Alarms	1100	40	1140	2	ESTOPCustomer	E STOP BLPH Platform	TRUE	FALSE	BOOL	n/a	n/a	ESTOP from BLPH - Correct BLPH error and reset safety system
TRUE	Alarms	1100	40	1140	3	ESTOPcontrolCabinet	E STOP Control Cabinet	TRUE	FALSE	BOOL	n/a	n/a	Release the safety button once it is safe to do so
TRUE	Alarms	1100	40	1140	4	ESTOPContainerDoor	ESTOP Container Door	TRUE	FALSE	BOOL	n/a	n/a	Release the safety button once it is safe to do so
TRUE	Alarms	1100	40	1140	5	ESTOPcoolantSkid	E STOP Coolant Skid	TRUE	FALSE	BOOL	n/a	n/a	Release the safety button once it is safe to do so
TRUE	Alarms	1100	40	1140	6	EFIBusStatus1	Safety Controller - 40/10ft Com Ch 1	TRUE	FALSE	BOOL	n/a	n/a	Inspect CANBus cables between Safety Controllers in UC20 and UC30, and fix loose cables or replace broken cables
TRUE	Alarms	1100	40	1140	7	EFIBusStatus2	Safety Controller - 40/10ft Com Ch 2	TRUE	FALSE	BOOL	n/a	n/a	Inspect CANBus cables between Safety Controllers in UC20 and UC30, and fix loose cables or replace broken cables
TRUE	Alarms	1100	40	1140	8	ESTOP10ft	Not Applicable	TRUE	FALSE	BOOL	n/a	n/a	Not Applicable
TRUE	Alarms	1100	40	1140	9	DoorRight_10ft	10ft Container - Door Right Open	TRUE	FALSE	BOOL	n/a	n/a	Close door and check safety switch
TRUE	Alarms	1100	40	1140	10	DoorLeft_10ft	10ft Container - Door Left Open	TRUE	FALSE	BOOL	n/a	n/a	Close door and check safety switch
TRUE	Alarms	1100	40	1140	11	smokeDetectorIntake	Smoke Detector, 40ft Middle	TRUE	FALSE	BOOL	n/a	n/a	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.
TRUE	Alarms	1100	40	1140	12	smokeDetectorOutletA	Smoke Detector, 40ft Left	TRUE	FALSE	BOOL	n/a	n/a	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.
TRUE	Alarms	1100	40	1140	13	smokeDetectorOutletB	Smoke Detector, 40ft Right	TRUE	FALSE	BOOL	n/a	n/a	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.
TRUE	Alarms	1100	40	1140	14	smokeDetector10ft	Smoke Detector, 10ft	TRUE	FALSE	BOOL	n/a	n/a	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.
TRUE	Alarms	1100	40	1140	15	hydrogenSensorVentIntakeok	Hydrogen Detector, 40ft Middle	TRUE	FALSE	BOOL	n/a	n/a	Check and fix any hydrogen leak.
TRUE	Alarms	1100	41	1141	0	hydrogenSensorOutletAok	Hydrogen Detector, 40ft Left	TRUE	FALSE	BOOL	n/a	n/a	Check and fix any hydrogen leak.
TRUE	Alarms	1100	41	1141	1	hydrogenSensorOutletBok	Hydrogen Detector, 40ft Right	TRUE	FALSE	BOOL	n/a	n/a	Check and fix any hydrogen leak.
TRUE	Alarms	1100	41	1141	2	FCwave 1 Error	FCwave 1 Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	3	FCwave 2 Error	FCwave 2 Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	4	FCwave 3 Error	FCwave 3 Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	5	FCwave 4 Error	FCwave 4 Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	6	FCwave 5 Error	FCwave 5 Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	7	FCwave 6 Error	FCwave 6 Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	8	HT Cool 1 Error	HT Coolant System 1 Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	9	HT Cool 2 Error	HT Coolant System 2 Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	10	LT Cool Error	LT Coolant System Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	11	Microgrid Error	Microgrid Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	12	Nanogrid Error	Nanogrid Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	13	Ventilation Error	Ventilation Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	14	Climate 40ft Error	40ft Climate Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	41	1141	15	Climate 10ft Error	10ft Climate Control Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	Alarms	1100	42	1142	0	H2 Heating Error	Hydrogen Heating System Error	TRUE	FALSE	BOOL	n/a	n/a	Mitigate alarms in relevant subsystem
TRUE	External Information	1200	0	1200			<Spare>						
TRUE	External Information	1200	1	1201			<Spare>						
TRUE	External Information	1200	2	1202			System efficiency			INT16	0.1	%	(DEIF Power + Pack Power) / (SUM'ed H2 flow converted to power) - realtime
TRUE	External Information	1200	3	1203			FC1 + DC/DC efficiency			INT16	0.1	%	Only FCwave Efficiency
TRUE	External Information	1200	4	1204			FC2 + DC/DC efficiency			INT16	0.1	%	Only FCwave Efficiency
TRUE	External Information	1200	5	1205			FC3 + DC/DC efficiency			INT16	0.1	%	Only FCwave Efficiency
TRUE	External Information	1200	6	1206			FC4 + DC/DC efficiency			INT16	0.1	%	Only FCwave Efficiency
TRUE	External Information	1200	7	1207			FC5 + DC/DC efficiency			INT16	0.1	%	Only FCwave Efficiency
TRUE	External Information	1200	8	1208			FC6 + DC/DC efficiency			INT16	0.1	%	Only FCwave Efficiency
TRUE	External Information	1200	9	1209			FC1 stack lifetime produced energy			UINT32	0.1	kWh - DC	stack A (voltage*current) + stack B (voltage*current) 214GWh = 1.07mio hours at full load = 30 topswaps@30.000h
TRUE	External Information	1200	11	1211			FC2 stack lifetime produced energy			UINT32	0.1	kWh - DC	stack A (voltage*current) + stack B (voltage*current) 214GWh = 1.07mio hours at full load = 30 topswaps@30.000h
TRUE	External Information	1200	13	1213			FC3 stack lifetime produced energy			UINT32	0.1	kWh - DC	stack A (voltage*current) + stack B (voltage*current) 214GWh = 1.07mio hours at full load = 30 topswaps@30.000h
TRUE	External Information	1200	15	1215			FC4 stack lifetime produced energy			UINT32	0.1	kWh - DC	stack A (voltage*current) + stack B (voltage*current) 214GWh = 1.07mio hours at full load = 30 topswaps@30.000h
TRUE	External Information	1200	17	1217			FC5 stack lifetime produced energy			UINT32	0.1	kWh - DC	stack A (voltage*current) + stack B (voltage*current) 214GWh = 1.07mio hours at full load = 30 topswaps@30.000h
TRUE	External Information	1200	19	1219			FC6 stack lifetime produced energy			UINT32	0.1	kWh - DC	stack A (voltage*current) + stack B (voltage*current) 214GWh = 1.07mio hours at full load = 30 topswaps@30.000h
TRUE	External Information	1200	21	1221			System lifetime produced energy			UINT32	1	kWh - AC	value from ABB breaker 2147GWh = 1.34mio hours @ 1.6MW
TRUE	External Information	1200	23	1223			FC1 H2 flow rate			INT16	0.01	kg/h	Estimate from Module Current - +/-15% at steady state
TRUE	External Information	1200	24	1224			FC2 H2 flow rate			INT16	0.01	kg/h	Estimate from Module Current - +/-15% at steady state
TRUE	External Information	1200	25	1225			FC3 H2 flow rate			INT16	0.01	kg/h	Estimate from Module Current - +/-15% at steady state

TRUE	External Information	1200	26	1226		FC4 H2 flow rate	INT16	0.01	kg/h	Estimate from Module Current - +/-15% at steady state
TRUE	External Information	1200	27	1227		FC5 H2 flow rate	INT16	0.01	kg/h	Estimate from Module Current - +/-15% at steady state
TRUE	External Information	1200	28	1228		FC6 H2 flow rate	INT16	0.01	kg/h	Estimate from Module Current - +/-15% at steady state
TRUE	External Information	1200	29	1229		H2 Consumption Status Word	WORD			
TRUE	External Information	1200			0	FC1 H2 consumption active	BOOL		0 = not active - 1 = active	
TRUE	External Information	1200			1	FC2 H2 consumption active	BOOL		0 = not active - 1 = active	
TRUE	External Information	1200			2	FC3 H2 consumption active	BOOL		0 = not active - 1 = active	
TRUE	External Information	1200			3	FC4 H2 consumption active	BOOL		0 = not active - 1 = active	
TRUE	External Information	1200			4	FC5 H2 consumption active	BOOL		0 = not active - 1 = active	
TRUE		1200			5	FC6 H2 consumption active	BOOL		0 = not active - 1 = active	
TRUE	External Information	1200			6 to 15	<Spare>	BOOL			
TRUE	External Information	1200	30	1230		Ambient Temperature	INT16	0.1	°C	
TRUE	External Information	1200	31	1231		Container intake air Temperature	INT16	0.1	°C	
TRUE	External Information	1200	32	1232		LT Coolant Return Temperature	INT16	0.1	°C	
TRUE	External Information	1200	33	1233		LT Cooling Forward Temperature	INT16	0.1	°C	
TRUE	External Information	1200	34	1234		HT1 Coolant Return Temperature	INT16	0.1	°C	
TRUE	External Information	1200	35	1235		HT1 Coolant Forward Temperature	INT16	0.1	°C	
TRUE	External Information	1200	36	1236		HT2 Coolant Return Temperature	INT16	0.1	°C	
TRUE	External Information	1200	37	1237		HT2 Coolant Forward Temperature	INT16	0.1	°C	
TRUE	External Information	1200	38	1238		FC1 Stack Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	39	1239		FC1 DCDC A Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	40	1240		FC1 DCDC B Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	41	1241		FC2 Stack Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	42	1242		FC2 DCDC A Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	43	1243		FC2 DCDC B Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	44	1244		FC3 Stack Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	45	1245		FC3 DCDC A Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	46	1246		FC3 DCDC B Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	47	1247		FC4 Stack Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	48	1248		FC4 DCDC A Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	49	1249		FC4 DCDC B Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	50	1250		FC5 Stack Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	51	1251		FC5 DCDC A Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	52	1252		FC5 DCDC B Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	53	1253		FC6 Stack Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	54	1254		FC6 DCDC A Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	55	1255		FC6 DCDC B Power	INT16	0.1	kW - DC	
TRUE	External Information	1200	56	1256		FC1 Stack Current String A	INT16	0.1	A - DC	
TRUE	External Information	1200	57	1257		FC1 Stack Current String B	INT16	0.1	A - DC	
TRUE	External Information	1200	58	1258		FC1 Stack Voltage String A	INT16	0.1	V - DC	
TRUE	External Information	1200	59	1259		FC1 Stack Voltage String B	INT16	0.1	V - DC	
TRUE	External Information	1200	60	1260		FC2 Stack Current String A	INT16	0.1	A - DC	
TRUE	External Information	1200	61	1261		FC2 Stack Current String B	INT16	0.1	A - DC	
TRUE	External Information	1200	62	1262		FC2 Stack Voltage String A	INT16	0.1	V - DC	
TRUE	External Information	1200	63	1263		FC2 Stack Voltage String B	INT16	0.1	V - DC	
TRUE	External Information	1200	64	1264		FC3 Stack Current String A	INT16	0.1	A - DC	
TRUE	External Information	1200	65	1265		FC3 Stack Current String B	INT16	0.1	A - DC	
TRUE	External Information	1200	66	1266		FC3 Stack Voltage String A	INT16	0.1	V - DC	
TRUE	External Information	1200	67	1267		FC3 Stack Voltage String B	INT16	0.1	V - DC	
TRUE	External Information	1200	68	1268		FC4 Stack Current String A	INT16	0.1	A - DC	
TRUE	External Information	1200	69	1269		FC4 Stack Current String B	INT16	0.1	A - DC	
TRUE	External Information	1200	70	1270		FC4 Stack Voltage String A	INT16	0.1	V - DC	
TRUE	External Information	1200	71	1271		FC4 Stack Voltage String B	INT16	0.1	V - DC	
TRUE	External Information	1200	72	1272		FC5 Stack Current String A	INT16	0.1	A - DC	
TRUE	External Information	1200	73	1273		FC5 Stack Current String B	INT16	0.1	A - DC	
TRUE	External Information	1200	74	1274		FC5 Stack Voltage String A	INT16	0.1	V - DC	
TRUE	External Information	1200	75	1275		FC5 Stack Voltage String B	INT16	0.1	V - DC	
TRUE	External Information	1200	76	1276		FC6 Stack Current String A	INT16	0.1	A - DC NOT tested	
TRUE	External Information	1200	77	1277		FC6 Stack Current String B	INT16	0.1	A - DC NOT tested	
TRUE	External Information	1200	78	1278		FC6 Stack Voltage String A	INT16	0.1	V - DC NOT tested	
TRUE	External Information	1200	79	1279		FC6 Stack Voltage String B	INT16	0.1	V - DC NOT tested	
TRUE	External Information	1200	80	1280		FC1 Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	82	1282		FC2 Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	84	1284		FC3 Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	86	1286		FC4 Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	88	1288		FC5 Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	90	1290		FC6 Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	92	1292		System ON Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	94	1294		PLC ON Hour Meter	UINT32	0.01	hrs	21mio hours = 2451 years
TRUE	External Information	1200	96	1296		FC1 start counter	INT16	1	no.	
TRUE	External Information	1200	97	1297		FC2 start counter	INT16	1	no.	
TRUE	External Information	1200	98	1298		FC3 start counter	INT16	1	no.	
TRUE	External Information	1200	99	1299		FC4 start counter	INT16	1	no.	
TRUE	External Information	1200	100	1300		FC5 start counter	INT16	1	no.	
TRUE	External Information	1200	101	1301		FC6 start counter	INT16	1	no.	
TRUE	External Information	1200	102	1302		System start counter	INT16	1	no.	
TRUE	External Information	1200	103	1303		FC1 shutdown counter	INT16	1	no.	
TRUE	External Information	1200	104	1304		FC2 shutdown counter	INT16	1	no.	
TRUE	External Information	1200	105	1305		FC3 shutdown counter	INT16	1	no.	
TRUE	External Information	1200	106	1306		FC4 shutdown counter	INT16	1	no.	
TRUE	External Information	1200	107	1307		FC5 shutdown counter	INT16	1	no.	
TRUE	External Information	1200	108	1308		FC6 shutdown counter	INT16	1	no.	
TRUE	External Information	1200	109	1309		System shutdown counter	INT16	1	no.	

TRUE	External Information	1200	110	1310	Main Output Voltage L1L2	INT16	0.1	V - AC	
TRUE	External Information	1200	111	1311	Main Output Voltage L2L3	INT16	0.1	V - AC	
TRUE	External Information	1200	112	1312	Main Output Voltage L3L1	INT16	0.1	V - AC	
TRUE	External Information	1200	113	1313	Main Output Voltage L1N	INT16	0.1	V - AC	
TRUE	External Information	1200	114	1314	Main Output Voltage L2N	INT16	0.1	V - AC	
TRUE	External Information	1200	115	1315	Main Output Voltage L3N	INT16	0.1	V - AC	
TRUE	External Information	1200	116	1316	Main Output Current L1	INT16	1	A - AC	
TRUE	External Information	1200	117	1317	Main Output Current L2	INT16	1	A - AC	
TRUE	External Information	1200	118	1318	Main Output Current L3	INT16	1	A - AC	
TRUE	External Information	1200	119	1319	Main Output Power	INT16	0.1	kW - AC	
TRUE	External Information	1200	120	1320	Main Output Reactive Power	INT16	0.1	kvar	
TRUE	External Information	1200	121	1321	Main Output Apparent Power	INT16	0.1	kVA	
TRUE	External Information	1200	122	1322	Main Output Power Factor	INT16	0.001	-	
TRUE	External Information	1200	123	1323	Main Busbar Frequency	UINT16	0.001	Hz	
TRUE	External Information	1200	124	1324	Main Busbar Voltage L1L2	INT16	0.1	V - AC	
TRUE	External Information	1200	125	1325	Main Busbar Voltage L2L3	INT16	0.1	V - AC	
TRUE	External Information	1200	126	1326	Main Busbar Voltage L3L1	INT16	0.1	V - AC	
TRUE	External Information	1200	127	1327	Main Busbar Voltage L1N	INT16	0.1	V - AC	
TRUE	External Information	1200	128	1328	Main Busbar Voltage L2N	INT16	0.1	V - AC	
TRUE	External Information	1200	129	1329	Main Busbar Voltage L3N	INT16	0.1	V - AC	
TRUE	External Information	1200	130	1330	AUX Voltage L1L2	INT16	0.1	V - AC	
TRUE	External Information	1200	131	1331	AUX Voltage L2L3	INT16	0.1	V - AC	
TRUE	External Information	1200	132	1332	AUX Voltage L3L1	INT16	0.1	V - AC	
TRUE	External Information	1200	133	1333	AUX Voltage L1N	INT16	0.1	V - AC	
TRUE	External Information	1200	134	1334	AUX Voltage L2N	INT16	0.1	V - AC	
TRUE	External Information	1200	135	1335	AUX Voltage L3N	INT16	0.1	V - AC	
TRUE	External Information	1200	136	1336	AUX Current L1	INT16	0.1	A - AC	
TRUE	External Information	1200	137	1337	AUX Current L2	INT16	0.1	A - AC	
TRUE	External Information	1200	138	1338	AUX Current L3	INT16	0.1	A - AC	
TRUE	External Information	1200	139	1339	AUX Power	INT16	0.1	kW - AC	
TRUE	External Information	1200	140	1340	AUX Reactive Power	INT16	0.1	kvar	
TRUE	External Information	1200	141	1341	AUX Apparent Power	INT16	0.1	kVA	
TRUE	External Information	1200	142	1342	AUX Power Factor	INT16	0.001	n/a	
TRUE	External Information	1200	143	1343	AUX Frequency	UINT16	0.001	Hz	
TRUE	External Information	1200	144	1344	Nanogrid Power	INT16	0.1	kW - DC	Nanogrid Breaker Total Power
FALSE	External Information	1200	145	1345	Energy transfer to battery	INT32	0.1	kWh - DC	<Not Implemented>
FALSE	External Information	1200	147	1347	Energy transfer from battery	INT32	0.1	kWh - DC	<Not Implemented>
FALSE	External Information	1200	149	1349	Battery Bus voltage	INT16	0.1	V - DC	<Not Implemented>
FALSE	External Information	1200	150	1350	Battery Bus current	INT16	0.1	A - DC	<Not Implemented>
FALSE	External Information	1200	151	1351	Battery string 1 current	INT16	0.1	A - DC	<Not Implemented>
FALSE	External Information	1200	152	1352	Battery string 2 current	INT16	0.1	A - DC	<Not Implemented>
FALSE	External Information	1200	154	1354	Battery string 4 current	INT16	0.1	A - DC	<Not Implemented>
FALSE	External Information	1200	155	1355	Battery Bus power	INT16	0.1	kW - DC	<Not Implemented>
FALSE	External Information	1200	156	1356	Battery DC/DC power	INT16	0.1	kW - DC	<Not Implemented>
FALSE	External Information	1200	157	1357	Battery string 1, cell voltage min	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	158	1358	Battery string 1, cell voltage max	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	159	1359	Battery string 1, cell voltage avg	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	160	1360	Battery string 2, cell voltage min	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	161	1361	Battery string 2, cell voltage max	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	162	1362	Battery string 2, cell voltage avg	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	163	1363	Battery string 3, cell voltage min	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	164	1364	Battery string 3, cell voltage max	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	165	1365	Battery string 3, cell voltage avg	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	166	1366	Battery string 4, cell voltage min	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	167	1367	Battery string 4, cell voltage max	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	168	1368	Battery string 4, cell voltage avg	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	169	1369	Battery pack, cell voltage min	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	170	1370	Battery pack, cell voltage max	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	171	1371	Battery pack, cell voltage avg	INT16	1	mV - DC	<Not Implemented>
FALSE	External Information	1200	172	1372	Battery string 1, min temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	173	1373	Battery string 1, max temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	174	1374	Battery string 1, avg temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	175	1375	Battery string 2, min temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	176	1376	Battery string 2, max temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	177	1377	Battery string 2, avg temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	178	1378	Battery string 3, min temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	179	1379	Battery string 3, max temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	180	1380	Battery string 3, avg temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	181	1381	Battery string 4, min temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	182	1382	Battery string 4, max temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	183	1383	Battery string 4, avg temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	184	1384	Battery pack, min temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	185	1385	Battery pack, max temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	186	1386	Battery pack, avg temp	INT16	0.1	°C	<Not Implemented>
FALSE	External Information	1200	187	1387	Battery pack SoC	INT16	0.1	%	<Not Implemented>
FALSE	External Information	1200	188	1388	Battery pack cycle count	INT16	1	no.	<Not Implemented>
FALSE	External Information	1200	189	1389	Charger System Status word	WORD			<Not Implemented>
FALSE	External Information	1200		0	Charger System on Fuel Cell supply	BOOL			<Not Implemented>
FALSE	External Information	1200		1	Charger System on Grid/Utility supply	BOOL			<Not Implemented>
FALSE	External Information	1200		2 to 15	<Spare>	BOOL			<Not Implemented>
FALSE	External Information	1200	190	1390	<Spare>				<Not Implemented>
FALSE	External Information	1200	191	1391	<Spare>				<Not Implemented>

FALSE	External Information	1200	192	1392	<Spare>	<Not Implemented>
FALSE	External Information	1200	193	1393	<Spare>	<Not Implemented>

Crosswind FC Package - Main PLC

Main FC Package Statemachine Index

State Index	State Name	C08-001 Reference	Comment
0	Wakeup	Initialization	Value not visible on modbus
3	EstablishComms	Initialization	Value not visible on modbus
6	Initialize	Initialization	
10	Sleep	Sleep	
14	StartupContainerVentilation	Wakeup	
17	FCwaveWakeup	Wakeup	
18	BatteryWakeup	n/a	Not Applicable for CW FC Package
19	HydrogenHeaterStartup	Wakeup	
20	Standby	Standby	
30	BatteryStartup	Startup	
40	NanogridStartup	Startup	
50	LTCoolantStartup	Startup	
60	MicrogridStartup	Startup	
70	FCwavesStartup	Startup	
100	Running	Running	
105	RampDownPower	Rampdown	
110	MicrogridShutdown	Rampdown	
120	ChargeBattery	Rampdown	
130	ShutdownFCwaves	Rampdown	
140	Aftercool	Aftercool	
160	ShutdownNanogrid	Shutdown	
170	ShutdownBattery	Shutdown	Not Applicable for CW FC Package
172	ShutdownHydorgenHeater	Shutdown	
175	PutBatteriesToSleep	Shutdown	Not Applicable for CW FC Package
180	PutFCwavesToSleep	Shutdown	
190	ShutdownVentilation	Shutdown	
200	Error	Error	
201	ErrorEmergShutdown	Error	
210	ResetError	Error	

Crosswind FC Package - Main PLC

Main FC Control Statemachine Index

State Index	State Name	Column1	Column2
0	PowerOff		
1	PowerUp		
20	WaitControllers		
25	FCwaveUnlocked		
26	StartupDCDCs		
27	SetDCDCsVoltageMode		
30	FCwavePrecharge		
40	FCwaveStandby		
80	StartupDCDCsActive		
95	StartupDCDCsPassive		
99	RampUpCurrent		
100	Running		
105	RampDownCurrent		
135	Shutdown		
200	Error		
210	ResetError		
211	ResetHLockError		
212	ResetFCwaveSafetyController		
213	ResetMainSafetyController		
300	DegasFCwave		
310	PrepareService		
311	Service		
320	Dryout		

Sub Section C08-003

Alarm list

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	1/24/2025	First Issue
002	4/2/2025	Update with corrective actions
003	21/08/2025	Updated in accordance with Modbus Table

Document Title:	**BLPH Project - Control System Alarm List**
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Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Alarm System Introduction
Full Title	Crosswind BLPH Project – FC Package Alarm System Introduction and Explanation
Abstract	*This document presents the details and reading guide for the FC Package Alarm System for the Crosswind BLPH project.*

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Revision Record

Rev #	Description	Revised By	Date
1.0	JWI		**25-03-2025**
2.0	PBL		02-04-2025
3.0	PBL		21-08-2025

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1.0 Purpose and Scope

This document presents the details and reading guide for the FC Package Alarm System for the Crosswind BLPH project.

2.0 Terminology

Table 1: List of Terminology

Abbreviation	Full Name
OT	Operational Technology
IACS	Industrial Automation and Control Systems
BLPH	Crosswind Hollandse Kust Noord Baseload Power Hub
HT	High Temperature
LT	Low Temperature
H2	Hydrogen
IsoMon	Isolation Monitor
CoolBreak	Coolant Breaker
P&ID	Process and Instrumentation Diagram
PSU	Power Supply Unit
SLD	Single Line Diagram (Electrical)
HV	High Voltage

3.0 Operator Expectations

The following is expected of the operator, which will be notified of the alarms and is responsible for reacting to the alarm codes

- Access to relevant documentation:
  - Fuel Cell Package P&ID
  - Fuel Cell Package SLD
  - Platform Safety Plan
- Understanding of the following:
  - Reading and understanding a P&ID
  - Reading and understanding a Single Line Diagram
  - Basic understanding of fuel cell package operation
  - Basic understanding of fuel cell fundamentals
  - Basic understanding of industrial control systems and electrical systems
  - Basic electrical troubleshooting knowledge is recommended.

4.0 Alarm System Introduction

An alarm is set up of several logical steps, to determine if an alarm is Active. The alarm is set up around a basic equation called the *Alarm Test*, where a process value is compared to a limit, with basic mathematical comparison-operators. An example below is shown with the Greater Than operator:

$$pv > limit$$

Here, *pv* is the Process Value – either a sensor value or a calculated value. If the equation yields True, the Alarm Test is True.

Please note that the pv and limit can be Boolean values. The operator will then always be the equality operator ('='). If the operator field is left blank, the equality operator is implicit.

When the Alarm Test is True, a timer denoted the Delay Time is started. If the Delay Time elapses, the alarm becomes Active. If the Alarm Test becomes False during the Delay Time, the Delay Time is reset. In other words, the Alarm Test must be true for the consecutive number of seconds denoted by the delay time.

An alarm can be Inactive in certain states. This means the Alarm Test is not evaluated. After the system transitions from a state where the alarm is Inactive to a state where the alarm is Active, the State Enable Delay must elapse before the Alarm Test is evaluated (and thus, before the Delay Time is started). Note that the State Enable Delay does not apply to a state transition where the alarm was Active in both states.

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5.0 Severities

The Severity has no effect on whether an alarm is Active or not, only how the system reacts to the alarm if it becomes Active. There are five different severities, from 0 to 4:

Severity 0 – Info: An information of a parameter being outside an optimal range but will not impair the system from running at full capacity. Action may be taken to restore optimal running conditions.

Severity 1 – Warning: A parameter is outside normal operating limits. System can still run, but possibly in a derated mode. Action should be planned to rectify the problem, as this parameter will likely lead to a shutdown of the system

Severity 2 – Delayed shutdown: A parameter is outside acceptable operating limits, but safe to operate for a short period. System will run normally for this short period, then perform a controlled shutdown. Problem must be rectified before a restart can be attempted.

Severity 3 – Controlled Shutdown: A parameter is outside safe operating limits. System will perform a controlled shutdown. Problem must be rectified before a restart can be attempted.

Severity 4 – Emergency Shutdown: A parameter is outside safe operating limits. This parameter would not allow a safe, controlled shutdown. Thus, the system will perform an immediate shutdown. Problem must be rectified before a restart can be attempted.

6.0 Corrective Action

The alarm list includes a column with a brief description of the suggested corrective action for each alarm. A column is also included with a yes/no indication of if the corrective action is plausible from a remote monitoring control station.

E.g., a high temperature warning might suggest reducing power requested from the FC package, which should be possible from a remote-operator station.

Another alarm might suggest inspection of a coolant system, which is not plausible from a remote-operator station.

Some alarms direct the operator to contact Ballard, either on occurrence or recurrence

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Alarm Examples

6.1 Example 1

As an example, we take alarm ID 22038. This has the following definition:

Table 2 - Alarm Example 1

ID	Sub-system	Alarm Name	Tagname	Unit	Oper-ator	Limit	Sev	Delay Time	State Enable Delay	Corrective Action	Remote Friendly
22038	LT Cooling	Return Temp High-High	=HE03+DA01-BT01	°C	>	55	3	20	0	Coolant System temperature is too high, maximum ambient temperature is 25°C	Yes

This alarm belongs to the LT Cooling subsystem and is activated if the Return Temperature becomes too high. The sensor which measures this is called =HE03+DA01-BT01. If this temperature is above 55 °C for 20 consecutive seconds, the alarm becomes Active. As it is a Severity 3 alarm, it would trigger a controlled shutdown of the LT Cooling subsystem. The Corrective action is a text for the operator, indicating what is possible to mitigate the issue – in this case waiting until the ambient temperature is reduced. The remote friendly text indicates if the alarm is plausibly fixed by a remote operator, in this case no action on the platform is needed.

6.2 Example 2

For another example, let's look at alarm 1014:

Table 3 - Alarm Example 2

ID	Sub-system	Alarm Name	Tagname	Unit	Oper-ator	Limit	Sev	Delay Time	State Enable Delay	Corrective Action	Remote Fiendly
1015	Main Control	Smoke Detector OutletB	=JA01+DA01-BQ06		=	TRUE	4	3	3	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.	No

This alarm belongs to the Main Control System. It is activated if Smoke Detector B in the 40 ft container is activated. The detector is called =JA01+DA01-BQ06. When this detector returns TRUE (high) for 3 consecutive seconds, the alarm becomes Active. As it is a Severity 4 alarm, it will trigger an emergency shutdown of the Main Control System.

This alarm is reset by removing and reseating the smoke detector, which is not feasible by a remote operator.

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AlarmID	ID Prefix	ID Suffix	SubSystem	Alarm Name	Tagname	Unit	Operator	Limit	Severity	Description	Delay Time	State Enable Delay	Corrective Action	Remote Friendly	Modbus Address	Modbus Bit
1001	1	1	MainControl	MainSafetyOK	=LA01+UC20-KE10			FALSE	4	Main Safety needs Reset	3	3	Reset Main Safety Controller once it is safe to do so	No	1140	0
1002	1	2	MainControl	SafetymodbusCommsDriverError				TRUE	4	Safety Controller - Com Error	3	3	Inspect network connection between Safety Controllers and main controller, and fix loose cables, replace broken cables and check network switches	No	1140	1
1003	1	3	MainControl	ESTOPCustomer	<RM/BLPH Scope>			FALSE	4	E STOP BLPH Platform	3	3	ESTOP from BLPH - Correct BLPH error and reset safety system	No	1140	2
1004	1	4	MainControl	ESTOPcontrolCabinet	=LA01+UC20-SG10			FALSE	4	E STOP Control Cabinet	3	3	Release the safety button once it is safe to do so	No	1140	3
1005	1	5	MainControl	ESTOPContainerDoor	=LB02+DA01-SG23			FALSE	4	ESTOP Container Door	3	3	Release the safety button once it is safe to do so	No	1140	4
1006	1	6	MainControl	ESTOPcoolantSkid	=LB02+DA04-SG4			FALSE	4	E STOP Coolant Skid	3	3	Release the safety button once it is safe to do so	No	1140	5
1007	1	7	MainControl	EFIBusStatus1	=LA01+UC20-KE10			FALSE	4	Safety Controller - 40/10ft Com Ch 1	3	3	Inspect CANBus cables between Safety Controllers in UC20 and UC30, and fix loose cables or replace broken cables		1140	6
1008	1	8	MainControl	EFIBusStatus2	=LA01+UC20-KE10			FALSE	4	Safety Controller - 40/10ft Com Ch 2	3	3	Inspect CANBus cables between Safety Controllers in UC20 and UC30, and fix loose cables or replace broken cables		1140	7
1009	1	9	MainControl	ESTOP10ft	n/a			FALSE	4	Not Applicable	3	3	Not Applicable		1140	8
1010	1	10	MainControl	DoorRight_10ft	=LB02+DA03-BG01			FALSE	4	10ft Container - Door Right Open	3	3	Close door and check safety switch	No	1140	9
1011	1	11	MainControl	DoorLeft_10ft	=LB02+DA03-BG02			FALSE	4	10ft Container - Door Left Open	3	3	Close door and check safety switch	No	1140	10
1012	1	12	MainControl	smokeDetectorIntake	=JA01+DA01-BQ04			FALSE	4	Smoke Detector, 40ft Middle	3	3	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.	No	1140	11
1013	1	13	MainControl	smokeDetectorOutletA	=JA01+DA01-BQ05			FALSE	4	Smoke Detector, 40ft Left	3	3	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.	No	1140	12
1014	1	14	MainControl	smokeDetectorOutletB	=JA01+DA01-BQ06			FALSE	4	Smoke Detector, 40ft Right	3	3	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.	No	1140	13
1015	1	15	MainControl	smokeDetector10ft	=JA01+DA03-BQ01			FALSE	4	Smoke Detector, 10ft	3	3	Remove the cause of smoke. Reset sensor by disconnecting from base and reconnect.	No	1140	14
1016	1	16	MainControl	hydrogenSensorVentIntakeok	=JA01+DA01-BQ01			FALSE	4	Hydrogen Detector, 40ft Middle	3	3	Check and fix any hydrogen leak.	No	1140	15
1017	1	17	MainControl	hydrogenSensorOutletAok	=JA01+DA01-BQ02			FALSE	4	Hydrogen Detector, 40ft Left	3	3	Check and fix any hydrogen leak.	No	1141	0
1018	1	18	MainControl	hydrogenSensorOutletBok	=JA01+DA01-BQ03			FALSE	4	Hydrogen Detector, 40ft Right	3	3	Check and fix any hydrogen leak.	No	1141	1
1019	1	19	MainControl	FCwave 1 Error				TRUE	3	FCwave 1 Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	2
1020	1	20	MainControl	FCwave 2 Error				TRUE	3	FCwave 2 Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	3
1021	1	21	MainControl	FCwave 3 Error				TRUE	3	FCwave 3 Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	4
1022	1	22	MainControl	FCwave 4 Error				TRUE	3	FCwave 4 Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	5
1023	1	23	MainControl	FCwave 5 Error				TRUE	3	FCwave 5 Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	6
1024	1	24	MainControl	FCwave 6 Error				TRUE	3	FCwave 6 Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	7
1025	1	25	MainControl	HT Cool 1 Error				TRUE	3	HT Coolant System 1 Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	8
1026	1	26	MainControl	HT Cool 2 Error				TRUE	3	HT Coolant System 2 Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	9
1027	1	27	MainControl	LT Cool Error				TRUE	3	LT Coolant System Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	10
1028	1	28	MainControl	Microgrid Error				TRUE	3	Microgrid Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	11
1029	1	29	MainControl	Nanogrid Error				TRUE	3	Nanogrid Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	12
1030	1	30	MainControl	Ventilation Error				TRUE	3	Ventilation Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	13
1031	1	31	MainControl	Climate 40ft Error				TRUE	3	40ft Climate Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	14
1032	1	32	MainControl	Climate 10ft Error				TRUE	3	10ft Climate Control Error	0	0	Mitigate alarms in relevant subsystem	Yes	1141	15
1033	1	33	MainControl	H2 Heating Error				TRUE	3	Hydrogen Heating System Error	0	0	Mitigate alarms in relevant subsystem	No	1142	0

Sub Section C99-001

Hydrogen Safety Concept

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Revision history		
Rev.	**Date.**	**Description**
001	10/05/2023	First official issue
002	16/04/2024	Updated to include H2 Pre-heater

Document Title:	**Megablock Hydrogen Safety Concept**
Document Number:	K559-2254-CWIWP4202202-C99-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-C99-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Megablock Hydrogen Safety Concept
Full Title	Introduction to Hydrogen Safety Concept for Ballard Megablock Solution
Abstract	This document provides an introduction to the hydrogen safety concept employed in the Ballard Megablock solution. This document documents the location of hydrogen manifolds, valves and couplings, and how the safety is handled for each (the Safety Concept). This document does not describe other parts of the safety for the Megablock, such as electrical safety and personal protective means. The fuel cell module (Ballard FCgen 200kW Fuel Cell Module) has an internal hydrogen safety concept, which is also described.

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Revision Record

Rev #	Description	Revised By	Date
0.1	Initial draft	EZE	April 2023
1.0	First official release	PBL	April 2023
2.0	Update to include hydrogen heater	PBL	April 2024

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1.0 Purpose and Scope

The purpose of this document is to introduce the hydrogen safety concept employed in the Ballard Megablock solution. This document will document the location of hydrogen manifolds, valves and couplings, and how the safety is handled for each (the Safety Concept).

This document does not describe other parts of the safety for the Megablock, such as electrical safety and personal protective means.

The fuel cell module (Ballard FCgen 200kW Fuel Cell Module) has an internal hydrogen safety concept, which will also be described.

The reader is expected to have basic familiarity with gas safety and hydrogen safety.

2.0 References

Table 1: Reference Documents

Document ID	Document Title	Source
IEC 62282-3-100:2020	Stationary Fuel Cell System – Safety	IEC
K559-2254-CWIWP4202202-C03-001	BLPH Project – P&IDs	BPSE
B01	BLPH Project – General Arrangement	BPSE
Directive 2014/34/EU	ATEX Directive	European Commission

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3.0 Hydrogen Supply Overview

3.1 Introduction

This section provides an overview of where hydrogen is supplied to the Megablock, how it is transported to the fuel cell system and how the fuel cell modules handle hydrogen safety. Each of these items is described in further details in following sections.

3.2 Hydrogen Flow

The hydrogen flow for the Megablock container is illustrated in Figure 1, below:

Figure 1: Hydrogen Overview for the Megablock Container

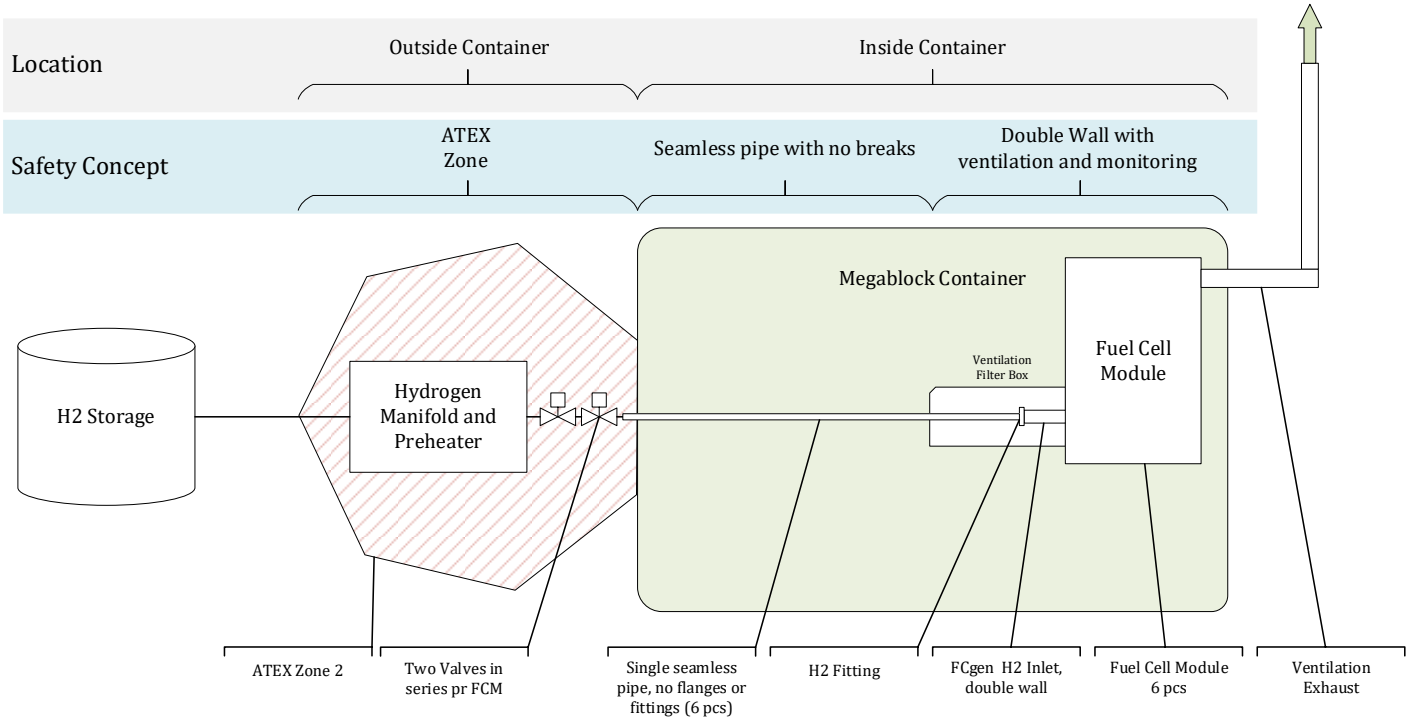


Illustration of the components in the hydrogen supply for the Megablock and the safety concept applicable for each segment.

The main components are:

- Hydrogen Inlet, Manifold and Preheater
  - Connection point for the hydrogen storage system.
  - Pressure transducer to monitor inlet pressure.
  - Hydrogen preheating system.

- Hydrogen Shutoff Valves
    - Direct acting solenoid valves, with each module having two in series.
- Module Supply Pipe
    - Seamless stainless-steel pipe, which carries hydrogen from the shutoff valves to the fuel cell module connection point. One pipe pr module, 6 pcs in total.
    - Pipe has no breaks or fittings outside of the Ventilation Filter Box.
- Ventilation Filter Box
    - Interface between single walled pipe inside container and dual wall inside Fuel Cell module. Ventilated and monitored space, with rapid air change. One filter box pr module, 6 in total.
- Fuel Cell Module
    - FCgen Fuel Cell Module.
    - Contains internal double-wall hydrogen containment system with rapid air changes and dual hydrogen detection sensors.

3.3 Overview Drawings

Better CAD Drawings

4.0 Safety Concepts

This section describes the different safety concepts applicable to parts of the hydrogen supply system for the Megablock.

4.1 ATEX Zone

For an ATEX zone, the safety concept is to follow the recommendations and requirements laid out in the Directive 2014/34/EU, commonly known as the ATEX directive. This results in all electrical components inside the zone having the “EX” marking, covering the zone class, gas type and expected temperature.

4.2 Seamless piping with no breaks

The piping between the ATEX zone and the ventilation filter box is a stainless-steel pipe with no fittings or other breaks between the ATEX zone and the controlled space in the

4.3 Double wall with ventilation and monitoring

The double wall concept is based around the idea of surrounding the hydrogen carrying pipe with a secondary pipe, with the space between the primary and secondary pipe being ventilated and a hydrogen detector measuring the hydrogen concentration. In this case, a leakage is drawn past the detectors by the ventilation air stream.

5.0 Hydrogen Supply Interface and Valve Array

Please refer to document C03 Process and Instrumentation Diagrams.

The interface for the external hydrogen connection is located on the outside of the container. This hydrogen supply inlet contains a pressure transducer and a distribution manifold to the valve array.

The valve array is comprised of two shutoff valves in series for each fuel cell module, providing a redundant method of interrupting the hydrogen supply to the individual modules. There is also installed a manual lockable shutoff fitting for each fuel cell module, facilitating lock-out, tag-out procedures before maintenance activities on the fuel cell modules.

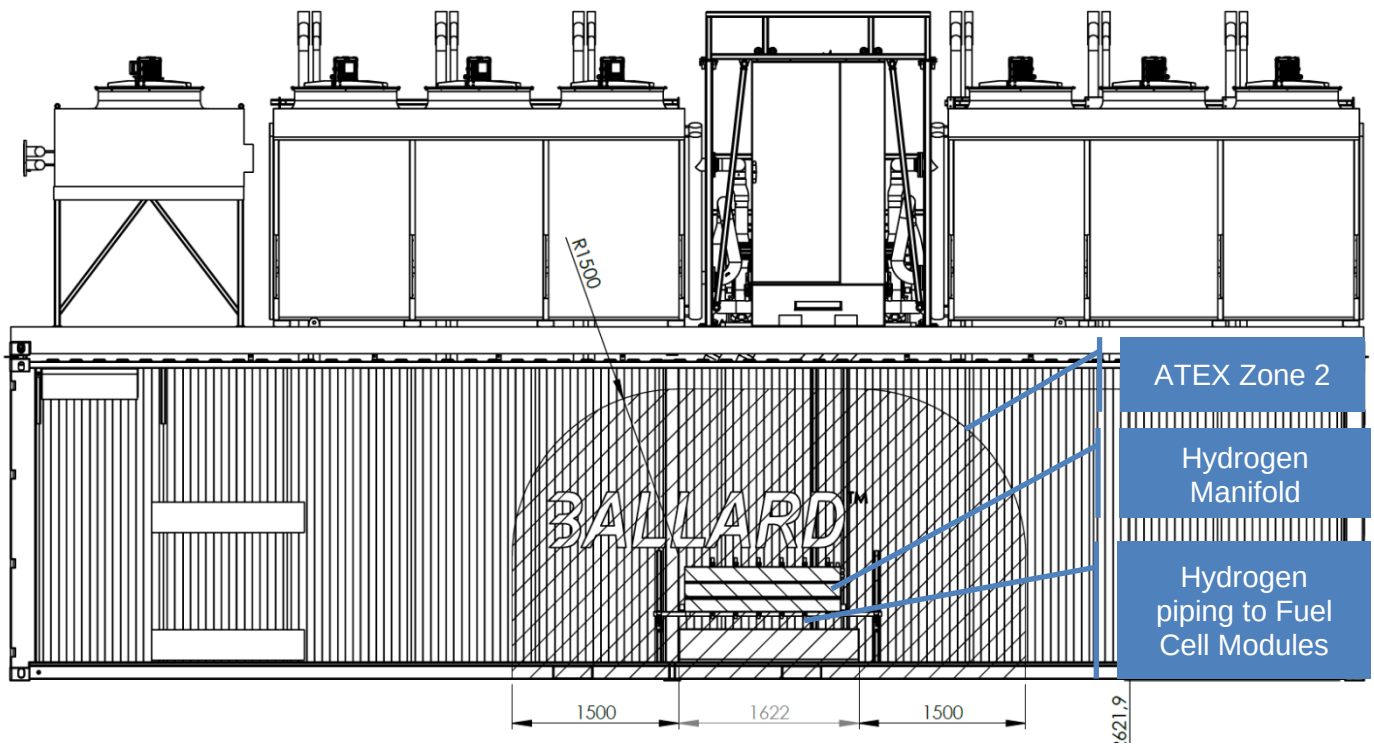
5.1 Hazardous Zone surrounding the Hydrogen Supply Interface and Valve Array

The area surrounding the hydrogen supply interface and the valve array is classified as ATEX Zone 2, where a hazardous mixture will not likely be present in normal operation, and if so, only for a short period.

The document describing the hazardous zone extent is K559-2254-CWIWP4202202-E99-002, with excerpts reproduce below in Figure 2.

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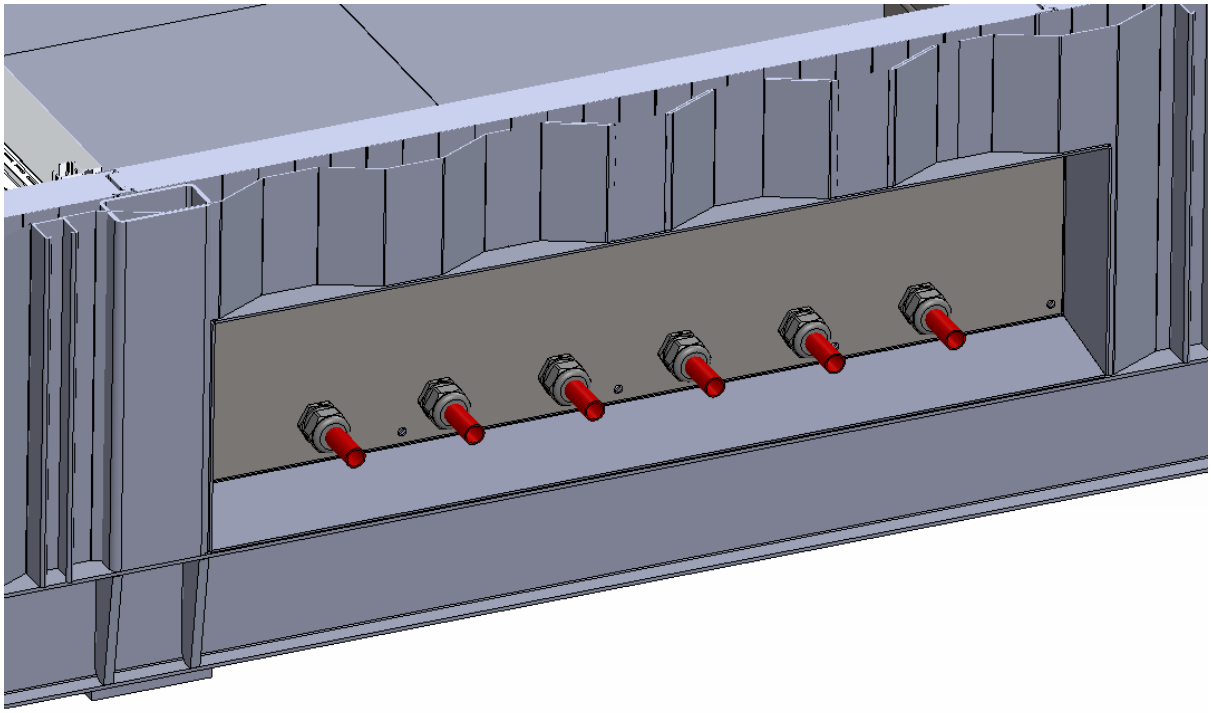
Figure 2: Hazardous Area



*Hazardous area on one side of the 40ft container (opposite air intake). Hydrogen intake and manifold shown above hydrogen piping to the fuel cell modules. Taken from **B01 General Arrangement**.*

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Figure 3: Hydrogen Piping – Container Entry



The piping entry into the container is show here, with the 6 hydrogen pipes shown in red. Each pipe is fixated with Ex-rated pipe gland.

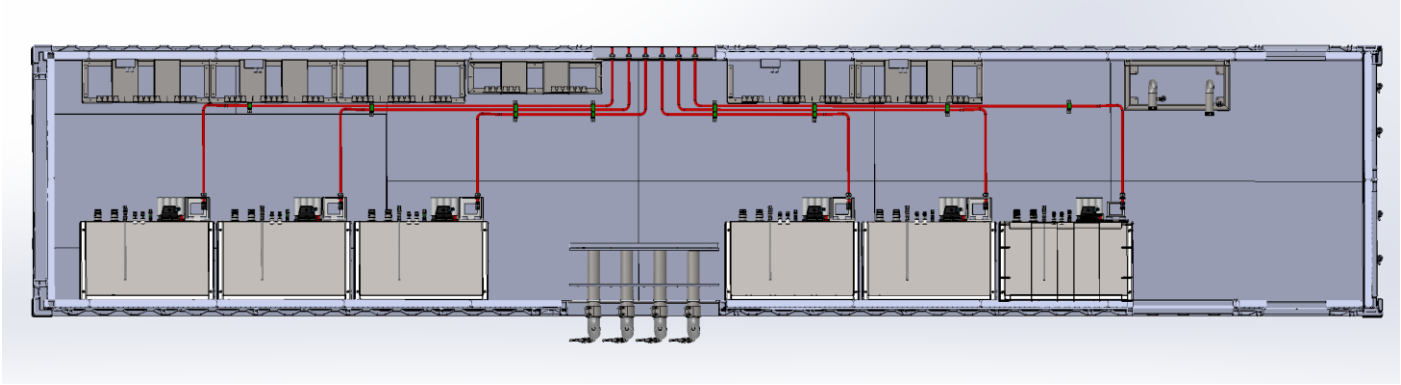
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6.0 Hydrogen Piping to Fuel Cell Modules

The hydrogen is transported from the hydrogen supply interface and the valve array to the fuel cell module in individual, seamless pipes with no breaks or fittings outside the controlled area of the valve array and the ventilation filter box (see section 7.0 Interface to Fuel Cell Module)

The routing of the hydrogen piping is illustrated in Figure 4: Hydrogen Piping.

Figure 4: Hydrogen Piping



Top down view of the 40ft container, with the piping between the valve array and the fuel cell module interface shown, highlighted in red.

The piping is placed below a metal grating floor, protecting it from impacts and incidental damage.

7.0 Interface to Fuel Cell Module

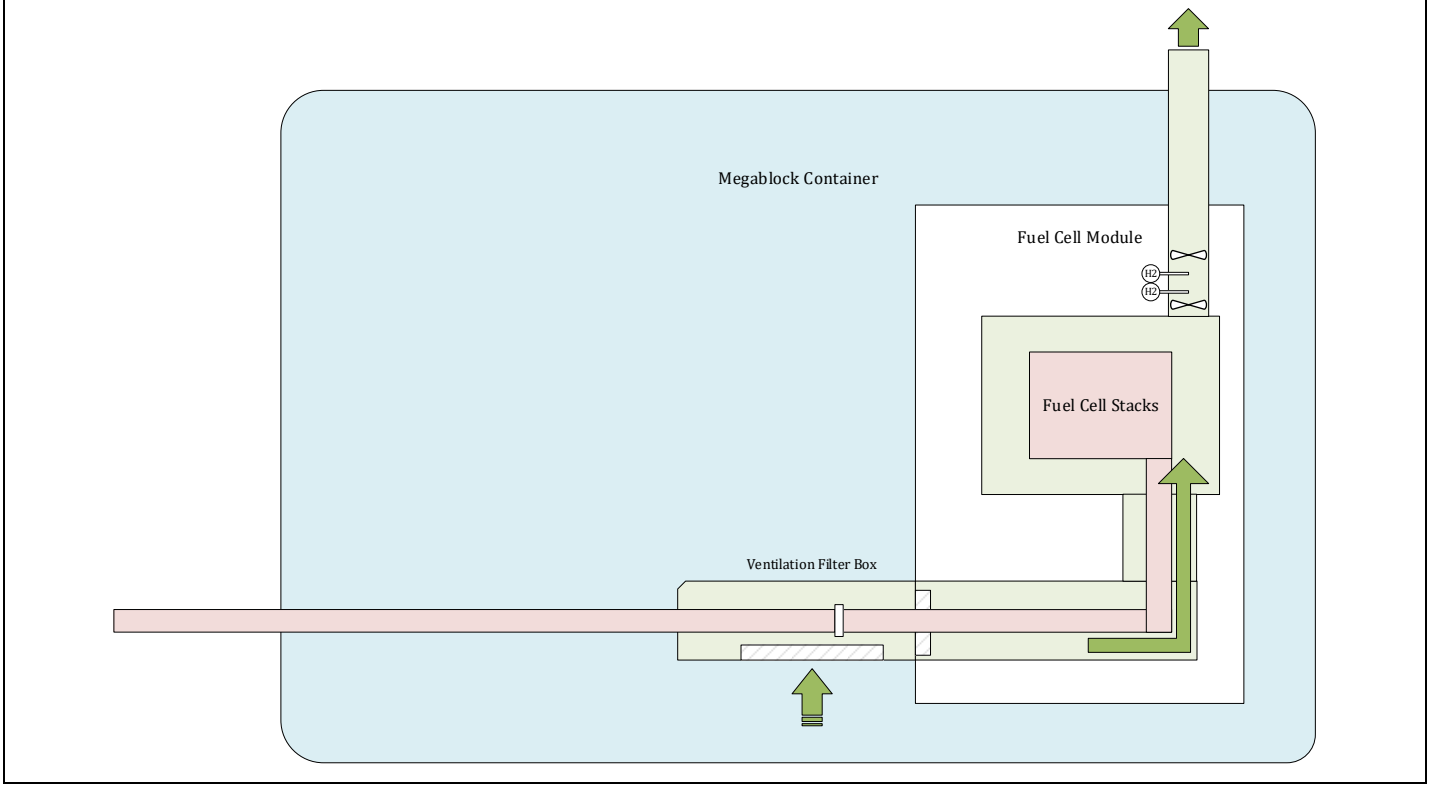
The hydrogen piping interface to the fuel cell module is a connected with double compression ring fitting, contained in a double wall shell, ventilated and monitored, as described in section “4.3 Double wall with ventilation and monitoring”.

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7.1 Ventilation Filter Box

The connection between the hydrogen piping and the fuel cell module is contained in the ventilation filter box, with the concept shown in Figure 5.

Figure 5: Ventilation filter box with airflow indications



Concept drawing for the ventilation filter box. Air is drawn in through the bottom of the filter box and drawn past all hydrogen containing components by redundant fans. The airstream is monitored by two hydrogen detectors

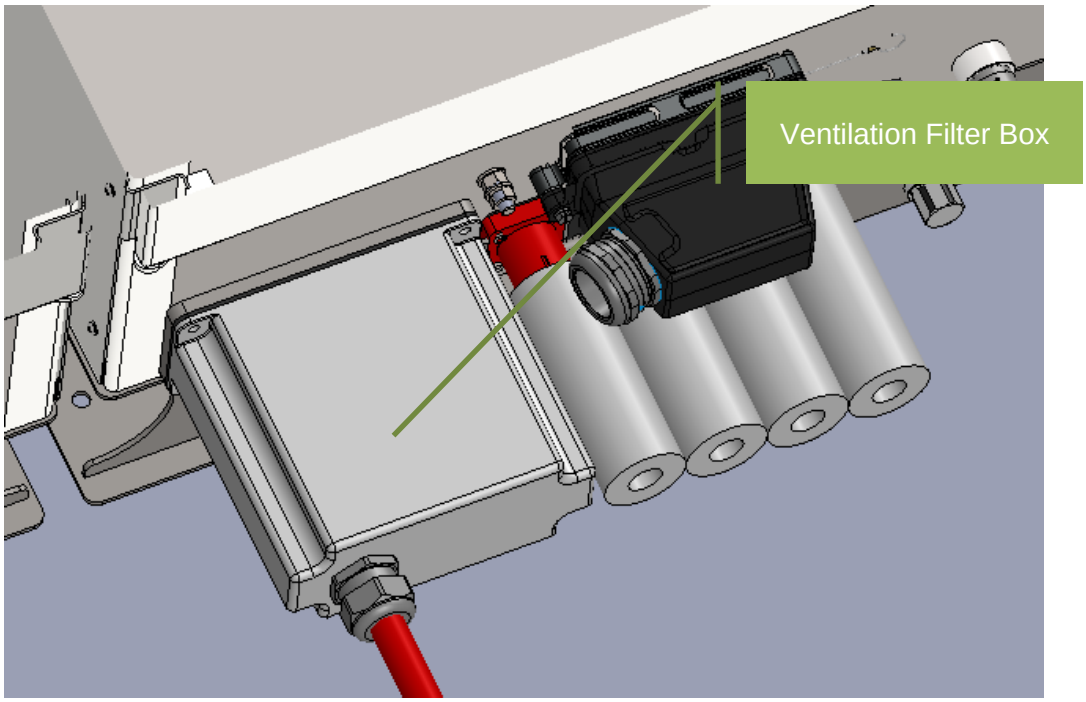
This box is shown in Figure 6 and as a cutaway in Figure 7. The pipe fitting connecting the pipe from the module to the supply pipe is shown in Figure 8.

The ventilation filter box serves the following purpose:

- Enclosure around the hydrogen fitting, enclosing the possible leakage point.
    - Kept at lower than ambient pressure by the module ventilation fans.
    - Airflow over the fitting is carried past module hydrogen sensors, detecting leakages.
- Filter the incoming air
    - Prevents buildup of dust and debris.

- Filter is located on the bottom of the box.

Figure 6: Ventilation Filter Box



The ventilation filter box, mounted of the front of the fuel cell module. Pipe gland fixates pipe to box structure. Air intake at the bottom of the box.

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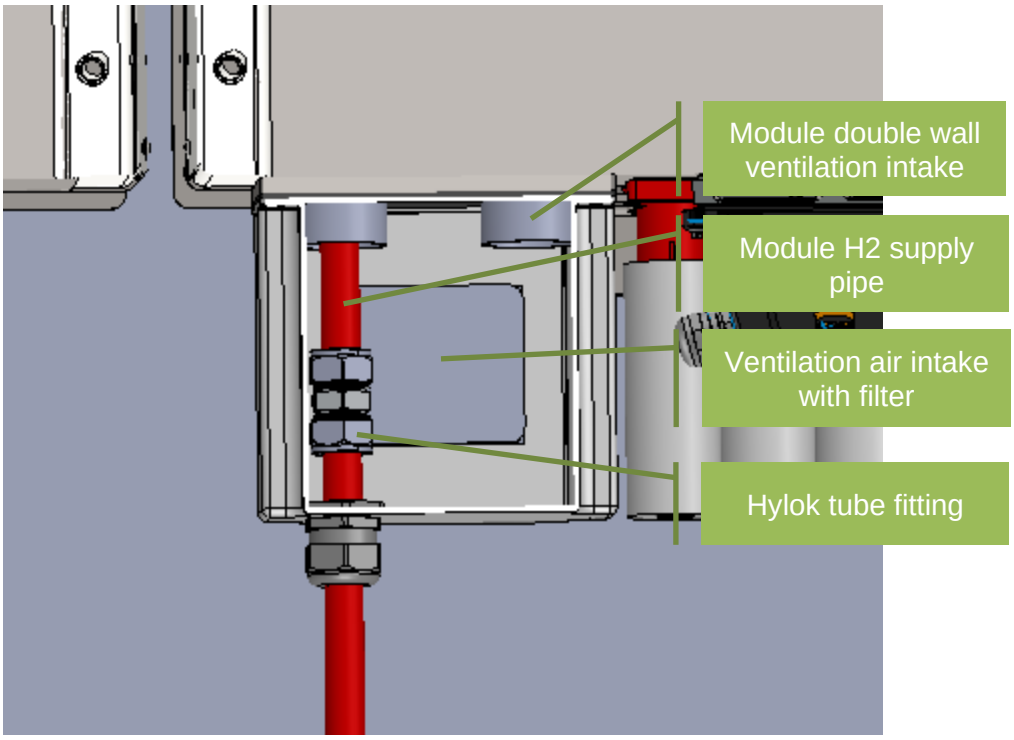
7.2 Ventilation Filter Box internal contents

The internal contents of the ventilation filter box is shown in Figure 7, below:

The air flow path is:

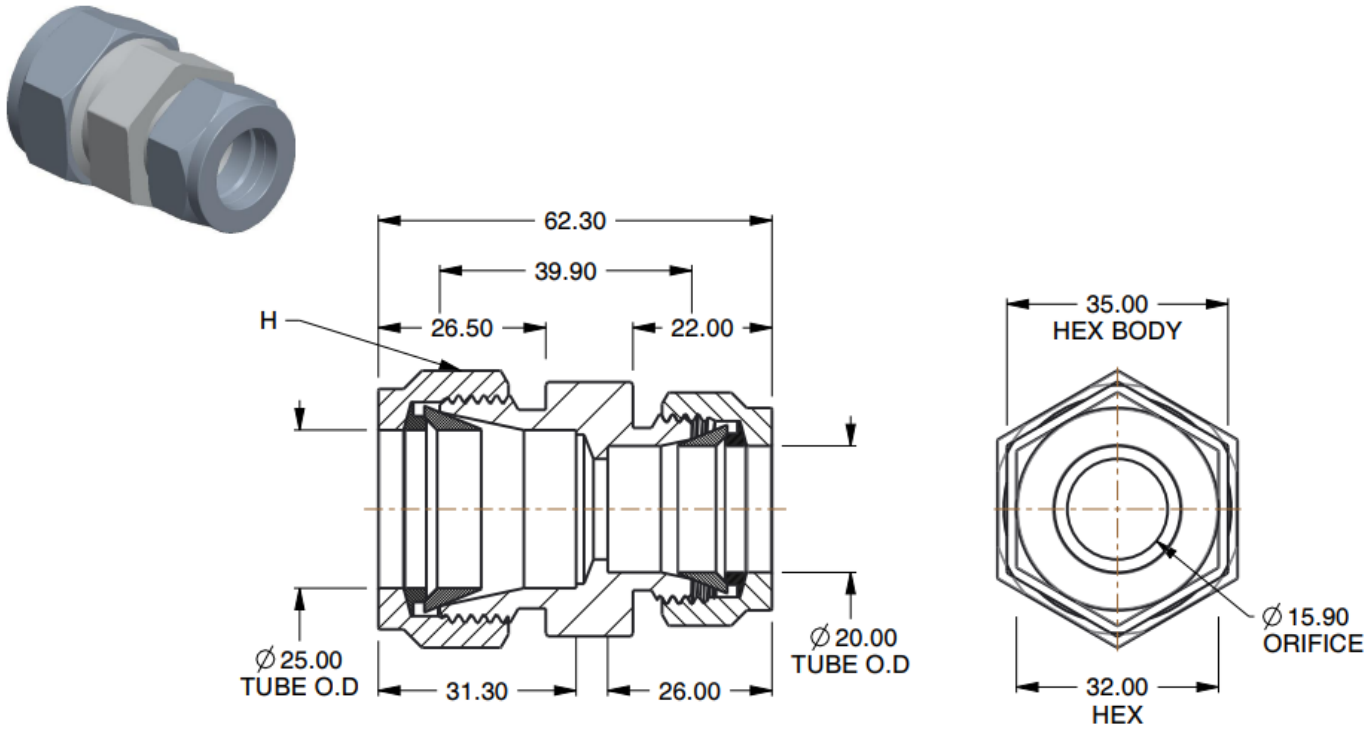
1. Air is drawn in through ventilation air intake through filter.
2. Air is drawn through the module double wall ventilation intake
3. Inside module, air is drawn past all hydrogen containing components (pipes, Valveblock and fuel cell stacks)
4. Redundant fans draw air out of the double wall structure and exhaust it to the module ventilation exhaust.
5. Hydrogen sensors are placed in the ventilation exhaust, monitoring the airstream for leakages.

Figure 7: Ventilation Filter box cutaway



Top-down cutaway view of the ventilation filter box, showing the hydrogen connection fitting and ventilation intake with module air inlet

Figure 8: Double compression ring reducing fitting



Mechanical drawing of double compression ring fitting for hydrogen. Reducing union from 25 to 20 mm OD shown. Material is SS316.

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8.0 Fuel Cell Module

The FCwave™ has 3 levels of safety:

1. Safety in normal operation
    a. Ventilation of hydrogen enclosure volume to prevent any build-up of hydrogen to a combustible level.
2. Safety in probable leakage scenarios
    a. Supervision of the fuel cell and shutting off hydrogen supply in the event of unsafe conditions.
3. Safety in catastrophic events
    a. Encapsulation in the event of a hydrogen explosion.

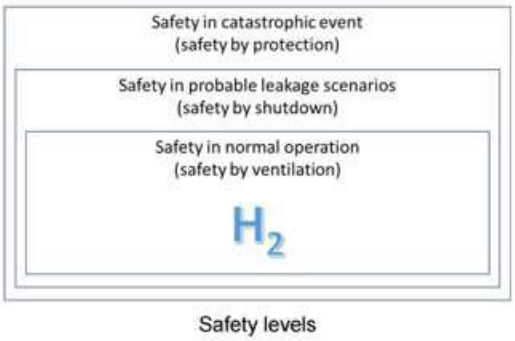


Figure 9. Safety levels of the FCwave™

Safety measures in place:

- Active ventilation through the enclosure
    - 100% redundant ventilation fan
    - No dead pockets for hydrogen – verified with CFD analysis
    - Ventilation flow monitored by safety controller
    - Flow switch
    - Tacho feedback from fans
- Negative pressure inside the enclosure
    - Differential pressure sensor
    - Enclosure sealed with a gasket at all possible openings
- Twin hydrogen sensors (range 0-4%) in ventilation air connected to:
    - Fuel cell controller
    - Safety controller

9.0 Container Hydrogen Detection

The container itself contains hydrogen sensors to detect hydrogen leakages.

The three hydrogen detectors are located at the following locations:

- Container Ventilation intake
    - Sensor located at the ventilation intake of the container and midpoint.
- Container ventilation outlet
    - Two sensors, one at each end of the container at the container ventilation outlets.

The ventilation outlet sensors detect and alarm in case of internal leakages. If a leakage is detected, the safety system shuts off the hydrogen supply valves and trigger emergency shutdown of the fuel cell modules and power converters inside the module.

See document “C07 Cause and Effect Charts” for details.

10.0 External Hydrogen Hazard

One hazard that the container can detect but not mitigate, is an external release of hydrogen impinging on the container and being drawn in with the ventilation system.

The planned mitigations are:

- Placement of the container outside hazardous areas from gas storage systems
- Orientation of the ventilation intake system, facing away from the gas storage system
- Installation of hydrogen detector on the ventilation intake, to detect the hazard and trigger internal emergency stop if hydrogen detection exceeds limit values.

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Sub Section C99-002

Hydrogen Preheating System Impact Assessment

Ballard Power Systems Europe A/S
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	02/04/2024	First official issue
002	23/01/2025	Updated according to CRS

Document Title:	**Hydrogen Preheating System Impact Assessment**
Document Number:	K559-2254-CWIWP4202202-C99-002
Revision:	Rev002
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-C99-002Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Hydrogen Preheating System Impact
Full Title	Crosswind/Baseload Power Hub Fuel Cell Hydrogen Preheating System Impact Assessment
Abstract	This document presents the hydrogen preheating system and its impact compared to excluding it. The hydrogen preheater conditions the hydrogen in cold ambient temperatures, to meet environmental specifications. For the preheater, a block diagram, functional description, and main components are outlined. Impacts are assessed for the fuel cell modules, physical plant and control system.

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Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	PBL	February 2024
1b	Update and expansion to clarify impact of proposed change on system scope	PBL	March 2024
1c	Added impact of increased pressure loss in the system due to the H2 heater	PBL	Apr 2024
2	Updates clarify to Code 2 response	PBL	Jan 2025

Checked by: MHA/ RKN	Date: 02-04-2024
Approved by: PBL	Date: 02-04-2024

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No table of figures entries found.

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1.0 Purpose and Scope

The purpose of this document is to introduce the concept and outline the execution of the hydrogen preheating system installed on the Crosswind Baseload Power Hub Fuel Cell Package (FC Package).

The purpose of the preheating system is to condition (heat) the hydrogen gas flowing to the Fuel Cell Modules inside the FC Package.

Following the introduction of the preheating system, the impact of the inclusion or exclusion of the preheater is assessed.

2.0 Background

The Fuel Cell Modules (FCwave) use hydrogen gas to produce electricity. The intake of gas has been specified to be acceptable between 0 and 80 degrees centigrade. Initial acceptance was given to intake hydrogen gas down to -10 degrees.

Further testing from the product development team showed that stability and performance of the module internal gas regulation was impacted when the hydrogen gas was below 12 degrees.

Ballard has designed and integrated a hydrogen preheating system, which will be installed on the FC Package.

The preheating system uses a heated water bath surrounding pipe coils leading to the fuel cell modules.

3.0 Impact of the hydrogen preheating system

This section details the impact of the inclusion of the preheating system, as well as expected impact on system performance if the preheating system is not installed.

3.1 Fuel Cell Module

The primary reason for including the preheating system is to avoid a corner case for the hydrogen pressure regulation system inside the fuel cell module, which in cold media temperatures, low inlet pressure and high flow combination may oscillate and limit the maximum output of the fuel cell module.

Including the preheater ensures the corner case is avoided, and the system will provide full power in all ambient conditions.

Not including the preheater can limit the power output of the fuel cell modules in some ambient conditions and cause increased wear on the hydrogen regulation components in the fuel cell modules.

3.2 Hydrogen manifold

The hydrogen manifold is impacted by the addition of the preheater, mainly by the physical inclusion of the device. From hydrogen flow perspective, the heater is a passive flow restriction and heating device, with no ability to actively control the flow of hydrogen.

The flow restriction will add ~200 mbar of pressure droop at full flow. Considerations for expansion of trapped gas is covered in Appendix 3 – Thermal Expansion of Trapped Gas.

The mass of the hydrogen heater and the internal liquid will add approximately 200 kg to the weight of the container.

3.3 Internal control system

The control system of the FC package will control the heater, by switching on and off the heating elements inside the preheater.

This is done via solid-state contactors, which have excellent operational lifetime, even with a high number of switching cycles. The control system has been programmed, tested, and verified with previous Megablock projects.

3.4 Time to start

The startup time for fuel cell package is not impacted in a Hot Standby scenario, where the hydrogen preheater is kept at operational temperature (for power consumption, see “E14 – Load List”).

In case the fuel cell package is at cold standby, the time to readiness depends on the ambient temperature. The heater can increase its temperature at approximately 2 degrees pr minute.

From an ambient temperature of -8 (Worst case), the heater requires about 20 minutes to reach initial operating temperature.

3.5 Impact to customer

The hydrogen heater materials and engineering is added as an integrated part of the FC package by Ballard.

The hydrogen interface point shifts from the no-heater position to the with-heater location. This is covered by existing TQs.

3.6 Service

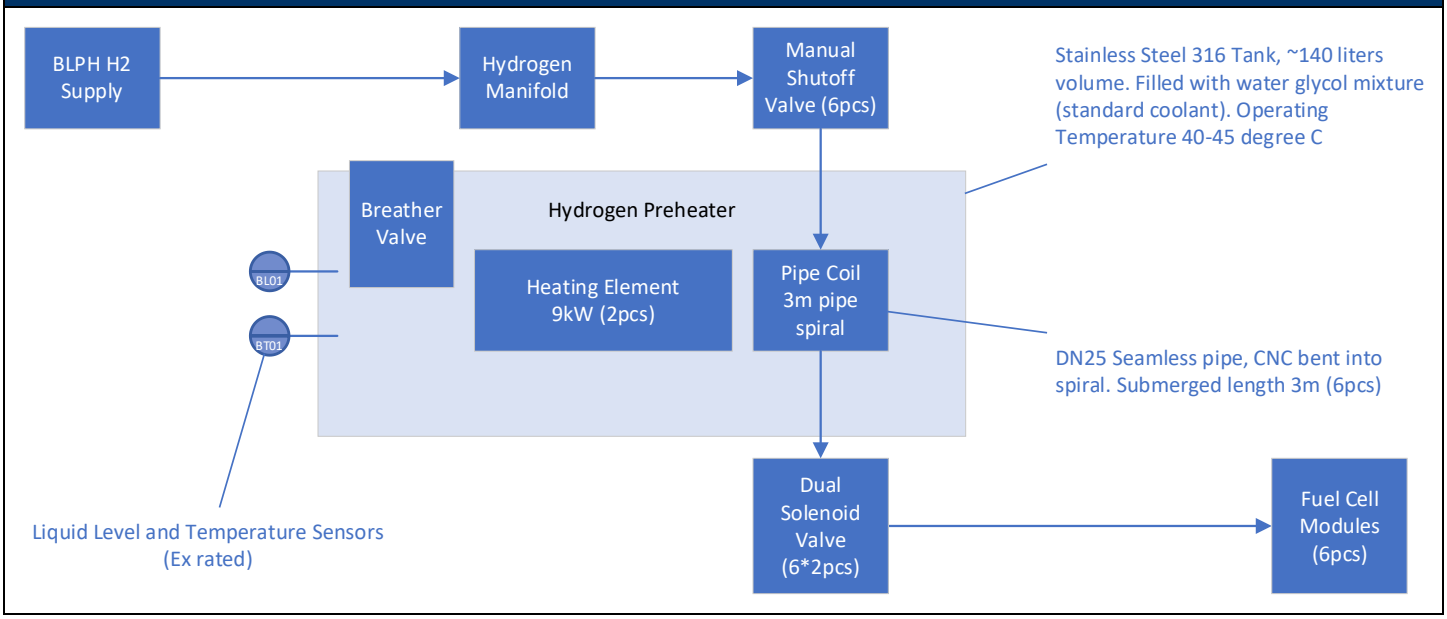
During ordinary service visits, the service technician shall top-up the contents of the preheater tank so evaporative losses are covered. No other service is expected.

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4.0 Block Diagram and Functional Description

The block diagram for the Hydrogen preheating system is shown in Figure 1. The method of operation is described below.

Figure 1: Hydrogen Preheater Block Diagram



The H2 preheating system uses heat from a pair of 9kW heating elements transferred via water/glycol mixture immersion to the pipe coils, carrying hydrogen to the fuel cell modules.

The hydrogen preheating system is used when the ambient temperature is below 10 degrees centigrade.

- Ambient temperature is sensed by the FC package controller (“controller”) via a sensor exposed to the ambient air (not shown on diagram).
- When the FC package is in Cold Standby, the hydrogen preheating system is inactive.
- When the FC package is in Hot Standby or Running, the hydrogen preheating system is active.
- The level of liquid inside the preheating system is monitored via a point level switch, ensuring that heaters are not activated without coolant to transfer the heat.
- When activated, a PID controller regulates the power to the heating elements to maintain a steady temperature inside the preheater. The operational temperature setpoint is 30 °C.
- The warm liquid transfers heat to the pipe coil and through the pipe wall to the gas stream, ensuring an optimal gas temperature to the FCwave fuel cell modules.

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5.0 Detailed P&ID and Image

For a detailed P&ID, refer to most recent version of “C03 P&ID.”

Figure 2: Hydrogen Preheater



Hydrogen preheater mounted to the side of a Megablock system. This configuration of the preheater has valves and shutoffs mounted elsewhere.

6.0 Components of the Hydrogen Heater

Note: ATEX considerations moved to the ATEX Dossier, document M99.

The following sections describe the components of the preheater.

6.1 Coolant Media

The heater contains Glad Long Life Ethylene Glycol Premix 50%, for details refer to document N07. This coolant is a premix, also used in the HT and LT coolant systems for the lowest amount of different coolant mediums.

Service for the above-mentioned chemicals is done every 20,000 hours or 2 years, whichever comes first. Under normal operation, there will be no direct consumption of the coolant. However, coolant level will be topped up during general service on the overall system. Coolant premix is either pre-positioned on platform or brought with service technician.

6.2 Hydrogen Pipe Coils

The pipe inside the hydrogen preheater is a single piece of seamless tubing, bent using a CNC bending machine. This ensures that there are no joints or other leakage points inside the preheater assembly.

All fittings are outside the preheater assembly, where any possible leakages may vent to open air, in a ATEX area.

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Figure 3: Hydrogen Pipe Coil



Half-length pipe coil used in testing setup. The production coils have double the length of piping. Made from seamless SS316 DN25 pipe on CNC bending machine.

6.3 Heating Elements

The heating elements in the system is 2 pieces 3 phase 400V, 9kW flanged immersion heaters. The heaters are Ex rated.

6.4 Temperature Sensor

The temperature sensor is a PT1000 sensor with a Ex barrier module between sensor and PLC.

6.5 Level Switch

The level switch is a sensor for point level detection in hazardous areas, manufactured by IFM. It is also installed with a Ex barrier module between sensor and PLC.

7.0 Appendix 2 – Energy Consumption

The hydrogen heater switches the pair of 9kW heating elements with a solid-state contactor.

The heating-up phase of the system will run a single 9kW heating element at 100% duty cycle (consuming 9kW of electricity off the AUX supply).

When at operating temperature, the heat transfer from the hydrogen heater to the surroundings is approximately 2kW with worst possible ambient conditions (-20°C ambient, rain and wind).

When the FC package is asked to operate and it switches from AUX supply to primary supply, it may use up to 18kW of power to maintain temperature.

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8.0 Appendix 3 – Thermal Expansion of Trapped Gas

One hazard of the system may be that cold gas is trapped inside the heater and subsequently expands when the heater is started, this heating expands the gas and leads to higher pressure.

The length of tubing is 3 meters inside the heater and less than 20 cm on each side, so a length of 4 meter is considered. The tube is 25mm outside diameter with 2mm wall thickness, so an internal diameter of 21mm is used.

The minimum operating temperature is -20°C and highest temperature conceivable is 100°C with an initial pressure of 10 barg (11 barA).

Volume of trapped gas:

$$V = \pi * r^2 * h \rightarrow V = \pi * (0{,}00105\ m)^2 * 4\ m = 0{,}00139\ m^3 = \ 1{,}39\ L$$

Moles of gas at -20°C (253,15 K):

$$n = \frac{PV}{RT} \rightarrow n = \frac{11\ barA\ * 1{,}39\ L}{0{,}08314\ \frac{L * barA}{K * mol} * 253{,}15\ K} = 0{,}726\ mol$$

Pressure of 0,726 mol of hydrogen at 100 °C (373,15 K), same volume:

$$P = \frac{nRT}{V} \rightarrow P = \frac{0{,}726\ mol * 0{,}08314\ \frac{L * barA}{K * mol} * 373{,}15\ K}{1{,}39\ L} = 16{,}2\ barA$$

Thus, the pressure increase is:

$$\Delta P = P_{100°C} - P_{-20°C} = 16{,}2\ barA - 11\ barA = 5{,}2\ bar$$

A pressure increase of 5,2 bar is well within materials specifications and valve limitations.

Section D

Data Sheets

Sub Section D01

Utilities Schedule

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Revision history		
Rev.	**Date.**	**Description**
001	03/02/2023	First Issue
002	17/02/2023	Mod. acc. to comments, new values
003	21/09/2023	Mod. acc. to comments, new values
004	30/11/2023	Modified according to comments

Document Title:	**BLPH Project - Utilities Schedule**	
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Title:	**Utilities Schedule**	Version:	Rev004
Description:	1 MW Power Container	Date:	November 30, 2023

Inputs

Hydrogen Supply [08]⁺ (Tag-Nr.: =HA01+DA02-XM01)						
Pressure			**Temperature**		**Mass Flow**	
Min.	Max.	Nominal	Min.	Max.	Min.*	Max.
barg	barg	barg	°C	°C	kg/h	kg/h
3.5	6.5	4.5	-8.4	80	3.24	105.84

Note: Hydrogen purity as per SAE J2719 or ISO 14687:2019 Type I, Type II – Grade D.

AUX Power Supply [17]⁺ (Tag-Nr.: =BA20+UC20-XB01)			
Control Voltage	**AUX Voltage**	**Connection**	**Current**
			Max.
Vac	Vac	-	A
230	400	3P+N+PE	32

Note: AUX power supplies all necessary auxiliaries and controls within Ballard's scope while fuel cells are not running.

MV Link - Input [21, 22]⁺ (Tag-Nr.: =BA30+DA03-TA30)				
Voltage	**Connection**	**Frequency**	**Power**	
			Min.	Max.
kVac	3-wire / 3-phase	Hz	kW	kW
6.6		50	10	150

Note: This is a bi-directional interface (power supplied during "Startup", "Rampdown" and "Aftercooling" modes).
Max. power depends on # of FCwave™ modules starting at the same time.

Total Air Intake [11, 23]⁺ (for Process and Ventilation) (Tag-Nr.: =JA01+DA02)					
Temperature		**Humidity**		**Mass Flow**	
Min.	Max.	Min.	Max.	Min.	Max.
°C	°C	%RH	%RH	g/s	g/s
-8.4	25	5	95	135 ("Standby" mode) 0 ("Sleep" mode)	~10,000 (@ 40 °C) ~6,000 (@ 25 °C)

Note: Air is sucked into the container from the surrounding environment, no need for a physical connection.

Cooling Air [04, 06]⁺ (for HT and LT coolers)					
Temperature		**Humidity**		**Mass Flow**	
Min.	Max.	Min.	Max.	Min.	Max.
°C	°C	%RH	%RH	g/s	g/s
-8.4	25	5	95	0	~123,500

Note: Air is sucked into the coolers from the surrounding environment, no need for a physical connection.

	Physical connection required.
	No physical connection required.

⁺ Number references from General Arrangements.
* During operation, otherwise 0.

Outputs

MV Link - Output [21, 22]+ (Tag-Nr.: =BA30+DA03-TA30)				
Voltage	Connection	Frequency	Power	
			Min.*	Max.
kVac	3-wire /	Hz	kW	MW
6.6	3-phase	50	50	1.05

Note: This is a bi-directional interface.

Water Drain [19]+ (Tag-Nr.: =JB01+DA02-XM01)			
Temperature		Volume Flow	
Min.	Max.	Min.	Max.
°C	°C	L/min	L/min
20	70	0	18

Note: Volume flow varies depending on environmental and operating conditions.
Max. value assumes all process water exits through the water drain.

Process Air Exhaust [09]+ (Tag-Nr.: =JA02+DA02-WM01..06)								
Temperature		Humidity	H_2 Concentration		Mass Flow (per FCwave™)		Mass Flow (Total)	
Min.	Max.		Startup	Operation	Min.*	Max.	Min.*	Max.
°C	°C	%RH	% vol H_2	% vol H_2	g/s	g/s	g/s	g/s
50	80	~100	< 2	< 2	100	260	100	1,560

Note: Exhaust air is blown out into the surrounding environment, no need for a physical connection.
During package-internal purge and pressure relief scenarios, the hydrogen is vented out through this process exhaust.

H_2 Enclosure Ventilation Air Exhaust [10]+ (Tag-Nr.: =JA02+DA02-WM07..12)					
Temperature		Mass Flow (per FCwave™)		Mass Flow (Total)	
Min.	Max.	Min.	Max.	Min.*	Max.
°C	°C	g/s	g/s	g/s	g/s
0	45	0	15	15	90

Note: Ventilation air is blown out into the surrounding environment, no need for a physical connection.
Detection of H_2 above 40% LFL or failure of a H_2 sensor leads to immediate shutdown of the module.

Container Ventilation Air Exhaust [24]+ (Tag-Nr.: =JA01+DA02-XT09..10)			
Temperature		Mass Flow	
Min.	Max.	Min.	Max.
°C	°C	g/s	g/s
0	53	135 ("Standby" mode) 0 ("Sleep" mode)	~8,350 (@ 40 °C) ~4,350 (@ 25 °C)

Note: Ventilation air is blown out into the surrounding environment, no need for a physical connection.

	Physical connection required.
	No physical connection required.

+ Number references from General Arrangements.
* During operation, otherwise 0.

Sub Section D03

1 MW Power Container Data Sheet

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Rev.	**Date.**	**Description**
001	20/01/2023	First Issue
002	15/12/2023	Modified acc. to comments, expanded

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Datasheet

1 MW AC Power Container for CrossWind

Revision Record			
Rev	**CO**	**Description**	Date
001	EZE	Initial release	2023-11-20
002	EZE	Format changed, content expanded, modified according to customer comments.	2023-12-15

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1.0 General Description

The stationary fuel cell system is based on 6 FCwave™ hydrogen fuel cells, built into a 40' HC container, capable of delivering 1 MW AC power. A transformer matching the local grid voltage is included in a separate 10' HC container and hence a complete microgrid can be established.

The containerized solution includes all the equipment necessary to operate the fuel cells and converts the DC power generated by the fuel cells into AC power. The container is delivered with a complete cooling system that dissipates the heat generated by the fuel cells and power conversion.

2.0 Technical Datasheet

FCwave™ 1 MW AC Power Container

Specification:	Value (Metric)	Value (Imperial)
Generator Specification:		
Max. Continuous Power @20 °C Ambient	1 MW AC	
Min. Continuous Power	0 kW	
Output Voltage @DC/AC Output @Transformer Output	 400 V @50 Hz – 3p+n (see transformer specs)	
Noise Level	75 dBA @10 m	75 dBA @32.97'
Fuel Cell Module Performance:		
Fuel Cell Model (Product Name)	FCwave™ 200 kW DC	
Container Configuration	6 x FCwave™	
Module Load Power Generation	55 to 200 kW DC	
Module Peak Fuel Efficiency	53 %	
Physical[1]:		
Fuel Cell Container (40') Dimensions (l x w x h)[2]	12.2 x 2.5 x 2.9 m	40 x 8.2 x 9.5'
Fuel Cell Container Weight	≤ 23,262 kg	≤ 51,284 lb
Painted Surface Treatment	C5M - RAL 7035 textured	
Container Doors, Intrusion Protection	System locking	
Cooling Skid Dimensions (l x w x h)	12.2 x 2.5 x 3.1 m	40 x 8.2 x 10.2'
Cooling Skid Weight	≤ 10,757 kg	≤ 23,715 kg lb

[1] *Figures are subject to modification during final design work and site adaptation.*
[2] *Based on standard 40' high-cube container*

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Transformer Container (10') Dimensions (l x w x h)[3]	3 x 2.44 x 2.9 m	10 x 8 x 9.5'
Transformer Container Weight	≤ 7,138 kg	≤ 15,737 lb
Transformer Specification:		
Type	TES-R2 EU548 Tier2	
Insulation Type	Cast Resin	
Cooling	Air Natural	
Loading Conditions	Converter THDi<10%	
Nominal Power	1,250 kVA	
Number of Phases	3	
Frequency	50 Hz	
Voltage Rating V_1/V_2	400 V / 6,600 V	
Tappings	±2 x 2.5%	
LV Current	1,804.27 A	
Vector Group	Dd0	
No-Load Losses	1,620 W +0% tol.	
Load Losses @75 °C (167 °F)	9,700 W +0% tol.	
Load Losses @120 °C (248 °F)	11,000 W +0% tol.	
No-Load Current	0.3%	
Impedance Voltage	5.0%	
Efficiency @120 °C (248 °F)		
4/4 cosfi 1	99.00%	
4/4 cosfi 0.8	98.75%	
Voltage Drop		
4/4 cosfi 1	1.001%	
4/4 cosfi 0.8	3.715%	
Thermal Insulation Class	F/F	
Primary Insulation Levels	7.2 – 20 – 60 kV	
Secondary Insulation Levels	1.1 – 3 kV	
Core Temperature Rise	100 °C	212 °F

[3] *Based on standard 10' high-cube container*

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Reactants & Cooling:		
Fuel Type	Gaseous hydrogen	
Hydrogen Grade	As per SAE spec. J2719 or ISO 14687:2019 Type I, Type II – Grade D	
Hydrogen Supply Pressure	3.5 – 6.5 bar(g)	
Hydrogen Consumption Rate, BOL	3 to 75.6 kg/h	6.61 to 166.67 lb/h
Cooling Media	Ethylene-glycol / DI-Water	
Cooling Mix	50% / 50%	
Total Cooling Media Volume	2,000 l	528.34 gal
AUX standby connection:		
AUX Voltage (3P+N+PE)	400 V AC	
AUX Current	32 A	
Safety Compliance:		
Certifications	CE, non-hazardous area	
Fire Alarm	Smoke detectors Warning by sound/light	
Monitoring:		
HMI, Basic Operation	In container, basic operation only	
SCADA/Control Interface	Modbus TCP/IP	
Safety Interface	Hardwire	
Remote Monitoring Interface	VPN Ethernet	

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Operating Conditions:		
Altitude	< 100 m	< 328’
Minimum Ambient Temperature, Operating	-8.4 °C	16.9 °F
Maximum Ambient Temperature, Operating	+25 °C	77 °F
Humidity	5% to 95% RH	
Wind Velocity[4]	31 m/s	69.35 mph
Weather	Designed for all year operation in temperate offshore areas, including wind driven rain and snow	
Salt Mist and Sea Salt Protection	Yes	
Flooding	Approximately 10 cm above ground level	Approximately 3.94” above ground level
Earthquake	Not earthquake safe, but designed to withstand customer-defined accelerations	

Note: If there are discrepancies between metric and imperial, it will be metric that applies.

[4] *10-minute mean wind velocity at 10 m elevation with 50 years return period*

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3.0 System Layout

The isometric views of the layout shown below are taken from the General Arrangements drawing. The cooling platform, incl. HT coolers, HT cooling pump sub-assemblies and LT cooler, is mounted on top of the 40' HC container. The 10' transformer container is installed next to the 40' container in an L-type arrangement. For more information, incl. details on the interface connections, please refer to the General Arrangements drawing (K559-2254-CWIWP4202202-B01-001).

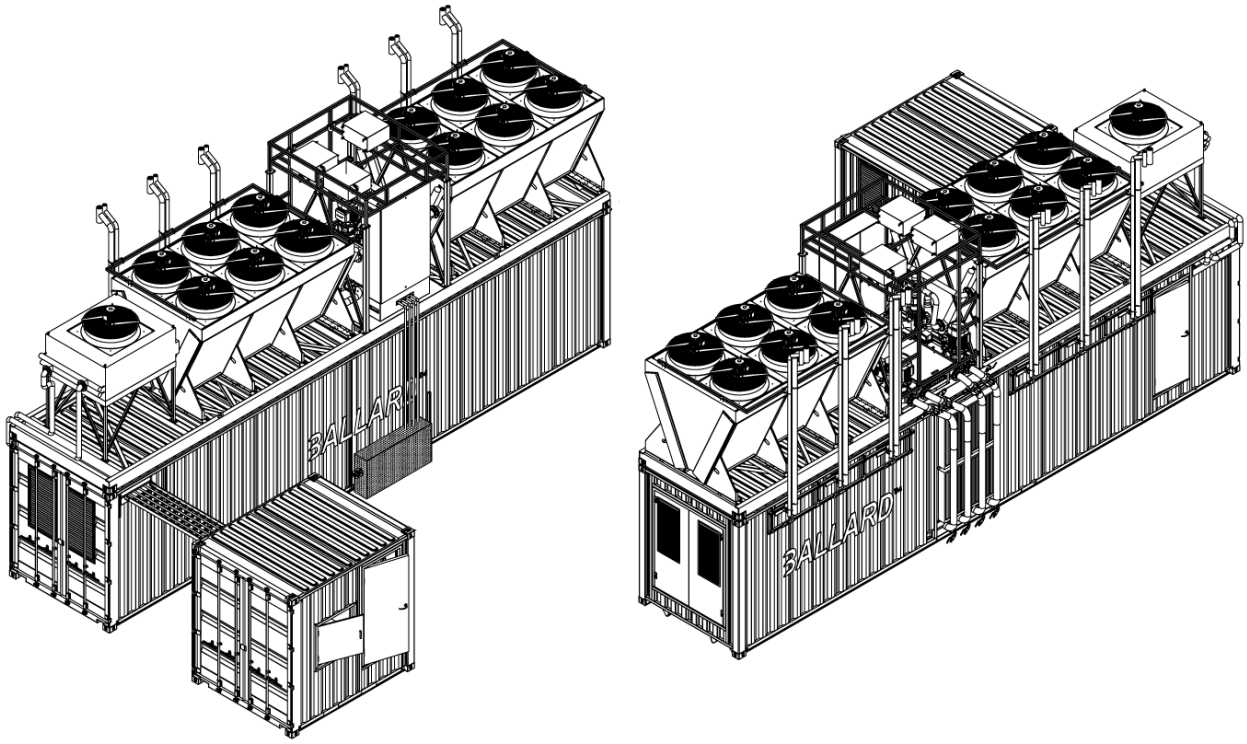


Figure 1. Isometric views of the 1 MW AC containerized solution.

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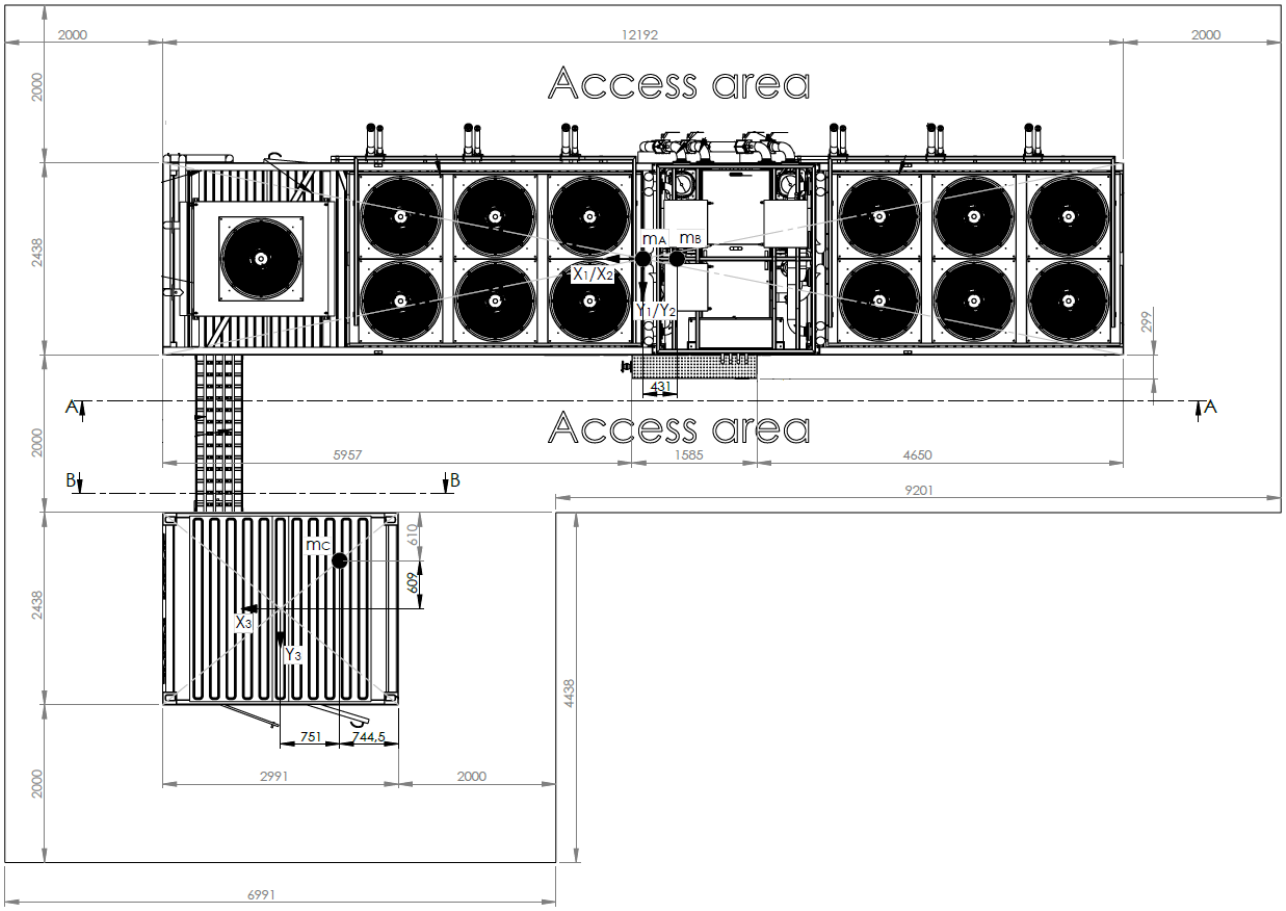


Figure 2. Top view of the 1 MW AC containerized solution.

The installation requires at least 2 meters (6.56’) service clearance to other installations.

To ensure proper function of the coolers, any buildings taller than 6.6 meters (21.65’) should be located at least 5 meters (16.4’) away.

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Here for life™
Template: FRM5104304

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4.0 Container Overview

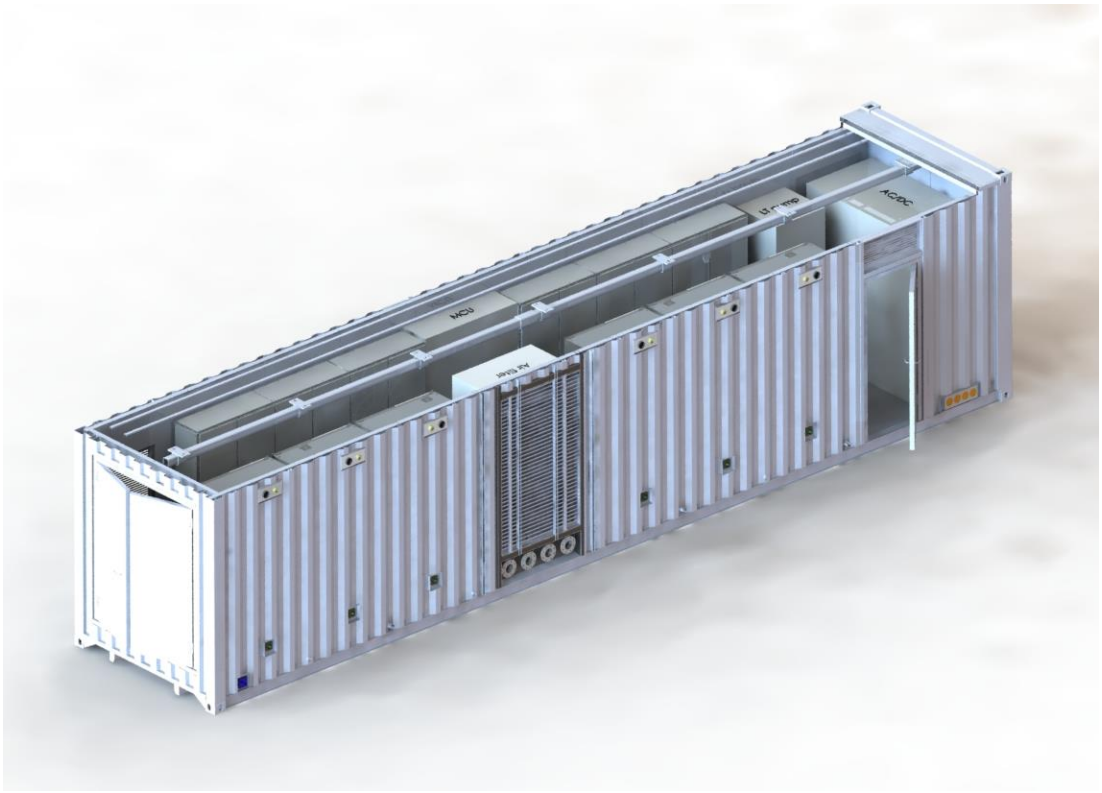


Figure 3. Visualization of the inside of the 40’ container (indicative).

The container contains the following main components:

1. Air filter with dampers and rain protection.
2. Container ventilation fans.
3. FCwave™ fuel cell modules.
4. H_2 intake manifold, incl. safety shut-off valves (opposite side).
5. Raised floor. Cooling, electrical, and interfacing is installed below the floor.
6. Container control unit (CCU) cabinet, which contains the computers and controls required to manage the container and all peripherals (e.g., coolers, transformer, power conditioning), manage load distribution and start/stop sequences as well as safety of the container. The CCU is the interface to the customer’s control system.
7. DC/DC cabinets for connecting each FCwave™ to a shared DC power bus, including necessary filters.
8. DC/AC cabinet for converting the full power capacity to the AC required, inclusive filters and connecting points for transformer.
9. Transformer to boost the AC output voltage to the customer-required voltage level (not shown).
10. Low temperature pump arrangements for cooling of power electronics, compressors, etc.
11. High temperature cooling for fuel cell stacks (not shown).
12. 2 access doors.
    The interior of the container is not to be considered a working area, and access should be prohibited during operation, unless by a trained service engineer.
13. Ventilation and process exhaust piping above FCwave™ (not shown).

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5.0 Water Drainage System

The fuel cell process will produce a max. of 18 L/min of deionized (DI) water at full load. For sizing purposes, it is assumed that all of this DI water condenses and exits through the process water drain. The DI water exiting from the system may be disposed of similar to tap water or reutilized for other purposes if needed by the customer.

The drainage system is internally designed so that it shall not freeze nor block the water flow. The drainage system outlet pipe is guided to the outside of the container, where care must be taken to ensure proper functionality, also during freezing.

6.0 Requirements for Upstream H_2 Delivery System

The integrator must provide sufficient hydrogen of quality, pressure, and temperature as specified in section 2.

The integrator must provide a block and bleed capability upstream of the module.

The hydrogen supply must be designed to prevent the inlet pressure to exceed 6.5 bar(g).

7.0 Hydrogen Safety

Every FCwave™ is equipped with a comprehensive safety system, preventing any leakages of Hydrogen inside the FCwave™ to develop into an explosive or flammable mixture. The safety system is verified and tested according to maritime safety codes and has been certified by the DNV for installation on ships.

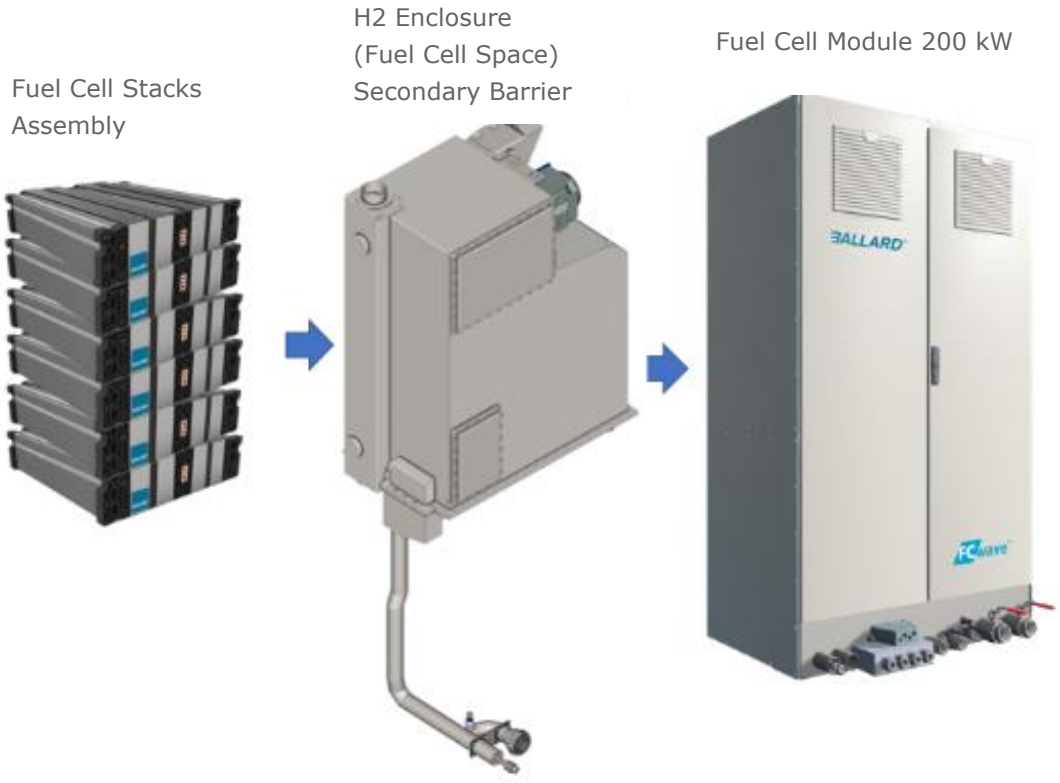


Figure 4. FCwave™ module, hydrogen enclosure, and stack assembly.

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The FCwave™ module has been designed with a hydrogen enclosure. The hydrogen enclosure is a unique design concept, which allows to separate the hydrogen related components such as fuel cell stacks from the auxiliary electrical components and control units.

The internal hydrogen supply installation is made as double wall piping, with a ventilated outer tube. Any leaked hydrogen will escape outside and will not build up to an explosive atmosphere inside the container.

With the hydrogen enclosure and the double wall barrier, the container is not regarded as an Atex zone, and is furthermore ventilated during operation.

The immediate outlet of the exhaust is typically to be considered an Atex zone.

The safety system for each FCwave™ is integrated with the CCU safety controller, such that any error will lead to a warning or safe shutdown, depending on the severity. The container is equipped with hydrogen sensors, which are integrated into the safety system.

For more information, please refer to the Hydrogen Safety Concept document (K559-2254-CWIWP4202202-C99-001).

8.0 Control and Monitoring System

Included in the delivery from Ballard is a Container Control Unit (CCU) for the complete embedded control of the container and auxiliary equipment required for the container to operate safely. The CCU will monitor and manage the power production according to the power requested by the customer.

The CCU is the interface to the customer's control system. The customer must supply a control system for communication with the CCU via Modbus Ethernet. Communication is bidirectional, sending operating instructions to the CCU and receiving status and alarms from the CCU, preferably to be visualized for the operator (must be included in the SCADA supply).

The CCU includes the option for connecting a PC-based engineering interface typically used during commissioning and service.

9.0 Emergency Shutdown

Emergency shutdown for the Stationary fuel cell system is an event, in which the hydrogen flow is stopped immediately, and the currents and voltages of the fuel cell modules are brought down to zero. Hydrogen flow will be handled in the gas handling unit.

The emergency shutdown procedure for the container system can be triggered by any of the FCwave™ fuel cell controllers or the CCU (e.g., due to an unsafe operating state):

- a safety system trip.
- a hydrogen alarm.
- a fire/smoke alarm.
- fuel cell control system.
- the container safety system.

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10.0 Block Diagram

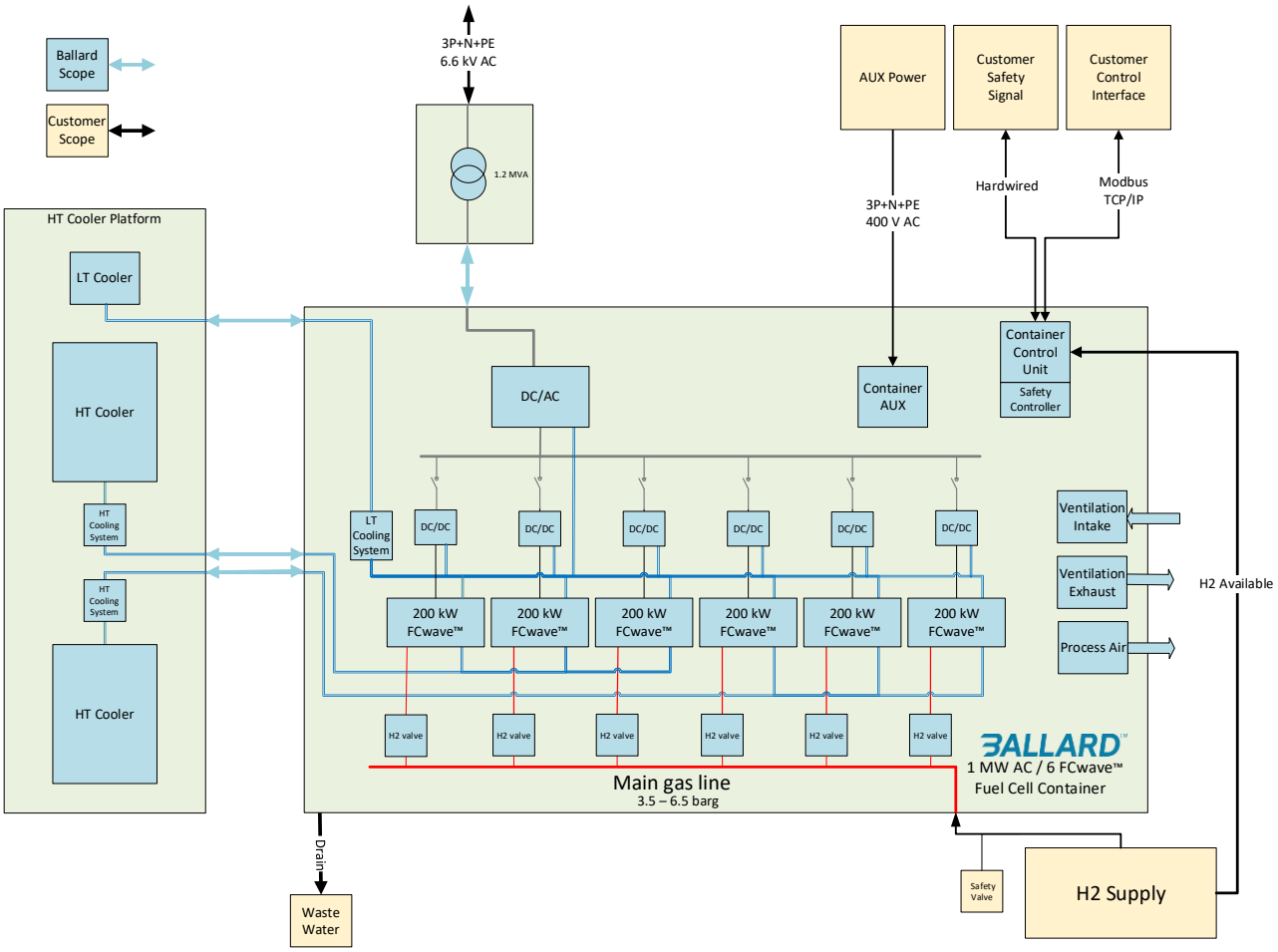


Figure 5. Block diagram of the 1 MW AC containerized solution.

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Sub Section D04

Noise Level Data Sheets

Ballard Power Systems Europe A/S
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	17/02/2023	First Issue

KBR
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DISCIPLINE ____ BY ____
DATE ____

Document Title:	**BLPH Project - Noise Level Data Sheets**
Document Number:	K559-2254-CWIWP4202202-D04-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-D04-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	D04
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Title:	**Noise Level Data Sheet**	Version:	Rev001
Description:	1 MW Power Container	Date:	February 17, 2023

Equipment Name	Amount	Tag Numbers	Data Origin	Overall Sound Power Level [dB(A)]	Distance from source [m]	Sound Power Level at 1.5 m [dB(A)]
HT Cooler Fan	2	-EQ01, -EQ02	Supplier Data Sheet	64	10	80.5*
LT Cooler Fan	1	-EQ03	Supplier Data Sheet	58	10	74.5*
FCwave™	6	+RE01…+RE06	Measurement	80	1	76.5*
Air Intake Fan	2	-GQ01, -GQ02	Supplier Data Sheet	91	1	87.5*
Container ventilation outlet	2	-	To be measured once installed	TBD	TBD	TBD

*Calculated values

Note: Only the loudest main components of the container solution are listed.

Sub Section D05

Material Safety Data Sheets

Ballard Power Systems Europe A/S
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9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	02/08/2024	First Issue

Document Title:	**BLPH Project - Material Safety Data Sheets**
Document Number:	K559-2254-CWIWP4202202-D05-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-D05-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	D05
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	D05 – Material Safety Data Sheets
Full Title	D05 – Material Safety Data Sheets
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	August 2, 2024

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1.0 Purpose

The purpose of this document is to provide Material Safety Data Sheets, in accordance with ISO 11014 or OSHA 1910 – 1200, for all relevant chemicals (incl. lubricants and coolants) supplied or recommended for use with the 1MW fuel cell container (MEGABLOCK) provided by Ballard Power Systems Europe to CrossWind.

2.0 References

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-N07-001	Chemicals and Catalysts	Ballard
K559-2254-CWIWP4202202-N08-001	Lubricants	Ballard
MAN-002	FCwave™ Fuel Cell Module Integration Manual v2.2.0	Ballard

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3.0 Overview of Material Safety Data Sheets

The complete list of coolants and lubricants used in the 1MW fuel cell container (MEGABLOCK) is shown below.

Manufacturer	Type	Name	Description / Use	Sub-assembly
BASF	Coolant	Glysantin® FC G20®	Used in the internal cooling loop of the fuel cell modules, where a low electrical conductivity is required. Pre-mixed 50/50 ethylene glycol-based coolant specifically developed to support the requirements in fuel cell technologies. It maintains a low and stable electrical conductivity, while at the same time providing protection against corrosion, frost and overheating.	FCwave™
Proviron	Coolant	proviflow® Neo	Used in both HT and LT cooling loops. Pre-mixed 50/50 ethylene glycol-based coolant with OAT (Organic Acid Technology) inhibitors and designed to offer freeze point suppression as well as protection against corrosion, hard water scaling and bacterial growth.	Container Solution
Putoline®	Lubricant	Ceramic Grease PV.20.01	High-grade assembly paste and high temperature lubricant grease without metal particles used for lubrication of bolts.	Container Solution
Chemours™	Lubricant	Krytox™ GPL 205	Chemically inert, PTFE thickened grease based on perfluoropolyether (PFPE) oils that is safe for use around hazardous chemicals, these lubricants are non-flammable and safe for use in oxygen service. They can be used in extreme conditions, such as continuous high temperatures of up to 204 °C (400 °F) and will survive short-term peak temperatures of up to 220 °C (429 °F).	FCwave™
	Lubricant	Krytox™ GPL 206	Chemically inert, PTFE thickened grease based on perfluoropolyether (PFPE) oils that is safe for use around hazardous chemicals, these lubricants are non-flammable and safe for use in oxygen service. They can be used in extreme conditions, such as continuous high temperatures of up to 260 °C (500 °F) and will survive short-term peak temperatures of up to 270 °C (518 °F).	

4.0 Material Safety Data Sheets

4.1 BASF Glysantin® FC G20®

BASF
We create chemistry

Safety Data Sheet
GLYSANTIN® FC G20® ELECTRIFIED®

Revision date : 2024/04/05 Page: 1/10
Version: 3.3 (30244083/SDS_GEN_US/EN)

1. Identification

Product identifier used on the label

GLYSANTIN® FC G20® ELECTRIFIED®

Recommended use of the chemical and restriction on use

Recommended use*: Ready-to-use engine coolants
Unsuitable for use: None known

* The "Recommended use" identified for this product is provided solely to comply with a Federal requirement and is not part of the seller's published specification. The terms of this Safety Data Sheet (SDS) do not create or infer any warranty, express or implied, including by incorporation into or reference in the seller's sales agreement.

Details of the supplier of the safety data sheet

Company:
BASF CORPORATION
100 Park Avenue
Florham Park, NJ 07932, USA
Fuel and Lubricant Solutions

E-mail address: RegXcellenceFuelLubes@basf.com

Emergency telephone number
24 Hour Emergency Response Information
CHEMTREC: 1-800-424-9300
BASF HOTLINE: 1-800-832-HELP (4357)

Other means of identification
Chemical family: inhibitors, in water

2. Hazards Identification

According to Regulation 2012 OSHA Hazard Communication Standard; 29 CFR Part 1910.1200

Classification of the product

Acute Tox.	4 (oral)	Acute toxicity
STOT RE	2	Specific target organ toxicity — repeated exposure

Label elements

Pictogram:



Signal Word:
Warning

Hazard Statement:

H302	Harmful if swallowed.
H373	May cause damage to organs (Kidney) through prolonged or repeated exposure.

Precautionary Statements (Prevention):

P260	Do not breathe dust/gas/mist/vapours.
P270	Do not eat, drink or smoke when using this product.
P264	Wash contaminated body parts thoroughly after handling.

Precautionary Statements (Response):

P314	Get medical advice/attention if you feel unwell.
P301 + P312	IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P330	Rinse mouth.

Precautionary Statements (Disposal):

P501	Dispose of contents/container in accordance with local regulations.

Hazards not otherwise classified

If applicable information is provided in this section on other hazards which do not result in classification but which may contribute to the overall hazards of the substance or mixture.

3. Composition / Information on Ingredients

According to Regulation 2012 OSHA Hazard Communication Standard; 29 CFR Part 1910.1200

ethylene glycol
CAS Number: 107-21-1
Content (W/W): >= 25.0 - < 75.0%
Synonym: 1,2-Ethanediol; Ethylene glycol

4. First-Aid Measures

Description of first aid measures

General advice:
Immediately remove contaminated clothing.

If inhaled:
Keep patient calm, remove to fresh air, seek medical attention.

If on skin:
Remove contaminated clothing. Rinse skin immediately with plenty of water for 15 - 20 minutes. If irritation develops, seek medical attention.

If in eyes:
Wash affected eyes for at least 15 minutes under running water with eyelids held open.

Hold eyes open and rinse slowly and gently with water for 15 to 20 minutes. Remove contact lenses, if present, after first 5 minutes, then continue rinsing. Seek medical attention.

If swallowed:
Immediately rinse mouth and then drink 200-300 ml of water, seek medical attention. Administer 50 ml of pure ethanol in a drinkable concentration.

Most important symptoms and effects, both acute and delayed

Symptoms: Information, i.e. additional information on symptoms and effects may be included in the GHS labeling phrases available in Section 2 and in the Toxicological assessments available in Section 11., (Further) symptoms and / or effects are not known so far

Information on: ethylene glycol
Symptoms: Overexposure may cause:, corneal injury, severe pain, skin irritation, coughing, respiratory disorders, dyspnea, nausea, headache, vomiting, dizziness, diarrhea, abdominal cramps
---
Hazards: No applicable information available.

Indication of any immediate medical attention and special treatment needed

5. Fire-Fighting Measures

Extinguishing media

Suitable extinguishing media:
water spray, dry powder, foam

Special hazards arising from the substance or mixture
Hazards during fire-fighting:
harmful vapours
Evolution of fumes/fog. The substances/groups of substances mentioned can be released in case of fire.

Advice for fire-fighters
Protective equipment for fire-fighting:
Firefighters should be equipped with self-contained breathing apparatus and turn-out gear.

Further information:
The degree of risk is governed by the burning substance and the fire conditions. Contaminated extinguishing water must be disposed of in accordance with official regulations.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
Use personal protective clothing. Breathing protection required.

Environmental precautions
Contain contaminated water/firefighting water. Do not discharge into drains/surface waters/groundwater.

Methods and material for containment and cleaning up
For small amounts: Pick up with absorbent material (e.g. sand, sawdust, general-purpose binder).
Dispose of absorbed material in accordance with regulations.
For large amounts: Pump off product.
Place absorbed material in the same container as the spilled substance/product for disposal.

7. Handling and Storage

Precautions for safe handling
No special measures necessary provided product is used correctly.

Protection against fire and explosion:
Take precautionary measures against static discharges.

Conditions for safe storage, including any incompatibilities
Segregate from oxidants.

Further information on storage conditions: Keep container tightly closed and dry; store in a cool place.

Storage stability:
Storage temperature: < 30 °C
Protect from temperatures above: 30 °C

8. Exposure Controls/Personal Protection

Components with occupational exposure limits

ethylene glycol	ACGIH, US:	TWA value 25 ppm Vapor fraction ;
	ACGIH, US:	STEL value 50 ppm Vapor fraction ;
	ACGIH, US:	STEL value 10 mg/m3 Inhalable fraction, Aerosole ;

Advice on system design:
No applicable information available.

Personal protective equipment

Respiratory protection:
Wear respiratory protection if ventilation is inadequate. Respiratory protection in case of vapour/aerosol release.

Hand protection:
Wear chemically impervious protective gloves.

Eye protection:
Safety glasses with side-shields.

Body protection:
Body protection must be chosen depending on activity and possible exposure, e.g. apron, protecting boots, chemical-protection suit (according to EN 14605 in case of splashes or EN ISO 13982 in case of dust).

General safety and hygiene measures:
No eating, drinking, smoking or tobacco use at the place of work. Handle in accordance with good industrial hygiene and safety practice.

9. Physical and Chemical Properties

Form:	liquid	
Odour:	of glycol	
Odour threshold:	not determined	
Colour:	colourless	
pH value:	approx. 5.5 (measured with the undiluted substance)	(ASTM D1287)
Freezing point:	approx. -38 °C	
Melting temperature:	No applicable information available.	
Boiling point:	approx. 108 °C (1,013 hPa)	(ASTM D1120)
Sublimation point:	No applicable information available.	
Flash point:	> 100 °C	(ISO 2592)
Flammability:	hardly combustible	(derived from flash point)
Lower explosion limit:	For liquids not relevant for classification and labelling. The lower explosion point may be 5 - 15 °C below the flash point.	
Upper explosion limit:	For liquids not relevant for classification and labelling.	
Autoignition:	435 °C	(DIN 51794)
Vapour pressure:	17 hPa (20 °C) 85 hPa (50 °C)	
Density:	1.065 g/cm3 (20 °C)	(ISO 2811-3)
Relative density:	No applicable information available.	
Vapour density:	not determined	
Partitioning coefficient n-octanol/water (log Pow):	Study scientifically not justified.	
Self-ignition temperature:	not self-igniting	
Thermal decomposition:	No decomposition if used as directed.	
Viscosity, dynamic:	No applicable information available.	
Viscosity, kinematic:	approx. 4 mm2/s (23 °C)	(DIN 51562)

	approx. 2.5 mm2/s (40 °C)	(DIN 51562)
Particle size:	The substance / product is marketed or used in a non solid or granular form.	
Solubility in water:	(15 °C) soluble	
Solubility (quantitative):	No applicable information available.	
Solubility (qualitative):	No applicable information available.	
Molar mass:	No applicable information available.	
Evaporation rate:	not determined	
Other Information:	If necessary, information on other physical and chemical parameters is indicated in this section.	

10. Stability and Reactivity

Reactivity
No hazardous reactions if stored and handled as prescribed/indicated.

Corrosion to metals:
No corrosive effect on metal.

Oxidizing properties:
not fire-propagating

Formation of flammable gases:	Remarks:	Forms no flammable gases in the presence of water.

Chemical stability
The product is stable if stored and handled as prescribed/indicated.

Possibility of hazardous reactions
No hazardous reactions when stored and handled according to instructions.
The product is chemically stable.

Conditions to avoid
Avoid open flames.

Incompatible materials
strong oxidizing agents

Hazardous decomposition products

Decomposition products:
Hazardous decomposition products: No hazardous decomposition products known.

Thermal decomposition:
No decomposition if used as directed.

11. Toxicological information

Primary routes of exposure

Routes of entry for solids and liquids are ingestion and inhalation, but may include eye or skin contact. Routes of entry for gases include inhalation and eye contact. Skin contact may be a route of entry for liquefied gases.

Acute Toxicity/Effects

Acute toxicity
Assessment of acute toxicity: Of moderate toxicity after single ingestion. Of low toxicity after short-term skin contact.

Oral
Type of value: LD (human)
Value: approx. 1,600 mg/kg

Information on: ethylene glycol
Type of value: LD (human)
Species: human (male/female)
Value: approx. 1,600 mg/kg

Inhalation
No applicable information available.

Dermal
Type of value: LD50
Species: rabbit
Value: > 2,000 mg/kg
Literature data.

Assessment other acute effects
Based on available data, the classification criteria are not met.

Irritation / corrosion
Assessment of irritating effects: Not irritating to eyes and skin.

Sensitization
Assessment of sensitization: Skin sensitizing effects were not observed in animal studies. Human data do not fully exclude a skin sensitizing potential.

Aspiration Hazard
No aspiration hazard expected.

Chronic Toxicity/Effects

Repeated dose toxicity
Assessment of repeated dose toxicity: Repeated exposure may affect certain organs.

Information on: ethylene glycol
Assessment of repeated dose toxicity: The substance may cause damage to the kidney after repeated ingestion. The substance may cause damage to the kidney after repeated skin contact with high doses.

Genetic toxicity
Assessment of mutagenicity: Based on the ingredients, there is no suspicion of a mutagenic effect.

Carcinogenicity
Assessment of carcinogenicity: The whole of the information assessable provides no indication of a carcinogenic effect.

Reproductive toxicity
Assessment of reproduction toxicity: Based on available data, the classification criteria are not met.

Teratogenicity
Assessment of teratogenicity: Based on available data, the classification criteria are not met.

Information on: ethylene glycol
Assessment of teratogenicity: Developmental toxicity was observed after oral ingestion of high doses in studies with rats and mice, but this effect was not seen in a study with rabbits. Mechanistic studies show that the rabbit is the relevant species for the classification for human health. As such, and since ethylene glycol is not a developmental toxicant in the rabbit, no classification is warranted.

Other Information
The product has not been tested. The statements on toxicology have been derived from the properties of the individual components.

12. Ecological Information

Toxicity

Aquatic toxicity
Assessment of aquatic toxicity:
There is a high probability that the product is not acutely harmful to aquatic organisms.

Microorganisms/Effect on activated sludge

Toxicity to microorganisms

Inhibition of degradation activity in activated sludge is not to be anticipated during correct introduction of low concentrations.

Persistence and degradability

Assessment biodegradation and elimination (H2O)
The single components are biological degradable.

Bioaccumulative potential

Assessment bioaccumulation potential
Accumulation in organisms is not to be expected.

Mobility in soil

Assessment transport between environmental compartments
The substance will not evaporate into the atmosphere from the water surface.
Adsorption to solid soil phase is not expected.

Additional information

Other ecotoxicological advice:
Do not release untreated into natural waters.

The product has not been tested. The statement has been derived from the properties of the individual components.

13. Disposal considerations

Waste disposal of substance:
Dispose of in accordance with national, state and local regulations. It is the waste generator's responsibility to determine if a particular waste is hazardous under RCRA.

Container disposal:
Dispose of in a licensed facility. Recommend crushing, puncturing or other means to prevent unauthorized use of used containers.

14. Transport Information

Land transport
USDOT
Not classified as a dangerous good under transport regulations

Sea transport
IMDG
Not classified as a dangerous good under transport regulations

Air transport
IATA/ICAO
Not classified as a dangerous good under transport regulations

Further information
DOT: This product is regulated if the amount in a single receptacle exceeds the Reportable Quantity (RQ). Please refer to Section 15 of this SDS for the RQ for this product. Bulk Shipments: RQ,UN3082 Environmentally Hazardous Substance, Liquid NOS (Ethyleneglycol), 9, PG III

15. Regulatory Information

Federal Regulations

Registration status:
Chemical TSCA, US released / listed

EPCRA 311/312 (Hazard categories): Refer to SDS section 2 for GHS hazard classes applicable for this product.

EPCRA 313:

CAS Number	Chemical name
107-21-1	ethylene glycol

CERCLA RQ	CAS Number	Chemical name
5000 LBS	107-21-1	ethylene glycol

State regulations

State RTK	CAS Number	Chemical name
PA	107-21-1	ethylene glycol
NJ	107-21-1	ethylene glycol

Safe Drinking Water & Toxic Enforcement Act, CA Prop. 65:

WARNING: This product can expose you to chemicals including ETHYLENE GLYCOL (INGESTED), which is known to the State of California to cause birth defects or other reproductive harm. For more information, go to www.P65Warnings.ca.gov.

NFPA Hazard codes:
Health: 1 Fire: 1 Reactivity: 0 Special:

HMIS III rating
Health: 1 Flammability: 1 Physical hazard: 0

16. Other Information

SDS Prepared by:
BASF NA Product Regulations
SDS Prepared on: 2024/04/05

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END OF DATA SHEET

4.2 Proviron proviflow® Neo

Proviflow Neo

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878
Issue date: 1/16/2024 Revision date: 1/16/2024 Supersedes version of: 12/15/2023 Version: 0.1

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Product form : Mixture
Trade name : Glad Long Life Ethylenglykol, Glad Proviflow N, Glad Proviflow Neo, Glad Proviflow N Ethylenglykol, Glad Ethylenglykol, Proviflow N, Proviflow Neo
REACH registration No. : 01-2119456816-28
PR nr : 4176178

1.2. Relevant identified uses of the substance or mixture and uses advised against

1.2.1. Relevant identified uses

Main use category : For professional use only
Use of the substance/mixture : Heat transfer fluids

1.2.2. Uses advised against

No additional information available

1.3. Details of the supplier of the safety data sheet

Supplier
Proviron Industries nv
Georges Gilliotstraat 60
BE 2620 Hemiksem
Belgium
T +32 3 870 88 20, F +32 3 877 23 33
info@proviron.com, www.proviron.com

1.4. Emergency telephone number

Country/Area	Organisation/Company	Address	Emergency number	Comment
Denmark	Giftlinjen Bispebjerg Hospital	Bispebjerg Bakke 23E Opgang 20 C 2400 Copenhagen	+45 82 12 12 12	

Importer:
L.C. Glad & Co. A/S
Vallensbækvej 65
2625 Vallensbæk
T + 43 62 20 21
www.lcglad.dk – info@lcglad.dk

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Classification according to Regulation (EC) No. 1272/2008 [EU-GHS/CLP]

Acute toxicity (oral), Category 4 H302
Specific target organ toxicity – Repeated exposure, Category 2 H373
Full text of H- and EUH-statements: see section 16

Adverse physicochemical, human health and environmental effects

No additional information available

1/16/2024 (Revision date) EU - en 1/10

Proviflow Neo

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

2.2. Label elements

Labelling according to Regulation (EC) No. 1272/2008 [EU-GHS/CLP]

Hazard pictograms (CLP) :



GHS07 GHS08

Signal word (CLP) : Warning

Contains : ethanediol; ethylene glycol

Hazard statements (CLP) : H302 - Harmful if swallowed.
H373 - May cause damage to organs (kidneys) through prolonged or repeated exposure (oral).

Precautionary statements (CLP) : P260 - Do not breathe dust/fume/gas/mist/vapours/spray.
P264 - Wash hands, forearms and face thoroughly after handling.
P270 - Do not eat, drink or smoke when using this product.
P301+P312 - IF SWALLOWED: Call a POISON CENTRE or doctor if you feel unwell.
P330 - Rinse mouth.

2.3. Other hazards

Other hazards which do not result in classification : Absorbed through the skin.

This substance/mixture does not meet the PBT criteria of REACH regulation, annex XIII
This substance/mixture does not meet the vPvB criteria of REACH regulation, annex XIII
Contains no PBT and/or vPvB substances ≥ 0.1% assessed in accordance with REACH Annex XIII

The mixture does not contain substance(s) included in the list established in accordance with Article 59(1) of REACH for having endocrine disrupting properties, or substance(s) are not identified as having endocrine disrupting properties in accordance with the criteria set out in Commission Delegated Regulation (EU) 2017/2100 or Commission Regulation (EU) 2018/605 at a concentration equal to or greater than 0,1 %

SECTION 3: Composition/information on ingredients

3.1. Substances

Not applicable

3.2. Mixtures

Name	Product identifier	%	Classification according to Regulation (EC) No. 1272/2008 [EU-GHS/CLP]
Monoethylene glycol	CAS: 107-21-1 EC/EINECS/ELINS: 203-473-3 EC Index-No.: 603-027-00-1 REACH-no: 01-2119456816-28	> 92	Acute Tox. 4 (Oral), H302 (ATE=500 mg/kg bodyweight) STOT RE 2, H373

Full text of H- and EUH-statements: see section 16

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures after inhalation : Remove person to fresh air and keep comfortable for breathing. Administer oxygen if breathing is difficult. Get immediate medical advice/attention.

First-aid measures after skin contact : Take off immediately all contaminated clothing. After contact with skin, wash immediately with plenty of water and soap. In all cases of doubt, or when symptoms persist, seek medical attention.

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Ballard Confidential
Printed on: Friday, August 02, 2024

First-aid measures after eye contact	:	Rinse immediately with plenty of water for 15 minutes. Get immediate medical advice/attention.
First-aid measures after ingestion	:	Do not induce vomiting. Rinse mouth out with water. Get immediate medical advice and attention.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/effects after inhalation	:	At high concentrations, the vapours can be irritating to the respiratory system. Cough.
Symptoms/effects after eye contact	:	May cause eye-irritation of susceptible persons.
Symptoms/effects after ingestion	:	Harmful if swallowed. May cause gastrointestinal irritation, nausea, vomiting and diarrhoea.
Chronic symptoms	:	Harmful: danger of serious damage to health by prolonged exposure if swallowed. Affects the liver. Material known to cause adverse reproductive effects.

4.3. Indication of any immediate medical attention and special treatment needed

No additional information available

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media	:	dry chemical powder, alcohol-resistant foam, carbon dioxide (CO2). Water spray.
Unsuitable extinguishing media	:	Strong water jet.

5.2. Special hazards arising from the substance or mixture

Reactivity in case of fire	:	On burning: release of carbon monoxide - carbon dioxide.

5.3. Advice for firefighters

Firefighting instructions	:	Use water stream to cool containers. Use water stream to cool containers.
Protection during firefighting	:	Wear fire resistant or flame retardant clothing. Extra personal protection: self-contained breathing apparatus.
Other information	:	Do not allow run-off from fire fighting to enter drains or water courses.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures	:	Eliminate every possible source of ignition. Avoid inhalation of vapours. Avoid contact with skin, eyes and clothing.

6.1.1. For non-emergency personnel

Protective equipment	:	Wear recommended personal protective equipment.

6.1.2. For emergency responders

Protective equipment	:	Wear recommended personal protective equipment.

6.2. Environmental precautions

Stop leak without risks if possible. Do not discharge into drains or the environment.

6.3. Methods and material for containment and cleaning up

For containment	:	Absorb remaining liquid with sand or inert absorbent and remove to safe place. Collect leaking liquid in sealable containers.
Methods for cleaning up	:	After cleaning, flush traces away with water.

6.4. Reference to other sections

No additional information available

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Proviflow Neo

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling	:	Skin resorption. Avoid contact with skin, eyes and clothing. Avoid the formation of mists in the atmosphere. Avoid inhalation of vapours. Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.
Hygiene measures	:	Wash hands immediately after handling the product. Do not eat, drink or smoke when using this product.

7.2. Conditions for safe storage, including any incompatibilities

Storage conditions	:	Keep only in the original container in a cool, well-ventilated place.
Storage temperature	:	0 – 40 °C
Heat and ignition sources	:	Avoid ignition sources.
Information on mixed storage	:	Keep away from oxidizing agents.
Storage area	:	Store in a cool, well-ventilated place.
Packaging materials	:	IBC - Composite with plastics inner receptacle - for liquids, with rigid plastics inner receptacle.

Switzerland

Storage class (LK)	:	LK 6.1 - Toxic materials

7.3. Specific end use(s)

No additional information available

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

8.1.1 National occupational exposure and biological limit values

Monoethylene glycol (107-21-1)	
EU - Indicative Occupational Exposure Limit (IOEL)	
Local name	Ethylene glycol
IOEL TWA	52 mg/m³
	20 ppm
IOEL STEL	104 mg/m³
	40 ppm
Remark	Skin

8.1.2. Recommended monitoring procedures

No additional information available

8.1.3. Air contaminants formed

No additional information available

8.1.4. DNEL and PNEC

No additional information available

8.1.5. Control banding

No additional information available

8.2. Exposure controls

8.2.1. Appropriate engineering controls

Appropriate engineering controls:
Ensure good ventilation of the work station.

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8.2.2. Personal protection equipment

8.2.2.1. Eye and face protection

Eye protection:
Protective goggles or face shield

8.2.2.2. Skin protection

Skin and body protection:
Avoid contact with skin, eyes and clothing. Take off immediately all contaminated clothing and wash it before reuse.

Hand protection:
Chemical resistant gloves (according to European standard ISO 374-1 or equivalent). Butyl rubber. Polyvinylchloride (PVC)

8.2.2.3. Respiratory protection

Respiratory protection:
In order to avoid inhalation of mist/vapour, all spraying must be done wearing adequate respirator. Do not breathe gas/vapour/aerosol. On heating : Breathing equipment. A2

8.2.2.4. Thermal hazards

No additional information available

8.2.3. Environmental exposure controls

Environmental exposure controls:
Do not discharge into drains or the environment.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Liquid
Colour	:	Not available
Appearance	:	Viscous.
Odour	:	odourless.
Odour threshold	:	Not available
Melting point	:	Not available
Freezing point	:	Not available
Boiling point	:	Not available
Flammability	:	Not available
Lower explosion limit	:	Not available
Upper explosion limit	:	Not available
Flash point	:	124 °C Closed cup
Auto-ignition temperature	:	Not available
Decomposition temperature	:	Not available
pH	:	Not available
pH solution	:	7.5 – 10 (50% aqueous solution @ 20°C)
Viscosity, kinematic	:	18 mm²/s (@ 25°C)
Solubility	:	Soluble in water.
Partition coefficient n-octanol/water (Log Kow)	:	Not available
Vapour pressure	:	Not available
Vapour pressure at 50°C	:	Not available
Density	:	1.111 g/ml (@ 20°C)
Relative density	:	Not available
Relative vapour density at 20°C	:	Not available
Particle characteristics	:	Not applicable

9.2. Other information

9.2.1. Information with regard to physical hazard classes

No additional information available

9.2.2. Other safety characteristics

No additional information available

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SECTION 10: Stability and reactivity

10.1. Reactivity

No additional information available

10.2. Chemical stability

Stable in use and storage conditions as recommended in item 7.

10.3. Possibility of hazardous reactions

Reacts with (some) acids: (increased) risk of fire/explosion.

10.4. Conditions to avoid

High temperature. Moisture. Direct sunlight.

10.5. Incompatible materials

Strong oxidizing agents. Aluminium. Rubbers.

10.6. Hazardous decomposition products

Carbon oxides (CO, CO2).

SECTION 11: Toxicological information

11.1. Information on hazard classes as defined in Regulation (EC) No 1272/2008

Acute toxicity (oral) : Harmful if swallowed.
Acute toxicity (dermal) : Not classified (Based on available data, the classification criteria are not met)
Acute toxicity (inhalation) : Not classified (Based on available data, the classification criteria are not met)

Proviflow Neo	
ATE CLP (oral)	533.824 mg/kg bodyweight

Monoethylene glycol (107-21-1)	
LD50 oral rat	7712 mg/kg
LD50 dermal	> 3500 mg/kg mouse
LC50 inhalation rat	> 2.5 mg/l

Skin corrosion/irritation : Not classified
Serious eye damage/irritation : Not classified
Respiratory or skin sensitisation : Not classified (Based on available data, the classification criteria are not met)
Germ cell mutagenicity : Not classified (Based on available data, the classification criteria are not met)
Carcinogenicity : Not classified (Based on available data, the classification criteria are not met)
Reproductive toxicity : Not classified (Based on available data, the classification criteria are not met)
STOT-single exposure : Not classified (Based on available data, the classification criteria are not met)
STOT-repeated exposure : May cause damage to organs (kidneys) through prolonged or repeated exposure (oral).

Monoethylene glycol (107-21-1)	
STOT-repeated exposure	May cause damage to organs through prolonged or repeated exposure.

Aspiration hazard : Not classified (Based on available data, the classification criteria are not met)

Proviflow Neo	
Viscosity, kinematic	18 mm²/s (@ 25°C)

11.2. Information on other hazards

No additional information available

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Proviflow Neo

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

SECTION 12: Ecological information

12.1. Toxicity

Hazardous to the aquatic environment, short–term (acute) : Not classified

Hazardous to the aquatic environment, long–term (chronic) : Not classified

Monoethylene glycol (107-21-1)	
LC50 - Fish [1]	72860 mg/l (Pimephales promelas)

12.2. Persistence and degradability

Proviflow Neo	
Persistence and degradability	Rapidly degradable

Monoethylene glycol (107-21-1)	
Persistence and degradability	Readily biodegradable.

12.3. Bioaccumulative potential

Monoethylene glycol (107-21-1)	
Bioaccumulative potential	Low bioaccumulation potential.

12.4. Mobility in soil

No additional information available

12.5. Results of PBT and vPvB assessment

Proviflow Neo
This substance/mixture does not meet the PBT criteria of REACH regulation, annex XIII
This substance/mixture does not meet the vPvB criteria of REACH regulation, annex XIII

12.6. Endocrine disrupting properties

No additional information available

12.7. Other adverse effects

No additional information available

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Regional waste regulation : Disposal must be done according to official regulations.

Waste treatment methods : Dispose of contents/container in accordance with licensed collector's sorting instructions.

Sewage disposal recommendations : Sewage treatment plant.

Product/Packaging disposal recommendations : Collect all waste in suitable and labelled containers and dispose according to local legislation.

SECTION 14: Transport information

In accordance with ADR / IMDG / IATA / ADN / RID

14.1. UN number or ID number

UN-No. (ADR) : Not applicable

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Proviflow Neo

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

UN-No. (IMDG)	:	Not applicable
UN-No. (IATA)	:	Not applicable
UN-No. (ADN)	:	Not applicable
UN-No. (RID)	:	Not applicable

14.2. UN proper shipping name

Proper Shipping Name (ADR)	:	Not applicable
Proper Shipping Name (IMDG)	:	Not applicable
Proper Shipping Name (IATA)	:	Not applicable
Proper Shipping Name (ADN)	:	Not applicable
Proper Shipping Name (RID)	:	Not applicable

14.3. Transport hazard class(es)

ADR

Transport hazard class(es) (ADR) : Not applicable

IMDG

Transport hazard class(es) (IMDG) : Not applicable

IATA

Transport hazard class(es) (IATA) : Not applicable

ADN

Transport hazard class(es) (ADN) : Not applicable

RID

Transport hazard class(es) (RID) : Not applicable

14.4. Packing group

Packing group (ADR)	:	Not applicable
Packing group (IMDG)	:	Not applicable
Packing group (IATA)	:	Not applicable
Packing group (ADN)	:	Not applicable
Packing group (RID)	:	Not applicable

14.5. Environmental hazards

Other information : No supplementary information available

14.6. Special precautions for user

Overland transport

Not applicable

Transport by sea

Not applicable

Air transport

Not applicable

Inland waterway transport

Not applicable

Rail transport

Not applicable

14.7. Maritime transport in bulk according to IMO instruments

Not applicable

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Proviflow Neo

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

15.1.1. EU-Regulations

REACH Annex XVII (Restriction List)

Contains no substance(s) listed on REACH Annex XVII (Restriction Conditions)

REACH Annex XIV (Authorisation List)

Contains no substance(s) listed on REACH Annex XIV (Authorisation List)

REACH Candidate List (SVHC)

Contains no substance(s) listed on the REACH Candidate List

PIC Regulation (Prior Informed Consent)

Contains no substance(s) listed on the PIC list (Regulation EU 649/2012 concerning the export and import of hazardous chemicals)

POP Regulation (Persistent Organic Pollutants)

Contains no substance(s) listed on the POP list (Regulation EU 2019/1021 on persistent organic pollutants)

Ozone Regulation (1005/2009)

Contains no substance(s) listed on the Ozone Depletion list (Regulation EU 1005/2009 on substances that deplete the ozone layer)

Dual-Use Regulation (428/2009)

Contains no substance subject to the COUNCIL REGULATION (EC) No 428/2009 of 5 May 2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items.

Explosives Precursors Regulation (2019/1148)

Contains no substance(s) listed on the Explosives Precursors list (Regulation EU 2019/1148 on the marketing and use of explosives precursors)

Drug Precursors Regulation (273/2004)

Contains no substance(s) listed on the Drug Precursors list (Regulation EC 273/2004 on the manufacture and the placing on market of certain substances used in the illicit manufacture of narcotic drugs and psychotropic substances)

15.1.2. National regulations

France

Occupational diseases	
Code	Description
RG 84	Conditions caused by liquid organic solvents for professional use: saturated or unsaturated aliphatic or cyclic liquid hydrocarbons and mixtures thereof; liquid halogenated hydrocarbons; nitrated derivatives of aliphatic hydrocarbons; alcohols; glycols, glycol ethers; ketones; aldehydes; aliphatic and cyclic ethers, including tetrahydrofuran; esters; dimethylformamide and dimethylacetamine; acetonitrile and propionitrile; pyridine; dimethylsulfone and dimethylsulfoxide

Germany

Employment restrictions	:	Observe restrictions according Act on the Protection of Working Mothers (MuSchG). Observe restrictions according Act on the Protection of Young People in Employment (JArbSchG).
Water hazard class (WGK)	:	Classification according to AwSV, Annex 1.
Hazardous Incident Ordinance (12. BImSchV)	:	Is not subject of the Hazardous Incident Ordinance (12. BImSchV)

Netherlands

ABM category	:	Not determined
SZW-lijst van kankerverwekkende stoffen	:	None of the components are listed
SZW-lijst van mutagene stoffen	:	None of the components are listed
SZW-lijst van reprotoxische stoffen – Borstvoeding	:	None of the components are listed
SZW-lijst van reprotoxische stoffen – Vruchtbaarheid	:	None of the components are listed
SZW-lijst van reprotoxische stoffen – Ontwikkeling	:	None of the components are listed

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Denmark

Danish National Regulations	:	Young people below the age of 18 years are not allowed to use the product Pregnant/breastfeeding women working with the product must not be in direct contact with the product

15.2. Chemical safety assessment

No additional information available

SECTION 16: Other information

Full text of H- and EUH-statements:	
Acute Tox. 4 (Oral)	Acute toxicity (oral), Category 4
H302	Harmful if swallowed.
H373	May cause damage to organs through prolonged or repeated exposure.
STOT RE 2	Specific target organ toxicity – Repeated exposure, Category 2

Safety Data Sheet (SDS), EU

Disclaimer:
The purpose of this safety data sheet is to provide information about the safety, health and environmental aspects of the product concerned. The information in this safety data sheet is based on current expertise. Proviron provides this information in good faith and to the best of its ability. This data sheet contains no guarantees as to the suitability of the product for a particular purpose or about any particular characteristics of the product. The purchaser/consumer is personally responsible for his/her use of the product and for taking precautions appropriate to its use.
This safety data sheet was originally drafted in Dutch or English. The translations were produced using professional language databanks intended specifically for the drafting of a safety data sheet.
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4.3 Putoline® Ceramic Grease PV.20.01

Ceramic Grease

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878
Issue date: 29-8-2018 Revision date: 21-6-2024 Supersedes version of: 13-10-2022 Version: 1.3

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Product form : Mixture
Trade name : Ceramic Grease
Product code : PV.20.01
Type of product : Paste
Product group : Trade product

1.2. Relevant identified uses of the substance or mixture and uses advised against

1.2.1. Relevant identified uses

Main use category : Industrial use,Professional use,Consumer use
Use of the substance/mixture : Lubricant
Function or use category : Lubricants and additives

1.2.2. Uses advised against

No additional information available

1.3. Details of the supplier of the safety data sheet

Putoline Oil
Dollegoorweg 15
NL 7602 EC Almelo
Netherlands
T 0031 (0)546 81 81 65
vib@putoline.com

1.4. Emergency telephone number

Country/Area	Organisation/Company	Address	Emergency number	Comment
Ireland	National Poisons Information Centre Beaumont Hospital	PO Box 1297 Beaumont Road 9	+353 1 809 2566 (Healthcare professionals-24/7) +353 1 809 2166 (public, 8am - 10pm, 7/7)	
United Kingdom	National Poisons Information Service (Cardiff Centre) University Hospital Llandough	Penlan Road CF64 2XX	0344 892 0111	Only for healthcare professionals

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Classification according to Regulation (EC) No. 1272/2008 [CLP]

Not classified

Adverse physicochemical, human health and environmental effects

To our knowledge, this product does not present any particular risk, provided it is handled in accordance with good occupational hygiene and safety practice.

2.2. Label elements

Labelling according to Regulation (EC) No. 1272/2008 [CLP]

No labelling applicable

21-6-2024 (Revision date)
21-6-2024 (Printing date)
EN (English)
1/10

Ceramic Grease

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

2.3. Other hazards

The mixture does not contain substance(s) included in the list established in accordance with Article 59(1) of REACH for having endocrine disrupting properties, or substance(s) are not identified as having endocrine disrupting properties in accordance with the criteria set out in Commission Delegated Regulation (EU) 2017/2100 or Commission Regulation (EU) 2018/605 at a concentration equal to or greater than 0,1 %

SECTION 3: Composition/information on ingredients

3.1. Substances

Not applicable

3.2. Mixtures

This mixture does not contain any substances to be mentioned according to the criteria of section 3.2 of REACH Annex II

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : If you feel unwell, seek medical advice.
First-aid measures after inhalation : Remove person to fresh air and keep comfortable for breathing.
First-aid measures after skin contact : Wash skin with plenty of water.
First-aid measures after eye contact : Rinse eyes with water as a precaution.
First-aid measures after ingestion : Call a poison center or a doctor if you feel unwell.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/effects after inhalation : Although no appropriate human or animal health effects data are known to exist, this material is expected to be an inhalation hazard.
Symptoms/effects after skin contact : None under normal conditions.
Symptoms/effects after eye contact : None under normal conditions.
Symptoms/effects after ingestion : None under normal conditions.

4.3. Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Water spray. Dry powder. Foam. Carbon dioxide.
Unsuitable extinguishing media : Do not use a heavy water stream.

5.2. Special hazards arising from the substance or mixture

Fire hazard : Combustible liquid.
Explosion hazard : No direct explosion hazard.
Hazardous decomposition products in case of fire : Incomplete combustion releases dangerous carbon monoxide, carbon dioxide and other toxic gases.

5.3. Advice for firefighters

Firefighting instructions : Fight fire from safe distance and protected location. Do not enter fire area without proper protective equipment, including respiratory protection.
Protection during firefighting : Do not attempt to take action without suitable protective equipment. Self-contained breathing apparatus. Complete protective clothing.

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SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures : Stop leak if safe to do so. Notify authorities if product enters sewers or public waters. Absorb spillage to prevent material damage.

6.1.1. For non-emergency personnel

Protective equipment : Wear recommended personal protective equipment.
Emergency procedures : Ventilate spillage area.

6.1.2. For emergency responders

Protective equipment : Do not attempt to take action without suitable protective equipment. For further information refer to section 8: "Exposure controls/personal protection".
Emergency procedures : Evacuate unnecessary personnel. Stop leak if safe to do so.

6.2. Environmental precautions

Avoid release to the environment.

6.3. Methods and material for containment and cleaning up

For containment : Absorb spilled material with sand or earth. Contain any spills with dikes or absorbents to prevent migration and entry into sewers or streams. Stop leak without risks if possible.
Methods for cleaning up : Mechanically recover the product.
Other information : Dispose of materials or solid residues at an authorized site.

6.4. Reference to other sections

For further information refer to section 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Additional hazards when processed : Not expected to present a significant hazard under anticipated conditions of normal use.
Precautions for safe handling : Ensure good ventilation of the work station. Wear personal protective equipment.
Hygiene measures : Do not eat, drink or smoke when using this product. Always wash hands after handling the product.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Keep in a cool, well-ventilated place away from heat.
Storage conditions : Keep cool. Protect from sunlight.
Storage temperature : < 40 °C
Packaging materials : Store always product in container of same material as original container.

7.3. Specific end use(s)

No additional information available

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

8.1.1 National occupational exposure and biological limit values

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Ceramic Grease	
EU - Indicative Occupational Exposure Limit (IOEL)	
Exposure limits/standards for materials that can be formed when handling this product. When mists/aerosols can occur the following is recommended	5 mg/m³ - ACGIH TLV (inhalable fraction).

8.1.2. Recommended monitoring procedures

No additional information available

8.1.3. Air contaminants formed

No additional information available

8.1.4. DNEL and PNEC

No additional information available

8.1.5. Control banding

No additional information available

8.2. Exposure controls

8.2.1. Appropriate engineering controls

Appropriate engineering controls:
Ensure good ventilation of the work station.

8.2.2. Personal protection equipment

Personal protective equipment:
Wear recommended personal protective equipment.

Personal protective equipment symbol(s):



8.2.2.1. Eye and face protection

Eye protection:
Safety glasses

8.2.2.2. Skin protection

Skin and body protection:
Wear suitable protective clothing

Hand protection:
Protective gloves

8.2.2.3. Respiratory protection

Respiratory protection:
In case of insufficient ventilation, wear suitable respiratory equipment

8.2.2.4. Thermal hazards

No additional information available

8.2.3. Environmental exposure controls

Environmental exposure controls:
Avoid release to the environment.

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SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Liquid
Colour	:	Beige.
Appearance	:	Paste.
Odour	:	characteristic.
Odour threshold	:	Not available
Melting point	:	Not applicable
Freezing point	:	Not applicable
Boiling point	:	Not available
Flammability	:	Non flammable.
Lower explosion limit	:	Not available
Upper explosion limit	:	Not available
Flash point	:	Not applicable
Auto-ignition temperature	:	Not applicable
Decomposition temperature	:	Not available
pH	:	Not available
Viscosity, kinematic	:	Not applicable
Solubility	:	Water: Insoluble / Slightly miscible
Partition coefficient n-octanol/water (Log Kow)	:	Not available
Vapour pressure	:	Not available
Vapour pressure at 50°C	:	Not available
Density	:	1,03 – 1,13 g/cm³
Relative density	:	Not applicable
Relative vapour density at 20°C	:	Not available
Particle characteristics	:	Not applicable

9.2. Other information

9.2.1. Information with regard to physical hazard classes

No additional information available

9.2.2. Other safety characteristics

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

The product is non-reactive under normal conditions of use, storage and transport.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Reacts violently with (strong) oxidizers.

10.4. Conditions to avoid

None under recommended storage and handling conditions (see section 7).

10.5. Incompatible materials

No additional information available

10.6. Hazardous decomposition products

Under normal conditions of storage and use, hazardous decomposition products should not be produced.

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SECTION 11: Toxicological information

11.1. Information on hazard classes as defined in Regulation (EC) No 1272/2008

Acute toxicity (oral)	:	Not classified
Acute toxicity (dermal)	:	Not classified
Acute toxicity (inhalation)	:	Not classified
Skin corrosion/irritation	:	Not classified
Serious eye damage/irritation	:	Not classified
Respiratory or skin sensitisation	:	Not classified
Germ cell mutagenicity	:	Not classified
Carcinogenicity	:	Not classified
Reproductive toxicity	:	Not classified
STOT-single exposure	:	Not classified
STOT-repeated exposure	:	Not classified
Aspiration hazard	:	Not classified

Ceramic Grease	
Viscosity, kinematic	Not applicable

11.2. Information on other hazards

No additional information available

SECTION 12: Ecological information

12.1. Toxicity

Ecology - general	:	The product is not considered harmful to aquatic organisms nor to cause long-term adverse effects in the environment.
Hazardous to the aquatic environment, short–term (acute)	:	Not classified
Hazardous to the aquatic environment, long–term (chronic)	:	Not classified

12.2. Persistence and degradability

Ceramic Grease	
Persistence and degradability	Rapidly degradable

12.3. Bioaccumulative potential

No additional information available

12.4. Mobility in soil

No additional information available

12.5. Results of PBT and vPvB assessment

No additional information available

12.6. Endocrine disrupting properties

No additional information available

12.7. Other adverse effects

No additional information available

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SECTION 13: Disposal considerations

13.1. Waste treatment methods

Regional waste regulation	:	Disposal must be done according to official regulations.
Waste treatment methods	:	Dispose of contents/container in accordance with licensed collector's sorting instructions.
Sewage disposal recommendations	:	Disposal must be done according to official regulations.
Product/Packaging disposal recommendations	:	Disposal must be done according to official regulations.
Additional information	:	Do not re-use empty containers.

SECTION 14: Transport information

In accordance with ADR / IMDG / IATA / ADN / RID

ADR	IMDG	IATA	ADN	RID
14.1. UN number or ID number				
Not regulated for transport				
14.2. UN proper shipping name				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
14.3. Transport hazard class(es)				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
14.4. Packing group				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
14.5. Environmental hazards				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
No supplementary information available				

14.6. Special precautions for user

Overland transport
Not regulated

Transport by sea
Not regulated

Air transport
Not regulated

Inland waterway transport
Not regulated

Rail transport
Not regulated

14.7. Maritime transport in bulk according to IMO instruments

Not applicable

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SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

15.1.1. EU-Regulations

REACH Annex XVII (Restriction List)

Contains no substance(s) listed on REACH Annex XVII (Restriction Conditions)

REACH Annex XIV (Authorisation List)

Contains no substance(s) listed on REACH Annex XIV (Authorisation List)

REACH Candidate List (SVHC)

Contains no substance(s) listed on the REACH Candidate List

PIC Regulation (Prior Informed Consent)

Contains no substance(s) listed on the PIC list (Regulation EU 649/2012 concerning the export and import of hazardous chemicals)

POP Regulation (Persistent Organic Pollutants)

Contains no substance(s) listed on the POP list (Regulation EU 2019/1021 on persistent organic pollutants)

Ozone Regulation (1005/2009)

Contains no substance(s) listed on the Ozone Depletion list (Regulation EU 1005/2009 on substances that deplete the ozone layer)

Dual-Use Regulation (428/2009)

Contains no substance subject to the COUNCIL REGULATION (EC) No 428/2009 of 5 May 2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items.

Explosives Precursors Regulation (2019/1148)

Contains no substance(s) listed on the Explosives Precursors list (Regulation EU 2019/1148 on the marketing and use of explosives precursors)

Drug Precursors Regulation (273/2004)

Contains no substance(s) listed on the Drug Precursors list (Regulation EC 273/2004 on the manufacture and the placing on market of certain substances used in the illicit manufacture of narcotic drugs and psychotropic substances)

15.1.2. National regulations

No additional information available

15.2. Chemical safety assessment

No chemical safety assessment has been carried out

SECTION 16: Other information

Indication of changes

Section	Changed item	Change	Comments
	Revision date	Modified	
	Supersedes	Modified	
4.1	First-aid measures general	Added	
4.2	Symptoms/effects after eye contact	Added	
4.2	Symptoms/effects after ingestion	Added	
4.2	Symptoms/effects after inhalation	Added	
4.2	Symptoms/effects after skin contact	Added	
5.2	Explosion hazard	Added	
5.2	Hazardous decomposition products in case of fire	Modified	
5.3	Firefighting instructions	Added	

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Indication of changes			
Section	**Changed item**	**Change**	**Comments**
6.1	Protective equipment	Added	
6.1	Emergency procedures	Added	
6.1	General measures	Added	
6.3	For containment	Added	
7.1	Additional hazards when processed	Added	
7.2	Technical measures	Added	
7.2	Packaging materials	Added	
7.2	Storage conditions	Modified	
8.2	Personal protective equipment	Added	
10.3	Possibility of hazardous reactions	Modified	
13.1	Additional information	Added	
13.1	Sewage disposal recommendations	Added	
13.1	Waste disposal recommendations	Added	
13.1	Regional waste regulation	Added	
13.1	H code	Added	

Abbreviations and acronyms:	
ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
ATE	Acute Toxicity Estimate
BCF	Bioconcentration factor
BLV	Biological limit value
BOD	Biochemical oxygen demand (BOD)
COD	Chemical oxygen demand (COD)
DMEL	Derived Minimal Effect level
DNEL	Derived-No Effect Level
EC-No.	European Community number
EC50	Median effective concentration
EN	European Standard
IARC	International Agency for Research on Cancer
IATA	International Air Transport Association
IMDG	International Maritime Dangerous Goods
LC50	Median lethal concentration
LD50	Median lethal dose
LOAEL	Lowest Observed Adverse Effect Level
NOAEC	No-Observed Adverse Effect Concentration
NOAEL	No-Observed Adverse Effect Level
NOEC	No-Observed Effect Concentration

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Abbreviations and acronyms:	
OECD	Organisation for Economic Co-operation and Development
OEL	Occupational Exposure Limit
PBT	Persistent Bioaccumulative Toxic
PNEC	Predicted No-Effect Concentration
RID	Regulations concerning the International Carriage of Dangerous Goods by Rail
SDS	Safety Data Sheet
STP	Sewage treatment plant
ThOD	Theoretical oxygen demand (ThOD)
TLM	Median Tolerance Limit
VOC	Volatile Organic Compounds
CAS-No.	Chemical Abstract Service number
N.O.S.	Not Otherwise Specified
vPvB	Very Persistent and Very Bioaccumulative
ED	Endocrine disrupting properties

Safety Data Sheet (SDS), EU

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.

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4.4 Krytox™ GPL 205

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Chemours™

Krytox™ GPL 205

Version	Revision Date:	SDS Number:	Date of last issue: 02.11.2023
3.3	29.05.2024	9582423-00007	Date of first issue: 15.09.2021

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Trade name : Krytox™ GPL 205

SDS-Identcode : 130000024223

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of the Substance/Mixture : Lubricant

Recommended restrictions on use : For industrial use only.
Do not use or resell Chemours™ materials in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless agreed to by Seller in a written agreement covering such use. For further information, please contact your Chemours representative.

1.3 Details of the supplier of the safety data sheet

Company : Chemours Netherlands B.V.
Baanhoekweg 22
3313 LA Dordrecht Netherlands

Telephone : +31-(0)-78-630-1011

Telefax : +31-78-6163737

E-mail address of person responsible for the SDS : sds-support@chemours.com

1.4 Emergency telephone number

+(44)-870-8200418 (CHEMTREC - Recommended)

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Classification (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

Not a hazardous substance or mixture.

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2.2 Label elements

Labelling (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

No hazard pictogram, no signal word, no hazard statement(s), no precautionary statement(s) required

2.3 Other hazards

This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.
The thermal decomposition vapours of fluorinated plastics may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

Components

Remarks : No hazardous ingredients

SECTION 4: First aid measures

4.1 Description of first aid measures

Protection of first-aiders : No special precautions are necessary for first aid responders.

If inhaled : If inhaled, remove to fresh air.
Get medical attention if symptoms occur.

In case of skin contact : Wash with water and soap as a precaution.
Get medical attention if symptoms occur.

In case of eye contact : Flush eyes with water as a precaution.
Get medical attention if irritation develops and persists.

If swallowed : If swallowed, DO NOT induce vomiting.
Get medical attention if symptoms occur.
Rinse mouth thoroughly with water.

4.2 Most important symptoms and effects, both acute and delayed

Symptoms : Inhalation may provoke the following symptoms:
Irritation
Lung oedema

Eye contact may provoke the following symptoms
Blurred vision
Discomfort

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Lachrymation

Skin contact may provoke the following symptoms:
Irritation
Redness

Inhalation may provoke the following symptoms:
Irritation
Shortness of breath

4.3 Indication of any immediate medical attention and special treatment needed

Treatment : Treat symptomatically and supportively.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media : Not applicable
Will not burn

Unsuitable extinguishing media : Not applicable
Will not burn

5.2 Special hazards arising from the substance or mixture

Specific hazards during fire-fighting : Exposure to combustion products may be a hazard to health.

Hazardous combustion products : Hydrogen fluoride
carbonyl fluoride
potentially toxic fluorinated compounds
aerosolized particulates
Carbon oxides

5.3 Advice for firefighters

Special protective equipment for firefighters : Wear self-contained breathing apparatus for firefighting if necessary. Use personal protective equipment.

Specific extinguishing methods : Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Use water spray to cool unopened containers.
Remove undamaged containers from fire area if it is safe to do so.
Evacuate area.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Personal precautions : Follow safe handling advice (see section 7) and personal pro-

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tective equipment recommendations (see section 8).

6.2 Environmental precautions

Environmental precautions : Avoid release to the environment.
Prevent further leakage or spillage if safe to do so.
Retain and dispose of contaminated wash water.
If spillage enters rivers or watercourses, inform the Environment Agency (emergency telephone number 0800 807060).

6.3 Methods and material for containment and cleaning up

Methods for cleaning up : Soak up with inert absorbent material.
For large spills, provide dyking or other appropriate containment to keep material from spreading. If dyked material can be pumped, store recovered material in appropriate container.
Clean up remaining materials from spill with suitable absorbent.
Local or national regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which regulations are applicable.
Sections 13 and 15 of this SDS provide information regarding certain local or national requirements.

6.4 Reference to other sections

See sections: 7, 8, 11, 12 and 13.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Technical measures : See Engineering measures under EXPOSURE CONTROLS/PERSONAL PROTECTION section.

Local/Total ventilation : Use only with adequate ventilation.

Advice on safe handling : Handle in accordance with good industrial hygiene and safety practice, based on the results of the workplace exposure assessment
Take care to prevent spills, waste and minimize release to the environment.

Do not breathe decomposition products.

Hygiene measures : If exposure to chemical is likely during typical use, provide eye flushing systems and safety showers close to the working place. When using do not eat, drink or smoke. Wash contaminated clothing before re-use.

7.2 Conditions for safe storage, including any incompatibilities

Requirements for storage : Keep in properly labelled containers. Store in accordance with

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areas and containers — the particular national regulations.

Advice on common storage : No special restrictions on storage with other products.

Further information on storage stability : No decomposition if stored and applied as directed.

7.3 Specific end use(s)

Specific use(s) : No data available

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Occupational Exposure Limits

Contains no substances with occupational exposure limit values.

Occupational exposure limits of decomposition products

Components	CAS-No.	Value type (Form of exposure)	Control parameters	Basis
hydrofluoric acid	7664-39-3	TWA	1.8 ppm 1.5 mg/m3 (Fluorine)	GB EH40
		STEL	3 ppm 2.5 mg/m3 (Fluorine)	GB EH40
		TWA	1.8 ppm 1.5 mg/m3	2000/39/EC
	Further information: Indicative			
		STEL	3 ppm 2.5 mg/m3	2000/39/EC
	Further information: Indicative			
Carbonyl difluoride	353-50-4	TWA	2.5 mg/m3 (Fluorine)	2000/39/EC
	Further information: Indicative			
Carbon dioxide	124-38-9	TWA	5,000 ppm 9,150 mg/m3	GB EH40
		STEL	15,000 ppm 27,400 mg/m3	GB EH40
		TWA	5,000 ppm 9,000 mg/m3	2006/15/EC
	Further information: Indicative			
Carbon monoxide	630-08-0	TWA	30 ppm 35 mg/m3	GB EH40
		STEL	200 ppm 232 mg/m3	GB EH40
		TWA	20 ppm 23 mg/m3	GB EH40
		STEL	100 ppm	GB EH40

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			117 mg/m3	
		STEL	100 ppm 117 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			
		STEL	100 ppm 117 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			

8.2 Exposure controls

Engineering measures
Processing may form hazardous compounds (see section 10).
Ensure adequate ventilation, especially in confined areas.
Minimize workplace exposure concentrations.

Personal protective equipment

Eye/face protection : Wear the following personal protective equipment:
Safety glasses
Equipment should conform to BS EN 166

Hand protection

Remarks : Wash hands before breaks and at the end of workday.

Skin and body protection : Skin should be washed after contact.

Respiratory protection : If adequate local exhaust ventilation is not available or exposure assessment demonstrates exposures outside the recommended guidelines, use respiratory protection.
Equipment should conform to BS EN 14387

Filter type : Combined particulates, acidic gas/vapour and organic vapour type (AE-P)

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance : Grease

Colour : white

Odour : odourless

Odour Threshold : No data available

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pH	:	7
Melting point/freezing point	:	320 °C
Initial boiling point and boiling range	:	No data available
Flash point	:	Method: Pensky-Martens closed cup Not applicable
Evaporation rate	:	Not applicable
Flammability (solid, gas)	:	Will not burn
Upper explosion limit / Upper flammability limit	:	No data available
Lower explosion limit / Lower flammability limit	:	No data available
Vapour pressure	:	Not applicable
Relative vapour density	:	Not applicable
Relative density	:	1.89 - 1.93 (24 °C)
Solubility(ies) Water solubility	:	insoluble
Partition coefficient: n-octanol/water	:	Not applicable
Auto-ignition temperature	:	No data available
Decomposition temperature	:	300 °C
Viscosity Viscosity, kinematic	:	Not applicable
Explosive properties	:	Not explosive
Oxidizing properties	:	The substance or mixture is not classified as oxidizing.

9.2 Other information

Particle size	:	No data available

SECTION 10: Stability and reactivity

10.1 Reactivity

Not classified as a reactivity hazard.

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10.2 Chemical stability
Stable under normal conditions.

10.3 Possibility of hazardous reactions
Hazardous reactions : Hazardous decomposition products will be formed at elevated temperatures.

10.4 Conditions to avoid
Conditions to avoid : None known.

10.5 Incompatible materials
Materials to avoid : None.

10.6 Hazardous decomposition products
Thermal decomposition : hydrofluoric acid
Carbonyl difluoride
Carbon dioxide
Carbon monoxide

SECTION 11: Toxicological information

11.1 Information on toxicological effects
Information on likely routes of exposure : Skin contact
Ingestion
Eye contact

Acute toxicity
Not classified based on available information.

Skin corrosion/irritation
Not classified based on available information.

Serious eye damage/eye irritation
Not classified based on available information.

Respiratory or skin sensitisation

Skin sensitisation
Not classified based on available information.

Respiratory sensitisation
Not classified based on available information.

Germ cell mutagenicity
Not classified based on available information.

Carcinogenicity
Not classified based on available information.

Reproductive toxicity
Not classified based on available information.

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STOT - single exposure
Not classified based on available information.

STOT - repeated exposure
Not classified based on available information.

Aspiration toxicity
Not classified based on available information.

SECTION 12: Ecological information

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment

Product:

Assessment	:	This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

12.6 Other adverse effects

Product:

Endocrine disrupting potential	:	This substance/mixture does not contain components considered to have endocrine disrupting properties for environment according to UK REACH Article 57(f).

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product	:	Dispose of in accordance with local regulations. According to the European Waste Catalogue, Waste Codes are not product specific, but application specific. Waste codes should be assigned by the user, preferably in discussion with the waste disposal authorities. Do not dispose of waste into sewer.
Contaminated packaging	:	Empty containers should be taken to an approved waste handling site for recycling or disposal.

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If not otherwise specified: Dispose of as unused product.

SECTION 14: Transport information

14.1 UN number

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.2 UN proper shipping name

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.3 Transport hazard class(es)

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.4 Packing group

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA (Cargo)	:	Not regulated as a dangerous good
IATA (Passenger)	:	Not regulated as a dangerous good

14.5 Environmental hazards
Not regulated as a dangerous good

14.6 Special precautions for user
Not applicable

14.7 Transport in bulk according to Annex II of Marpol and the IBC Code
Remarks : Not applicable for product as supplied.

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SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Relevant EU provisions transposed through retained EU law

UK REACH List of restrictions (Annex 17)	:	Not applicable
UK REACH Candidate list of substances of very high concern (SVHC) for Authorisation	:	Not applicable
The Persistent Organic Pollutants Regulations (retained Regulation (EU) 2019/1021 as amended for Great Britain)	:	Not applicable
Regulation (EC) No 1005/2009 on substances that deplete the ozone layer	:	Not applicable
UK REACH List of substances subject to authorisation (Annex XIV)	:	Not applicable
GB Export and import of hazardous chemicals - Prior Informed Consent (PIC) Regulation	:	Not applicable

Control of Major Accident Hazards Regulations 2015 (COMAH)
Not applicable

15.2 Chemical safety assessment

A Chemical Safety Assessment has not been carried out.

SECTION 16: Other information

Other information	:	Krytox™ and any associated logos are trademarks or copyrights of The Chemours Company FC, LLC. Chemours™ and the Chemours Logo are trademarks of The Chemours Company. Before use read Chemours safety information. For further information contact the local Chemours office or nominated distributors. Items where changes have been made to the previous version are highlighted in the body of this document by two vertical lines.

Full text of other abbreviations

2000/39/EC	:	Europe. Commission Directive 2000/39/EC establishing a first list of indicative occupational exposure limit values
2004/37/EC	:	Europe. Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens

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		at work
2006/15/EC	:	Europe. Indicative occupational exposure limit values
2017/164/EU	:	Europe. Commission Directive 2017/164/EU establishing a fourth list of indicative occupational exposure limit values
GB EH40	:	UK. EH40 WEL - Workplace Exposure Limits
2000/39/EC / TWA	:	Limit Value - eight hours
2000/39/EC / STEL	:	Short term exposure limit
2004/37/EC / STEL	:	Short term exposure limit
2004/37/EC / TWA	:	Long term exposure limit
2006/15/EC / TWA	:	Limit Value - eight hours
2017/164/EU / STEL	:	Short term exposure limit
2017/164/EU / TWA	:	Limit Value - eight hours
GB EH40 / TWA	:	Long-term exposure limit (8-hour TWA reference period)
GB EH40 / STEL	:	Short-term exposure limit (15-minute reference period)

ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways; ADR - Agreement concerning the International Carriage of Dangerous Goods by Road; AIIC - Australian Inventory of Industrial Chemicals; ASTM - American Society for the Testing of Materials; bw - Body weight; CLP - Classification Labelling Packaging Regulation; Regulation (EC) No 1272/2008; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardisation; DSL - Domestic Substances List (Canada); ECHA - European Chemicals Agency; EC-Number - European Community number; ECx - Concentration associated with x% response; ELx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 - Half maximal inhibitory concentration; ICAO - International Civil Aviation Organization; IECSC - Inventory of Existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial Safety and Health Law (Japan); ISO - International Organisation for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal Concentration to 50 % of a test population; LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose); MARPOL - International Convention for the Prevention of Pollution from Ships; n.o.s. - Not Otherwise Specified; NO(A)EC - No Observed (Adverse) Effect Concentration; NO(A)EL - No Observed (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Co-operation and Development; OPPTS - Office of Chemical Safety and Pollution Prevention; PBT - Persistent, Bioaccumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals; RID - Regulations concerning the International Carriage of Dangerous Goods by Rail; SADT - Self-Accelerating Decomposition Temperature; SDS - Safety Data Sheet; SVHC - Substance of very high concern; TCSI - Taiwan Chemical Substance Inventory; TECI - Thailand Existing Chemicals Inventory; TSCA - Toxic Substances Control Act (United States); UN - United Nations; UNRTDG - United Nations Recommendations on the Transport of Dangerous Goods; vPvB - Very Persistent and Very Bioaccumulative

Further information

Sources of key data used to compile the Safety Data Sheet	:	Internal technical data, data from raw material SDSs, OECD eChem Portal search results and European Chemicals Agency, http://echa.europa.eu/

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The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and shall not be considered a warranty or quality specification of any type. The information provided relates only to the specific material identified at the top of this SDS and may not be valid when the SDS material is used in combination with any other materials or in any process, unless specified in the text. Material users should review the information and recommendations in the specific context of their intended manner of handling, use, processing and storage, including an assessment of the appropriateness of the SDS material in the user's end product, if applicable.

GB / EN

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4.5 Krytox™ GPL 206

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Chemours™

Krytox™ GPL 206

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SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Trade name : Krytox™ GPL 206

SDS-Identcode : 130000031500

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of the Substance/Mixture : Lubricant

Recommended restrictions on use : For industrial use only.
Do not use or resell Chemours™ materials in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless agreed to by Seller in a written agreement covering such use. For further information, please contact your Chemours representative.

1.3 Details of the supplier of the safety data sheet

Company : Chemours Netherlands B.V.
Baanhoekweg 22
3313 LA Dordrecht Netherlands

Telephone : +31-(0)-78-630-1011

Telefax : +31-78-6163737

E-mail address of person responsible for the SDS : sds-support@chemours.com

1.4 Emergency telephone number

+(44)-870-8200418 (CHEMTREC - Recommended)

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Classification (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

Not a hazardous substance or mixture.

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2.2 Label elements

Labelling (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

No hazard pictogram, no signal word, no hazard statement(s), no precautionary statement(s) required

2.3 Other hazards

This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.
The thermal decomposition vapours of fluorinated plastics may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

Components

Remarks : No hazardous ingredients

SECTION 4: First aid measures

4.1 Description of first aid measures

Protection of first-aiders : No special precautions are necessary for first aid responders.

If inhaled : If inhaled, remove to fresh air.
Get medical attention if symptoms occur.

In case of skin contact : Wash with water and soap as a precaution.
Get medical attention if symptoms occur.

In case of eye contact : Flush eyes with water as a precaution.
Get medical attention if irritation develops and persists.

If swallowed : If swallowed, DO NOT induce vomiting.
Get medical attention if symptoms occur.
Rinse mouth thoroughly with water.

4.2 Most important symptoms and effects, both acute and delayed

Symptoms : Inhalation may provoke the following symptoms:
Irritation
Lung oedema

Eye contact may provoke the following symptoms
Blurred vision
Discomfort

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Lachrymation

Skin contact may provoke the following symptoms:
Irritation
Redness

Inhalation may provoke the following symptoms:
Irritation
Shortness of breath

4.3 Indication of any immediate medical attention and special treatment needed

Treatment : Treat symptomatically and supportively.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media : Not applicable
Will not burn

Unsuitable extinguishing media : Not applicable
Will not burn

5.2 Special hazards arising from the substance or mixture

Specific hazards during fire-fighting : Exposure to combustion products may be a hazard to health.

Hazardous combustion products : Hydrogen fluoride
carbonyl fluoride
potentially toxic fluorinated compounds
aerosolized particulates
Carbon oxides

5.3 Advice for firefighters

Special protective equipment for firefighters : Wear self-contained breathing apparatus for firefighting if necessary. Use personal protective equipment.

Specific extinguishing methods : Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Use water spray to cool unopened containers.
Remove undamaged containers from fire area if it is safe to do so.
Evacuate area.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Personal precautions : Follow safe handling advice (see section 7) and personal pro-

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tective equipment recommendations (see section 8).

6.2 Environmental precautions

Environmental precautions : Avoid release to the environment.
Prevent further leakage or spillage if safe to do so.
Retain and dispose of contaminated wash water.
If spillage enters rivers or watercourses, inform the Environment Agency (emergency telephone number 0800 807060).

6.3 Methods and material for containment and cleaning up

Methods for cleaning up : Soak up with inert absorbent material.
For large spills, provide dyking or other appropriate containment to keep material from spreading. If dyked material can be pumped, store recovered material in appropriate container.
Clean up remaining materials from spill with suitable absorbent.
Local or national regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which regulations are applicable.
Sections 13 and 15 of this SDS provide information regarding certain local or national requirements.

6.4 Reference to other sections

See sections: 7, 8, 11, 12 and 13.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Technical measures : See Engineering measures under EXPOSURE CONTROLS/PERSONAL PROTECTION section.

Local/Total ventilation : Use only with adequate ventilation.

Advice on safe handling : Handle in accordance with good industrial hygiene and safety practice, based on the results of the workplace exposure assessment
Take care to prevent spills, waste and minimize release to the environment.

Do not breathe decomposition products.

Hygiene measures : If exposure to chemical is likely during typical use, provide eye flushing systems and safety showers close to the working place. When using do not eat, drink or smoke. Wash contaminated clothing before re-use.

7.2 Conditions for safe storage, including any incompatibilities

Requirements for storage : Keep in properly labelled containers. Store in accordance with

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areas and containers — the particular national regulations.

Advice on common storage : No special restrictions on storage with other products.

Further information on storage stability : No decomposition if stored and applied as directed.

7.3 Specific end use(s)

Specific use(s) : No data available

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Occupational Exposure Limits

Contains no substances with occupational exposure limit values.

Occupational exposure limits of decomposition products

Components	CAS-No.	Value type (Form of exposure)	Control parameters	Basis
hydrofluoric acid	7664-39-3	TWA	1.8 ppm 1.5 mg/m3 (Fluorine)	GB EH40
		STEL	3 ppm 2.5 mg/m3 (Fluorine)	GB EH40
		TWA	1.8 ppm 1.5 mg/m3	2000/39/EC
	Further information: Indicative			
		STEL	3 ppm 2.5 mg/m3	2000/39/EC
	Further information: Indicative			
Carbonyl difluoride	353-50-4	TWA	2.5 mg/m3 (Fluorine)	2000/39/EC
	Further information: Indicative			
Carbon dioxide	124-38-9	TWA	5,000 ppm 9,150 mg/m3	GB EH40
		STEL	15,000 ppm 27,400 mg/m3	GB EH40
		TWA	5,000 ppm 9,000 mg/m3	2006/15/EC
	Further information: Indicative			
Carbon monoxide	630-08-0	TWA	30 ppm 35 mg/m3	GB EH40
		STEL	200 ppm 232 mg/m3	GB EH40
		TWA	20 ppm 23 mg/m3	GB EH40
		STEL	100 ppm	GB EH40

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Chemours™

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			117 mg/m3	
		STEL	100 ppm 117 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			
		STEL	100 ppm 117 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			

8.2 Exposure controls

Engineering measures

Processing may form hazardous compounds (see section 10).
Ensure adequate ventilation, especially in confined areas.
Minimize workplace exposure concentrations.

Personal protective equipment

Eye/face protection : Wear the following personal protective equipment:
Safety glasses
Equipment should conform to BS EN 166

Hand protection

Remarks : Wash hands before breaks and at the end of workday.

Skin and body protection : Skin should be washed after contact.

Respiratory protection : If adequate local exhaust ventilation is not available or exposure assessment demonstrates exposures outside the recommended guidelines, use respiratory protection.
Equipment should conform to BS EN 14387

Filter type : Combined particulates, acidic gas/vapour and organic vapour type (AE-P)

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance : Grease

Colour : white

Odour : odourless

Odour Threshold : No data available

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pH	:	7
Melting point/freezing point	:	320 °C
Initial boiling point and boiling range	:	No data available
Flash point	:	Method: Pensky-Martens closed cup Not applicable
Evaporation rate	:	Not applicable
Flammability (solid, gas)	:	Will not burn
Upper explosion limit / Upper flammability limit	:	No data available
Lower explosion limit / Lower flammability limit	:	No data available
Vapour pressure	:	Not applicable
Relative vapour density	:	Not applicable
Relative density	:	1.89 - 1.93 (24 °C)
Solubility(ies) Water solubility	:	insoluble
Partition coefficient: n-octanol/water	:	Not applicable
Auto-ignition temperature	:	No data available
Decomposition temperature	:	300 °C
Viscosity Viscosity, kinematic	:	Not applicable
Explosive properties	:	Not explosive
Oxidizing properties	:	The substance or mixture is not classified as oxidizing.

9.2 Other information

Particle size	:	No data available

SECTION 10: Stability and reactivity

10.1 Reactivity

Not classified as a reactivity hazard.

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10.2 Chemical stability
Stable under normal conditions.

10.3 Possibility of hazardous reactions
Hazardous reactions : Hazardous decomposition products will be formed at elevated temperatures.

10.4 Conditions to avoid
Conditions to avoid : None known.

10.5 Incompatible materials
Materials to avoid : None.

10.6 Hazardous decomposition products
Thermal decomposition : hydrofluoric acid
Carbonyl difluoride
Carbon dioxide
Carbon monoxide

SECTION 11: Toxicological information

11.1 Information on toxicological effects
Information on likely routes of exposure : Skin contact
Ingestion
Eye contact

Acute toxicity
Not classified based on available information.

Skin corrosion/irritation
Not classified based on available information.

Serious eye damage/eye irritation
Not classified based on available information.

Respiratory or skin sensitisation

Skin sensitisation
Not classified based on available information.

Respiratory sensitisation
Not classified based on available information.

Germ cell mutagenicity
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Carcinogenicity
Not classified based on available information.

Reproductive toxicity
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STOT - single exposure
Not classified based on available information.

STOT - repeated exposure
Not classified based on available information.

Aspiration toxicity
Not classified based on available information.

SECTION 12: Ecological information

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment

Product:

Assessment	:	This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

12.6 Other adverse effects

Product:

Endocrine disrupting potential	:	This substance/mixture does not contain components considered to have endocrine disrupting properties for environment according to UK REACH Article 57(f).

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product	:	Dispose of in accordance with local regulations. According to the European Waste Catalogue, Waste Codes are not product specific, but application specific. Waste codes should be assigned by the user, preferably in discussion with the waste disposal authorities. Do not dispose of waste into sewer.
Contaminated packaging	:	Empty containers should be taken to an approved waste handling site for recycling or disposal.

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Version	Revision Date:	SDS Number:	Date of last issue: 02.11.2023
3.3	17.05.2024	9582813-00006	Date of first issue: 15.09.2021

If not otherwise specified: Dispose of as unused product.

SECTION 14: Transport information

14.1 UN number

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.2 UN proper shipping name

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.3 Transport hazard class(es)

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.4 Packing group

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA (Cargo)	:	Not regulated as a dangerous good
IATA (Passenger)	:	Not regulated as a dangerous good

14.5 Environmental hazards
Not regulated as a dangerous good

14.6 Special precautions for user
Not applicable

14.7 Transport in bulk according to Annex II of Marpol and the IBC Code
Remarks : Not applicable for product as supplied.

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SAFETY DATA SHEET
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SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Relevant EU provisions transposed through retained EU law

UK REACH List of restrictions (Annex 17)	:	Not applicable
UK REACH Candidate list of substances of very high concern (SVHC) for Authorisation	:	Not applicable
The Persistent Organic Pollutants Regulations (retained Regulation (EU) 2019/1021 as amended for Great Britain)	:	Not applicable
Regulation (EC) No 1005/2009 on substances that deplete the ozone layer	:	Not applicable
UK REACH List of substances subject to authorisation (Annex XIV)	:	Not applicable
GB Export and import of hazardous chemicals - Prior Informed Consent (PIC) Regulation	:	Not applicable

Control of Major Accident Hazards Regulations 2015 (COMAH)
Not applicable

15.2 Chemical safety assessment

A Chemical Safety Assessment has not been carried out.

SECTION 16: Other information

Other information	:	Krytox™ and any associated logos are trademarks or copyrights of The Chemours Company FC, LLC. Chemours™ and the Chemours Logo are trademarks of The Chemours Company. Before use read Chemours safety information. For further information contact the local Chemours office or nominated distributors. Items where changes have been made to the previous version are highlighted in the body of this document by two vertical lines.

Full text of other abbreviations

2000/39/EC	:	Europe. Commission Directive 2000/39/EC establishing a first list of indicative occupational exposure limit values
2004/37/EC	:	Europe. Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens

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		at work
2006/15/EC	:	Europe. Indicative occupational exposure limit values
2017/164/EU	:	Europe. Commission Directive 2017/164/EU establishing a fourth list of indicative occupational exposure limit values
GB EH40	:	UK. EH40 WEL - Workplace Exposure Limits
2000/39/EC / TWA	:	Limit Value - eight hours
2000/39/EC / STEL	:	Short term exposure limit
2004/37/EC / STEL	:	Short term exposure limit
2004/37/EC / TWA	:	Long term exposure limit
2006/15/EC / TWA	:	Limit Value - eight hours
2017/164/EU / STEL	:	Short term exposure limit
2017/164/EU / TWA	:	Limit Value - eight hours
GB EH40 / TWA	:	Long-term exposure limit (8-hour TWA reference period)
GB EH40 / STEL	:	Short-term exposure limit (15-minute reference period)

ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways; ADR - Agreement concerning the International Carriage of Dangerous Goods by Road; AIIC - Australian Inventory of Industrial Chemicals; ASTM - American Society for the Testing of Materials; bw - Body weight; CLP - Classification Labelling Packaging Regulation; Regulation (EC) No 1272/2008; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardisation; DSL - Domestic Substances List (Canada); ECHA - European Chemicals Agency; EC-Number - European Community number; ECx - Concentration associated with x% response; ELx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 - Half maximal inhibitory concentration; ICAO - International Civil Aviation Organization; IECSC - Inventory of Existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial Safety and Health Law (Japan); ISO - International Organisation for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal Concentration to 50 % of a test population; LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose); MARPOL - International Convention for the Prevention of Pollution from Ships; n.o.s. - Not Otherwise Specified; NO(A)EC - No Observed (Adverse) Effect Concentration; NO(A)EL - No Observed (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Co-operation and Development; OPPTS - Office of Chemical Safety and Pollution Prevention; PBT - Persistent, Bioaccumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals; RID - Regulations concerning the International Carriage of Dangerous Goods by Rail; SADT - Self-Accelerating Decomposition Temperature; SDS - Safety Data Sheet; SVHC - Substance of very high concern; TCSI - Taiwan Chemical Substance Inventory; TECI - Thailand Existing Chemicals Inventory; TSCA - Toxic Substances Control Act (United States); UN - United Nations; UNRTDG - United Nations Recommendations on the Transport of Dangerous Goods; vPvB - Very Persistent and Very Bioaccumulative

Further information

Sources of key data used to compile the Safety Data Sheet	:	Internal technical data, data from raw material SDSs, OECD eChem Portal search results and European Chemicals Agency, http://echa.europa.eu/

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The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and shall not be considered a warranty or quality specification of any type. The information provided relates only to the specific material identified at the top of this SDS and may not be valid when the SDS material is used in combination with any other materials or in any process, unless specified in the text. Material users should review the information and recommendations in the specific context of their intended manner of handling, use, processing and storage, including an assessment of the appropriateness of the SDS material in the user's end product, if applicable.

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Sub Section D99

ATEX Components Data Sheets

Ballard Power Systems Europe A/S
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	30/08/2024	First Issue
002	15/11/2024	Expanded following ATEX Register (K02-002)

Document Title:	**BLPH Project - ATEX Components Data Sheets**
Document Number:	K559-2254-CWIWP4202202-D99-001
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Code:	D99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	D99 – ATEX Components Data Sheets
Full Title	Data Sheets of equipment for hazardous area of 1MW hydrogen fuel cell container for Crosswind
Abstract	

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Revision Record

Rev #	Description	Revised By	Date [dd/mm/yyyy]
1.0	Initial Release	RBS	19/09/2024
2.0	Expanded following ATEX Register (K02-002)	RBS	15/11/2024

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1.0 Purpose

The purpose of this document is to provide the data sheets of the equipment for hazardous area of the 1MW fuel cell container (MEGABLOCK) provided by Ballard Power Systems Europe to CrossWind.

2.0 References

Table 1 – List of references.

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-K02-002	ATEX Register	Ballard

3.0 List of ATEX Equipment

The ATEX Register lists the following ATEX equipment as shown in the table below. For more details please refer to the ATEX Register.

Table 2 – List of ATEX equipment (extract from document K559-2254-CWIWP4202202-K02-002).

No.	Revision	Tag Number	Description	Location	Manufacturer	Model Type Catalogue Number	Serial Number	ATEX Certification Marking
1	04	BL01	Electronic level sensor; Operating voltage 18…30 DC V; ATEX; M12 Connector; Gold-plated contacts	=HA01+DA02 - H2 Supply System	IFM Electronic AS	LMT01A LMACE-A12E-QSKG-1/US/3D/3G	10000160523	II 3G Ex nA IIC T4 Gc
2	04	BL01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Black	=HA01+DA02 - H2 Supply System	IFM Electronic AS	EVC14A ADOGH040VAT0025H04/3G/2D	N/A	II 3G EX ec IIC Gc
3	04	BP01	Pressure Transducer, 0-10 barg, 4-20mA, ATEX, -25 to 85°C Ta, M12 Connector, 10..30 VDC, 2-wire, G1/2 Process Connection, FPM Seal	=HA01+DA02 - H2 Supply System	HUBA Controls AG	Pressure Transducer 520 Series	N/A	Ex II 1/2G Ex ia IIC T4 Ga/Gb
4	04	BP01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	II 2G Ex ia IIC T6 Gb
5	04	TF01	BP01 - Pressure Sensor – Ex Barrier (9113B-U9)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U9	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA
6	04	BT01	Temperature sensor: liquids and gases Connection: stainless steel (1.4404 / 316L) Ambient temperature: -25…80 °C	=HA01+DA02 - H2 Supply System	IFM Electronic AS	TT1050 TT-100KBBD10-...../US/	100000113592	N/A
7	04	BT02-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	Ex ia IIC T6 Gb
8	04	TF01	BT01 - Temperature Sensor – Ex Barrier (9113B-U9)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U8	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA
9	04	EA01	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-1	Ex d IIC T4 Gb
10	04	EA01-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 135 CH	N/A	N/A
11	04	EA01	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB
12	04	EA02	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-2	Ex d IIC T4 Gb
13	04	EA02-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 135 CH	N/A	N/A
14	04	EA02	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB
15	04	QM1.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb
16	04	QM1.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
17	04	QM1.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
18	04	QM2.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
19	04	QM2.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
20	04	QM2.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
21	04	QM1.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb
22	04	QM1.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
23	04	QM1.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
24	04	QM2.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
25	04	QM2.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
26	04	QM2.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
27	04	QM1.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb
28	04	QM1.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
29	04	QM1.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
30	04	QM2.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
31	04	QM2.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
32	04	QM2.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
33	04	QM1.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
34	04	QM1.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
35	04	QM1.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
36	04	QM2.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
37	04	QM2.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
38	04	QM2.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
39	04	QM1.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
40	04	QM1.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
41	04	QM1.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
42	04	QM2.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
43	04	QM2.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
44	04	QM2.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
45	04	QM1.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
46	04	QM1.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
47	04	QM1.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
48	04	QM2.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
49	04	QM2.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
50	04	QM2.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
51	04	XT01	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
52	04	XT02	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
53	04	XT03	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
54	04	XT04	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
55	04	XT05	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
56	04	XT06	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
57	04	XT07	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Non EX Box	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
58	04	XT07	M32 to M20 Ex Reducer	=HA01+DA02 - Non EX Box	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
59	04	XT08	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
60	04	XT08	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
61	04	XT09	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
62	04	XT09	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
63	04	XT10	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
64	04	XT10	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
65	04	XT11	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
66	04	XT11	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb

4.0 Equipment Data Sheets

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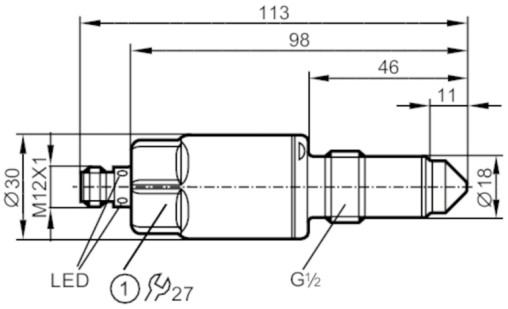
4.1 BL01 – Electronic Level Sensor, LMT01A

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LMT01A

Sensor for point level detection in hazardous areas

LMACE-A12E-QSKG-1/US/3D/3G



1 Tightening torque 20...25 Nm

CE EC 1935/2004 EHEDG Certified Ex FDA IO-Link UKCA

Product characteristics		
Number of inputs and outputs		Number of digital outputs: 2
Factory setting		oils; oil-based media; powder
Process connection		threaded connection G 1/2 sealing cone
Application		
Special feature		Gold-plated contacts
Media		Liquids; viscous media; powder
Cannot be used for		See the operating instructions, chapter "Function and features".
Medium temperature	[°C]	-20...85
Probe length	[mm]	11
Tank pressure	[bar]	-1...40
Electrical data		
Operating voltage	[V]	18...30 DC
Current consumption	[mA]	< 50
Protection class		III
Reverse polarity protection		yes
Measuring principle		capacitive
Inputs / outputs		
Number of inputs and outputs		Number of digital outputs: 2
Outputs		
Total number of outputs		2
Output signal		switching signal; IO-Link
Electrical design		PNP/NPN
Number of digital outputs		2
Output function		normally open / normally closed; (parameterisable)
Max. voltage drop switching output DC	[V]	2.5
Permanent current rating of switching output DC	[mA]	100

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LMT01A

Sensor for point level detection in hazardous areas

LMACE-A12E-QSKG-1/US/3D/3G

Short-circuit protection		yes	
Type of short-circuit protection		pulsed	
Overload protection		yes	
Measuring/setting range			
Factory setting		oils; oil-based media; powder	
Response times			
Response time	[s]	< 0.5	
Interfaces			
Communication interface		IO-Link	
Transmission type		COM2 (38,4 kBaud)	
IO-Link revision		1.1	
SDCI standard		IEC 61131-9	
Profiles		Smart Sensor: Process Data Variable; Device Identification	
SIO mode		yes	
Required master port type		A	
Process data analogue		1	
Process data binary		2	
Min. process cycle time	[ms]	2.3	
Supported DeviceIDs		**Type of operation**	**DeviceID**
		default	305
Operating conditions			
Ambient temperature	[°C]	-20...60	
Storage temperature	[°C]	-40...85	
Protection		IP 67; (when used outside the hazardous area: IP 68 / IP 69)	
Tests / approvals			
ATEX marking		II 3D Ex tc IIIC T90°C Dc X	
		II 3G Ex nA IIC T4 Gc X	
EMC		DIN EN 61000-6-2	
		DIN EN 61000-6-4	open tanks
		DIN EN 61000-6-3	closed tanks
Shock resistance		DIN EN 68000-2-27	50 g (11 ms)
Vibration resistance		DIN EN 68000-2-6	20 g (10...2000 Hz)
MTTF	[years]	223	
Mechanical data			
Weight	[g]	218	
Dimensions	[mm]	Ø 30 / L = 113	
Materials		stainless steel (316L/1.4404); PEEK; PEI; FKM	
Materials (wetted parts)		PEEK; surface characteristics: Ra < 0,8 / Rz 4	
Process connection		threaded connection G 1/2 sealing cone	
Displays / operating elements			
Display		switching status	LED, yellow
		operating status	LED, green

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LMT01A

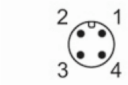
Sensor for point level detection in hazardous areas

LMACE-A12E-QSKG-1/US/3D/3G

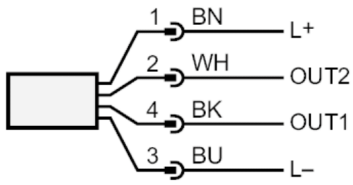
Remarks	
Pack quantity	1 pcs.

Electrical connection

Connector: 1 x M12; coding: A; Contacts: gold-plated



Connection



OUT1:	switching output IO-Link Teach
OUT2:	switching output
	colours to DIN EN 60947-5-2
	Core colours :
BK =	black
BN =	brown
BU =	blue
WH =	white

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4.2 BL01-WG01 – Connecting Cable with Socket for Level Sensor, EVC14A

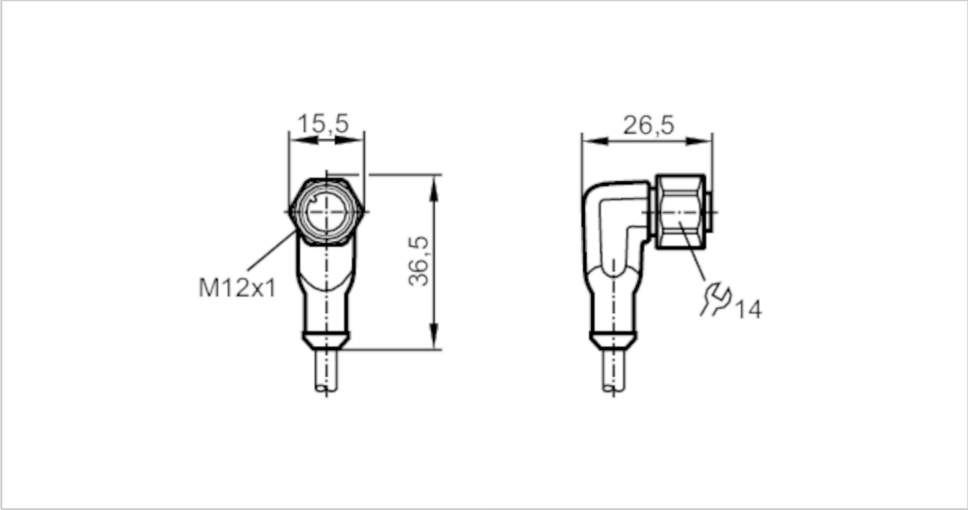
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EVC14A

Forbindelseskabel med hunstik

ADOAH040VAT0025H04/3G/2D



Applikation		
Special funktion		Halogenfri; guldbelagte kontakter
Kompatibel med maling		ja
Elektriske Data		
Driftspænding	[V]	< 60 AC/DC
Kapslingsklasse		II
Max strømbelastning total	[A]	2
Omgivende forhold		
Omgivelsestemperatur	[°C]	-20...60
Kapslingsklasse		IP 67; (ved brug udenfor ATEX området: IP 68 / IP 69K)
Godkendelser / Tests		
Godkendelse		BVS 08 ATEX E 109 U; IECEx BVS 08.0041 U
ATEX mærkning		II 3G Ex ec IIC Gc; II 2D Ex tb IIIC Db IP65/IP67
Mekaniske data		
Vægt	[g]	833
Dimensioner	[mm]	26,5 x 15,5 x 36,5
Materiale		Kapsling: TPU orange; pakning: FKM
Materiale - omløber		rustfri stål (1.4404 / 316L)
Bemærkning		
Emballage-enheder		1 stk.

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EVC14A

Forbindelseskabel med hunstik

ADOAH040VAT0025H04/3G/2D

Elektrisk tilslutning

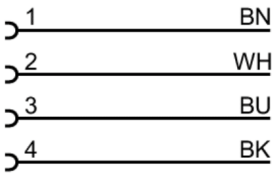
Kabel: 25 m, PUR, Halogenfri, sort, Ø 4,9 mm; 4 x 0,34 mm² (42 x Ø 0,1 mm)

Elektrisk tilslutning - Hunstik

Stik: 1 x M12, vinklet; kodning: A; Låsning: rustfri stål (1.4404 / 316L); Kontakter: guldbelagt; tilspændingsmoment: 1,2...1,5 Nm



Tilslutning



	Ledningsfarver :
BK =	sort
BN =	brun
BU =	blå
WH =	hvid

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4.3 BP01 – Pressure Sensor, 520 Series

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Huba Control

Relative pressure transmitter
Type 520

The compact type 520 pressure transmitter is based upon the Huba Control developed thick film technology where the pressure measuring cell is fully welded.
This transmitter meets the high burst protection demands and is suitable for the use in all types of refrigerants including ammonia.

Pressure range
-1 ... 9 bar /
0 ... 2.5 – 1000 bar

+ Compact, rugged construction
+ Welded without sealing parts, no elastomer seals
+ Large selection of connections available.
+ Saving time by quick cable mounting by the customer with swift connector

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Technical overview

Pressure range

Relative	-1 ... 9 bar / 0 ... 2.5 – 1000 bar

Operating conditions

Medium	Liquids, gases and refrigerants (incl. ammonia)	
Temperature	Medium -40 ... +135 °C	(Ex) -30 ... +120 °C)
	Ambient -30 ... +85 °C	(Ex) -25 ... +85 °C)
	Storage -50 ... +100 °C	
Tolerable overload	≤ 6 bar 5 x fs	
	> 6 bar 3 x fs (max. 1500 bar)	
Rupture pressure	≤ 6 bar 10 x fs	
	> 6 bar 6 x fs (max. 2500 bar)	

Materials

Cover		Stainless steel 1.4404 / AISI 316L (inside thread Schrader 1.4305 / AISI 303 only)
Plug accommodation		Polyarylamide 50% GF UL 94 V-0
Materials in contact with medium	Pressure connection	Stainless steel 1.4404 / AISI 316L (inside thread Schrader 1.4305 / AISI 303 only)
	Sensor	Stainless steel

Electrical overview

		Output	Power supply	Load	Current consumption
2 wire		4 ... 20 mA	7 ... 33 VDC	$< \frac{\text{supply voltage} - 7\,V}{0.02\,A}$ [Ohm]	< 23 mA
	(Ex)	4 ... 20 mA	10 ... 30 VDC	$< \frac{\text{supply voltage} - 10\,V}{0.02\,A}$ [Ohm]	< 23 mA
3 wire		0 ... 5 V	7 ... 33 VDC	>10 kOhm / < 100 nF	< 7 mA
		1 ... 6 V	8 ... 33 VDC	>10 kOhm / < 100 nF	< 7 mA
		0 ... 10 V	12 ... 33 VDC	>10 kOhm / < 100 nF	< 7 mA
		0 ... 10 V	12 ... 33 VDC / 24 VAC ± 15%	>10 kOhm / < 100 nF	< 7 mA
		ratiom. 10 ... 90%	5 VDC ± 10%	>10 kOhm / < 100 nF	< 7 mA
	(Ex)	ratiom. 10 ... 90%	5 VDC ± 10%	>10 kOhm / < 100 nF	< 7 mA
Polarity reversal protection		Short circuit proof and protected against polarity reversal. Each connection is protected against crossover up to max. supply voltage.			
Insulation voltage				standard	500 VDC

Dynamic response

Response time	< 2 ms, 1 ms typ.
Load cycle	< 100 Hz

Electrical connection	**Protection standard**	**Protection class**
Swift connector with or without cable 1.5 / 2.0 / 3.0 / 5.0 m (PVC spec.)	IP 67	III
Connector DIN EN 175301-803-A or C (industrial standard 9.4 mm)	IP 65	III
Metri Pack Serie 150	IP 67	III
Connector M12x1	IP 67	III
Braids	IP 65	III
Connector RAST 2.5 (3 wire, only)	IP 00	III

Pressure connection

Inside thread	7/16 - 20 UNF	without or with Schrader
	½ -14 NPT	(≤ 60 bar)
	G ¼	with O-Ring seal FPM (-30 ... +135 °C)
Outside thread	7/16 - 20 UNF	sealing cone 45°
	¼ -18 NPT	
	7/16 - 20 UNF	sealed at back SAE 4 with O-Ring seal FPM (-20 ... +135 °C)
	G ¼	sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM (-30 ... +135 °C)
	G ¼	sealed at back and manometer (combi) with profile seal ring in FPM (-30 ... +135 °C) (≤ 60 bar)
	R ¼	EN 10226
	G ½	sealed at back and manometer (combi) with profile seal ring in FPM (-30 ... +135 °C)
	⅛ - 27 NPT	(≤ 60 bar)
	G ⅛	sealed at front (≤ 60 bar)
	G ⅛	sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM (-30 ... +135 °C) (> 60 bar - without ATEX certificate)
	M10x1	sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM (-30 ... +135 °C) (≤ 60 bar)
	M20x1.5	sealed at front and manometer (combi)
	G ½, G ¼	sealed at front

Installation arrangement

Unrestricted

Tests / Admissions

Electromagnetic compatibility	CE conformity acc. EN 61326-2-3
Enhanced EMC protection	EN 50121-3-2
Shock acc. IEC 68-2-27	100 g, 11 ms half sine wave, all 6 directions, free fall from 1 m on concrete (6x)
Constant shock acc. IEC 68-2-29	40 g for 6 ms, 1000x all 3 directions
Vibration acc. IEC 68-2-6	20 g, 15 ... 2000 Hz, 15 ... 25 Hz with amplitude ± 15 mm, 1 Octave/min. all 3 directions, 50 constant load
UL	ANSI/UL 61010-1 acc. E325110
Drinking water approval	NSF/ANSI 61/372 acc. MH60087
	WRAS
EAC	

Protection against explosion (Ex)	**ratiom. 10 ... 90%**	**4 ... 20 mA**
Intrinsic safety «i»	Ex II 1/2 G Ex ia IIC T4 Ga/Gb	Ex II 1/2 G Ex ia IIC T4 Ga/Gb
	Ex II 1/2 D Ex ia IIIC T125°C Da/Db	Ex II 1/2 D Ex ia IIIC T125°C Da/Db
EC type examination certificate	SEV 15 ATEX 0173	SEV 10 ATEX 0145
Connection to certified intrinsically safe resistive circuits with maximum values	Ui ≤ 15 VDC; Ii ≤ 200 mA; Pi ≤ 750 mW	Ui ≤ 30 VDC; Ii ≤ 100 mA; Pi ≤ 750 mW
Effective internal inductance and capacitance for versions with plugs complying with EN 175301-803-A or M12x1	Li = 0 nH; Ci ≤ 150 nF	Li = 0 nH; Ci = 0 nF
IECEx		SEV 16.0007

Weight

~ 90 g

Packaging (Please state on order)

Single packaging in cardboard	accessories integrated
Multiple packaging in cardboard (25 pcs)	

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TEMPLATE FRM5100236 0H

Ballard Confidential

Printed on: Friday, November 15, 2024

Accuracy

Parameter		Unit	
Characteristic line a [1]		% fs	± 0.3
Resolution		% fs	0.1
Thermal characteristic [2]	max.	% fs/10K	± 0.2
Long term stability acc. EN 60770-1	max.	% fs	± 0.25

Test conditions: 25 °C, 45% RH, power supply 24 VDC

Order code selection table in bar

			520.	1 X	2 X	3 X	4 X	5 X	6 X	7 X	8 X	9 X	10 X	11 X
Pressure range [3]	-1 ... 9 bar			9	0	6								
	0 ... 2.5 bar			9	1	4								
	0 ... 4 bar			9	1	5								
	0 ... 6 bar			9	1	7								
	0 ... 10 bar			9	3	0								
	0 ... 16 bar			9	3	1								
	0 ... 25 bar			9	3	2								
	0 ... 40 bar			9	3	3								
	0 ... 60 bar			9	4	0								
	0 ... 100 bar			9	4	1								
	0 ... 160 bar			9	4	2								
	0 ... 250 bar			9	4	3								
	0 ... 400 bar			9	5	4								
	0 ... 600 bar			9	5	5								
	0 ... 1000 bar			9	5	7								
Application	standard						S	0						
	for oxygen applications						S	1				0		
	with drinking water approval NSF/ANSI 61/372, WRAS						S	4				0	1	
Output / power supply	0 ... 5 V	7 ... 33 VDC							1					
	1 ... 6 V	8 ... 33 VDC							6					
	0 ... 10 V	12 ... 33 VDC							2					
		12 ... 33 VDC Enhanced EMC protection							C	1,2,3				
		12 ... 33 VDC / 24 VAC ±15% *(not possible with M12x1, metri Pack, RAST, braids)*							8					
	ratiom. 10 ... 90%	5 VDC ±10%							7					
		5 VDC ±10% Ex protection						0,4	9	1,3			1	
	4 ... 20 mA	7 ... 33 VDC							3					
		7 ... 33 VDC Enhanced EMC protection *(not possible with Braids)*							A					
		10 ... 30 VDC Ex protection						0,4	4	1,3			1	
Electrical connection	Connector [4]	DIN EN 175301-803-A								1				
		DIN EN 175301-803-C (industrial standard 9.4 mm)								2				
		M12x1 *2w: IN=1 / OUT=3 3w: IN=1 / OUT=4 / GND=3*								3				
		M12x1 *2w: IN=1 / OUT=4 3w: IN=1 / OUT=3 / GND=4*								M				
		M12x1 *2w: IN=1 / OUT=2 3w: IN=1 / OUT=2 / GND=3*								P				
		RAST 2.5						0,4	7	4				
		Metri Pack Serie 150						0,4		5				
	Braids	80 ±10 mm						0,4		6				
		290 ±10 mm						0,4		7				
		480 ±10 mm						0,4		8				
		730 ±10 mm						0,4		9				
	Swift connector	without cable								0				
		with cable 1.5 m								L				
		with cable 2.0 m								N				
		with cable 3.0 m								Q				
		with cable 5.0 m								R				
Pressure connection [2]	Inside thread	7/16"-20 UNF sealing cone with schrader						0,4			0	0	N	
		7/16"-20 UNF sealing cone									K		1	
		½ -14 NPT [5]									D		1	
		G ¼ with O-Ring seal FPM									1		1	
	Outside thread	7/16"-20 UNF sealing cone									2		1	
		¼ -18 NPT									3		1	
		G ¼ sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM									4		1	
		G ¼ sealed at back and manometer with profile seal ring in FPM									5	0	1	
		R ¼ acc. to EN 10226									7		1	
		G ½ sealed at back and manometer with profile seal ring in FPM						0,1			8		1	
		7/16"-20 UNF sealed at back SAE 4 with O-Ring seal FPM						0,1			G		1	
		⅛ - 27 NPT [5]									A		1	
		G ⅛ sealed at front [3]									M		1	
		G ⅛ sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM [6]						0,1			H		1	
		M10x1 sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM [5]						0,1			F		1	
		M20x1.5 sealed at front and manometer (combi)									E		1	
		G ¼ sealed at front									J		1	
		G ½ sealed at front									9		1	
Pressure orifice	without (inclusive pressure tip orifice from 100 bar on)											0		
	with											2		
Material pressure connection	Stainless steel 1.4305 / AISI 303												N	
	Stainless steel 1.4404 / AISI 316L												1	
Pressure range variation (optional)	Indicate W and state range on order (e.g.: W0... + 3bar/OUT0...5V)													W

[1] typ. ; max. 0.5% fs (incl. zero point, full scale, linearity, hysteresis and repeatability) [2] -15 ... 85 °C [3] Other pressure ranges or pressure connections on request
[4] Delivery without female connector [5] Pressure range ≤ 60 bar [6] Pressure range ≤ 250 bar (max. rupture pressure 1000 bar)

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Order code selection table in psi			520.	1 X	2 X	3 X	4 X	5 X	6 X	7 X	8 X	9 X	10 X	11 X
Pressure range [1]	-15 ... 130 psi			9	A	6								
	0 ... 30 psi			9	B	4								
	0 ... 60 psi			9	B	5								
	0 ... 100 psi			9	B	7								
	0 ... 200 psi			9	C	1								
	0 ... 300 psi			9	C	2								
	0 ... 500 psi			9	C	3								
	0 ... 750 psi			9	D	0								
	0 ... 1000 psi			9	D	1								
	0 ... 2000 psi			9	D	2								
	0 ... 3000 psi			9	D	3								
	0 ... 5000 psi			9	E	4								
	0 ... 7500 psi			9	E	5								
	0 ... 14500 psi			9	E	7								
Application	standard						S	0						
	for oxygen applications						S	1				0		
	with drinking water approval NSF/ANSI 61/372, WRAS						S	4				0	1	
Output / power supply	0 ... 5 V	7 ... 33 VDC							1					
	1 ... 6 V	8 ... 33 VDC							6					
	0 ... 10 V	12 ... 33 VDC							2					
		12 ... 33 VDC Enhanced EMC protection							C	1,2,3				
		12 ... 33 VDC / 24 VAC ±15% *(not possible with M12x1, metri pack, RAST, braids)*							8					
	ratiom. 10 ... 90%	5 VDC ±10%							7					
		5 VDC ±10% Ex protection						0,4	9	1,3			1	
	4 ... 20 mA	7 ... 33 VDC							3					
		7 ... 33 VDC Enhanced EMC protection *(not possible with Braids)*							A					
		10 ... 30 VDC Ex protection						0,4	4	1,3			1	
Electrical connection	Connector [2]	DIN EN 175301-803-A								1				
		DIN EN 175301-803-C (industrial standard 9.4 mm)								2				
		M12x1 *2w: IN=1 / OUT=3 3w: IN=1 / OUT=4 / GND=3*								3				
		M12x1 *2w: IN=1 / OUT=4 3w: IN=1 / OUT=3 / GND=4*								M				
		M12x1 *2w: IN=1 / OUT=2 3w: IN=1 / OUT=2 / GND=3*								P				
		RAST 2.5						0,4	7	4				
		Metri Pack Serie 150						0,4		5				
	Braids	80 ±10 mm						0,4		6				
		290 ±10 mm						0,4		7				
		480 ±10 mm						0,4		8				
		730 ±10 mm						0,4		9				
	Swift connector	without cable								0				
		with cable 1.5 m								L				
		with cable 2.0 m								N				
		with cable 3.0 m								Q				
		with cable 5.0 m								R				
Pressure connection [1]	Inside thread	7/16-20 UNF sealing cone with schrader						0,4			0	0	N	
		7/16-20 UNF sealing cone									K		1	
		½ -14 NPT [3]									D		1	
		G ¼ with O-Ring seal FPM									1		1	
	Outside thread	7/16-20 UNF sealing cone									2		1	
		¼ -18 NPT									3		1	
		G ¼ sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM									4		1	
		G ¼ sealed at back and manometer with profile seal ring in FPM									5	0	1	
		R ¼ acc. to EN 10226									7		1	
		G ½ sealed at back and manometer with profile seal ring in FPM						0,1			8		1	
		7/16-20 UNF sealed at back SAE 4 with O-Ring seal FPM						0,1			G		1	
		⅛ - 27 NPT [3]									A		1	
		G ⅛ sealed at front [3]									M		1	
		G ⅛ sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM [4]						0,1			H		1	
		M10x1 sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM [3]						0,1			F		1	
		M20x1.5 sealed at front and manometer (combi)									E		1	
		G ¼ sealed at front									J		1	
		G ½ sealed at front									9		1	
Pressure orifice	without (inclusive pressure tip orifice from 2000 psi on)											0		
	with											2		
Material pressure connection	Stainless steel 1.4305 / AISI 303												N	
	Stainless steel 1.4404 / AISI 316L												1	
Pressure range variation (optional)	Indicate W and state range on order (e.g.: W0... + 400psi/OUT0...5V)													W

[1] Other pressure ranges or pressure connections on request
[2] Delivery without female connector
[3] Pressure range ≤ 870 psi
[4] Pressure range ≤ 3000 psi (max. rupture pressure 14500 bar)

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Order code selection table in MPa			520.	1 X	2 X	3 X	4 X	5 X	6 X	7 X	8 X	9 X	10 X	11 X
Pressure range [1]	-0.1 ... 0.9 MPa			9	F	6								
	0 ... 0.25 MPa			9	G	4								
	0 ... 0.4 MPa			9	G	5								
	0 ... 0.6 MPa			9	G	7								
	0 ... 1 MPa			9	H	0								
	0 ... 1.6 MPa			9	H	1								
	0 ... 2.5 MPa			9	H	2								
	0 ... 4 MPa			9	H	3								
	0 ... 6 MPa			9	K	0								
	0 ... 10 MPa			9	K	1								
	0 ... 16 MPa			9	K	2								
	0 ... 25 MPa			9	K	3								
	0 ... 40 MPa			9	L	4								
	0 ... 60 MPa			9	L	5								
	0 ... 100 MPa			9	L	7								
Application	standard						S	0						
	for oxygen applications						S	1				0		
	with drinking water approval NSF/ANSI 61/372, WRAS						S	4				0	1	
Output / power supply	0 ... 5 V	7 ... 33 VDC							1					
	1 ... 6 V	8 ... 33 VDC							6					
	0 ... 10 V	12 ... 33 VDC							2					
		12 ... 33 VDC Enhanced EMC protection							C	1,2,3				
		12 ... 33 VDC / 24 VAC ±15% *(not possible with M12x1, metri Pack, RAST, braids)*							8					
	ratiom. 10 ... 90%	5 VDC ±10%							7					
		5 VDC ±10% Ex protection						0,4	9	1,3				
	4 ... 20 mA	7 ... 33 VDC							3					
		7 ... 33 VDC Enhanced EMC protection *(not possible with Braids)*							A					
		10 ... 30 VDC Ex protection						0,4	4	1,3				
Electrical connection	Connector [2]	DIN EN 175301-803-A								1				
		DIN EN 175301-803-C *(industrial standard 9.4 mm)*								2				
		M12x1 *2w: IN=1 / OUT=3 3w: IN=1 / OUT=4 / GND=3*								3				
		M12x1 *2w: IN=1 / OUT=4 3w: IN=1 / OUT=3 / GND=4*								M				
		M12x1 *2w: IN=1 / OUT=2 3w: IN=1 / OUT=2 / GND=3*								P				
		RAST 2.5						0,4	7	4				
		Metri Pack Serie 150						0,4		5				
	Braids	80 ±10 mm						0,4		6				
		290 ±10 mm						0,4		7				
		480 ±10 mm						0,4		8				
		730 ±10 mm						0,4		9				
	Swift connector	without cable								0				
		with cable 1.5 m								L				
		with cable 2.0 m								N				
		with cable 3.0 m								Q				
		with cable 5.0 m								R				
Pressure connection [1]	Inside thread	7/16-20 UNF sealing cone with schrader						0,4			0	0	N	
		7/16-20 UNF sealing cone									K		1	
		½ -14 NPT [3]									D		1	
		G ¼ with O-Ring seal FPM									1		1	
	Outside thread	7/16-20 UNF sealing cone									2		1	
		¼ -18 NPT									3		1	
		G ¼ sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM									4		1	
		G ¼ sealed at back and manometer with profile seal ring in FPM									5	0	1	
		R ¼ acc. to EN 10226									7		1	
		G ½ sealed at back and manometer with profile seal ring in FPM						0,1			8		1	
		7/16-20 UNF sealed at back SAE 4 with O-Ring seal FPM						0,1			G		1	
		⅛ - 27 NPT [3]									A		1	
		G ⅛ sealed at front [3]									M		1	
		G ⅛ sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM [4]						0,1			H		1	
		M10x1 sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM [3]						0,1			F		1	
		M20x1.5 sealed at front and manometer (combi)									E		1	
		G ¼ sealed at front									J		1	
		G ½ sealed at front									9		1	
Pressure orifice	without (inclusive pressure tip orifice from 10 MPa on)											0		
	with											2		
Material pressure connection	Stainless steel 1.4305 / AISI 303												N	
	Stainless steel 1.4404 / AISI 316L												1	
Pressure range variation (optional)	Indicate W and state range on order (e.g.: W0... + 0.3MPa/OUT0...5V)													W

[1] Other pressure ranges or pressure connections on request
[2] Delivery without female connector
[3] Pressure range ≤ 6 MPa
[4] Pressure range ≤ 25 MPa (max. rupture pressure 100 MPa)

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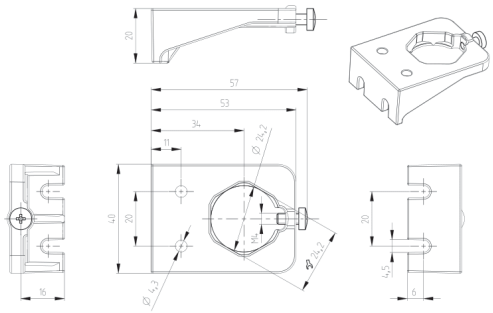
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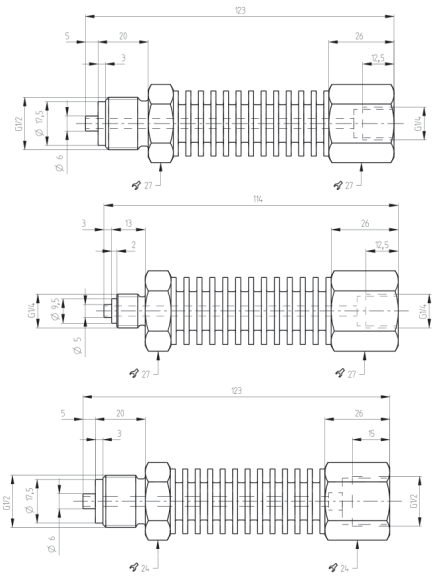
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Accessories *(supplied loose)*	Order number
Swift connector	117312
Female connector DIN EN 175301-803-A with seal	103510
Female connector DIN EN 175301-803-C with seal	104244
Corner-wire box for connector M12x1	106975
Corner-wire box for connector M12x1 with cable 2.0 m	114604
Straight-wire box for connector M12x1	114570
Straight-wire box for connector M12x1 with cable 2.0 m	114605
Mounting bracket with screw	118716
Heat sink with outside thread G ½ sealed at front - inside thread G ½	105631
Heat sink with outside thread G ½ sealed at front - inside thread G ¼	105073
Heat sink with outside thread G ¼ sealed at front - inside thread G ¼	105074
Calibration certificate (≤ 600 bar)	104551

Mounting bracket



Heat sink



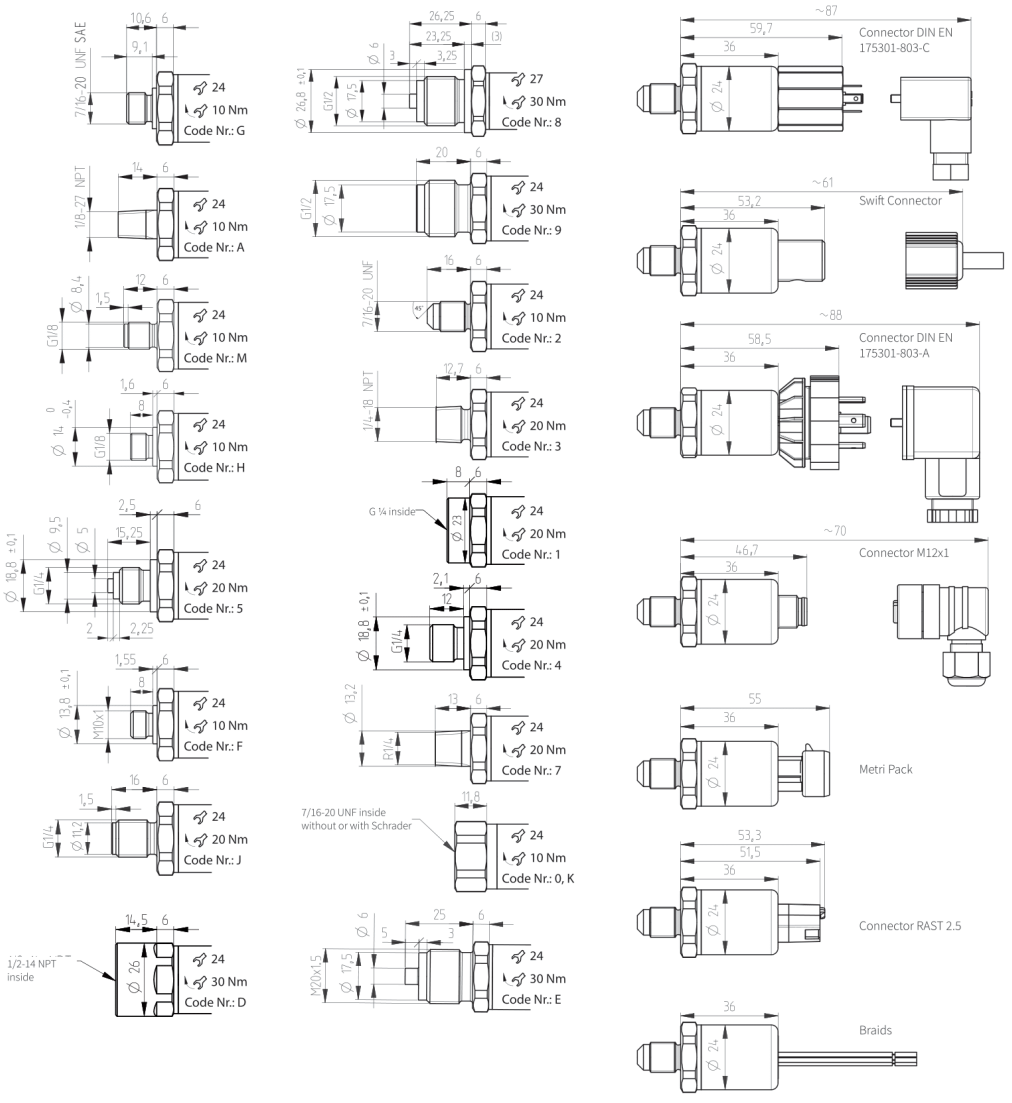
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Dimensions in mm



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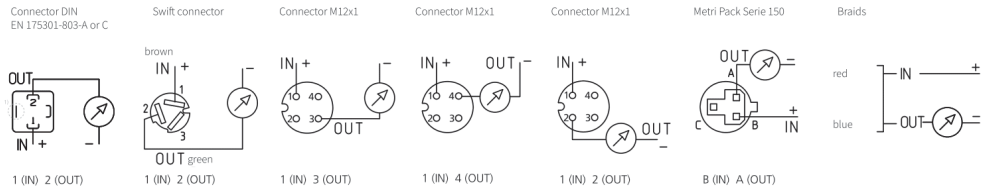
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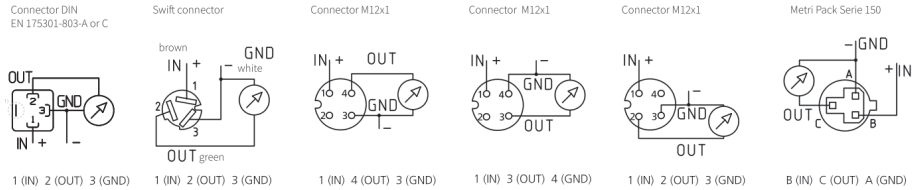
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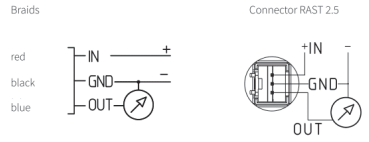
Electrical connections

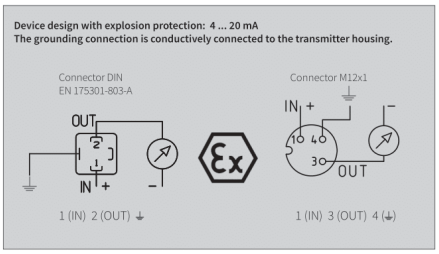
2 wire

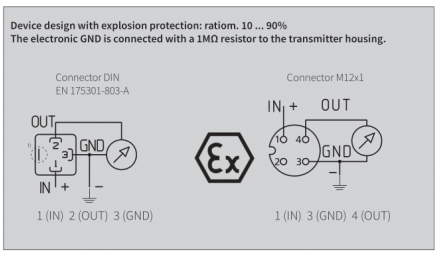


3 wire









[1] Not connected with transmitter housing

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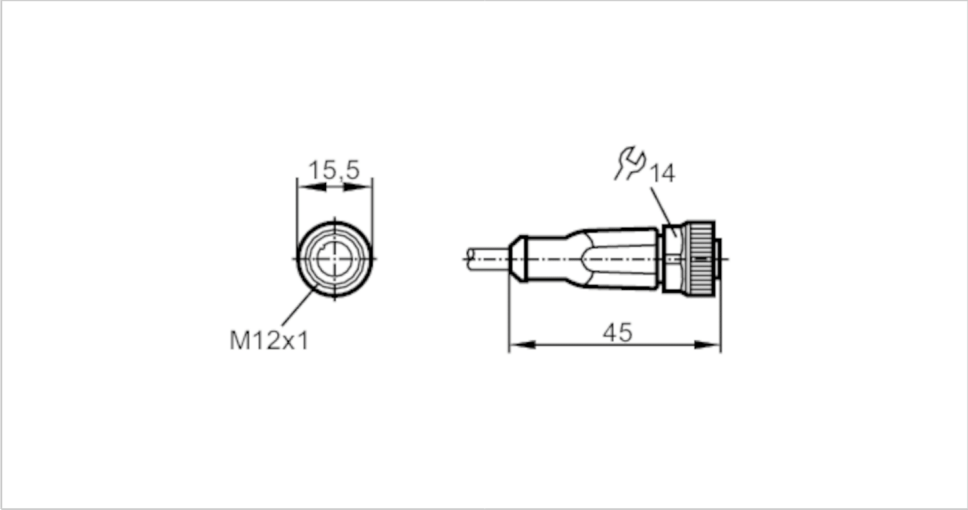
4.4 BP01-WG01 – Connecting Cable with Socket for Pressure Sensor, ENC03A

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ENC03A

Female cordset

ADOGH040MSN0010H04/1G/1D



Application		
System		Free from silicone; Halogen-free; gold-plated contacts
Free from silicone		yes
Compatible with paint		yes
Electrical data		
Operating voltage	[V]	< 30 DC
Protection class		II
Max. input power	[mW]	group II: 1000; group III: 1000
Max. current load total	[A]	1
Operating conditions		
Ambient temperature	[°C]	-25...85
Note on ambient temperature		for use in hazardous areas: ambient temperature according to unit marking
Protection		IP 67; (when used outside the hazardous area: IP 68 / IP 69K)
Tests / approvals		
Approval		BVS 11 ATEX E 009 X; IECEx BVS 11.0002 X
ATEX marking		II 1G Ex ia IIB T6 Ga Ta: -25...75°C
		II 2G Ex ia IIC T6 Gb Ta: -25...75°C
		II 1G Ex ia IIB T5 Ga Ta: -25...85°C
		II 2G Ex ia IIC T5 Gb Ta: -25...85°C
		II 1D Ex ia IIIB T200 85°C Da Ta: -25...75°C
		II 1D Ex ia IIIB T200 95°C Da Ta: -25...85°C
		II 1D Ex ia IIIC T200 70°C Da Ta: -20...60°C

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ENC03A

Female cordset

ADOGH040MSN0010H04/1G/1D

Safety classification		
Max. internal capacitance	[nF]	1
Max. internal inductance	[µH]	20
Mechanical data		
Weight	[g]	351.7
Dimensions	[mm]	15.5 x 15.5 x 45
Material		housing: TPU (urethane) orange; sealing: FKM
Material nut		brass, nickel-plated
Remarks		
Remarks		Special conditions for safe operation apply for use in hazardous areas. Observe the corresponding notes in the operating instructions (Ex protection related part).
Pack quantity		1 pcs.

Electrical connection

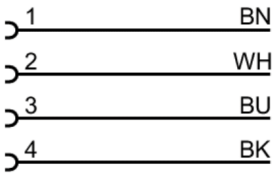
Cable: 10 m, PUR, Halogen-free, blue, Ø 4.9 mm; 4 x 0.34 mm² (42 x Ø 0.1 mm)

Electrical connection - Socket

Connector: 1 x M12, straight; coding: A; Locking: brass, nickel-plated; Contacts: gold-plated; Tightening torque: 0.6...1.5 Nm



Connection



	Core colors :
BK =	black
BN =	brown
BU =	blue
WH =	white

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4.5 TF01 – Pressure Sensor Ex Barrier, 9113B-U9

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PR electronics

PERFORMANCE MADE SMARTER



Temperature / mA converter

9113B

- Input for RTD, TC and mA
- Active / passive mA output via the same two terminals
- 1 or 2 channels
- Can be supplied separately or installed on power rail, PR type 9400
- SIL 2-certified via Full Assessment

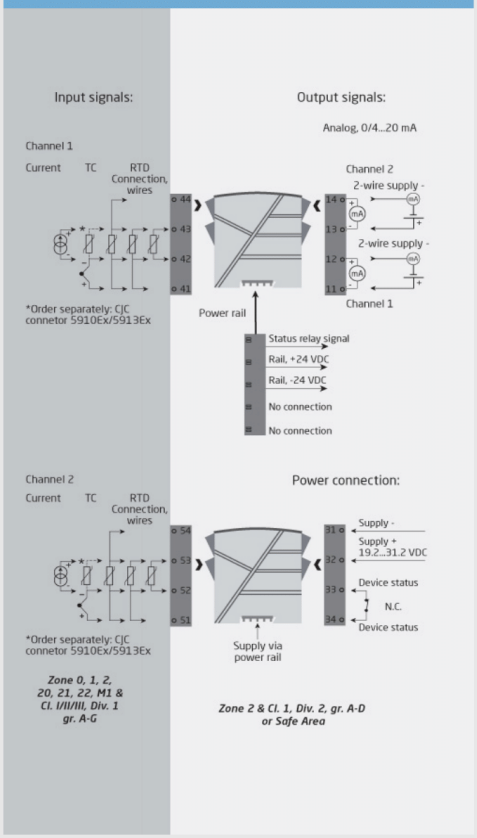
Advanced features
- Configuration and monitoring by way of detachable display front (PR 4500); process calibration and signal simulation.
- Copying of the configuration from one device to others of the same type via the display front.
- TC inputs can use either the internal CJC or a terminal with a built-in Pt100 sensor (PR 5910Ex, channel 1 / PR 5913Ex, channel 2) for higher accuracy.
- Advanced monitoring of internal communication and stored data.
- SIL 2 functionality is optional and must be activated in a menu point.

Application
- 9113Bxx can be mounted in the safe area or in zone 2 / Class 1, Division 2 and receive signals from zone 0, 1, 2 and zone 20, 21, 22 including mining / Class I/II/III, Division 1, Gr. A-G.
- Conversion and scaling of temperature (Pt, Ni and TC) and active current signals.
- The 9113 has been designed, developed and certified for use in SIL 2 applications according to the requirements of IEC 61508.
- Suitable for the use in systems up to Performance Level "d" according to ISO-13849.

Technical characteristics
- 1 green and 2 red front LEDs indicate operation status and malfunction.
- 2.6 kVAC galvanic isolation between input, output and supply.

Mounting
- The devices can be mounted vertically or horizontally without distance between neighbouring units.

Applications



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Order

Type	Channels	I.S. / Ex approvals
9113B	Single : A	ATEX, IECEx, FM, INMETRO, EAC-Ex, UKEX : -
	Double : B	UL 913, ATEX, IECEx, FM, INMETRO, EAC-Ex, UKEX : -U9
		KCs, ATEX, IECEx, FM, INMETRO, EAC-Ex, UKEX : -KCs

Example: 9113BB

Environmental Conditions

Operating temperature	-20°C to +60°C
Storage temperature	-20°C to +85°C
Calibration temperature	20...28°C
Relative humidity	< 95% RH (non-cond.)
Protection degree	IP20
Installation in	Pollution degree 2 & meas. / overvoltage cat. II

Mechanical specifications

Dimensions (HxWxD)	109 x 23.5 x 104 mm
Dimensions (HxWxD) w/ PR 4500	109 x 23.5 x 131 mm
Weight approx.	250 g
DIN rail type	DIN EN 60715/35 mm
Wire size	0.13...2.08 mm^2 AWG 26...14 stranded wire
Screw terminal torque	0.5 Nm
Vibration	IEC 60068-2-6
2...13.2 Hz	±1 mm
13.2...100 Hz	±0.7 g

Common specifications

Supply

Supply voltage	19.2...31.2 VDC
Fuse	400 mA SB / 250 VAC
Max. required power	≤ 0.8 W/≤ 1.4 W (1 ch./2 ch.)
Max. power dissipation, 1 / 2 ch.	≤ 0.8 W / ≤ 1.4 W

Isolation voltage

Test /working: Input to any	2.6 kVAC / 300 VAC reinforced isolation
Analog output to supply	2.6 kVAC / 300 VAC reinforced isolation
Status relay to supply	1.5 kVAC / 150 VAC reinforced isolation

Response time

Temperature input, programmable (0...90%, 100...10%)	1...60 s
mA / V input (programmable)	0.4...60 s
Programming	PR 4500 communication interfaces
Signal / noise ratio	Min. 60 dB (0...100 kHz)
Signal dynamics, input	24 bit
Signal dynamics, output	16 bit
Accuracy	Better than 0.1% of sel. range
EMC immunity influence	< ±0.5% of span
Extended EMC immunity: NAMUR NE21, A criterion, burst	< ±1% of span

Input specifications

RTD input

RTD type	Pt10/20/50/100/200/250; Pt300/Pt400/500/1000; Ni50/100/120/1000
Cable resistance per wire	50 Ω (max.)
Sensor current	Nom. 0.2 mA
Effect of sensor cable resistance (3-/4-wire)	< 0.002 Ω / Ω
Sensor error detection	Programmable ON / OFF

TC input

Thermocouple type	B, E, J, K, L, N, R, S, T, U, W3, W5, LR
Cold junction compensation (CJC) via ext. sensor in 5910	20...28°C ≤ ±1°C, -20...20°C / 28...70°C ≤ 2°C
CJC via int. mounted sensor	±(2.0°C + 0.4°C * Δt)
Sensor error detection	Programmable ON or OFF (only wire breakage)
Sensor error current: When detecting / else	Nom. 2 µA / 0 µA

Current input

Measurement range	0...23 mA
Programmable measurement ranges	0...20 and 4...20 mA
Input resistance	Nom. 20 Ω + PTC 50 Ω
Sensor error detection	Programmable ON / OFF

Output specifications

Current output

Signal range	0...23 mA
Programmable signal ranges	0...20/4...20/20...0/20...4 mA
Load (@ current output)	≤ 600 Ω
Load stability	≤ 0.01% of span / 100 Ω
Sensor error indication	0 / 3.5 / 23 mA / none
NAMUR NE43 Upscale/Downscale	23 mA / 3.5 mA
Output limitation, on 4...20 and 20...4 mA signals	3.8...20.5 mA
Output limitation, on 0...20 and 20...0 mA signals	0...20.5 mA
Current limit	≤ 28 mA

Passive 2-wire mA output

Max. external 2-wire supply	26 VDC
Effect of external 2-wire supply voltage variation	< 0.005% of span / V

Status relay

Max. voltage	125 VAC / 110 VDC
Max. current	0.5 AAC / 0.3 ADC
Max. AC power	62.5 VA / 32 W

Observed authority requirements

EMC	2014/30/EU & UK SI 2016/1091
LVD	2014/35/EU & UK SI 2016/1101
ATEX	2014/34/EU & UK SI 2016/1107
RoHS	2011/65/EU & UK SI 2012/3032
EAC	TR-CU 020/2011
EAC Ex	TR-CU 012/2011
EAC LVD	TR-CU 004/2011

9113B-080724

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Approvals

ATEX	KEMA 07ATEX0148 X
IECEx	KEM 09.0052X
UKEX	DEKRA 21UKEX0175X
UKEX	DEKRA 23UKEX0109X
c FM us	FM19US0059X / FM19CA0032X
INMETRO	DEKRA 23.0005X
c UL us, UL 61010-1	E314307
c UL us, UL 913	E233311 (only 9113xx-U9)
KCs	21_AV4BO_0173X / 21_AV4BO_0174X (only 9113Bx-KCs)
EAC Ex	RU C-DK.HA65.B.00355/19
DNV Marine	TAA00000JD
ClassNK	TA24034M
SIL	SIL 2 certified & fully assessed acc. to IEC 61508

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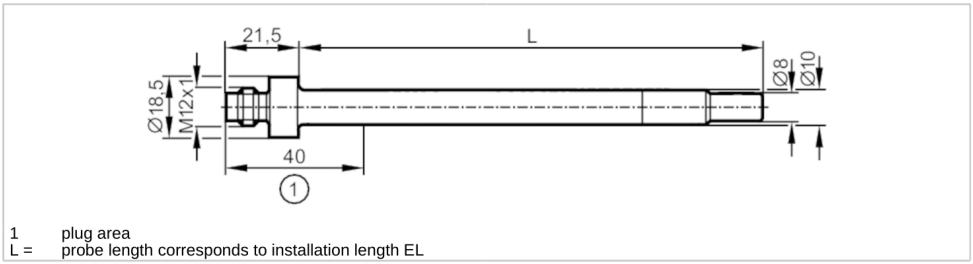
4.6 BT01 – Temperature Sensor, TT1050

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TT1050

Temperature probe sensor

TT-100KBBD10-...../US/



1 plug area
L = probe length corresponds to installation length EL

Product characteristics			
Measuring range		-40...150 °C	-40...302 °F
Process connection		Ø 10 mm	
Installation length EL	[mm]	160	
Application			
Special feature		Gold-plated contacts	
Measuring element		1 x Pt 1000; (to DIN EN 60751, class A)	
Media		liquids and gases	
Pressure rating	[bar]	160	
Minimum installation depth	[mm]	15	
Electrical data			
Protection class		III	
Measuring/setting range			
Probe length L	[mm]	160	
Measuring range		-40...150 °C	-40...302 °F
Accuracy / deviations			
Accuracy	[K]	± (0,15 K + 0,002 x|t|)	
Response times			
Dynamic response T05 / T09	[s]	1 / 3; (to DIN EN 60751)	
Operating conditions			
Ambient temperature	[°C]	-25...80	
Note on ambient temperature		plug area	
Storage temperature	[°C]	-40...100	
Protection		IP 68; IP 69K	
Tests / approvals			
Shock resistance		DIN EN 60068-2-27	50 g (11 ms)
Vibration resistance		DIN EN 60068-2-6	10 g (10...2000 Hz)
MTTF	[years]	22831	
Mechanical data			
Weight	[g]	54.3	
Dimensions	[mm]	Ø 10	
Materials		stainless steel (316L/1.4404)	

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TT1050

Temperature probe sensor

TT-100KBBD10-...../US/

Materials (wetted parts)		stainless steel (316L/1.4404)
Process connection		Ø 10 mm
Probe diameter	[mm]	10
Installation length EL	[mm]	160

Remarks

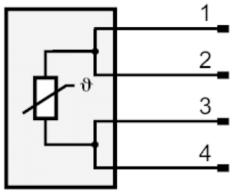
Remarks	The values for accuracy apply to flowing water.
Pack quantity	1 pcs.

Electrical connection

Connector: 1 x M12; coding: A; Contacts: gold-plated



Connection



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4.7 BT02-WG01 – Connecting Cable with Socket for Temperature Sensor, ENC03A

[Please refer to data sheet from Section 4.4.]

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4.8 TF01 – Temperature Sensor Ex Barrier, 9113B-U9

[Please refer to data sheet from Section 4.5.]

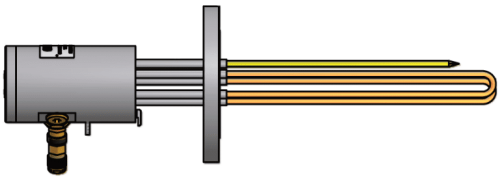
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4.9 EA01..02 – Immersion Heater, D-8640

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Explosion-proof Immersion Heater Type D-8640

Sinus Jevi has developed explosionproof Ex 'de' heating equipment, for hazardous area. The flame-proof (d) enclosures have been designed for non save areas to protect the environment against gas-explosions, caused by sparking by electrical connections of the heating elements and control devices.



SINUS JEVI

Liquids Gasses Solids Spaces Resistors

Sinus-Jevi Electric Heating B.V. Aambeeld 19 1671 NT Medemblik +31 (0) 227 549 100 www.sinusjevi.com

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Catalogue Immersion Heaters type D-8640

Gas and Dust flame-proof immersion heater type D-8640
For hazardous areas, Sinus Jevi has developed explosion-proof Ex 'de' heating equipment, designed and manufactured in accordance with EN-IEC 60079-0, EN-IEC 60079-1, EN 60079-7 and EN-IEC 60079-31 certified by the independent testing institute ISSeP. The certificates cover zone 1 and zone 2 for hazardous areas. Gas groups II A, II B and II C and temperature classes T6-T1. Dust group Ex tb zone 21.

The flame-proof (d) enclosures have been designed for non save areas to protect the environment against gas-explosions, caused by sparking by electrical connections of the heating elements and control devices. Several types of enclosures for immersion heaters, flanged or screwed, have been described on the next pages.
Each type covers a range of a maximum number of installed hairpin shaped heating elements and giving a range of installed capacities.

The screwed types for dimensions up to 3".
The terminal enclosures have a IP66 degree of protection.
Standard the enclosure is coated with two layers, a zinc silicate primer and a top coating. Other coatingsystems on request.

All heaters are standard internal wired on terminals.

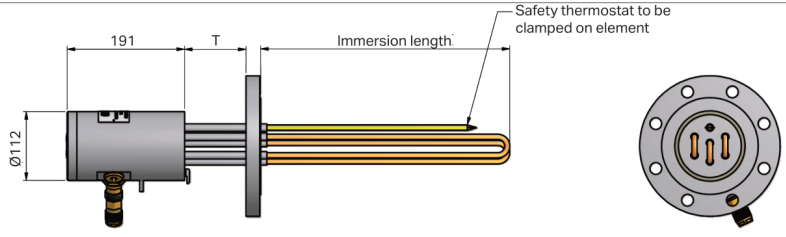
The maximum temperature for the terminal enclosure during operation is 80°C (based on maximum 50°C ambient temperature). If cable entry exceeds 70°C, high temperature cables must be used. The required minimum distance between enclosure and connection flange, to ensure the temperature limit of 80°C in the enclosure, is listed in the following table as a function of temperature classes. Maximum number of cable entries: 2 pcs M25/M20

Marking ATEX	Ex II 2 G D	
	Ex d IIC T6-T1 Gb	EN/IEC 60079-1
	Ex tb IIIC T110°C Db	EN/IEC 60079-31

Type D-8640 Ex II 2G D - Ex d IIC T6-T1 Gb - Ex tb IIIC T110°C Db

Type	Flange 150 LBS	Elements Ø8.5	Elements Ø10.2	Elements Ø12.7	Elements Ø16	Immersion length (mm)	Maximum capacity in oil (Watt)	Maximum capacity in water (Watt)	Maximum capacity in gases (Watt)
D-8640-D021-05	2"	Number of elements depend on diameter, pitch and material				500	1.000	3.000	800
D-8640-D021-07	2"					750	1.700	5.000	1.000
D-8640-D021-10	2"					1.000	2.300	7.000	2.000
D-8640-D021-15	2"					1.500	3.600	11.000	3.000
D-8640-D021-20	2"					2.000	4.900	12.000	4.000
D-8640-D021-25	2"					2.500	6.200	12.000	5.000
D-8640-D021-30	2"					3.000	7.500	12.000	6.000
D-8640-F031-05	3"					500	1.500	4.500	1.200
D-8640-F031-07	3"					750	2.500	7.000	2.000
D-8640-F031-10	3"					1.000	3.500	10.000	3.000
D-8640-F031-15	3"					1.500	5.500	15.000	4.500
D-8640-F031-20	3"					2.000	7.000	20.000	6.000
D-8640-F031-25	3"					2.500	9.000	25.000	7.500
D-8640-F031-30	3"					3.000	11.500	30.000*	9.000
D-8640-H061-05	4"					500	3.000	9.000	2.400
D-8640-H061-07	4"					750	5.000	14.000	4.000
D-8640-H061-10	4"					1.000	7.000	20.000	6.000
D-8640-H061-15	4"					1.500	11.000	30.000*	9.000
D-8640-H061-20	4"					2.000	14.000	30.000*	12.000
D-8640-H061-25	4"					2.500	18.000	30.000*	15.000
D-8640-H061-30	4"					3.000	23.000	30.000*	18.000

* Limitation power by cable entry



- Flange connection with tubular type heating element

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Description
Suitable for heating of fluids both liquids and gases and also solids. The heater consists of a certified flameproof enclosure D-8640, containing:
- certified electric heating elements (Ex e II) tubular, ceramic or cartridge heating elements.
- one manually protective thermostat with manual reset or one thermocouple or pt100 as a safety device. Thermocouple and pt100 are only applicable in combination with an external temperature controller executed with a manual reset.
- threaded holes for cable entries and/or plugs of a certified flameproof model Ex d II B or Ex d II C.

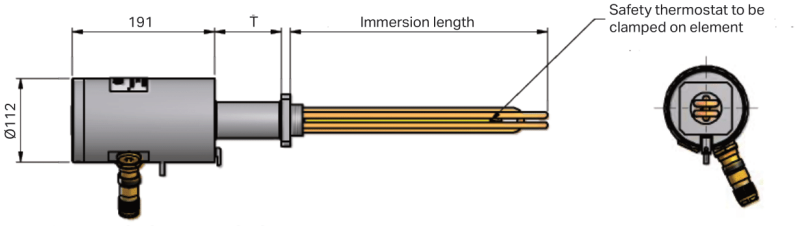
The flame-proof enclosure has been built up out of a seamless body, a top cover and base plate. Each cover and base plate has been provided with 6 screw thread windings with a total length of 18 mm. The connection length of the threaded joint between cover or base plate and body should always be 5 thread windings minimum. The cover has been locked with an M4 screw and the base plate with an M6 screw. In the base plate of the enclosure spacer tubes can be welded in which the heating elements are brazed or welded.

Temperature class		Distance enclosure to heater (T)
T6	85°C	50 mm
T5	100°C	75 mm
T4	135°C	100 mm
T3	200°C	150 mm
T2	300°C	200 mm
T1	450°C	250 mm

Technical specification
- Tubular heating elements with a diameter of Ø8.5 mm up to and including Ø16 mm and cartridge heating elements of Ø12.5 mm up to including Ø31.5 mm can be applied, also ceramic elements from Ø26 mm up to including Ø46 mm.
- Material of the enclosure: carbon, low alloy steel, or ferrous steel.
- Material of heating elements: stainless steels AISI 304, AISI 321, AISI 316, AISI 904L, Inconel 600, Incoloy 800, Incoloy 825, Titanium, SMO, Copper alloy or Nickel alloy.
- Degree of protection of the enclosure: IP66.
- The maximum allowable energy-dissipation of the heating elements has been based on a maximum Watt density, determined by the temperature class, type of medium and process conditions.

The temperature setting of the thermostat, thermocouple or pt100, as stated in the EC type Examination Certificate, is applicable only for heaters immersed into a hazardous fluid flow.

If the heater has not been immersed into a hazardous fluid but forms a part of an apparatus located in a hazardous zone, the temperature setting has to prevent the maximum temperature of the outside of the apparatus to exceed the temperature according to the temperature classification.



- Threaded boss from 1½" G BSP up to 3" G BSP with tubular type heating element.

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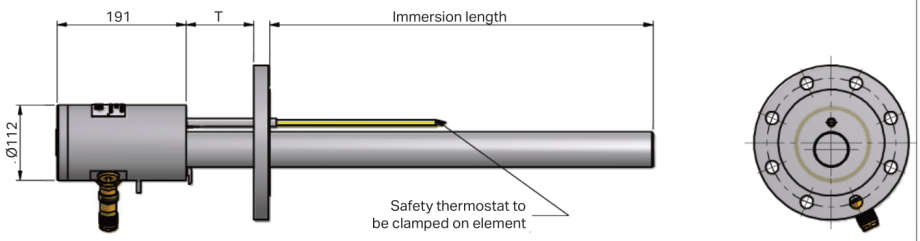
Catalogue Immersion Heaters type D-8640

Flame-proof immersion heater type D-8640 for high working temperatures

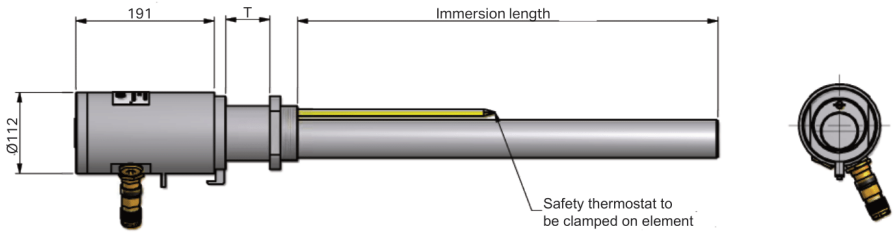
Flame-proof immersion heaters with retractable ceramic core elements.
Single or multi core heaters. For horizontal installation (vertical installation available on request).
The ceramic core elements can be withdrawn for inspection or replacement without having to drain the system.

- Ambient temperature -30°C - +50°C (-50°C ... +50°C on request)
- The maximum allowable voltage is 690 Volt.

Marking ATEX Ex II 2 G D
Ex d IIC T6-T1 Gb EN/IEC 60079-1
Ex tb IIIC T110°C Db EN/IEC 60079-31



- Flange connection with cartridge or retractable ceramic heating element



- Threaded boss from 1½" G BSP up to 3" G BSP with cartridge or retractable ceramic heating element.

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Gas and Dust flame-proof immersion heater type D-8640 VARIATION for relative low working temperatures

Description
The heater serie D-8640 variation is designed to heat a wide range of liquids, gases and solids.
The heater consists of a certified flameproof enclosure Ex d II C T6 - T1 Gb, certified electric heating elements Ex e II and a manually reset protective safety device. Unheated length heating elements into the medium is 30 mm minimum.
The surface loading of the elements in the heater is determined by the thermal characteristics of the fluid or gas being heated and its operating temperature and pressure.
The heaters are designed to operate within an ambient temperature range of -30°C to +50°C.

Heating elements
The heater consists of certified electric heating elements Ex e II which can be tubular heating elements with a diameter up to Ø16 mm or cartridge heating elements up to a diameter of Ø31.5 mm or retractable ceramic core elements Ø26 mm - Ø46 mm placed in a metal sheath with welded end plate.
Voltage supply up to 690 Volt.

Mounting
Threaded boss or flange connection in carbon steel or high alloy steel.

Set point safety thermostat
Set point on safety thermostat in medium:

Temperature class T1 to T4:	110°C
Temperature class T5:	90°C
Temperature class T6:	75°C

Set point on safety thermostat inside the terminal enclosure:

Temperature class T1 to T4:	90°C
Temperature class T5:	85°C
Temperature class T6:	70°C

If the cable entries exceed 70°C suitable high temperature cabling methods must be used. A warning label on the outside of the enclosure next to the cable gland shows the maximum allowable temperature. By a working temperature of more than 90°C the terminal enclosure will be at a distance from the heater. See table on page 3.

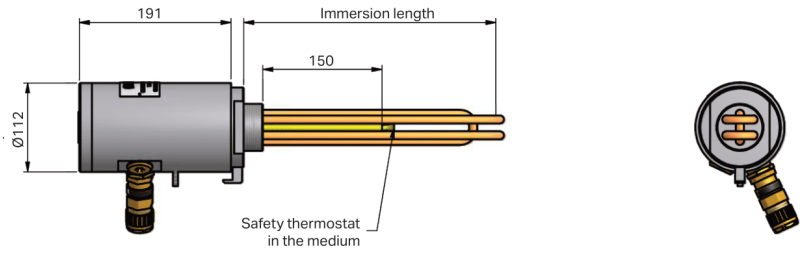
Temperature safety
Minimum of 1 over temperature thermostat or thermocouple or pt100 must be installed for guarding flange, plate or screw head and junction box temperature and must be either:
- Manually reset at the control panel by key switch or special tool
- Manually reset unit inside the terminal enclosure (klixon)
- Possibly with added manually reset unit on the highest surface temperature of the apparatus

When the electric heater type D-8640 and his variation does not have a temperature regulation of its own, the process medium temperature for each combination must be regulated with a seperate flameproof control thermostat, thermocouple or Pt100 and a seperate safety thermostat, thermocouple or Pt100 with manual reset. Both devices shall guarantee the temperature limit and the temperature class.

Special note
The end user must ensure that the heating elements are always inserted into the liquid or gas.
The end user must ensure that there is always a protection against an incorrect direction of flow (e.g. an one way valve). The lowest temperature of the liquid or gas flow is always at the end where the terminal enclosure is situated.

Terminal enclosure
The terminal enclosure can be either direct on or stand off depending on the process temperature.

Marking ATEX	Ex II 2 G D	
	Ex d IIC T6-T1 Gb	EN/IEC 60079-1
	Ex tb IIIC T110°C Db	EN/IEC 60079-31



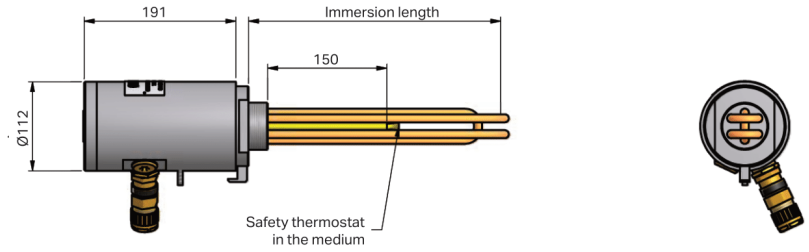
- Threaded boss from 1½" G BSP up to 3" G BSP with tubular heating element.

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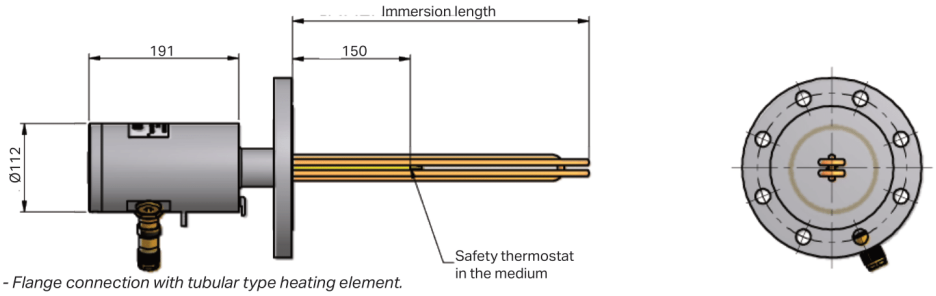
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Catalogue Immersion Heaters type D-8640

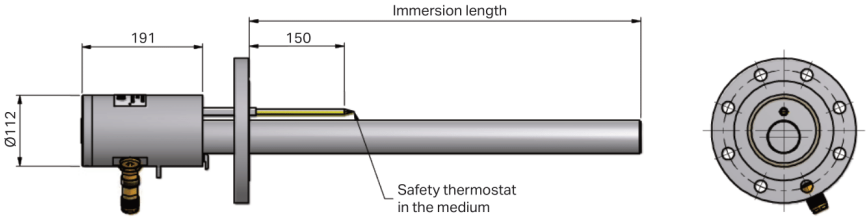
Flame-proof immersion heater type D-8640 VARIATION for low working temperatures



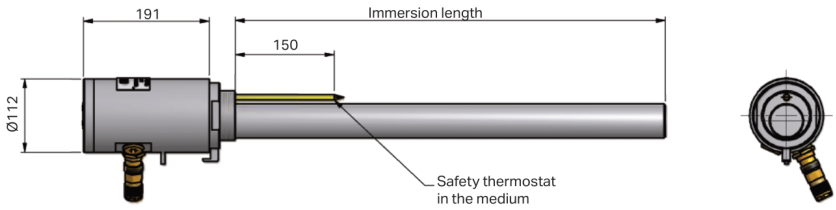
- Threaded boss from 1½" G BSP up to 3" G BSP with tubular heating element.



- Flange connection with tubular type heating element.



- Flange connection with cartridge or retractable ceramic heating element.



- Threaded boss from 1½" G BSP up to 3" G BSP with cartridge or retractable ceramic heating element.

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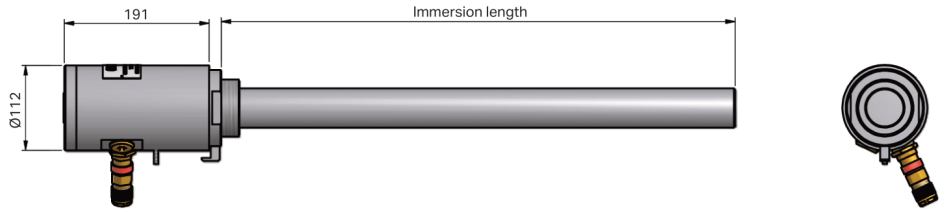
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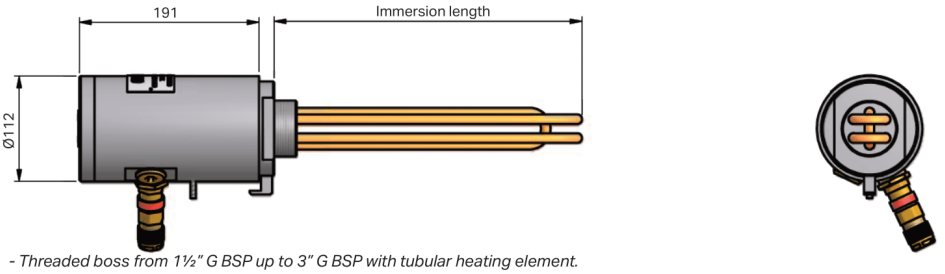
Flame-proof immersion heater type D-8640 VARIATION for low working temperatures

Note: safety thermostat in the enclosure



- Threaded boss from 1½" G BSP up to 3" G BSP with cartridge type heating element.

Note: safety thermostat in the enclosure



- Threaded boss from 1½" G BSP up to 3" G BSP with tubular heating element.

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Sinus is one of the pioneers in the field of explosion proof heating equipment, today we are still operating at the forefront. We manufacture according to ATEX as well as IECEx and EAC directives.

For the production of Ex-proof equipment a PQAN (Product Quality Assurance Notification) is issued by TUV-Nord. Our ISO-9001 and ISO-14001 systems are also monitored by this organisation.

NIBE

953A.1101E • 10-14

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4.10 EA01-WD01 and EA02-WD01 – Control Cable for Immersion Heater, CLASSIC 135 CH

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1123460	DATA SHEET	LAPP
valid from: 15.01.2024	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	

Application

ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV are screened halogen free, highly flame retardant power and control cables designed for the European and North American market, for occasional flexible use and fixed installation subject to normal mechanical load conditions. They are also suitable for use in dry or damp areas. They are suitable for outdoor use if the indicated temperature range is observed. They are suitable for occasional, non-automated movements. The maximum tensile load is 15 N/mm² of conductor cross-section during installation and operation. Compulsory guidance is not permitted.
The screening braid protects against interference from electrical fields.

Application range:
Public buildings, plant engineering, industrial machinery, heating and air-conditioning systems and particularly where human and animal life as well as valuable property exposed to high risk of fire hazards

USE gem. UL: FRPE sheathed cable for internal wiring of appliances or external interconnection

Design

Design	acc. to UL AWM Style 21156, UL 758 based on EN 50525-3-11
Certification	UL AWM Style 21156 (File No. E63634), UL 758 EN 13501-6 and EN 50575 Classification of fire behaviour (article/dimension range see www.lappkabel.com/cpr)
Conductor	fine wire strands of bare copper, acc. to IEC 60228 resp. EN 60228, Class 5
Insulation	halogen free compound TI6, acc. to EN 50363-7, with increased requirements
Core identification code	acc. to VDE 0293-1 up to 5 cores: colour-coded acc. to HD 308 S2, with or without GN/YE ground conductor starting at 6 cores: black cores with white numbers, with or without GN/YE ground conductor, acc. to EN 50334
Stranding	cores are stranded in layers
Wrapping	plastic foil
Screen	braid of tinned copper, coverage = 85% (nominal value)
Outer sheath	halogen free compound TM7 acc. to EN 50363-8 colour: black, similar RAL 9005

Electrical properties at 20 °C

Nominal voltage	EN U_0/U: 600/1000 V UL: 1000 V
Test voltage	core / core: 4000 V AC core / screen: 3000 V AC

Mechanical and thermal properties

Minimum bending radius	occasional flexing: 20 x outer diameter fixed installation: 6 x outer diameter
Temperature range	occasional flexing (EN): -25 °C up to +70 °C max. conductor temp. occasional flexing (UL): up to +75 °C max. conductor temp. fixed installation (EN): -40 °C up to +80 °C max. conductor temp. fixed installation (UL): up to +75 °C max. conductor temp.
Flammability	flame retardant acc. to IEC 60332-1-2 resp. EN 60332-1-2 UL: Cable flame test acc. to UL 1581 §1061 no flame-propagation acc. to IEC 60332-3-24 resp. EN 60332-3-24 or acc. to IEC 60332-3-25 resp. EN 60332-3-25
Halogen free	acc. to IEC 60754-1 resp. EN 60754-1
Corrosivity of gases	acc. to IEC 60754-2 resp. EN 60754-2
Smoke density	acc. to IEC 61034-2 resp. EN 61034-2
Toxicity	acc. to EN 50306-1 (≤ 6)

We reserve all rights according to DIN ISO 16016.
PDC 0019/06_03.23EN

1123460	DATA SHEET	LAPP
valid from: 15.01.2024	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	

UV resistance	acc. to EN 50525-1 cables with black sheath are suitable for permanent outdoor use. acc. to EN 50618 acc. to EN 50620 acc. to EN ISO 4892-2-2013, method A (change of colour allowed)
Ozone resistance	acc. to EN 50396, method B
Tests	acc. to IEC 60811 resp. EN 60811, EN 50395, EN 50396, UL 1581
General requirements	These cables are conform to the EU-Directive 2014/35/EU (Low Voltage Directive). A part of these cables (see www.lappkabel.com/cpr) are classified in accordance with the EU-Regulation no. 305/2011 (CPR).
Environmental information	These cables meet the substance-specific requirements of the EU Directive 2011/65/EU (RoHS).

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PDC 0019/06_03.23EN

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4.11 EA01..02 – Cable Gland for Immersion Heater, ICG 653 UNIV Os M20

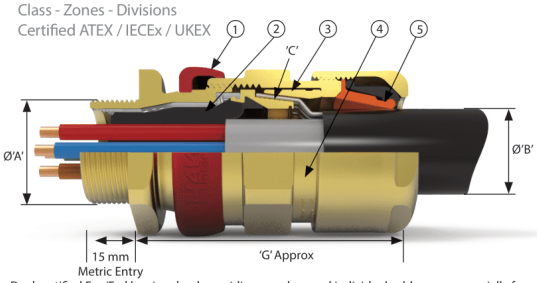
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CABLE GLAND BARRIER SERIES

ICG/653/UNIV

Flameproof, Increased Safety, Dust Protection and Restricted Breathing
Class - Zones - Divisions
Certified ATEX / IECEx / UKEX



- 1 Inspectable Deluge Seal
  - Offering IP66, IP67, IP68 & IP69 Ingress Protection
- 2 Transparent Elastomeric Fully Inspectable Compound Pot – compatible with both injectable resin and 2 part compound
- 3 Reversible Armour Clamp
  - For all types of armour and braid
- 4 Patented Cable Gland Tightening Guide
  - Helps prevent damage caused by over tightening
- 5 Unique Rear Seal - Offering ultimate sealing over an extremely wide cable acceptance range

International Approvals

Dual certified Exe/Exd barrier gland, providing a seal around individual cable cores, especially for cables that exhibit "cold flow" characteristics, are not effectively filled, have hygroscopic fillers or contains fibre optic cores. For use with single wire armour 'W', wire braid 'X', steel tape armour 'Z' elastomer and plastic insulated cables. The ICG/653/UNIVERSAL is available with either ExPress liquid barrier resin or QSP 2-part hand mix compound, both with a cure time 30 minutes

Cable Gland Selection Table

Size Ref.	Entry Thread Size 'A'		Cable Acceptance Details								'G'	Hexagon Dimensions	
			Inner Sheath/Cores				Outer Sheath 'B'		Armour/Braid 'C'				
	Metric	NPT*	Max Inner Sheath Dia	Max Over Core Dia	Max No of Cores	Max No of Fibre Optic	Min	Max	Orientation 1	Orientation 2		Across Flats	Across Corners
Os	M20[2]	½"	8.1**	8	12	48	5.5	12	0.8 / 1.25	0.0 / 0.8	58.4	24	26.5
O	M20[2]	½"	11.7	8.8	12	48	9.5	16	0.8 / 1.25	0.0 / 0.8	58.4	24	26.5
A	M20	¾" or ½"	14	10.8	15	72	12.5	20.5	0.8 / 1.25	0.0 / 0.8	60.6	30	32.5
B	M25	1" or ¾"	19.9	15.9	30	144	16.9	26	1.25 / 1.6	0.0 / 0.7	67.3	36	39.5
C	M32	1¼" or 1"	26.2	21.9	42	-	22	33	1.6 / 2.0	0.0 / 0.7	73.2	46	50.5
C2	M40	1½" or 1¼"	32.3	26.7	60	-	28	41	1.6 / 2.0	0.0 / 0.7	78.3	55	60.6
D	M50	2" or 1 1½"	44.2	37.7	80	-	36	52.6	1.8 / 2.5	0.0 / 1.0	97.5	65	70.8
E	M63	2½" or 2"	56	49	100	-	46	65.3	1.8 / 2.5	0.0 / 1.0	93.5	80	88
F	M75	3" or 2½"	68	59.8	120	-	57	78	1.8 / 2.5	0.0 / 1.0	104.5	95	104

[1] All dimensions in millimetres (except * where dimensions are in inches). Metric entry threads are 1.5mm pitch as standard, 15mm length of thread.
[2] Are available with M16 entry thread, which reduces Max Over Core Diameter to 7mm.

***Recommended value to suit integrated Express resin stop. May be increased to 10.0 if QSP compound or alternative Express resin stop method are used.*

Technical Data

Material Options	Manufactured in Brass, Nickel Plated Brass or 316L Stainless Steel
Ingress Protection	IP66, IP67, IP68 (30 metres for 7 days, special instruction apply), IP69 to IEC/EN 60529 and NEMA 4X
Enclosure Protection	IK10 to IEC 62262
Deluge Protection	to DTS01
Operating Temperature	-60°C to +80°C
Applications	Suitable for use in Zone 1, Zone 21, Zone 2 and Zone 22
Approvals	
Protection Class	Ex II 2GD Ex db IIC Gb; Ex eb IIC Gb; Ex nR IIC Gc; Ex tb IIIC Db
ATEX Certificate No	CML 18ATEX1268X CML 19ATEX4507 (Ex nR)
IECEx Certificate No	CML 18.0131X CML 21.0012X (Ex nR)
UKEX Certificate No	CML 21UKEX1132X CML 21UKEX4133X (Ex nR)
Construction & Test Standards	IEC/EN 62444 (Anchorage Type D), IEC/EN 60079-0, 1, 7, 15, 31
Marine Approvals	ABS: 19-LD1876514-1-PDA BV: 43523/B0 DNV: TAE0000BS
Additional Certifications	CCC: 2020312313000317 EAC: No EA3C RU C-GB.HA91.B.00264/21 EQM: 20-11-27224/Q20-11-000979/NB0007 Inmetro: IEx 14.0272X KCs: 17-KA4BO-0159X to 0167X PESO: P450038 SONCAP: LCOGB049552-0500
NEC/CEC	
NEC Protection Class	Class I Div 1 ABCD Class II Div 2 EFG and Class III Class I, Zone I, AEx db IIC Gb, AEx eb IIC Gb; Zone 21, AEx tb IIIC Db
CEC Protection Class	Class I Div 1 ABCD Class II Div 2 EFG and Class III Ex db IIC Gb; Ex eb IIC Gb; Ex tb IIIC Db
c CSA us Certificate	1024328
Construction & Test Standards	UL2225, UL1203, UL514B, CSA C22.2 NO. 0-10, CSA C22.2 NO. 174-18, CSA 22.2 60079-0, CSA 22.2 60079-1, CSA 22.2 60079-7 and CSA 22.2 60079-31

HAWKE International

Contact Hubbell T: +44 (0)141 882 5555 E: getintouchuk@hubbell.com
www.hubbell.com/hawke

HUBBELL Harsh & Hazardous

HHI-HKE-Multi-ICG-653-UNIV-COLDFLOW-AND-BARRIER-GLAND-SPEC-UK-2023 V1.3

Alternative Reversible Armour Clamping Ring Size Selection

Size Ref	Orientation 1	Orientation 2
B	0.9 - 1.25	0.5 - 0.9
C	1.2 - 1.6	0.6 - 1.2
C2	1.2 - 1.6	0.6 - 1.2
D	1.45 - 1.8	1.0 - 1.45
E	1.45 - 1.8	1.0 - 1.45
F	1.45 - 1.8	1.0 - 1.45

Ordering Information

If brass is required please omit material selection
Format for ordering is as follows: Alternative Ring (R), add suffix R to ordering information
All barrier glands are supplied with Express resin as standard. If QSP (Quick Set Putty) is required please select Q in compound selection

Cable Gland Type	Size	Thread	Material	(Optional)	Compound
653U	C	M32		R	
653U	C	1.25	NP	R	Q

Example Code: 653UCM32R
Assembly instructions are supplied with the cable gland
Please note all NPT entries should be state as a decimal
Please refer to part code logic information page for further details on product options

ExPress Barrier Resin

Specify your barrier gland with our ExPress injectable resin for faster, easier installation
A liquid injectable and fast curing resin, allowing for faster installation time than traditional 2-part compounds. Utilising a unique clear compound chamber for full visibility of the flameproof seal during installation and inspection, the ExPress barrier resin is unparalleled as a global solution, with a 30 minute gel time and unrivalled ease of use.
All barrier glands are now supplied with Express Resin as standard.





EXPRESS

Cable Gland **Tightening Guide**

Whilst Hawke International goes to great lengths to ensure products are designed to be as simple to install, inspect and maintain as is possible, differing levels of competency, training and understanding can lead to glands being incorrectly installed. With hazardous area products, any poor installation issues can not only lead to expensive equipment failure, but also potential explosion risks and associated risk to life.

To help address issues with the overtightening of cable glands and the resultant damage to cables and seals, Hawke International has developed the patented **INBUILT TIGHTENING GUIDE**.

Without the need for fiddly measuring systems, the guide provides a permanent visual indication of the gland tightness through installation, inspection and maintenance.

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4.12 QM1.1..1.6 and QM2.1..2.6 – Solenoid Valve, NF X E210D488E 24/DC

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ASCO™

OPERATORS

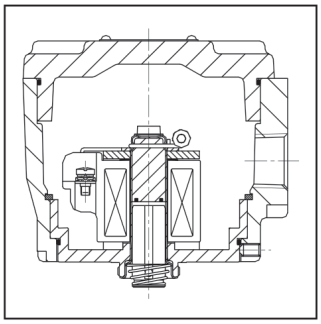
for potentially explosive atmospheres
flameproof enclosure
II 2G/D Ex **d** IIC T6..T4 Gb / Ex **tb** IIIC Db IP66/IP67
aluminium or stainless steel enclosure

Series
NF
WSNF

FEATURES

- *Explosionproof operator for use in potentially explosive atmospheres according to ATEX-Directive 2014/34/EU*
  EC type examination certificate no.: ***LCIE 00 ATEX 6008 X***
  IECEx Certificate of Conformity no.: ***IECEx LCI 07.0015X***
- *Compliance with the Essential Health and Safety Requirements has been assured by compliance with the International and European Standards EN-IEC 60079-0, EN-IEC 60079-1 and EN-IEC 60079-31*
- *Easy electrical installation by means of a screw terminal coil*
- *Enclosure provided with a 1/2 NPT threaded entry hole (M20 x 1,5 in option) for a broad range of cable entries*
- *Ingress protection degree IP66/67*
- *A wide range of valves can be supplied with the operator*





CONSTRUCTION

Solenoid enclosure	NF	Chromated aluminium, epoxy coated
	WSNF	Stainless steel (AISI 316L)
Bonnet	NF	Steel (zinc plated)
	WSNF	Stainless steel (nickel plated)
Core, core tube and plugnut	all	Stainless steel
Shading coil	all	Copper or silver
Nameplate	NF	Stainless steel
	WSNF	Stainless steel
Coil connection	all	Embedded screw terminals
Fasteners & screws	all	Stainless steel
Safety code		IECEx / Ex II 2G Ex d IIC T6..T4 Gb
		IECEx / Ex II 2D Ex tb IIIC 85°C..135°C Db IP66/67

ELECTRICAL CHARACTERISTICS

Standard voltages	DC (=) : 24V - 48V
(Other voltages and 60 Hz on request)	AC (~) : 24V - 48V - 115V - 230V(3) / 50 Hz

TEMPERATURE CLASSIFICATION TABLES

AC (~) solenoids

Pn (watt)	solenoid size MXX	solenoid size M12			maximum ambient °C (1) surface temperature T6 85°C	T5 100°C	T4 135°C	T3 200°C
insulation class F/H (155°C/180°C) 100% E.D.								
1,85(2)(3)		●			75	80		
3,7 (2)		●			60	75	100	
5,8 (2)		●			60	75	100	
10,0 (2)	●				40	60	75	
10,0 (2)		●			40	60	100	
10,5	●				25	40	60	
13,4 (2)	●				40	60	75	
14,1 (2)		●			40	60	90	
15,4		●			25	40	60	
16,5		●			40	60	75	
16,7	●					25	40	
20,0		●				25	40	
20,5	●						25	
28,0		●					25	

DC (=) solenoids

Pn (watt)	solenoid size MXX	solenoid size M12			maximum ambient °C (1) surface temperature T6 85°C	T5 100°C	T4 135°C	T3 200°C
insulation class F/H (155°C/180°C) 100% E.D.								
1,8		●			75	80		
3,6		●			60	75	100	
5,7		●			60	75	100	
10,0		●			40	60	100	
11,2	●				40	60	75	
14,0		●			40	60	90	
16,8		●			40	60	75	
19,7	●				25	40	60	
23,0		●			25	40	60	
26,6		●			25	40	60	
29,5		●				25	40	
36,2		●				25	40	

Check the wattage compatibility with the product selected.
(1) **The minimum allowable ambient temperature is -60°C for the operator.** Actual temperature range can be limited depending on valve operation limits.
(2) AC (~): rectified coil construction.
(3) 230 V AC does not exist (Pn 1,85 W).

ORDERING INFORMATION

A valve supplied with the explosionproof operator will be identified with prefix NF or WSNF before the catalogue number.

Example: **NF** E 210D095 230V/50 Hz

- **NF** — operator
- E — pipe thread ISO 7/1
- 210D095 — basic number
- 230V/50 Hz — voltage

A valve supplied with the explosionproof operator will be identified with electrical interface FN, FS, FT or FU in the 15-digit product code.

15-DIGIT PRODUCT CODE

E 262 K 232 **FN** V00 H1

- E — Thread connection
- 262 — Product series
- K — Revision letter
- 232 — Valves version
- **FN** — Electrical interface
- V00 — Options
- H1 — Voltage - class

Electrical interface
FN = NF
FS = WSNF
FT = NFET
FU = WSNFET

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ASCO™

OPERATORS SERIES NF/WSNF

OPTIONS

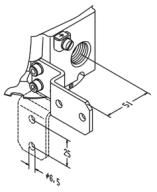
- Operators for mining, I M2 Ex d I, contact us

ORDERING EXAMPLES:

NF	B	327 B 001		230V / 50 Hz
NF	G	551 B 405		230V / 50 Hz
NFET	G	327 B 001	V	230V / 50 Hz
WSNF	E	272 A 047	MS	24V / DC
WSNF	B	320 A 184	E	24V / DC

prefix
pipe thread
basic number
voltage
suffix

MOUNTING BRACKET



Bracket kit no. **C139824**
contains: Stainless steel 304 SS screws and bracket

15-DIGIT PRODUCT CODE

E	262	K	232	**FN**	V00	H1
E	262	K	232	**FS**	V00	F8
E	262	K	232	**FT**	V00	FT
E	262	K	232	**FU**	V00	H9

Thread connection
Product series
Revision letter
Valves version
Electrical interface
Voltage - class
Options

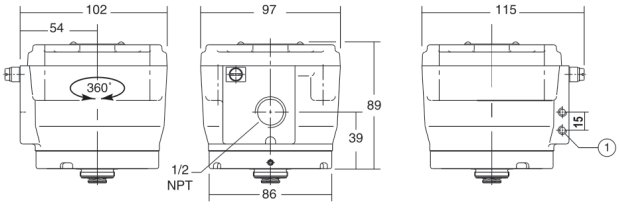
CONNECTIONS

- Any ATEX approved cable entry device can be fitted in the 1/2 NPT threaded entry hole (M20 x 1.5 in option). Refer to the nameplate for identification of the maximum cable temperature
- Internal and external earthing connection
- The operator can be rotated through 360° to select the most favourable position for cable entry

DIMENSIONS (mm), **WEIGHT** (kg)



TYPE NF-WSNF
Prefix "NF" , "WSNF" Solenoid / Electrical interface FN/FS/FT/FU
Aluminium, stainless steel
(NF, epoxy coated)
EN-IEC 60079-1 and EN-IEC 60079-31
II 2G Ex d IIC Gb, II 2D Ex tb IIIC Db IP66/67



series	weight
NF	1,4
WSNF	2,7

(1) 2 mounting holes M5, depth 9 mm

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4 - Explosionproof equipment

4.13 QM1.1..1.6 and QM2.1..2.6 – 1/2" NPT to M20 Adaptor, ADU102904

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Metallic (Exd/Exe) adaptors and reducers - AD-U / RD-U Series



Type AD-U



Type RD-U

Redapt AD-U and RD-U series of explosion-proof metallic adaptors and reducers provide a method of matching electrical thread forms on hazardous area approved equipment whilst ensuring the integrity and Ex approval of the installation is maintained.

Manufactured from hexagon material to facilitate easy installation, they are also supplied complete with a captive O-ring seal. The O-ring is located within a recess on the face of the product, helping to protect the O-ring from the environmental damage and ensuring it is not displaced during installation. Designed for hazardous area applications and the range is certified to protection concepts Exd "Flameproof" and Exe "Increased Safety" for use in Zone 1 and Zone 2 applications. Also certified Ex tb "dust tight" for use in Zone 21 & 22 applications.

Materials

- Brass CZ121
- 316 stainless steel
- Aluminium
- Mild steel

Threadforms

- Metric
- NPT
- PG
- ISO Pipe (BSP)
- ET

Plating options

- Electroless nickel
- Zinc
- Chromated
- Others on application

Technical specifications

Code of protection categories
ATEX: I M2/II 2 GD
IECEx: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/Gb, Ex tb IIIC Db (Aluminium not mining)
CSA: RD-U Ex db / Ex eb IIC Gb IP66/67/68; Cl I Zn 1 AEx eb / AEx db IIC Gb IP54; Cl I Div1 Gr ABCD Cl II Gr EFG Cl III; Type 3 AD-U Ex db / Ex eb IIC Gb IP66/67/68; Cl I Zn 1 AEx eb / AEx db IIC Gb IP54; Cl I Div1 Gr ABCD Cl II Gr EFG Cl III; Type 3
Compliance standards
ATEX: EN 60079-0, EN 60079-1, EN 60079-7, EN 60079-31
IECEx: IEC 60079-0, IEC 60079-1, IEC 60079-7, IEC 60079-31
CSA: CAN/CSA C22.2 No. 60079-0, No. 60079-1, No. 60079-7, ANSI/UL 60079-0, 60079-1, 60079-7, UL1203
Certificate details
ATEX: ITS16ATEX101339X
IECEx: IECEx ITS 16.0013X
EAC: RU C-GB.M**Ю**62.B.06225
CSA: CSA01CA1248014X
INMETRO: NCC 18.0133 X
CCoE: P362565/1 (AD-U) ; P485509 (RD-U)
Temperature
Temperature will depend on the type of O-ring used:
None: -60°C to +200°C
Nitrile: -30°C to +80°C (supplied as standard)
EPDM: -50°C to +100°C
Neoprene: -40°C to +80°C
Viton: -20°C to +180°C
Silicone: -60°C to +180°C
Fluorosilicone: -60°C to +130°C
The maximum temperature is limited to +150°C for Group I applications
Ingress protection (IP):
IP64 when fitted without sealing washer. IP66/IP68 when fitted with O-ring or thread sealant according to manufacturer's instructions.
Part number:
Please refer to part numbering system below

Download certificates and documents here

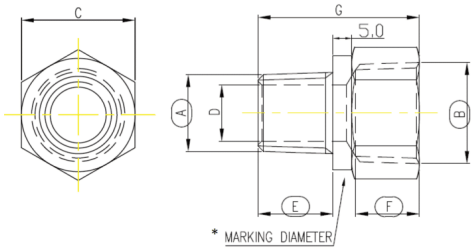
Available thread sizes and corresponding bore size

Metric	Bore	NPT	Bore	ISO Pipe	Bore	ET	Bore	PG	Bore
M16	10.00	-	-	3/8"	10.00	5/8"	10.00	PG7	8.00
M20	14.00	½"	15.00	½"	15.00	¾"	14.00	PG9	10.00
M25	18.00	¾"	19.00	¾"	19.00	1"	18.00	PG11	13.50
M32	24.00	1"	25.00	1"	25.00	1 ¼"	24.00	PG13.5	14.00
M40	32.00	1 ¼"	32.00	1 ¼"	32.00	1 ½"	32.00	PG16	16.00
M50	41.00	1 ½"	38.00	1 ½"	38.00	2"	41.00	PG21	21.00
M63	53.00	2"	49.00	2"	49.00	2 ½"	53.00	PG29	29.00
M75	64.00	2 ½"	60.00	2 ½"	60.00	3"	64.00	PG36	38.00
M80 x 2.0	69.00	3"	75.00	3"	75.00	-	-	PG42	45.00
M85 x 2.0	73.00	3 ½"	88.00	3 ½"	88.00	-	-	PG48	50.00
M90 x 2.0	78.00	4"	100.00	4"	100.00	-	-	-	-

Sizes M12 to M120 available.

Metallic (Exd/Exe) adaptors and reducers - Dimensions

AD-U



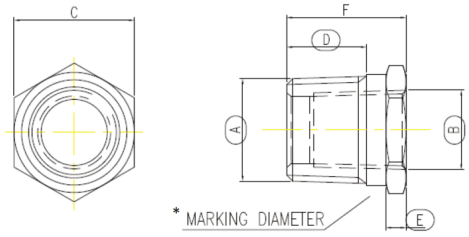
A	B	C	D	E	F	G
Male	Female	A/F	Bore	Thread length	Thread depth	Total length
M16	M16	23.4	10.0	16.0	17.0	38.5
	M20	23.4	10.0	16.0	17.0	38.5
M20	M20	27.0	14.0	16.0	17.0	38.5
	M25	30.5	14.0	16.0	17.0	38.5
M25	M25	31.8	18.0	16.0	17.0	38.5
	M32	37.6	18.0	16.0	17.0	38.5
M32	M32	37.6	24.0	16.0	17.0	38.5
	M40	47.2	24.0	16.0	17.0	38.5
M40	M40	47.2	32.0	16.0	16.5	38.5
	M50	55.9	32.0	16.0	17.0	39.5
M50	M50	57.2	41.0	16.0	17.0	39.5
	M63	70.1	41.0	16.0	17.0	39.5
M63	M63	70.1	53.0	16.0	17.0	39.5
	M75	90.2	53.0	16.0	17.0	39.5
M75	M75	90.2	64.0	16.0	16.5	39.5
	M90	106.4	64.0	16.0	22.0	45.0
M90	M90	106.4	78.0	20.0	22.0	49.0
	M100	114.3	78.0	20.0	22.0	49.0
M100	M100	114.3	88.0	20.0	22.0	49.0

A	B	C	D	E	F	G
Male	Female	A/F	Bore	Thread length	Thread depth	Total length
1/2 NPT	1/2 NPT	23.4	15.0	20.0	20.0	46.0
	3/4 NPT	30.5	15.0	20.0	20.0	46.0
3/4 NPT	3/4 NPT	30.5	19.0	20.0	20.0	46.0
	1 NPT	37.6	19.0	20.0	25.0	51.0
1 NPT	1 NPT	37.6	25.0	25.0	25.0	56.0
	1. 1/4 NPT	47.2	25.0	25.0	25.0	56.0
1. 1/4 NPT	1. 1/4 NPT	47.2	32.0	25.0	25.0	56.0
	1. 1/2 NPT	55.9	32.0	25.0	25.0	57.0
1. 1/2 NPT	1. 1/2 NPT	55.9	38.0	25.0	25.0	57.0
	2 NPT	70.1	38.0	25.0	25.0	57.0
2 NPT	2 NPT	70.1	49.0	25.0	25.0	57.0
	2. 1/2 NPT	80.0	49.0	25.0	35.0	67.0
2. 1/2 NPT	2. 1/2 NPT	80.0	60.0	35.0	35.0	77.0
	3 NPT	106.4	60.0	35.0	35.0	77.0
3 NPT	3 NPT	106.4	75.0	35.0	35.0	77.0
	3. 1/2 NPT	114.3	75.0	35.0	35.0	78.0
	4 NPT	127.0	75.0	35.0	35.0	78.0
3. 1/2 NPT	3. 1/2 NPT	114.3	88.0	35.0	35.0	78.0
	4 NPT	127.0	88.0	35.0	35.0	78.0
4 NPT	4 NPT	127.0	100.0	35.0	35.0	78.0

*Note: stainless steel may not have the roll marking diameter.

Metallic (Exd/Exe) adaptors and reducers - Dimensions

RD-U



A	B	C	D	E	F
Male	Female	A/F	Thread length	Hexagon length	Total length
M20	M16 & below	27.0	16.0	5.0	26.0
M25	M20 & below	31.8	16.0	5.0	26.0
M32	M25 & below	37.6	16.0	5.0	26.0
M40	M32 & below	47.2	16.0	5.0	26.0
M50	M40 & below	57.2	16.0	6.0	27.0
M63	M50 & below	70.1	16.0	6.0	27.0
M75	M63 & below	90.2	16.0	6.0	27.0
M80	M75 & below	90.2	20.0	6.0	31.0
M85	M75 & below	106.4	20.0	6.0	31.0
M90	M80 & below	106.4	20.0	6.0	31.0
M100	M90 & below	114.3	20.0	6.0	31.0
M110	M90 & below	120.7	20.0	7.0	32.0

A	B	C	D	E	F
Male	Female	A/F	Thread length	Hexagon length	Total length
3/4 NPT	1/2 NPT & below	27.9	20.0	5.0	30.0
1 NPT	3/4 NPT & below	34.9	25.0	5.0	35.0
1. 1/4 NPT	1 NPT & below	44.5	25.0	5.0	35.0
1. 1/2 NPT	1.1/4 NPT & below	52.1	25.0	5.0	35.0
2 NPT	1.1/2 NPT & below	61.2	25.0	6.0	36.0
2. 1/2 NPT	2 NPT & below	80.0	35.0	6.0	46.0
3 NPT	2.1/2 NPT & below	90.2	35.0	6.0	46.0
3. 1/2 NPT	3 NPT & below	106.4	35.0	6.0	46.0
4 NPT	3.1/2 NPT & below	120.7	35.0	7.0	47.0

*Note: stainless steel may not have the roll marking diameter.

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Metallic (Exd/Exe) adaptors and reducers - Product coding

Product	Digits 1 & 2
Exd/Exe ADAPTOR	**AD**
Exd/Exe REDUCER	**RD**

Certification	Digit 3
U	Exd I and IIC & Exe I and IIC

Material	Digit 4
1	Brass
2	Mild steel
3	Stainless steel
5	Aluminium

Plating	Digit 5
0	Unplated
1	Electroless nickel
2	Zinc
6	Chromated

Digits 6 & 7, Male thread – Digits 8 & 9, Female thread

Metric	ET imperial conduit	NPT	NPSM	ISO pipe parallel (BSPP)	ISO pipe taper (BSPT)	PG
02 M12						
03 M16	17 5/8" ET	**29 ½" NPT**	42 ½" NPSM	55 ½" BSPP	68 ½" BSPT	79 PG7
04 M20	18 ¾" ET	30 ¾" NPT	43 ¾" NPSM	56 ¾" BSPP	69 ¾" BSPT	80 PG9
05 M25	19 1" ET	31 1" NPT	44 1" NPSM	57 1" BSPP	70 1" BSPT	81 PG11
06 M32	20 1¼" ET	32 1¼" NPT	45 1¼ " NPSM	58 1¼" BSPP	71 1¼" BSPT	82 PG13.5
07 M40	21 1½" ET	33 1½" NPT	46 1½" NPSM	59 1½" BSPP	72 1½" BSPT	83 PG16
08 M50	22 2" ET	34 2" NPT	47 2" NPSM	60 2" BSPP	73 2" BSPT	84 PG21
09 M63	23 2½" ET	35 2½" NPT	48 2½" NPSM	61 2½" BSPP	74 2½" BSPT	85 PG29
10 M75	24 3" ET	36 3" NPT	49 3" NPSM	62 3" BSPP	75 3" BSPT	86 PG36
11 M80 x 2.0	ET Special	37 3½" NPT	50 3½" NPSM	63 3½" BSPP	76 3½" BSPT	87 PG42
12 M85 x 2.0		38 4" NPT	51 4" NPSM	64 4" BSPP	77 4" BSPT	88 PG48
13 M90 x 2.0		NT Special	NS Special	BP Special	BT Special	PG Special
14 M100 x 2.0						
15 M110 x 2.0						
BZ M120 x 2.0						

Example

Digits 1 & 2		Digit 3		Digit 4		Digit 5		Digits 6 & 7		Digits 8 & 9
AD	-	**U**	-	**1**	-	**1**	-	**29**	-	**04**
Adaptor		Exd/e certified		Brass		Nickel-plated		1/2" NPT (male)		M20 (female)

Notes:
- Always quote male thread first
- Threadform codes below to be used for both male and female threads.

Adaptors and reducers selection guide

STEP 1 – To obtain the correct reference number, select the male size from the left hand column, then refer horizontally across the page to the female size (i.e. M32 (male) x M40 (female) = 208). Reference numbers in blue are adaptors; other references are reducers.

Female Size

	Metric													NPT								PG							
Male	M16	M20	M25	M32	M40	M50	M63	M75	M80	M85	M90	M100	M110	M120	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	PG7&9	PG11	PG13.5	PG16	PG21	PG29	PG36	PG42
M16	201	201													216										201	201	201					
M20	301	202	203												217	218									301	202	202	202	204			
M25	303	303	257	206											303	219	221								303	303	303	257	204			
M32	305	305	305	206	208										305	305	221	223							305	305	305	305	207	258		
M40	307	307	307	307	208	209									307	307	307	223	224						307	307	307	307	307	208	209	
M50	309	309	309	309	309	259	211								309	309	309	309	225	226					309	309	309	309	309	309	210	210	211
M63	310	310	310	310	310	310	211	212							310	310	310	310	310	226	227				310	310	310	310	310	310	310	310	211
M75	311	311	311	311	311	311	311	212	261	213	213				311	311	311	311	311	311	360	228			311	311	311	311	311	311	311	311	311
M80	311	311	311	311	311	311	311	261	261	214	214																					
M85	312	312	312	312	312	312	312	214	214	214	214																					
M90	312	312	312	312	312	312	312	312	214	214	214	215			312	312	312	312	312	312	312	229	230	231								
M100	313	313	313	313	313	313	313	313	313	313	215	215	262	263	313	313	313	313	313	313	313	313	230	231								
M110	325	325	325	325	325	325	325	325	325	325	325	262	262	263																		
M120	326	326	326	326	326	326	326	326	326	326	326	326	263	263																		

	Metric										NPT										PG									
NPT	M16	M20	M25	M32	M40	M50	M63	M75	M90	M100	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	5"	PG7&9	PG11	PG13.5	PG16	PG21	PG29	PG36	PG42	PG48
1/2"	314	232	234								245	246										314	232	232	232	265				
3/4"	315	315	234	235							315	246	247									315	315	315	234	235				
1"	316	316	316	236	237						316	316	248	249								316	316	316	316	236	237			
1 1/4"	317	317	317	317	237	238					317	317	317	249	250							317	317	317	317	317	237	238		
1 1/2"	318	318	318	318	318	238	240				318	318	318	318	250	251						318	318	318	318	318	318	238	239	240
2"	319	319	319	319	319	319	240	241			319	319	319	319	319	251	252					319	319	319	319	319	319	319	319	240
2 1/2"	320	320	320	320	320	320	320	242	243		320	320	320	320	320	320	253	254				320	320	320	320	320	320	320	320	320
3"	321	321	321	321	321	321	321	321	243	244	321	321	321	321	321	321	321	254	255			321	321	321	321	321	321	321	321	321
3 1/2"	322	322	322	322	322	322	322	322	322	244	322	322	322	322	322	322	322	322	255	256		322	322	322	322	322	322	322	322	322
4"	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	256	264	323	323	323	323	323	323	323	323	323
5"	–	–	–	–	–	–	–	–	–	–	327	327	327	327	327	327	327	327	327	327	–	–	–	–	–	–	–	–	–	–

	Metric								NPT							PG									
PG	M16	M20	M25	M32	M40	M50	M63	M75	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	PG7&9	PG11	PG13.5	PG16	PG21	PG29	PG36	PG42	PG48
7&9	201	201							216							201	201	201						
11	202	202	203						217	218						301/202	202	202	202					
13.5	301	202	203						217	218						301	202	202	202	204				
16	302	203	203						218	218	221					302	302	203	203	204				
21	304	304	205	206	206				304	220	221					304	304	304	304	205	258			
29	306	306	306	306	208	209			306	306	223	223	224			306	306	306	306	208	209			
36	308	308	308	308	308	209	211		308	308	308	224	224			308	308	308	308	308	209	210	211	
42	324	324	324	324	324	210	211		324	324	324	324	324	226		324	324	324	324	324	324	210	211	
48	310	310	310	310	310	310	211	211	310	310	310	310	310	226	227	310	310	310	310	310	310	310	211	

Adaptors and reducers selection guide

STEP 2 – Having obtained the reference number, go to the relevant column within the dimension tables to obtain the adaptor or reducer's dimensions. Please note that these dimensions refer to metallic products only.

Adaptors

Metric x metric, metric x PG, PG x metric, PG x PG																			
Reference numbers	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	257	258	259
Hex across flats	23.4	27.0	30.5	33.0	36.0	37.6	37.6	47.2	55.9	61.2	70.1	90.2	106.4	106.4	114.3	23.4	31.8	41.3	57.2
Hex across corners	26.8	31.0	35.0	38.0	41.5	43.2	43.2	53.4	64.3	70.4	81.8	103.7	122.4	122.4	131.4	26.8	36.1	47.7	66.0
Male thread length	16	16	16	16	16	16	16	16	16	16	16	16	16	20	20	15	16	16	16
Female thread length	17	17	17	17	17	17	17	17	17	17	17	17	22	22	22	20	17	17	17
Total length	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	39.5	39.5	39.5	39.5	45.0	49.0	49.0	42.0	38.5	38.5	39.5

Metric x NPT, PG x NPT																			
Reference numbers	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	261	262	263	-
Hex across flats	27.0	30.5	32.0	37.6	37.6	41.3	47.2	55.9	57.2	70.1	80.0	106.4	106.4	114.3	127.0	90.2	120.7	139.7	-
Hex across corners	31.0	35.0	36.7	43.2	43.2	47.5	53.4	64.3	66.0	81.8	92.0	122.4	122.4	131.4	147.0	104.1	139.4	161.3	-
Male thread length	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	20	20	-
Female thread length	20	20	20	20	25	25	26	26	26	27	40	35	42	42	44	22	22	22	-
Total length	42	42	42	42	47	47	47	48	48	48	58	58	62	62	62	48	48	49	-

NPT x metric, NPT x PG																			
Reference numbers	232	233	234	235	236	237	238	239	240	241	242	243	244	260	265	-	-	-	-
Hex across flats	23.4	28.6	30.5	37.6	37.6	44.5	55.9	70.1	70.1	90.2	90.2	106.4	114.3	90.2	33.0	-	-	-	-
Hex across corners	26.8	32.9	35.0	43.2	43.2	51.1	64.3	70.4	81.8	103.7	103.7	122.4	131.4	103.7	38.0	-	-	-	-
Male thread length	20	20	20	20	25	25	25	25	25	25	35	35	35	16	20				
Female thread length	17	17	17	17	17	17	17	17	17	17	17	22	22	35	77	-	-	-	-
Total length	43	43	43	43	48	48	49	49	49	49	59	64	64	58	43	-	-	-	-

NPT x NPT																			
Reference numbers	245	246	247	248	249	250	251	252	253	254	255	256	264	-	-	-	-	-	-
Hex across flats	23.4	30.5	37.6	37.6	47.2	55.9	70.1	80.0	80.0	106.4	114.3	127.0	158.8	-	-	-	-	-	-
Hex across corners	26.8	35.0	43.2	43.2	53.4	64.3	81.8	92.0	92.0	122.4	131.4	146.0	183.3	-	-	-	-	-	-
Male thread length	20	20	20	25	25	25	25	25	35	35	35	35	35	-	-	-	-	-	-
Female thread length	20	20	25	25	25	25	25	35	35	35	35	35	47	-	-	-	-	-	-
Total length	46	46	51	56	56	57	57	67	77	77	78	78	81	-	-	-	-	-	-

Reducers

Metric and PG																			
Reference numbers	301	302	303	304	305	306	307	308	309	310	311	312	313	324	325	326	-	-	-
Hex across flats	27.0	30.5	31.8	36.0	37.6	44.5	47.2	55.9	57.2	70.1	90.2	106.4	114.3	61.2	120.7	127.0	-	-	-
Hex across corners	31.0	35.0	36.7	41.5	43.2	51.1	53.4	64.3	66.0	81.8	103.7	122.4	131.0	70.7	139.4	146.6	-	-	-
Male thread length	16	16	16	16	16	16	16	16	16	16	16	20	20	16	16	16	-	-	-
Total length	26	26	26	26	26	26	26	27	27	27	27	31	31	27	28	28	-	-	-

NPT																			
Reference numbers	314	315	316	317	318	319	320	321	322	323	327	-	-	-	-	-	-	-	-
Hex across flats	23.4	27.9	34.9	44.5	52.1	61.2	80.0	90.2	106.4	120.7	146.0	-	-	-	-	-	-	-	-
Hex across corners	26.8	32.1	40.2	51.1	59.9	70.4	92.0	103.7	122.4	138.8	168.6	-	-	-	-	-	-	-	-
Male thread length	20	20	25	25	25	25	35	35	35	35	35	-	-	-	-	-	-	-	-
Total length	30	30	35	35	35	36	46	46	46	47	47	-	-	-	-	-	-	-	-

Thread dimension chart

ISO metric

BS 3643 1.5mm pitch

Size	Major dia.	TPI
M12	11.97	16.93
M16	15.97	16.93
M20	19.97	16.93
M25	24.97	16.93
M32	31.97	16.93
M40	39.97	16.93
M50	49.97	16.93
M63	62.97	16.93
M75	74.97	16.93
2.0mm pitch		
M80	79.97	12.70
M85	84.97	12.70
M90	89.97	12.70
M100	99.97	12.70
M110	109.97	12.70
M120	119.97	12.70

NPT

ANSI.ASME B1.20.1

Size	Pipe dia.	TPI
½"	21.34	14.00
¾"	26.67	14.00
1"	33.40	11.50
1¼"	42.16	11.50
1½"	48.26	11.50
2"	60.33	11.50
2½"	73.03	8.00
3"	88.90	8.00
3½"	101.60	8.00
4"	114.30	8.00

PG

DIN 40430

Size	Major dia.	TPI
PG7	12.50	20.00
PG9	15.20	18.00
PG11	18.60	18.00
PG13.5	20.40	18.00
PG16	22.50	18.00
PG21	28.30	16.00
PG29	37.00	16.00
PG36	47.00	16.00
PG42	54.00	16.00
PG48	59.30	16.00

Alternate ISO pipe thread designations

UK	**BSP P**arallel or **T**aper BS2279 (BS21)
Europe	**G** (Parallel) **GK** (Taper) **R** (Parallel) **RK** (Taper)
Japan	**PF** (Parallel) JIS B 303
CIS	**K mpy** (Taper)

BSP ISO pipe thread

ISO R/7; UNI 6125

Size	Pipe Dia.	TPI
⅜"	16.66	19.00
½"	20.96	14.00
¾"	26.44	14.00
1"	33.25	11.00
1¼"	41.91	11.00
1½"	47.80	11.00
2"	59.61	11.00
2½"	75.18	11.00
3"	87.88	11.00

ET imperial conduit

BS31

Size	Major dia.	TPI
⅝"	15.88	18.00
¾"	19.05	16.00
1"	25.40	16.00
1¼"	31.75	16.00
1½"	38.10	14.00
2"	50.80	14.00
2½"	63.50	14.00
3"	76.20	14.00

Thread dimension substitution chart

Metric	NPT (or NPS)	PG	BSP ISO Pipe	ET
M16	–	7, 9	–	⅝"
M20	½"	11, 13.5	½"	¾"
M25	¾"	16	¾"	1"
M32	1"	21	1"	1¼"
M40	1¼"	29	1¼"	1½"
M50	1½"	36	1½"	2"
M63	2"	42, 48	2"	2½"
M75	2½"	–	2½"	3"
M90 x 2.0	3"	–	3"	–
M100 x 2.0	3½"	–	–	–
M110 x 2.0	–	–	–	–
M120 x 2.0	–	–	–	–

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Part numbering system

Codes

Page No.	Product	Digits 1 & 2
Adaptors and reducers		
14-17	**AD**	Adaptor
14-17	RD	Reducer
18	TA	Swivel - in-line male to female
18	TC	Swivel - in-line female to female
18	TD	Swivel - in-line male to male
18	TP	Swivel - 90° male to female
18	TQ	Swivel - 90° female to female
18	TR	Swivel - 90° male to male
19	AY	'Y' adaptor
20	AT	'T' adaptor
21	AR	90° adaptor
22	AM	Male to male adaptor
23	AF	Female to female adaptor
24-25	DB	Insulated adaptor
Stopping Plugs		
26-27	PD	Dome head plug
28	PA	Type A plug
28	PB	Type B plug
Breather Drains		
31	DP	Breather drain (Exe)
32	BD	Breather drain (Exde)
Other products		
34	UN	Union - male to female
34	UF	Union - female to female
35	AE	Earth lead adaptor

Certification	Digit 3
U	Exd I and IIC & Exe I and IIC
D	Exd I and IIC
E	Exe I and IIC
F	Industrial (marked product)

Material	Digit 4
1	Brass
2	Mild steel
3	Stainless steel
4	Glass filled nylon
5	Aluminium
6	Nylon 6
7	Red fibre

Plating	Digit 5
0	Unplated
1	Electroless nickel
2	Zinc
6	Chromated

Example

Digits 1 & 2		Digit 3		Digit 4		Digit 5		Digits 6 & 7		Digits 8 & 9
AD	-	**U**	-	**1**	-	**1**	-	**29**	-	**04**
Adaptor		Exd/e certified		Brass		Nickel-plated		1/2" NPT (male)		M20 (female)

Always quote male thread first.

EATON
Powering Business Worldwide

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4.14 QM1.1..QM1.6 and QM2.1..QM2.6 – Cable Gland for Solenoid Valve, 501/421 O M20 Brass

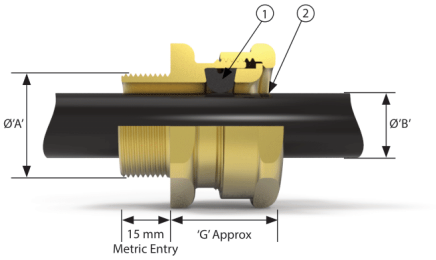
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CABLE GLAND COMPRESSION SERIES

501/421

Flameproof, Increased Safety, Dust Protection and Restricted Breathing
Class - Zones
Certified ATEX / IECEx / UKEX / c CSA us

International Approvals



■1 Elastomeric Exd Flameproof and Exe Increased Safety seal on cable outer sheath

■2 Rounded Cable entry to prevent cable damage

The 501/421 dual certified Exe/Exd cable gland is intended for use on non-armoured elastomer and plastic insulated cables.
This cable gland may be used with braided cables where the braid and outer sheath pass into the enclosure.
The braid must then be suitably terminated inside the enclosure. For Exd applications, the cable must be suitable in compliance with with BS EN 60079-14.

Cable Gland Selection Table

Size Ref.	Entry Thread Size		Cable Acceptance Details – Outer Sheath 'B'				Max Length 'G'	Hexagon Dimensions	
			Standard Seal		Alternative Seal (S)				
	Metric	NPT*	Min.	Max.	Min.	Max.		Across Flats	Across Corners
2K	M16	–	3.2	8.0	–	–	23.5	19.0	21.2
Os	M20[2]	½"	3.2	8.0	–	–	23.8	24.0	26.5
O	M20[2]	½"	6.5	11.9	–	–	23.8	24.0	26.5
A	M20	¾" or ½"	10.0	14.3	9.0	13.4	24.8	30.0	32.5
B	M25	1" or ¾"	13.0	20.2	9.5	15.4	25.8	36.0	39.5
C	M32	1¼" or 1"	19.5	26.5	15.5	21.2	29.2	46.0	50.5
C2	M40	1½" or 1¼"	25.0	32.5	22	28	30.5	55.0	60.6
D	M50	2" or 1½"	31.5	44.4 / 42.3[1]	27.5	34.8	40.4	65.0	70.8
E	M63	2½" or 2"	42.5	56.3 / 54.3[1]	39	46.5	38.2	80.0	88.0
F	M75	3" or 2½"	54.5	68.2 / 65.3[1]	49.5	58.3	40.5	95.0	104.0
G	M80	3½"	67.0	73.0	–	–	41	106.4	115.0
H	M90	3½"	67.0	77.6	–	–	41.0	115.0	130.0
J	M100	4"	77.0	91.6	–	–	41.0	127.0	142.0

All dimensions in millimetres (except * where dimensions are in inches)
Os - F size metric entry threads are 1.5mm pitch as standard, 15mm length of thread
G - J size metric entry threads are 2mm pitch as standard, 20mm length of thread

[1] *Smaller value is applicable when selecting reduced NPT entry option.*
[2] *Sizes Os and O are available with an M16 thread size. For O size with M16 thread, the maximum cable outer sheath diameter is 10.9mm*

HAWKE International

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www.hubbell.com/hawke

HUBBELL Harsh & Hazardous

HH-HKE-Multi-501-421-COMPRESSION-GLAND-SPEC-UK-2023 V8

CABLE GLAND COMPRESSION SERIES

Technical Data

Material Options	Manufactured in Brass, Nickel Plated Brass or 316L Stainless Steel
Ingress Protection	IP66, IP67 and IP68 (30 metres for 7 days, special instructions apply) to IEC/EN 60529 and NEMA 4X
Enclosure Protection	IK10 to IEC 62262
Deluge Protection	Deluge Protection to DTS01
Operating Temperature	-60°C to +100°C
Applications	Suitable for use in Zone 1, Zone 21, Zone 2 and Zone 22
Approvals	
Protection Class	Ex II 2GD Ex db IIC Gb; Ex eb IIC Gb; Ex nR IIC Gc; Ex tb IIIC Db
ATEX Certificate No	CML 19ATEX1167X CML 19ATEX4507X (Ex nR)
IECEx Certificate No	CML 19.0045X CML 21.0012X (Ex nR)
UKEX Certificate No	CML 21UKEX1161X CML 21UKEX4133X (Ex nR)
Construction & Test Standards	IEC/EN 62444 (Anchorage Type B), IEC/EN 60079-0, 1, 7, 15, 31
Marine Approvals	ABS: 19-LD1876514-1-PDA BV: 43523/B0 DNV: TAE0000BS
Additional Certifications	CCC: 2020312313000315 EAC: No EA3C RU C-GB.HA91.B.00264/21 EQM: 20-11-27224/Q20-11-000979/NB0007 Inmetro: IEx 14.0272X KCs: KTL 17-KA4BO-0120X to 0128X India: PESO P450038 SONCAP: LCOGB049552-0500
NEC / CEC	
NEC Protection Class	Class I, Zone I, AEx eb IIC Gb; Zone 21, AEx tb IIIC Db
CEC Protection Class	Class I, Div.2 Groups ABCD; Class II Div.2, Groups EFG; Class III Ex db IIC Gb; Ex eb IIC Gb
c CSA us Certificate Number	CSA1015065
Construction & Test Standards	UL 60079-0, UL 60079-7, UL 60079-31, CSA 22.2 No: 60079-0, CSA 22.2 No: 60079-1, CSA 22.2 No: 60079-7, CSA 22.2 No: 60079-31, UL514B; UL1203; UL 2225

Ordering Information

Format for ordering is as follows: Alternative Seal (S), add suffix S to ordering information

Cable Gland Type	Size	Thread	Material	(Optional)
501/421	C	M32	Brass	S
501/421	C	1¼" NPT	Brass	S

Order Example: 501/421 C M32 Brass S

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4.15 XT01..06 – Compression Seal for Wall Penetration, Roxtec RS 50 B Ex-kit

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Roxtec RS B Ex kit

The Roxtec RS B Ex is a round entry seal including a sleeve for bolting. The seal consists of two halves and an adaptable center with removable layers. Compression is integrated in the seal.

- For use in hazardous locations
- Attachment by bolting



RS 100 B Ex AISI 316 woc/primed



RS 75 B Ex AISI 316/AISI 316

Galvanized mild steel

Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 25 B Ex AISI316/GALV	3.6 - 12	36 - 36	0.43	EXRSB0250002118
RS 43 B Ex AISI316/GALV	4 - 23	54 - 54	0.9	EXRSB0430002118
RS 50 B Ex AISI316/GALV	8 - 30	65 - 65	1.4	101918
RS 75 B Ex AISI316/GALV	24 - 54	91 - 91	2	EXRSB0750002118
RS 100 B Ex AISI316 WOC/GALV	48 - 70	116 - 116	2.9	EXRSB0100102118
RS 100 B Ex AISI316/GALV	48 - 70	116 - 116	3	EXRSB1000002118
RS 125 B Ex AISI316 WOC/GALV	66 - 98	142 - 142	3.6	EXRSB0125102118
RS 125 B Ex AISI316/GALV	66 - 98	142 - 142	4.3	EXRSB1250002118
RS 150 B Ex AISI316 WOC/GALV	93 - 119	166 - 166	4.5	EXRSB0150102118

Primed mild steel

Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 100 B Ex AISI316 WOC/PRIMED	48 - 70	116 - 118	2.9	EXRSB0100102112
RS 125 B Ex AISI316 WOC/PRIMED	66 - 98	142 - 144	3.4	EXRSB0125102112
RS 150 B Ex AISI316 WOC/PRIMED	93 - 119	166 - 168	4.2	EXRSB0150102112

Stainless steel

Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 25 B Ex AISI316/AISI316	3.6 - 12	36 - 38	0.48	EXRSB0250002121
RS 43 B Ex AISI316/AISI316	4 - 23	54 - 56	0.9	EXRSB0430002121
RS 50 B Ex AISI316/AISI316	8 - 30	65 - 67	1.4	EXRSB0500002121

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Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 75 B Ex AISI316/AISI316	24 - 54	91 - 93	2.1	EXRSB0750002121
RS 100 B Ex AISI316 WOC/AISI316	48 - 70	116 - 118	2.7	EXRSB0100102121
RS 100 B Ex AISI316/AISI316	48 - 70	116 - 116	4.4	EXRSB1000002121
RS 125 B Ex AISI316 WOC/AISI316	66 - 98	142 - 144	3.6	EXRSB0125102121
RS 125 B Ex AISI316/AISI316	66 - 98	142 - 142	3.9	163616
RS 150 B Ex AISI316 WOC/AISI316	93 - 119	166 - 168	4.1	EXRSB0150002121

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4.16 XT07..09 – Cable Gland for Wall Penetration, 501/421 O M20 Brass

[Please refer to data sheet from Section 4.14.]

4.17 XT07..09 – M32 to M20 Reducer, RDU100604

[Please refer to data sheet from Section 4.13.]

4.18 XT10..11 – Cable Gland for Wall Penetration, 501/421 A M20 Brass

[Please refer to data sheet from Section 4.14.]

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4.19 XT10..11 – M40 to M20 Reducer, RDU100704

[Please refer to data sheet from Section 4.13.]

Section E

Instrument and Electrical Drawings

Sub Section E03-001

Introduction and overview

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	18/7/2025	Updated as build

Document Title:	**BLPH Project - Panel Cabinet Layout: Introduction and Overview**
Document Number:	K559-2254-CWIWP4202202-E03-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-E03-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Electrical Cabinet Documentation Introduction and Overview
Full Title	Crosswind/Baseload Power Hub Fuel Cell Package Electrical Cabinet Documentation Introduction and Overview
Abstract	The purpose of this document is to assist the reader of the E03 series of electrical documentation to understand the context and relation of the individual documents

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Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	PBL	June 2024
2	Update for "As Built Documentation"	PBL	July 2025

Checked by: n/a	Date: n/a
Approved by: n/a	Date: n/a

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1.0 Purpose and Scope

The purpose of this document is to provide the reader of the E03 series of documents with an overview of the electrical cabinets present in the Fuel Cell Package and the documents providing the documentation for each of them.

2.0 Electrical Cabinets

2.1 List of Cabinets

Designation	Description	Physical Location
GB01..GB06	Fuel Cell Modules (FCwave #1..#6)	40ft Container, one side of the container
UC01..UC06	Fuel Cell DCDC Converter Cabinet	40ft container, opposite fuel cells
UC20	40ft Container control Cabinet	40ft container, middle on DCDC side
UC30	Coolant Skid Control Cabinet	On the coolant skid, middle
UC31	10ft Container Control Cabinet	10ft container, behind control panel access hatch
UC41	Coolant Skid VFD Cabinet	On the coolant skid, back-to-back with UC30
UC50	AC Power Distribution	40ft container, facing entrance door

Table 1 - List of Cabinets

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3.0 Document contents

The documentation for the cabinets follows a standard template as follows:

3.1 Panel Information and Introduction

The section serves as front page and standard compliance requirements.

- Front Page with cabinet DT and name
- Ballard Standard wire color page
- Ballard Tagging Standard page
- Table of Contents

3.2 Controller IO Schematics

This section is only present if the cabinet contains PLC/Safety PLC racks. The section outlines the construction of the PLC and the cards in the PLC rack(s). For each input/output (DI/DO/AI/AO), the associated control loop is outlined.

3.3 Electrical Design Documentation

This section contains the multiline electrical documentation. Reader is expected to be familiar with electrical drawings.

3.4 Terminal Connections

This section contains terminal block listings and layouts for all terminal blocks.

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4.0 Overview of Panel Locations in FC Package

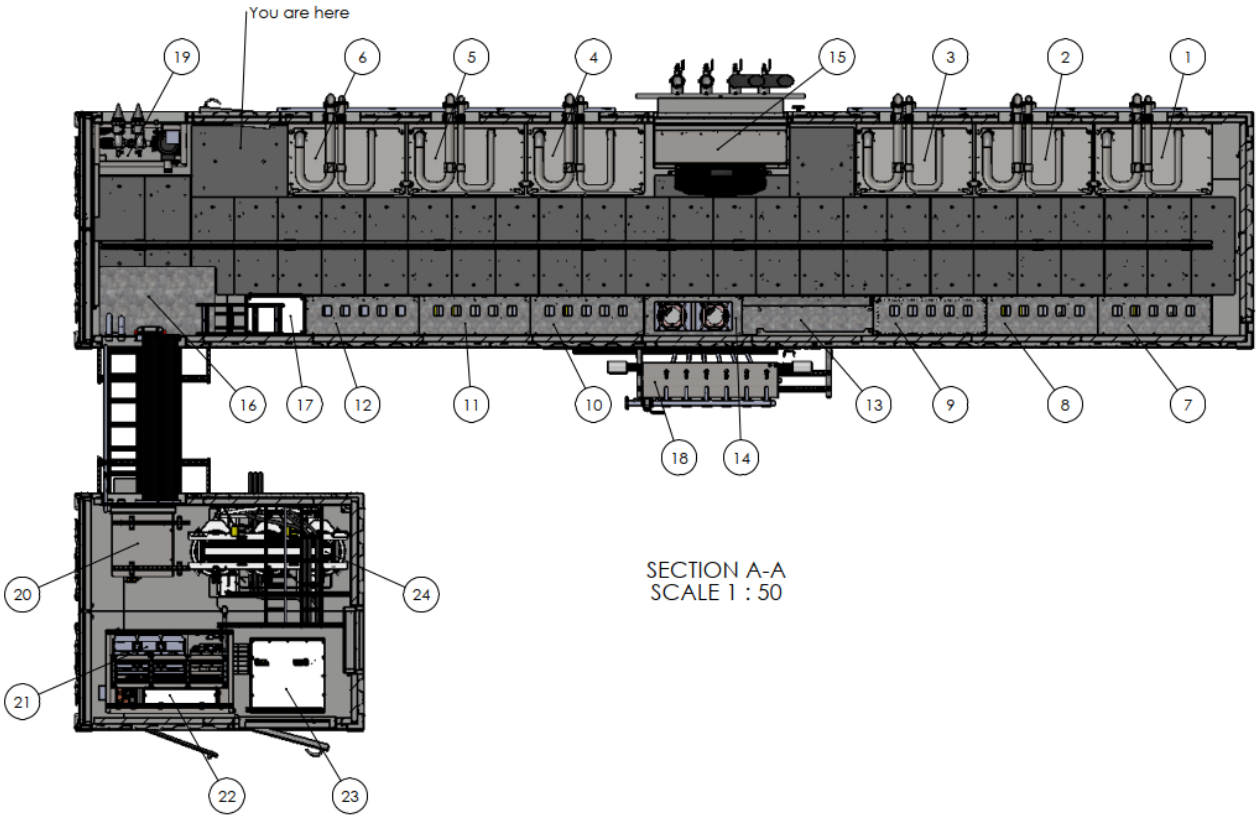
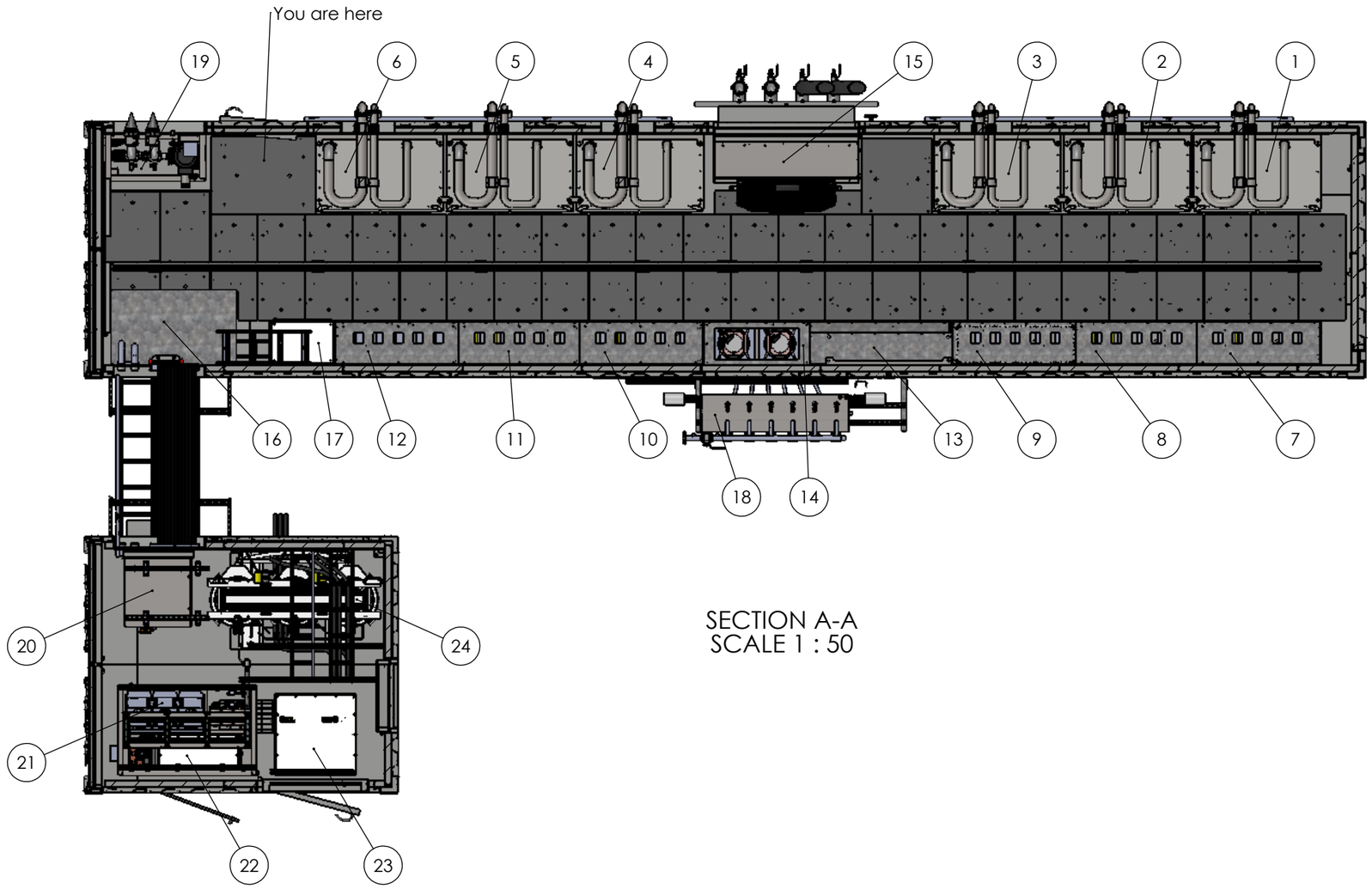


Figure 1 - Panel Locations (see Figure 2 for legend)

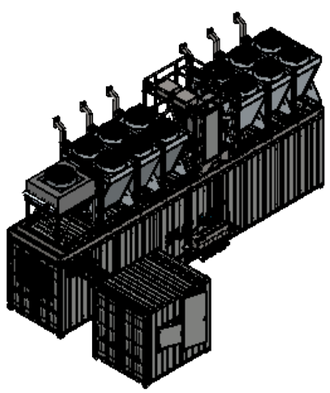
1	Fuelcell Module 1	GB01
2	Fuelcell Module 2	GB02
3	Fuelcell Module 3	GB03
4	Fuelcell Module 4	GB04
5	Fuelcell Module 5	GB05
6	Fuelcell Module 6	GB06
7	Fuelcell DC/DC Cabinet 1	UC01
8	Fuelcell DC/DC Cabinet 2	UC02
9	Fuelcell DC/DC Cabinet 3	UC03
10	Fuelcell DC/DC Cabinet 4	UC04
11	Fuelcell DC/DC Cabinet 5	UC05
12	Fuelcell DC/DC Cabinet 6	UC06
13	Controle Cabinet	UC20
14	Internal Container Ventilation	UC07
15	Container Ventilation	
16	AUX Transformer	TA03
17	AUX AC Cabintet	UC50
18	H2 Heater	EB01
19	LT Pump Rack	GP11
20	Container Ventilation	GQ10
21	Main DC/AC	TB30
22	Controle Cabinet	UC31
23	Breaker Cabinet	FC30
24	MV Transformer	TA30

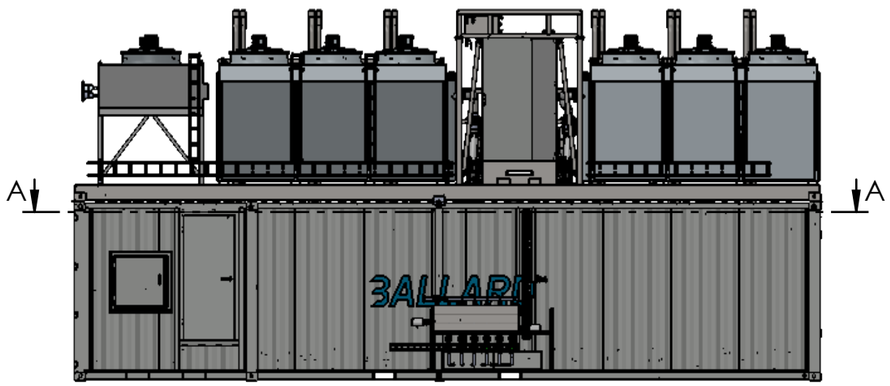
Figure 2 - Legend for Panel Locations

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SECTION A-A
SCALE 1 : 50





1	Fuelcell Module 1	GB01
2	Fuelcell Module 2	GB02
3	Fuelcell Module 3	GB03
4	Fuelcell Module 4	GB04
5	Fuelcell Module 5	GB05
6	Fuelcell Module 6	GB06
7	Fuelcell DC/DC Cabinet 1	UC01
8	Fuelcell DC/DC Cabinet 2	UC02
9	Fuelcell DC/DC Cabinet 3	UC03
10	Fuelcell DC/DC Cabinet 4	UC04
11	Fuelcell DC/DC Cabinet 5	UC05
12	Fuelcell DC/DC Cabinet 6	UC06
13	Controle Cabinet	UC20
14	Internal Container Ventilation	UC07
15	Container Ventilation	
16	AUX Transformer	TA03
17	AUX AC Cabintet	UC50
18	H2 Heater	EB01
19	LT Pump Rack	GP11
20	Container Ventilation	GQ10
21	Main DC/AC	TB30
22	Controle Cabinet	UC31
23	Breaker Cabinet	FC30
24	MV Transformer	TA30

Sub Section E03-002

UC20 40ft Control Cabinet

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	28/03/2025	Update with RM safety relay
003	29/09/2025	Update according to CRS - as buid

Document Title:	**BLPH Project - Panel Cabinet Layout: UC20 40ft Control Cabinet**
Document Number:	K559-2254-CWIWP4202202-E03-002
Revision:	Rev003
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-E03-002Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8

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+UC20

Ballard Power Systems Europe - Technology Solutions

Cabinet: 40ft Container Control
Location: 40ft Container, Middle

Vin = 400VAC, 3ph

Ikmax = 6kA - AC Supply

IP20

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& A01

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Front Page		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 255

FRM5103656/0B

Ballard Power Systems Europe - Technology Solutions, Cabinet Wiring Colors

Standard Basis: EN 61439

Required wire standard compliance:

Required: IEC Wire
Required: UL Recognized
Required: CSA/UL

Wire Numbering:

- Wires inside panels are to be numbered
- Wire number system is perferably "potential oriented with subnumber"
- All wires of the same potential (e.g. DC Common) have the same main number, with sequential subnumber.
- Potential numbers with fewer digits may be leading zero padded (e.g. 19 -> 019)
- Separator between main and subnumber is "."

Example: 019.1 BUWH 0.75mm²

- 019 — Wire potential number
- 1 — Wire sequential subnumber with separator
- BUWH — Wire color code (Dark Blue with White stripe)
- 0.75mm² — Wire dimension

AC Wiring Colors

AC Power Circuit (Generic)	Black (BK)
AC Phase L1	Brown (BN)
AC Phase L2	Black (BK)
AC Phase L3	Grey (GY)
AC Neutral	Light Blue (BU)
Externally supplied circuit	Orange (OG)

DC Wiring Colors

DC Power Circuit	Black (BK)
DC Control Voltage (24V)	Dark Blue (BU)
DC Control Voltage Refence (0V)	Dark Blue with White Stripe (BUWH)
Signal Wire (DI, DO)	White (WH)
Signal Wire (AI, AO)	Violet (VT)
Externally supplied circuit	Orange (OG)

PE Wiring Colors

Protective Earth (PE)	Green/Yellow (GNYE)

Conductor Colour Identification

IEC 60757:1983 Designation	Description
BK	Black
BN	Brown
RD	Red
OG	Orange
YE	Yellow
GN	Green
BU	Blue
VT	Violet
GY	Gray
WH	White
PK	Pink
GD	Gold
TQ	Turquoise
SR	Silver
GNYE	Green/Yellow
SH	Shield

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& A01

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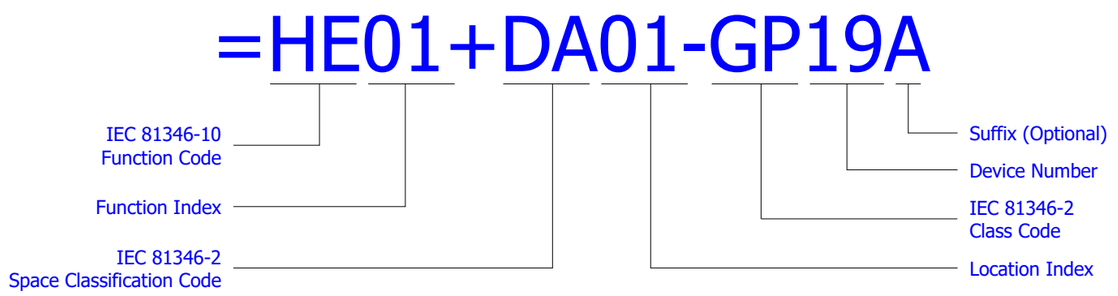
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Standard Wire Colors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 255

Ballard Power Systems Europe - Technology Solutions Device Tag Process

A Ballard Device Tagname consists of three parts:
- A function designation (=)
  - According to IEC81346-10, Table B.1 and B2.
  - Always two letters followed by two digits
- A location designation (+)
  - According to IEC81346-2, Table 4
  - Always two letters followed by two digits
- A class code (-)
  - According to IEC81346-2, Table 2
  - Always two letters followed by two or three digits plus optional suffix

Sample fully qualified Device Tag (DT) for a Coolant Pump



IEC81346-10 Function Examples

IEC 81346-10 Table B.1 and B.2 provide a class definition system, which provides a two letter code for the functional description
Table B.1 is used for power supply systems and table B.2 for other systems

IEC 81346-10 Table B.1 / B.2	Function Codes (Example)
=AA	Structural System, Load support (Frame)
=BA	Transporting Electrical Energy (Power Converters)
=HA	Supply System, Gaseous Matter (Gas Piping)
=HE	Supply System, Heating/Cooling (Radiator)
=JA	Distribution System, Gaseous Matter (Gas Handling Unit)
=JB	Distribution System, Liquid Matter (Fluid Drain)
=LA	Control System, Process (PLC, SCADA)
=LB	Control System, Safety (Safety PLC)
=QA	Storage System, Gaseous Matter (Gas Storage)
=RE	Energy Conversion System, Chemical to Electricity (Fuel cells, Batteries)

IEC81346-2 Space Classification

IEC 81346-2 Table 4 provide a classification scheme for spaces, which provides a two and three letter code for the space (location) classification.
Class code "1" and "1" is used for the location scheme

IEC 81346-2 Table 4	Location Codes (Example)
+GB	Space for power generation, Chemical (Fuel Cells)
+DA	Space for active technical equipment
+UC	Space for electrical equipment (Electrical Cabinet)

IEC81346-2 Class Code

IEC 81346-2 Class Codes is a scheme for defined objects for reference designations according to their inherent function

IEC 81346-2 Table 2	Class Codes (Example)
-BA	Sensing, electrical potential (Voltage Transducer)
-BC	Sensing, electrical current (Current Transducer)
-BP	Sensing, pressure (Pressure Transducer)
-BT	Sensing, temperature (Temperature Transducer)
-EA	Emitting, light (Light Fixture)
-FC	Protecting, overcurrent (Fuse, MCCB)
-GB	Generating, Chemical Reaction (Fuel Cell)
-GP	Generating, Liquid Flow (Pump)
-GQ	Generating, Gas Flow (Van, Ventilator)
-KE	Processing, Electrical signals (PLC)
-KF	Processing, Information (Network Switch)
-MA	Driving, Torque (AC Motor)
-QA	Controlling, Electric Current (Contactor, Motor Starter)
-QB	Controlling, Electric Separation (Disconnector)
-QM	Controlling, Fluid On/Off (Valve)
-QN	Controlling, Fluid Regulation (Damper, Gas Control Valve)
-WD	Guiding, Low Voltage Electric Energy (AC or DC power Cable)
-WE	Guiding, Reference Potential (Grounding Wire/Cable)
-WG	Guiding, Electric Signals (Control, Network Cable)

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
= ++ + UC20 & A01	

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Tagging Standard		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 3 / 255

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Ballard Power Systems Europe - Technology Solutions

Controller IO Overview Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C02

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DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Controller IO Overview Introduction		

ALL SHEETS ARE THE SAME REVISION STATUS | SIZE A3 | LANGUAGE EN | SHEET/TOTAL 4 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE01
DEIF AMC300
Fuel Cell Genset Controller
Container Control Cabinet

-Slot1
DEIF PSM3.1
Power Supply Module 3.1

PSM3.1

	PE PE		Frame Ground					
	1 12-24V		Supply +					
	2 0V		Supply COM					
	3 R1 COM		Status OK Relay COM					
A1.0	4 DO1	DO1	Status OK Relay					
	5 R2 COM		Relay 2 COM					
A1.1	6 DO2	DO2	Relay 1 Out					
	7 R3 COM		Relay 3 COM					
A1.2	8 DO3	DO3	Relay 3 Out					

EtherCAT Master Ring Topology — EtherCAT +&C01/5.4:C X03 — Ethernet-1 IN

EtherCAT Master Ring Topology — EtherCAT +&C01/5.4:C X03 — Ethernet-2 OUT

Bus Master
Multi-line 300

-Slot2
ACM3.1
Alternating Current Module 3.1

ACM3.1

1 L1	BA20_BA01_L1	AUX Customer Supply - L1 Voltage		
2 L2	BA20_BA01_L2	AUX Customer Supply - L2 Voltage		
3 L3	BA20_BA01_L3	AUX Customer Supply - L3 Voltage		
4 N	BA20_BA01_N	AUX Customer Supply - N Voltage		
5 L1	BA20_BA02_L1	Nanogrid Internal - L1 Voltage		
6 L2	BA20_BA02_L2	Nanogrid Internal - L2 Voltage		
7 L3	BA20_BA02_L3	Nanogrid Internal - L3 Voltage		
8 N	BA20_BA02_N	AUX Customer Supply - N Voltage		
9 L1-S1	BA20_BC01_L1	AUX Customer Supply - L1 Current		
10 L1-S2	CH1-S2	Channel 1 - S2		
11 L2-S1	BA20_BC01_L2	AUX Customer Supply - L2 Current		
12 L2-S2	CH2-S2	Channel 2 - S2		
13 L3-S1	BA20_BC01_L3	AUX Customer Supply - L3 Current		
14 L3-S2	CH3-S2	Channel 3 - S2		
15 4-S1	CH4-S1	Channel 4 - S1		
16 4-S2	CH4-S2	Channel 4 - S2		

-Slot3
&C03/104.3
&C03/85.5
&C03/42.3
&C03/105.8
&C03/32.6
&C03/27.7
&C03/27.7
&C03/27.7
&C03/27.7
IOM3.1
Alternating Current Module 3.1

IOM3.1

3 1 2	1 DO1.1	JS_EA01	Container light 1/3	
	2 R1 COM		Relay 1 Common	
	3 DO1.2		Relay 1 NC	
6 4 5	4 DO2.1	JS_EA02	Container lighting, 40ft 2/2	
	5 R2 COM		Relay 2 Common	
	6 DO2.2		Relay 2 NC	
9 7 8	7 DO3.1	JS_EA03	Container light 3/3 UPS Supply	&C03/104.3
	8 R3 COM		Relay 3 Com	&C03/104.3
	9 DO3.2		Relay 3 NC	
12 10 11	10 DO4.1	JB01_QB18_EB01	Heatracing drain	&C03/85.5
	11 R4 COM		Relay 4 Com	&C03/85.5
	12 DO4.2		Relay 4 NC	
	13 DI01	UC20_FCXX	400/230VAC Fuse Trip	&C03/42.3
	14 DI02	UC20_FC101	24VDC Fuse Trip	&C03/42.5
	15 DI03	DA01_SG100	Light Switch Container	&C03/105.8
	16 DI04	UC50_QA01_FB	Container Nanogrid Supply Feedback	
	17 DI05	UC50_QA02_FB	Container AUX Supply Feedback	
	18 DI06	UC20_FC210	24VDC light Fuse Trip	&C03/32.6
	19 DI07		Spare	
	20 DI08	UC20_RB30_RDY	PLC UPS Battery Ready	&C03/27.7
	21 DI09	UC20_RB30_BAT	PLC UPS Battery Operation	&C03/27.7
	22 DI10	UC20_RB30_SOH	PLC UPS Battery Low SOH	&C03/27.7
	23 COM		Supply COM	&C03/27.7

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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REVISION INFORMATION	
DESCRIPTION	
DATE	29-Sep-25

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Main Rack 1/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 5 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE01
DEIF AMC300
Fuel Cell Genset Controller

-Slot4

&C03/64.1
&C03/64.2
&C03/64.3
&C03/64.4
&C03/92.1
&C03/45.4
&C03/45.5
&C03/45.5
&C03/85.2
IOM3.2
IO Module 3.2

IOM3.2

1	R1 COM	&C03/64.1		Relay 1 In
2	DO1	&C03/64.2	FC1_RESET	FC1 Safety PLC Circuit Reset
3	R2 COM	&C03/64.3		Relay 2 COM
4	DO2	&C03/64.3	FC2_RESET	FC2 Safety PLC Circuit Reset
5	R3 COM	&C03/64.4		Relay 3 In
6	DO3	&C03/64.4	FC3_RESET	FC3 Safety PLC Circuit Reset
7	R4 COM			Relay 4 In
8	DO4			Relay 4 Out
9	AO1	&C03/92.1	JA01_QM01_SP	Ventilation Intake 1 Damper Postion SP
10	AO1 COM	&C03/92.2		AO1 COM
11	AO2	&C03/92.4	JA01_QM02_SP	Ventilation Intake 2 Damper Postion SP
12	AO2 COM	&C03/92.4		AO2 COM
13	AO3		LT_QN01_SP	LT Mixing Valve Setpoint
14	AO3 COM			AO3 COM
15	AO4			Spare
16	AO4 COM			AO4 COM
17	DI1	&C03/45.4	VT_GB03	FC3 24V Supply Feedback
18	DI2	&C03/45.5	VT_GB04	FC4 24V Supply Feedback
19	DI3			Spare
20	DI4			Spare
21	DI1-4 COM	&C03/45.5		DI1-4 COM
22	AI1	&C03/92.3	JA01_QM01_FB	Ventilation Intake 1 Damper Postion FB
23	AI1 COM	&C03/92.3		AI1 COM
24	AI2	&C03/92.5	JA01_QM02_FB	Ventilation Intake 2 Damper Postion FB
25	AI2 COM	&C03/92.5		AI2 COM
26	AI3		LT_QN01_FB	LT Mixing Valve Feedback
27	AI3 COM			AI3 COM
28	AI4	&C03/85.2	JB01_BL02_LSH	Condensate Drain Tank High Level
29	AI4 COM			AI4 COM

-Slot5

&C03/96.1
&C03/96.4
&C03/95.7
&C03/95.2
&C03/101.2
&C03/91.7
IOM3.3
IO Module 3.3

IOM3.3

1	AI1	&C03/96.1	JA01_BT01_TT	Ventilation Intake Temperature
2	AI1			Spare
3	AI1			Spare
4	AI2	&C03/96.4	JA01_BT02_TT	Container Temperature
5	AI2	&C03/96.4		Spare
6	AI2	&C03/96.4		Spare
7	AI3	&C03/96.6	JA01_BT03_TT	Container Temperature
8	AI3	&C03/96.7		Spare
9	AI3	&C03/96.7		Spare
10	AI4		JA01_BP05_TT	Vent. Duct Air Temperature
11	AI4			Spare
12	AI4			Spare
13	AI5			Spare
14	AI5	&C03/95.7	JA01_BP01_PDT	Ventilation Intake Filter Differential-pressure
15	AI5	&C03/95.7		Spare
16	AI6			Spare
17	AI6	&C03/95.2	JA01_BP02_PDT	Container Indoor/Outdoor Diffential Pressure
18	AI6	&C03/95.2		COM
19	AI7			Spare
20	AI7	&C03/101.2	HE03_DA01_BP01	LT Circuit Differential-pressure
21	AI7	&C03/101.2		COM
22	AI8	&C03/91.7	JA01_EB01_TT	Container Heater Internal Temperature
23	AI8			Spare
24	AI8			Spare
25	AI9			Spare
26	AI9			Spare
27	AI9			Spare
28	AI10			Spare
29	AI10			Spare
30	AI10			Spare

-Slot6

&C03/99.3
&C03/100.3
IOM3.3
IO Module 3.3

IOM3.3

1	AI1			Spare
2	AI1		LT_BF01_FT	LT Coolant Flow
3	AI1			-
4	AI2			Spare
5	AI2	&C03/99.3	HE03_DA01_BP02	LT feed pressure FC1
6	AI2	&C03/99.3		-
7	AI3			Spare
8	AI3	&C03/99.4	HE03_DA01_BP03	LT feed pressure FC2
9	AI3	&C03/99.4		-
10	AI4			Spare
11	AI4	&C03/99.6	HE03_DA01_BP04	LT feed pressure FC3
12	AI4	&C03/99.6		-
13	AI5			Spare
14	AI5	&C03/100.3	HE03_DA01_BP05	LT feed pressure FC4
15	AI5	&C03/100.3		-
16	AI6			Spare
17	AI6	&C03/100.4	HE03_DA01_BP06	LT feed pressure FC5
18	AI6	&C03/100.4		-
19	AI7			Spare
20	AI7	&C03/100.6	HE03_DA01_BP07	LT feed pressure FC6
21	AI7			-
22	AI8		LT_BT04_TT	LT Return Temperature
23	AI8			Spare
24	AI8			Spare
25	AI9		LT_BT05_TT	LT Radiator Return Temperature
26	AI9			Spare
27	AI9			Spare
28	AI10		LT_BT06_TT	LT Forward Temperature
29	AI10			Spare
30	AI10			Spare

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Main Rack 2/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 6 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE01
DEIF AMC300
Fuel Cell Genset Controller

-Slot7
DEIF PCM3.1
Processor and
Communication
Module 3.1

PCM3.1

CAN-A H
1
Other bus systems X01
CAN-A SH
2
Other bus systems X01
CAN-A L
3
Other bus systems X01

CAN-B H
4
Other bus systems X01
CAN-B SH
5
Other bus systems X01
CAN-B L
6
Other bus systems X01

SD Card

Ethernet-3
1
ETH1 Other bus systems X02

Ethernet-4
1
AGI Screen Connection Other bus systems X03

Ethernet-5
1
ETH04 Other bus systems X04

CPU
Multi-line 300

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Main Rack 3/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 7 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE02
DEIF AMC300
Fuel Cell Genset Controller - Extension Rack

-Slot1
DEIF PSM3.2
Power Supply Module 3.2

PSM3.2

	PE PE		Frame Ground	
	1 12-24V		Supply +	
	2 0V		Supply COM	
	3 R1 COM		Status OK Relay COM	
A52.4	4 DO1	DO1	Status OK Relay	
	5 R2 COM		Relay 2 COM	
A52.5	6 DO2	DO2	Relay 1 Out	
	7 R3 COM		Relay 3 COM	
A52.6	8 DO3	DO3	Relay 3 Out	

Ethernet-1
EtherCAT Follower Ring Topology — EtherCAT +&C01/5.6:C X03 — IN

Ethernet-2
EtherCAT Follower Ring Topology — EtherCAT +&C01/5.7:C X03 — OUT

Bus Follower
Multi-line 300

-Slot02
IOM3.3
IO Module 3.3

IOM3.3

1 AI1			Spare
2 AI2			Spare
3 AI3			Spare
4 AI4			Spare
5 AI5			Spare
6 AI6			Spare
7 AI7			Spare
8 AI8			Spare
9 AI9			Spare
10 AI10			Spare
11 AI11			Spare
12 AI12			Spare
13 AI13			Spare
14 AI14			Spare
15 AI15			Spare
16 AI16			Spare
17 AI17			Spare
18 AI18			Spare
19 AI19			Spare
20 AI20			Spare
21 AI21			Spare
22 AI22			Spare
23 AI23			Spare
24 AI24			Spare
25 AI25			Spare
26 AI26			Spare
27 AI27			Spare
28 AI28			Spare
29 AI29			Spare
30 AI30			Spare

-Slot03
&C03/91.2
&C03/43.2
&C03/43.1
&C03/33.7
&C03/33.7
&C03/33.7
&C03/33.7
&C03/36.7
&C03/33.7
&C03/36.7
&C03/36.7
&C03/36.7
&C03/39.7
&C03/39.7
&C03/39.7
&C03/39.7
&C03/39.7
IOM3.4
IO Module 3.4

IOM3.4

	1 12-24V			Supply +
	2 DO01	&C03/91.2	JA01_EB01_1	Heating element 1 ON
	3 DO02	&C03/91.4	JA01_EB01_2	Heating element 2 ON
	4 DO03	&C03/91.5	JA01_EB01_3	Heating element 3 ON
A3.1	5 DO04		DO04	Digital Out 04
	6 DO05	&C03/43.2	UC20_KF20.2	FC1 24V Toggle
	7 DO06	&C03/43.3	UC20_KF20.4	FC2 24V Toggle
	8 DO07	&C03/43.4	UC20_KF21.2	FC3 24V Toggle
	9 DO08	&C03/43.5	UC20_KF21.4	FC4 24V Toggle
	10 DO09	&C03/43.6	UC20_KF22.2	FC5 24V Toggle
	11 DO10	&C03/43.7	UC20_KF22.4	FC6 24V Toggle
A4.0	12 DO11		DO11	Digital Out 11
A4.1	13 DO12		DO12	Digital Out 12
	14 COM	&C03/43.1		Supply COM
E6.5	15 DI01		DI01	Digital In 01
E6.6	16 DI02		DI02	Digital In 02
E6.7	17 DI03		DI03	Digital In 03
	18 DI04	&C03/33.7	UC20_RB01_RDY	FC1+2 UPS Battery Ready
	19 DI05	&C03/33.7	UC20_RB01_BAT	FC1+2 UPS Battery Operation
	20 DI06	&C03/33.7	UC20_RB01_SOH	FC1+2 UPS Battery Low SOH
	21 DI07	&C03/33.7	UC20_RB01_DIS	FC1+2 UPS Battery Discharged
	22 DI08	&C03/36.7	UC20_RB02_RDY	FC3+4 UPS Battery Ready
	23 COM	&C03/33.7		Supply COM
	24 DI09	&C03/36.7	UC20_RB02_BAT	FC3+4 UPS Battery Operation
	25 DI10	&C03/36.7	UC20_RB02_SOH	FC3+4 UPS Battery Low SOH
	26 DI11	&C03/36.7	UC20_RB02_DIS	FC3+4 UPS Battery Discharged
	27 DI12	&C03/39.7	UC20_RB03_RDY	FC5+6 UPS Battery Ready
	28 DI13	&C03/39.7	UC20_RB03_BAT	FC5+6 UPS Battery Operation
	29 DI14	&C03/39.7	UC20_RB03_SOH	FC5+6 UPS Battery Low SOH
	30 DI15	&C03/39.7	UC20_RB03_DIS	FC5+6 UPS Battery Discharged
E8.4	31 DI16		DI16	Digital In 16
	32 COM	&C03/39.7		Supply COM

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Extension Rack 1/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 8 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE02
DEIF AMC300
Fuel Cell Genset Controller - Extension Rack

-Slot04

&C03/66.5
&C03/69.5
&C03/67.1
IOM3.4
IO Module 3.4

IOM3.4

1	12-24V			Supply +
2	DO01	&C03/66.5	GB01_MD_ENABLE	MD_Enable Signal
3	DO02	&C03/69.5	GB02_MD_ENABLE	MD_Enable Signal
4	DO03			SPARE
5	DO04			SPARE
6	DO05			SPARE
7	DO06			SPARE
8	DO07			SPARE
9	DO08			SPARE
10	DO09			SPARE
11	DO10			SPARE
12	DO11			SPARE
13	DO12			SPARE
14	COM			Supply COM
15	DI01	&C03/67.1	GB01_SAFE_FIRE	SAFE_FIRE Safety Signal
16	DI02	&C03/67.2	GB01_SAFE_H2CONC	SAFE_H2CONC Safety Signal
17	DI03	&C03/67.3	GB01_SAFE_VENT	SAFE_VENT Safety Signal
18	DI04	&C03/67.4	GB01_SAFE_WD	SAFE_WD Safety Signal
19	DI05	&C03/67.7	GB01_SAFE_FIREMALF	SAFE_FIREMALF Safety Signal
20	DI06	&C03/67.8	GB01_SAFE_EXTERN	SAFE_EXTERN Safety Signal
21	DI07	&C03/66.3	GB01_FCM_OK	Fuel Cell Module OK
22	DI08	&C03/70.1	GB02_SAFE_FIRE	SAFE_FIRE Safety Signal
23	COM			Supply COM
24	DI09	&C03/70.2	GB02_SAFE_H2CONC	SAFE_H2CONC Safety Signal
25	DI10	&C03/70.3	GB02_SAFE_VENT	SAFE_VENT Safety Signal
26	DI11	&C03/70.4	GB02_SAFE_WD	SAFE_WD Safety Signal
27	DI12	&C03/70.7	GB02_SAFE_FIREMALF	SAFE_FIREMALF Safety Signal
28	DI13	&C03/70.8	GB02_SAFE_EXTERN	SAFE_EXTERN Safety Signal
29	DI14	&C03/69.3	GB02_FCM_OK	Fuel Cell Module OK
30	DI15			SPARE
31	DI16			SPARE
32	COM			Supply COM

=RE01+GB01-KE02-Slot04:

-Slot05

&C03/73.1
&C03/73.7
&C03/73.8
&C03/72.3
&C03/76.1
&C03/76.7
&C03/76.8
&C03/75.3
IOM3.4
IO Module 3.4

IOM3.4

1	12-24V			Supply +
2	DO01	&C03/72.5	GB03_MD_ENABLE	MD_Enable Signal
3	DO02	&C03/75.5	GB04_MD_ENABLE	MD_Enable Signal
4	DO03			SPARE
5	DO04			SPARE
6	DO05			SPARE
7	DO06			SPARE
8	DO07			SPARE
9	DO08			SPARE
10	DO09			SPARE
11	DO10			SPARE
12	DO11			SPARE
13	DO12			SPARE
14	COM			Supply COM
15	DI01	&C03/73.1	GB03_SAFE_FIRE	SAFE_FIRE Safety Signal
16	DI02	&C03/73.2	GB03_SAFE_H2CONC	SAFE_H2CONC Safety Signal
17	DI03	&C03/73.3	GB03_SAFE_VENT	SAFE_VENT Safety Signal
18	DI04	&C03/73.4	GB03_SAFE_WD	SAFE_WD Safety Signal
19	DI05	&C03/73.7	GB03_SAFE_FIREMALF	SAFE_FIREMALF Safety Signal
20	DI06	&C03/73.8	GB03_SAFE_EXTERN	SAFE_EXTERN Safety Signal
21	DI07	&C03/72.3	GB03_FCM_OK	Fuel Cell Module OK
22	DI08	&C03/76.1	GB04_SAFE_FIRE	SAFE_FIRE Safety Signal
23	COM			Supply COM
24	DI09	&C03/76.2	GB04_SAFE_H2CONC	SAFE_H2CONC Safety Signal
25	DI10	&C03/76.3	GB04_SAFE_VENT	SAFE_VENT Safety Signal
26	DI11	&C03/76.4	GB04_SAFE_WD	SAFE_WD Safety Signal
27	DI12	&C03/76.7	GB04_SAFE_FIREMALF	SAFE_FIREMALF Safety Signal
28	DI13	&C03/76.8	GB04_SAFE_EXTERN	SAFE_EXTERN Safety Signal
29	DI14	&C03/75.3	GB04_FCM_OK	Fuel Cell Module OK
30	DI15			SPARE
31	DI16			SPARE
32	COM			Supply COM

-Slot06

&C03/79.1
&C03/79.7
&C03/79.8
&C03/78.3
&C03/82.1
&C03/82.7
&C03/82.8
&C03/81.3
IOM3.4
IO Module 3.4

IOM3.4

1	12-24V			Supply +
2	DO01	&C03/78.5	GB05_MD_ENABLE	MD_Enable Signal
3	DO02	&C03/81.5	GB06_MD_ENABLE	MD_Enable Signal
4	DO03			SPARE
5	DO04			SPARE
6	DO05			SPARE
7	DO06			SPARE
8	DO07			SPARE
9	DO08			SPARE
10	DO09			SPARE
11	DO10			SPARE
12	DO11			SPARE
13	DO12			SPARE
14	COM			Supply COM
15	DI01	&C03/79.1	GB05_SAFE_FIRE	SAFE_FIRE Safety Signal
16	DI02	&C03/79.2	GB05_SAFE_H2CONC	SAFE_H2CONC Safety Signal
17	DI03	&C03/79.3	GB05_SAFE_VENT	SAFE_VENT Safety Signal
18	DI04	&C03/79.4	GB05_SAFE_WD	SAFE_WD Safety Signal
19	DI05	&C03/79.7	GB05_SAFE_FIREMALF	SAFE_FIREMALF Safety Signal
20	DI06	&C03/79.8	GB05_SAFE_EXTERN	SAFE_EXTERN Safety Signal
21	DI07	&C03/78.3	GB05_FCM_OK	Fuel Cell Module OK
22	DI08	&C03/82.1	GB06_SAFE_FIRE	SAFE_FIRE Safety Signal
23	COM			Supply COM
24	DI09	&C03/82.2	GB06_SAFE_H2CONC	SAFE_H2CONC Safety Signal
25	DI10	&C03/82.3	GB06_SAFE_VENT	SAFE_VENT Safety Signal
26	DI11	&C03/82.4	GB06_SAFE_WD	SAFE_WD Safety Signal
27	DI12	&C03/82.7	GB06_SAFE_FIREMALF	SAFE_FIREMALF Safety Signal
28	DI13	&C03/82.8	GB06_SAFE_EXTERN	SAFE_EXTERN Safety Signal
29	DI14	&C03/81.3	GB06_FCM_OK	Fuel Cell Module OK
30	DI15		DI15	Digital In 15
31	DI16		DI16	Digital In 16
32	COM			Supply COM

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DESCRIPTION	
DATE	29-Sep-25

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Extension Rack 2/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 9 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE02
DEIF AMC300
Fuel Cell Genset Controller - Extension Rack

-Slot07
&C03/64.5
&C03/64.5
&C03/64.6
&C03/93.1
&C03/94.1
&C03/45.6
&C03/45.8
&C03/93.2
&C03/94.2
IOM3.2
IO Module 3.2

IOM3.2

1	R1 COM	&C03/64.5		Relay 1 In
2	DO1	&C03/64.5	FC4_RESET	FC4 Safety PLC Circuit Reset
3	R2 COM	&C03/64.6		Relay 2 COM
4	DO2	&C03/64.6	FC5_RESET	FC5 Safety PLC Circuit Reset
5	R3 COM			Relay 3 In
6	DO3		FC6_RESET	FC6 Safety PLC Circuit Reset
7	R4 COM			Relay 4 In
8	DO4			Relay 4 Out
9	AO1	&C03/93.1 &C03/94.1	JA01_QM03_SP	Ventilation Outlet A Damper Postion SP
10	AO1 COM	&C03/93.2 &C03/94.2		AO1 COM
11	AO2	&C03/93.6 &C03/94.6	JA01_QM04_SP	Ventilation Outlet B Damper Postion SP
12	AO2 COM	&C03/93.6 &C03/94.6		AO2 COM
13	AO3			Ventilation Outlet C Damper Postion SP
14	AO3 COM			AO3 COM
15	AO4			Ventilation Intake D Damper Postion SP
16	AO4 COM			AO4 COM
17	DI1			FC4 24V Supply Feedback
18	DI2	&C03/45.6	VT_GB05	FC5 24V Supply Feedback
19	DI3	&C03/45.7	VT_GB06	FC6 24V Supply Feedback
20	DI4			Spare
21	DI1-4 COM	&C03/45.8		DI1-4 COM
22	AI1	&C03/93.2 &C03/94.2	JA01_QM03_FB	Ventilation Outlet A Damper Postion FB
23	AI1 COM	&C03/93.3 &C03/94.3		AI1 COM
24	AI2	&C03/93.5 &C03/94.5	JA01_QM04_FB	Ventilation Outlet B Damper Postion FB
25	AI2 COM	&C03/93.5 &C03/94.5		AI2 COM
26	AI3			Ventilation Outlet C Damper Postion FB
27	AI3 COM			AI3 COM
28	AI4			Ventilation Intake D Damper Postion FB
29	AI4 COM			AI4 COM

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C02

REVISION INFORMATION	
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Extension Rack 3/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 10 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE03

DEIF AMC300
Fuel Cell Genset Controller - Extension Rack 2

-Slot1

&C03/44.6
&C03/44.7
PSM3.2
Power Supply
Module 3.2

PSM3.2

1	12-24V		Frame Ground
2	0V		Supply +
PE	PE		Supply COM
7	R1 COM	&C03/44.6	Status OK Relay COM
8	DO1	&C03/44.7 FC5_24VON	FC5 24V Supply On Signal
3	R2 COM		Relay 2 COM
4	DO1	DO2	<Reserved>
5	R3 COM		Relay 3 COM
6	DO2	DO3	Relay 3 Out

Ethernet-1
IN
Rack Connection IN EtherCAT +&C01/5.8:C X03

Ethernet-2
OUT
Rack Connection OUT EtherCAT +&C01/5.9:C X03

Bus Slave
Multi-line 300

-Slot2

&C03/44.1
&C03/44.1
&C03/44.2
&C03/44.2
&C03/44.4
&C03/44.4
&C03/44.5
&C03/44.5
&C03/45.1
&C03/45.3
IOM3.2
IO Module 3.2

IOM3.2

1	R1 COM	&C03/44.1	Relay 1 In
2	DO1	&C03/44.1 FC1_24VON	FC1 24V Supply On Signal
3	R2 COM	&C03/44.2	Relay 2 COM
4	DO2	&C03/44.2 FC2_24VON	FC2 24V Supply On Signal
5	R3 COM	&C03/44.4	Relay 3 In
6	DO3	&C03/44.4 FC3_24VON	FC3 24V Supply On Signal
7	R4 COM	&C03/44.5	Relay 4 In
8	DO4	&C03/44.5 FC4_24VON	FC4 24V Supply On Signal
9	AO1		Spare
10	AO1 COM		AO1 COM
11	AO2		Spare
12	AO2 COM		AO2 COM
13	AO3		Spare
14	AO3 COM		AO3 COM
15	AO4		Spare
16	AO4 COM		AO4 COM
17	DI1	&C03/45.1 VT_GB01	FC1 24V Supply Feedback
18	DI2	&C03/45.2 VT_GB02	FC2 24V Supply Feedback
19	DI3		FC3 24V Supply Feedback
20	DI4		Spare
21	DI1-4 COM	&C03/45.3	DI1-4 COM
22	AI1		Spare
23	AI1 COM		AI1 COM
24	AI2		Spare
25	AI2 COM		AI2 COM
26	AI3		Spare
27	AI3 COM		AI3 COM
28	AI4		Spare
29	AI4 COM		AI4 COM

-Slot3

&C03/102.1
&C03/102.3
IOM3.3
IO Module 3.3

IOM3.3

1	AI1	H2_BT01_TT	FC1 Hydrogen Supply Pipe Temperature
2	AI2		Spare
3	AI3		Spare
4	AI4	H2_BT02_TT	FC2 Hydrogen Supply Pipe Temperature
5	AI5		Spare
6	AI6		Spare
7	AI7	H2_BT03_TT	FC3 Hydrogen Supply Pipe Temperature
8	AI3		Spare
9	AI9		Spare
10	AI10	H2_BT04_TT	FC4 Hydrogen Supply Pipe Temperature
11	AI11		Spare
12	AI12		Spare
13	AI13	H2_BT05_TT	FC5 Hydrogen Supply Pipe Temperature
14	AI14		Spare
15	AI15		Spare
16	AI16		FC6 Hydrogen Supply Pipe Temperature
17	AI17		Spare
18	AI18		Spare
19	AI19 &C03/102.1	HE03_DA01_BT01	FC1 HT Coolant Outlet Temperature
20	AI20 &C03/102.1		Spare
21	AI21 &C03/102.1		Spare
22	AI22 &C03/102.3	HE03_DA01_BT02	FC2 HT Coolant Outlet Temperature
23	AI23 &C03/102.3		Spare
24	AI24 &C03/102.3		Spare
25	AI25 &C03/102.4	HE03_DA01_BT03	FC3 HT Coolant Outlet Temperature
26	AI26 &C03/102.4		Spare
27	AI27 &C03/102.5		Spare
28	AI28		Spare
29	AI29		Spare
30	AI30		Spare

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C02

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Extension Rack 2 1/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 11 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20-KE03
DEIF AMC300
Fuel Cell Genset Controller - Extension Rack 2

Slot4
&C03/86.1
&C03/86.4
&C03/87.1
&C03/103.1
IOM3.3
IO Module 3.3

IOM3.3

1	AI1	&C03/86.1	UC01_BT01_TT	Cabinet temperature UC01
2	AI2	&C03/86.1		Spare
3	AI3	&C03/86.1		Spare
4	AI4	&C03/86.4	UC02_BT01_TT	Cabinet temperature UC02
5	AI5	&C03/86.4		Spare
6	AI6	&C03/86.4		Spare
7	AI7	&C03/86.7	UC03_BT01_TT	Cabinet temperature UC03
8	AI8	&C03/86.7		Spare
9	AI9	&C03/86.7		Spare
10	AI10	&C03/87.1	UC04_BT01_TT	Cabinet temperature UC04
11	AI11	&C03/87.1		Spare
12	AI12	&C03/87.1		Spare
13	AI13	&C03/87.4	UC05_BT01_TT	Cabinet temperature UC05
14	AI14	&C03/87.4		Spare
15	AI15	&C03/87.4		Spare
16	AI16	&C03/87.7	UC06_BT01_TT	Cabinet temperature UC06
17	AI17	&C03/87.7		Spare
18	AI18	&C03/87.7		Spare
19	AI19	&C03/103.1	HE03_DA01_BT04	FC4 HT Coolant Outlet Temperature
20	AI20	&C03/103.1		Spare
21	AI21	&C03/103.1		Spare
22	AI22	&C03/103.3	HE03_DA01_BT05	FC5 HT Coolant Outlet Temperature
23	AI23	&C03/103.3		Spare
24	AI24	&C03/103.3		Spare
25	AI25	&C03/103.4	2HE03_DA01_BT06	FC6 HT Coolant Outlet Temperature
26	AI26			Spare
27	AI27			Spare
28	AI28			Spare
29	AI29			Spare
30	AI30			Spare

-Slot5
&C03/97.3
IOM3.3
IO Module 3.3

IOM3.3

1	AI1			Spare
2	AI2	&C03/97.3	JA01_BU01_TT	Container Ambient Temperature - Center
3	AI3	&C03/97.4		Spare
4	AI4			Spare
5	AI5	&C03/97.4	JA01_BU01_RH	Container Relative Humidity
6	AI6	&C03/97.4		Spare
7	AI7			Spare
8	AI8	&C03/97.5	JA01_BU01_CO2	Container CO2 Concentration
9	AI9	&C03/97.5		Spare
10	AI10			Spare
11	AI11	&C03/97.6	JA01_BU01_VOC	Container Ambient VOC Concentration
12	AI12	&C03/97.6		Spare
13	AI13			Spare
14	AI14			Spare
15	AI15			Spare
16	AI16			Spare
17	AI17			Spare
18	AI18			Spare
19	AI19			Spare
20	AI20			Spare
21	AI21			Spare
22	AI22			Spare
23	AI23			Spare
24	AI24			Spare
25	AI25			Spare
26	AI26			Spare
27	AI27			Spare
28	AI28			Spare
29	AI29			Spare
30	AI30			Spare

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C02

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DATE
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, Extension Rack 2 2/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 12 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Safety System, Control Cabinet

-KE10
24 VDC
Safety PLC, PLC

+ A1
- A2
X03 BUS
<CANbus>
BUS EFI1_A &C03/46.1
BUS EFI1_B &C03/46.1
BUS EFI2_A &C03/46.1

EFI bus Master

-KE11
24 VDC
Safety PLC, Modbus Gateway

PORT 1
1
-X1
Other bus systems
Safety PLC

Other bus systems
-X2
2
PORT 2

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C02

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Safety Controller, 40ft Container 1/5		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 13 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Safety System, Control Cabinet

-KE12

&C03/46.2
&C03/47.1
&C03/47.2
&C03/47.5
&C03/59.5
&C03/59.3
&C03/47.6
&C03/57.2
&C03/59.4
&C03/25.1
8DI, 4DO
Safe Digital Input/Output Module

Flexi Soft, expansion module, I/O module, FX3-XTIO

X1	&C03/25.1	KE12PULSE01	KE12 Test pulse output CH1
X2	&C03/25.2	KE12PULSE02	KE12 Test pulse output CH2
+ A1			
- A2			
I1	&C03/47.1	UC20_SG10_CH1	E-stop UC20 CH01
I2	&C03/47.2	UC20_SG10_CH2	E-stop UC20 CH02
I3	&C03/47.5	UC20_SG11.S	Reset Button E-Stop
I4		UC20_KF17_FB	KF17 Feedback safety relay
I5	&C03/59.5	UC30_SG20-1	Coolant Skid ESTOP CH1
I6	&C03/59.6	UC30_SG20-2	Coolant Skid ESTOP CH2
I7	&C03/59.3	UC30_KF10_FB	Coolant Skid Safety Relay FB
I8		UC21_KF108	Feedback safety relay UC21
Q1	&C03/47.6	UC20_SG11.P	Reset Button E-Stop Light
Q2	&C03/57.2	UC20_KF17	KF17 Safety Relay Coil
Q3	&C03/59.4	UC30_KF10_Q	Coolant Skid Safety Relay Coil
Q4			Spare

SICK.1044125

-KE13

&C03/46.3
&C03/64.2
&C03/48.3
&C03/49.3
&C03/25.2
8DI, 4DO
Safe Digital Input/Output Module

Flexi Soft, expansion module, I/O module, FX3-XTIO

X1	&C03/25.2	KE13PULSE01	KE13 Test pulse output CH1
X2	&C03/25.3	KE13PULSE02	KE13 Test pulse output CH2
+ A1			
- A2			
I1	&C03/48.4	UC20_KF100	Feedback Safety Relay GB01 & UC01
I2		GB01	SAFE_Main GB01
I3	&C03/49.4	UC20_KF101	Feedback Safety Relay GB02 & UC02
I4		GB02	SAFE_Main GB02
I5	&C03/64.2	FC1_RESET_IN	FC1 Safety PLC Circuit Reset
I6			SPARE
I7	&C03/64.3	FC2_RESET_IN	FC2 Safety PLC Circuit Reset
I8			SPARE
Q1	&C03/48.3	UC20_KF100	Coil Safety relay GB01 & UC01
Q2		GB01	SAFE_In GB01
Q3	&C03/49.3	UC20_KF101	Coil Safety relay GB02 & UC02
Q4		GB02	SAFE_In GB02

SICK.1044125

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
= ++ + UC20 & C02	

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Safety Controller, 40ft Container 2/5		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 14 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Safety System, Control Cabinet

-KE14

&C03/46.5
&C03/64.4
&C03/50.3
&C03/51.3
&C03/25.4
8DI, 4DO
Safe Digital Input/Output Module

Flexi Soft, expansion module, I/O module, FX3-XTIO

X1		&C03/25.4	KE14PULSE01	KE14 Test pulse output CH1
X2		&C03/25.5	KE14PULSE02	KE14 Test pulse output CH2
+	A1			
-	A2			
I1		&C03/50.4	UC20_KF102	Feedback Safety Relay GB03 & UC03
I2			GB03	SAFE_Main GB03
I3		&C03/51.4	UC20_KF103	Feedback Safety Relay GB04 & UC04
I4			GB04	SAFE_Main GB04
I5		&C03/64.4	FC3_RESET_IN	FC3 Safety PLC Circuit Reset
I6				
I7		&C03/64.5	FC4_RESET_IN	FC4 Safety PLC Circuit Reset
I8				
Q1		&C03/50.3	UC20_KF102	Coil Safety relay GB03 & UC03
Q2			GB03	SAFE_In GB03
Q3		&C03/51.3	UC20_KF103	Coil Safety relay GB04 & UC04
Q4			GB04	SAFE_In GB04

SICK.1044125

-KE15

8DI, 4DO
FC6 Safety PLC Circuit Reset

Flexi Soft, expansion module, I/O module, FX3-XTIO

X1		&C03/25.6	KE15PULSE01	KE15 Test pulse output CH1
X2		&C03/25.7	KE15PULSE02	KE15 Test pulse output CH2
+	A1			
-	A2			
I1		&C03/52.4	UC20_KF104	Feedback Safety Relay GB05 & UC05
I2			GB05	SAFE_Main GB05
I3		&C03/53.4	UC20_KF105	Feedback Safety Relay GB06 & UC06
I4			GB06	SAFE_Main GB06
I5		&C03/64.6	FC5_RESET_IN	FC5 Safety PLC Circuit Reset
I6				
I7		&C03/64.8	FC6_RESET_IN	FC6 Safety PLC Circuit Reset
I8				
Q1		&C03/52.3	UC20_KF104	Coil Safety relay GB05 & UC05
Q2			GB05	SAFE_In GB05
Q3		&C03/53.3	UC20_KF105	Coil Safety relay GB06 & UC06
Q4			GB06	SAFE_In GB06

SICK.1044125

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C02

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Safety Controller, 40ft Container 3/5		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 15 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Safety System, Control Cabinet

-KE16
&C03/46.7
&C03/62.4
&C03/63.5
&C03/63.6
&C03/57.3
&C03/56.2
&C03/26.1
Safety Digital
Input/Output Module

Flexi Soft, expansion module, I/O module, FX3-XTIO

X1	&C03/26.1	KE16PULSE01	KE16 Test pulse output CH1
X2	&C03/26.2	KE16PULSE02	KE16 Test pulse output CH2
+ A1			
- A2			
I1	&C03/57.3	+UC20-KF16	Coil Safety Relay Nanogrid DC/AC
I2		JA01_BQ04_ASZ	Smoke Detector Ventilation Inlet
I3		JA01_BQ05_ASZ	Smoke Detector Ventilation Outlet A
I4		JA01_BQ06_ASZ	Smoke Detector Ventilation Outlet B
I5			ESTOP - 40ft Container Door CH1
I6			ESTOP - 40ft Container Door CH2
I7	&C03/62.4	SG23_CH1	ESTOP - 40ft Container Door CH1
I8	&C03/62.5	SG23_CH2	ESTOP - 40ft Container Door CH2
Q1	&C03/56.2 &C03/56.3	+UC20-KF16	Coil Safety Relay Nanogrid DC/AC
Q2	&C03/63.7	UC20_KF53	Customer Gas Status
Q3	&C03/63.5	UC20_KF50	Customer Safety Status
Q4	&C03/63.6	UC20_KF51	Customer Fire Status

SICK.1044125

-KE17
1 AI
Safe Analog Input Module

Flexi Soft Analog input module, FX3-ANA0

AI+ AI1+		JA01_BQ01_AZT	H2 Sensor Ventilation Inlet
AI1- AI- AI1-			
AI2+ AI+ AI2+			
AI2- AI- AI2-			

SICK.1051134

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C02

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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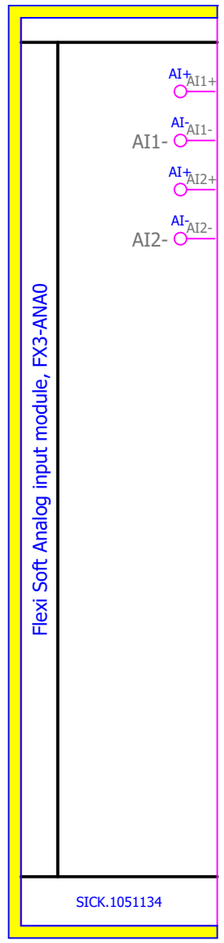
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Safety Controller, 40ft Container 4/5		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 16 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Safety System, Control Cabinet

-KE18
1 AI
Safe Analog Input Module



JA01_BQ02_AZT

H2 Sensor Ventilation Outlet A

-KE19
1 AI
Safe Analog Input Module



JA01_BQ03_AZT

H2 Sensor Ventilation Outlet B

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet		REVISION	12	
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet				
SHEET TYPE/DESC	Safety Controller, 40ft Container 5/5				
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	17 / 255	

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Ballard Power Systems Europe - Technology Solutions

Multiline Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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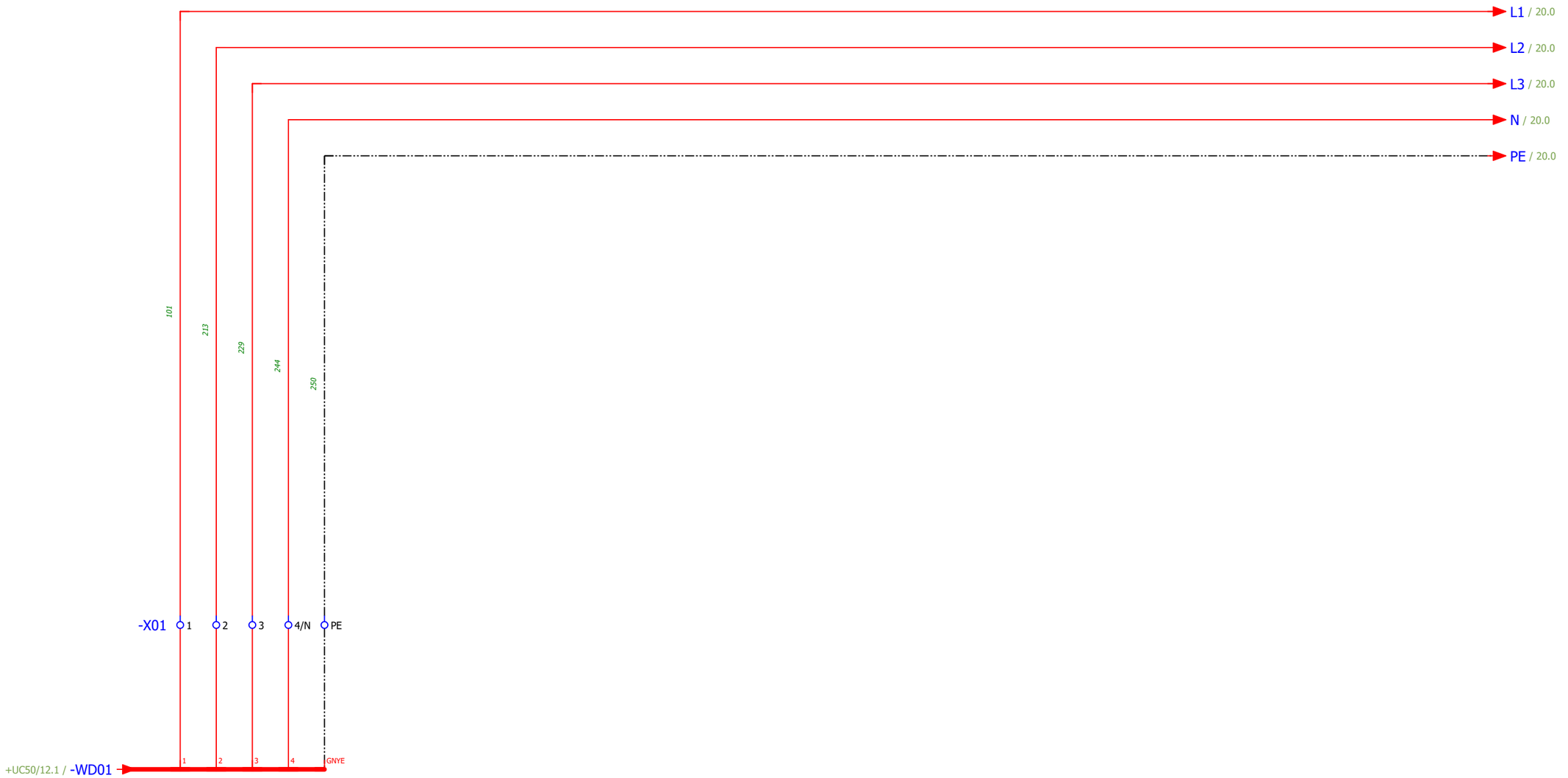
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Multiline Documentation Intro		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 18 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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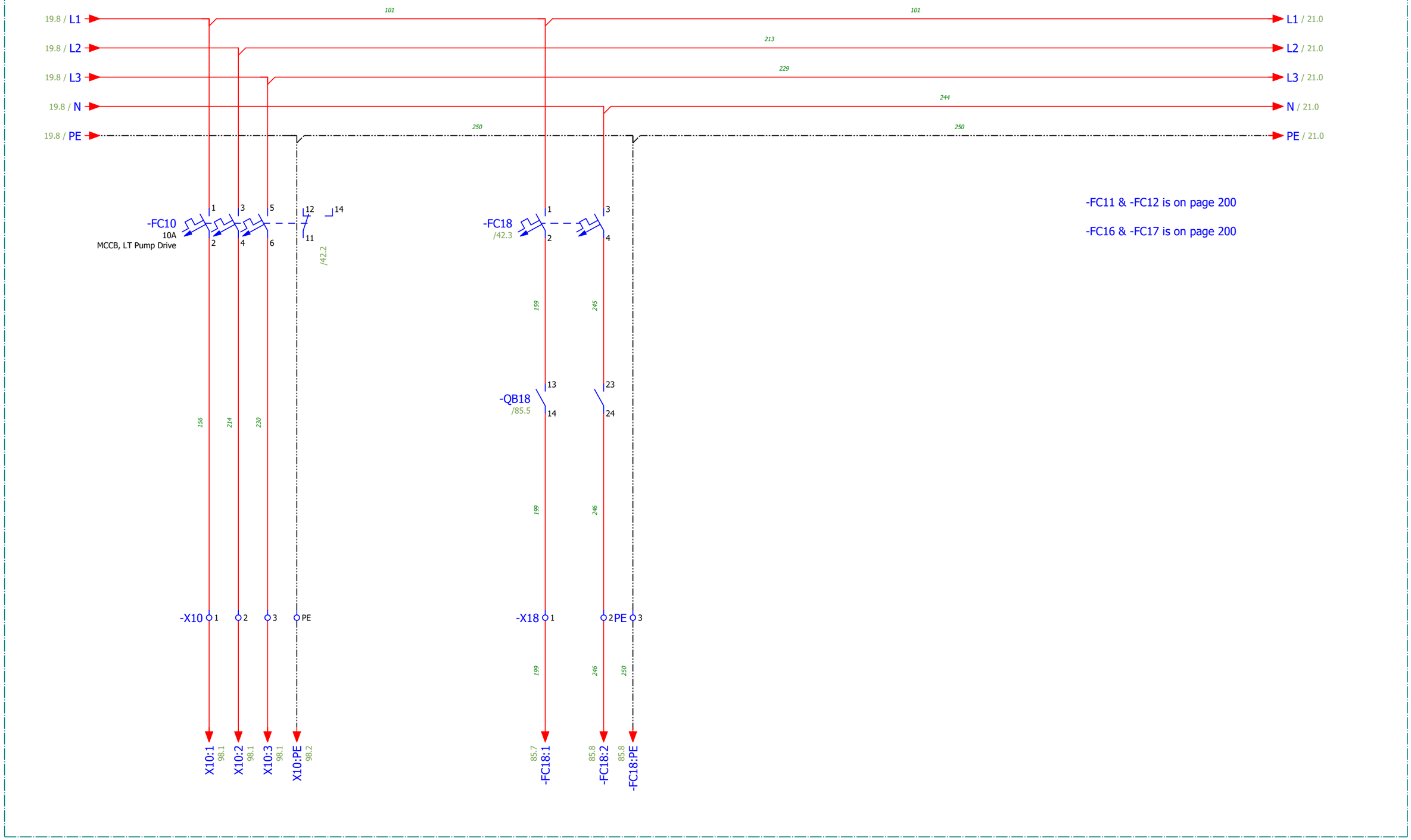
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft container MCU Power supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 19 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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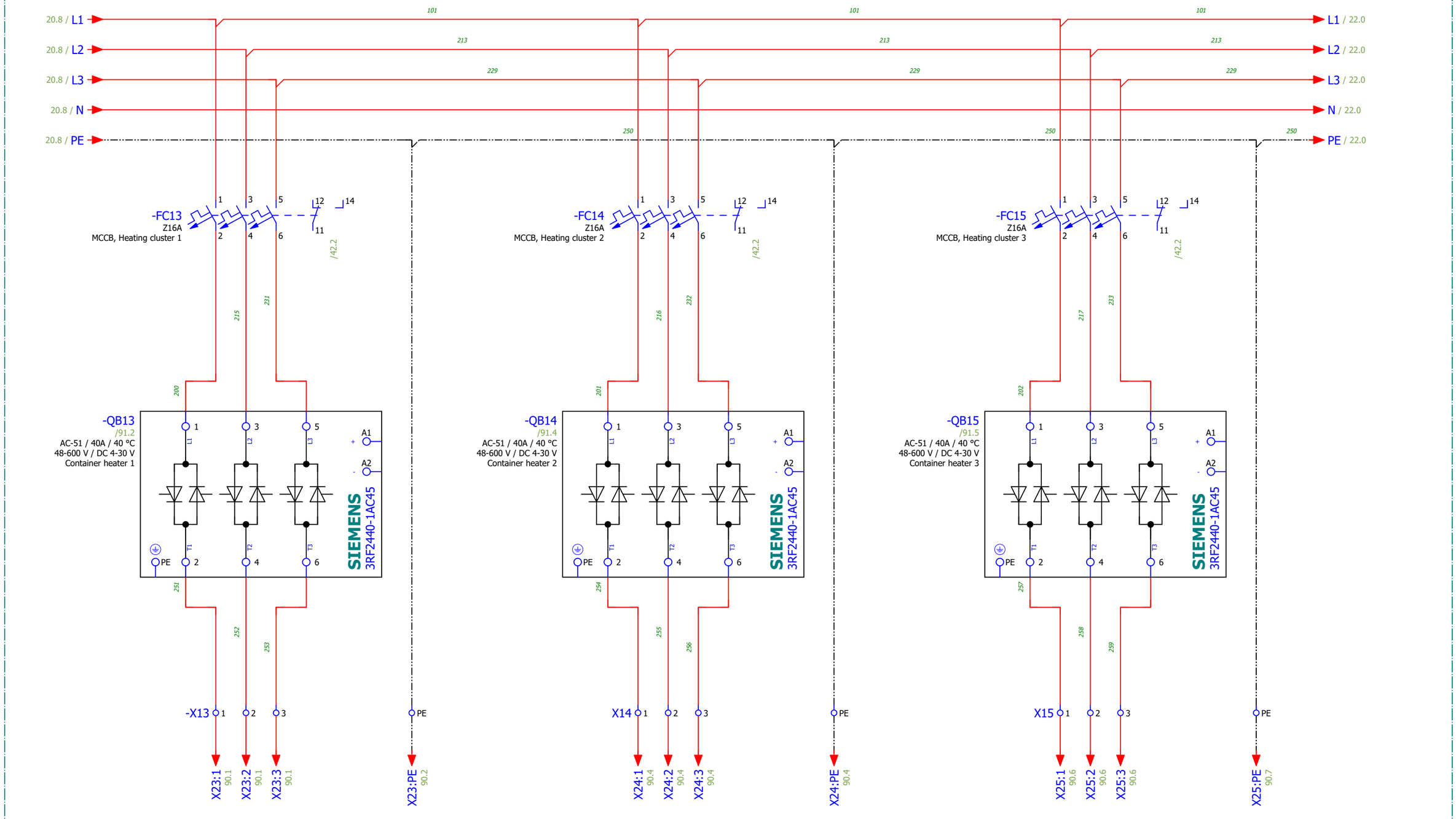
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft container MCU Power supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 20 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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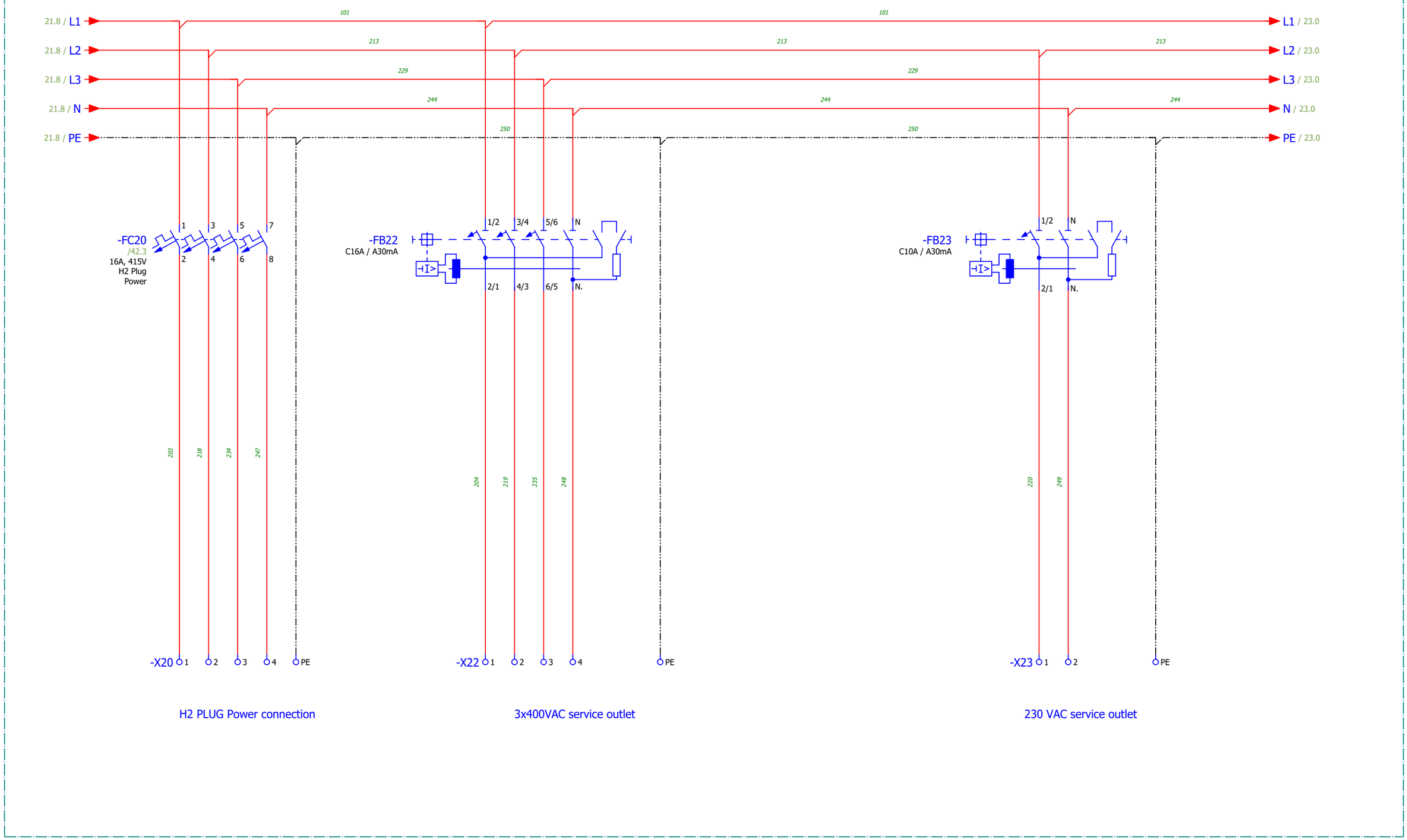
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft container Heater control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 21 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



H2 PLUG Power connection

3x400VAC service outlet

230 VAC service outlet

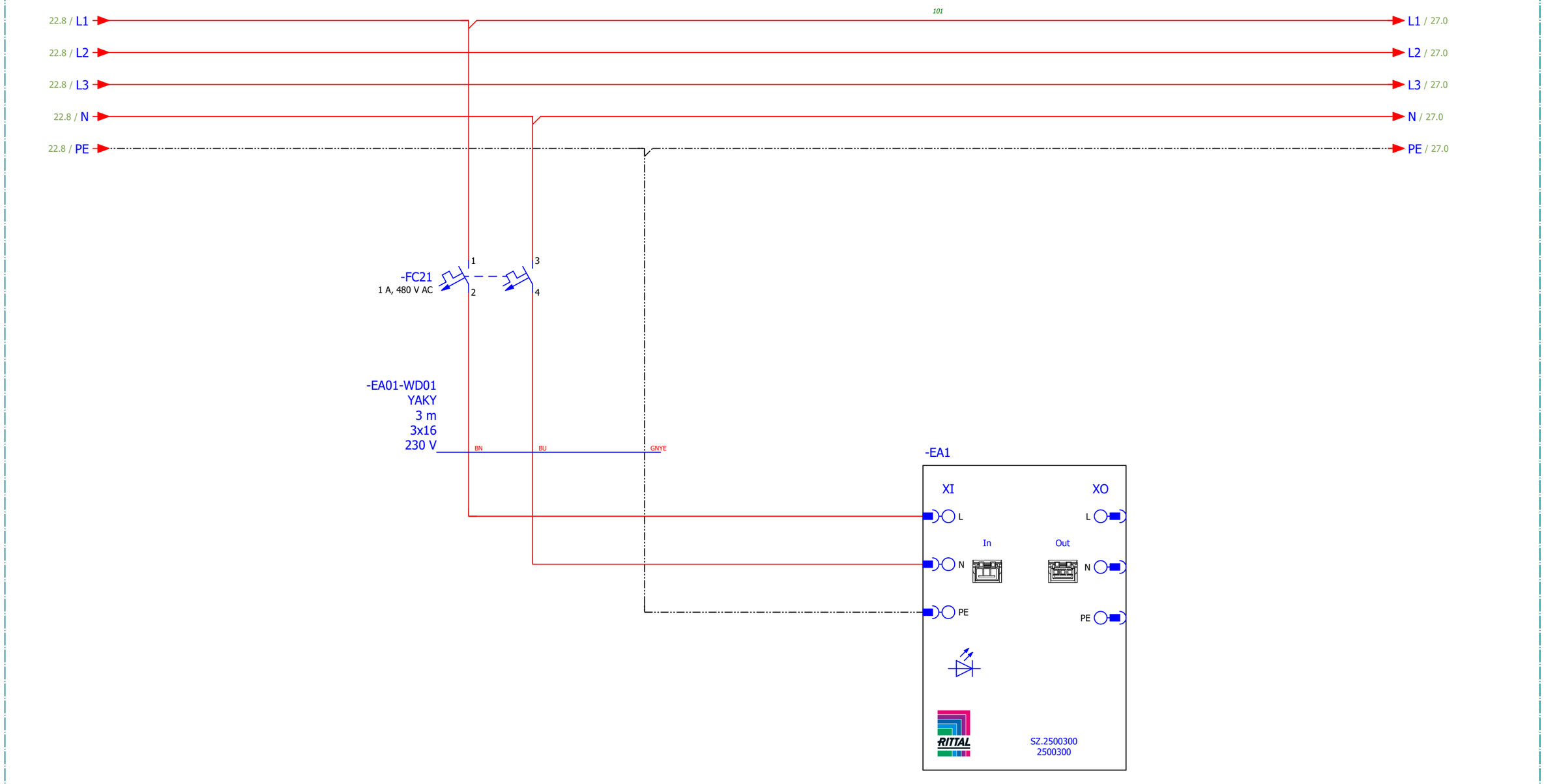
Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	40ft container Service outlets		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 22 / 255
=	++	+ UC20	& C03	29-Sep-25						

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20

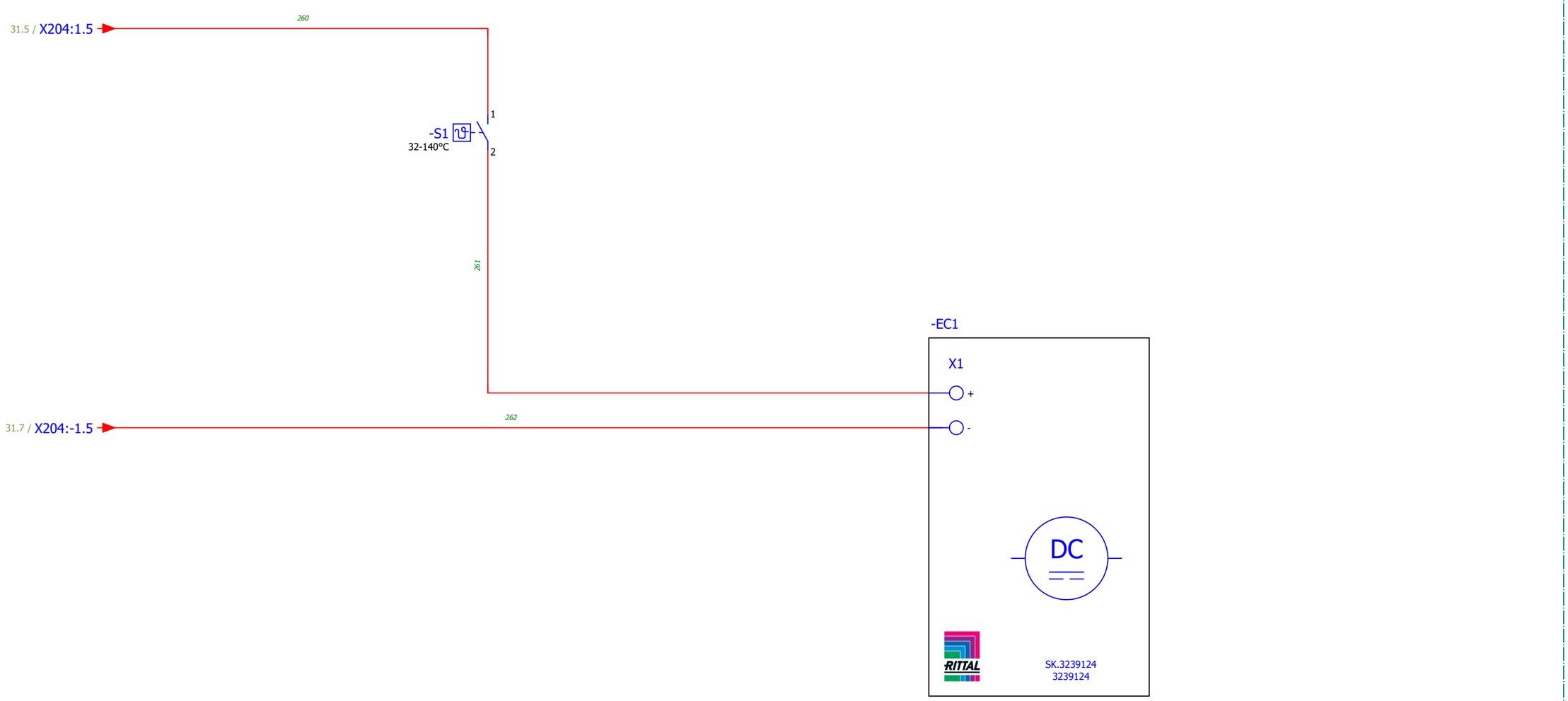
Container Safety System, Control Cabinet 40 ft



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EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	40ft container Cabinet light		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 23 / 255
=	++	+ UC20	& C03	29-Sep-25						

FRM5103656/0B

=LA01+UC20
Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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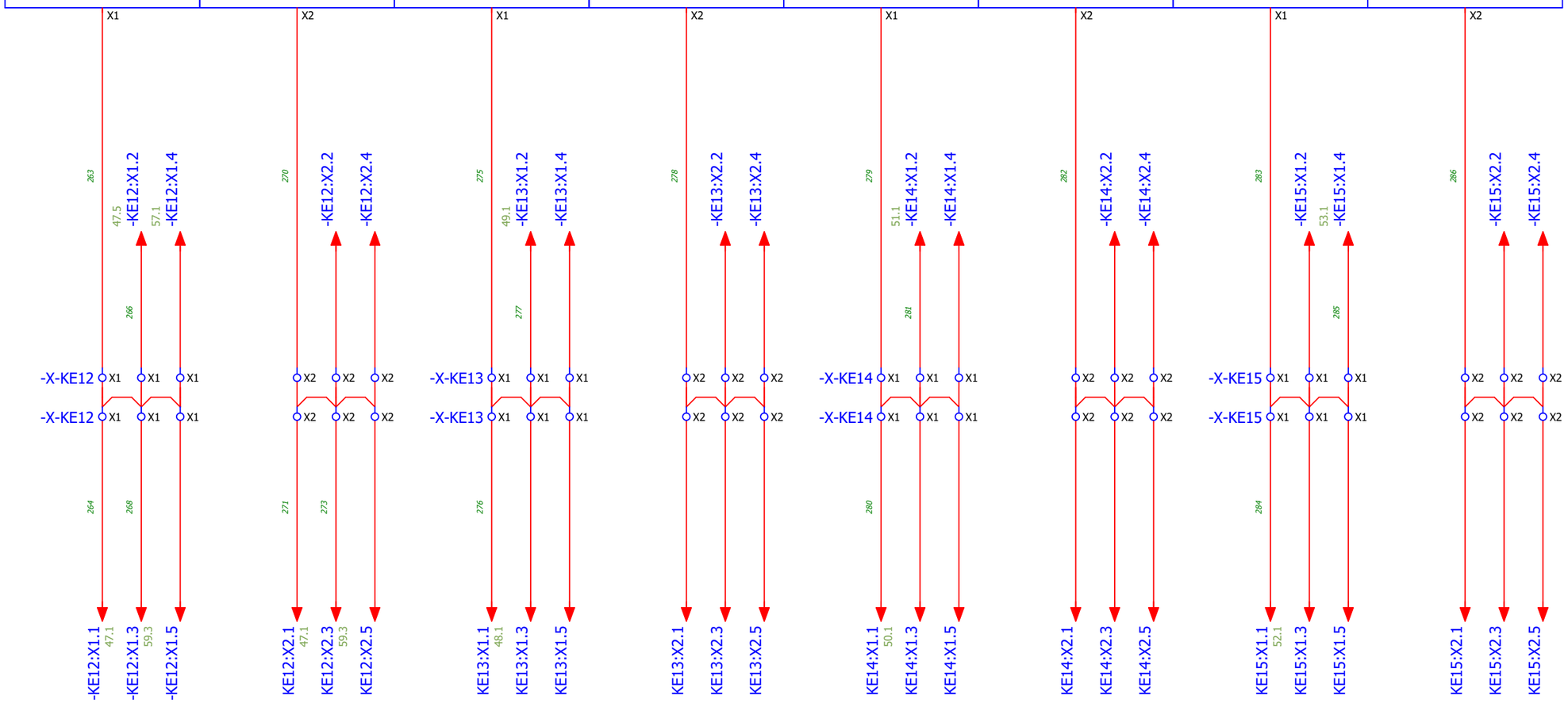
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft container Cabinet fan		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 24 / 255

=LA01+UC20
Container Safety System, Control Cabinet 40 ft

KE12 Test pulse output CH1	KE12 Test pulse output CH2	KE13 Test pulse output CH1	KE13 Test pulse output CH2	KE14 Test pulse output CH1	KE14 Test pulse output CH2	KE15 Test pulse output CH1	KE15 Test pulse output CH2
KE12PULSE01	KE12PULSE02	KE13PULSE01	KE13PULSE02	KE14PULSE01	KE14PULSE02	KE15PULSE01	KE15PULSE02
&C02/14.1	&C02/14.1	&C02/14.5	&C02/14.5	&C02/15.1	&C02/15.1	&C02/15.4	&C02/15.4
-KE12		KE13		KE14		-KE15	



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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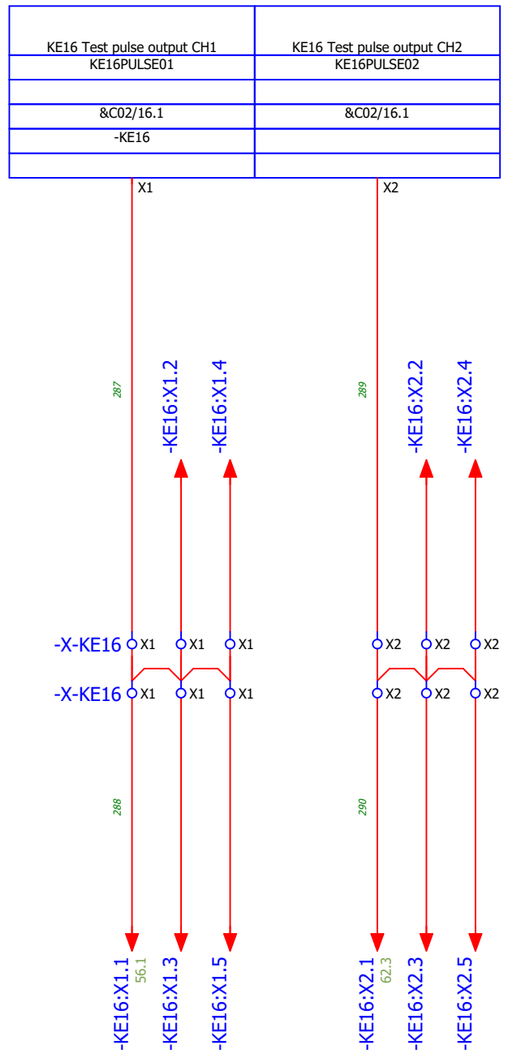
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Pulse generator		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 25 / 255

FRM5103656/0B

=LA01+UC20

Container Safety System, Control Cabinet 40 ft

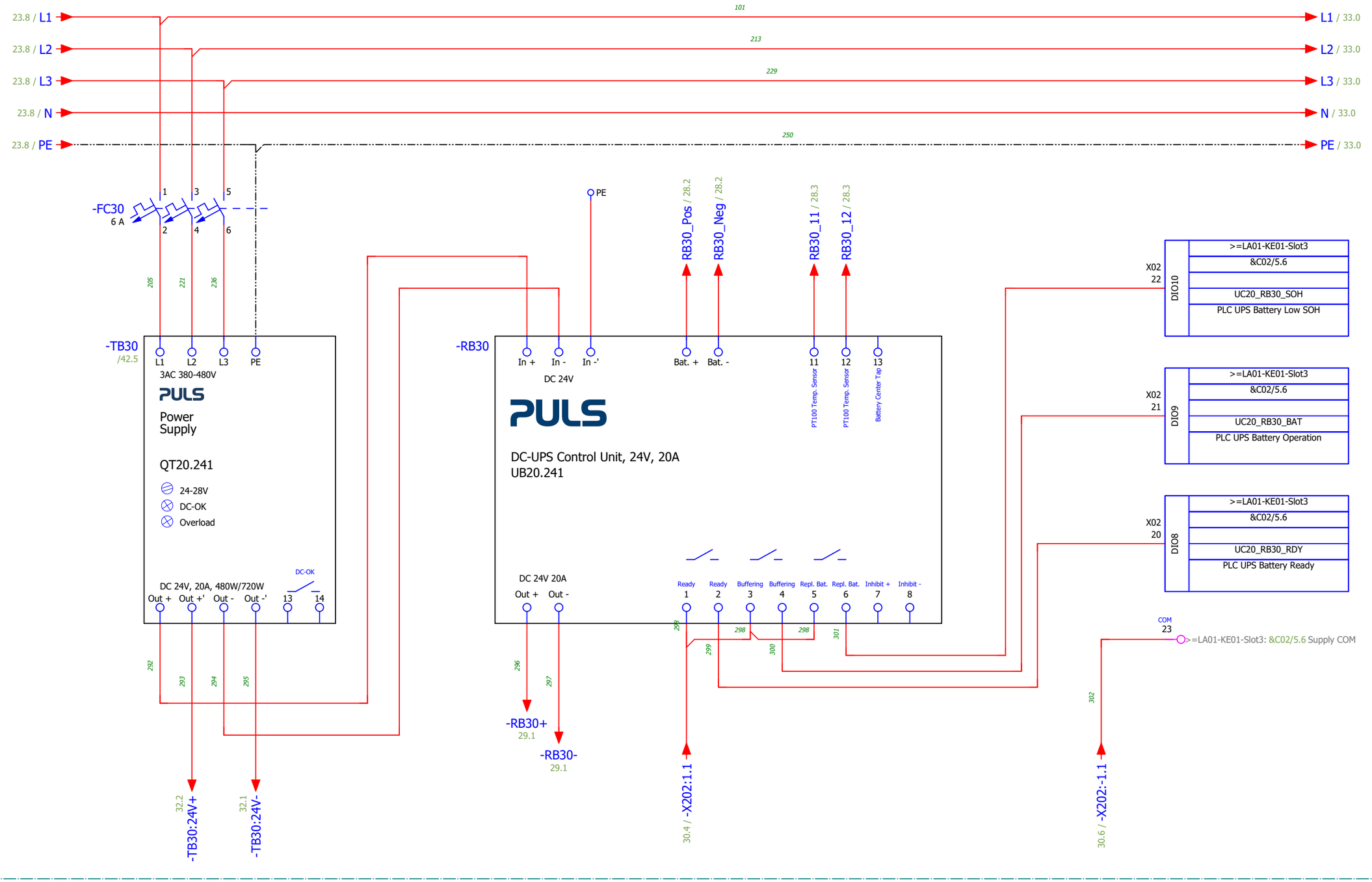


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EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	40ft Container - Pulse generator		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 26 / 255
=	++	+ UC20	& C03	29-Sep-25						

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - 24V Supply and UPS		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 27 / 255

0	1	2	3	4	5	6	7	8

=LA01+DA01

-CA30

PULS

Battery Module, 24V, 12Ah
UZK24.121

DC 24V
Out + Out -

PT100 Temp. Sensor 11
PT100 Temp. Sensor 12
Battery Center Tap 13

-CA30-WD01
ÖLFLEX CLASSIC 100 H
3G2,5
450 V
Battery supply RB30 1 2

-CA30-WG01
ÖLFLEX® CLASSIC 130 H
3G1
300/500 V
1 2 Temp sensor CA30

27.4 / >+UC20-RB30_Pos
27.4 / >+UC20-RB30_Neg
27.5 / >+UC20-RB30_11
27.5 / >+UC20-RB30_12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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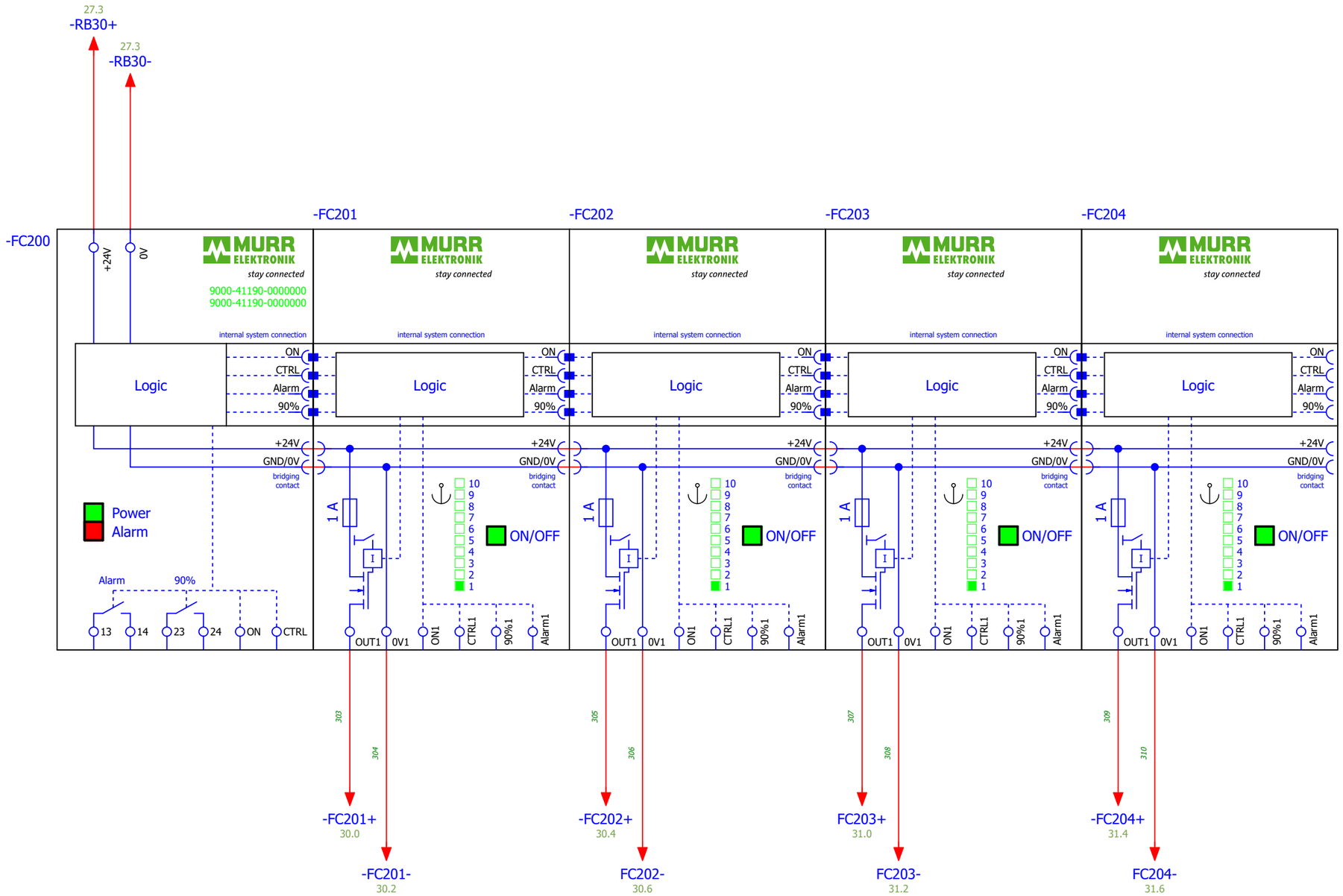
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - 24V Backup Battery		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 28 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20



Reference Item Number	Ballard Part # TBD		
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EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - 24 VDC Supply Fuses		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 29 / 255

FRM5103656/0B

=LA01+UC20

Safety

FC201+ 29.2

-X201 0.1

1.2	1.4	1.6	2.2	2.4	2.6	3.2	3.4	3.6	
48.1	56.1	57.1	64.0				57.1		-X201:1.2 … -X201:3.6
311	313	315	316				320		
1.1	1.3	1.5	2.1	2.3	2.5	3.1	3.3	3.5	
312	314		317	318	319				
46.1	59.3		64.0	60.0	61.1				-X201:1.1 … -X201:3.5

FC201- 29.3

-X201- 1-

1.2	1.4	1.6	2.2	2.4	2.6	3.2	3.4	3.6	
48.1	56.1	57.1	60.0						-X201:-1.2 … -X201:-3.6
311	322	324	326	328					
1.1	1.3	1.5	2.1	2.3	2.5	3.1	3.3	3.5	
321	323	325	327	329	330				
46.1	48.1	56.1	57.1	60.0	61.1				-X201:-1.1 … -X201:-3.5

Internal 24VDC Supply

FC202+ 29.4

-X202 1

1.2	1.4	1.6	2.2	2.4	2.6	3.2	3.4	3.6	
33.4	108.2	106.1	85.4	42.1					-X202:1.2 … -X202:3.6
332	334	336	338						
1.1	1.3	1.5	2.1	2.3	2.5	3.1	3.3	3.5	
	335	337	340						
27.4	39.4	43.0	107.2	42.1	36.4				-X202:1.1 … -X202:3.5

FC202- 29.4

-X202- 1-

1.2	1.4	1.6	2.2	2.4	2.6	3.2	3.4	3.6	
33.6	108.2	106.1	85.4						-X202:-1.2 … -X202:-3.6
354	355	357	359						
1.1	1.3	1.5	2.1	2.3	2.5	3.1	3.3	3.5	
356	358	360	361						
27.6	39.7	43.1	107.1	91.0	43.0				-X202:-1.1 … -X202:-3.5

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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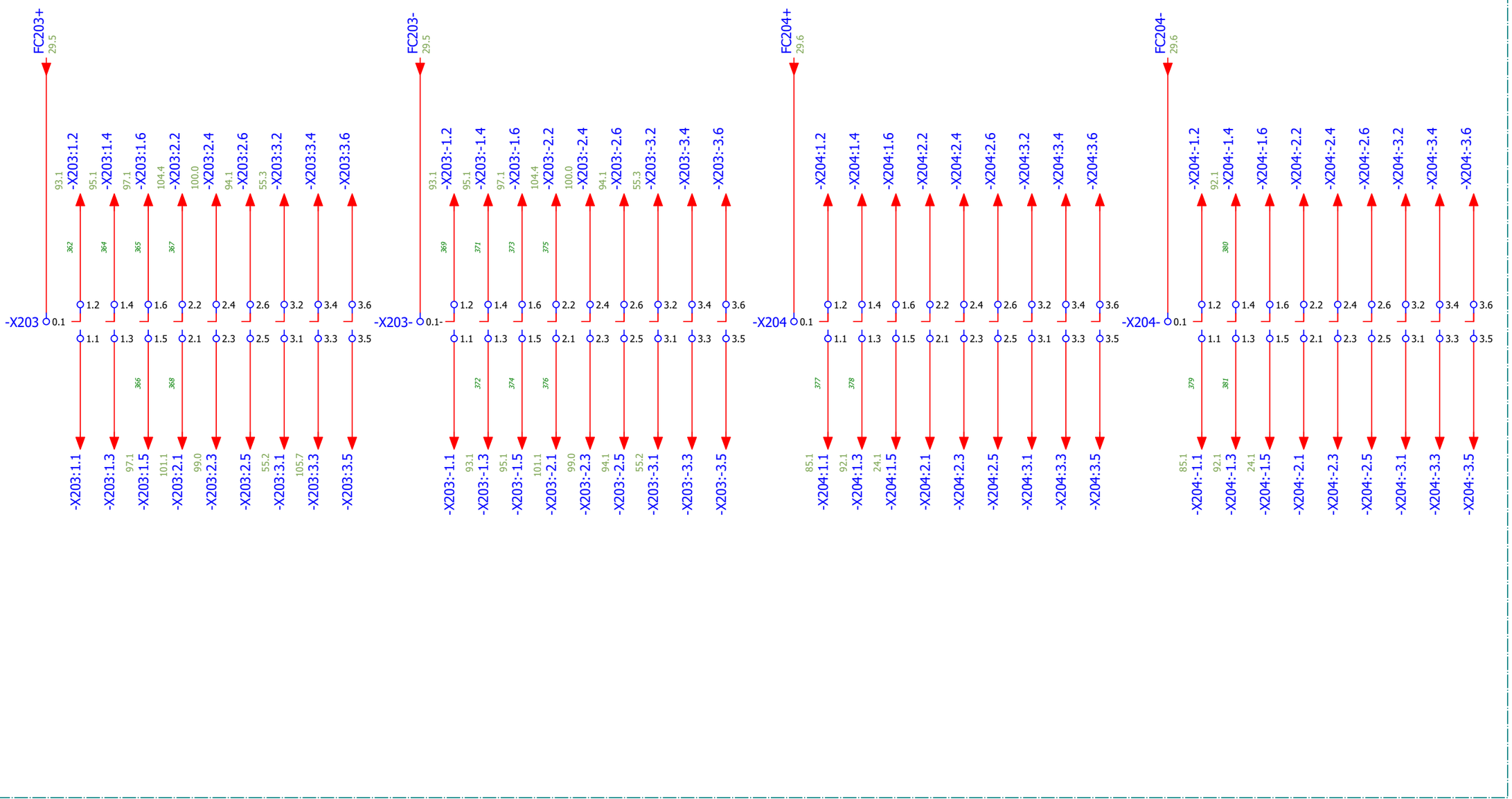
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - 24 VDC Supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 30 / 255

=LA01+UC20

External 24VDC Supply

External 24VDC Supply + Cabinet ventilation



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION	
DESCRIPTION	
DATE	
29-Sep-25	

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - 24 VDC Supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 31 / 255

=LA01+UC20

-TB30:24V-
27.2

-TB30:24V+
27.1

24VDC light Fuse Trip
UC20_FC210

&C02/5.6
>=LA01-KE01-Slot3
DIO6
X02 18

No Alarm = 24VDC High

-FC210
Weidmüller AMG FIM-C
+24V | Bridge +24V | Bridge +24V | Bridge +24V | Bridge +24V | Bridge BUS | Bridge BUS
GND | GND Bridge | GND Bridge | GND Bridge | GND Bridge | Alarm | Reset

384

-FC210.1
Weidmüller AMG ELM-6
Bridge +24V | Bridge +24V | Bridge BUS | Bridge BUS
6 A
1+ | 1+ Bridge | 1- | 1- Bridge | GND Bridge | GND Bridge

-FC210.2
Weidmüller AMG ELM-6
Bridge +24V | Bridge +24V | Bridge BUS | Bridge BUS
6 A
1+ | 1+ Bridge | 1- | 1- Bridge | GND Bridge | GND Bridge

382 383 385 386

-FC210.1+ 104.1
-FC210.1- 104.1
-FC210.2+ 105.0
-FC210.2- 105.0

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - 24 VDC Supply Container light		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 32 / 255

FRM5103656/0B

=LA01+UC20

27.7 / L1 → L1 / 36.0 (101)
27.7 / L2 → L2 / 36.0 (213)
27.7 / L3 → L3 / 36.0 (229)
27.7 / N → N / 36.0
27.7 / PE → PE / 36.0 (250)

-FC31
6 A
1 3 5
2 4 6
206 222 237

-TB01
L1 L2 L3 PE
3AC 380-480V

PULS
Power Supply
QT40.241
24-28V
DC-OK
Overload
Single/Parallel Mode

DC 24V, 40A, 960W/1440W
Out + Out +' Out - Out -' 13 14 15 16
DC-OK Shut-Down
387 388

>=LA01+DA01-RB01-WG01
UNITRONIC®-FD CP (TP) PLUS
4x0,5
500 V
Temp Sensor CA01
WH BN

>=LA01+DA01-RB01-WD01
ÖLFLEX® CLASSIC 110 CH
3x2,5
300/500 V
Battery Supply RB01
1 2

RB01_11 / 34.2
RB01_12 / 34.3
RB01_Pos / 34.1
RB01_Neg / 34.2

-RB01
FC1+2 24V UPS Module
IN + - BAT_MON 11 12 BAT + 13 -
OUT + - 7 8 1 2 3 4 5 6 14 15 PE
Inhibit + Inhibit - Rdy Rdy Buffer Buffer BAT. Replace BAT. Replace Low BAT. Low BAT.
331 331 331 331
389 390 391 392 393 394

PULS
UB40.21
DC-UPS CONTROL UNIT

-RB01+
35.0
-RB01-
35.0

30.4 / -X202:1.2

X02 18 DI04
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB01_RDY
FC1+2 UPS Battery Ready

X02 19 DI05
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB01_BAT
FC1+2 UPS Battery Operation

X02 20 DI06
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB01_SOH
FC1+2 UPS Battery Low SOH

X02 21 DI07
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB01_DIS
FC1+2 UPS Battery Discharged

COM 23
>=LA01-KE02-Slot03: &C02/8.6 Supply COM

30.6 / -X202:-1.2

PE

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1+2 24V Supply and UPS		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 33 / 255

FRM5103656/0B

=LA01+DA01

-CA01

PULS

Battery Module, 24V, 12Ah
UZK24.121

DC 24V
Out + Out -

PT100 Temp. Sensor 11
PT100 Temp. Sensor 12
Battery Center Tap 13

33.4 / >+UC20-RB01_Pos
33.4 / >+UC20-RB01_Neg
33.4 / >+UC20-RB01_11
33.4 / >+UC20-RB01_12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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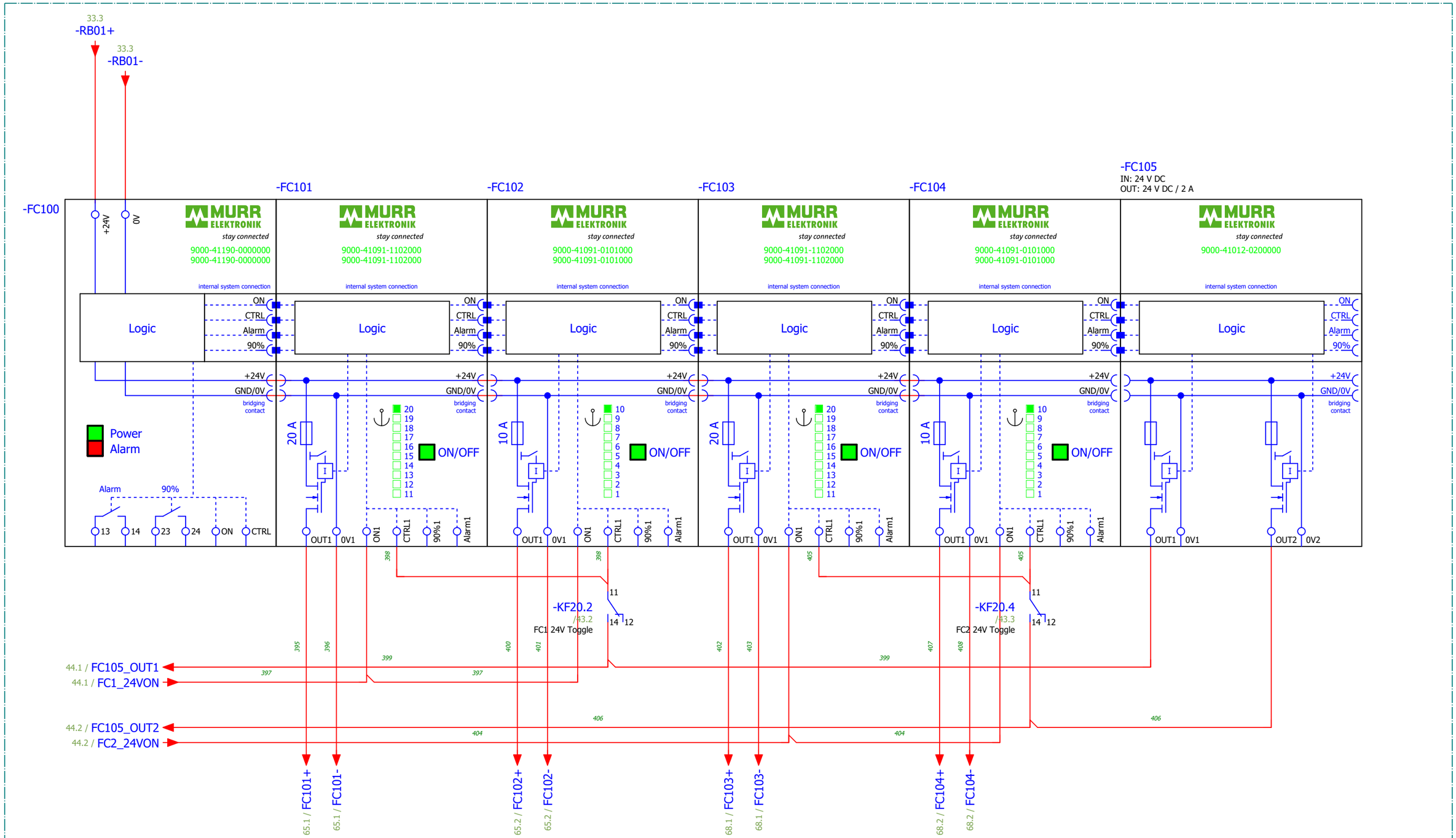
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1+2 24V Backup Battery		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 34 / 255

FRM5103656/0B

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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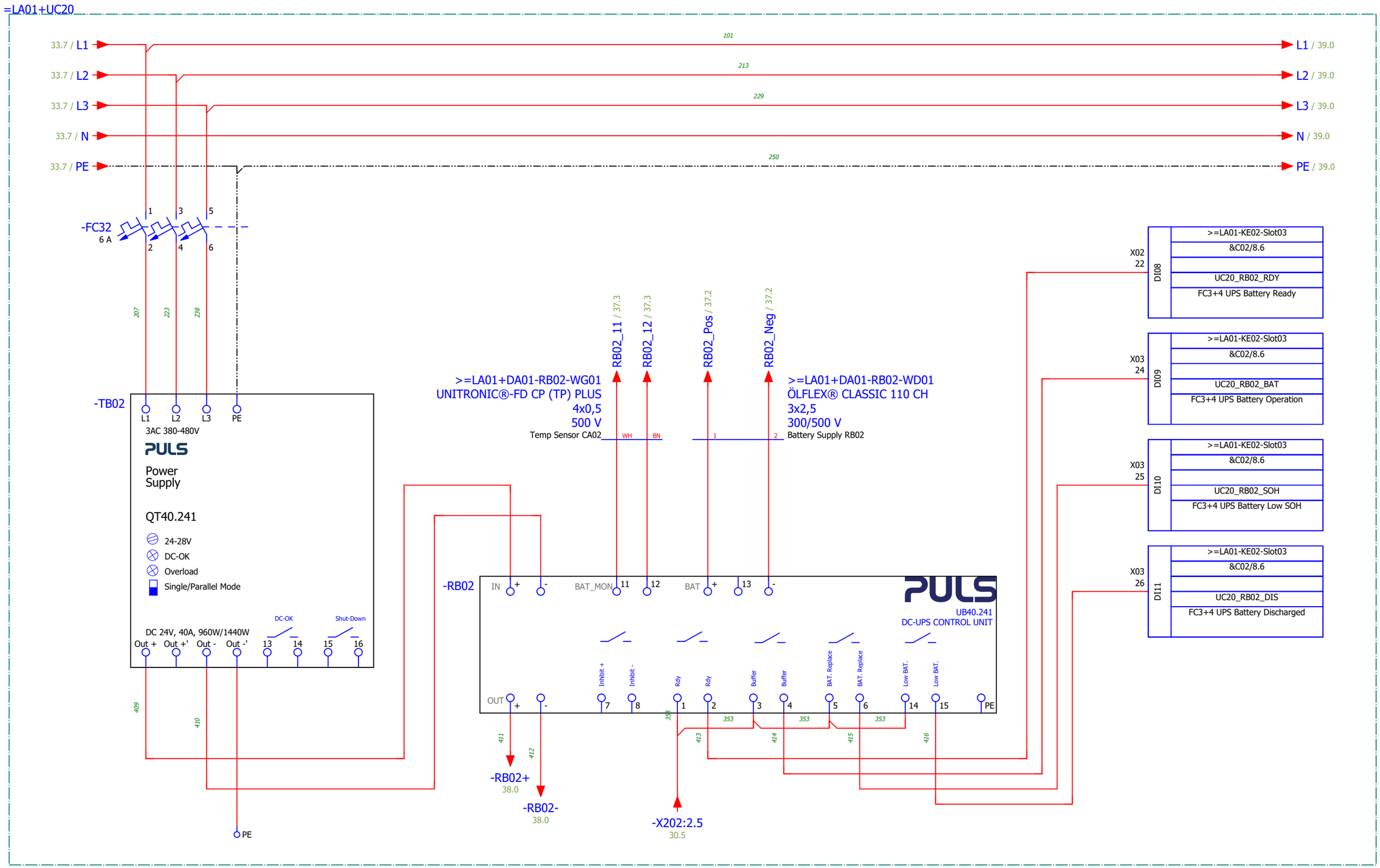
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1+2 24V Fuses		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 35 / 255



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC3+4 Supply and UPS		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 36 / 255

=LA01+DA01

-CA02

PULS

Battery Module, 24V, 12Ah
UZK24.121

DC 24V
Out + Out -

PT100 Temp. Sensor
PT100 Temp. Sensor
Battery Center Tap
11 12 13

36.4 / >+UC20-RB02_Pos
36.4 / >+UC20-RB02_Neg
36.4 / >+UC20-RB02_11
36.4 / >+UC20-RB02_12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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=	++	+ UC20	& C03

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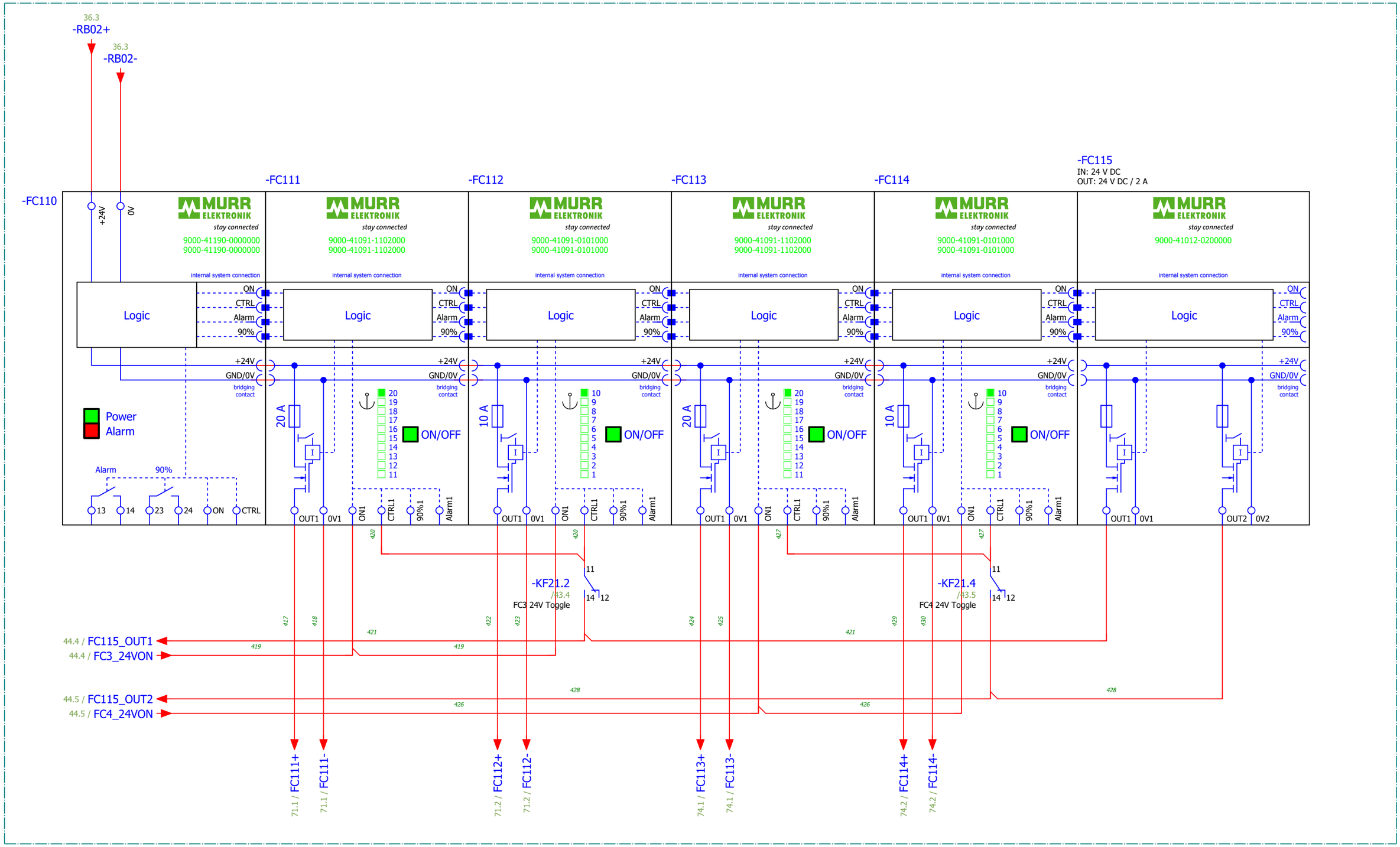
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC3+4 24V Backup Battery		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 37 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC3+4 24V Fuses		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 38 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

36.7 / L1 → 101 → L1 / 88.0
36.7 / L2 → 213 → L2 / 88.0
36.7 / L3 → 229 → L3 / 88.0
36.7 / N → N /
36.7 / PE → 250 → PE / 88.0

-FC33
6 A
1 3 5
2 4 6

208 224 239

-TB03
L1 L2 L3 PE
3AC 380-480V

PULS
Power Supply
QT40.241
24-28V
DC-OK
Overload
Single/Parallel Mode

DC 24V, 40A, 960W/1440W
Out + Out +' Out - Out -' 13 14 15 16
DC-OK Shut-Down

431 432

PE

>=LA01+DA01-RB03-WG01
UNITRONIC®-FD CP (TP) PLUS
4x0,5
500 V
Temp Sensor CA03
WH BN

RB03_11 / 40.3
RB03_12 / 40.3
RB03_Pos / 40.2
RB03_Neg / 40.2

>=LA01+DA01-RB03-WD01
ÖLFLEX® CLASSIC 110 CH
3x2,5
300/500 V
Battery Supply RB03
1 2

-RB03
IN + - BAT_MON 11 12 BAT + 13 -
OUT + - 7 8 1 2 3 4 5 6 14 15 PE
Inhibit + Inhibit - Rdy Rdy Buffer Buffer BAT. Replace BAT. Replace Low BAT. Low BAT.

PULS
UB40.241
DC-UPS CONTROL UNIT

333 333 333
338
433 434 435 436 437 438

-RB03+
41.0
-RB03-
41.0
-X202:1.3
30.5

X03 27 DI12
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB03_RDY
FC5+6 UPS Battery Ready

X03 28 DI13
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB03_BAT
FC5+6 UPS Battery Operation

X03 29 DI14
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB03_SOH
FC5+6 UPS Battery Low SOH

X03 30 DI15
>=LA01-KE02-Slot03
&C02/8.6
UC20_RB03_DIS
FC5+6 UPS Battery Discharged

COM 32
>=LA01-KE02-Slot03: &C02/8.6 Supply COM
-X202:-1.3
30.7

Reference Item Number	Ballard Part # TBD		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC5+6 24V Supply and UPS		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 39 / 255

=LA01+DA01

-CA03

PULS

Battery Module, 24V, 12Ah
UZK24.121

DC 24V
Out + Out -

PT100 Temp. Sensor 11
PT100 Temp. Sensor 12
Battery Center Tap 13

39.4 / >=LA01+UC20-RB03_Pos
39.4 / >=LA01+UC20-RB03_Neg
39.4 / >=LA01+UC20-RB03_11
39.4 / >=LA01+UC20-RB03_12

Reference Item Number	Ballard Part # TBD		
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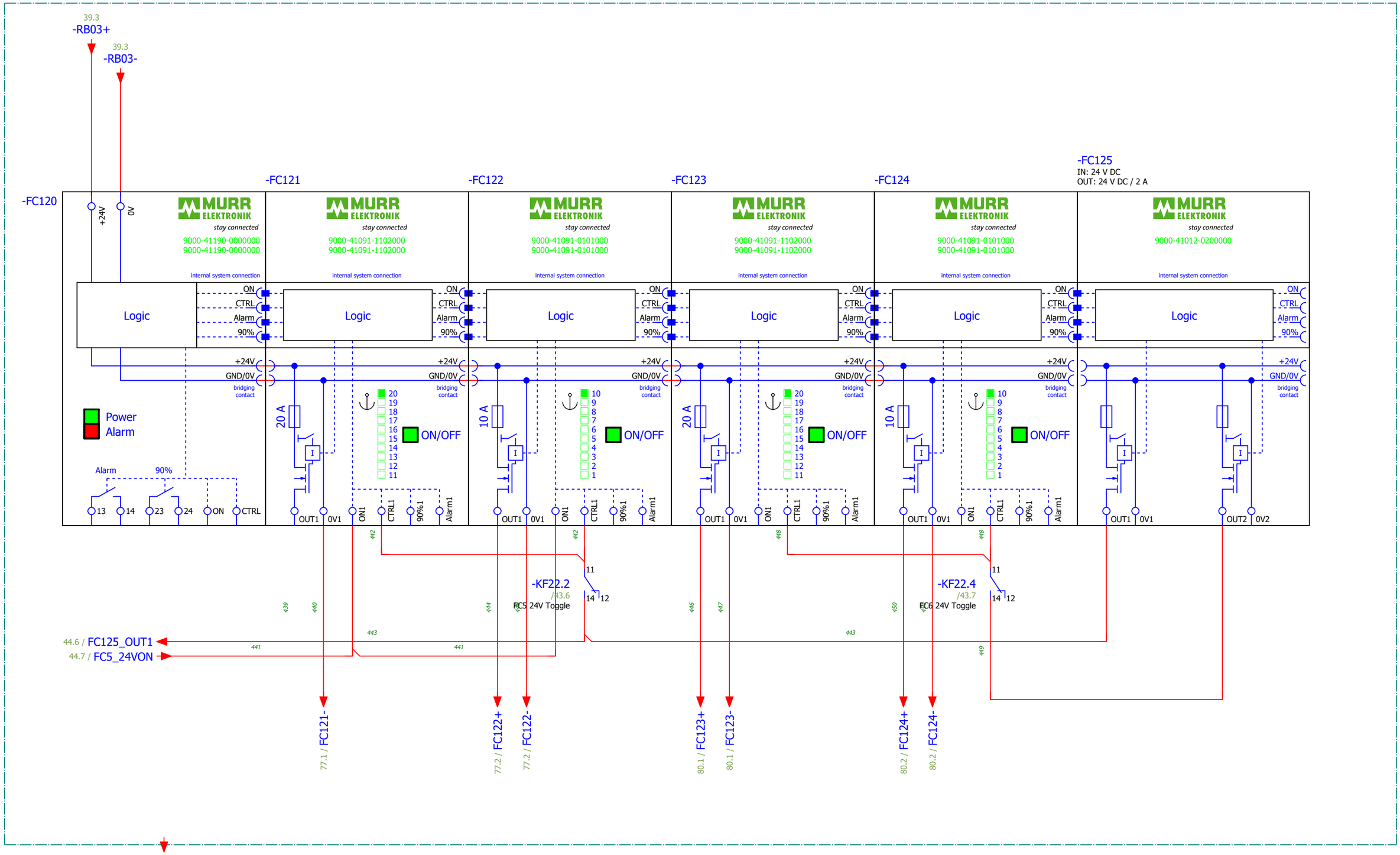
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC5+6 Backup Battery		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 40 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
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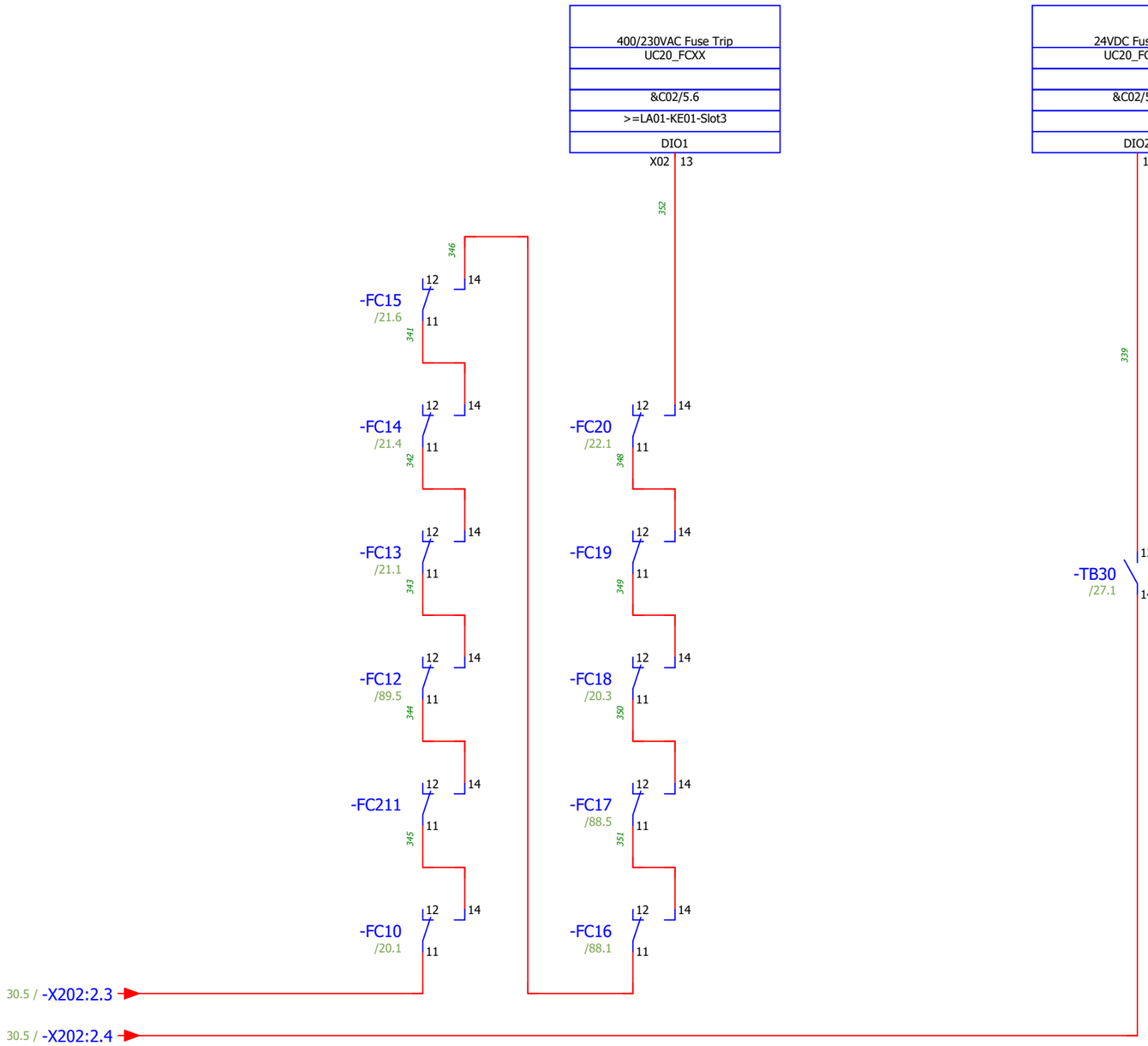
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC5+6 24V Fuses		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 41 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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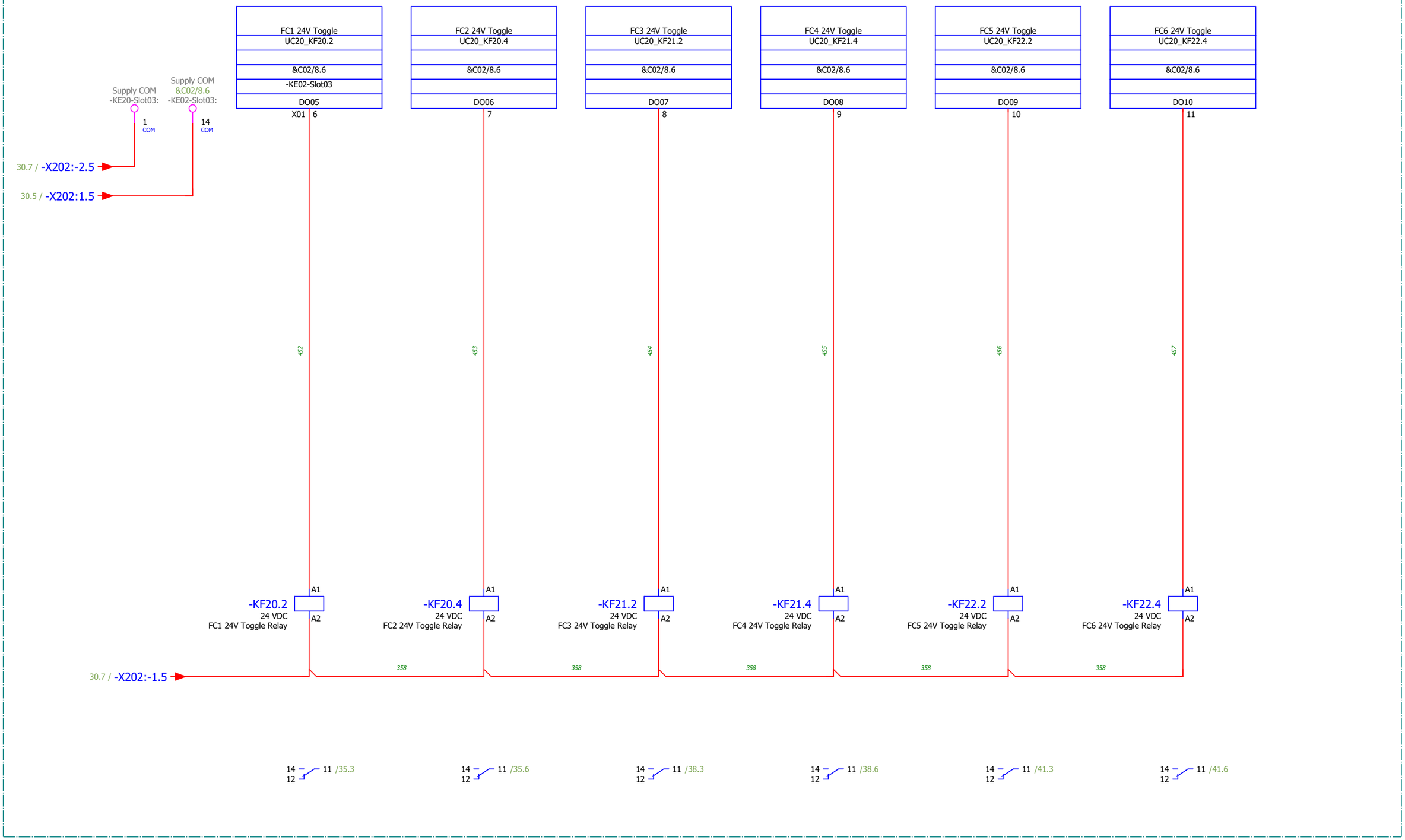
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft container MCU Fuse trip feed back		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 42 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Control System, Control Cabinet 40 ft



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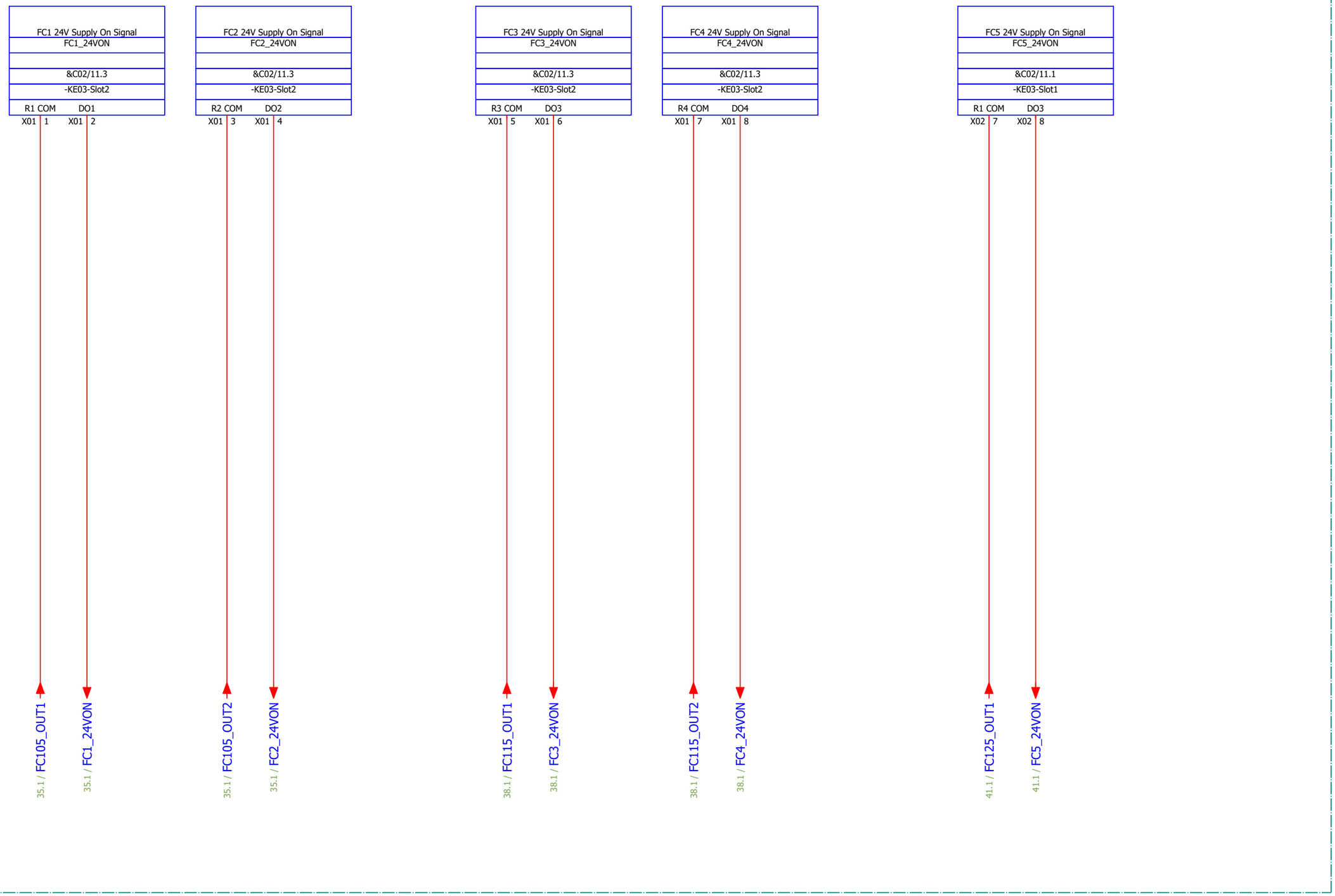
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1-6 24V Toggle		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 43 / 255

FRM5103656/0B

=LA01+UC20

Container Control System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1-6 24V Toggle On		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 44 / 255

=LA01+UC20

Container Control System, Control Cabinet 40 ft

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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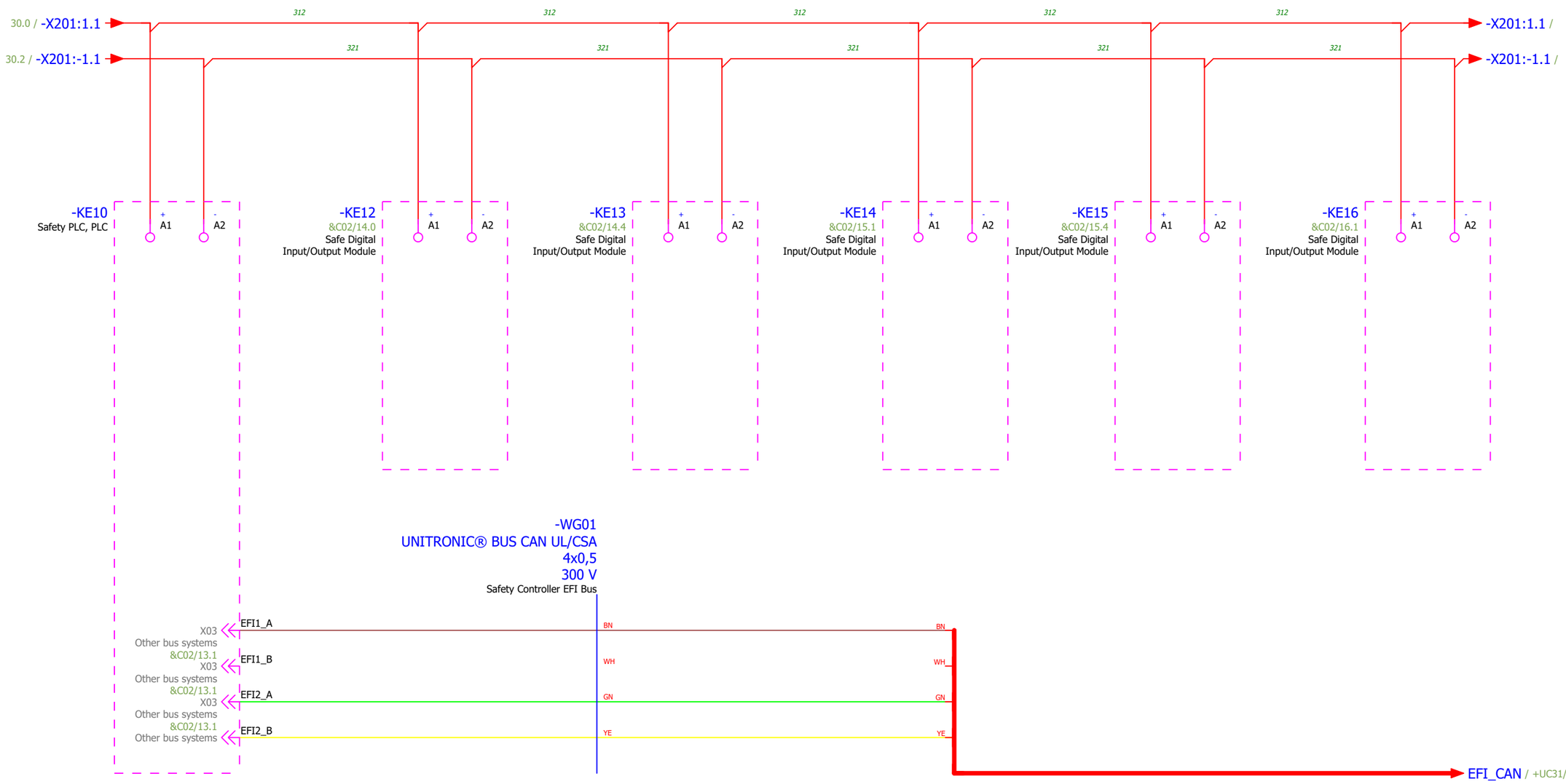
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1-6 24V Feedback		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 45 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

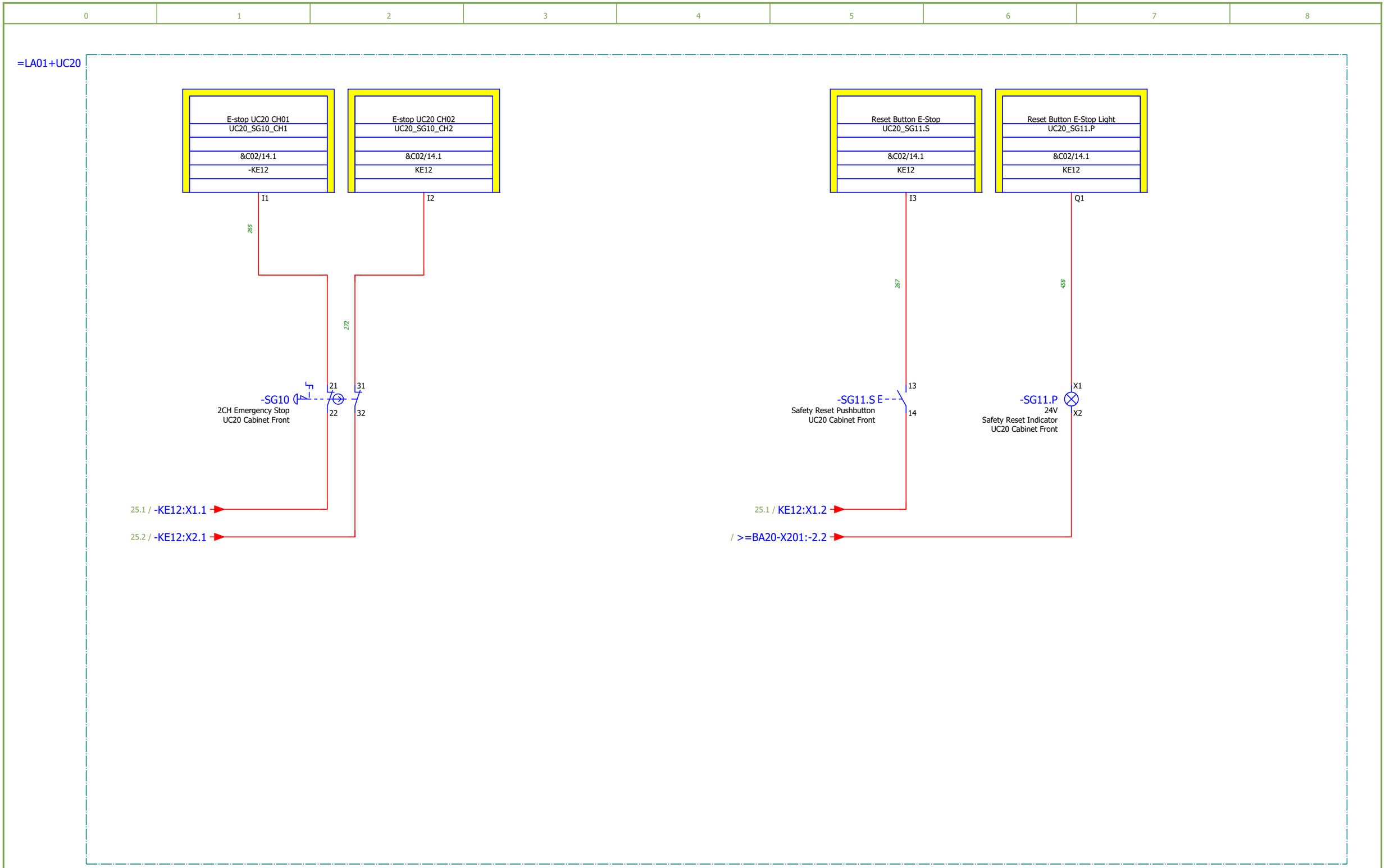
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet - Safety PLC 24V Supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 46 / 255



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION
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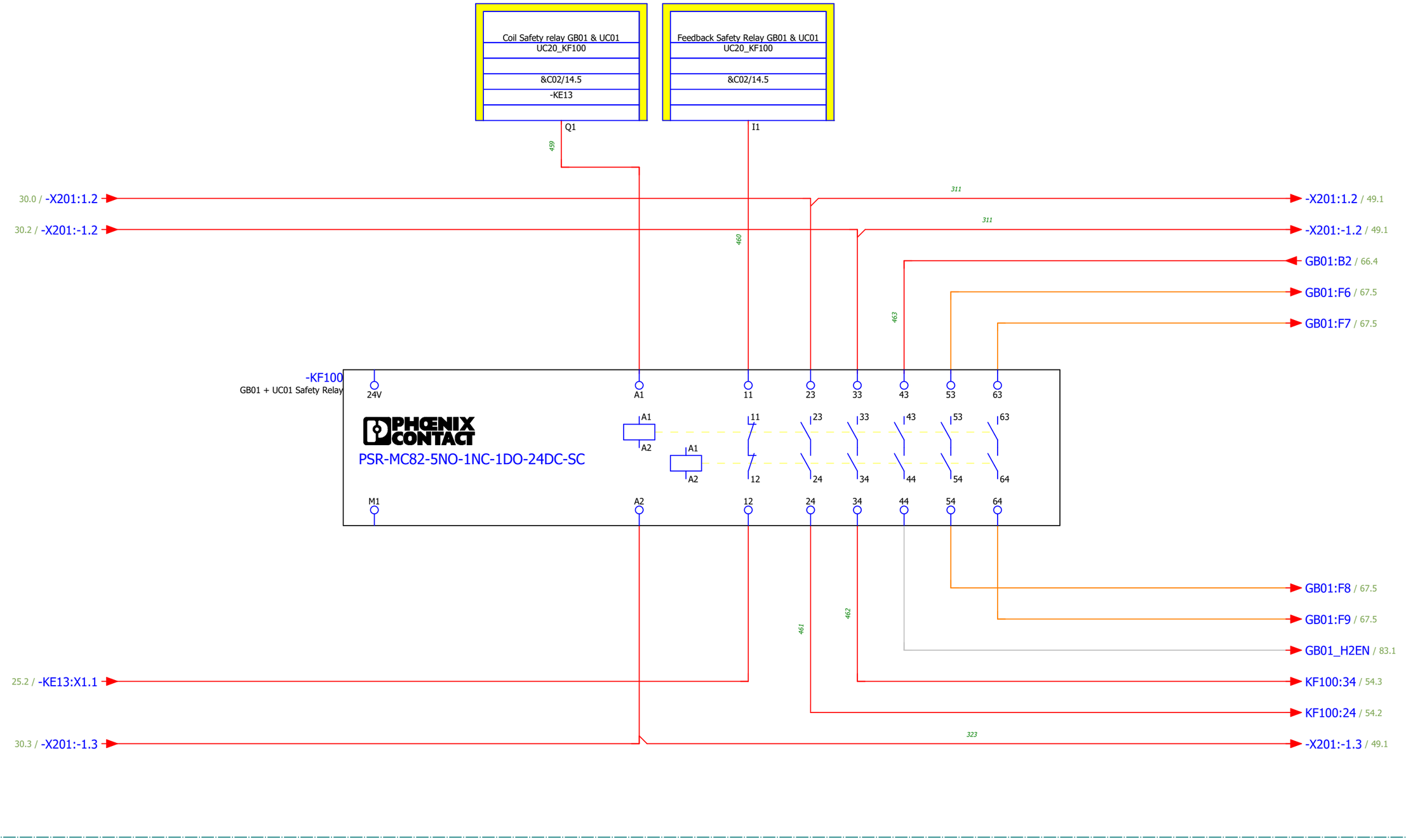
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet - Emergency stop button		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 47 / 255

FRM5103656/0B

=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION	
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DATE	
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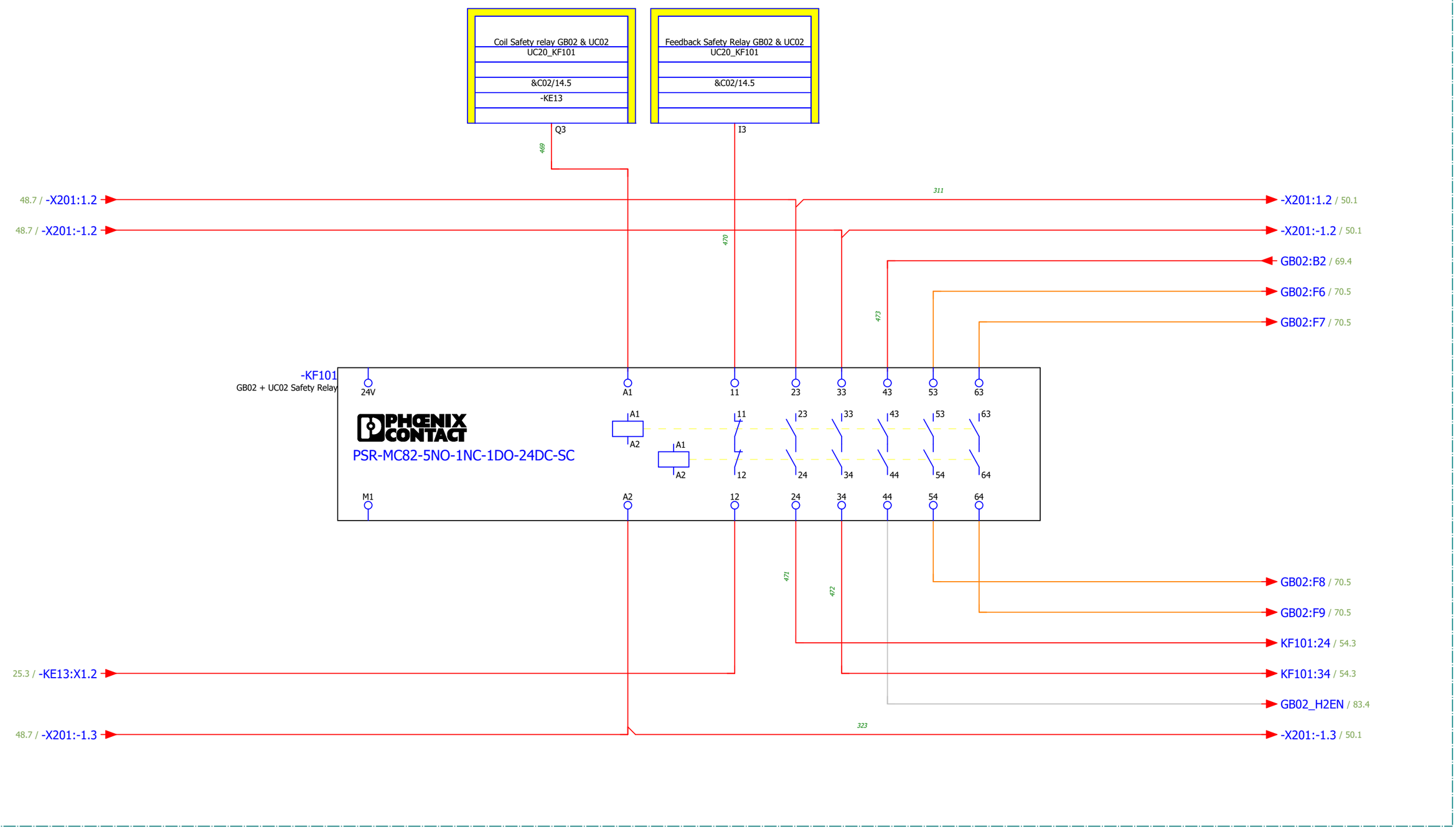
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, GB01 + UC01 Safety Relay		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 48 / 255

FRM5103656/0B

=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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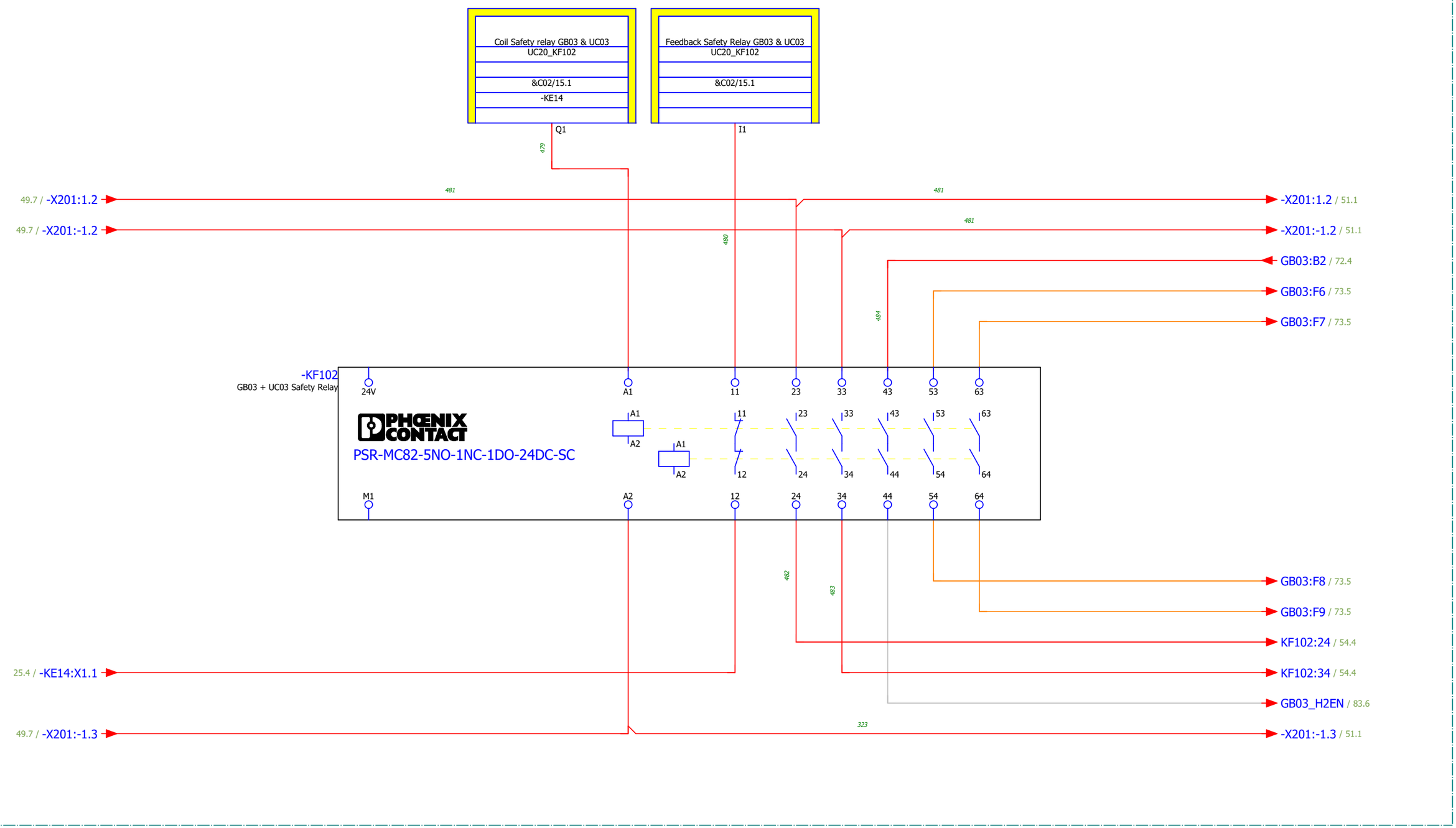
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, GB02 + UC02 Safety Relay		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 49 / 255

FRM5103656/0B

=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DATE	29-Sep-25

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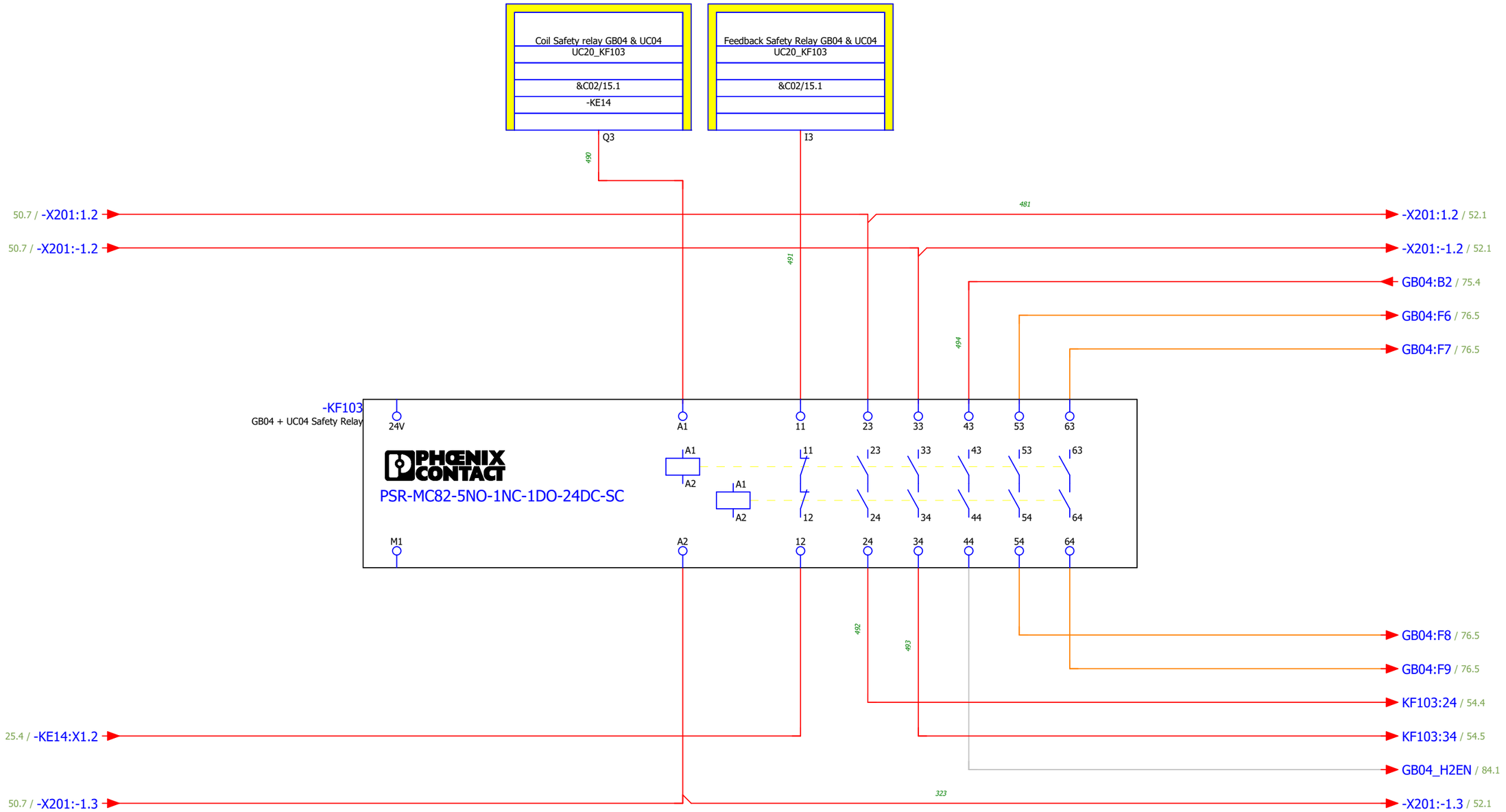
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, GB03 + UC03 Safety Relay		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 50 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

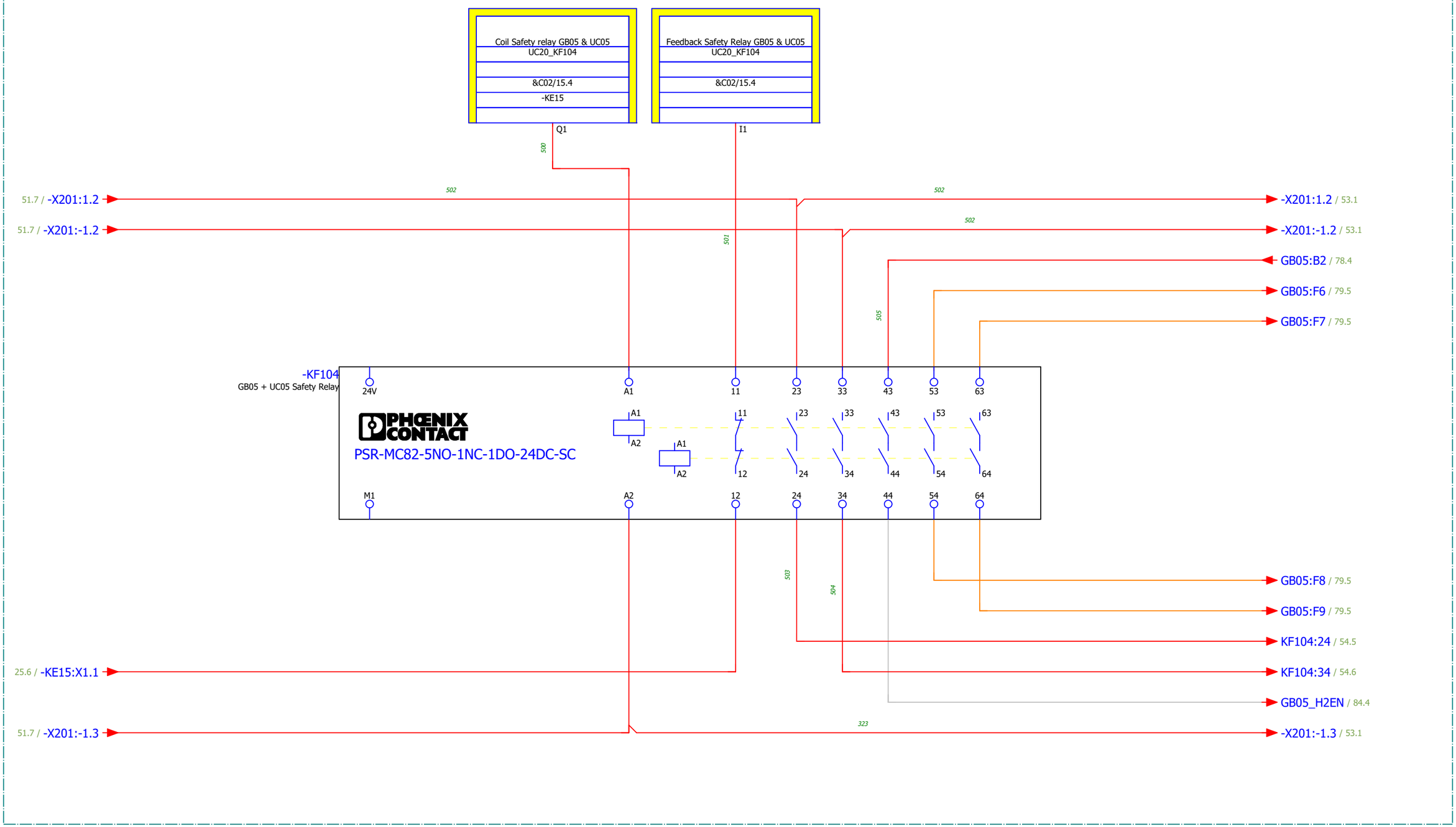
=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM		SHEET TYPE/DESC	40ft Control Cabinet, GB04 + UC04 Safety Relay		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 51 / 255
=	++	+ UC20	& C03	29-Sep-25						

FRM5103656/0B

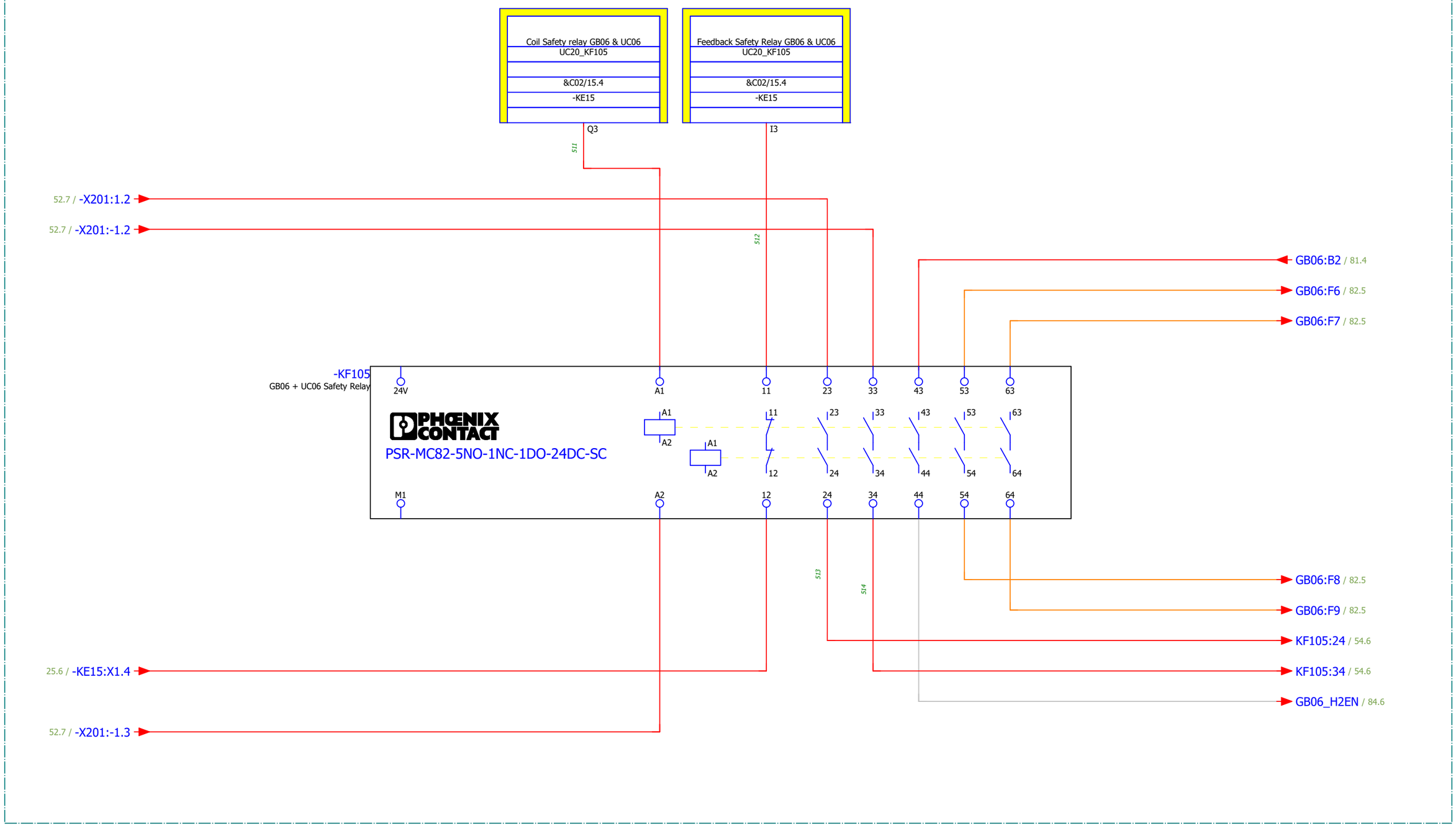
=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	40ft Control Cabinet, GB05 + UC05 Safety Relay		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 52 / 255
=	++	+ UC20	& C03	29-Sep-25						

FRM5103656/0B

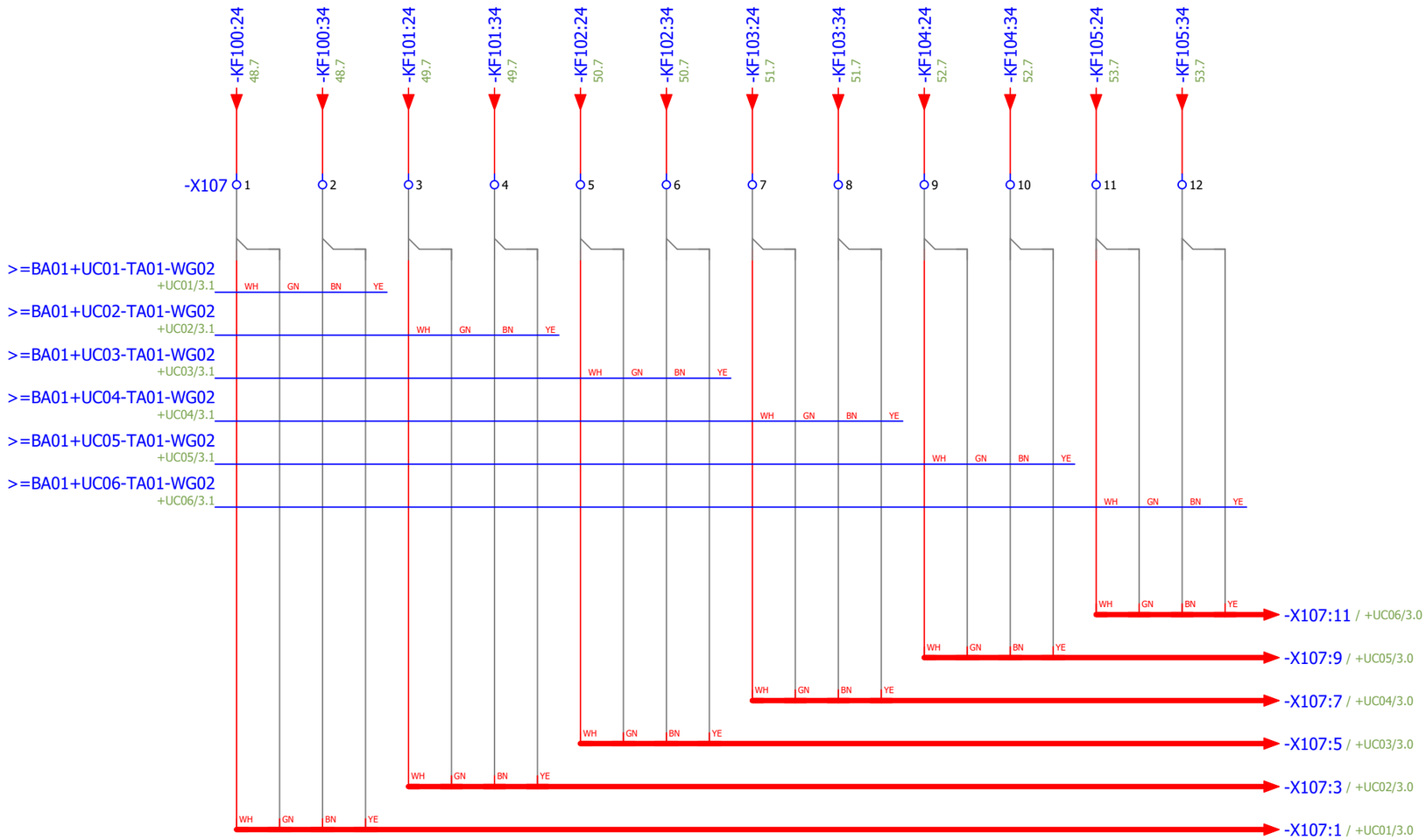
=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	40ft Control Cabinet, GB06 + UC06 Safety Relay		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 53 / 255
=	++	+ UC20	& C03	29-Sep-25						

FRM5103656/0B

=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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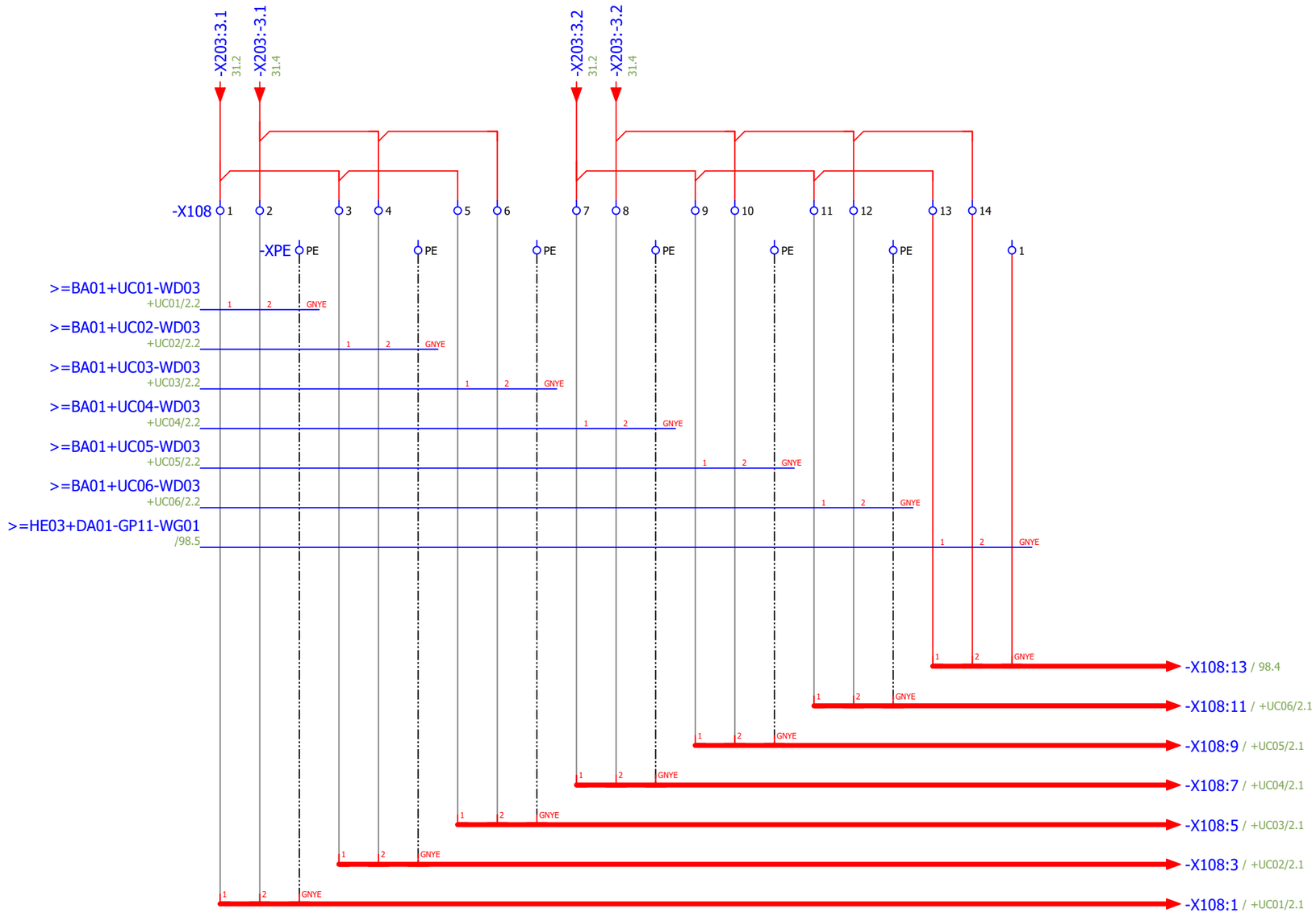
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, -X107 STO Connections UC01 - UC06		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 54 / 255

FRM5103656/0B

=LA01+UC20
Control System



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, -X108 24VDC Connections UC01 - UC06		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 55 / 255

=LA01+UC20

Coil Safety Relay Nanogrid DC/AC
&C02/16.1
-KE16
Q1

Coil Safety Relay Nanogrid DC/AC
+UC20-KF16
&C02/16.1
Q1

520
521
522
523
524
525

-X101 1 2 3 4

-KF106
Safety Relay, Nanogrid

24V A1 11 23 33 43 53 63

PHOENIX CONTACT
PSR-MC82-5NO-1NC-1DO-24DC-SC

A1 A2 11 12 23 24 33 34 43 44 53 54 63 64

M1 A2 12 24 34 44 54 64

26.1 / KE16:X1.1
30.3 / -X201:-1.5
30.1 / -X201:1.4
30.3 / -X201:-1.4

313
322

=LA01+UC20

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, Safety Relay Nanogrid		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 56 / 255

=LA01+UC20

KF17 Safety Relay Coil
UC20_KF17
&C02/14.1
-KE12

Coil Safety Relay Nanogrid DC/AC
+UC20-KF16
&C02/16.1
-KE16

Q2
I1

527
528
531
532
533
534

-KF107
Safety Relay, +UC20

PHOENIX CONTACT
PSR-MC82-5NO-1NC-1DO-24DC-SC

24V A1 11 23 33 43 53 63
A1 A2 A1 A2
11 12 23 24 33 34 43 44 53 54 63 64
M1 A2 12 24 34 44 54 64

-X102 1 2 3 4

-KF107:23 58.1
-KF107:33 58.1
-KF107:43 58.1
-KF107:53 58.1

529
315
324

25.1 / KE12:X1.4
30.3 / -X201:-2.1
30.1 / -X201:1.6
30.3 / -X201:-1.6
30.2 / -X201:3.6

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, LT Pump		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 57 / 255

0	1	2	3	4	5	6	7	8

=HE03+DA01
Control System

57.6 / >=LA01+UC20-KF107:23
57.6 / >=LA01+UC20-KF107:33
57.6 / >=LA01+UC20-KF107:43
57.7 / >=LA01+UC20-KF107:53

-GP11.WG02
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
STO LT Pump

-TA11
/98.1
/98.4
/98.4

1	2	3	4	21	22	23	25	26	28	29
SD1+	SD1-	SD2+	SD2-	RO1 NC	RO1 CO	RO1 NO	RO2 CO	RO2 NO	TI1+	TI1-

535

VACON

VACON NX
STO board
OPT-AF

X10 OFF

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, STO LT pump		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 58 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC30
Control Cabinet, Coolant Skid

=HA01+DA02
Exterior location, hydrogen supply

=LA01+UC20
Control Cabinet, 40ft Container

Coolant Skid Safety Relay FB
UC30_KF10_FB
&C02/14.1
-KE12
I7

Coolant Skid Safety Relay Coil
UC30_KF10_Q
&C02/14.1
-KE12
Q3

Coolant Skid ESTOP CH1
UC30_SG20-1
&C02/14.1
-KE12
I5

Coolant Skid ESTOP CH2
UC30_SG20-2
&C02/14.1
I6

536
537
269
274

Safety 0V

30.1 / >=LA01-X201:1.3

25.2 / -KE12:X2.3 — KE12 Pulse CH2

25.1 / -KE12:X1.3 — KE12 Pulse CH1

-X100 1 2 3 4 5 6 7

+UC30/20.0 / -WG01 — 4x1 from Coolant Skid

-XT08
/59.1
EX Cable gland
Wall pass-through

+UC30/20.3 / -WG02 — 18G0,75 From Coolant Skid

-XT08
/59.1
EX Cable gland
Wall pass-through

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet, Safety Coolant Skid		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 59 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

H2 Sensor Ventilation Inlet
JA01_BQ01_AZT
>=LB02+UC20-KE17
AI+ AI- AI+ AI-
AI1+ AI1- AI2+ AI2-

H2 Sensor Ventilation Outlet A
JA01_BQ02_AZT
>=LB02+UC20-KE18
AI+ AI- AI+ AI-
AI1+ AI1- AI2+ AI2-

H2 Sensor Ventilation Outlet B
JA01_BQ03_AZT
>=LB02+UC20-KE19
AI+ AI- AI+ AI-
AI1+ AI1- AI2+ AI2-

538 540 542

328 328

30.3 / -X201:-2.4
30.1 / -X201:2.3
30.3 / -X201:-2.3

-X103 1 2 3 4 5 6 7 8 9 10 11 12

=JA01+DA01

-BQ01-WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
H2 Sensor Ventlation Inlet Signal
1 2 3 4

-BQ02-WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
H2 Sensor Ventlation Outlet A Signal
1 2 3 4

-BQ03-WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
H2 Sensor Ventlation Outlet B Signal
1 2 3 4

-BQ01
0-100 %LEL to 4-20mA
H2 Sensor
Ventilation Inlet

+ - mA PE
1 2 3 4

Dräger

4-20mA
H2 - %LEL

-BQ02
0-100 %LEL to 4-20mA
H2 Sensor
Ventilation Outlet A

+ - mA PE
1 2 3 4

Dräger

4-20mA
H2 - %LEL

-BQ03
0-100 %LEL to 4-20mA
H2 Sensor
Ventilation Outlet B

+ - mA PE
1 2 3 4

Dräger

4-20mA
H2 - %LEL

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Safety, Hydrogen Sensors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 60 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

KE16 Test pulse output CH2
>=LB02+UC20-KE16
X2

Smoke Detector Ventilation Inlet
JA01_BQ04_ASZ
>=LB02+UC20-KE16
I2

KE16 Test pulse output CH1
>=LB02+UC20-KE16
X1

Smoke Detector Ventilation Outlet A
JA01_BQ05_ASZ
>
I3

Smoke Detector Ventilation Outlet B
JA01_BQ06_ASZ
I4

544
545
546
544
547
548

30.1 / -X201:2.5
30.3 / -X201:-2.5

-X104 1 2 3 4 5 6 7 8 9 10 11 12

=JA01+DA01

-BQ04-WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
Smoke Detector Ventlation Inlet Signal

-BQ05-WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
Smoke Detector Ventlation Outlet B Signal

-BQ06-WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
Smoke Detector Ventlation Outlet B Signal

-BQ04
Smoke Detector
Ventilation Inlet

-BQ05
Smoke Detector
Ventilation Outlet A

-BQ06
Smoke Detector
Ventilation Outlet B

-X2
IN COM OUT 1 2 3 4

2 3
1

Orbis Marine Relay Base
ORB-RB-40004-MAR

-X1
IN COM OUT LED

-BQ04
Smoke Detector
Ventilation Inlet

-BQ05
Smoke Detector
Ventilation Outlet A

-BQ06
Smoke Detector
Ventilation Outlet B

-X1
IN COM OUT LED

Orbis Marine Smoke Detector
ORB-OP-42001-MAR

Reference Item Number	Ballard Part # TBD		
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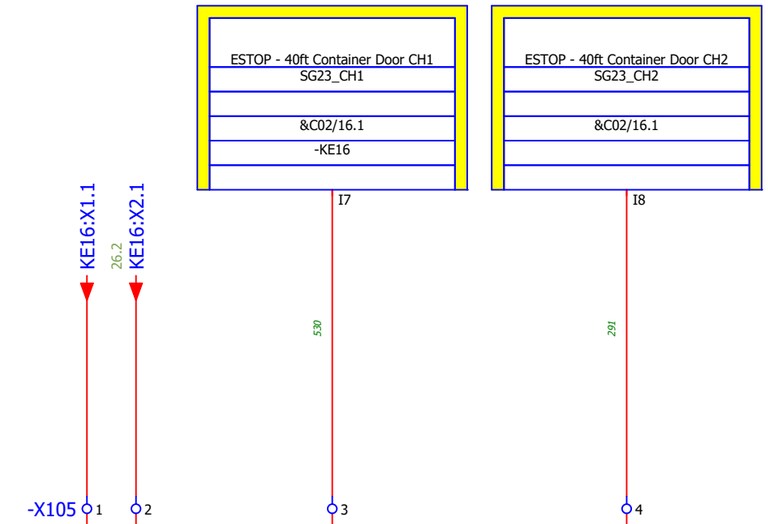
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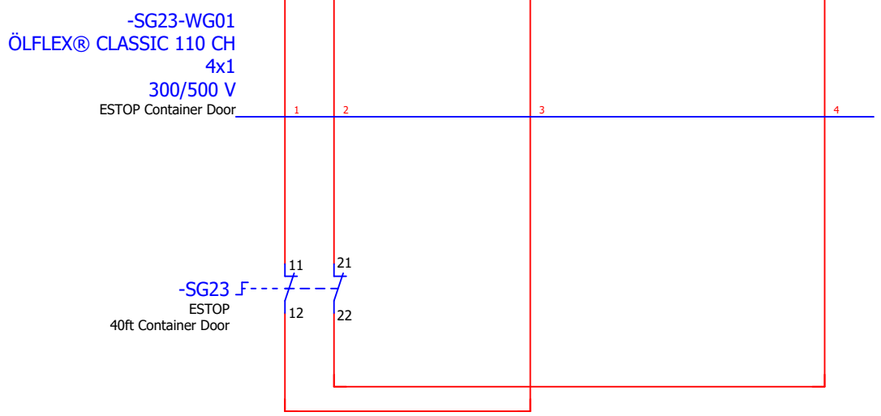
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Safety, Smoke Detectors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 61 / 255

0	1	2	3	4	5	6	7	8

=LA01
Control Cabinet, 40ft Container Inside



=LB02+DA01
40ft Container Inside



Reference Item Number	Ballard Part # TBD		
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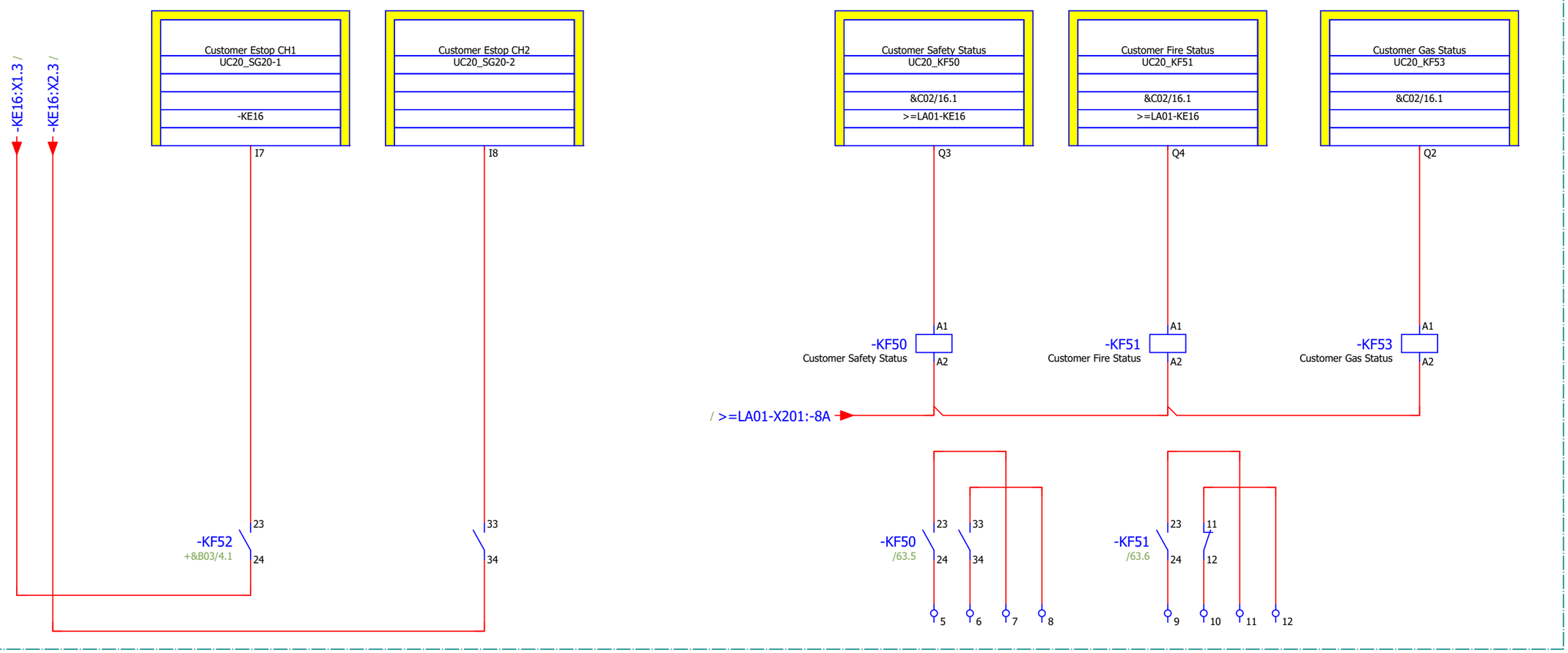
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Safety, ESTOP Container Door		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 62 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LB02
Control Cabinet, 40ft Container Inside



>=EXT+
Customer Scope

23 24 /63.5
23 24 +&B03/4.6
33 34 /63.5
33 34 +&B03/4.6

11 12 /63.6
23 24 /63.6
23 24 +&B03/4.3

23 24 +&B03/4.4

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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=	++	+ UC20	& C03

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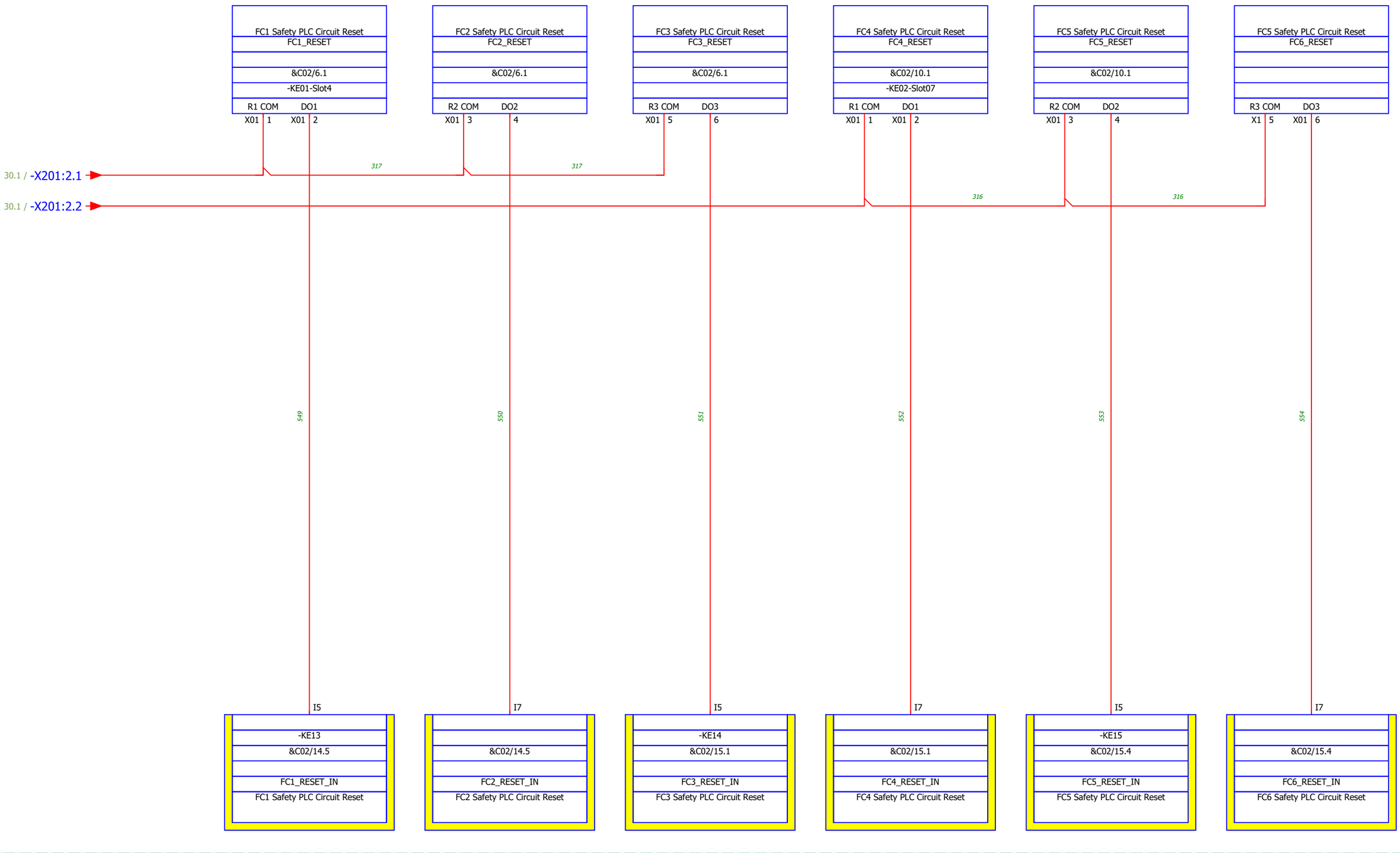
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DRAWING	5500232B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Customer Interface Diagram, ???		
SHEET TYPE/DESC	40ft Container - Safety, Customer Interface		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 63 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20



Reference Item Number	Ballard Part # TBD		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet - FC1-6 Safety Circuit Reset		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 64 / 255

=LA01+UC20
40ft Container, Control Cabinet

-KF201
16 port
100/10 Ethernet Switch

Ethernet
2
Port 2

>=RE01+GB01-GB01-XG01
/80.3
Cat 6A
FC1 Ethernet

FC101_24VFB / 45.1
-FC101+ / 35.2
FC101- / 35.2
FC101_0VFB / 45.3
FC102+ / 35.3
FC102- / 35.3
-X50:4 / 83.1

-X_PE 1
-X50 1 2 3 4

=RE01+GB01
FCwave #1

-GB01-WD05
CLASSIC 110 CH
5x6
300/500 V
FCwave #1 24V Supply
GNYE 1 2 3 4

-GB01-WG01
Cat.6A PUR
8x24
300 V
FCwave #1 Ethernet

-XZ01
/66.0
/67.0
FCwave #2 Control Connector
-PE PE
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD Not Connected

GB01-X_E01
/66.0
/67.0
FCwave #1 Control Connector
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1: 24V and Ethernet		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 65 / 255

=LA01+UC20
40ft Container, Control Cabinet

Fuel Cell Module OK
GB01_FCM_OK
&C02/9.1
>=RE01+GB01-KE02-Slot04
DI07
X02 21

MD_Enable Signal
GB01_MD_ENABLE
&C02/9.1
-KE02-Slot04
DO01
X01 2

48.7
GB01:B2

555 VT 0,5 mm²
556 VT 0,5 mm²

-X60 13 14 15

=RE01+GB01
FCwave #1

-GB01-WG02
/67.0
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
13 14 15

FC1_FCM_OK
FC1_H2_EN
FC1_MD_EN

-XZ01
/65.0
FCwave #2 Control Connector
-SlotB
1 2 3

GB01-X_E01
/65.0
/67.0
FCwave #1 Control Connector
-SlotB
1 2 3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1: Control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 66 / 255

=LA01+UC20
40ft Container, Control Cabinet

SAFE_Main GB01 | GB01 | >=LB02-KE13 | I2
SAFE_FIRE Safety Signal | GB01_SAFE_FIRE | &C02/9.1 | -KE02-Slot04 | DI01 | X02 15
SAFE_H2CONC Safety Signal | GB01_SAFE_H2CONC | &C02/9.1 | >=RE01+GB01-KE02-Slot04 | DI02 | X02 16
SAFE_VENT Safety Signal | GB01_SAFE_VENT | &C02/9.1 | DI03 | 17
SAFE_WD Safety Signal | GB01_SAFE_WD | &C02/9.1 | DI04 | 18
SAFE_In GB01 | GB01 | >=LB02-KE02-KE13 | Q2
SAFE_FIREMALF Safety Signal | GB01_SAFE_FIREMALF | &C02/9.1 | >=RE01+GB01-KE02-Slot04 | DI05 | X02 19
SAFE_EXTERN Safety Signal | GB01_SAFE_EXTERN | &C02/9.1 | >=RE01+GB01-KE02-Slot04 | DI06 | X02 20

557 VT 0,5 mm² | 558 VT 0,5 mm² | 559 VT 0,5 mm² | 560 VT 0,5 mm² | 561 VT 0,5 mm²
GB01:F6 / 48.7 — 465 OG 0,5 mm²
GB01:F7 / 48.7 — 467 OG 0,5 mm²
GB01:F8 / 48.7 — 466 OG 0,5 mm²
GB01:F9 / 48.7 — 468 OG 0,5 mm²
562 VT 0,5 mm² | 563 VT 0,5 mm² | 564 VT 0,5 mm²

-X60 1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB01
FCwave #1

-GB01-WG02
/66.4
CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals

1 FC1_SAFE_MAIN
2 FC1_SAFE_FIRE
3 FC1_SAFE_H2
4 FC1_SAFE_VENT
5 FC1_SAFE_WD
6 FC1_ESTOP_OUT1
7 FC1_ESTOP_OUT2
8 FC1_ESTOP_IN1
9 FC1_ESTOP_IN2
10 FC1_SAFE_IN
11 FC1_SAFE_FIREMALF
12 FC1_SAFE_EXTERN

-XZ01
/65.0
FCwave #2 Control Connector
-SlotF: 1 2 3 4 5 6 7 8 9 10 11 12

GB01-X_E01
/65.0
/66.0
FCwave #1 Control Connector
-SlotF: 1 2 3 4 5 6 7 8 9 10 11 12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC1: Safety		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 67 / 255

FRM5103656/0B

=LA01+UC20
40ft Container, Control Cabinet

-KF201
16 port
100/10 Ethernet Switch

Ethernet
3
Port 3

FC103_24VFB / 45.2
-FC103+ / 35.4
FC103- / 35.4
FC104+ / 35.5
FC104- / 35.5
-X51:4 / 83.3

>=RE01+GB02-GB02-XG01
Cat 6A
FC1 Ethernet
1

-X_PE 1
-X51 1 2 3 4

=RE01+GB02
FCwave #2

-GB02-WD05
CLASSIC 110 CH
5x6
300/500 V
FCwave #1 24V Supply
GNYE 1 2 3 4

-GB02-WG01
Cat.6A PUR
8x24
300 V
FCwave #1 Ethernet

-XZ01
/69.0
/70.0
FCwave #2 Control Connector
-PE
PE
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD
Not Connected

GB02-X_E01
/69.0
/70.0
FCwave #1 Control Connector
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC2: 24V and Ethernet		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 68 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20
40ft Container, Control Cabinet

Fuel Cell Module OK
GB02_FCM_OK
&C02/9.1
>=RE01+GB01-KE02-Slot04
DI14
X03 29

MD_Enable Signal
GB02_MD_ENABLE
&C02/9.1
-KE02-Slot04
DO02
X01 3

49.7
GB02:B2

565 VT 0,5 mm²
566 VT 0,5 mm²

-X61 13 14 15

=RE01+GB02
FCwave #2

-GB02-WG02
/70.0
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
13 14 15

FC1_FCM_OK
FC1_H2_EN
FC1_MD_EN

-XZ01
/68.0
FCwave #2 Control Connector
-SlotB 1 2 3

GB02-X_E01
/68.0
/70.0
FCwave #1 Control Connector
-SlotB 1 2 3

Reference Item Number	Ballard Part # TBD		
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=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC2: Control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 69 / 255

=LA01+UC20
40ft Container, Control Cabinet

SAFE_Main GB02 | GB02 | >=LB02-KE13 | I4
SAFE_FIRE Safety Signal | GB02_SAFE_FIRE | &C02/9.1 | >=RE01+GB01-KE02-Slot04 | DI08 | X02 22
SAFE_H2CONC Safety Signal | GB02_SAFE_H2CONC | &C02/9.1 | DI09 | X03 24
SAFE_VENT Safety Signal | GB02_SAFE_VENT | &C02/9.1 | DI10 | 25
SAFE_WD Safety Signal | GB02_SAFE_WD | &C02/9.1 | DI11 | 26
SAFE_In GB02 | GB02 | >=LB02-KE02-KE13 | Q4
SAFE_FIREMALF Safety Signal | GB02_SAFE_FIREMALF | &C02/9.1 | >=RE01+GB01-KE02-Slot04 | DI12 | X03 27
SAFE_EXTERN Safety Signal | GB02_SAFE_EXTERN | &C02/9.1 | >=RE01+GB01-KE02-Slot04 | DI13 | X03 28

GB02:F6 / 49.7
GB02:F7 / 49.7
GB02:F8 / 49.7
GB02:F9 / 49.7

567 VT 0,5 mm² | 568 VT 0,5 mm² | 569 VT 0,5 mm² | 570 VT 0,5 mm² | 571 VT 0,5 mm²
475 OG 0,5 mm² | 477 OG 0,5 mm² | 476 OG 0,5 mm² | 478 OG 0,5 mm²
572 VT 0,5 mm² | 573 VT 0,5 mm² | 574 VT 0,5 mm²

-X61 1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB02
FCwave #2

-GB02-WG02
/69.4
CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals

1 FC1_SAFE_MAIN
2 FC1_SAFE_FIRE
3 FC1_SAFE_H2
4 FC1_SAFE_VENT
5 FC1_SAFE_WD
6 FC1_ESTOP_OUT1
7 FC1_ESTOP_OUT2
8 FC1_ESTOP_IN1
9 FC1_ESTOP_IN2
10 FC1_SAFE_IN
11 FC1_SAFE_FIREMALF
12 FC1_SAFE_EXTERN

-XZ01
/68.0
FCwave #2 Control Connector
-SlotF 1 2 3 4 5 6 7 8 9 10 11 12

GB02-X_E01
/68.0
/69.0
FCwave #1 Control Connector
-SlotF 1 2 3 4 5 6 7 8 9 10 11 12

Reference Item Number	Ballard Part # TBD		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC2: Safety		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 70 / 255

=LA01+UC20
40ft Container, Control Cabinet

-KF201
16 port
100/10 Ethernet Switch

Ethernet
4
Port 4

FC111_24VFB / 45.4
-FC111+ / 38.2
FC111- / 38.2
FC111_0VFB / 45.5
FC112+ / 38.3
FC112- / 38.3
-X52:4 / 83.6

>=RE01+GB03-GB03-XG01
Cat 6A
FC1 Ethernet
1

-X_PE 1
-X52 1 2 3 4

=RE01+GB03
FCwave #3

-GB03-WD05
CLASSIC 110 CH
5x6
300/500 V
FCwave #1 24V Supply
GNYE 1 2 3 4

-GB03-WG01
Cat.6A PUR
8x24
300 V
FCwave #1 Ethernet

-XZ01
/72.0
/73.0
FCwave #2 Control Connector
-PE
PE
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD
Not Connected

GB03-X_E01
/72.0
/73.0
FCwave #1 Control Connector
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC3: 24V and Ethernet		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 71 / 255

=LA01+UC20
40ft Container, Control Cabinet

Fuel Cell Module OK
GB03_FCM_OK
&C02/9.4
-KE02-Slot05
DI07
X02 21

MD_Enable Signal
GB03_MD_ENABLE
&C02/9.4
DO01
X01 2

50.7
GB03:B2

575 VT 0,5 mm²
576 VT 0,5 mm²

-X62 13 14 15

=RE01+GB03
FCwave #3

-GB03-WG02
/73.0
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
13 14 15

FC1_FCM_OK
FC1_H2_EN
FC1_MD_EN

-XZ01
/71.0
FCwave #2 Control Connector
-SlotB
1 2 3

GB03-X_E01
/71.0
/73.0
FCwave #1 Control Connector
-SlotB
1 2 3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC3: Control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 72 / 255

=LA01+UC20
40ft Container, Control Cabinet

SAFE_Main GB03 | GB03 | >=LB02-KE14 | I2
SAFE_FIRE Safety Signal | GB03_SAFE_FIRE | &C02/9.4 | -KE02-Slot05 | DI01 | X02 15
SAFE_H2CONC Safety Signal | GB03_SAFE_H2CONC | &C02/9.4 | DI02 | 16
SAFE_VENT Safety Signal | GB03_SAFE_VENT | &C02/9.4 | DI03 | 17
SAFE_WD Safety Signal | GB03_SAFE_WD | &C02/9.4 | DI04 | 18
SAFE_In GB03 | GB03 | >=LB02-KE14 | Q2
SAFE_FIREMALF Safety Signal | GB03_SAFE_FIREMALF | &C02/9.4 | -KE02-Slot05 | DI05 | X02 19
SAFE_EXTERN Safety Signal | GB03_SAFE_EXTERN | &C02/9.4 | -KE02-Slot05 | DI06 | X02 20

GB03:F6 / 50.7
GB03:F7 / 50.7
GB03:F8 / 50.7
GB03:F9 / 50.7

577 VT 0,5 mm² | 578 VT 0,5 mm² | 579 VT 0,5 mm² | 580 VT 0,5 mm² | 581 VT 0,5 mm²
486 OG 0,5 mm² | 488 OG 0,5 mm² | 487 OG 0,5 mm² | 489 OG 0,5 mm²
582 VT 0,5 mm² | 583 VT 0,5 mm² | 584 VT 0,5 mm²

-X62 1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB03
FCwave #3

-GB03-WG02
/72.4
CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals

1 2 3 4 5 6 7 8 9 10 11 12

FC1_SAFE_MAIN | FC1_SAFE_FIRE | FC1_SAFE_H2 | FC1_SAFE_VENT | FC1_SAFE_WD | FC1_ESTOP_OUT1 | FC1_ESTOP_OUT2 | FC1_ESTOP_IN1 | FC1_ESTOP_IN2 | FC1_SAFE_IN | FC1_SAFE_FIREMALF | FC1_SAFE_EXTERN

-XZ01
/71.0
FCwave #2 Control Connector
-SlotF
1 2 3 4 5 6 7 8 9 10 11 12

GB03-X_E01
/71.0
/72.0
FCwave #1 Control Connector
-SlotF
1 2 3 4 5 6 7 8 9 10 11 12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC3: Safety		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 73 / 255

FRM5103656/0B

=LA01+UC20
40ft Container, Control Cabinet

-KF201
16 port
100/10 Ethernet Switch

Ethernet
5
Port 5

FC113_24VFB / 45.5
-FC113+ / 38.4
FC113- / 38.4
FC114+ / 38.5
FC114- / 38.5
-X53:4 / 84.1

>=RE01+GB04-GB04-XG01
Cat 6A
FC1 Ethernet
1

-X_PE 1
-X53 1 2 3 4

=RE02+GB04
FCwave #4

-GB04-WD05
CLASSIC 110 CH
5x6
300/500 V
FCwave #1 24V Supply
GNYE 1 2 3 4

-GB04-WG01
Cat.6A PUR
8x24
300 V
FCwave #1 Ethernet

-XZ01
/75.0
/76.0
FCwave #2 Control
Connector
-PE
PE
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD
Not Connected

GB04-X_E01
/75.0
/76.0
FCwave #1
Control Connector
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC4: 24V and Ethernet		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 74 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20
40ft Container, Control Cabinet

Fuel Cell Module OK
GB04_FCM_OK
&C02/9.4
-KE02-Slot05
DI14
X03 29

MD_Enable Signal
GB04_MD_ENABLE
&C02/9.4
DO02
X01 3

51.7
GB04:B2

585 VT 0,5 mm²
586 VT 0,5 mm²

-X63 13 14 15

=RE02+GB04
FCwave #4

-GB04-WG02
/76.0
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
13 14 15

FC1_FCM_OK
FC1_H2_EN
FC1_MD_EN

-XZ01
/74.0
FCwave #2 Control Connector
-SlotB
1 2 3

GB04-X_E01
/74.0
/76.0
FCwave #1 Control Connector
-SlotB
1 2 3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC4: Control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 75 / 255

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8

=LA01+UC20
40ft Container, Control Cabinet

SAFE_Main GB04 | GB04 | >=LB02-KE14 | I4
SAFE_FIRE Safety Signal | GB04_SAFE_FIRE | &C02/9.4 | -KE02-Slot05 | DI08 | X02 22
SAFE_H2CONC Safety Signal | GB04_SAFE_H2CONC | &C02/9.4 | DI09 | X03 24
SAFE_VENT Safety Signal | GB04_SAFE_VENT | &C02/9.4 | DI10 | 25
SAFE_WD Safety Signal | GB04_SAFE_WD | &C02/9.4 | DI11 | 26
SAFE_In GB04 | GB04 | >=LB02-KE14 | Q4
SAFE_FIREMALF Safety Signal | GB04_SAFE_FIREMALF | &C02/9.4 | -KE02-Slot05 | DI12 | X03 27
SAFE_EXTERN Safety Signal | GB04_SAFE_EXTERN | &C02/9.4 | -KE02-Slot05 | DI13 | X03 28

587 VT 0,5 mm² | 588 VT 0,5 mm² | 589 VT 0,5 mm² | 590 VT 0,5 mm² | 591 VT 0,5 mm²
GB04:F6 / 51.7 → 496 OG 0,5 mm²
GB04:F7 / 51.7 → 498 OG 0,5 mm²
GB04:F8 / 51.7 → 497 OG 0,5 mm²
GB04:F9 / 51.7 → 499 OG 0,5 mm²
592 VT 0,5 mm² | 593 VT 0,5 mm² | 594 VT 0,5 mm²

-X63: 1 2 3 4 5 6 7 8 9 10 11 12

=RE02+GB04
FCwave #4

-GB04-WG02
/75.4
CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
1 2 3 4 5 6 7 8 9 10 11 12
FC1_SAFE_MAIN | FC1_SAFE_FIRE | FC1_SAFE_H2 | FC1_SAFE_VENT | FC1_SAFE_WD | FC1_ESTOP_OUT1 | FC1_ESTOP_OUT2 | FC1_ESTOP_IN1 | FC1_ESTOP_IN2 | FC1_SAFE_IN | FC1_SAFE_FIREMALF | FC1_SAFE_EXTERN

-XZ01
/74.0
FCwave #2 Control Connector
-SlotF: 1 2 3 4 5 6 7 8 9 10 11 12

GB04-X_E01
/74.0
/75.0
FCwave #1 Control Connector
-SlotF: 1 2 3 4 5 6 7 8 9 10 11 12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC4: Safety		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 76 / 255

FRM5103656/0B

=LA01+UC20
40ft Container, Control Cabinet

-KF201
16 port
100/10 Ethernet Switch

Ethernet
6
Port 6

>=RE01+GB05-GB05-XG01
Cat 6A
FC1 Ethernet

FC121_24VFB / 45.6
-FC121+ / 41.1
FC121- / 41.2
FC121_0VFB / 45.8
FC122+ / 41.3
FC122- / 41.3
-X54:4 / 84.3

-X_PE 1
-X54 1 2 3 4

=RE02+GB05
FCwave #5

-GB05-WD05
CLASSIC 110 CH
5x6
300/500 V
FCwave #1 24V Supply
GNYE 1 2 3 4

-GB05-WG01
Cat.6A PUR
8x24
300 V
FCwave #1 Ethernet

-XZ01
/78.0
/79.0
FCwave #2 Control
Connector
-PE PE
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD Not Connected

GB05-X_E01
/78.0
/79.0
FCwave #1
Control Connector
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC5: 24V and Ethernet		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 77 / 255

=LA01+UC20
40ft Container, Control Cabinet

Fuel Cell Module OK
GB05_FCM_OK
&C02/9.6
-KE02-Slot06
DI07
X02 21

MD_Enable Signal
GB05_MD_ENABLE
&C02/9.6
DO01
X01 2

52.7
GB05:B2

595 VT 0,5 mm²
596 VT 0,5 mm²

-X64 13 14 15

=RE02+GB05
FCwave #5

-GB05-WG02
/79.0
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
13 14 15
FC1_FCM_OK
FC1_H2_EN
FC1_MD_EN

-XZ01
/77.0
FCwave #2 Control Connector
-SlotB
1 2 3

GB05-X_E01
/77.0
/79.0
FCwave #1 Control Connector
-SlotB
1 2 3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC5: Control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 78 / 255

=LA01+UC20
40ft Container, Control Cabinet

SAFE_Main GB05 | GB05 | >=LB02-KE15 | I2
SAFE_FIRE Safety Signal | GB05_SAFE_FIRE | &C02/9.6 | -KE02-Slot06 | DI01 | X02 15
SAFE_H2CONC Safety Signal | GB05_SAFE_H2CONC | &C02/9.6 | DI02 | 16
SAFE_VENT Safety Signal | GB05_SAFE_VENT | &C02/9.6 | DI03 | 17
SAFE_WD Safety Signal | GB05_SAFE_WD | &C02/9.6 | DI04 | 18
SAFE_In GB05 | GB05 | >=LB02-KE15 | Q2
SAFE_FIREMALF Safety Signal | GB05_SAFE_FIREMALF | &C02/9.6 | -KE02-Slot06 | DI05 | X02 19
SAFE_EXTERN Safety Signal | GB05_SAFE_EXTERN | &C02/9.6 | -KE02-Slot06 | DI06 | X02 20

GB05:F6 / 52.7
GB05:F7 / 52.7
GB05:F8 / 52.7
GB05:F9 / 52.7

597 VT 0,5 mm² | 598 VT 0,5 mm² | 599 VT 0,5 mm² | 600 VT 0,5 mm² | 601 VT 0,5 mm²
507 OG 0,5 mm² | 509 OG 0,5 mm² | 508 OG 0,5 mm² | 510 OG 0,5 mm²
602 VT 0,5 mm² | 603 VT 0,5 mm² | 604 VT 0,5 mm²

-X64 1 2 3 4 5 6 7 8 9 10 11 12

=RE02+GB05
FCwave #5

-GB05-WG02
/78.4
CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals

1 FC1_SAFE_MAIN
2 FC1_SAFE_FIRE
3 FC1_SAFE_H2
4 FC1_SAFE_VENT
5 FC1_SAFE_WD
6 FC1_ESTOP_OUT1
7 FC1_ESTOP_OUT2
8 FC1_ESTOP_IN1
9 FC1_ESTOP_IN2
10 FC1_SAFE_IN
11 FC1_SAFE_FIREMALF
12 FC1_SAFE_EXTERN

-XZ01
/77.0
FCwave #2 Control Connector
-SlotF
1 2 3 4 5 6 7 8 9 10 11 12

GB05-X_E01
/77.0
/78.0
FCwave #1 Control Connector
-SlotF
1 2 3 4 5 6 7 8 9 10 11 12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC5: Safety		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 79 / 255

FRM5103656/0B

=LA01+UC20
40ft Container, Control Cabinet

-KF201
16 port
100/10 Ethernet Switch

Ethernet
7
Port 7

FC123_24VFB / 45.7
-FC123+ / 41.4
-FC123- / 41.4
-FC124+ / 41.5
-FC124- / 41.5
-X55:4 / 84.6

>=RE01+GB01-GB01-XG01
/65.3
Cat 6A
FC1 Ethernet

-X_PE 1
-X55 1 2 3 4

=RE02+GB06
FCwave #6

-GB06-WD05
CLASSIC 110 CH
5x6
300/500 V
FCwave #1 24V Supply
GNYE 1 2 3 4

-GB06-WG01
Cat.6A PUR
8x24
300 V
FCwave #1 Ethernet

-XZ01
/81.0
/82.0
FCwave #2 Control Connector
-PE PE
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD Not Connected

GB06-X_E01
/81.0
/82.0
FCwave #1 Control Connector
-SlotA 1 2
-SlotE 1 2
-SlotC 1-8
-SlotD

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC6: 24V and Ethernet		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 80 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
40ft Container, Control Cabinet

Fuel Cell Module OK
GB06_FCM_OK
&C02/9.6
-KE02-Slot06
DI14
X03 29

MD_Enable Signal
GB06_MD_ENABLE
&C02/9.6
DO02
X01 3

53.7
GB06:B2

0,5 mm² VT 605

0,5 mm² VT 606

-X65 13 14 15

=RE02+GB06
FCwave #6

-GB06-WG02
/82.0
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
13 14 15

FC1_FCM_OK
FC1_H2_EN
FC1_MD_EN

-XZ01
/80.0
FCwave #2 Control Connector
-SlotB
1 2 3

GB06-X_E01
/80.0
/82.0
FCwave #1 Control Connector
-SlotB
1 2 3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC6: Control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 81 / 255

=LA01+UC20
40ft Container, Control Cabinet

SAFE_Main GB06 | GB06 | >=LB02-KE15 | I4
SAFE_FIRE Safety Signal | GB06_SAFE_FIRE | &C02/9.6 | -KE02-Slot06 | DI08 | X02 22
SAFE_H2CONC Safety Signal | GB06_SAFE_H2CONC | &C02/9.6 | DI09 | X03 24
SAFE_VENT Safety Signal | GB06_SAFE_VENT | &C02/9.6 | DI10 | 25
SAFE_WD Safety Signal | GB06_SAFE_WD | &C02/9.6 | DI11 | 26
SAFE_In GB06 | GB06 | >=LB02-KE15 | Q4
SAFE_FIREMALF Safety Signal | GB06_SAFE_FIREMALF | &C02/9.6 | -KE02-Slot06 | DI12 | X03 27
SAFE_EXTERN Safety Signal | GB06_SAFE_EXTERN | &C02/9.6 | -KE02-Slot06 | DI13 | X03 28

607 VT 0,5 mm² | 608 VT 0,5 mm² | 609 VT 0,5 mm² | 610 VT 0,5 mm² | 611 VT 0,5 mm²
GB06:F6 / 53.7 — 516 OG 0,5 mm²
GB06:F7 / 53.7 — 518 OG 0,5 mm²
GB06:F8 / 53.7 — 517 OG 0,5 mm²
GB06:F9 / 53.7 — 519 OG 0,5 mm²
612 VT 0,5 mm² | 613 VT 0,5 mm² | 614 VT 0,5 mm²

-X65 1 2 3 4 5 6 7 8 9 10 11 12

=RE02+GB06
FCwave #6

-GB06-WG02
/81.4
CLASSIC 110 CH
18x0,75
300/500 V
Fcwave #1 24V Signals
1 2 3 4 5 6 7 8 9 10 11 12
FC1_SAFE_MAIN | FC1_SAFE_FIRE | FC1_SAFE_H2 | FC1_SAFE_VENT | FC1_SAFE_WD | FC1_ESTOP_OUT1 | FC1_ESTOP_OUT2 | FC1_ESTOP_IN1 | FC1_ESTOP_IN2 | FC1_SAFE_IN | FC1_SAFE_FIREMALF | FC1_SAFE_EXTERN

-XZ01
/80.0
FCwave #2 Control Connector
-SlotF
1 2 3 4 5 6 7 8 9 10 11 12

GB06-X_E01
/80.0
/81.0
FCwave #1 Control Connector
-SlotF
1 2 3 4 5 6 7 8 9 10 11 12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - FC6: Safety		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 82 / 255

FRM5103656/0B

=LA01+UC20
Container Control Cabinet, 40ft

-X50:4 / 65.2
GB01_H2EN / 48.7
-X51:4 / 68.2
GB02_H2EN / 49.7
-X52:4 / 71.2
GB03_H2EN / 50.7

0,5 mm² WH 615
0,5 mm² WH 464
0,5 mm² WH 616
0,5 mm² WH 474
0,5 mm² WH 617
0,5 mm² WH 485

-X106 1 2 3 4 5 6

X106 / 84.1

=HA01+DA02-AC01
Hydrogen Supply System - Non EX Box

-XT07
EX Cable gland
Wall pass-through

AC01-WG01
H2 Valve Connections
300/500 V
18x0,75
6 m
ÖLFLEX® CLASSIC 110 CH
/84.1

XD01 / 84.1

-XD01 1 2 3 4 5 6

=HA01+DA02
Hydrogen Supply System

-QM1.1-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
-QM1.1 x1 x2

-QM1.2-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
-QM1.2 x1 x2

-QM1.3-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
-QM1.3 x1 x2

-QM2.1-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
-QM2.1 x1 x2

-QM2.2-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
-QM2.2 x1 x2

-QM2.3-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
-QM2.3 x1 x2

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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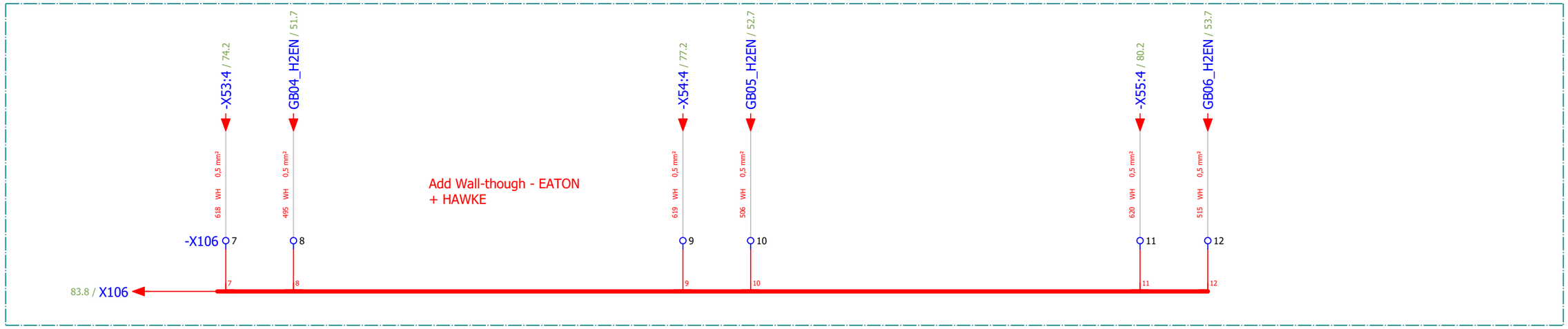
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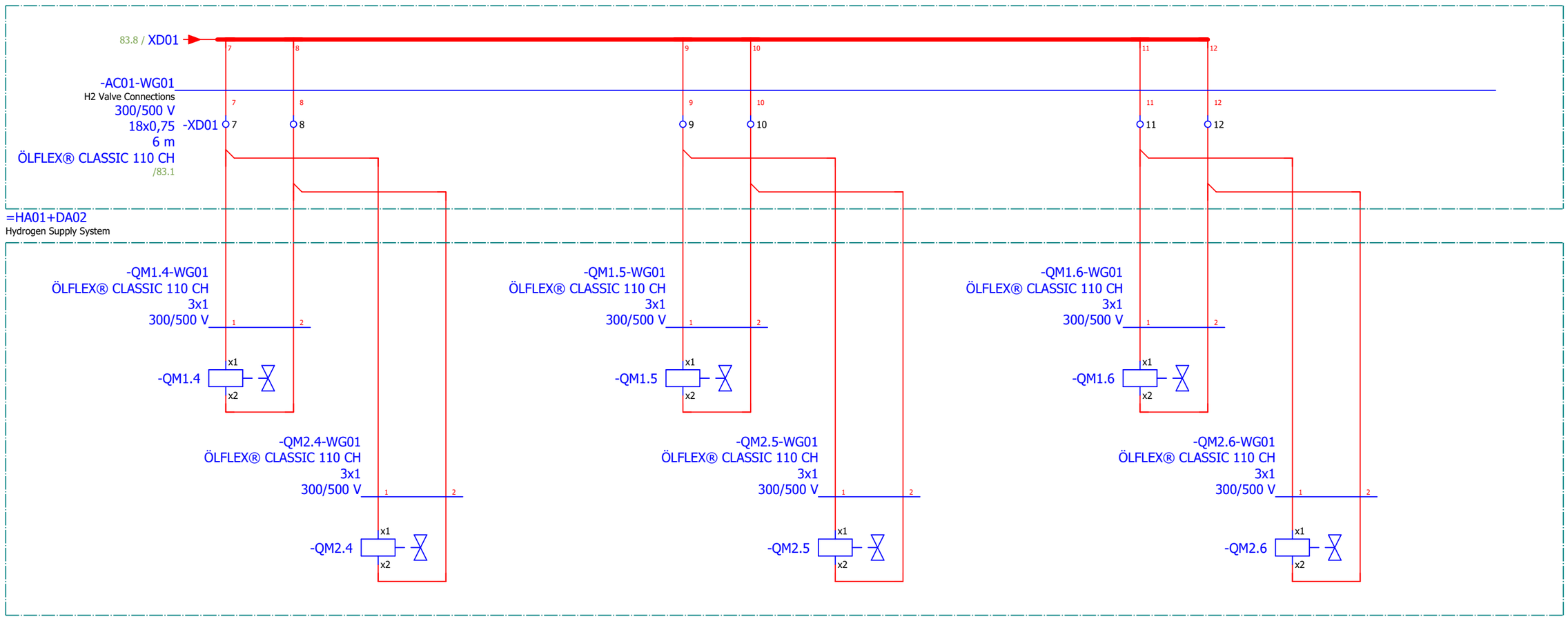
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Hydrogen Valve Cable FC1 - FC3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 83 / 255

=LA01+UC20
Container Control Cabinet, 40ft



=HA01+DA02-AC01
Hydrogen Supply System - Non-EX Box



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Hydrogen Valve Cable FC4 -FC6		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 84 / 255

FRM5103656/0B

=LA01+UC20
Container Control Cabinet, 40ft Container

Condensate Drain Tank High Level
JB01_BL02_LSH
&C02/6.1
-KE01-Slot4
AI4
X03 28

Heatracing drain
JB01_QB18_EB01
&C02/5.6
-KE01-Slot3
DO4.1
X01 10 11

622

30.5 / -X202:2.2

A1
-QB18
A2

30.7 / -X202:-2.2

621

31.4 / -X204:1.1

31.6 / -X204:-1.1

-X110 1 2 3 4

20.3 -FC18:1
20.3 -FC18:2
20.4 -FC18:PE

=JA01+DA01
Condensate Drain System, Inside 40ft Container

-BL02-WG01
PUR
10 m
4x0,34
50/60 V
Process Drain Tank Level Signal
BN BU BK WH

-BL01-XG01
M12 F
1 2 3 4

-BL02
Process Water
Catchment Tank
Level Transmitter
1 L+
3 L-
4 Out 1/ IO-Link
2 Out 2
V

-EB01
/90.0
Heatracing drain line
L
PE
N

1 2
R3 R4
R5 R6
7 8
13 14 /20.3
23 24 /20.3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Fuel Cell Drain line		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 85 / 255

=LA01+UC20
Control Cabinet

Cabinet temperature UC01
UC01_BT01_TT
&C02/12.1
-KE03-Slot4
AI1 AI20 AI21
X01 1 2 3
623 624 625

Cabinet temperature UC02
UC02_BT01_TT
&C02/12.1
-KE03-Slot4
AI4 AI23 AI24
X02 4 5 6
626 627 628

Cabinet temperature UC03
UC03_BT01_TT
&C02/12.1
AI7 AI26 AI27
X03 7 8 9
629 630 631

-X120 1 2 3 4 5 6 7 8 9 10 11 12

=BA01+UC01
DC/DC cabinet 1

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
FC1 HT Outlet Temp Signal
BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT01
EL: 160 mm
FC1 HT Outlet
Temperature
1 2 3 4
PT1000
M12

=BA01+UC02
DC/DC cabinet 2

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
FC1 HT Outlet Temp Signal
BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT01
EL: 160 mm
FC1 HT Outlet
Temperature
1 2 3 4
PT1000
M12

=BA01+UC03
DC/DC cabinet 3

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
FC1 HT Outlet Temp Signal
BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT01
EL: 160 mm
FC1 HT Outlet
Temperature
1 2 3 4
PT1000
M12

Reference Item Number	Ballard Part # TBD		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container -DC/DC cab 1 - 3 Temperature		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 86 / 255

=LA01+UC20
Control Cabinet

Cabinet temperature UC04
UC04_BT01_TT
&C02/12.1
-KE03-Slot4
AI10 AI20 AI21
X04 10 11 12
632 633 634
-X120 13 14 15 16

Cabinet temperature UC05
UC05_BT01_TT
&C02/12.1
AI13 AI23 AI24
X05 13 14 15
635 636 637
17 18 19 20

Cabinet temperature UC06
UC06_BT01_TT
&C02/12.1
AI16 AI23 AI24
X06 16 17 18
638 639 640
21 22 23 24

=BA02+UC04
DC/DC cabinet 4

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
FC1 HT Outlet Temp Signal
BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT01
EL: 160 mm
FC1 HT Outlet
Temperature
1 2 3 4
PT1000
M12

=BA02+UC05
DC/DC cabinet 5

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
FC1 HT Outlet Temp Signal
BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT01
EL: 160 mm
FC1 HT Outlet
Temperature
1 2 3 4
PT1000
M12

=BA02+UC06
DC/DC cabinet 6

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
FC1 HT Outlet Temp Signal
BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT01
EL: 160 mm
FC1 HT Outlet
Temperature
1 2 3 4
PT1000
M12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - DC/DC cab 4 - 6 Temperature		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 87 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control Cabinet, 40ft Container

39.7 / L1
39.7 / L2
39.7 / L3
39.7 / PE

101
213
229
250

L1 / 89.0
L2 / 89.0
L3 / 89.0
PE / 89.0

-FC16
/42.3
6A, B-curve
MCCB, DCDC Cooling Fan A

-FC17
/42.3
6A, B-curve
MCCB, DCDC Cooling Fan B

209
225
240
210
226
241

-X16 PE 1 2 3
-X17 PE 1 2 3

108.7
>=LA01-WG206
BN WH
641
643

=JA01+DA01
Power Converters Cooling 40ft Container

-GQ08-WD01
ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV
4x2,5
0,6/1,0 kV
GNYE 1 2 3

-GQ09-WD01
ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV
4x2,5
0,6/1,0 kV
GNYE 1 2 3

-AC07-WG01
/108.5
BUS CAN FD P
2x0,5
300 V
Ventilation (Upper) Signal
BN WH

-AC08
93x93mm
Junction Box

-AC07
93x93mm
Junction Box

-RE01
643
641
120 Ω
1 2 3 4

-GQ08-WD02
0,6/1 kV
4x2,5
0,6/1,0 kV
DCDC Cooling Fan A Power
GNYE BN BK GY

-GQ08-WG01
2x0,5
300 V
DCDC Cooling Fan B Signal
BN
WH

-GQ09-WD02
0,6/1 kV
4x2,5
0,6/1,0 kV
DCDC Cooling Fan B Power
GNYE BN BK GY

-GQ09-WG01
2x0,5
300 V
DCDC Cooling Fan A Signal
BN WH

-GQ08
1kW
DCDC Cooling Fan A
PE PE L1 L2 L3 NC COM 0-10V RSB RSA GND 10V
1 2 3 4 5 6 7 8 10 11 12 13
M 3~
PE

-GQ09
1kW
DCDC Cooling Fan B
PE PE L1 L2 L3 NC COM 0-10V RSB RSA GND 10V
1 2 3 4 5 6 7 8 10 11 12 13
M 3~
PE

Reference Item Number	Ballard Part # TBD		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - DCDC Ventilation Fans		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 88 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control Cabinet, 40ft Container

88.8 / L1
88.8 / L2
88.8 / L3
88.8 / PE
101
213
229
250
L1 /
L2 /
L3 /
PE /

-FC11
6A, B-curve
MCCB, Ventiation Fan A
1 3 5
2 4 6
211 227 242

-FC12
/42.2
6A, B-curve
MCCB, Ventilation Fan B
1 3 5
2 4 6
212 228 243

108.7
>=LA01-WG202
WH OR SH

-X11 1 2 3 PE
-X12 1 2 3 PE

=JA01+DA01
Container Ventilation System 40ft Container Inside

-GQ06-WD01
/89.0
0,6/1 kV
4x2,5
0,6/1,0 kV
Ventilation (Upper) Supply
BK 1 BK 2 BK 3 GNYE

-GQ06-WG01
/108.4
BUS CAN FD P
2x0,5
300 V
Ventilation (Upper) Signal
WH OR SH

WH BN

-GQ07-WD01
/89.5
0,6/1 kV
4x2,5
0,6/1,0 kV
Ventilation (Lower) Supply
BK 1 BK 2 BK 3 GNYE

-GQ07-WG01
BUS CAN FD P
2x0,5
300 V
Ventilation (Upper) Signal
WH BN SH
WH BN

-GQ06-WD01
/89.1
1 2 3 PE

-GQ06-XD01
4x2,5
1 2 3 PE
211 227 242 250

-GQ06
4,3 kW
Container Ventilation Fan
(Upper)
L1 L2 L3 PE
GND IO1 IO2 IO3 Vout GND RSA RSB RSA RSB
-CON1
-CON2
M
3~

-GQ07-WD01
/89.5
1 2 3 4

-GQ07-XD01
4x2,5
1 2 3 PE
212 228 243 250

-GQ07
4,3 kW
Container Ventilation Fan
(Lower)
L1 L2 L3 PE
GND IO1 IO2 IO3 Vout GND RSA RSB RSA RSB
-CON1
-CON2
M
3~

644 642
-GQ07-RA01
120Ω
RS485 Termination
Resistor

Reference Item Number	Ballard Part # TBD		
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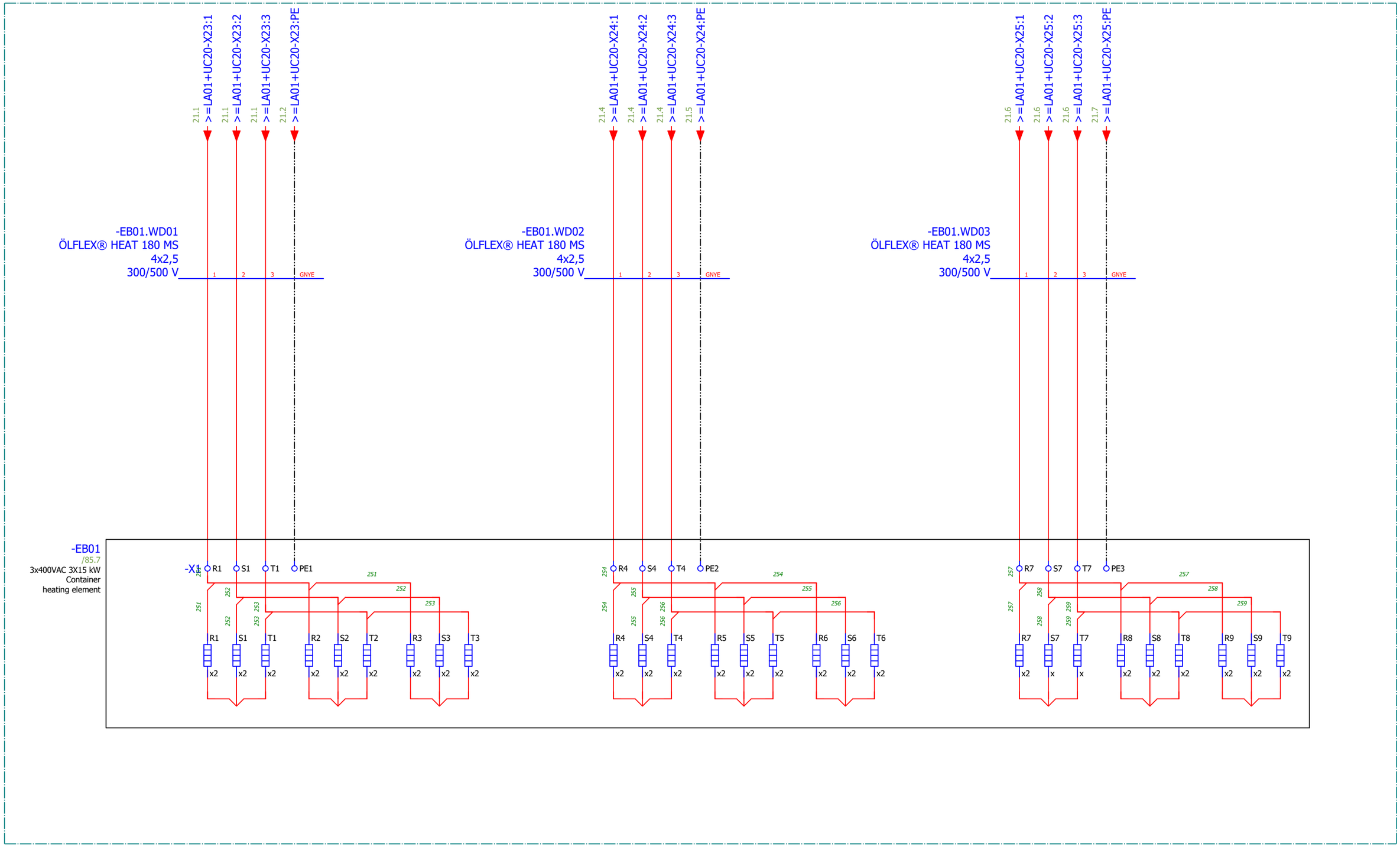
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Ventilation Intake Fans		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 89 / 255

=JA01+DA01

Container Safety System, Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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EPLAN Project Pages	627		
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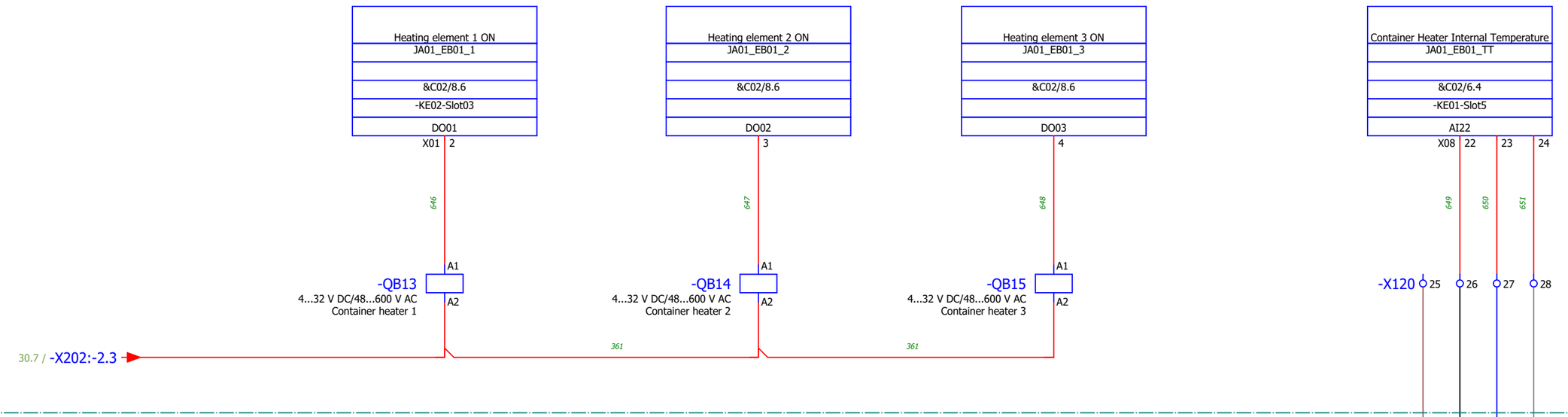
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft container heater		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 90 / 255

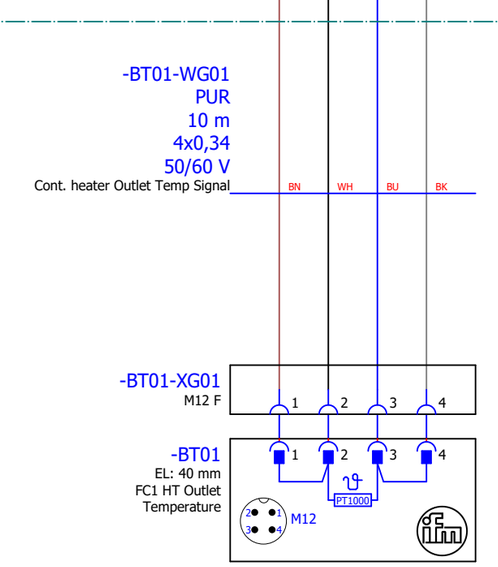
FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20



=JA01+UC07
Container Heating System
40ft Container



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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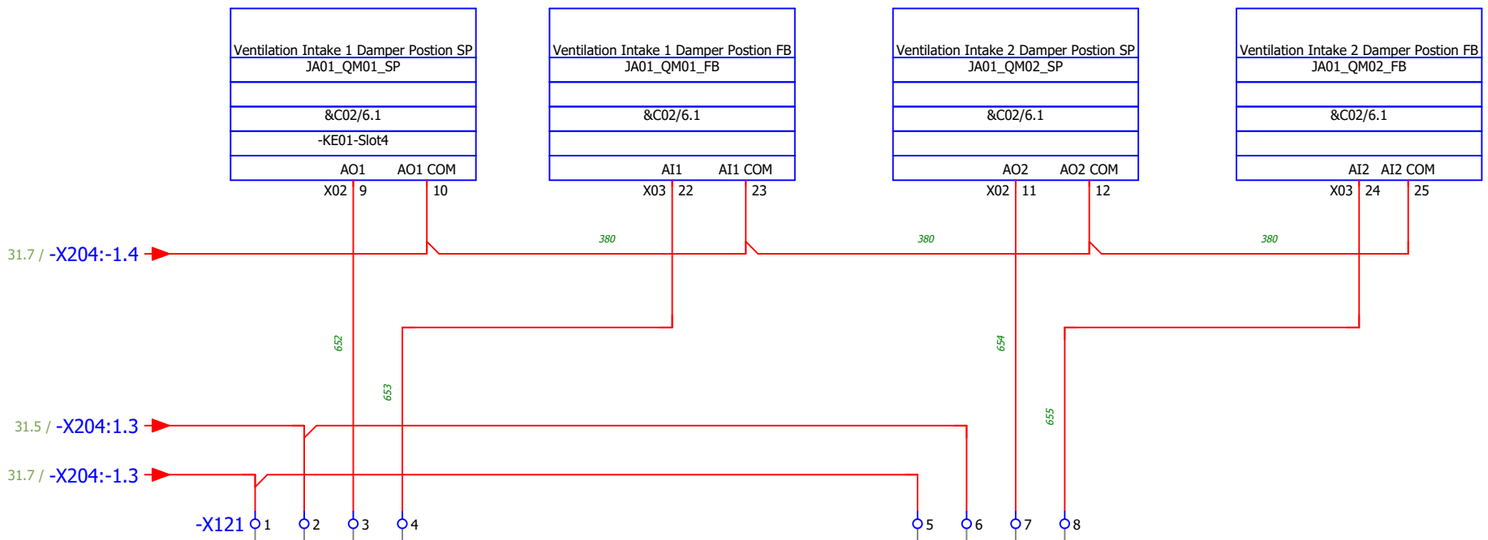
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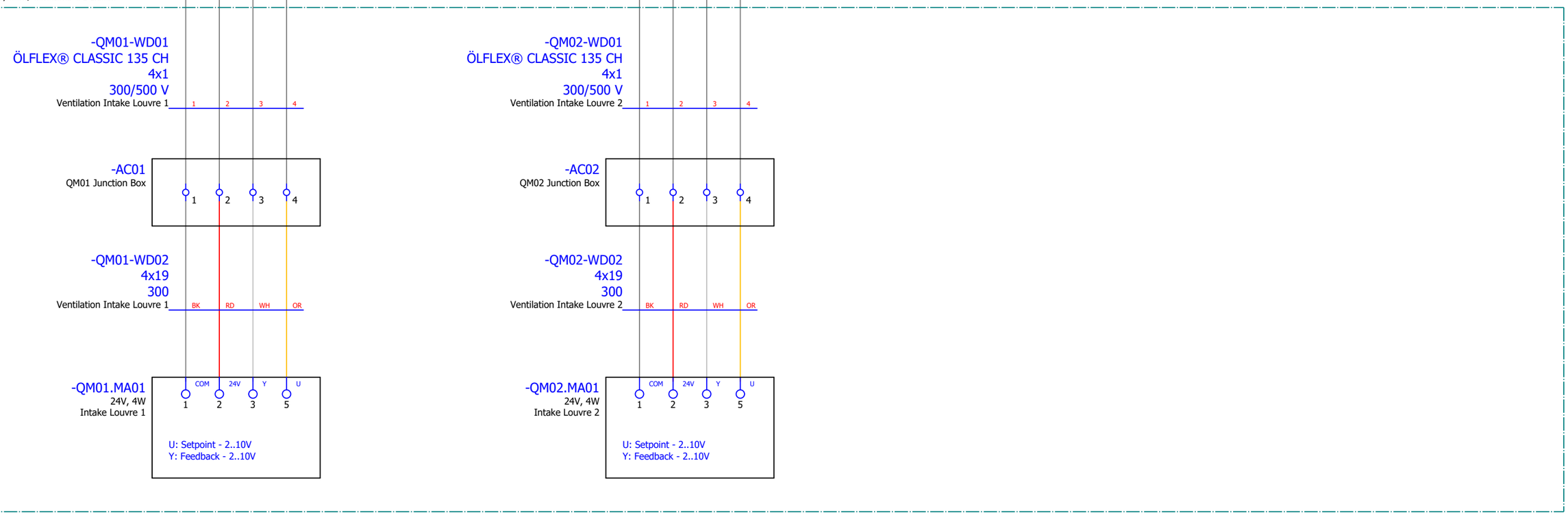
DRAWING	601456B UC20 40ft Control Cabinet		REVISION	12	
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet				
SHEET TYPE/DESC	40ft Container - Container Heating Control				
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	91 / 255	

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control System, Container #1 Inside



=JA01+DA01
Ventilation System, Container #1 Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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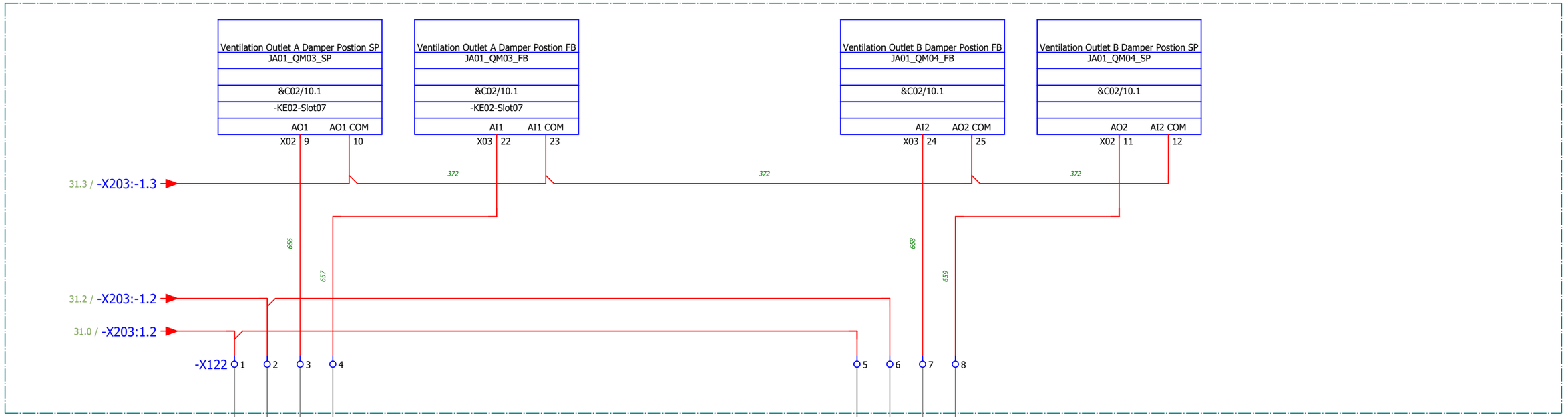
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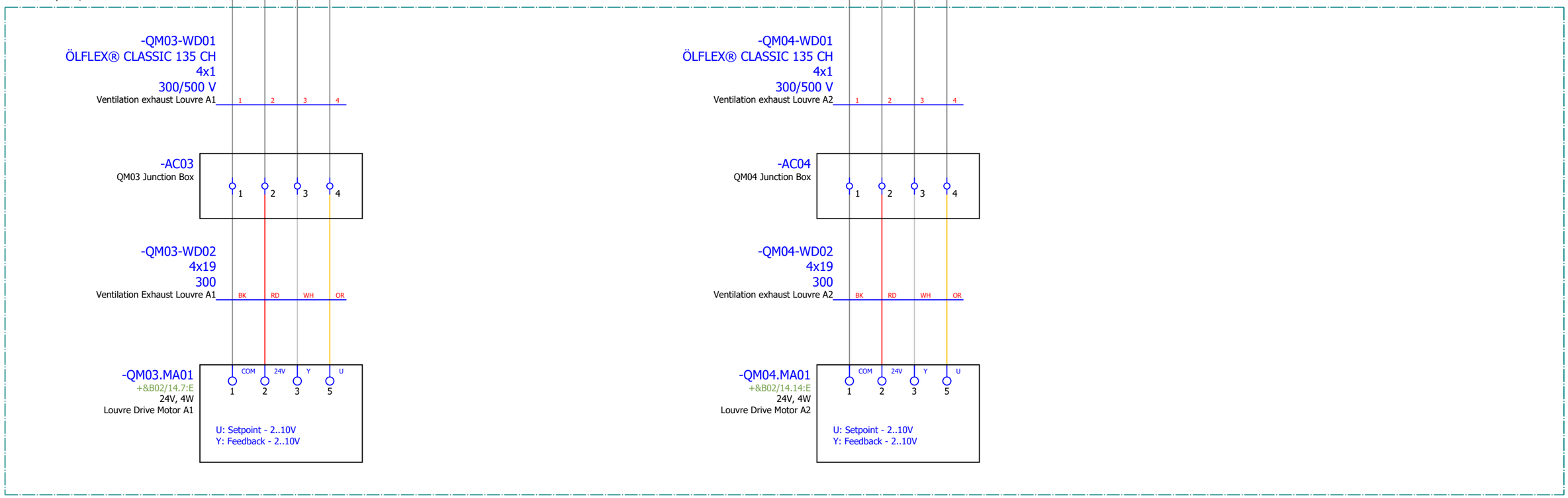
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Container Intake Louvres		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 92 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control System, Container #1 Inside



=JA01+DA01
Ventilation System, Container #1 Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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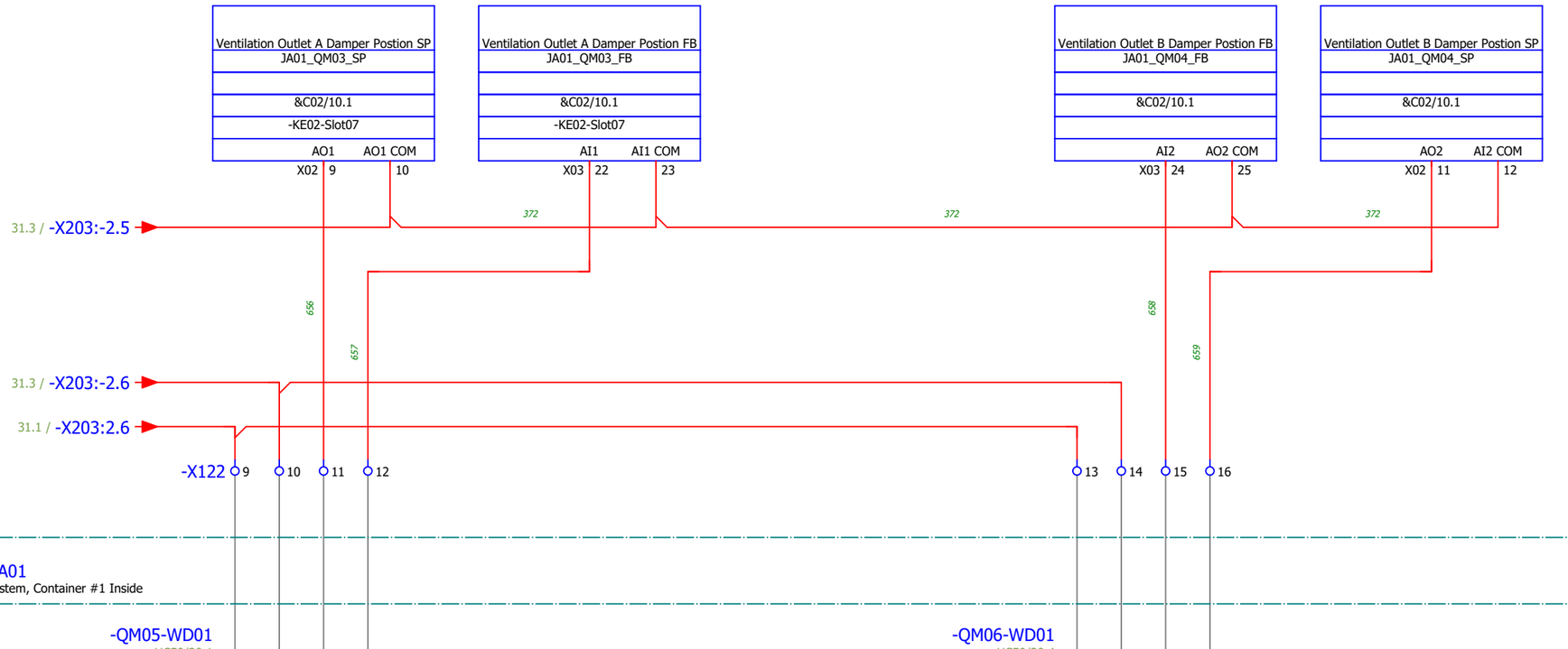
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Container Exhaust Louvre A		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 93 / 255

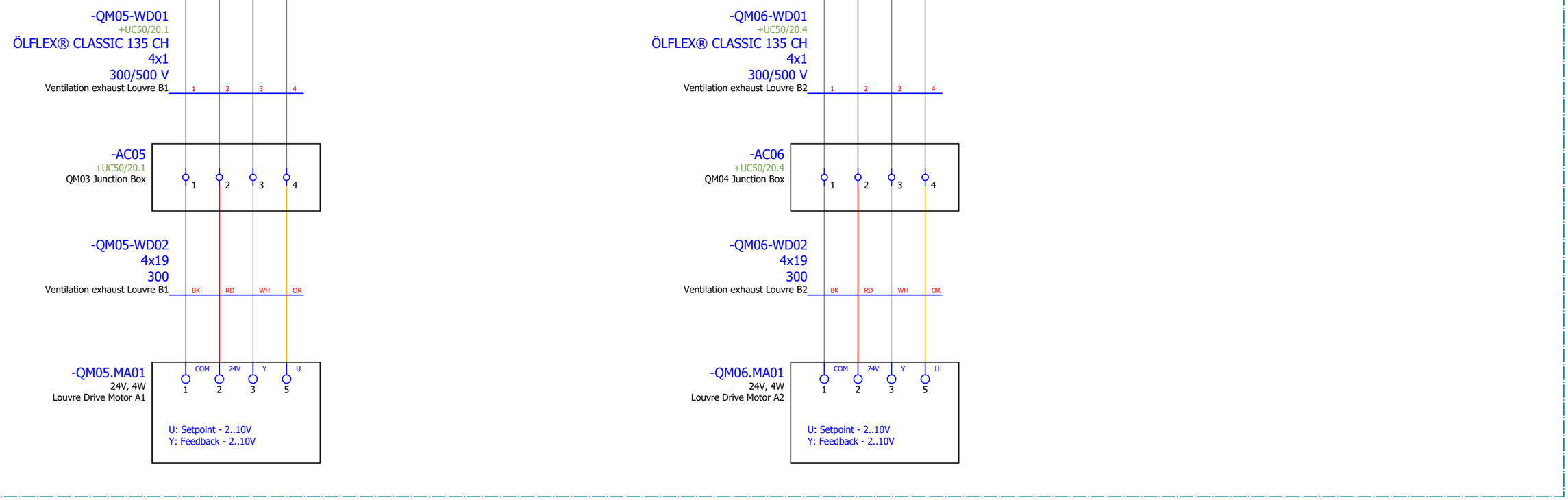
FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control System, Container #1 Inside



=JA01+DA01
Ventilation System, Container #1 Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Container Exhaust Louvre B		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 94 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control System, Container #1 Inside

Container Indoor/Outdoor Diffential Pressure
JA01_BP02_PDT
&C02/6.4
-KE01-Slot5
AI6 AI6
X06 17 18

Ventilation Intake Filter Differential-pressure
JA01_BP01_PDT
&C02/6.4
-KE01-Slot5
AI5 AI5
X05 14 15

31.3 / -X203:-1.5
374
660
661
31.1 / -X203:1.4
31.3 / -X203:-1.4
-X123 1 2 3 4 5 6

=JA01+DA01
Ventilation System, Container #1 Inside

-BP02-WD01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
In/Out dP Sensor 1 2 3

-BP02
Container Indoor/Outdoor Diffential Pressure Sensor
UB+ GND AOU1 AOI1
AC/DC 24 V
DC 0...5/10V
DC 4...20mA
ON 1 2 3 4 5 6
Setting: -100 to 100 Pa

-BP01-WD01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
Intake dP Sensor 1 2 3

-BP01
Intake dP Transducer
UB+ GND AOU1 AOI1
AC/DC 24 V
DC 0...5/10V
DC 4...20mA
ON 1 2 3 4 5 6
Setting: 0 to 500 Pa

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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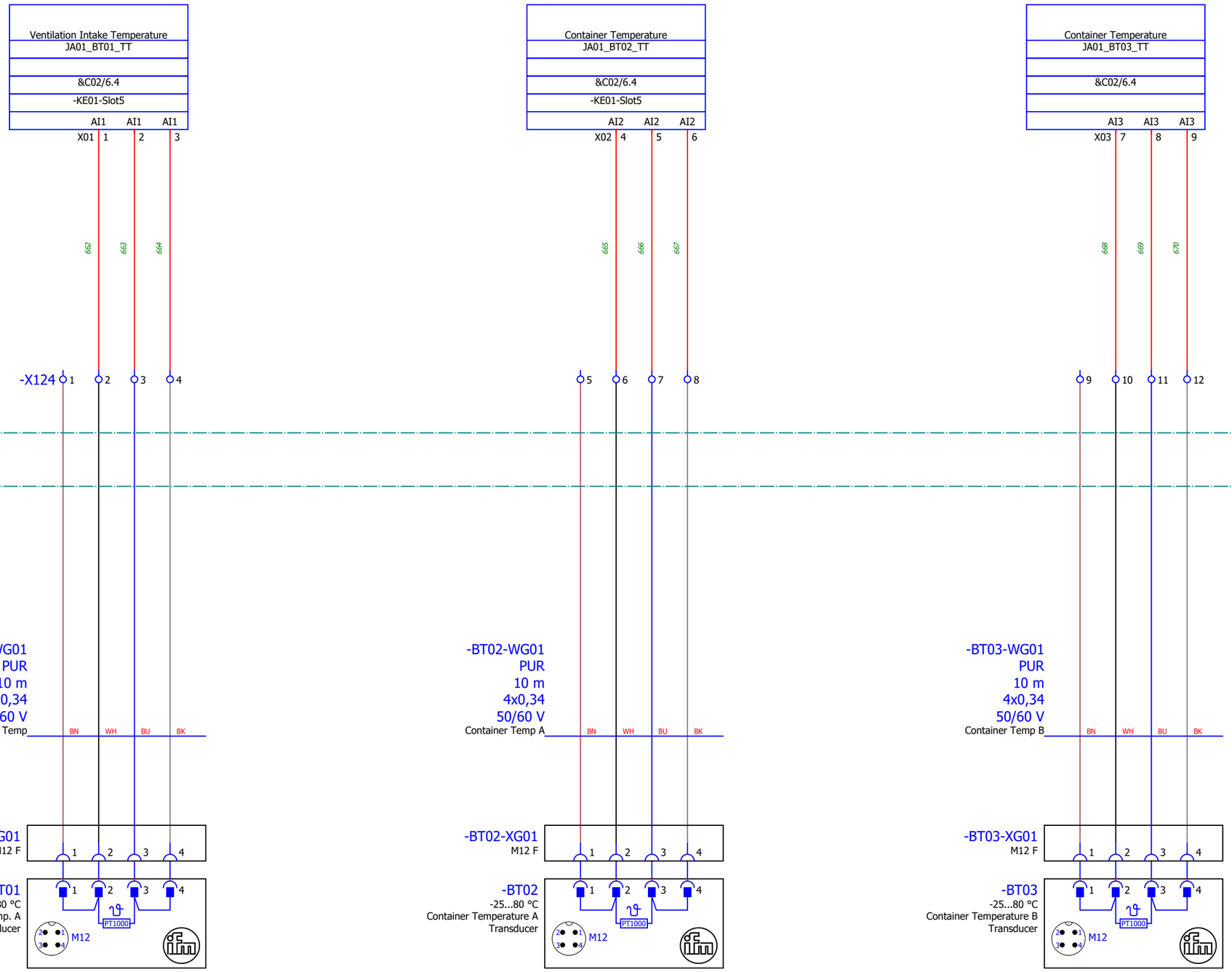
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Container In/Out and Filter Diff Pressure		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 95 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control System, Container #1 Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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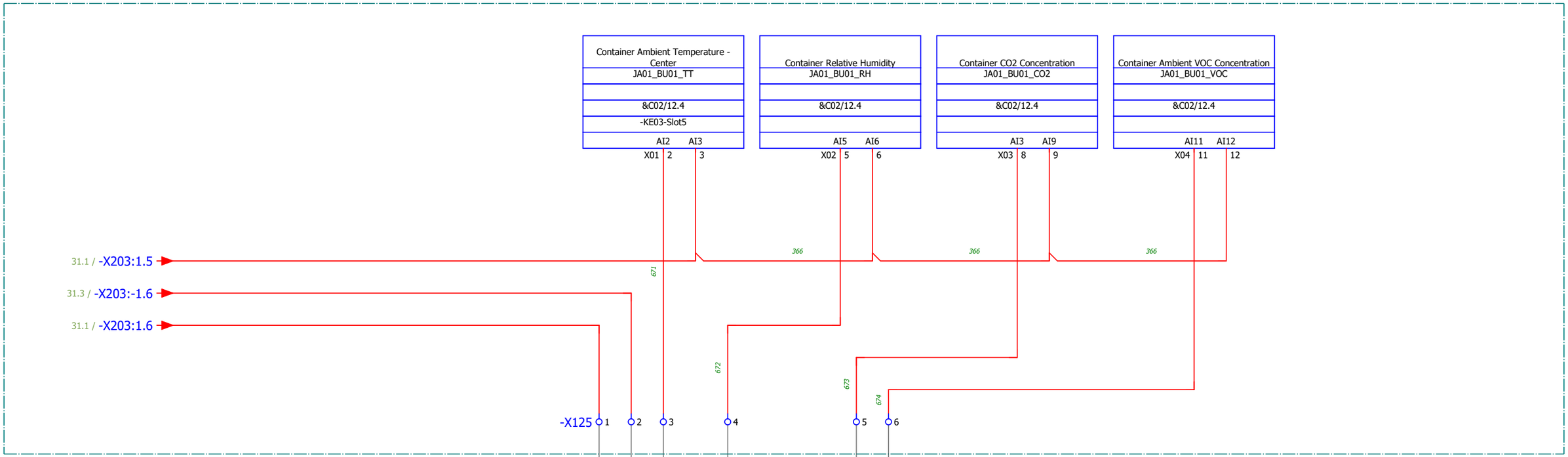
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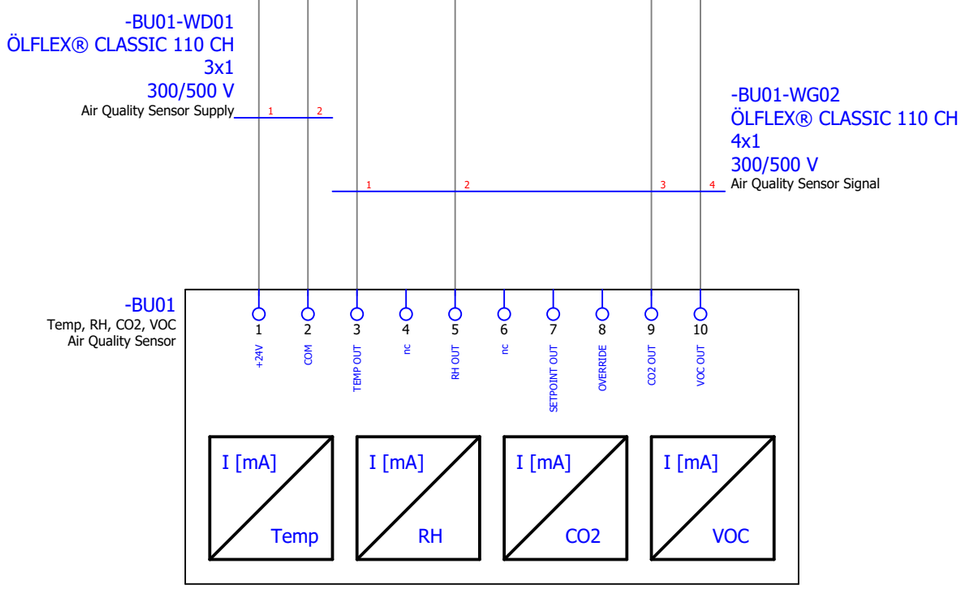
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Container Temp Sensors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 96 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control Cabinet, 40ft Container



=JA01+DA01
40ft Container, Ventilation System



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Container Air Quality Sensor		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 97 / 255

=HE03+DA01
LT Coolant System

-GP11.WD01
/98.1
ÖLFLEX® CLASSIC 135 CH
4x2,5
300/500 V
Power supply LT Pump

>=LA01+UC20-X10:1 20.1
>=LA01+UC20-X10:2 20.1
>=LA01+UC20-X10:3 20.1
>=LA01+UC20-X10:PE 20.2

-TA11
/58.2
/98.4
/98.4
4kW, 3x 380-500 VAC

L1 L2 L3 PE1
INPUT

VACON
Vacon NXP
NXP00095-A5H1SSV

MOTOR DC SUPPLY BRAKE
U/T1 V/T2 W/T3 PE2 B- B+/R+ R-

-GP11.WD02
/98.1
ÖLFLEX® CLASSIC 135 CH
4x2,5
300/500 V
Power supply LT Pump

U1 V1 W1
M
3~
-GP11
4kW
LT
Coolant Pump
PE

55.6 / >=LA01+UC20-X108:13

-GP11-WG01
/55.2
ÖLFLEX CLASSIC 110
3G1
300 V
24 VDC supply VFD LT Pump

-TA11
/58.2
/98.1
/98.4
OPT-A1
Danfoss Vacon Control Unit

1 Vref
2 AI1+
3 AI1-
4 AI2+
5 AI2-
6 24V Supply
7 GND Supply
8 DIN1
9 DIN2
10 DIN3
11 CMA
12 24V Supply
13 GND Supply
14 DIN4
15 DIN5
16 DIN6
17 CMB
18 AO1+
19 AO1-
20 DO1

Danfoss Vacon NX
OPT-A1 Control Board

GP11.WG3 /

-TA11
/58.2
/98.1
/98.4

1 RJ-45
2 RJ-45

LED Indications
RN ER BS

VACON
VACON NX
Dual Port Ethernet option board
OPT-E9

Reference Item Number	Ballard Part # TBD		
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=	++	+ UC20	& C03

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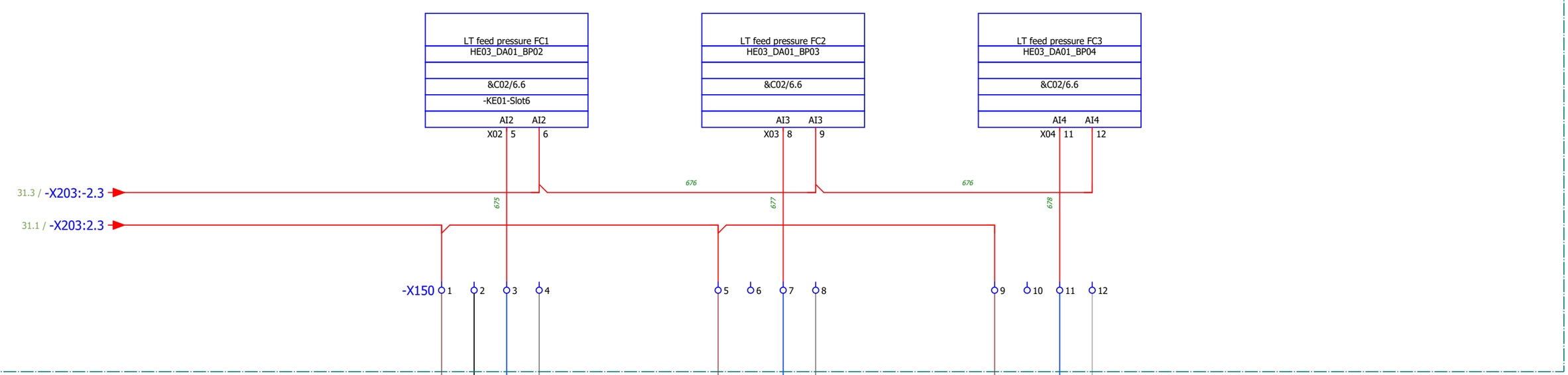
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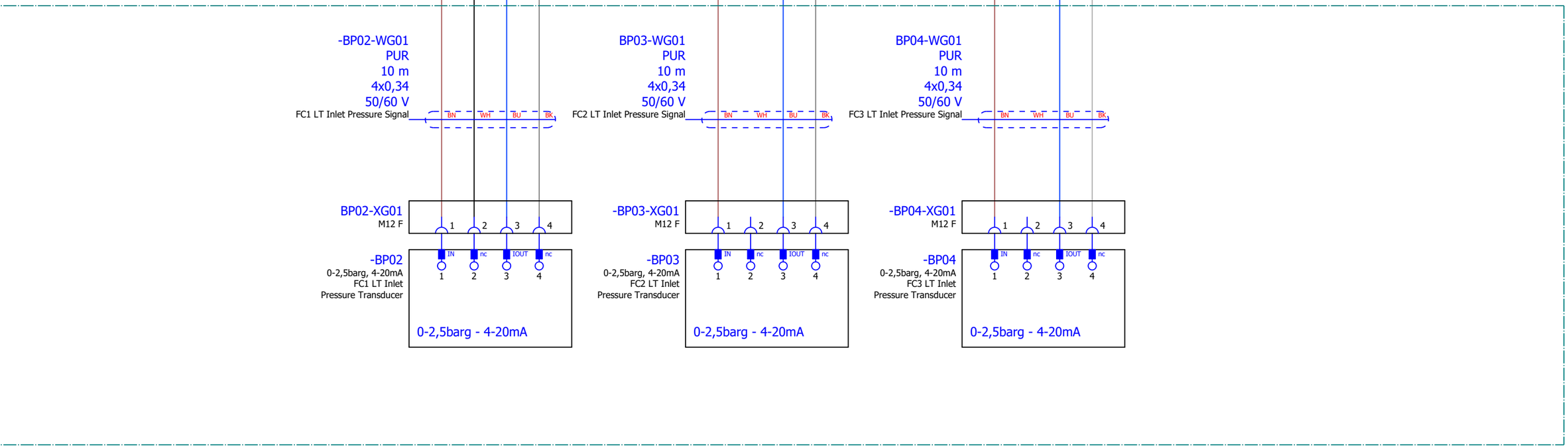
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft container - LT Pump Power Supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 98 / 255

=LA01+UC20



=HE03+DA01



Reference Item Number	Ballard Part # TBD		
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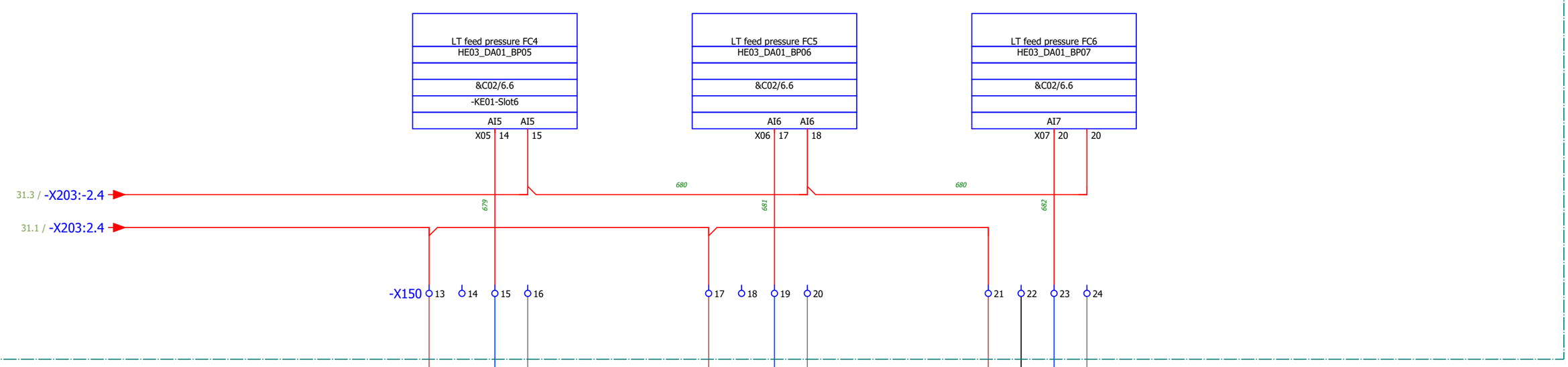
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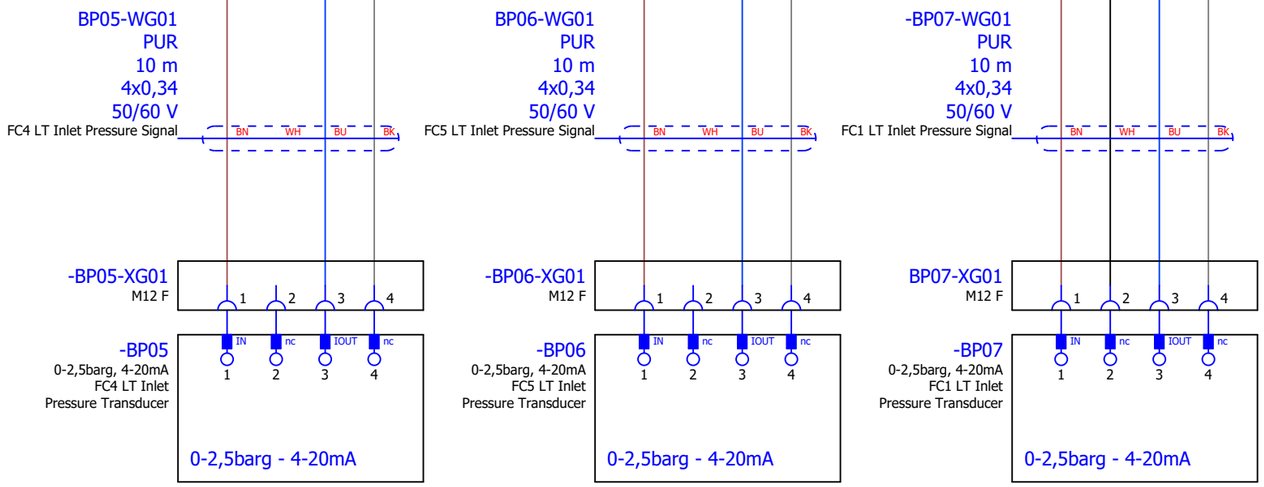
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - LT Cooling System		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 99 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20



=HE03+DA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - LT Cooling System		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 100 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20

LT Circuit Differential-pressure
HE03_DA01_BP01
&C02/6.4
-KE01-Slot5
AI7 AI7
X07 20 21

31.3 / -X203:-2.1

683

31.1 / -X203:2.1

-X150 25 26 PE

=HE03+DA01

-BP01-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
LT Circuit dP Signal
1 2 3

-BP01-XD01
DIN 43650 Form A
Valve Plug
1 2 3 PE

-BP01
LT Circuit
Differential-pressure
Transmitter
UB+ nc AOU1 PE
AC/DC
24 V
DC
4..20mA
0..4 barg

BELIMO

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - LT Cooling System		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 101 / 255

=LA01+UC20
Control Cabinet

FC1 HT Coolant Outlet Temperature
HE03_DA01_BT01
&C02/11.6
-KE03-Slot3
AI19 AI20 AI21
X07 19 20 21

FC2 HT Coolant Outlet Temperature
HE03_DA01_BT02
&C02/11.6
-KE03-Slot3
AI22 AI23 AI24
X08 22 23 24

FC3 HT Coolant Outlet Temperature
HE03_DA01_BT03
&C02/11.6
AI25 AI26 AI27
X09 25 26 27

684 685 686 687 688 689 690 691 692

-X160 1 2 3 4 5 6 7 8 9 10 11 12

=HE01+DA01
HT Coolant System #1, Inside 40ft Container

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
FC1 HT Outlet Temp Signal
BN WH BU BK

-BT02-WG01
PUR
10 m
4x0,34
50/60 V
FC2 HT Outlet Temp Signal
BN WH BU BK

-BT03-WG01
PUR
10 m
4x0,34
50/60 V
FC3 HT Outlet Temp Signal
BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT02-XG01
M12 F
1 2 3 4

-BT03-XG01
M12 F
1 2 3 4

-BT01
EL: 160 mm
FC1 HT Outlet Temperature
1 2 3 4
PT1000
M12

-BT02
EL: 160 mm
FC2 HT Outlet Temperature
1 2 3 4
PT1000
M12

-BT03
EL: 160 mm
FC3 HT Outlet Temperature
1 2 3 4
PT1000
M12

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - HT #1/2 Module Outlet Temperature		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 102 / 255

0	1	2	3	4	5	6	7	8

=LA01+UC20
Control Cabinet

FC4 HT Coolant Outlet Temperature
HE03_DA01_BT04
&C02/12.1
-KE03-Slot4
AI19 AI20 AI21
X07 19 20 21

FC5 HT Coolant Outlet Temperature
HE03_DA01_BT05
&C02/12.1
AI22 AI23 AI24
X08 22 23 24

FC6 HT Coolant Outlet Temperature
2HE03_DA01_BT06
&C02/12.1
AI25 AI23 AI24
X09 25 23 24

693 694 695 696 697 698 699 700 701

-X160 13 14 15 16 17 18 19 20 21 22 23 24

=HE02+DA01
HT Coolant System #2, Inside 40ft Container

-BT04-WG01
PUR
10 m
4x0,34
50/60 V
FC4 HT Outlet Temp Signal
BN WH BU BK

-BT05-WG01
PUR
10 m
4x0,34
50/60 V
FC5 HT Outlet Temp Signal
BN WH BU BK

-BT06-WG01
PUR
10 m
4x0,34
50/60 V
FC5 HT Outlet Temp Signal
BN WH BU BK

-BT04-XG01
M12 F
1 2 3 4

-BT05-XG01
M12 F
1 2 3 4

-BT06-XG01
M12 F
1 2 3 4

-BT04
EL: 160 mm
FC4 HT Outlet Temperature
1 2 3 4
PT1000
M12
2 1 3 4

-BT05
EL: 160 mm
FC5 HT Outlet Temperature
1 2 3 4
PT1000
M12
2 1 3 4

-BT06
EL: 160 mm
FC5 HT Outlet Temperature
1 2 3 4
PT1000
M12
2 1 3 4

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

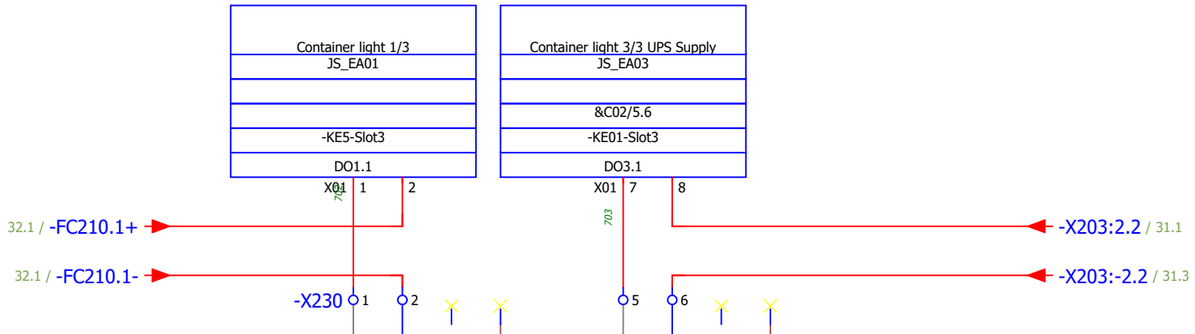
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - HT #2/2 Module Outlet Temperature		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 103 / 255

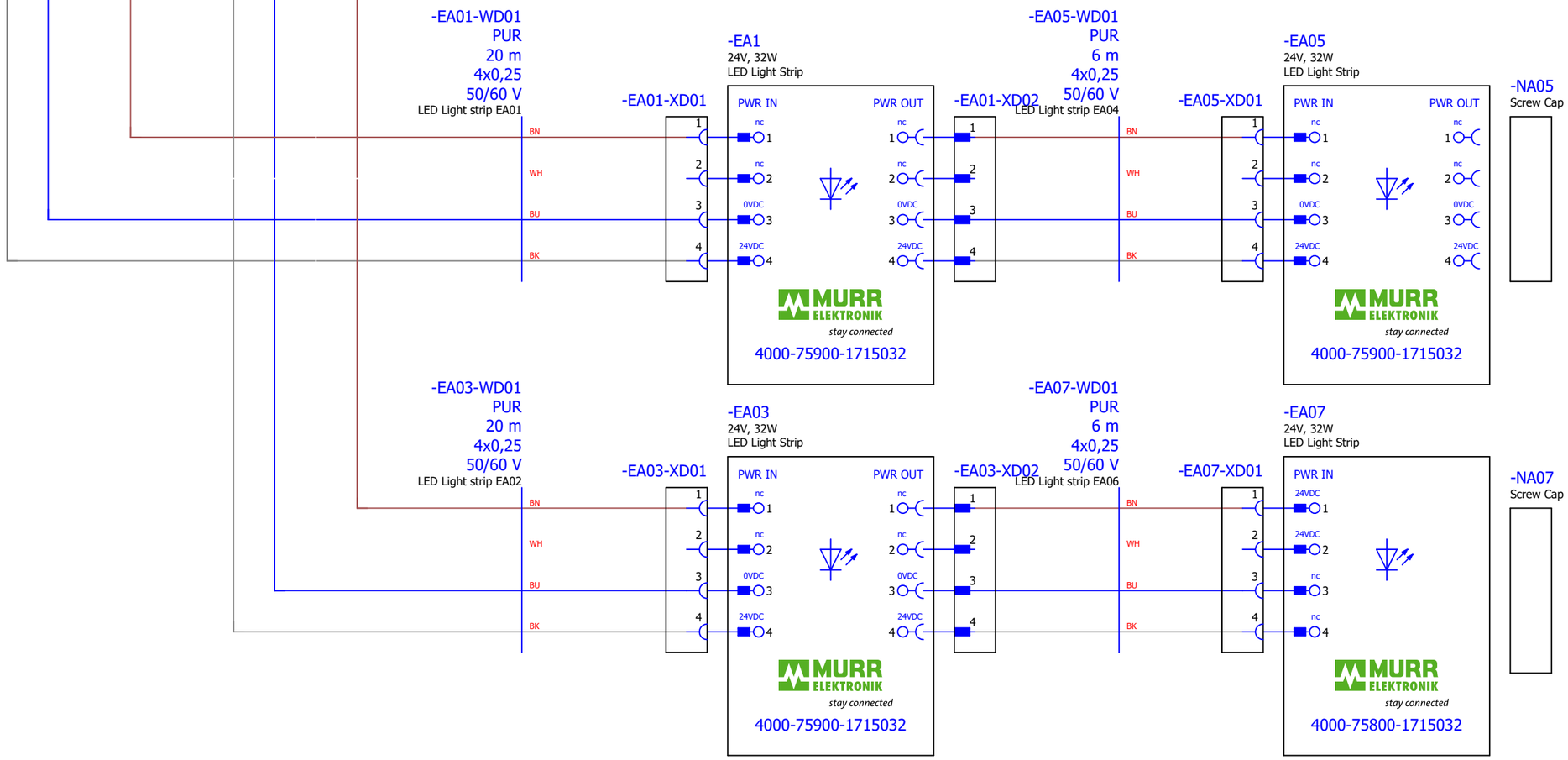
0	1	2	3	4	5	6	7	8

=LA01+UC20



=JA01+DA01

Container Ventilation, Inside Container #1



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DESCRIPTION
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Lighting 1/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 104 / 255

=LA01+UC20

Container light 2/3
JS_EA02
-KE5-Slot3
DO2.1
X01 4 5

32.3 / -FC210.2+
32.4 / -FC210.2-
-X230 3 4

Light Switch Container
DA01_SG100
&C02/5.6
-KE01-Slot3
DIO3
X02 15

31.2 / -X203:3.3
7 8

=JA01+DA01
Container Ventilation, Inside Container #1

-EA02-WD01
PUR
20 m
4x0,25
50/60 V
LED Light strip EA05

-EA02
24V, 32W
LED Light Strip

-EA02-XD01
PWR IN
PWR OUT
BN
WH
BU
BK
nc
0VDC
24VDC
MURR ELEKTRONIK
stay connected
4000-75900-1715032

-EA02-XD02

-EA06-WD01
PUR
6 m
4x0,25
50/60 V
LED Light strip EA06

-EA06
24V, 32W
LED Light Strip

-EA06-XD01

-SG01-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
1 2

-SG01 E
13
14

-EA04-WD01
PUR
20 m
4x0,25
50/60 V
LED Light strip EA07

-EA04
24V, 32W
LED Light Strip

-EA04-XD01

-EA04-XD02

-EA08-WD01
PUR
6 m
4x0,25
50/60 V
LED Light strip EA08

-EA08
24V, 32W
LED Light Strip

-EA08-XD01

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC20 | & C03

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DATE
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Lighting 2/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 105 / 255

=LA01+UC20

=HA01+DA02
Exterior location, hydrogen supply

Placed Top right side of cabinet

-X202:-1.6
30.7

-X202:1.6
30.5

-KF200-XD01
1 2 3 4 5 6

-KF200
16 port switch
V1- V1+ COM NO V2- V2+
-U1:1 2 3 4 5 6
PWR1 FAULT PWR2

-U2
Chassis
CHA

Other bus systems
1 2 3 4 5 6 7 8
9 10 11 12 13 14
15 16

-KF200-WG01
Cat.6
STP 1
/ KE01-Slot7:P1
Deif Ethernet Port 1

-KF200-WG02
Cat.6
STP
108.4 / -KF210:1

-KF200-WG16
-KF200-WG15
Cat.6
4x2x
STP 1
-KF200:16 / 107.1

-KF200:15 / Cooling skid

-XT11
EX Cable gland
Wall pass-through

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet - Ethernet switch 1		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 106 / 255

FRM5103656/0B

=LA01+UC20

Placed bottom right side of cabinet

-X202:-2.1
30.7

-X202:2.1
30.5

-KF201-XD01

1 2 3 4 5 6

-KF201
16 port switch

V1- V1+ COM NO V2- V2+

-U1:1 2 3 4 5 6

PWR1 FAULT PWR2

-U2
Chassis
CHA

Other bus systems 1 2 3 4 5 6 7 8

Other bus systems 9 10 11 12 13 14

Other bus systems 15 16

106.6 / -KF200:16

-KF201:16 /

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

REVISION INFORMATION
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DATE
29-Sep-25

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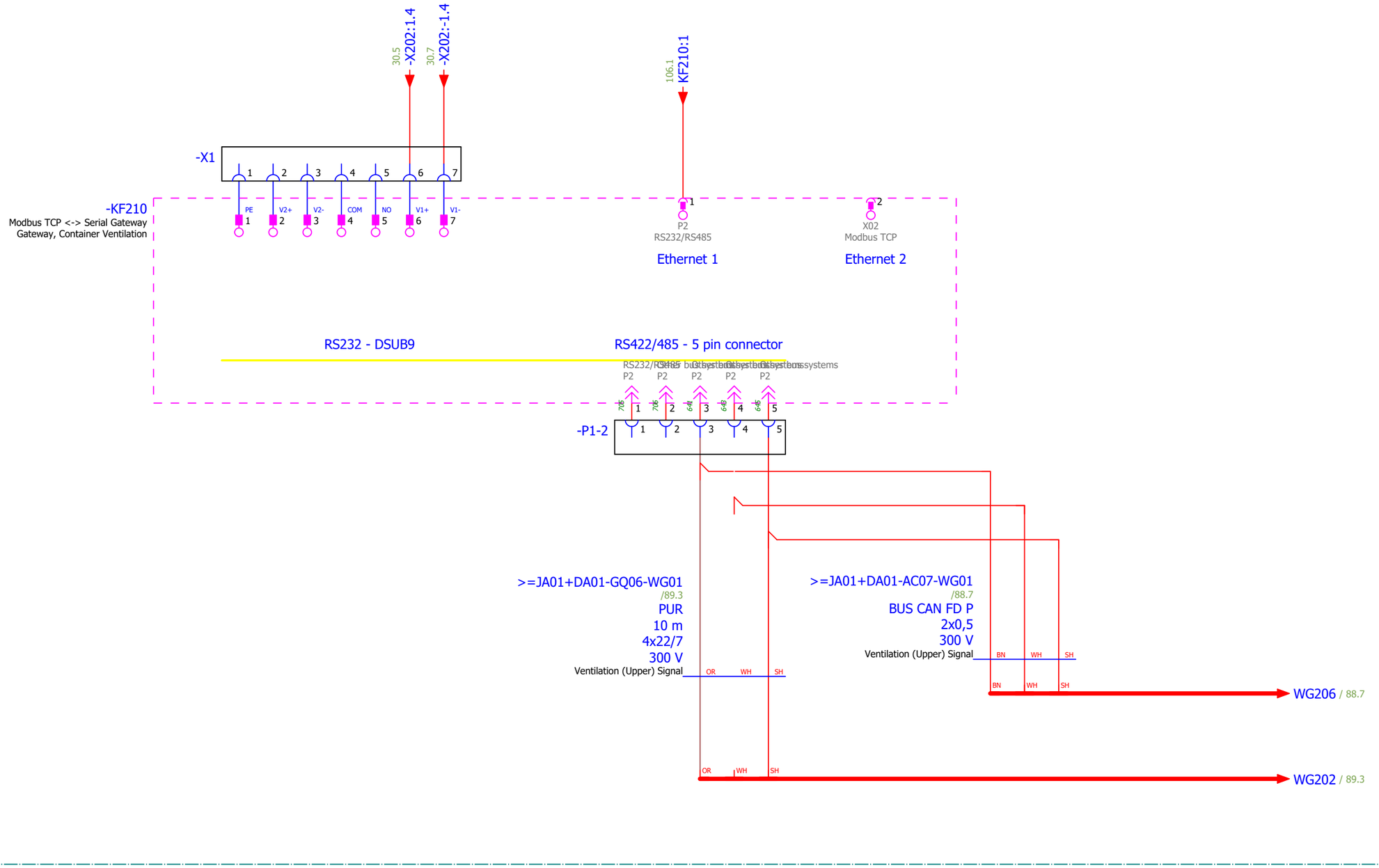
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Control Cabinet - Ethernet switch 2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 107 / 255

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC20
Container Control System
Control Cabinet 40 ft



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C03

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	40ft Container - Modbus Converter		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 108 / 255

FRM5103656/0B

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Ballard Power Systems Europe - Technology Solutions

Panel Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Panel Documentation and Layout		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 109 / 255

FRM5103656/0B

Terminal-strip overview

F14_001

Terminal strip	Terminal strip definition text	Terminals					Graphical page of terminal diagrams
		first	last	Total PE	Total N	Total number	
=BA20-XB01		1	1	0	0	1	
=LA01-PE		3	3	0	0	1	
=LA01-X-KE12		X1	X2	0	0	12	
=LA01-X-KE13		X1	X2	0	0	12	
=LA01-X-KE14		X1	X2	0	0	12	
=LA01-X-KE15		X1	X2	0	0	12	
=LA01-X-KE16		X1	X2	0	0	12	
=LA01-X01		1	PE	0	0	5	
=LA01-X10		1	PE	0	0	4	
=LA01-X11		1	3	1	0	4	
=LA01-X12		1	3	1	0	4	
=LA01-X13		1	PE	0	0	4	
=LA01-X14		1	PE	0	0	4	
=LA01-X15		1	PE	0	0	4	
=LA01-X16		1	3	1	0	4	
=LA01-X17		1	3	1	0	4	
=LA01-X18		1	2	0	0	2	
=LA01-X20		1	PE	0	0	5	
=LA01-X22		1	PE	0	0	5	
=LA01-X23		1	PE	0	0	3	
=LA01-X50		1	4	0	0	4	
=LA01-X51		1	4	0	0	4	
=LA01-X52		1	4	0	0	4	
=LA01-X53		1	4	0	0	4	
=LA01-X54		1	4	0	0	4	
=LA01-X55		1	4	0	0	4	
=LA01-X60		1	15	0	0	15	
=LA01-X61		1	15	0	0	15	
=LA01-X62		1	15	0	0	15	
=LA01-X63		1	15	0	0	15	
=LA01-X64		1	15	0	0	15	
=LA01-X65		1	15	0	0	15	
=LA01-X100		1	7	0	0	7	
=LA01-X101		1	4	0	0	4	
=LA01-X102		1	4	0	0	6	
=LA01-X103		1	12	0	0	12	
=LA01-X104		1	12	0	0	12	

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Terminal-strip overview

F14_001

Terminal strip	Terminal strip definition text	Terminals					Graphical page of terminal diagrams
		first	last	Total PE	Total N	Total number	
=LA01-X105		1	4	0	0	4	
=LA01-X106		1	12	0	0	12	
=LA01-X107		1	12	0	0	12	
=LA01-X108		1	14	0	0	14	
=LA01-X110		1	4	0	0	6	
=LA01-X120		1	28	0	0	31	
=LA01-X121		1	8	0	0	10	
=LA01-X122		3	16	0	0	18	
=LA01-X123		1	6	0	0	8	
=LA01-X124		11	12	0	0	13	
=LA01-X125		1	6	0	0	6	
=LA01-X150		1	PE	0	0	30	
=LA01-X160		1	24	0	0	26	
=LA01-X201		0.1	0.1	0	0	1	
=LA01-X201-		1-	1-	0	0	1	
=LA01-X202		1	1	0	0	1	
=LA01-X202-		1-	1-	0	0	1	
=LA01-X203		0.1	0.1	0	0	1	
=LA01-X203-		0.1-	0.1-	0	0	1	
=LA01-X204		0.1	0.1	0	0	1	
=LA01-X204-		0.1	0.1	0	0	1	
=LA01-X230		1	8	0	0	8	
=LA01-XPE		1	PE	0	0	7	
=LA01-X_PE		1	1	0	0	6	
=LB02-X101		9	12	0	0	4	

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DESCRIPTION	
DATE	
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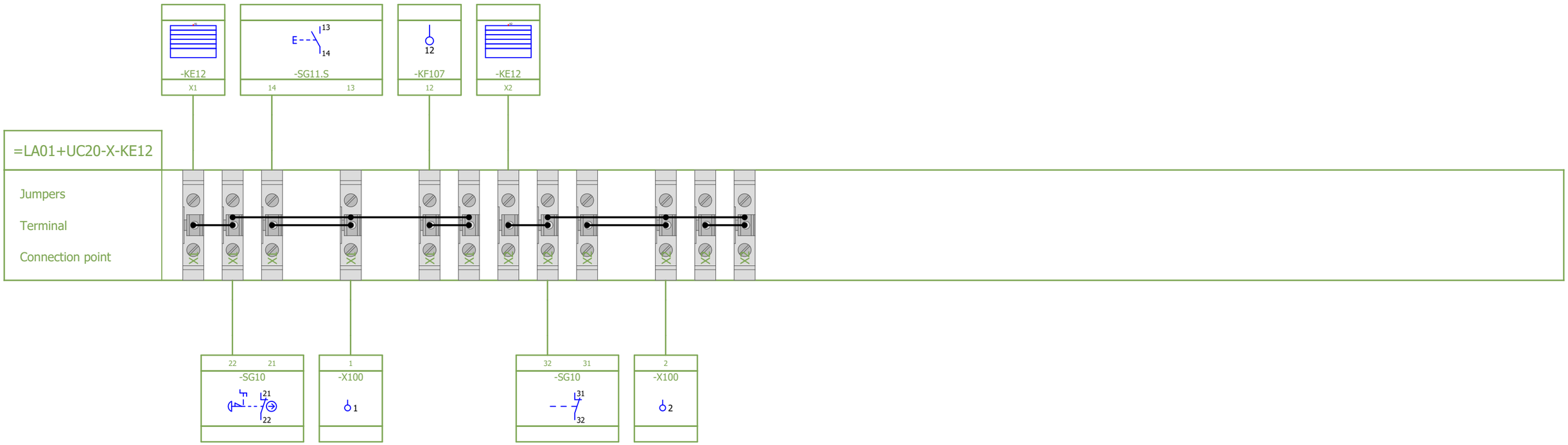
DRAWING		REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-strip overview : =LA01+UC20-X105 - =LB02+UC20-X101		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 110.a

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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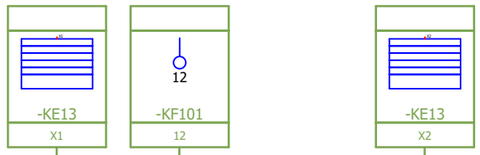
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X-KE12		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 112 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

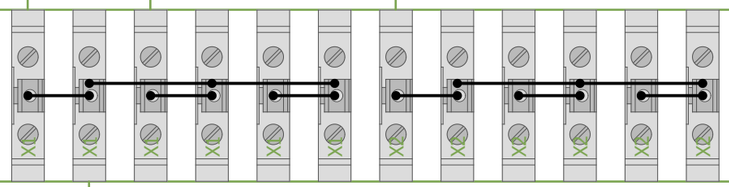


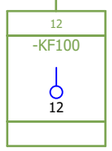
=LA01+UC20-X-KE13

Jumpers

Terminal

Connection point





External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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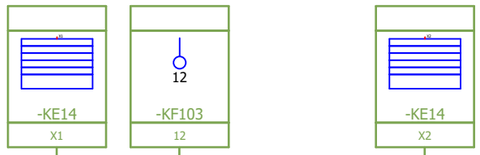
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X-KE13		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 113 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

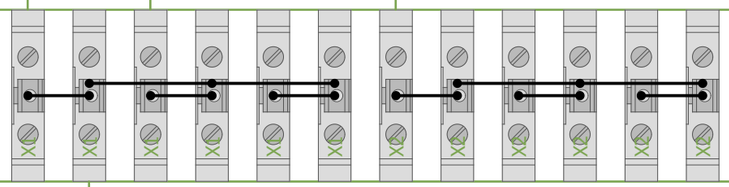


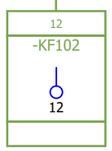
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Jumpers

Terminal

Connection point





External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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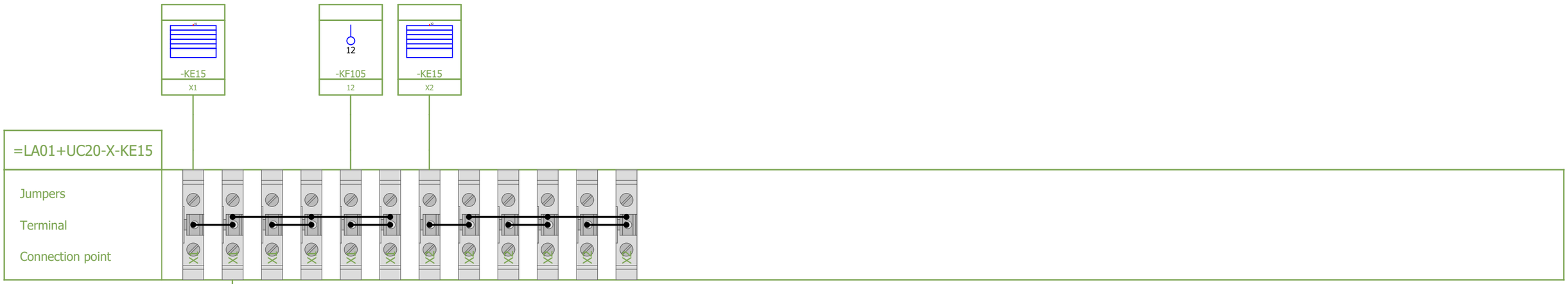
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X-KE14		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 114 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X-KE15		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 115 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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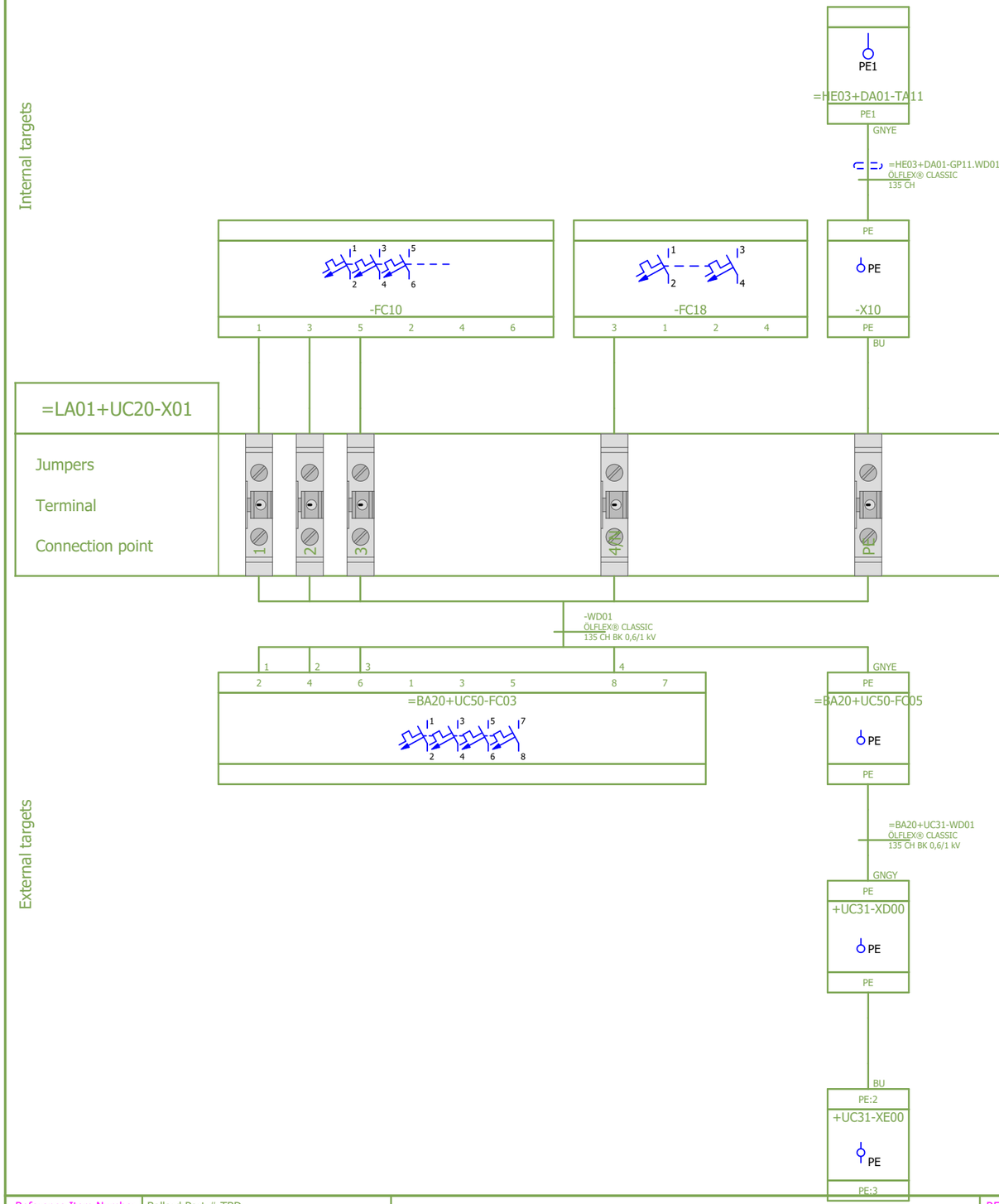
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 116 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC20 | & C04

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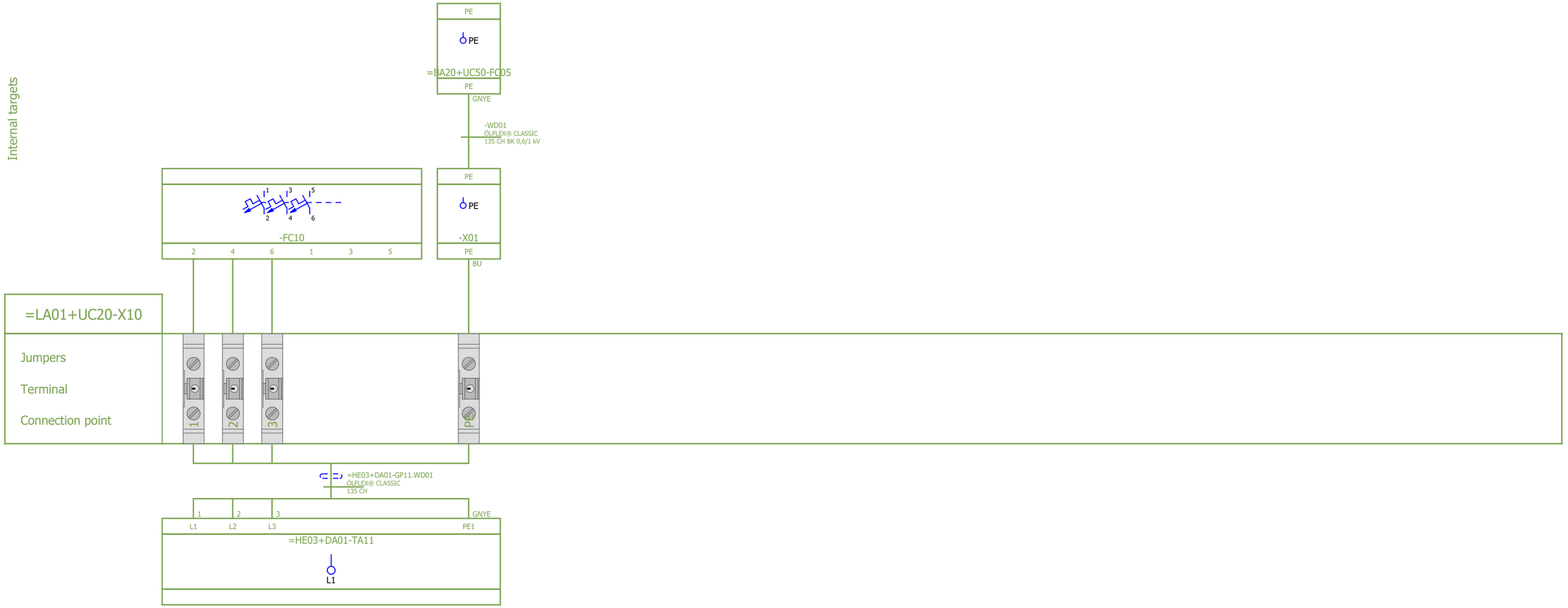
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 117 / 255

Terminal-connection diagram

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PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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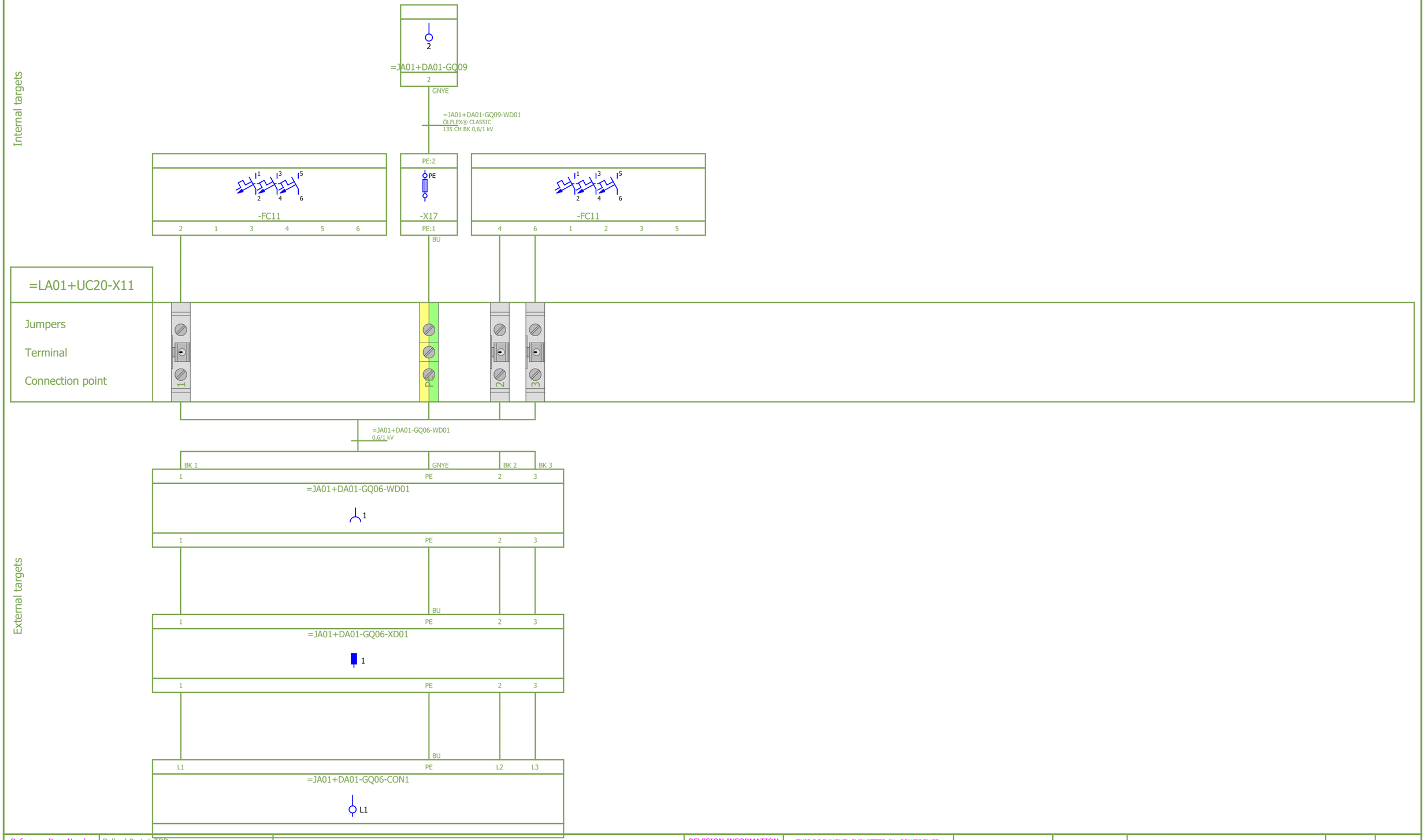
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X10		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 118 / 255

Terminal-connection diagram

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PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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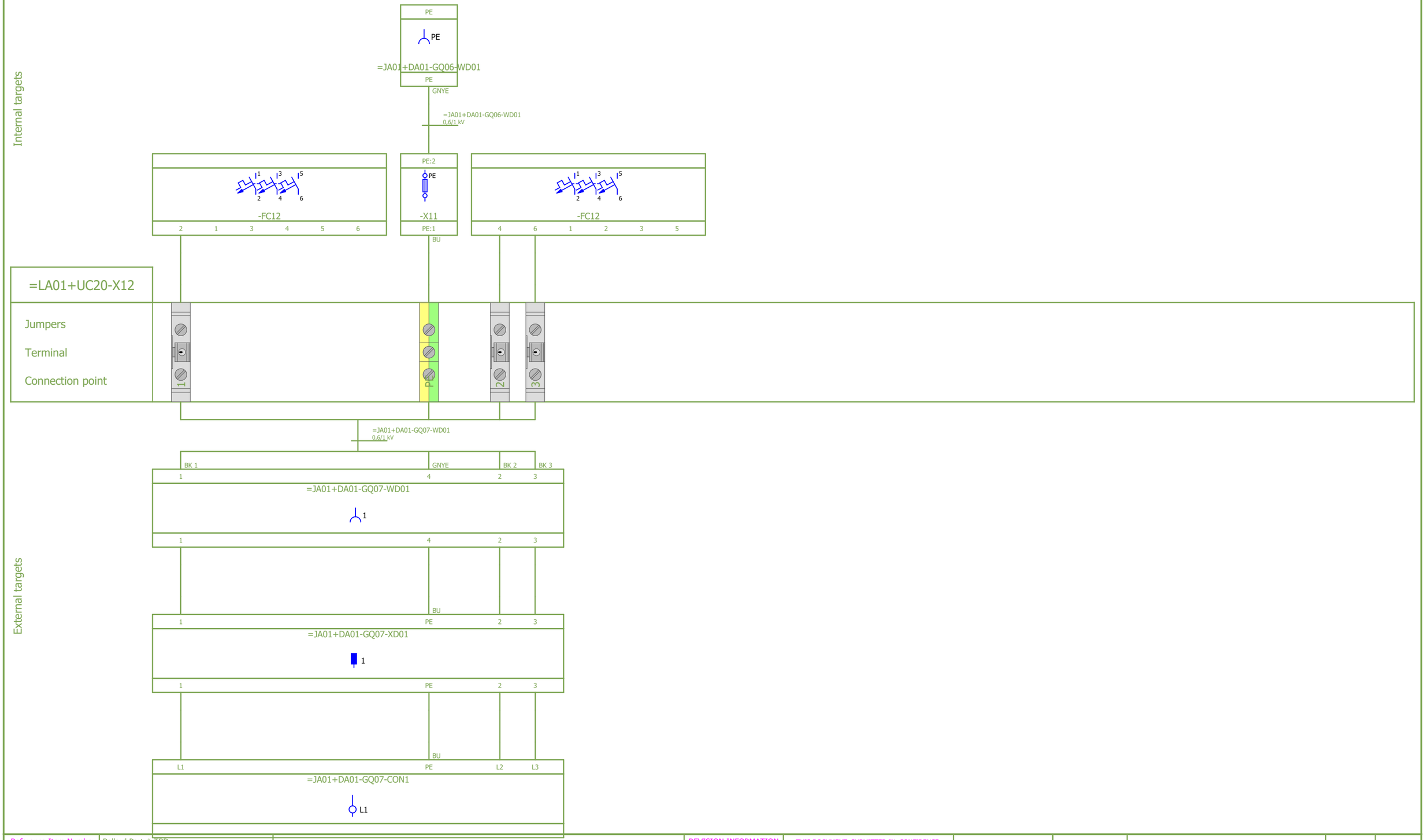
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Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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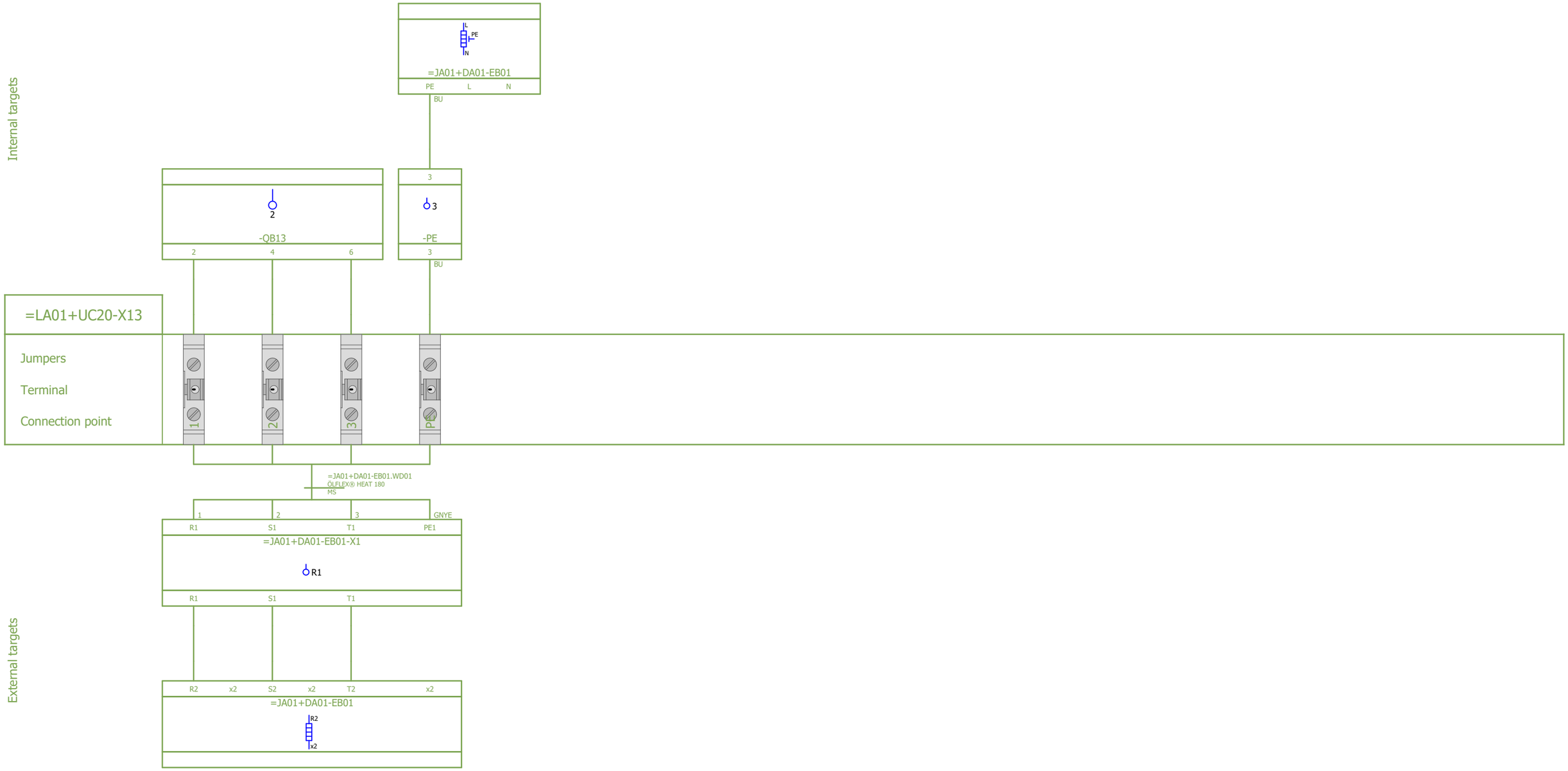
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Terminal-connection diagram

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PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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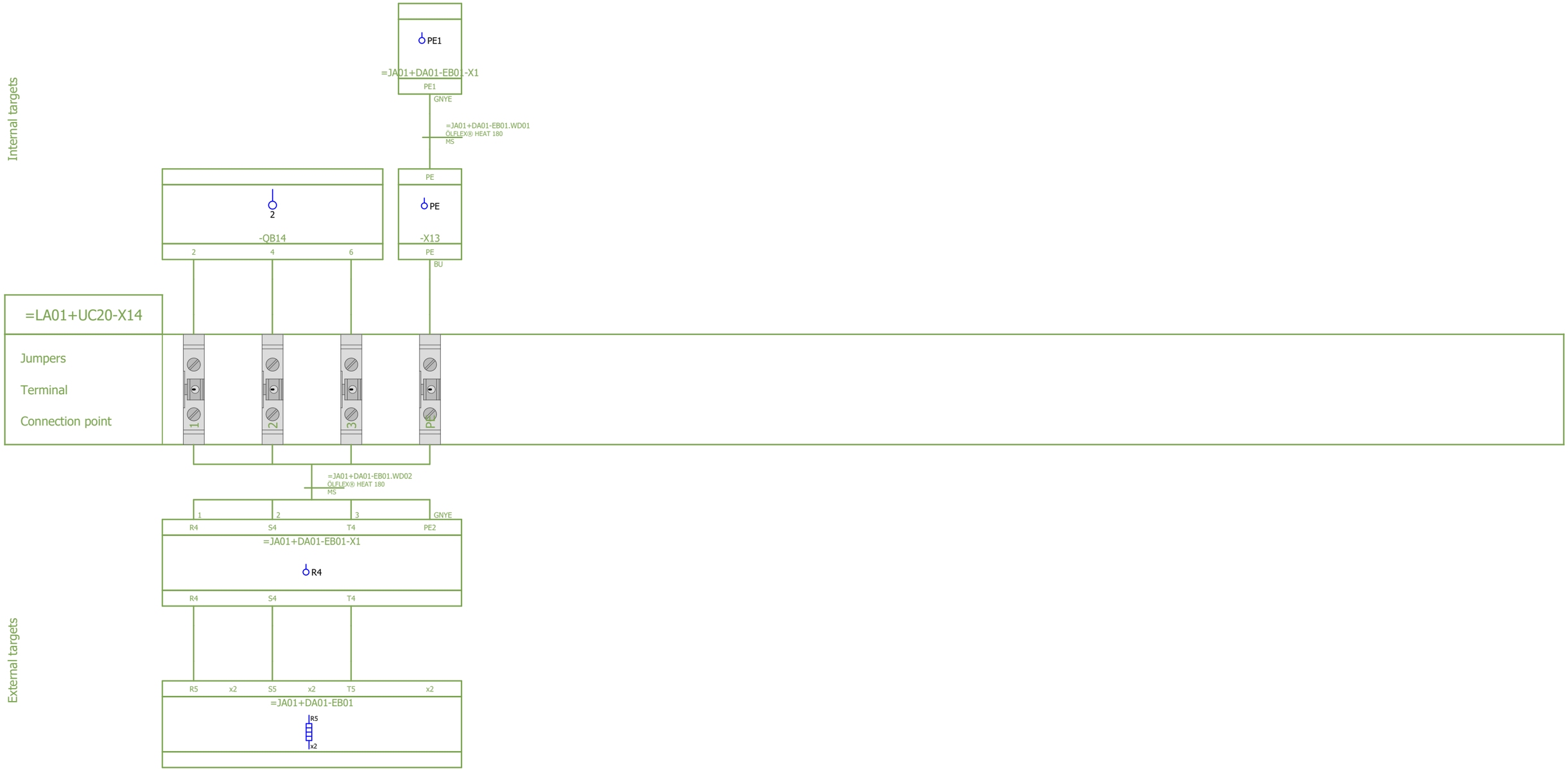
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Terminal-connection diagram

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PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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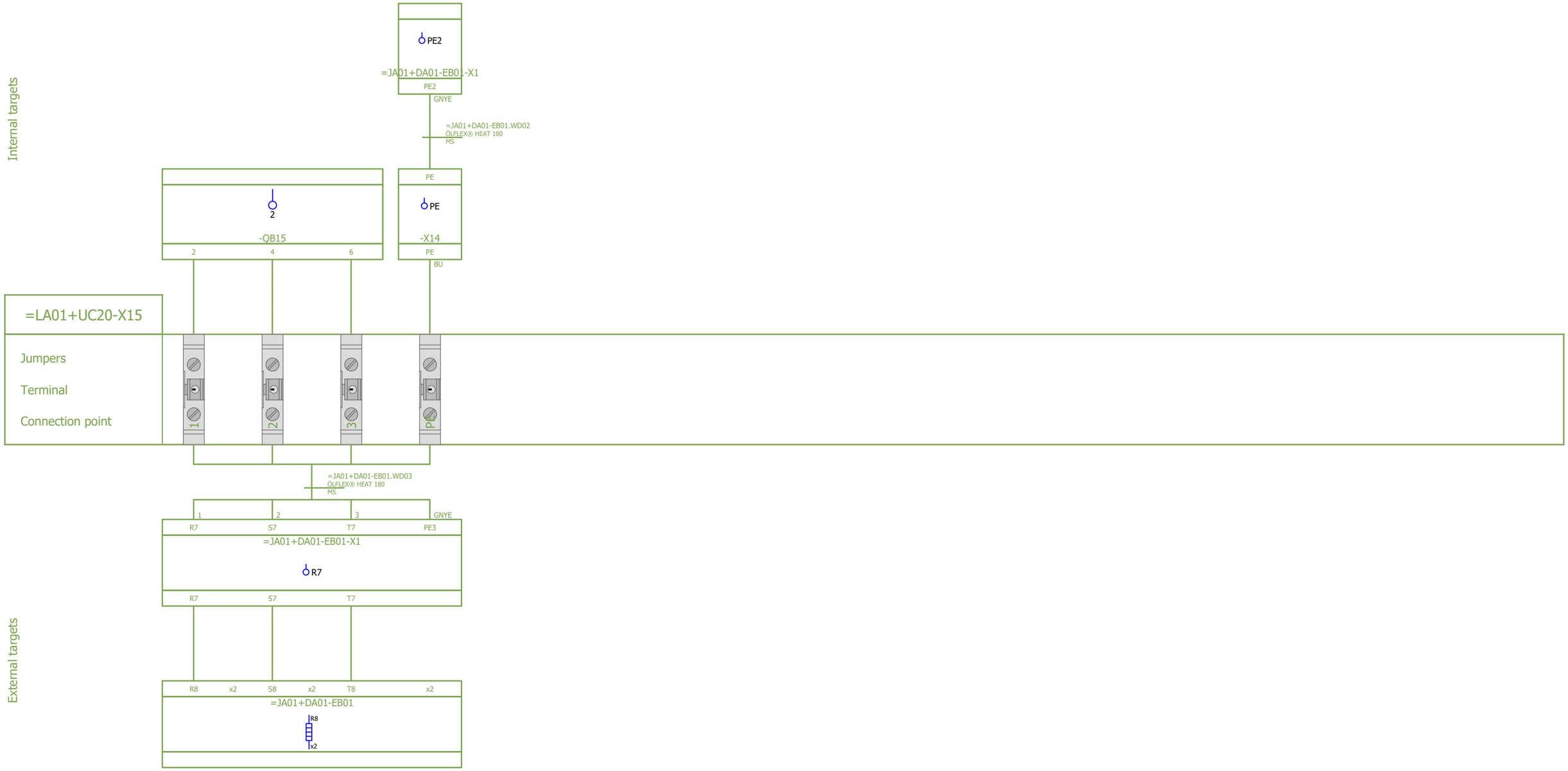
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FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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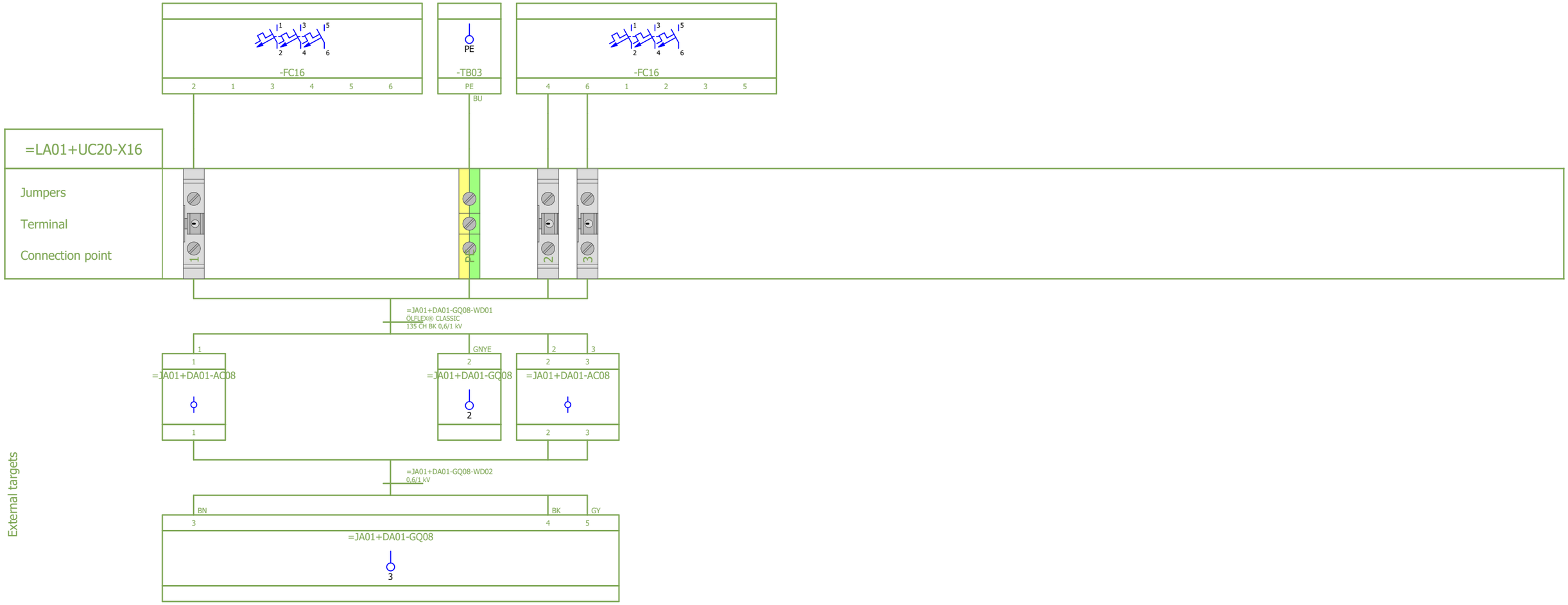
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 123 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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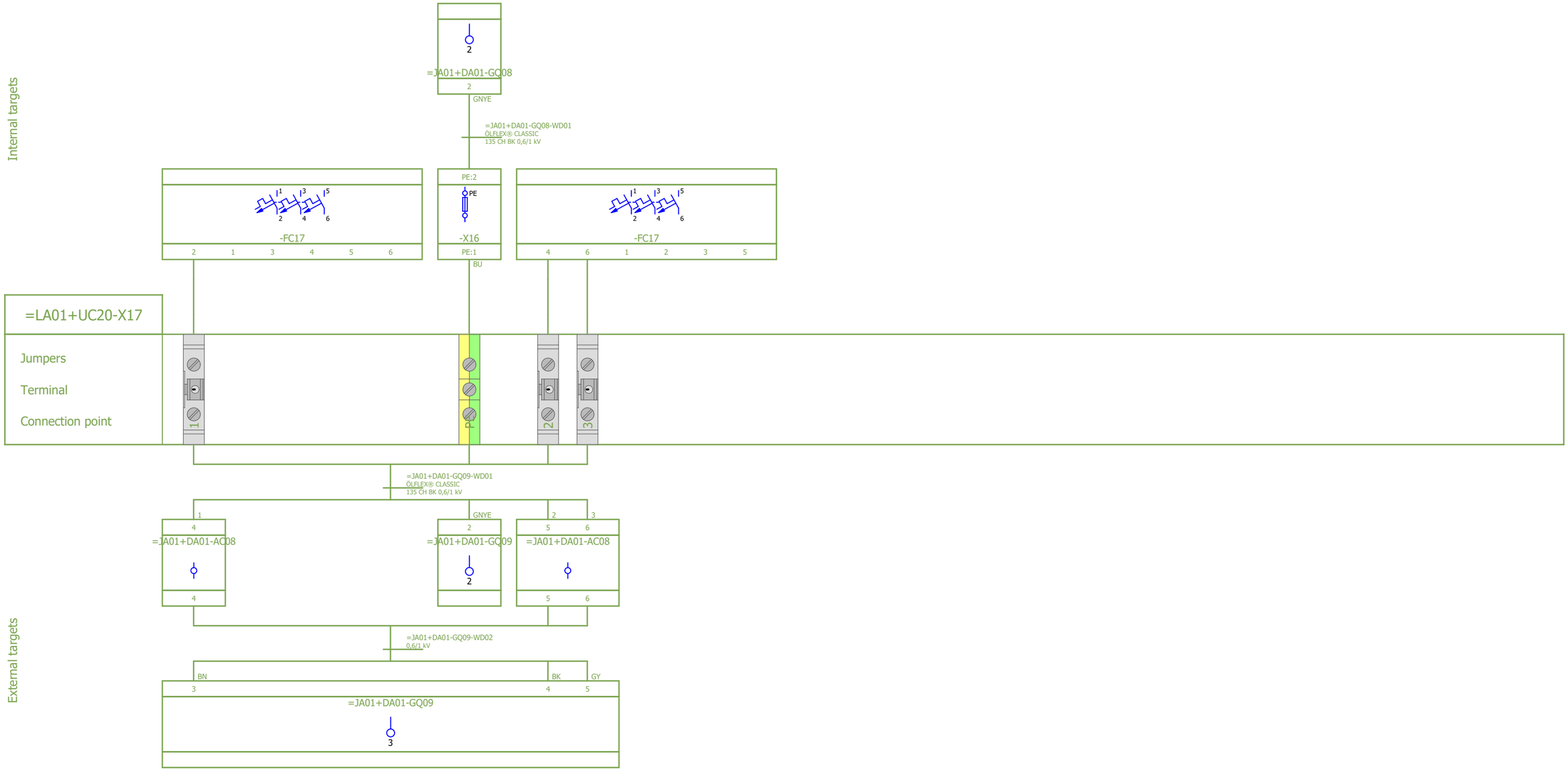
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 124 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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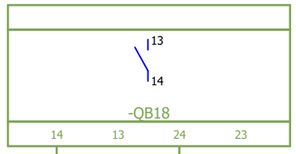
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Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

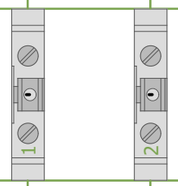


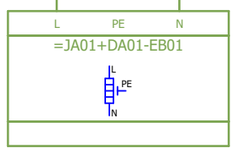
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Jumpers

Terminal

Connection point





External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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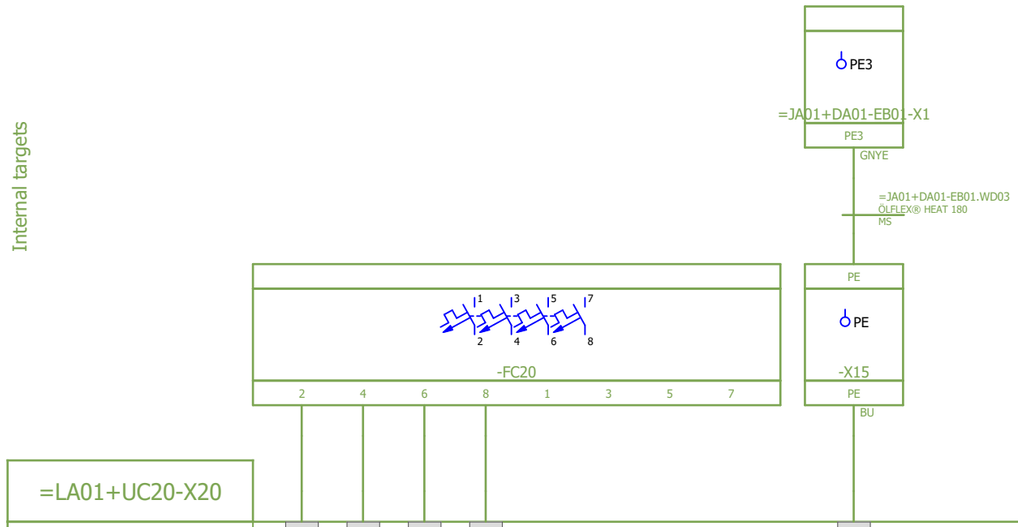
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 126 / 255

Terminal-connection diagram

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Internal targets



=LA01+UC20-X20

Jumpers

Terminal

Connection point

1 2 3 4 PE

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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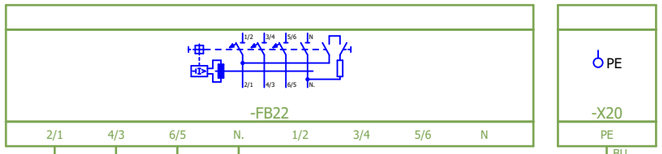
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 127 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



=LA01+UC20-X22

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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EPLAN Project Pages	627		
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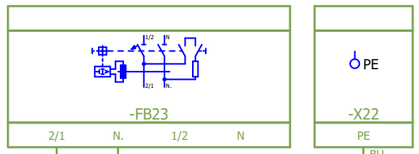
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 128 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



=LA01+UC20-X23

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DATE
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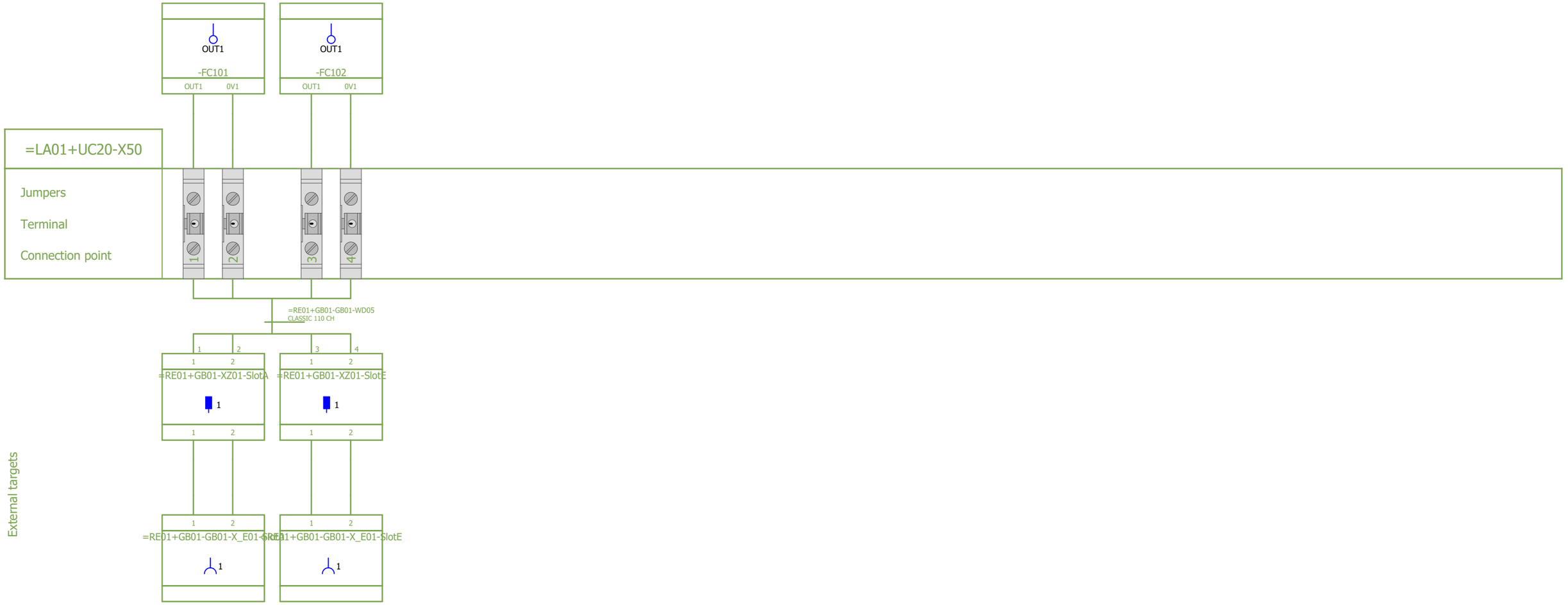
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X23		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 129 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DESCRIPTION
DATE
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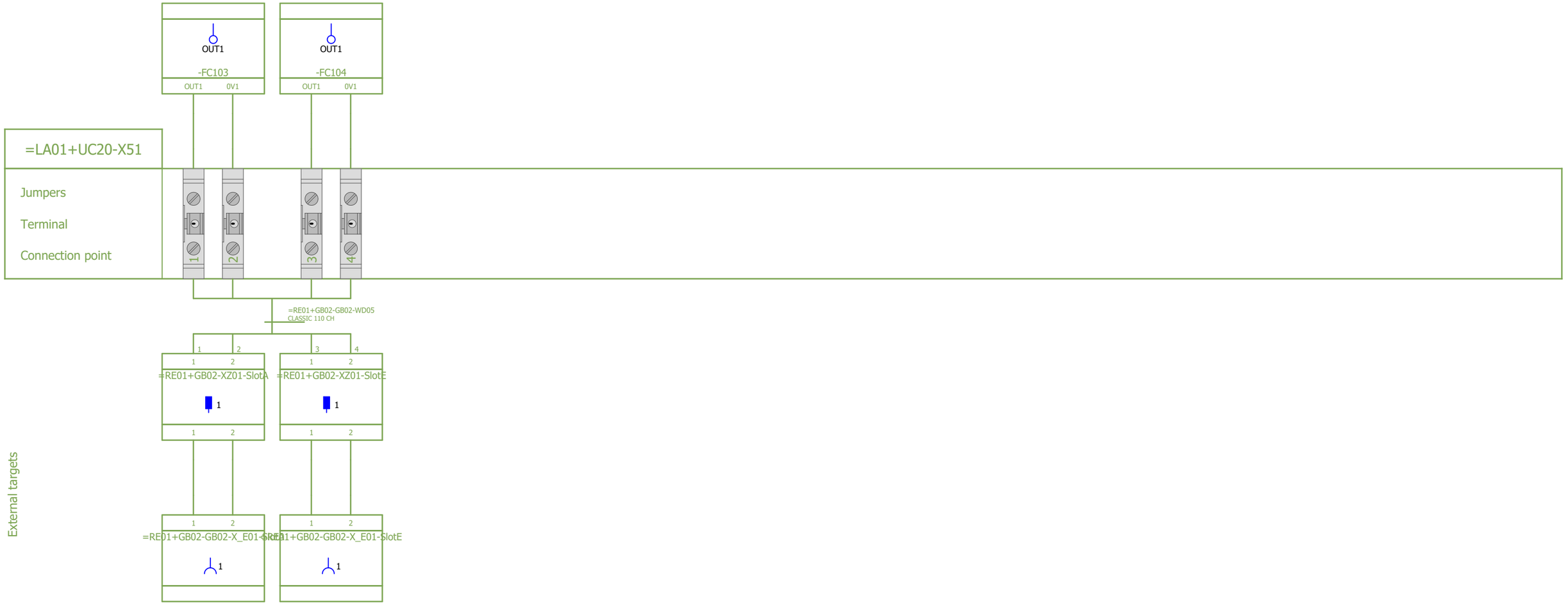
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X50		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 130 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

REVISION INFORMATION	
DESCRIPTION	
DATE	29-Sep-25

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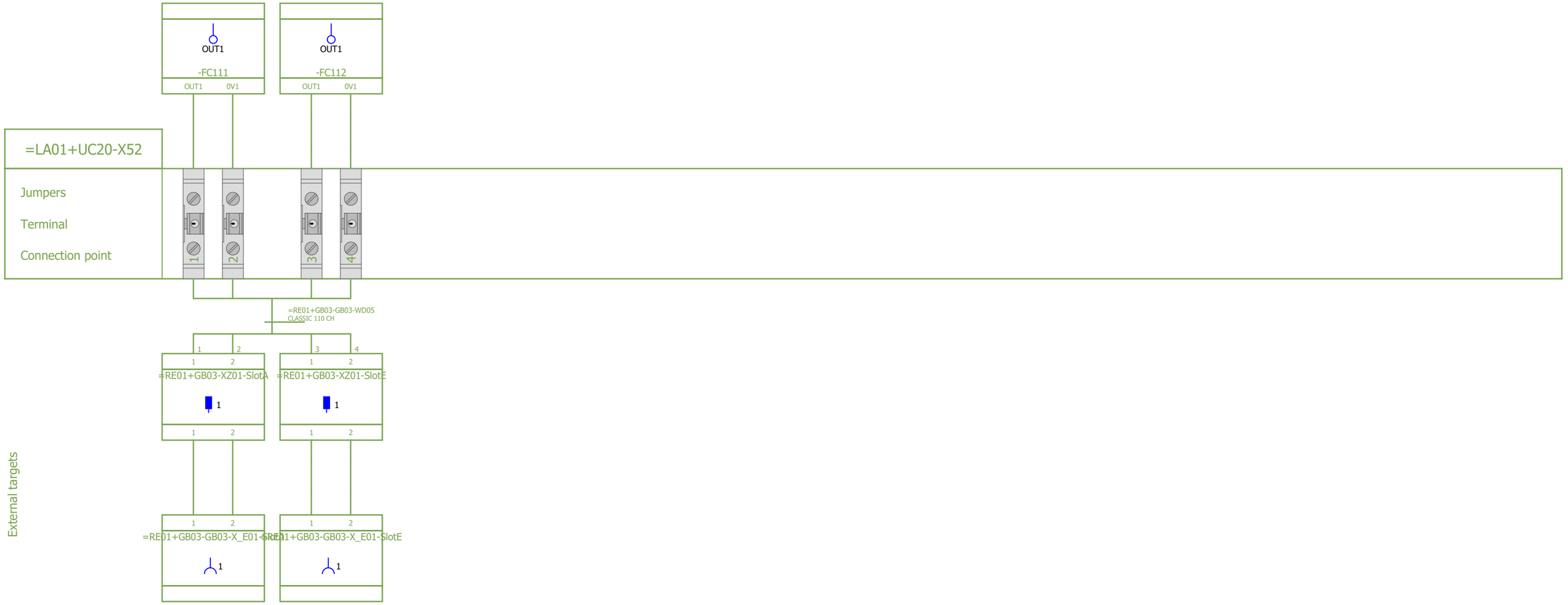
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X51		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 131 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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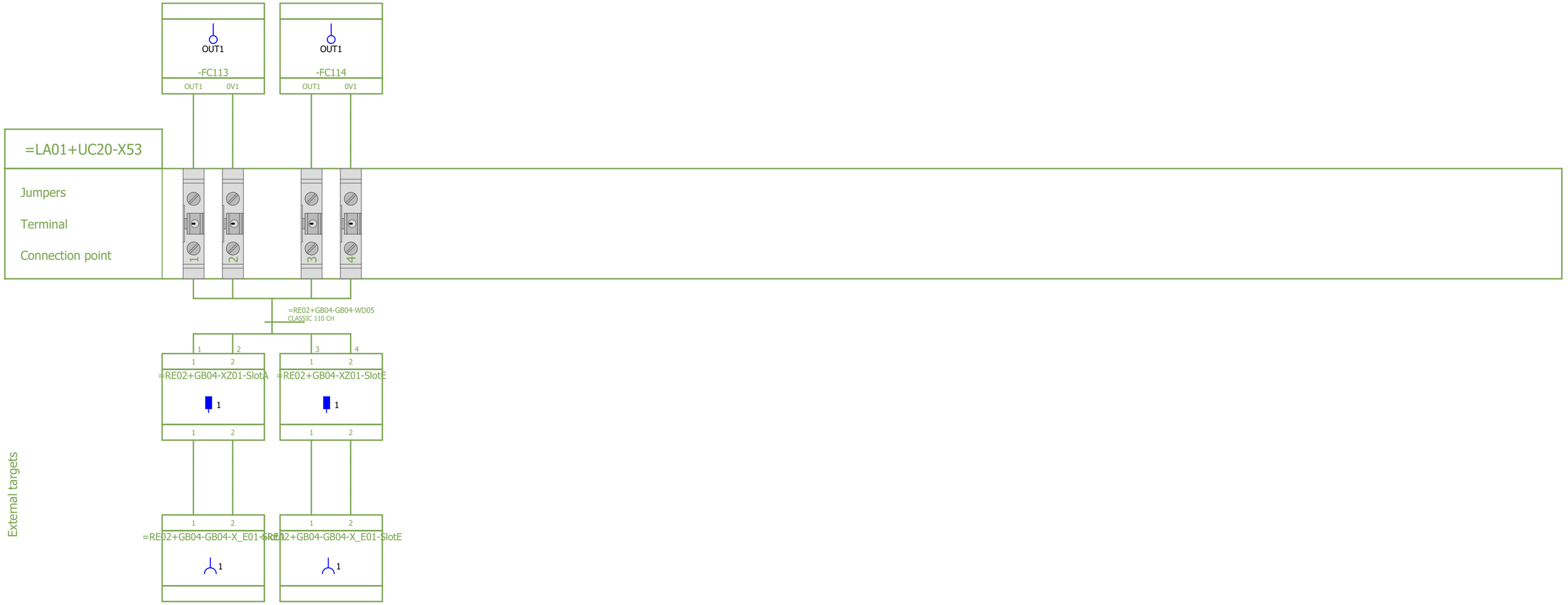
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X52		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 132 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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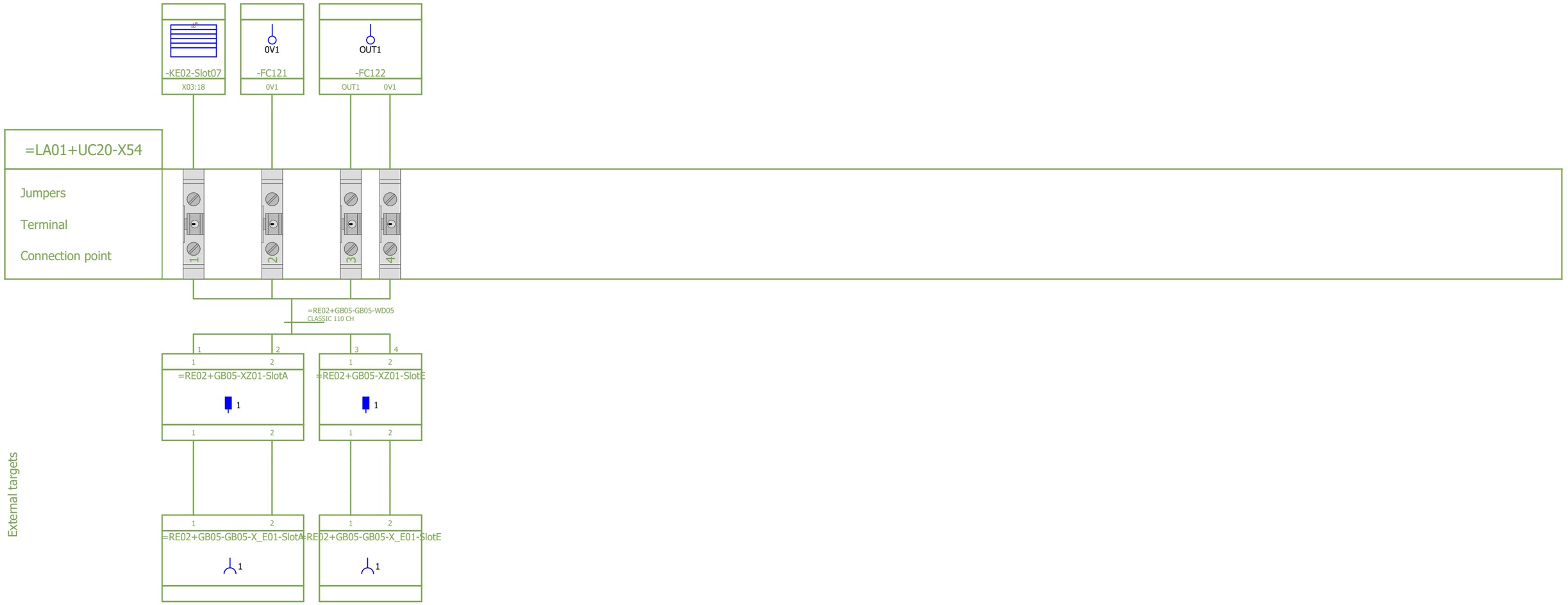
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X53		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 133 / 255

Terminal-connection diagram

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Internal targets



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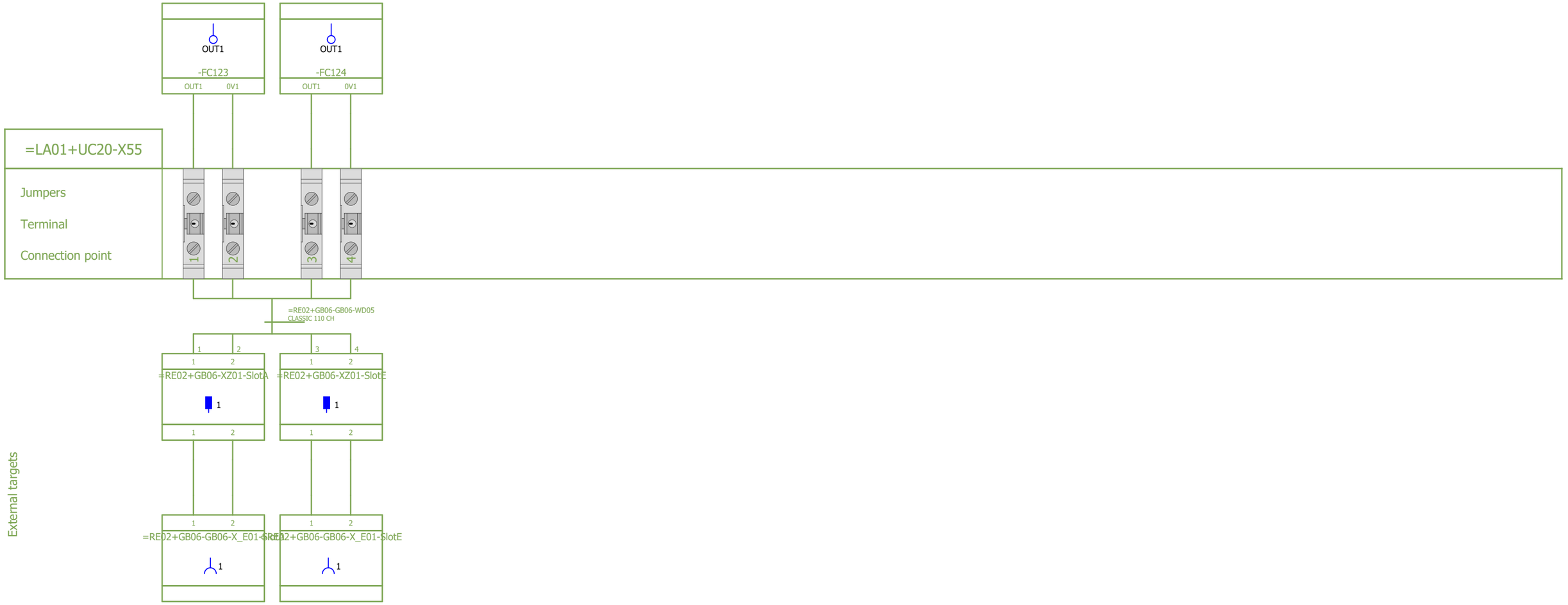
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X54		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 134 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X55		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 135 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

=LB02-KE13 | -KE02-Slot04 | =RE01+GB01-KE02-Slot04 | -KF100 | =LB02-KE13 | =RE01+GB01-KE02-Slot04 | -KF100 | -KE02-Slot04

I2	X02:15	X02:16	X02:17	X02:18	53	63	54	64	Q2	X02:19	X02:20	X02:21	43	X01:2
VT	VT	VT	VT	VT	OG	OG	OG	OG	VT	VT	VT	VT		VT

=LA01+UC20-X60

Jumpers

Terminal

Connection point

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

=RE01+GB01-GB01-WG02
ÖLFLEX® CLASSIC
110 CH

1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB01-XZ01-SlotF

1

1 2 3

=RE01+GB01-XZ01-SlotB

1

External targets

1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB01-GB01-X_E01-SlotF

1

1 2 3

=RE01+GB01-GB01-X_E01-SlotB

1

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X60		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 136 / 255

FRM5103656/0B

Terminal-connection diagram

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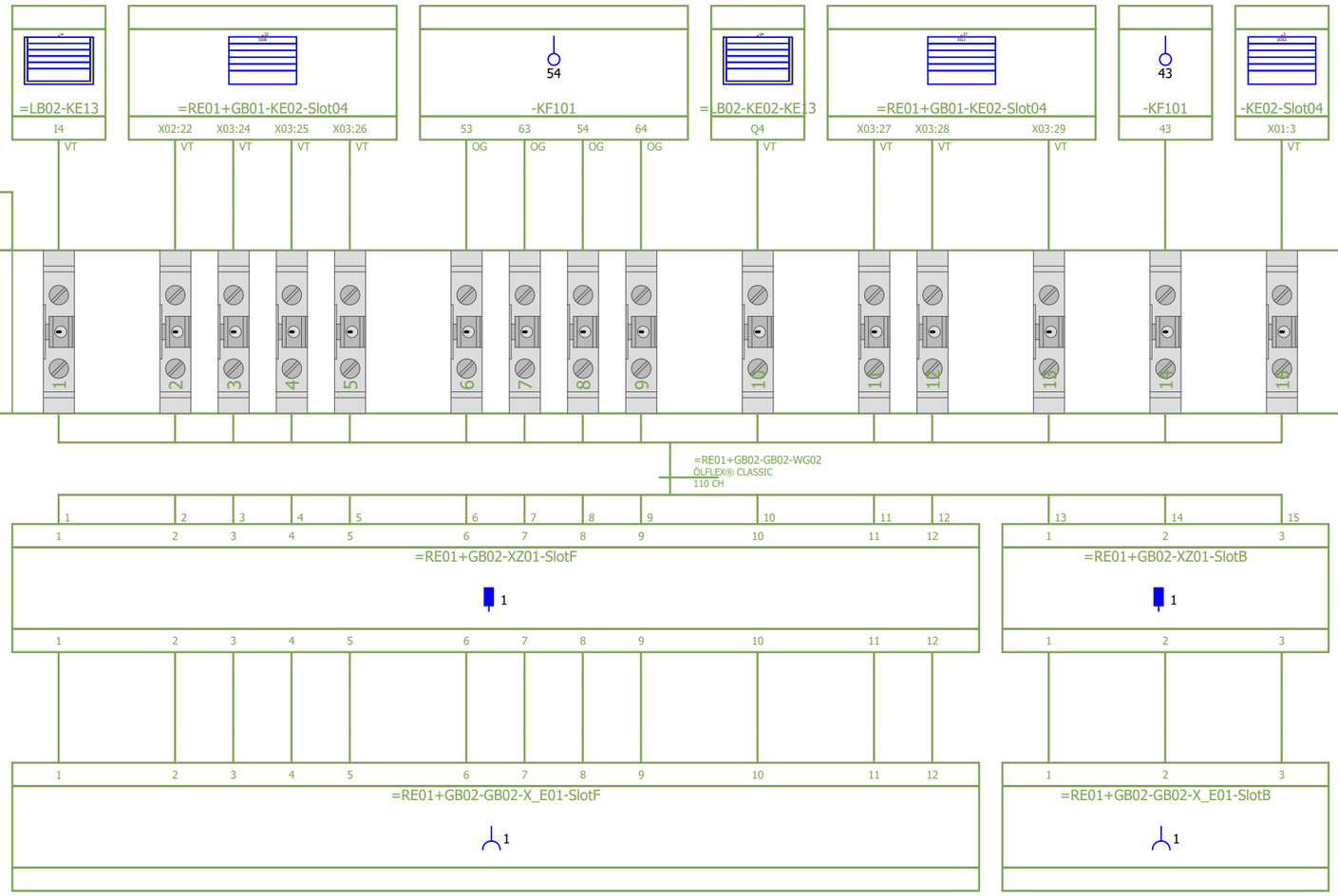
Internal targets

=LA01+UC20-X61

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X61		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 137 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

=LA01+UC20-X62

Jumpers

Terminal

Connection point

=LB02-KE14	-KE02-Slot05				-KF102				=LB02-KE14	-KE02-Slot05			-KF102	-KE02-Slot05
I2	X02:15	X02:16	X02:17	X02:18	53	63	54	64	Q2	X02:19	X02:20	X02:21	43	X01:2
VT	VT	VT	VT	VT	OG	OG	OG	OG	VT	VT	VT	VT	VT	VT
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

54

43

=RE01+GB03-GB03-WG02
ÖLFLEX® CLASSIC
110 CH

1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB03-XZ01-SlotF

1

1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB03-XZ01-SlotB

1

1 2 3

External targets

1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB03-GB03-X_E01-SlotF

1

1 2 3 4 5 6 7 8 9 10 11 12

=RE01+GB03-GB03-X_E01-SlotB

1

1 2 3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X62		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 138 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

=LA01+UC20-X63

Jumpers

Terminal

Connection point

	=LB02-KE14	-KE02-Slot05				-KF103				=LB02-KE14	-KE02-Slot05			-KF103	-KE02-Slot05
	I4	X02:22	X03:24	X03:25	X03:26	53	63	54	64	Q4	X03:27	X03:28	X03:29	43	X01:3
	VT	VT	VT	VT	VT	OG	OG	OG	OG	VT	VT	VT	VT	VT	VT
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

54 43

=RE02+GB04-GB04-WG02
ÖLFLEX® CLASSIC
110 CH

External targets

=RE02+GB04-XZ01-SlotF

1

=RE02+GB04-XZ01-SlotB

1

=RE02+GB04-GB04-X_E01-SlotF

1

=RE02+GB04-GB04-X_E01-SlotB

1

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X63		
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Terminal-connection diagram

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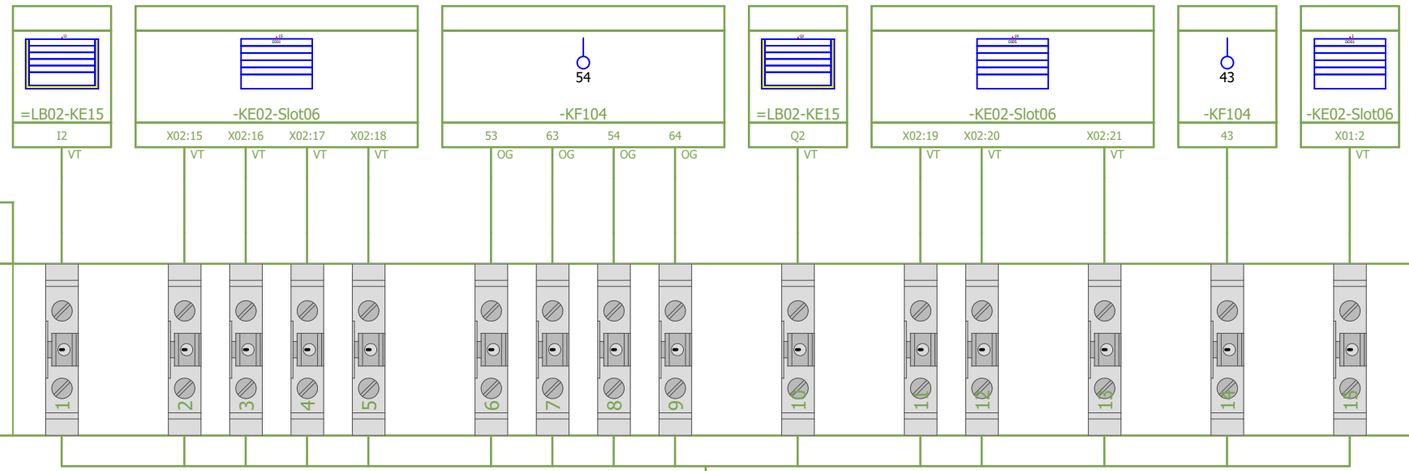
Internal targets

=LA01+UC20-X64

Jumpers

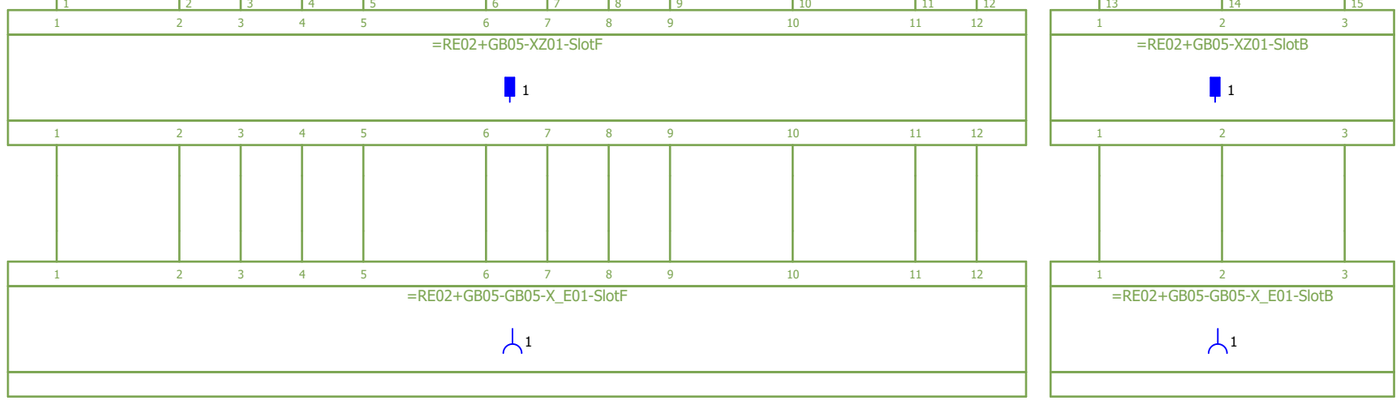
Terminal

Connection point



=RE02+GB05-GB05-WG02
ÖLFLEX® CLASSIC
110 CH

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X64		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 140 / 255

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Terminal-connection diagram

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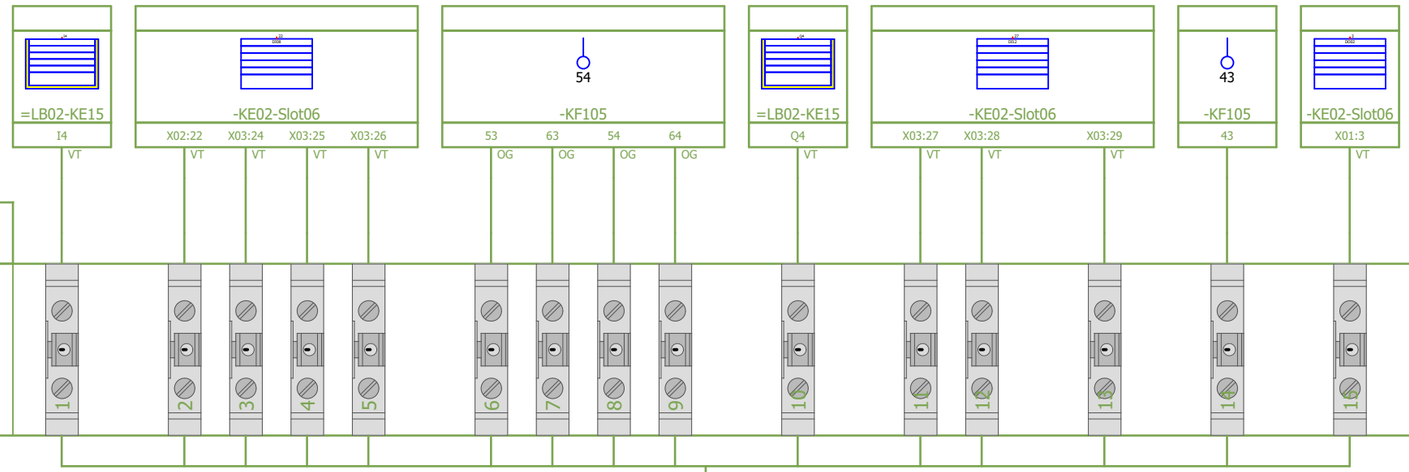
Internal targets

=LA01+UC20-X65

Jumpers

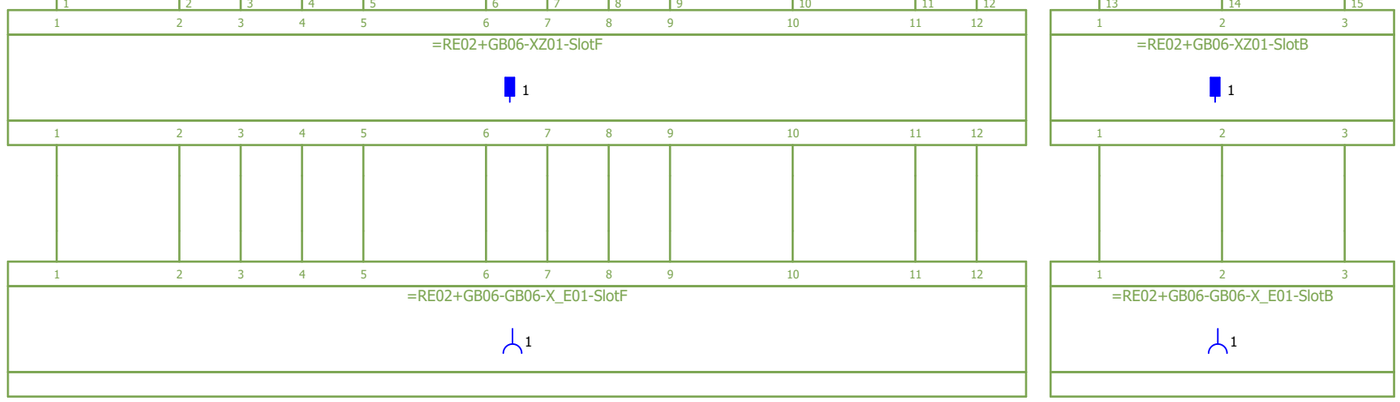
Terminal

Connection point



=RE02+GB06-GB06-WG02
ÖLFLEX® CLASSIC
110 CH

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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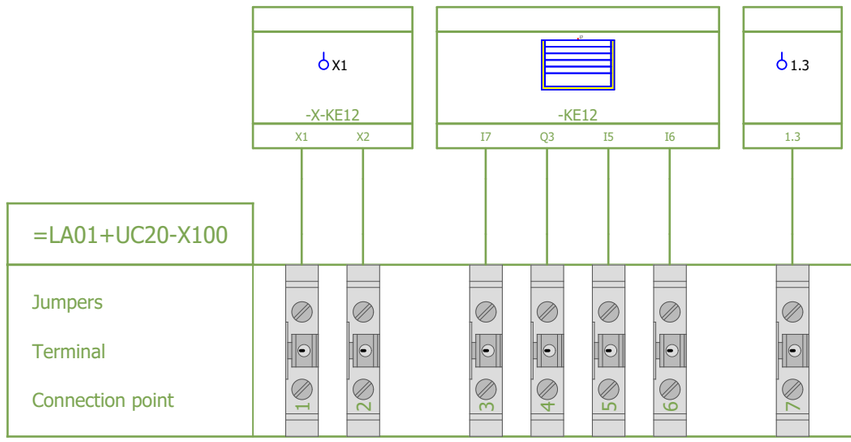
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X65		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 141 / 255

Terminal-connection diagram

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PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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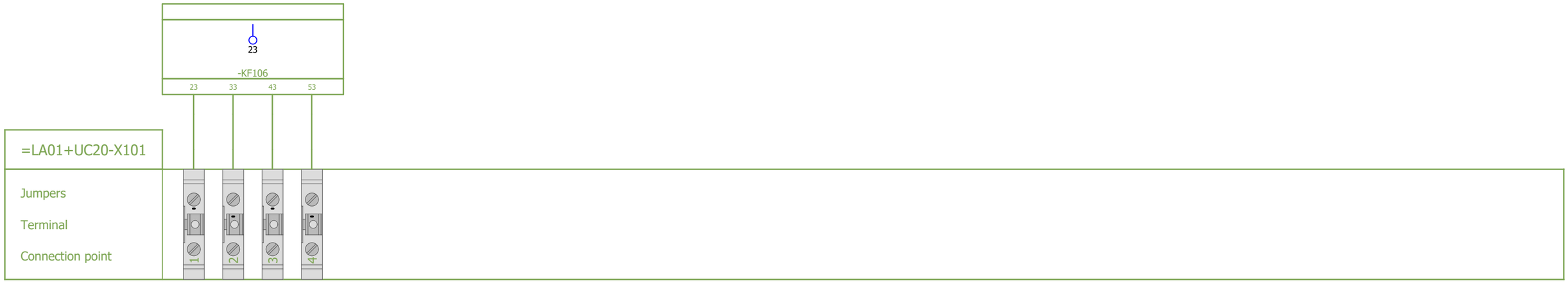
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X100		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 142 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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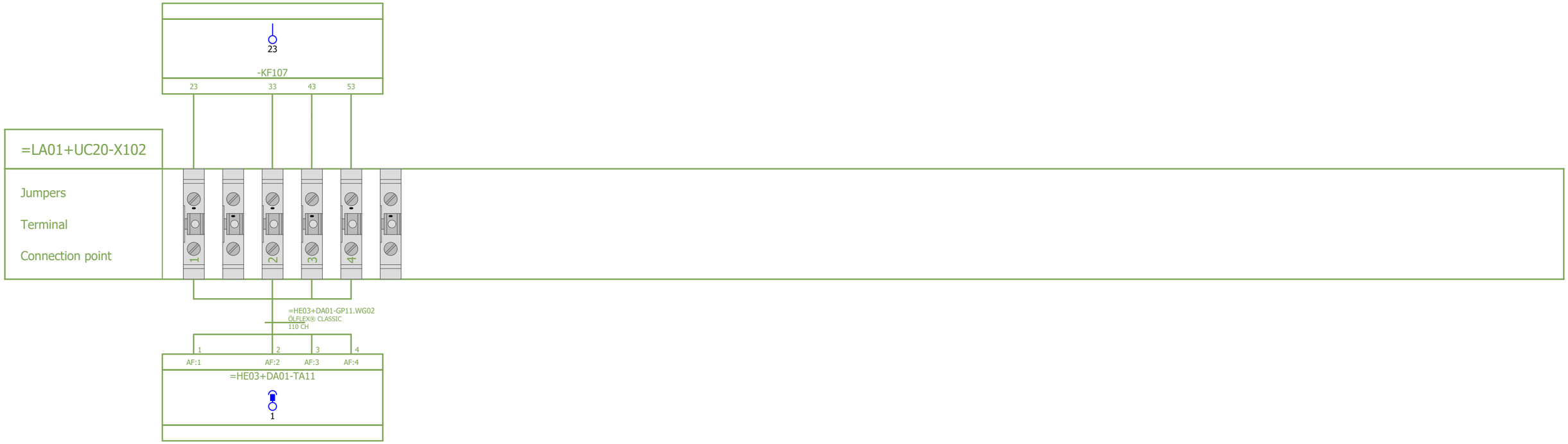
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X101		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 143 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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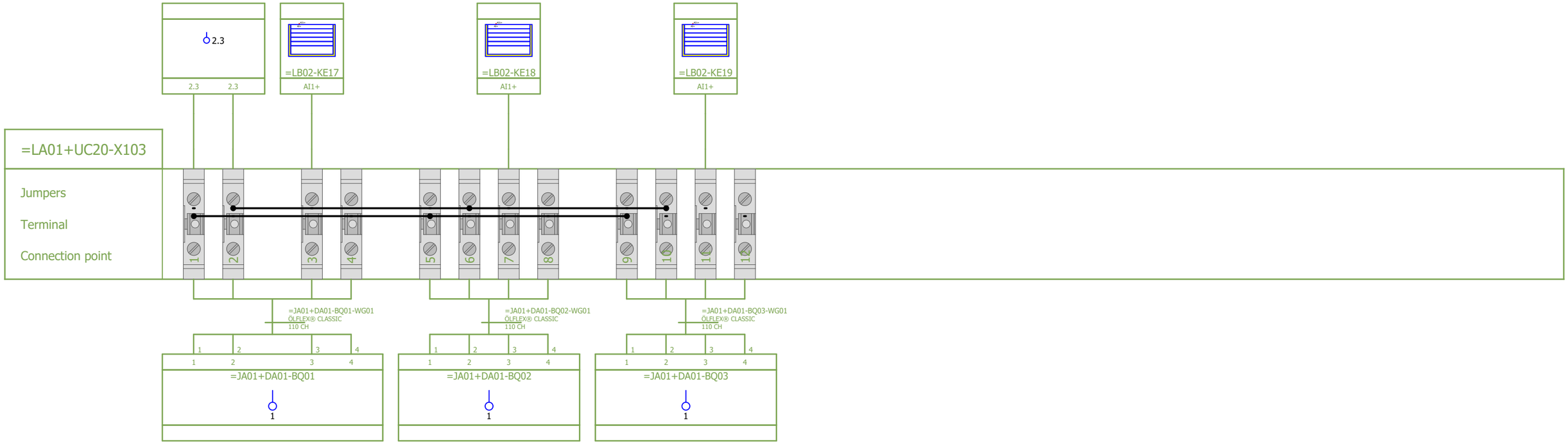
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X102		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 144 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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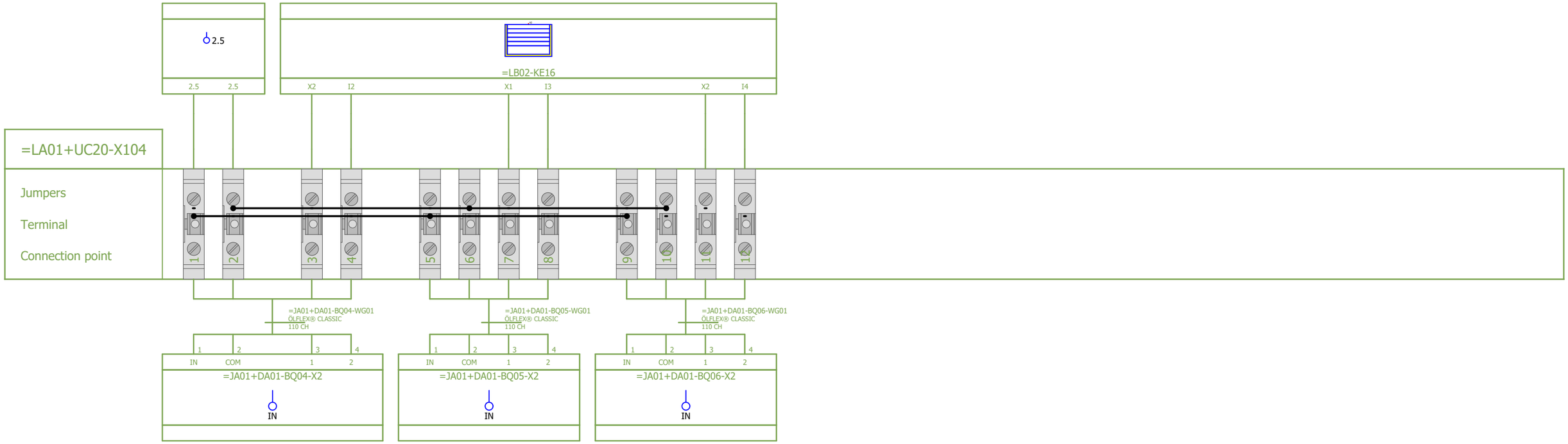
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X103		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 145 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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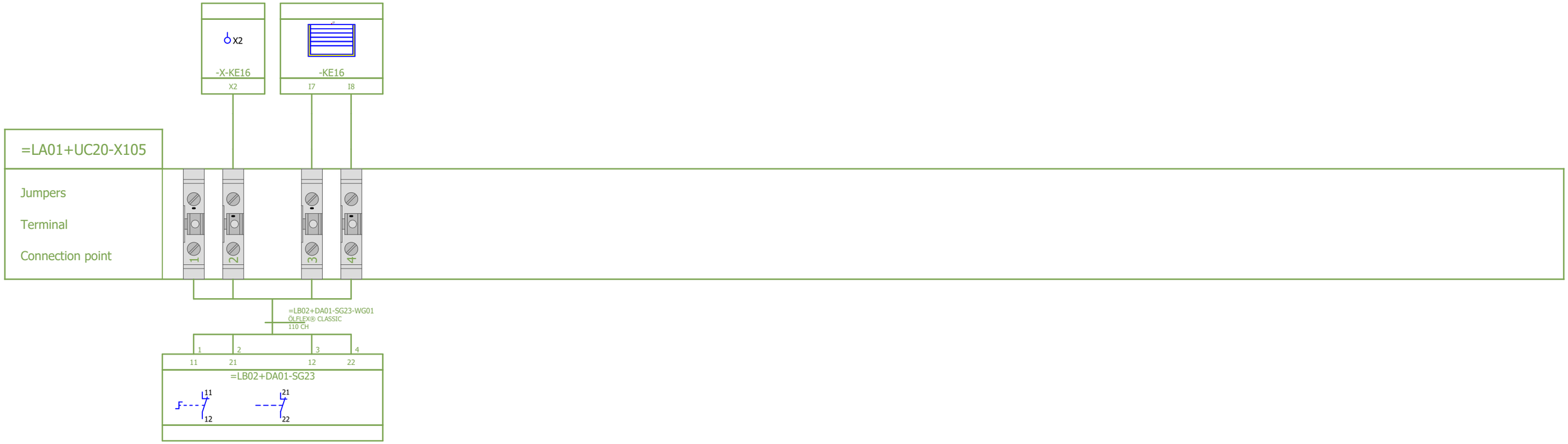
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X104		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 146 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X105		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 147 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

=LA01+UC20-X106

Jumpers

Terminal

Connection point

1 2 3 4 5 6 7 8 9 10 11 12

	-X50	-KF100	-X51	-KF101	-X52	-KF102	-X53	-KF103	-X54	-KF104	-X55	-KF105
	WH	WH	WH	WH	WH	WH	WH	WH	WH	WH	WH	WH
	4	44	4	44	4	44	4	44	4	44	4	44
	4		4		4		4		4		4	
	=RE01+GB01-GB01-WD05 CLASSIC 110 CH		=RE01+GB02-GB02-WD05 CLASSIC 110 CH		=RE01+GB03-GB03-WD05 CLASSIC 110 CH		=RE02+GB04-GB04-WD05 CLASSIC 110 CH		=RE02+GB05-GB05-WD05 CLASSIC 110 CH		=RE02+GB06-GB06-WD05 CLASSIC 110 CH	
	4		4		4		4		4		4	
	=RE01+GB01-XZ01-SlotE		=RE01+GB02-XZ01-SlotE		=RE01+GB03-XZ01-SlotE		=RE02+GB04-XZ01-SlotE		=RE02+GB05-XZ01-SlotE		=RE02+GB06-XZ01-SlotE	
	2		2		2		2		2		2	
	2		2		2		2		2		2	
	=RE01+GB01-GB01-X_E01-SlotE		=RE01+GB02-GB02-X_E01-SlotE		=RE01+GB03-GB03-X_E01-SlotE		=RE02+GB04-GB04-X_E01-SlotE		=RE02+GB05-GB05-X_E01-SlotE		=RE02+GB06-GB06-X_E01-SlotE	
	2		2		2		2		2		2	

Reference Item Number	Ballard Part # TBD
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EPLAN Revision	12
EPLAN Project Pages	627
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X106		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 148 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

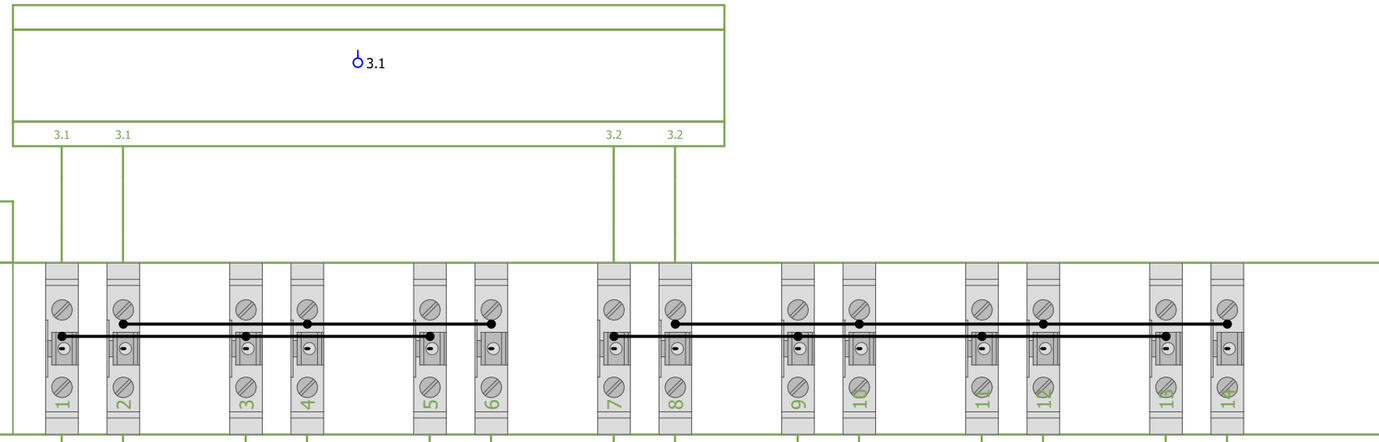
External targets

=LA01+UC20-X108

Jumpers

Terminal

Connection point



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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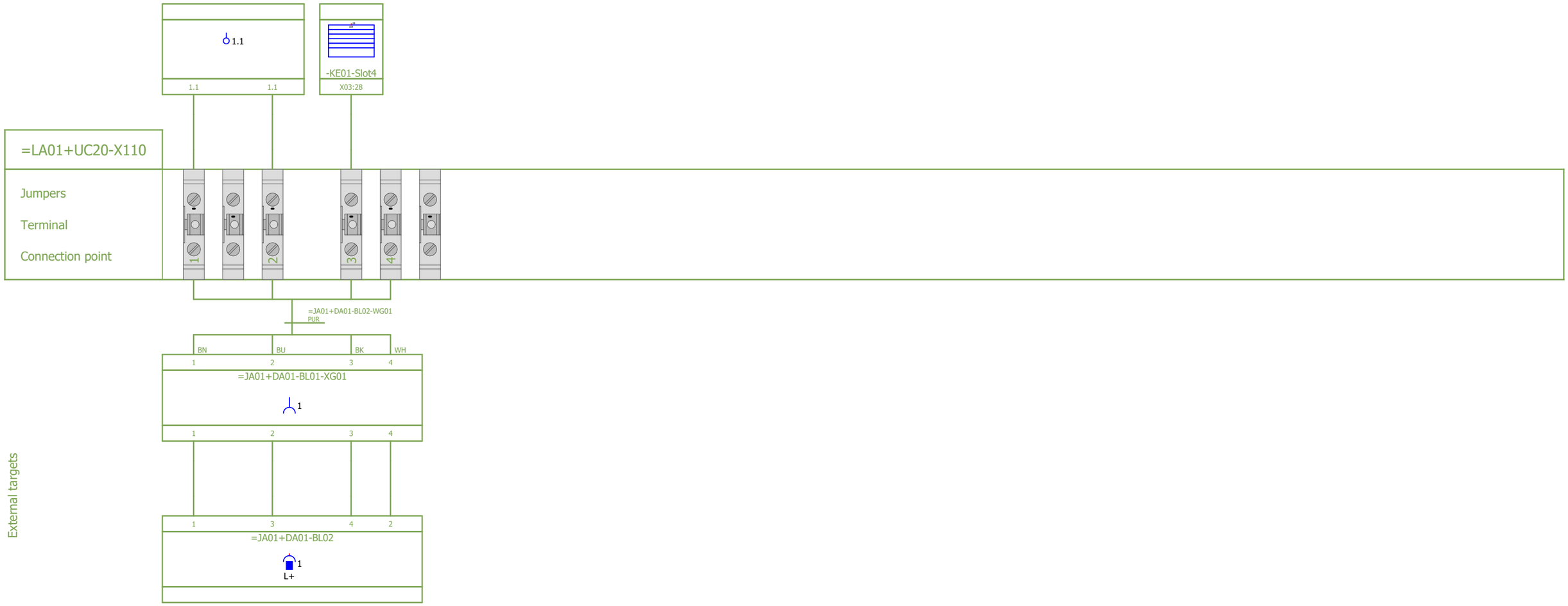
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X108		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 149 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X110		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 150 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

=LA01+UC20-X120

Jumpers

Terminal

Connection point

-KE03-Slot4

X01:1 X01:2 X01:3 X02:4 X02:5 X02:6 X03:7 X03:8 X03:9 X04:10 X04:11 X04:12 X05:13 X05:14 X05:15 X06:16

AI20

1 2 16 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 21 22 23

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Reference Item Number	Ballard Part # TBD
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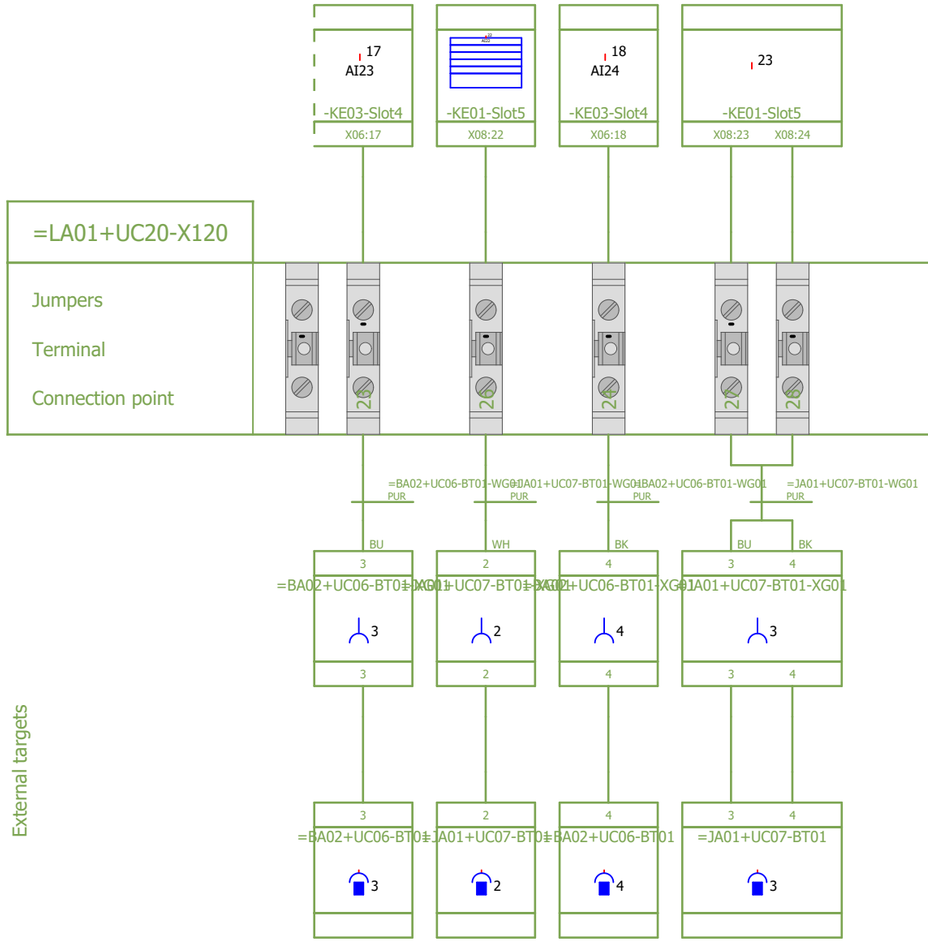
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X120		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 151 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING TITLE			
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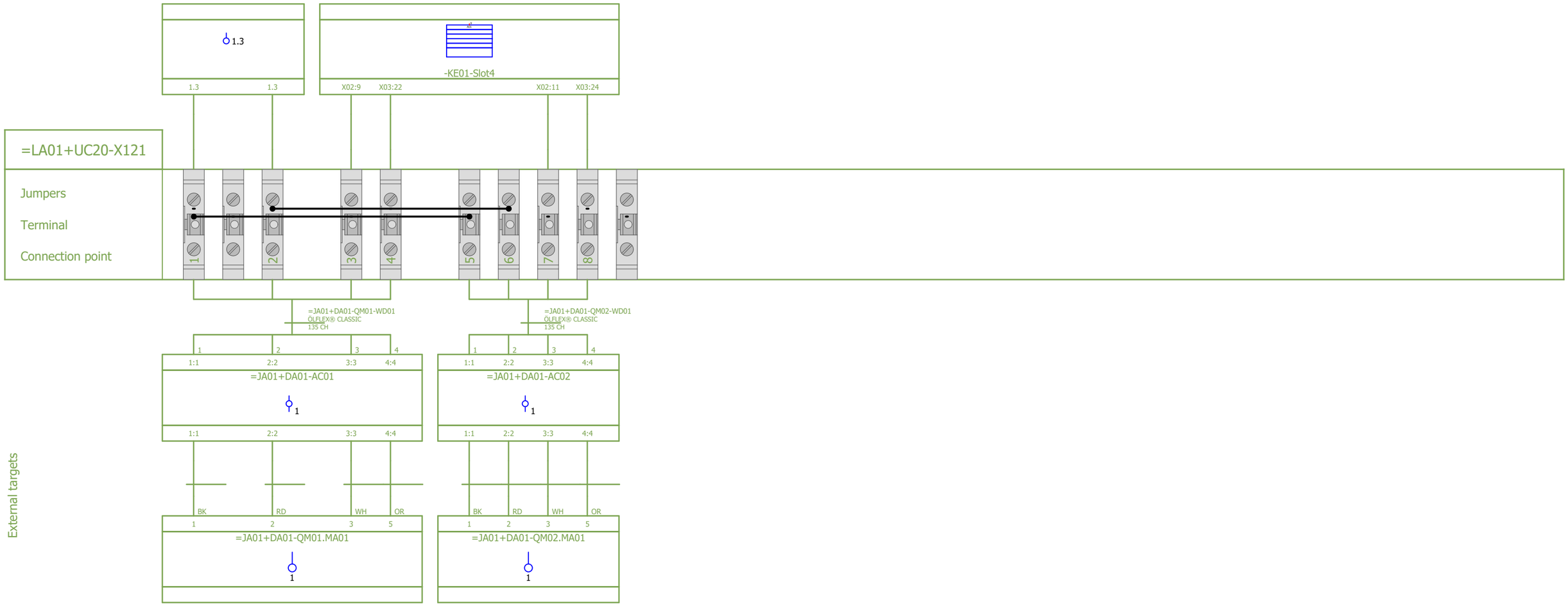
FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets



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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X121		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 153 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

=LA01+UC20-X122

Jumpers

Terminal

Connection point

-KE02-Slot07 X02:9 X02:9

1.2 1.2 1.2 2.6 2.6

-KE02-Slot07 X03:22 X03:22 X03:24 X03:24 X02:11 X02:11

3 | 14 | 11 | 12 | 9 | 10 | 4 | 5 | 13 | 16 | 6 | 7 | 14 | 16 | 8 | | 16 |

=JA01+DA01-QM03-WD01 ÖLFLEX® CLASSIC 135 CH 3
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WH 3 =JA01+DA01-QM05.MA01 3
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RD 2
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RD 2
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OR 5 =JA01+DA01-QM05.MA01 5
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WH 3
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WH 3
OR 5 =JA01+DA01-QM04.MA01 5
OR 5 =JA01+DA01-QM06.MA01 5

Reference Item Number	Ballard Part # TBD		
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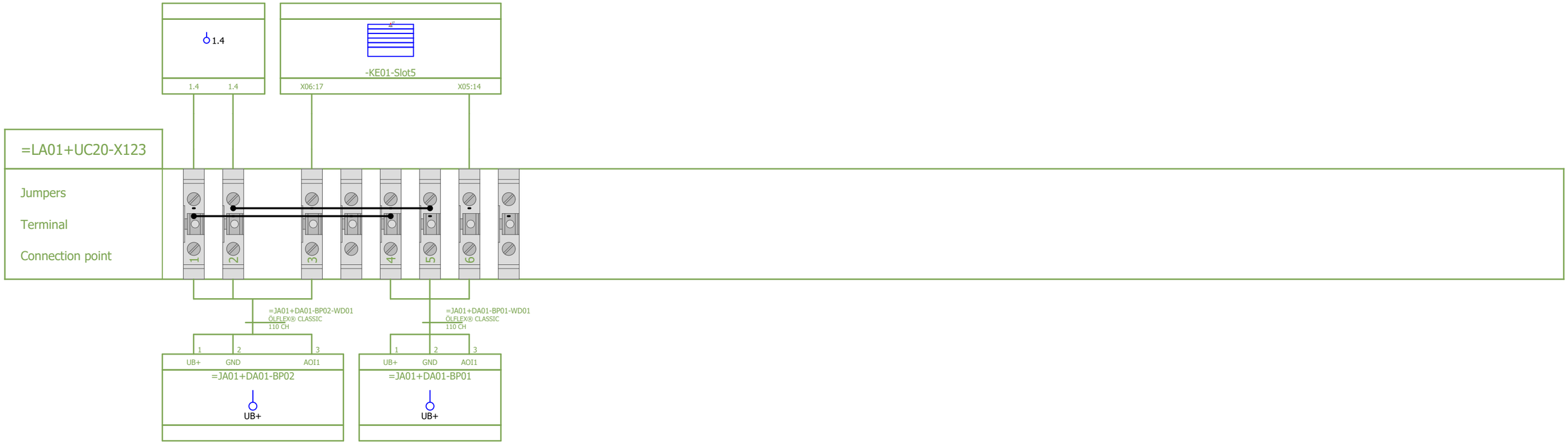
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 154 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

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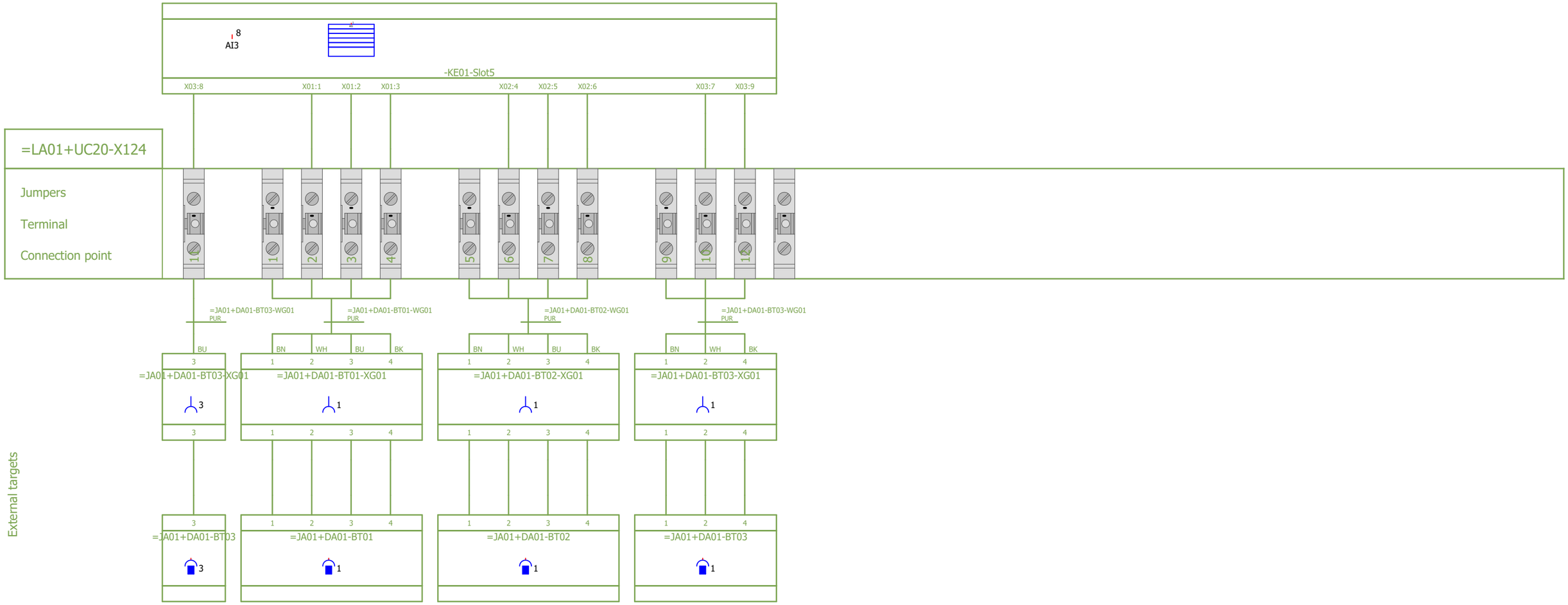
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X123		
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Terminal-connection diagram

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External targets



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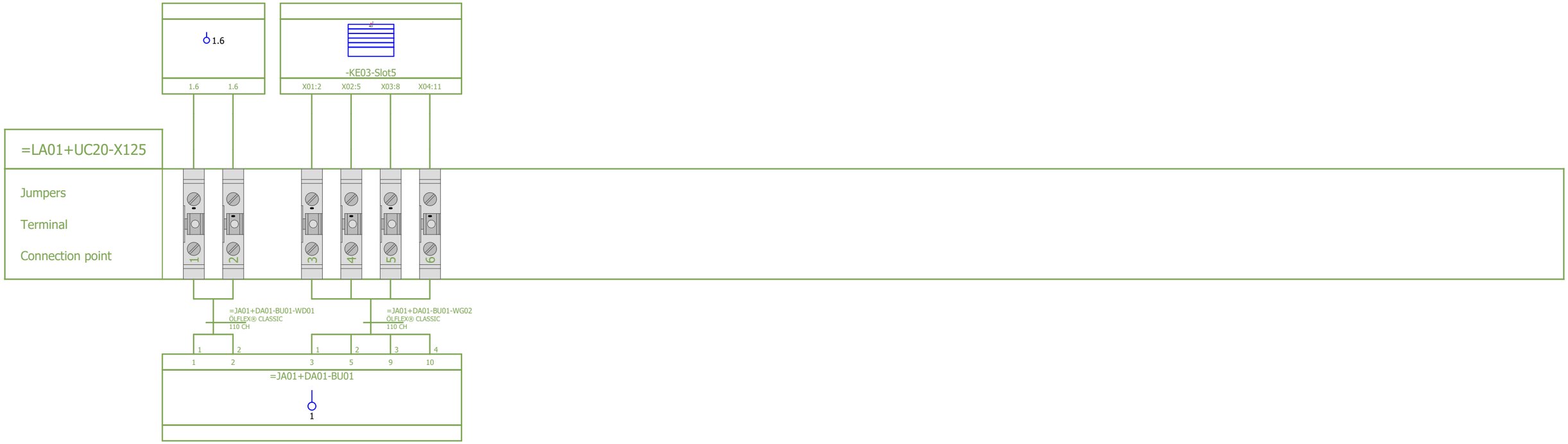
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X124		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 156 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X125		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 157 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

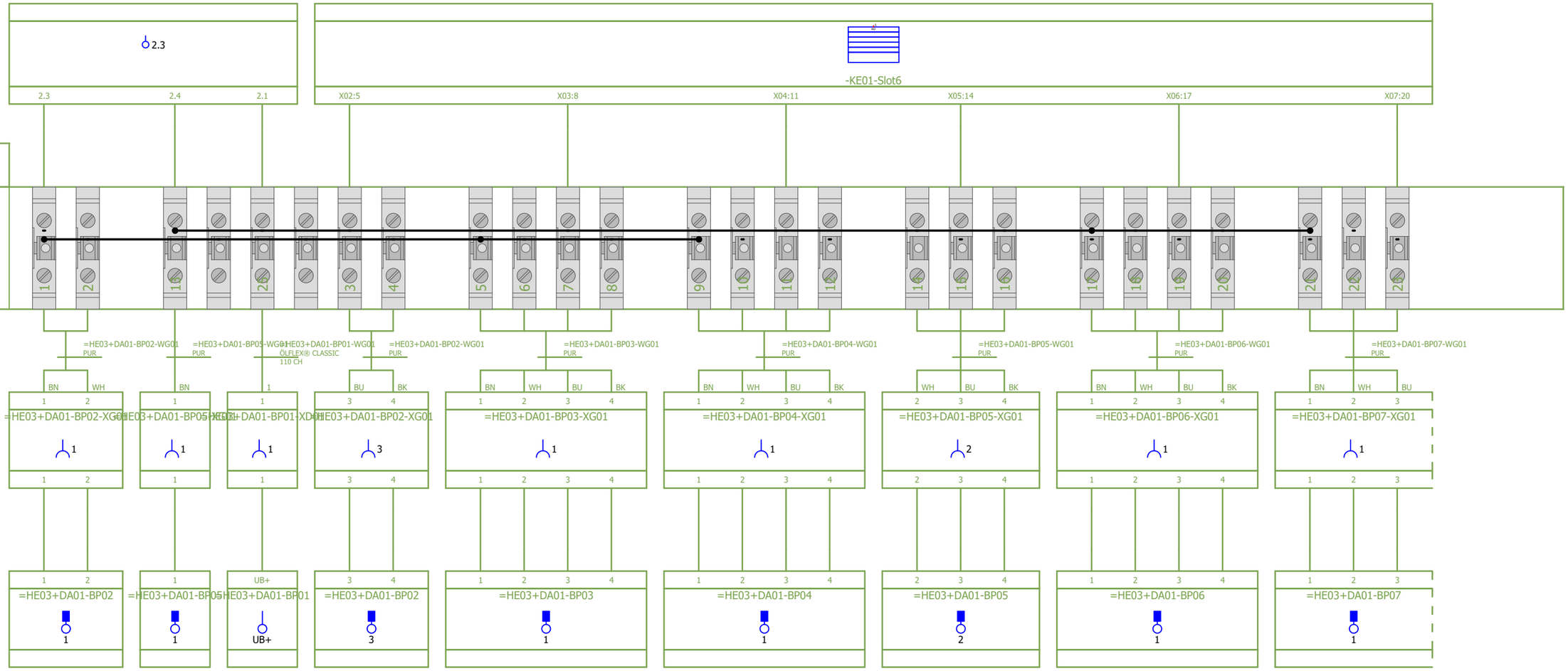
External targets

=LA01+UC20-X150

Jumpers

Terminal

Connection point



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DESCRIPTION
DATE
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X150		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 158 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

-KE01-Slot5
X07:20

=LA01+UC20-X150

Jumpers

Terminal

Connection point

24 | 24 | PE

=HE03+DA01-BP07-WG01
PUR
BK
4
4

=HE03+DA01-BP01-WG01
ÖLFLEX® CLASSIC
110 CH
2 | 3
3 | PE
3 | PE

=HE03+DA01-BP07-XG01

=HE03+DA01-BP01-XD01

4

3

4

4

=HE03+DA01-BP07

4

AOU1 | PE

=HE03+DA01-BP01

AOU1

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X150		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 159 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

=LA01+UC20-X160

Jumpers

Terminal

Connection point

-KE03-Slot3

20
AI20

X07:19 X07:20 X07:21 X08:22 X08:23 X08:24 X09:25 X09:26 X09:27

-KE03-Slot4

20
AI20

X07:19 X07:20 X07:21 X08:22 X08:23 X08:24 X09:25 X09:23 X09:24

1 2 16 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 21 22 23 24

=HE01+DA01-BT01-WG01 PUR BN WH
=HE02+DA01-BT04-WG01 PUR BN
=HE01+DA01-BT01-WG01 PUR BU BK
=HE01+DA01-BT02-WG01 PUR BN WH BU BK
=HE01+DA01-BT03-WG01 PUR BN WH BU BK
=HE02+DA01-BT04-WG01 PUR WH BU BK
=HE02+DA01-BT05-WG01 PUR BN WH BU BK
=HE02+DA01-BT06-WG01 PUR BN WH BU BK

=HE01+DA01-BT01-XG01 1 2 1
=HE02+DA01-BT04-XG01 1 1
=HE01+DA01-BT01-XG01 3 3 4
=HE01+DA01-BT02-XG01 1 1 2 3 4
=HE01+DA01-BT03-XG01 1 1 2 3 4
=HE02+DA01-BT04-XG01 2 2 3 4
=HE02+DA01-BT05-XG01 1 1 2 3 4
=HE02+DA01-BT06-XG01 1 1 2 3 4

=HE01+DA01-BT01 1 2 1
=HE02+DA01-BT04 1 1
=HE01+DA01-BT01 3 3 4
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=HE02+DA01-BT04 2 2 3 4
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=HE02+DA01-BT06 1 1 2 3 4

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC20 | & C04

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X160		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 160 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

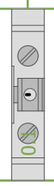


=LA01+UC20-X201

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

REVISION INFORMATION	
DESCRIPTION	
DATE	
29-Sep-25	

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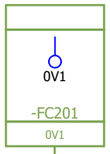
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X201		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 161 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

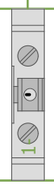


=LA01+UC20-X201-

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X201-		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 162 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

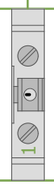


=LA01+UC20-X202

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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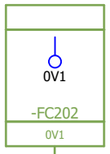
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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X202		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 163 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

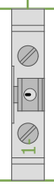


=LA01+UC20-X202-

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X202-		
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Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

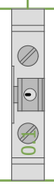


=LA01+UC20-X203

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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REVISION INFORMATION	
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DATE	
29-Sep-25	

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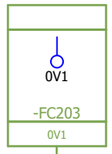
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 165 / 255

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

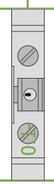


=LA01+UC20-X203-

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X203-		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 166 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

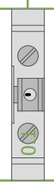


=LA01+UC20-X204

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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=	++	+ UC20	& C04

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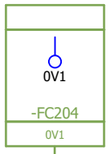
THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM

DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X204		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 167 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

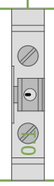


=LA01+UC20-X204-

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

REVISION INFORMATION	
DESCRIPTION	
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X204-		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 168 / 255

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

=LA01+UC20-X230

Jumpers

Terminal

Connection point

-KE5-Slot3	-FC210.1	-KE5-Slot3	-FC210.2	-KE01-Slot3		-KE01-Slot3
X01:1	1-	X01:4	1-	X01:7	2.2 3.3	X02:15

1 2 3 4 5 6 7 8

=JA01+DA01-EA01-WD01 PUR BK BU
=JA01+DA01-EA02-WD01 PUR BK BU
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=JA01+DA01-EA01-XD01	=JA01+DA01-EA02-XD01	=JA01+DA01-EA03-XD01	=JA01+DA01-SG01
4 3	4 3	4 3	13 14
4	4	4	E 13 14
4 3	4 3	4 3	

=JA01+DA01-EA1	=JA01+DA01-EA02	=JA01+DA01-EA03
4 3	4 3	4 3
4	4	4

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& C04

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DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC20-X230		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 169 / 255

FRM5103656/0B

Cable Overview / Cable Schedule

F10_001_Ballard

Cable Name	Function Text	Source (From)	Target (To)	Cable Type	All Conductors	Cross-Section [Unit]	Length [Unit]	Manufacturer	Type Number	Order Number
=HE01+DA01-BT01-WG01	FC1 HT Outlet Temp Signal	=HE01+DA01-BT01-XG01	=LA01-X160	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE01+DA01-BT02-WG01	FC2 HT Outlet Temp Signal	=HE01+DA01-BT02-XG01	=LA01-X160	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE01+DA01-BT03-WG01	FC3 HT Outlet Temp Signal	=HE01+DA01-BT03-XG01	=LA01-X160	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE02+DA01-BT04-WG01	FC4 HT Outlet Temp Signal	=HE02+DA01-BT04-XG01	=LA01-X160	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE02+DA01-BT05-WG01	FC5 HT Outlet Temp Signal	=HE02+DA01-BT05-XG01	=LA01-X160	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE02+DA01-BT06-WG01	=	=HE02+DA01-BT06-XG01	=LA01-X160	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BF01-WG01	LT Circuit Flow Signal	=BA20+UC50-X10	=HE03+DA01-BF01-XD01	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BP01-WG01	LT Circuit dP Signal	=HE03+DA01-BP01-XD01	=LA01-X150	ÖLFLEX® CLASSIC 110 CH	3	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
=HE03+DA01-BP02-WG01	FC1 LT Inlet Pressure Signal	=HE03+DA01-BP02-XG01	=LA01-X150	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BP03-WG01	FC2 LT Inlet Pressure Signal	=HE03+DA01-BP03-XG01	=LA01-X150	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BP04-WG01	FC3 LT Inlet Pressure Signal	=HE03+DA01-BP04-XG01	=LA01-X150	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BP05-WG01	FC4 LT Inlet Pressure Signal	=HE03+DA01-BP05-XG01	=LA01-X150	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BP06-WG01	FC5 LT Inlet Pressure Signal	=HE03+DA01-BP06-XG01	=LA01-X150	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BP07-WG01	FC1 LT Inlet Pressure Signal	=HE03+DA01-BP07-XG01	=LA01-X150	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=HE03+DA01-BT04-WG01	LT Return Temp Signal	=BA20+UC50-X10	=HE03+DA01-BT04-XG01	PUR	4	0,34 mm²	15 m	IFM Electronic AS	ADOAH040MSS0015K04	EVC698
=HE03+DA01-BT05-WG01	LT Radiator Outlet Signal	=BA20+UC50-X10	=HE03+DA01-BT05-XG01	PUR	4	0,34 mm²	15 m	IFM Electronic AS	ADOAH040MSS0015K04	EVC698
=HE03+DA01-GP11-WG01	24 VDC supply VFD LT Pump	=LA01-X108	=HE03+DA01-TA11	ÖLFLEX CLASSIC 110	3G	1 mm²		Lapp Group	ÖLFLEX CLASSIC 110	1119 203
=HE03+DA01-GP11.WD01	Power supply LT Pump	=LA01-X10	=HE03+DA01-TA11	ÖLFLEX® CLASSIC 135 CH	4	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123342
=HE03+DA01-GP11.WD02	=	=HE03+DA01-GP11	=HE03+DA01-TA11	ÖLFLEX® CLASSIC 135 CH	4	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123342
=HE03+DA01-GP11.WG02	STO LT Pump	=LA01-X102	=HE03+DA01-TA11	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=HE03+DA01-QN01.WG01	LT Mixing Valve Supply and Signal	=BA20+UC50-X10	=HE03+DA01-TF01	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=HE03+DA01-QN01.WG02	=	=HE03+DA01-QN01.MA01	=HE03+DA01-TF01	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-AC07-WG01	Ventilation (Upper) Signal	=JA01+DA01-AC07	=LA01-P1-2	BUS CAN FD P	2	0,5 mm²		Lapp Group	UNITRONIC® BUS CAN FD P	2170278
								Lapp Group	UNITRONIC® BUS CAN FD P	2170278
=JA01+DA01-BL02-WG01	Process Drain Tank Level Signal	=JA01+DA01-BL01-XG01	=LA01-X110	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=JA01+DA01-BP01-WD01	Intake dP Sensor	=LA01-X123	=JA01+DA01-BP01	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BP02-WD01	In/Out dP Sensor	=LA01-X123	=JA01+DA01-BP02	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BQ01-WG01	H2 Sensor Ventlation Inlet Signal	=LA01-X103	=JA01+DA01-BQ01	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BQ02-WG01	H2 Sensor Ventlation Outlet A Signal	=LA01-X103	=JA01+DA01-BQ02	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BQ03-WG01	H2 Sensor Ventlation Outlet B Signal	=LA01-X103	=JA01+DA01-BQ03	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BQ04-WG01	Smoke Detector Ventlation Inlet Signal	=LA01-X104	=JA01+DA01-BQ04-X2	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BQ05-WG01	Smoke Detector Ventlation Outlet B Signal	=LA01-X104	=JA01+DA01-BQ05-X2	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BQ06-WG01	=	=LA01-X104	=JA01+DA01-BQ06-X2	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-BT01-WG01	Container Intake Air Temp	=JA01+DA01-BT01-XG01	=LA01-X124	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=JA01+DA01-BT02-WG01	Container Temp A	=JA01+DA01-BT02-XG01	=LA01-X124	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=JA01+DA01-BT03-WG01	Container Temp B	=JA01+DA01-BT03-XG01	=LA01-X124	PUR	4	0,34 mm²	10 m	IFM Electronic AS	ADOGH040VAT0025H04/3G/2D	EVC540
=JA01+DA01-BU01-WD01	Air Quality Sensor Supply	=LA01-X125	=JA01+DA01-BU01	ÖLFLEX® CLASSIC 110 CH	3	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
=JA01+DA01-BU01-WG02	Air Quality Sensor Signal	=LA01-X125	=JA01+DA01-BU01	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059
=JA01+DA01-EA01-WD01	LED Light strip EA01	=JA01+DA01-EA01-XD01		PUR	4	0,25 mm²	20 m			
			=LA01-X230							
=JA01+DA01-EA02-WD01	LED Light strip EA05	=JA01+DA01-EA02-XD01		PUR	4	0,25 mm²	20 m			
			=LA01-X230							
			=JA01+DA01-EA04-XD01							
=JA01+DA01-EA03-WD01	LED Light strip EA02	=JA01+DA01-EA03-XD01		PUR	4	0,25 mm²	20 m			
			=LA01-X230							
=JA01+DA01-EA04-WD01	LED Light strip EA07	=JA01+DA01-EA04-XD01		PUR	4	0,25 mm²	20 m			

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC20 | & D01

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable overview : =HE01+DA01-BT01-WG01 - =JA01+DA01-EA04-WD01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 170 / 255

0	1	2	3	4	5	6	7	8

Cable Overview / Cable Schedule

F10_001_Ballard

Cable Name	Function Text	Source (From)	Target (To)	Cable Type	All Conductors	Cross-Section [Unit]	Length [Unit]	Manufacturer	Type Number	Order Number
=JA01+DA01-EA05-WD01	LED Light strip EA04	=JA01+DA01-EA01-XD02	=JA01+DA01-EA05-XD01	PUR	4	0,25 mm²	6 m			
=JA01+DA01-EA06-WD01	LED Light strip EA06	=JA01+DA01-EA02-XD02	=JA01+DA01-EA06-XD01	PUR	4	0,25 mm²	6 m			
=JA01+DA01-EA07-WD01	=	=JA01+DA01-EA03-XD02	=JA01+DA01-EA07-XD01	PUR	4	0,25 mm²	6 m			
=JA01+DA01-EA08-WD01	LED Light strip EA08	=JA01+DA01-EA04-XD02	=JA01+DA01-EA08-XD01	PUR	4	0,25 mm²	6 m			
=JA01+DA01-EB01.WD01		=JA01+DA01-EB01-X1	=LA01-X13	ÖLFLEX® HEAT 180 MS	4	2,5 mm²		Lapp Group	ÖLFLEX® HEAT 180 MS	00466303
=JA01+DA01-EB01.WD02		=JA01+DA01-EB01-X1	=LA01-X14	ÖLFLEX® HEAT 180 MS	4	2,5 mm²		Lapp Group	ÖLFLEX® HEAT 180 MS	00466303
=JA01+DA01-EB01.WD03		=JA01+DA01-EB01-X1	=LA01-X15	ÖLFLEX® HEAT 180 MS	4	2,5 mm²		Lapp Group	ÖLFLEX® HEAT 180 MS	00466303
=JA01+DA01-GQ06-WD01	Ventilation (Upper) Supply	=JA01+DA01-GQ06-WD01	=LA01-X11	0,6/1 kV	4	2,5 mm²		Murrelektronik	MQ15 Female 0° to open cable, 10m	7000-P8221-P361000
=JA01+DA01-GQ06-WG01	Ventilation (Upper) Signal	=LA01-P1-2	=JA01+DA01-GQ06-CON2	BUS CAN FD P	2	0,5 mm²		Lapp Group	UNITRONIC® BUS CAN FD P	2170278
								Murrelektronik	7000-14541-7981000	7000-14541-7981000
=JA01+DA01-GQ07-WD01	Ventilation (Lower) Supply	=JA01+DA01-GQ07-WD01	=LA01-X12	0,6/1 kV	4	2,5 mm²		Murrelektronik	MQ15 Female 0° to open cable, 10m	7000-P8221-P361000
=JA01+DA01-GQ07-WG01	Ventilation (Upper) Signal	=JA01+DA01-GQ06-CON2	=JA01+DA01-GQ07-CON2	BUS CAN FD P	2	0,5 mm²		Lapp Group	UNITRONIC® BUS CAN FD P	2170278
=JA01+DA01-GQ08-WD01		=LA01-X16	=JA01+DA01-AC08	ÖLFLEX® CLASSIC 135 CH	BK 0,6/1 kV	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	1123478
			=JA01+DA01-GQ08							
=JA01+DA01-GQ08-WD02	DCDC Cooling Fan A Power	=JA01+DA01-AC08	=JA01+DA01-GQ08	0,6/1 kV	4	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	1123478
=JA01+DA01-GQ08-WG01	DCDC Cooling Fan B Signal	=JA01+DA01-AC07	=JA01+DA01-GQ08		2	0,5 mm²		Lapp Group	UNITRONIC® BUS CAN FD P	2170278
=JA01+DA01-GQ09-WD01		=LA01-X17	=JA01+DA01-AC08	ÖLFLEX® CLASSIC 135 CH	BK 0,6/1 kV	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	1123478
			=JA01+DA01-GQ09							
=JA01+DA01-GQ09-WD02	DCDC Cooling Fan B Power	=JA01+DA01-AC08	=JA01+DA01-GQ09	0,6/1 kV	4	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	1123478
=JA01+DA01-GQ09-WG01	DCDC Cooling Fan A Signal	=JA01+DA01-AC07	=JA01+DA01-GQ09		2	0,5 mm²		Lapp Group	UNITRONIC® BUS CAN FD P	2170278
=JA01+DA01-QM01-WD01	Ventilation Intake Louvre 1	=JA01+DA01-AC01	=LA01-X121	ÖLFLEX® CLASSIC 135 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
=JA01+DA01-QM02-WD01	Ventilation Intake Louvre 2	=JA01+DA01-AC02	=LA01-X121	ÖLFLEX® CLASSIC 135 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
=JA01+DA01-QM03-WD01	Ventilation exhaust Louvre A1	=JA01+DA01-AC03	=LA01-X122	ÖLFLEX® CLASSIC 135 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
=JA01+DA01-QM04-WD01	Ventilation exhaust Louvre A2	=JA01+DA01-AC04	=LA01-X122	ÖLFLEX® CLASSIC 135 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
=JA01+DA01-QM05-WD01	Ventilation exhaust Louvre B1	=JA01+DA01-AC05	=LA01-X122	ÖLFLEX® CLASSIC 135 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
			=BA20+UC50-X11					Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
=JA01+DA01-QM06-WD01	Ventilation exhaust Louvre B2	=JA01+DA01-AC06	=LA01-X122	ÖLFLEX® CLASSIC 135 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
			=BA20+UC50-X11					Lapp Group	ÖLFLEX® CLASSIC 135 CH	1123270
=JA01+DA01-SG01-WG01		=LA01-X230	=JA01+DA01-SG01	ÖLFLEX® CLASSIC 110 CH	3	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035056
=LA01+DA01-CA30-WD01	Battery supply RB30	=LA01+DA01-CA30	=LA01-RB30	ÖLFLEX CLASSIC 100 H	3G	2,5 mm²		Lapp Group	ÖLFLEX CLASSIC 100 H	0014 103
=LA01+DA01-CA30-WG01	Temp sensor CA30	=LA01+DA01-CA30	=LA01-RB30	ÖLFLEX® CLASSIC 130 H	3G	1 mm		Lapp Group	ÖLFLEX® CLASSIC 130 H	1123067
=LA01+DA01-RB01-WD01	Battery Supply RB01	=LA01+DA01-CA01	=LA01-RB01	ÖLFLEX® CLASSIC 110 CH	3	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035089
=LA01+DA01-RB01-WG01	Temp Sensor CA01	=LA01+DA01-CA01	=LA01-RB01	UNITRONIC®-FD CP (TP) PLUS	4	0,5 mm²		Lapp Group	UNITRONIC®-FD CP (TP) PLUS	0030937
=LA01+DA01-RB02-WD01	Battery Supply RB02	=LA01+DA01-CA02	=LA01-RB02	ÖLFLEX® CLASSIC 110 CH	3	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035089
=LA01+DA01-RB02-WG01	Temp Sensor CA02	=LA01+DA01-CA02	=LA01-RB02	UNITRONIC®-FD CP (TP) PLUS	4	0,5 mm²		Lapp Group	UNITRONIC®-FD CP (TP) PLUS	0030937
=LA01+DA01-RB03-WD01	Battery Supply RB03	=LA01+DA01-CA03	=LA01-RB03	ÖLFLEX® CLASSIC 110 CH	3	2,5 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035089
=LA01+DA01-RB03-WG01	Temp Sensor CA03	=LA01+DA01-CA03	=LA01-RB03	UNITRONIC®-FD CP (TP) PLUS	4	0,5 mm²		Lapp Group	UNITRONIC®-FD CP (TP) PLUS	0030937
=LA01-EA01-WD01		=LA01-X23	=LA01-EA1	YAKY	3	16 AWG	3 m	Rittal	SZ.2500500	2500500
		=LA01-FC21								
		=LA01-TB30								
=LA01-KE01-WG01		=LA01-KE01-Slot1	=LA01-KE02-Slot1					Lapp Group	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	2172363
=LA01-KE02-WG01		=LA01-KE02-Slot1	=LA01-KE03-Slot1					Lapp Group	IE-6A-RJ45-L0.5-P-4-26-7-RJ45	2172363
=LA01-KE03-WG01		=HA01+DA02-XT10	=LA01-KE03-Slot1	Profinet 4pair cabling Cat.6A FRNC flexi	8	23 mm²		Lapp Group	Profinet 4pair cabling Cat.6A FRNC flexible	2170931
=LA01-KF200-WG01	STP			Cat.6						
=LA01-KF200-WG02	=	=LA01-KF200	=LA01-KF210	Cat.6						
=LA01-KF200-WG15	=	=HA01+DA02-XT11	=LA01-KF200	Cat.6	4x2					

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC20 | & D01

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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DRAWING		REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable overview : =JA01+DA01-EA05-WD01 - =LA01+UC20-KF200-WG15		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 170.a /

FRM5103656/0B

0	1	2	3	4	5	6	7	8

Cable Overview / Cable Schedule

F10_001_Ballard

Cable Name	Function Text	Source (From)	Target (To)	Cable Type	All Conductors	Cross-Section [Unit]	Length [Unit]	Manufacturer	Type Number	Order Number
=LA01-KF200-WG16	STP	=LA01-KF200	=LA01-KF201	Cat.6	4x2					
=LA01-WD01	Supply UC20 MCU cabinet	=LA01-X01	=BA20+UC50-FC03	ÖLFLEX® CLASSIC 135 CH	BK 0,6/1 kV	16 mm²		Lapp Group	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	1123493
			=BA20+UC50-FC05							
=LB02+DA01-SG23-WG01	ESTOP Container Door	=LA01-X105	=LB02+DA01-SG23	ÖLFLEX® CLASSIC 110 CH	4	1 mm²		Lapp Group	ÖLFLEX® CLASSIC 110 CH	10035059

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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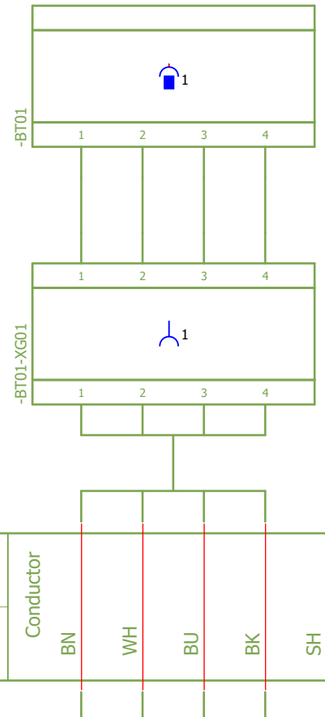
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DRAWING		REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable overview : =LA01+UC20-KF200-WG16 - =LB02+DA01-SG23-WG01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 170.b /

Cable connection diagram

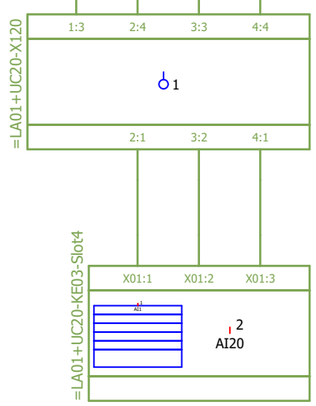
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PBL 29-Sep-25

Internal targets



=BA01+UC01-BT01-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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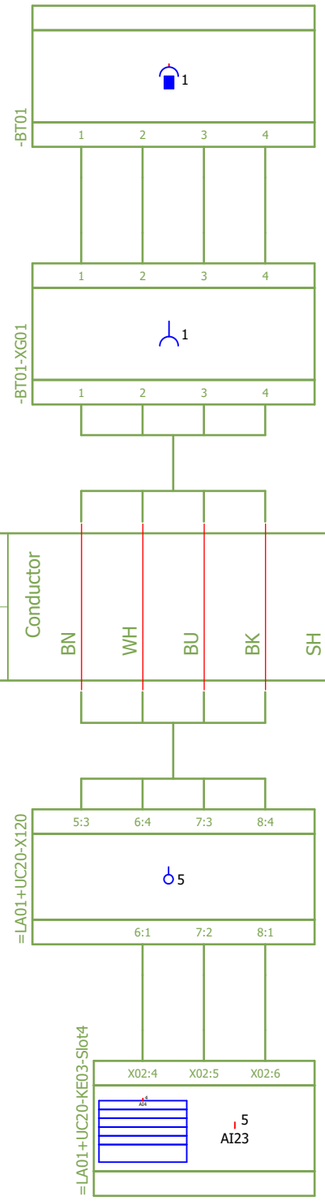
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =BA01+UC01-BT01-WG01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 173 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=BA01+UC02-BT01-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DESCRIPTION
DATE
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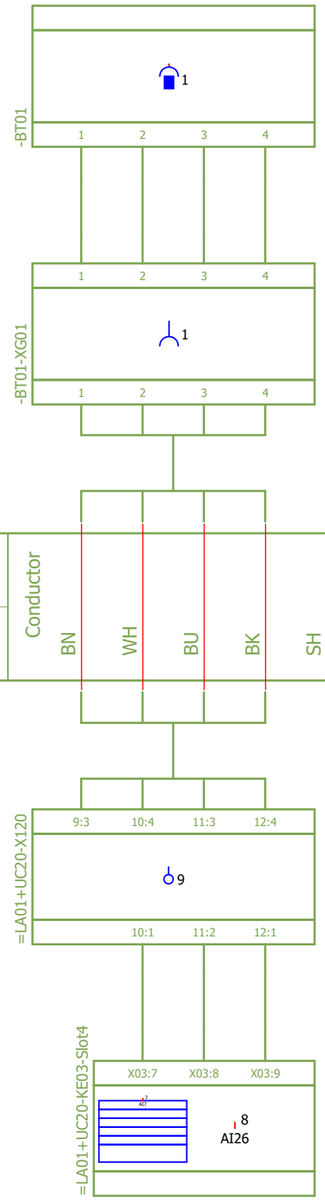
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Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=BA01+UC03-BT01-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets

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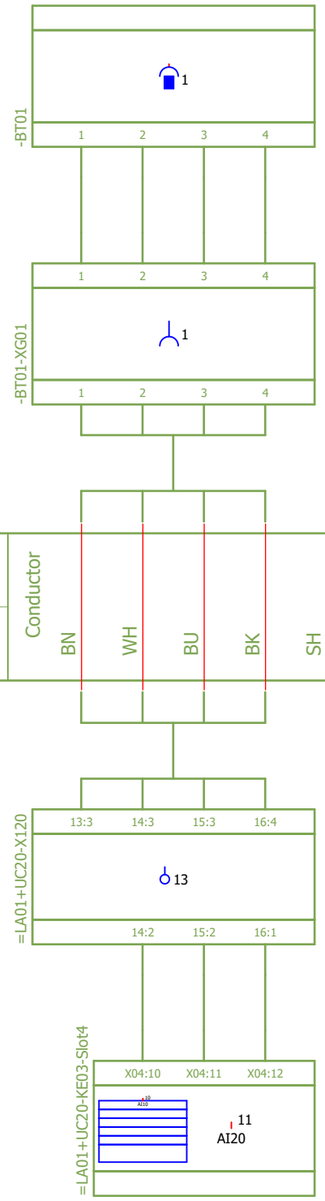
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FRM5103656/0B

Cable connection diagram

F07_001
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Internal targets



=BA02+UC04-BT01-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets

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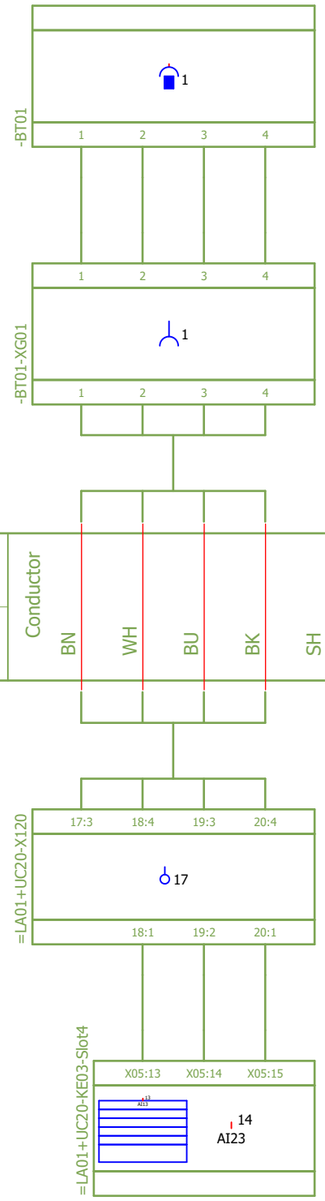
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Cable connection diagram

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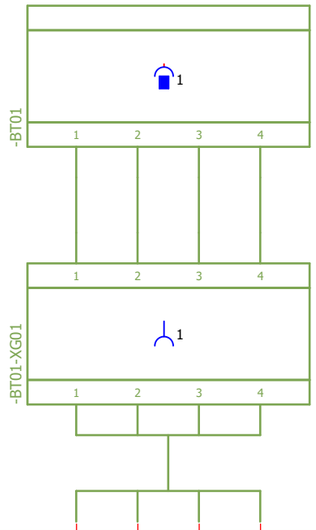
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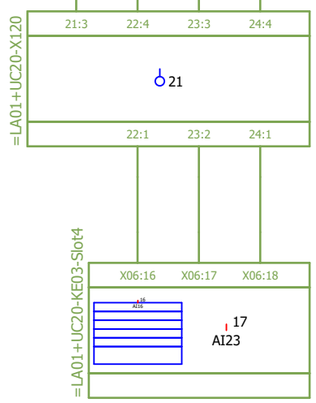
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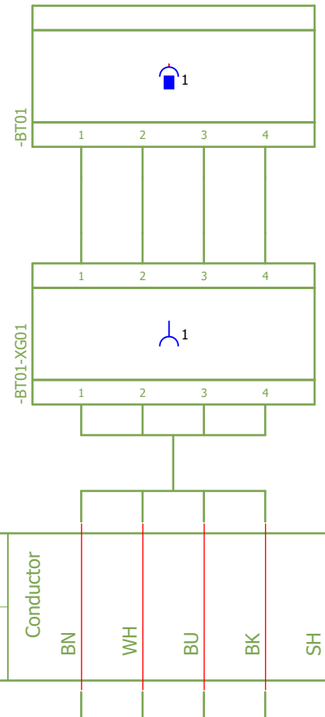
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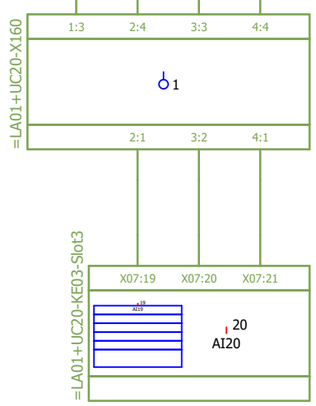
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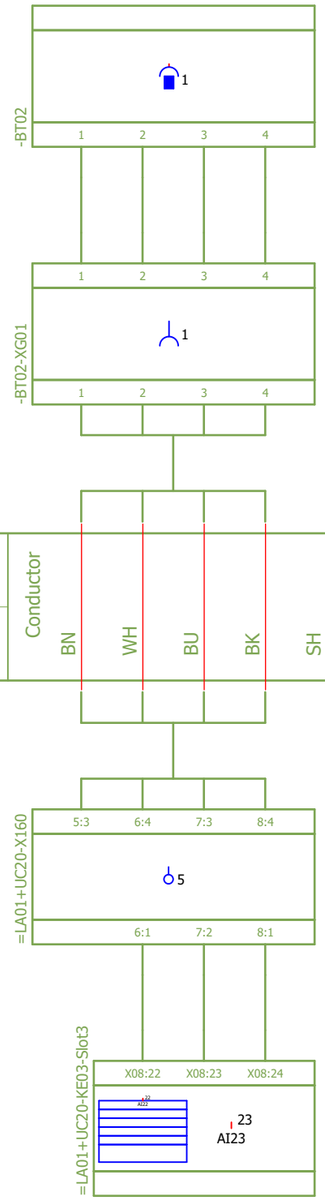
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Cable connection diagram

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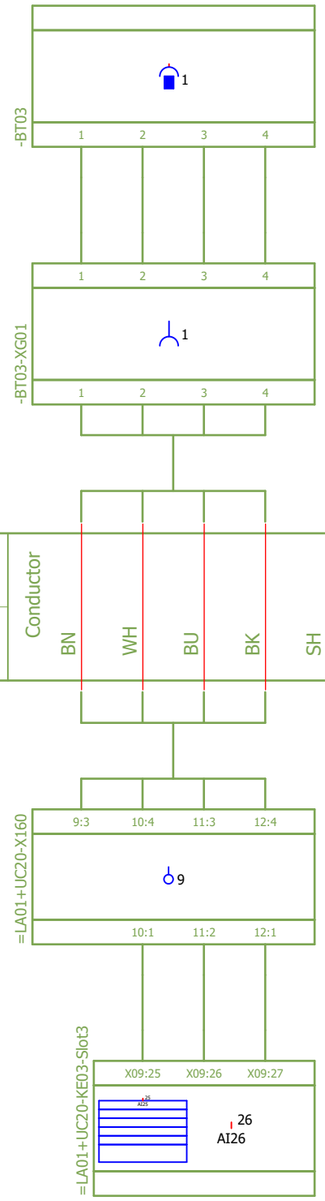
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Cable connection diagram

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Internal targets



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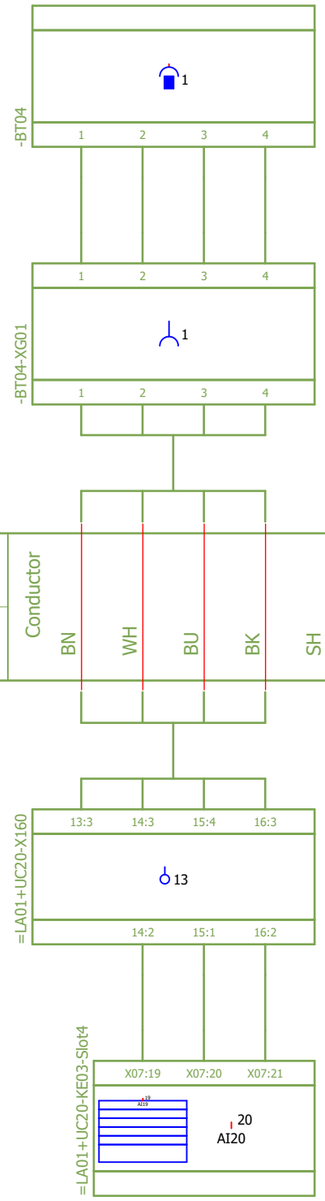
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Cable connection diagram

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Internal targets



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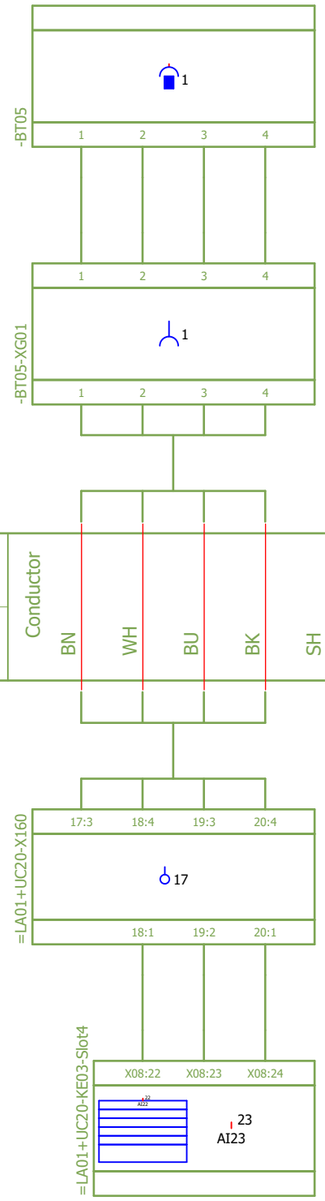
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Cable connection diagram

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External targets

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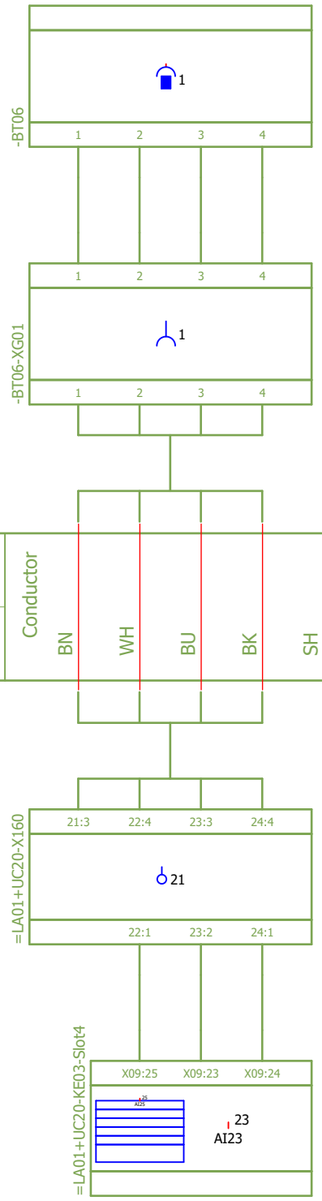
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Cable connection diagram

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Internal targets



External targets

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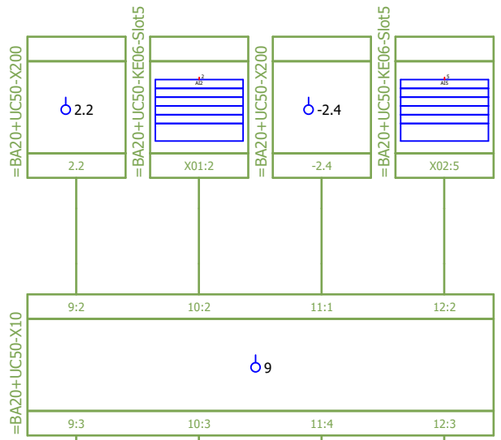
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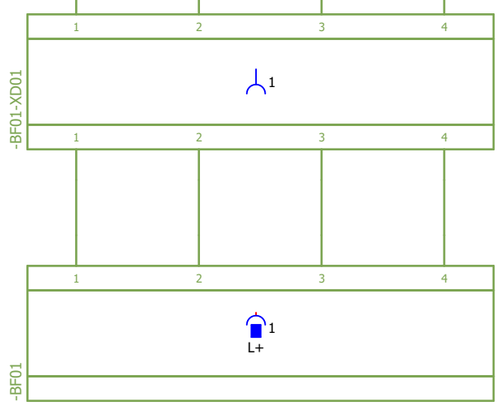
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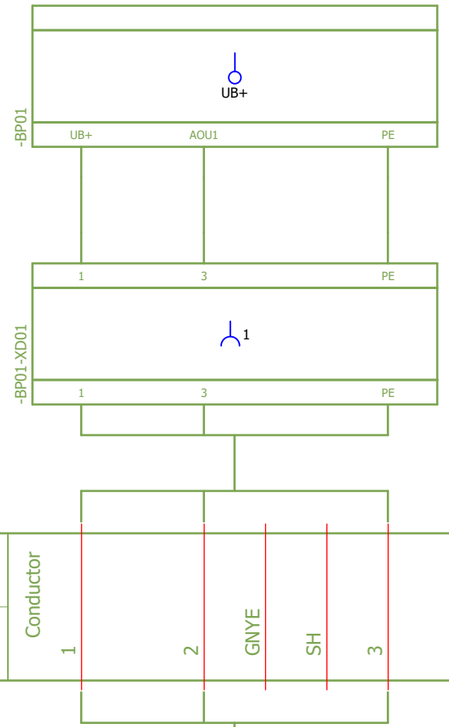
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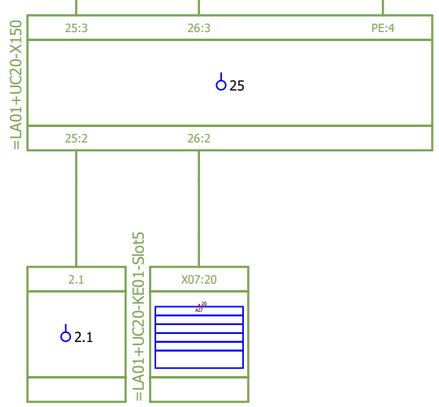
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Internal targets



=HE03+DA01-BP01-WG01	Conductor	1	2	GNYE	SH	3
ÖLFLEX® CLASSIC 110 CH						

External targets



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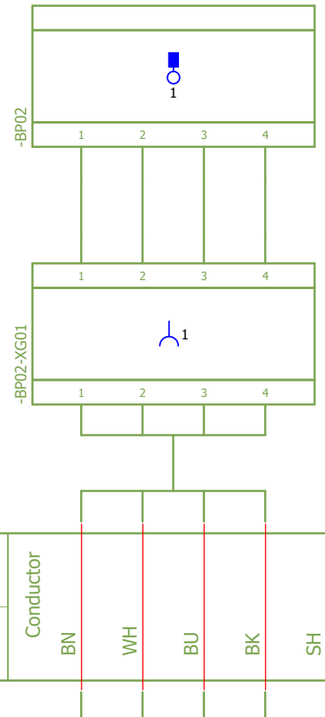
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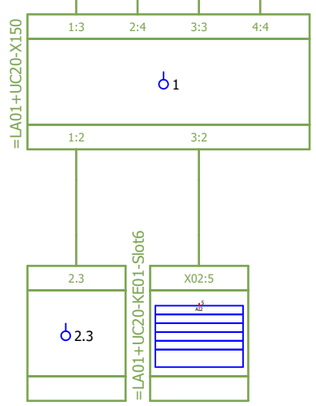
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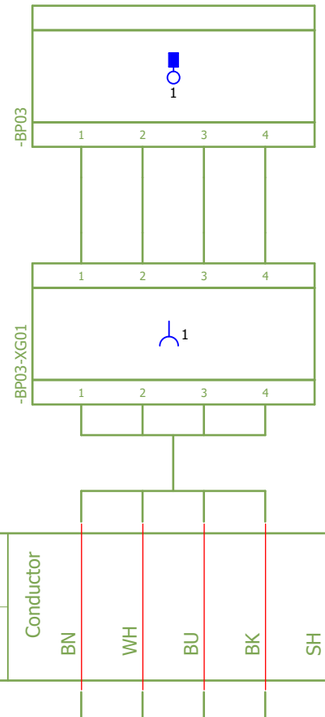
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SHEET TYPE/DESC	Cable-connection diagram =HE03+DA01-BP02-WG01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 187 / 255

FRM5103656/0B

Cable connection diagram

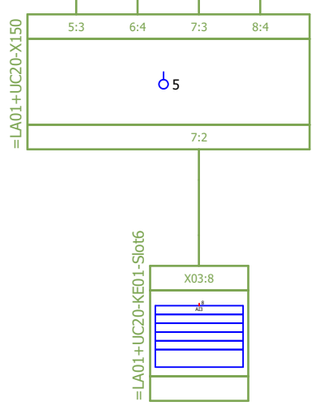
F07_001
PBL 29-Sep-25

Internal targets



=HE03+DA01-BP03-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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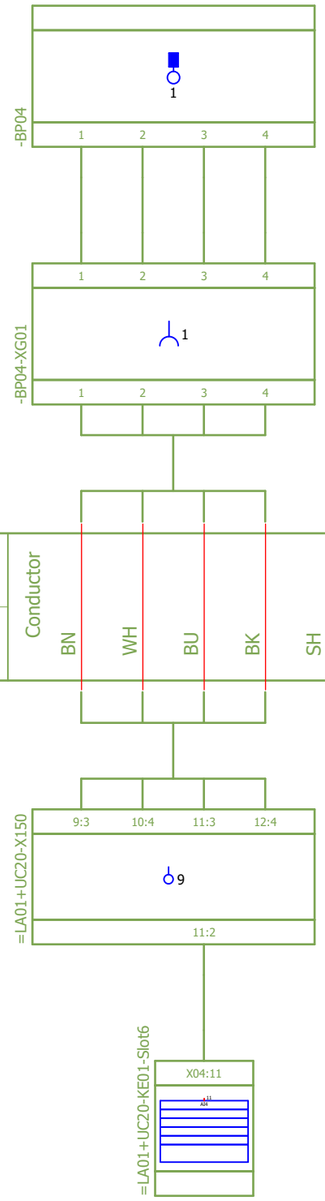
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =HE03+DA01-BP03-WG01		
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Cable connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
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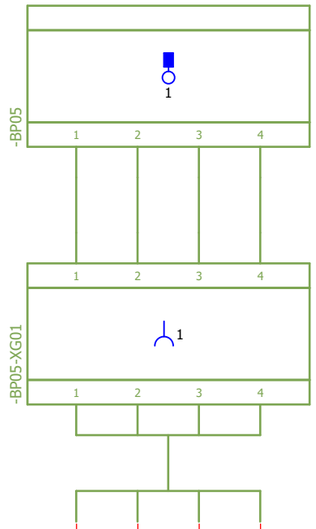
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FRM5103656/0B

Cable connection diagram

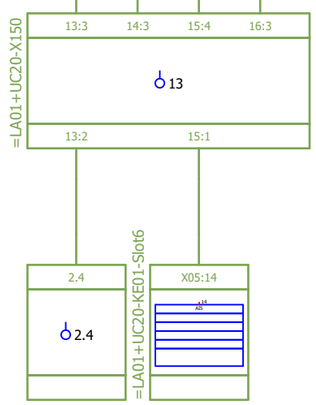
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Internal targets



=HE03+DA01-BP05-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets



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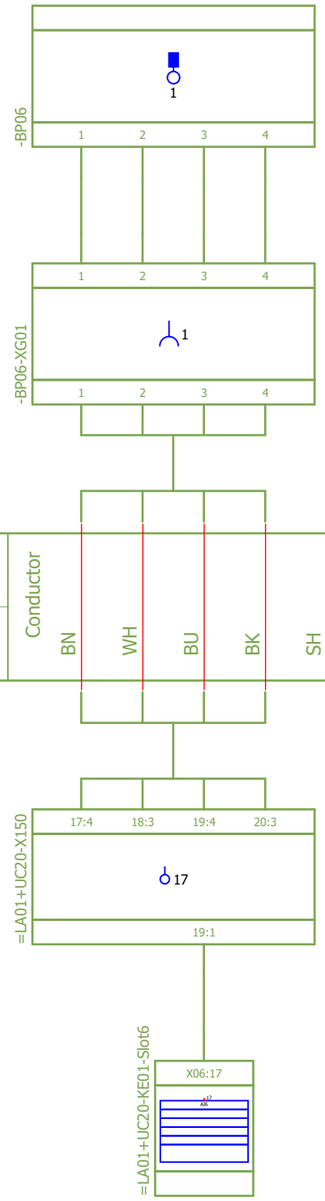
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



External targets

=HE03+DA01-BP06-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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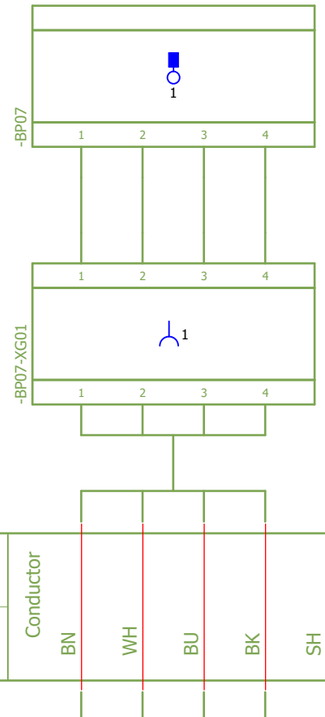
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Cable connection diagram

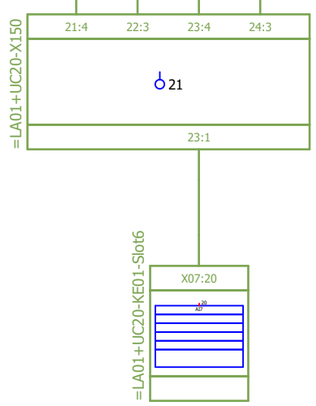
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PBL 29-Sep-25

Internal targets



=HE03+DA01-BP07-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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EPLAN Project Pages	627		
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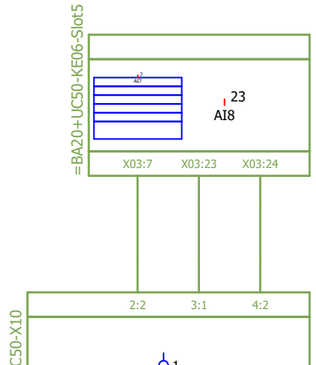
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Cable connection diagram

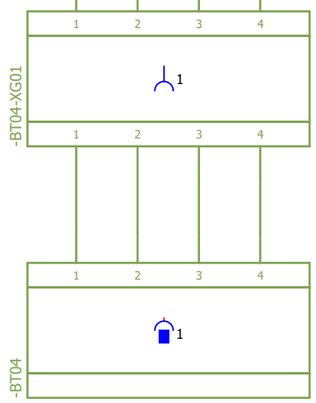
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PBL 29-Sep-25

Internal targets



=HE03+DA01-BT04-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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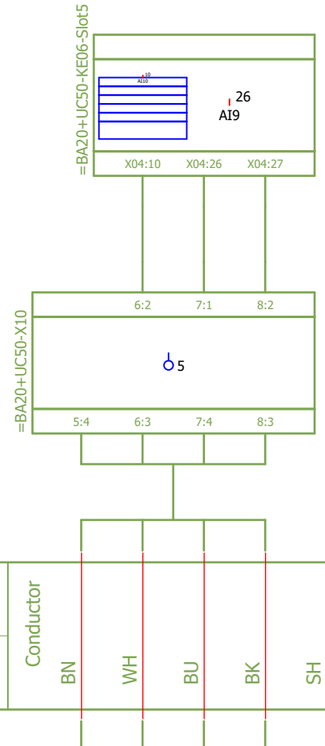
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 193 / 255

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Cable connection diagram

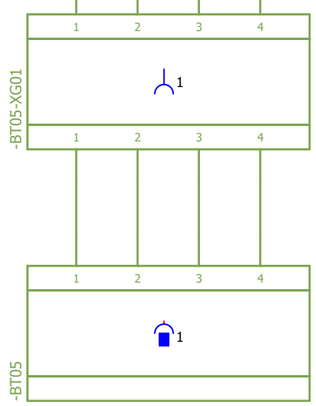
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PBL 29-Sep-25

Internal targets



=HE03+DA01-BT05-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets



Reference Item Number	Ballard Part # TBD		
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DRAWING TITLE			
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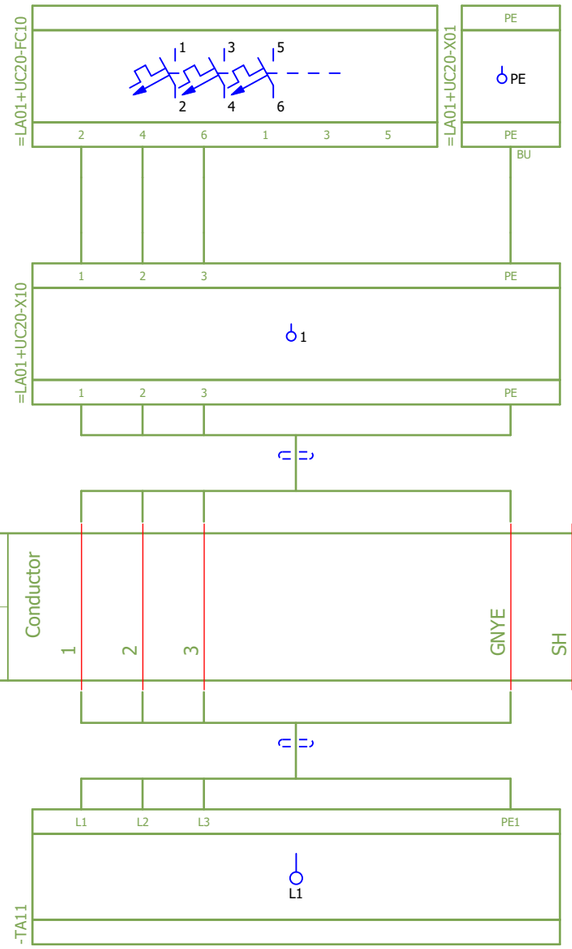
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0	1	2	3	4	5	6	7	8

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=HE03+DA01-GP11.WD01	Conductor	1	2	3	GNYE	SH
ÖLFLEX® CLASSIC 135 CH						

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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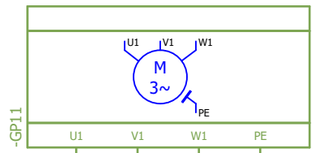
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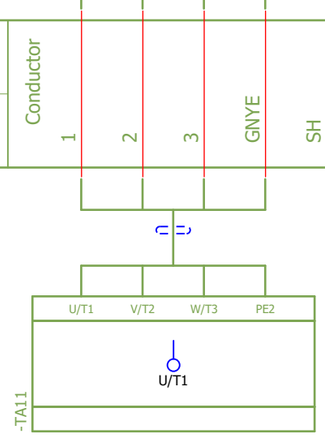
Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=HE03+DA01-GP11.WD02	Conductor	1	2	3	GNYE	SH
ÖLFLEX® CLASSIC 135 CH						



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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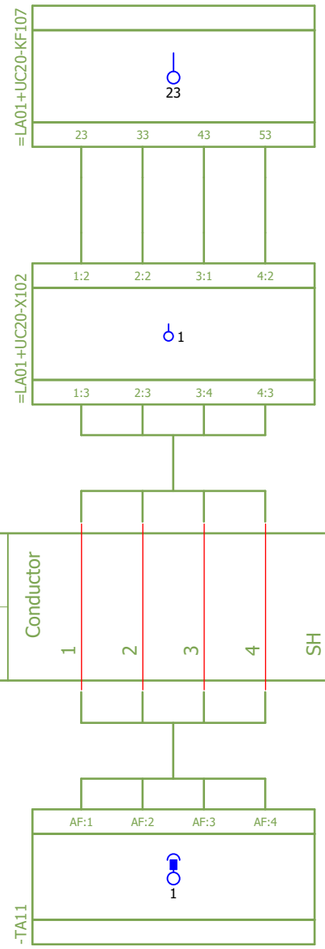
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Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=HE03+DA01-GP11.WG02	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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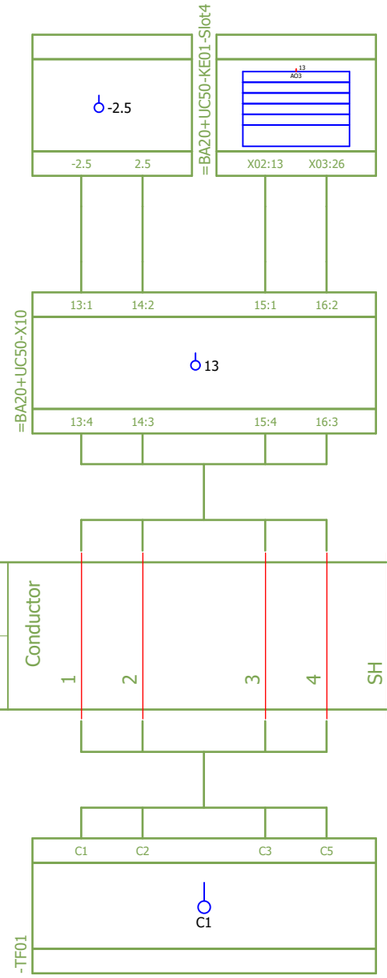
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Cable connection diagram

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Internal targets



=HE03+DA01-QN01.WG01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						

External targets

Reference Item Number	Ballard Part # TBD		
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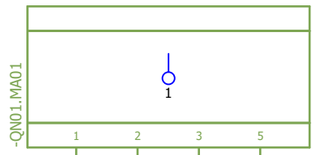
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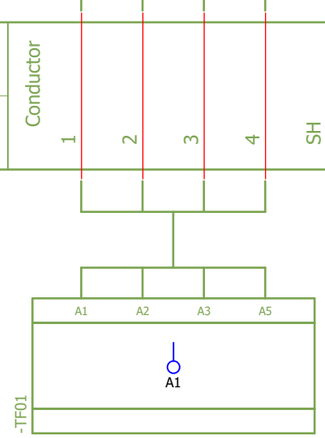
Cable connection diagram

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Internal targets



=HE03+DA01-QN01.WG02	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						



External targets

Reference Item Number	Ballard Part # TBD		
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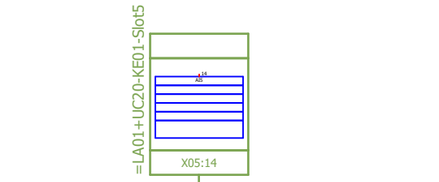
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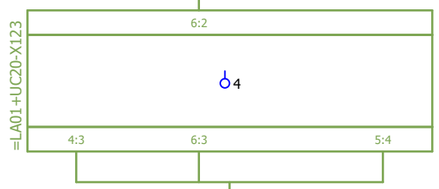
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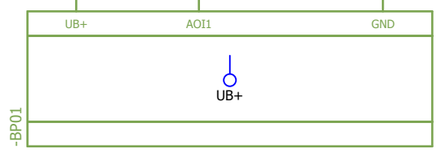
F07_001
PBL 29-Sep-25

Internal targets





=JA01+DA01-BP01-WD01	Conductor	1	2	3	4	SH	2
ÖLFLEX® CLASSIC 110 CH							



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

REVISION INFORMATION
DESCRIPTION
DATE
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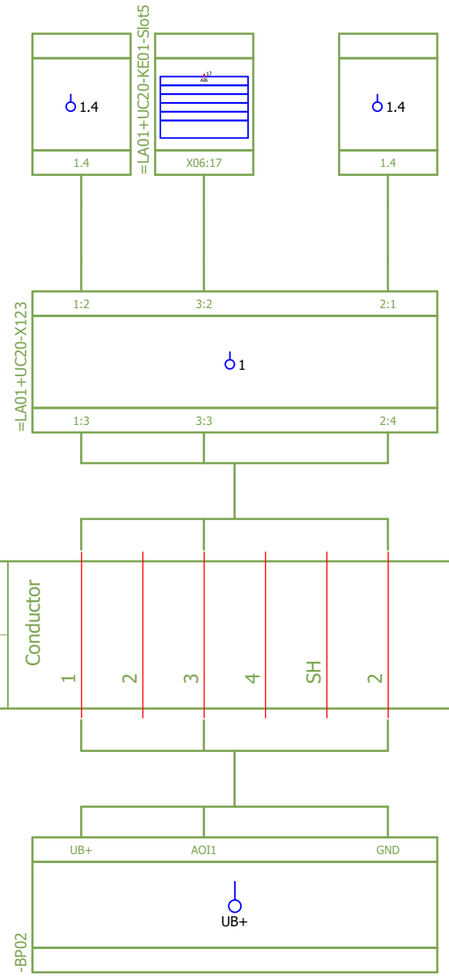
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BP02-WD01	Conductor	1	2	3	4	SH	2
ÖLFLEX® CLASSIC 110 CH							

External targets

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EPLAN Project Pages	627		
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DRAWING TITLE			
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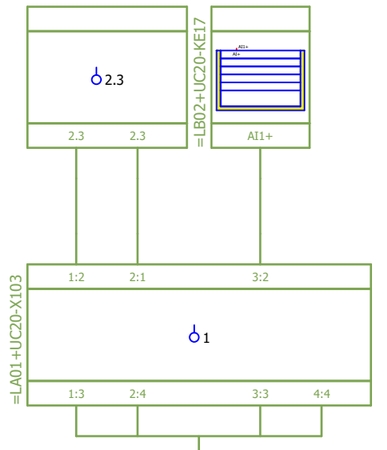
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FRM5103656/0B

Cable connection diagram

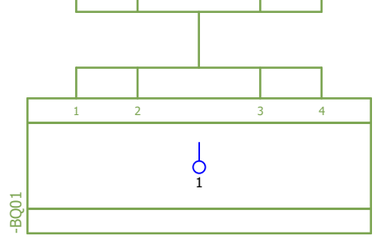
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BQ01-WG01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						

External targets



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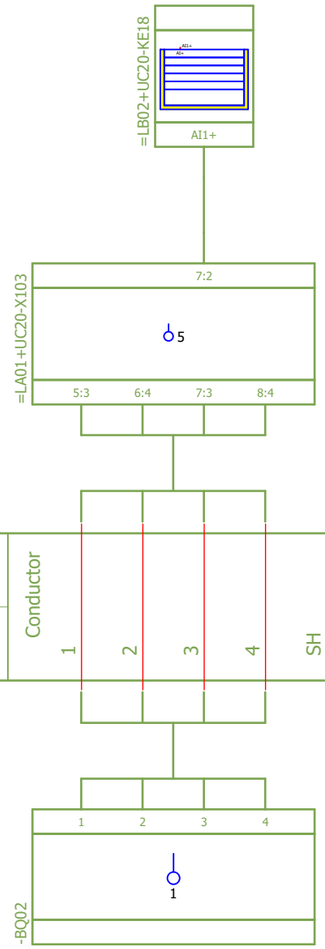
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BQ02-WG01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						

External targets

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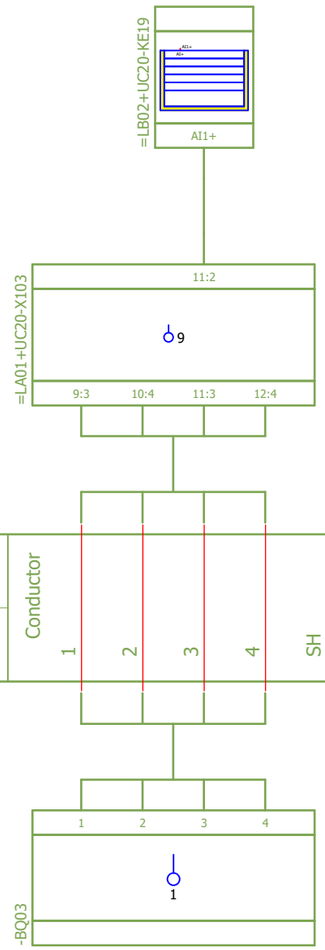
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BQ03-WG01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						

External targets

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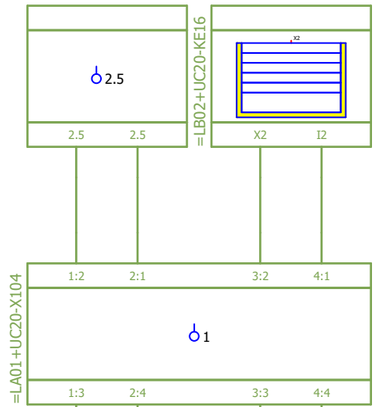
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FRM5103656/0B

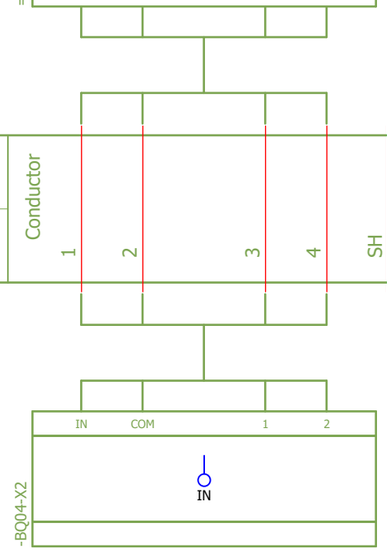
Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BQ04-WG01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						



External targets

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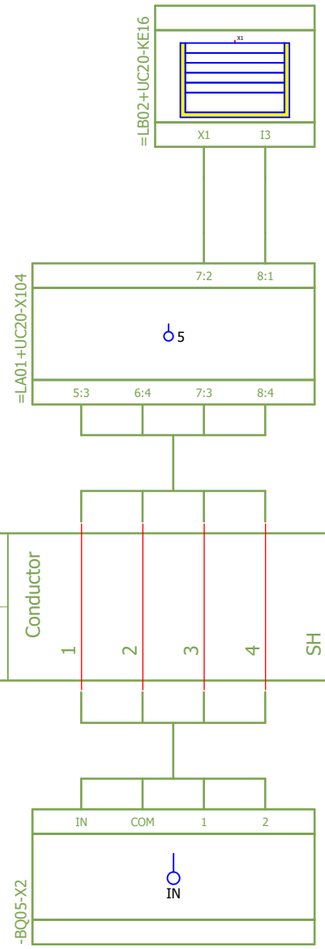
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BQ05-WG01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						

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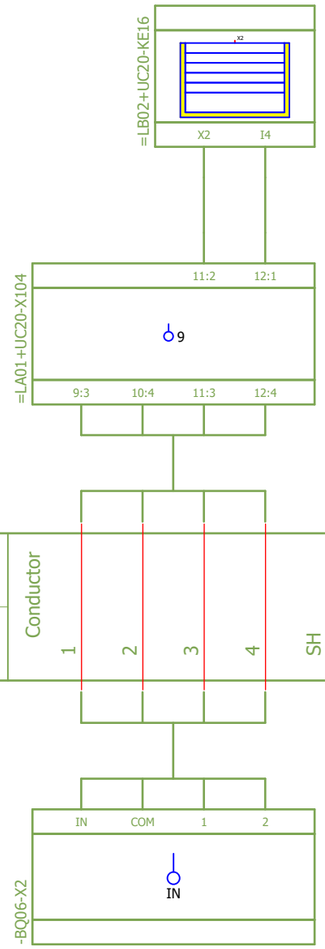
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



External targets

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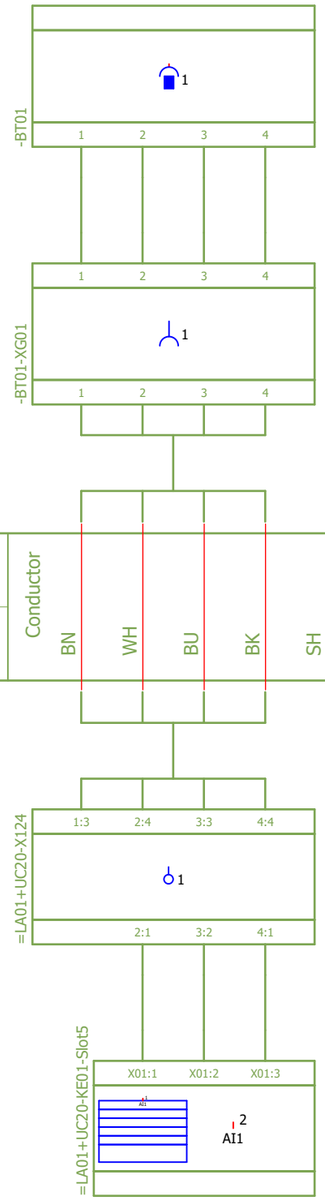
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



External targets

=JA01+DA01-BT01-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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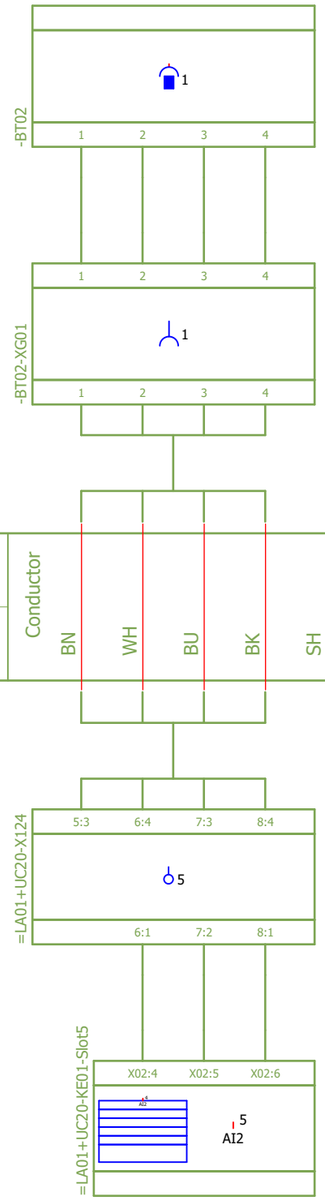
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BT02-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets

Reference Item Number	Ballard Part # TBD		
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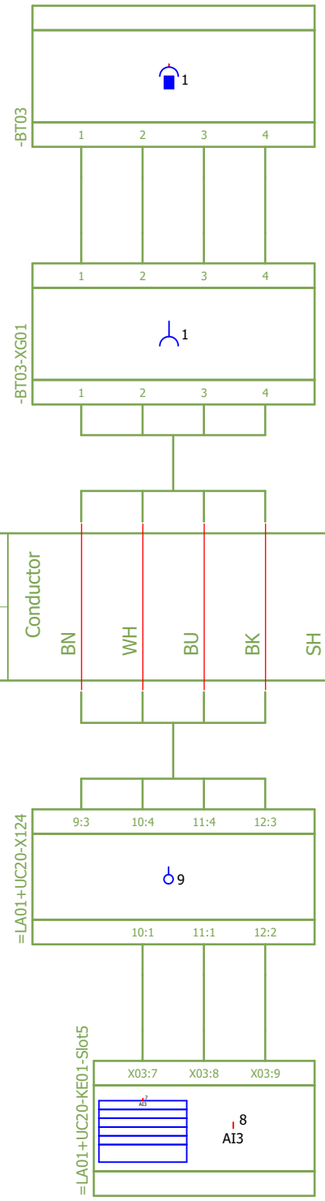
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-BT03-WG01	Conductor	BN	WH	BU	BK	SH
PUR						

External targets

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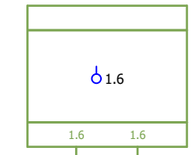
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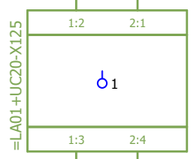
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Cable connection diagram

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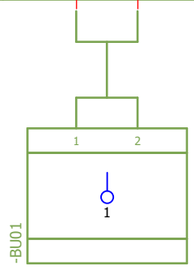
Internal targets





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=JA01+DA01-BU01-WD01	Conductor	1	2	GNYE	SH
ÖLFLEX® CLASSIC 110 CH					



-BU01

External targets

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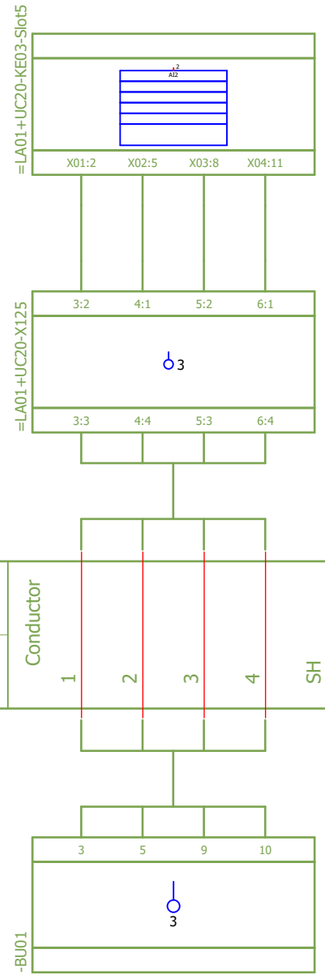
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FRM5103656/0B

Cable connection diagram

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Internal targets



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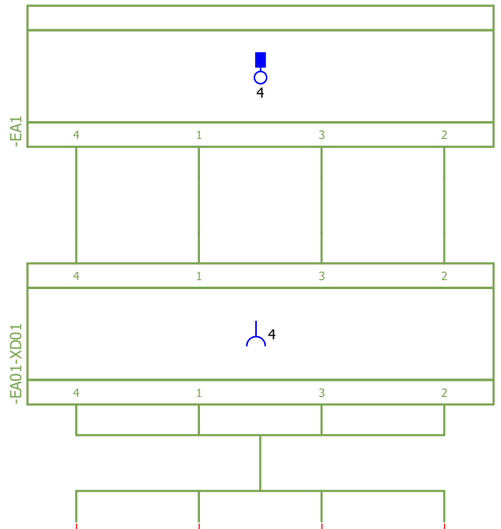
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FRM5103656/0B

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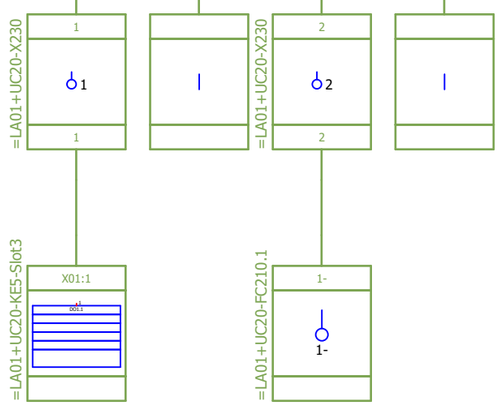
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Internal targets



=JA01+DA01-EA01-WD01	Conductor	BK	BN	BU	WH
PUR					

External targets



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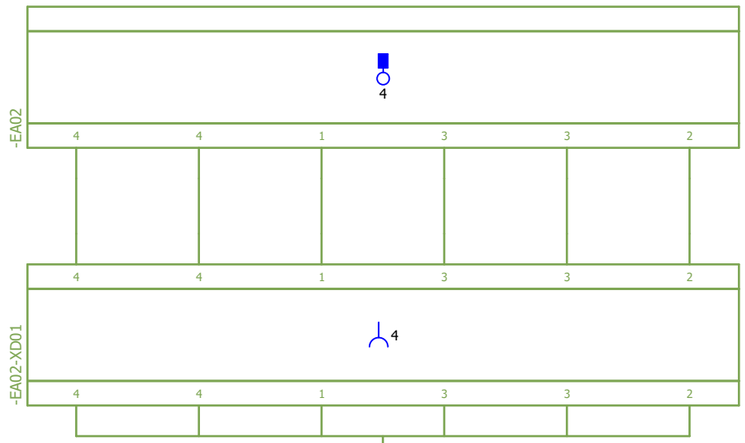
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 213 / 255

FRM5103656/0B

Cable connection diagram

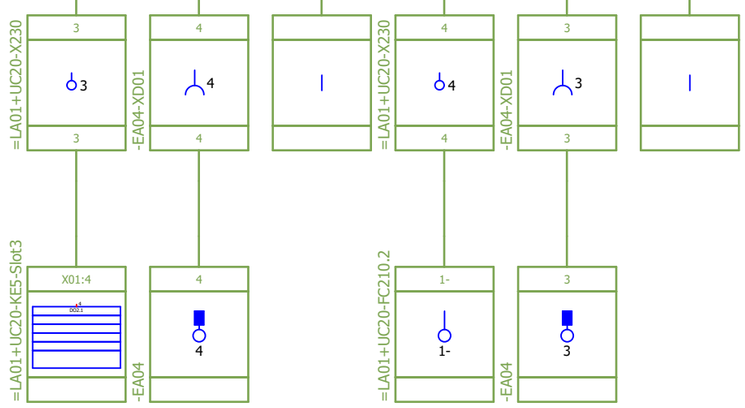
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-EA02-WD01	Conductor	BK	BK	BN	BU	BU	WH
PUR							

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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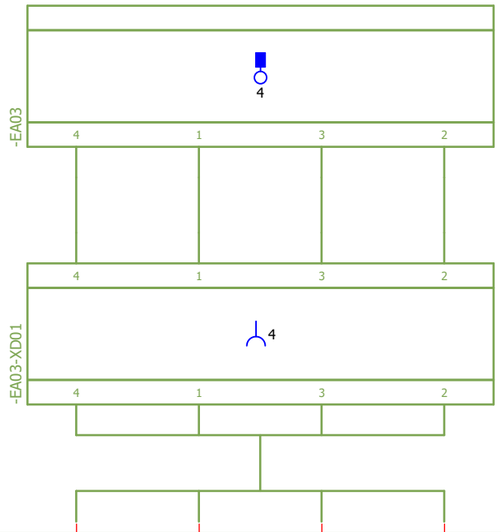
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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =JA01+DA01-EA02-WD01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 214 / 255

Cable connection diagram

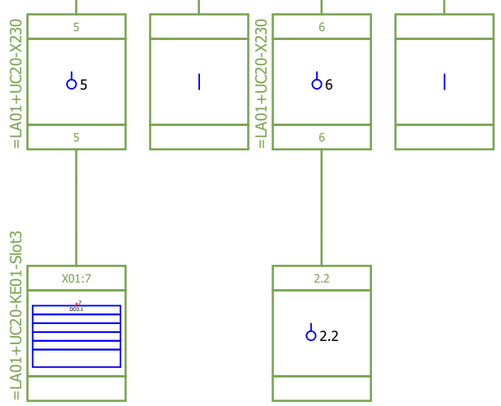
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PBL 29-Sep-25

Internal targets



=JA01+DA01-EA03-WD01	Conductor	BK	BN	BU	WH
PUR					

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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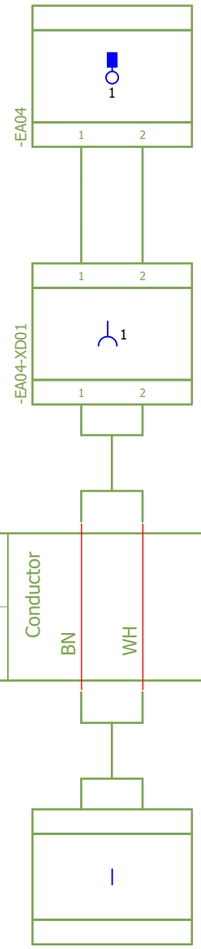
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 215 / 255

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-EA04-WD01	Conductor	
PUR	BN	WH

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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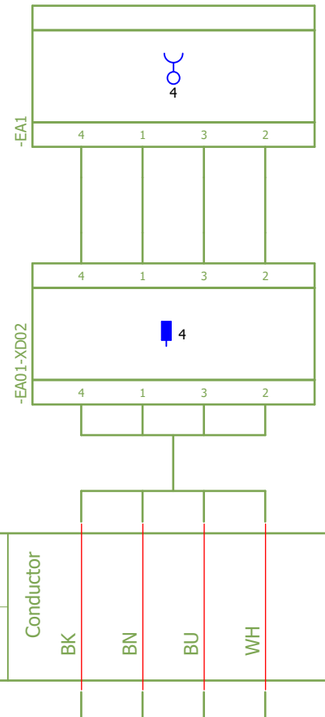
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DRAWING TITLE			
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Cable connection diagram

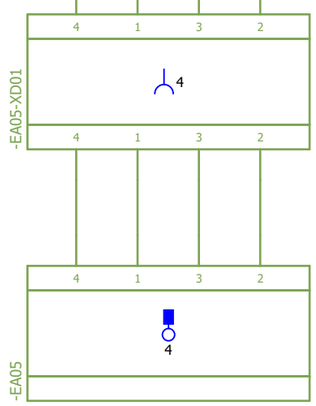
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-EA05-WD01	Conductor	BK	BN	BU	WH
PUR					

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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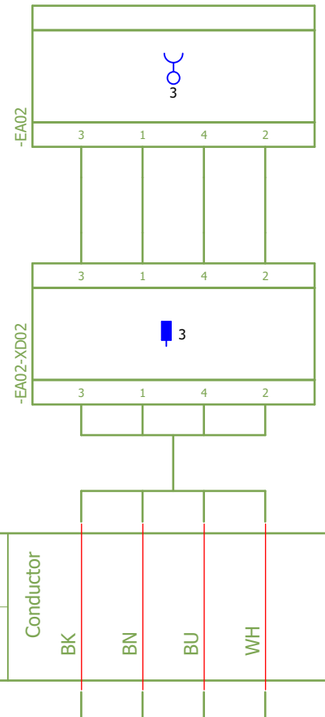
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 217 / 255

FRM5103656/0B

Cable connection diagram

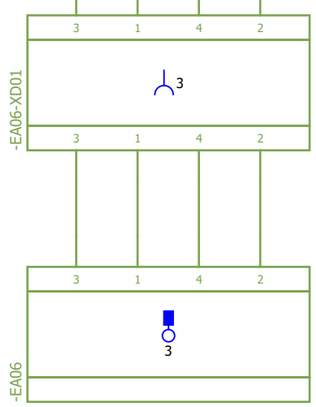
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-EA06-WD01	Conductor	BK	BN	BU	WH
PUR					

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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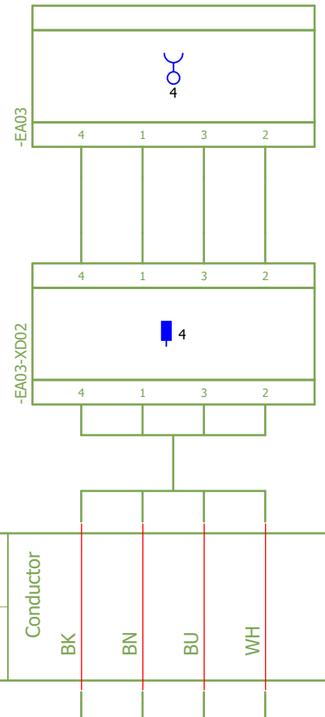
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 218 / 255

FRM5103656/0B

Cable connection diagram

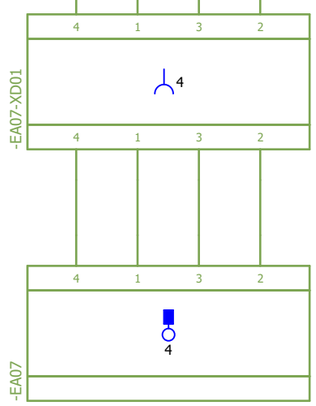
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-EA07-WD01	Conductor	BK	BN	BU	WH
PUR					

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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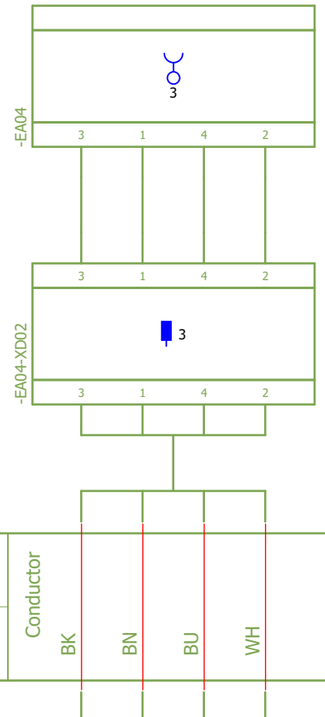
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 219 / 255

FRM5103656/0B

Cable connection diagram

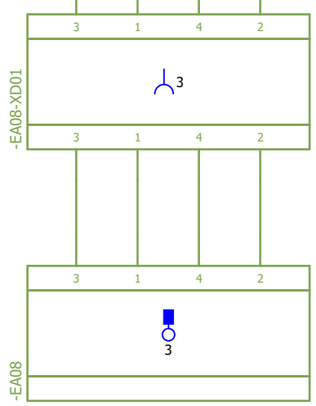
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-EA08-WD01	Conductor	BK	BN	BU	WH
PUR					

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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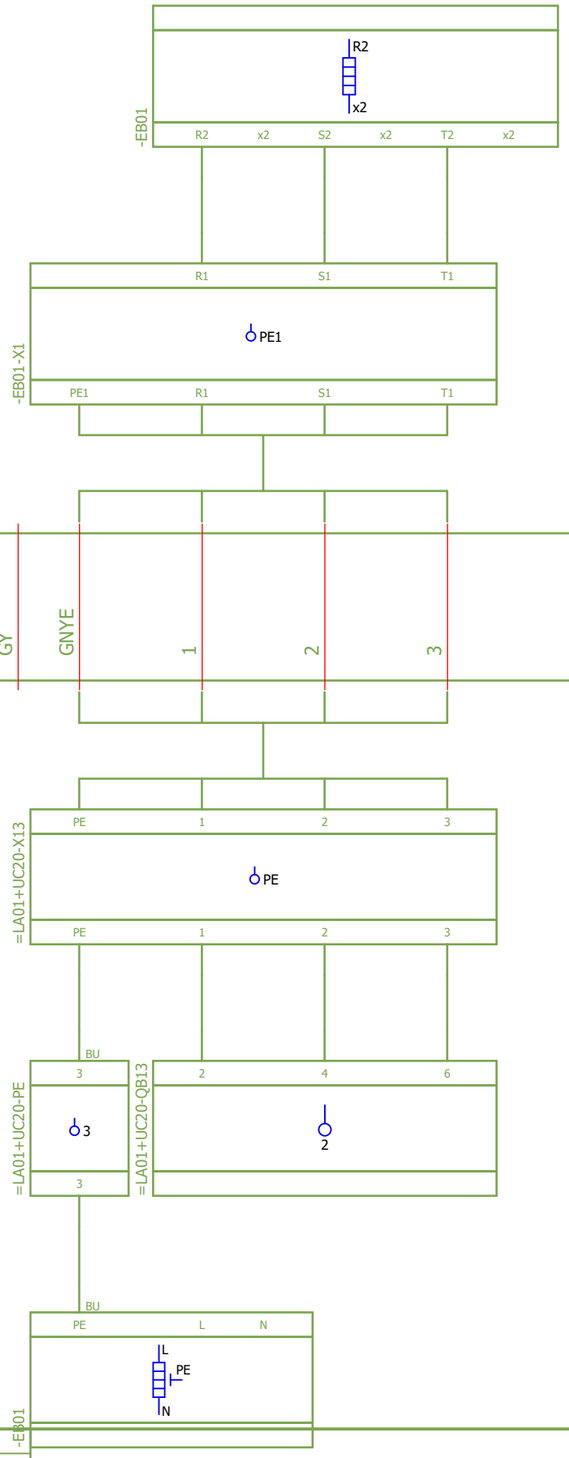
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 220 / 255

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DATE	29-Sep-25

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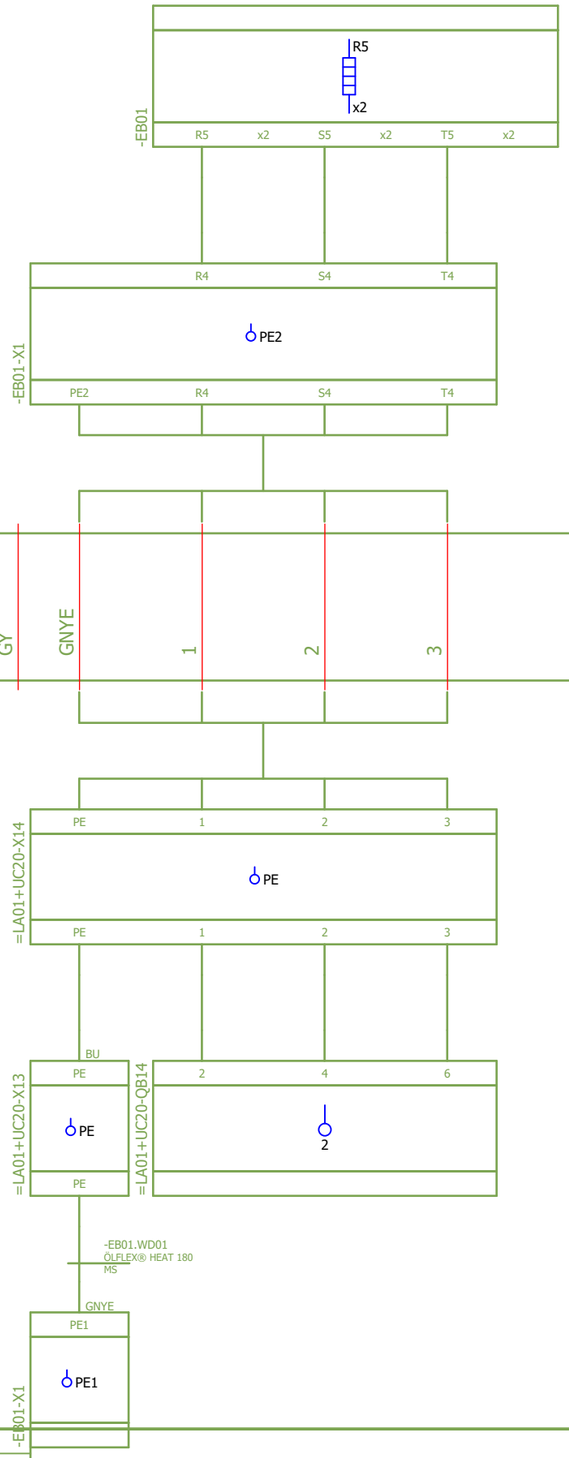
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 221 / 255

FRM5103656/0B

Cable connection diagram

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PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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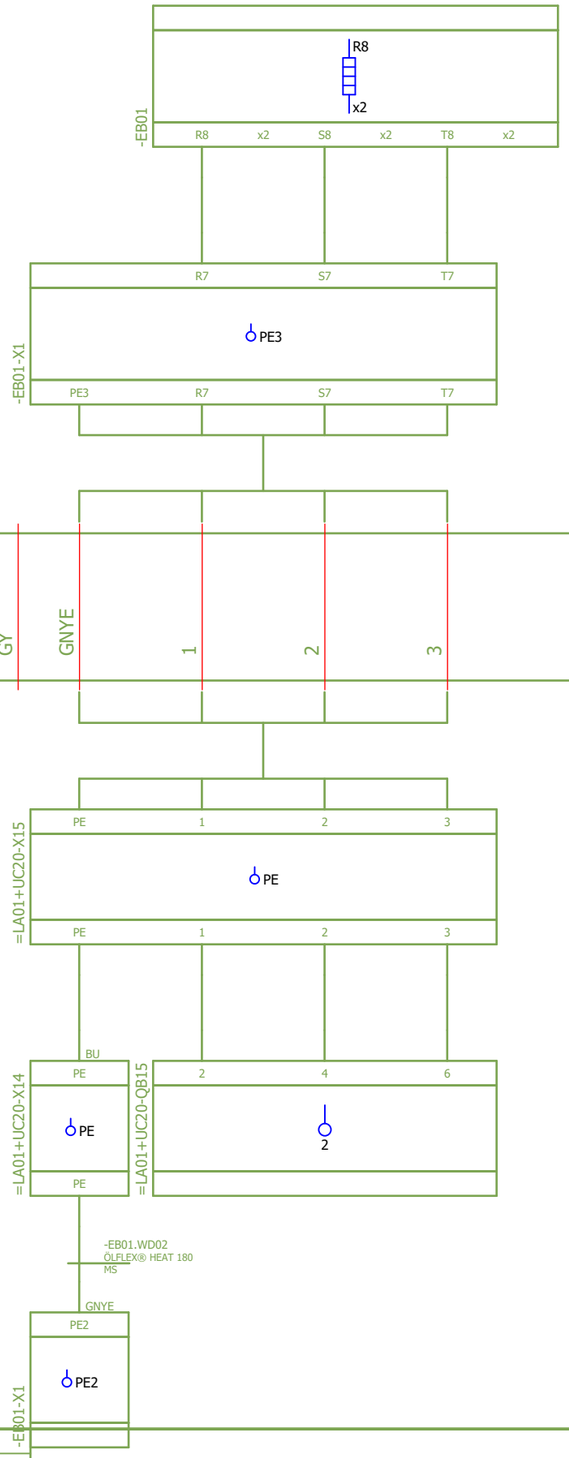
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FRM5103656/0B

Cable connection diagram

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PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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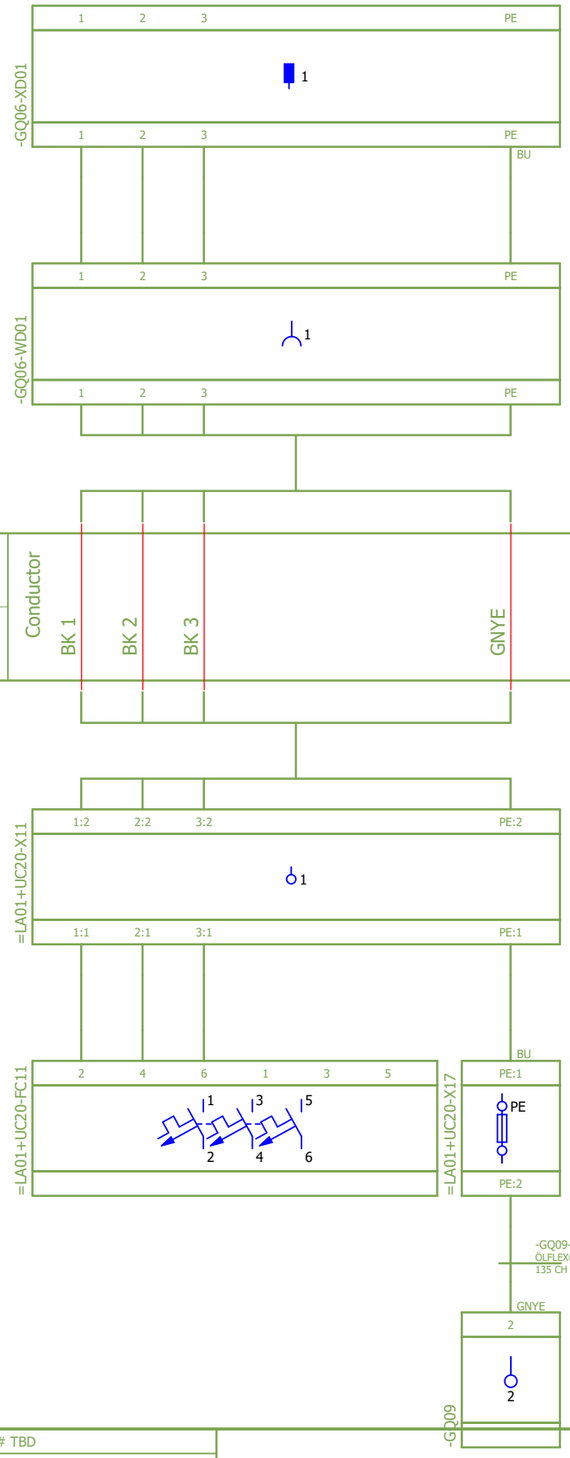
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FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ06-WD01	Conductor	BK 1	BK 2	BK 3	GNYE
0,6/1 kV					

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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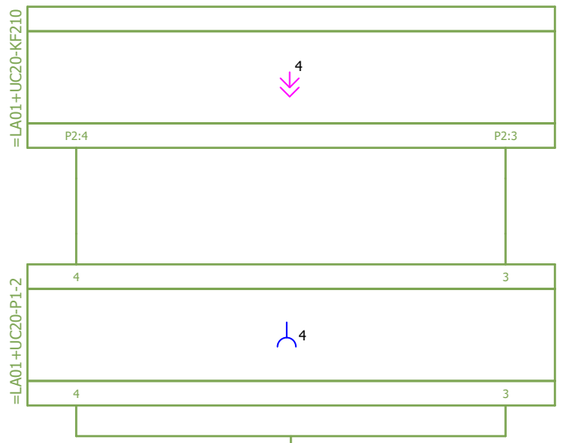
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DRAWING TITLE			
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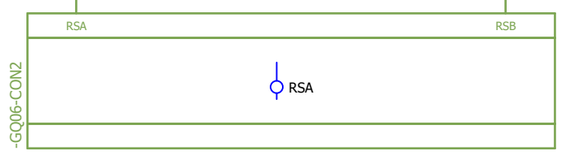
Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ06-WG01	Conductor	WH	BN	SH	WH	BU	YE	OG	OR
BUS CAN FD P									



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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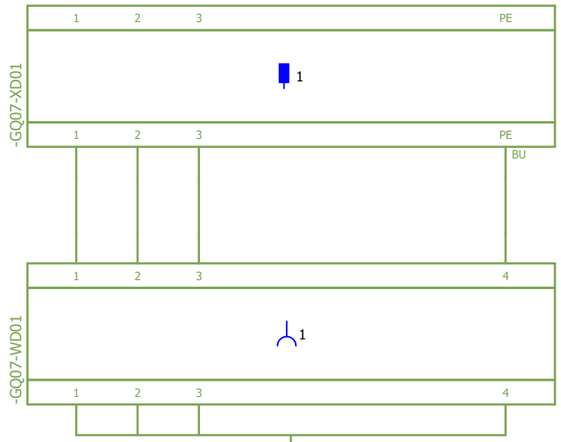
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DRAWING TITLE			
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FRM5103656/0B

Cable connection diagram

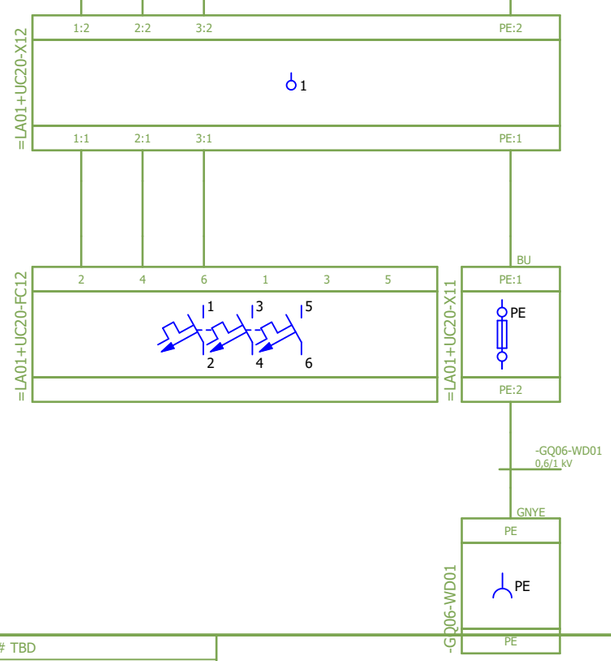
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ07-WD01	Conductor	BK 1	BK 2	BK 3	GNYE
0,6/1 kV					

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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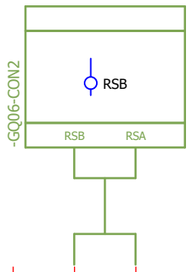
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 226 / 255

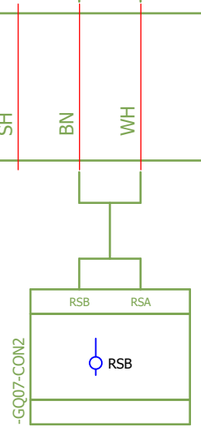
Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ07-WG01	Conductor	WH	BN	SH	BN	WH
BUS CAN FD P						



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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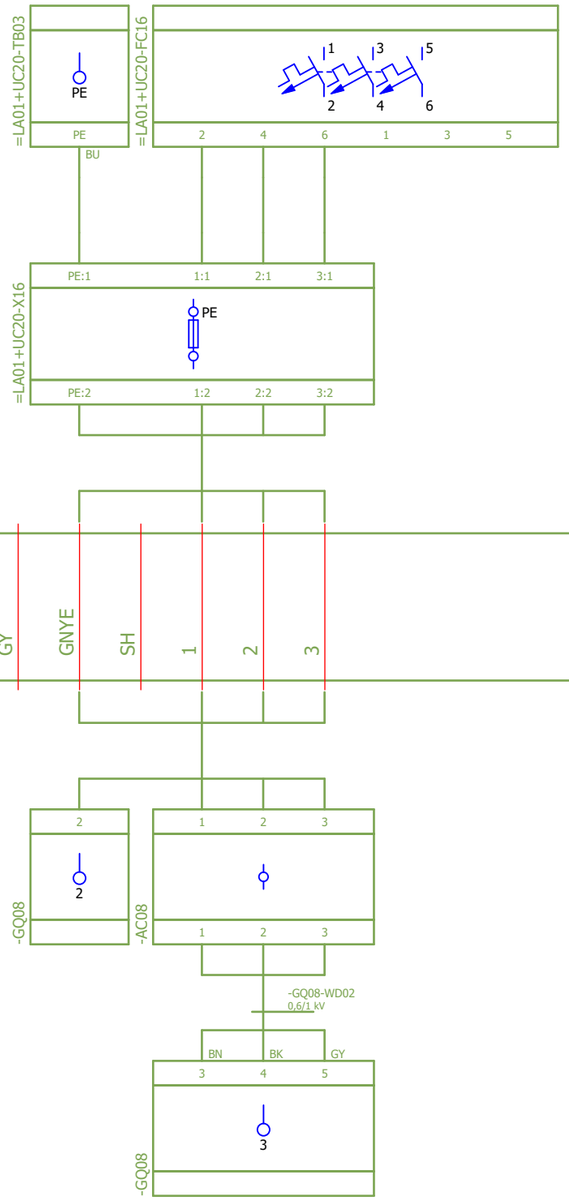
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DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =JA01+DA01-GQ07-WG01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 227 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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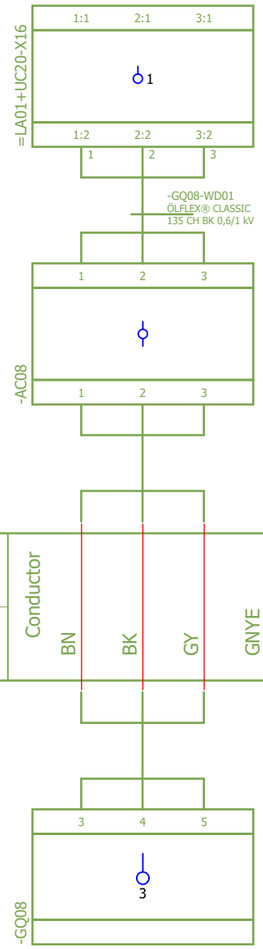
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 228 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ08-WD02	Conductor	BN	BK	GY	GNYE	SH
0,6/1 kV						

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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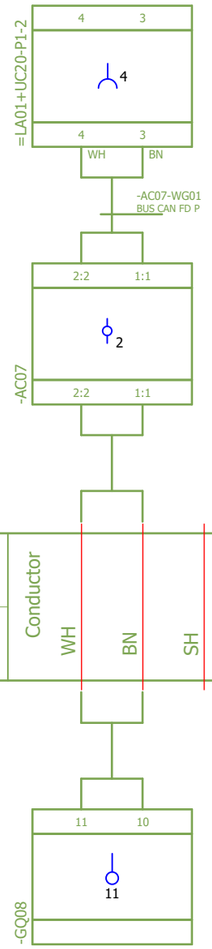
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 229 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ08-WG01	Conductor	WH	BN	SH

External targets

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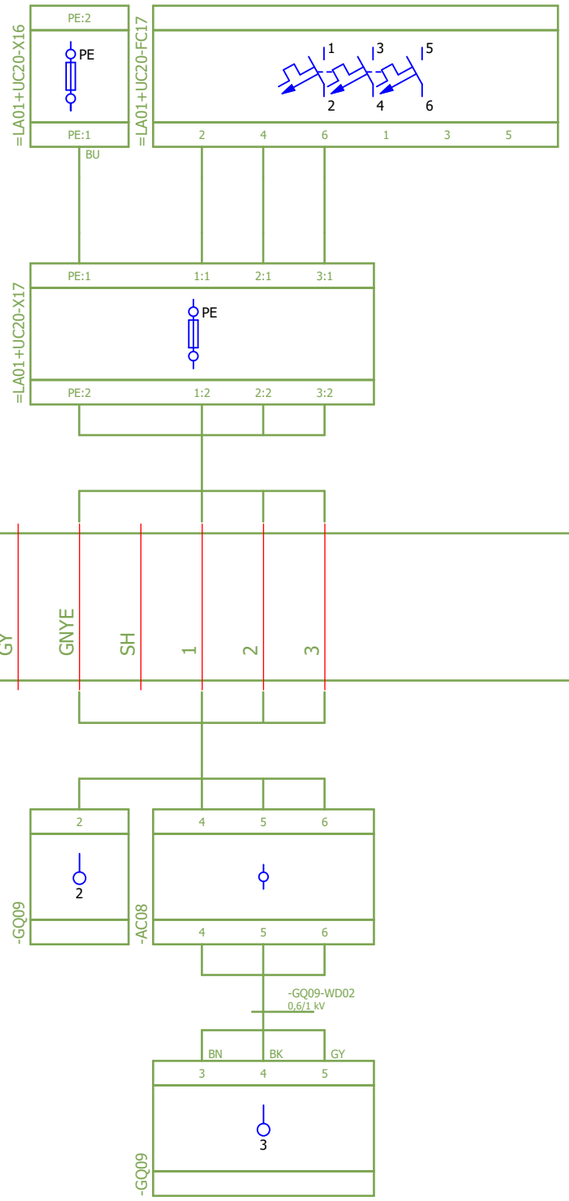
FRM5103656/0B

0	1	2	3	4	5	6	7	8

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



Reference Item Number	Ballard Part # TBD		
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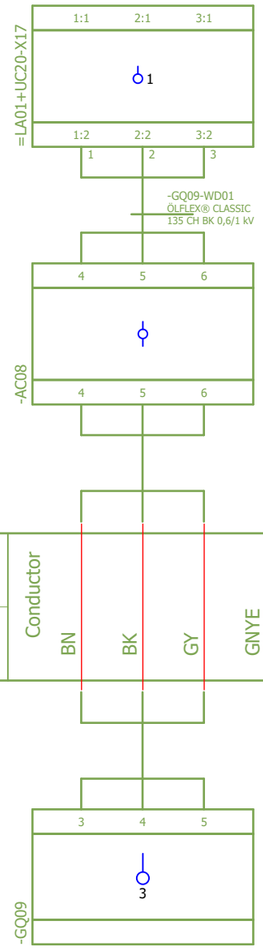
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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =JA01+DA01-GQ09-WD01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 231 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ09-WD02	Conductor	BN	BK	GY	GNYE	SH
0,6/1 kV						

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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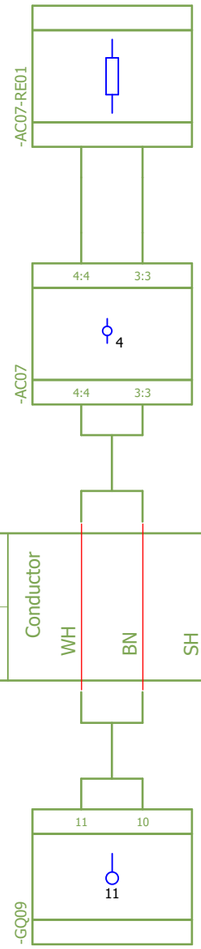
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Cable connection diagram

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PBL 29-Sep-25

Internal targets



=JA01+DA01-GQ09-WG01	Conductor	WH	BN	SH

External targets

Reference Item Number	Ballard Part # TBD		
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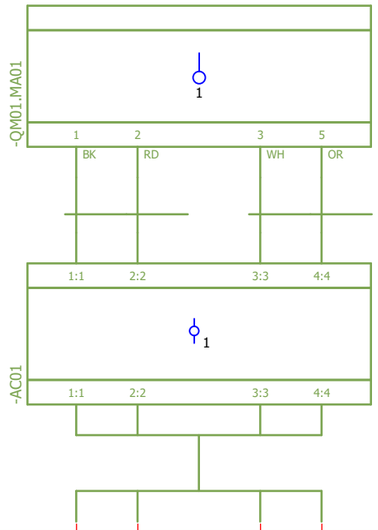
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Cable connection diagram

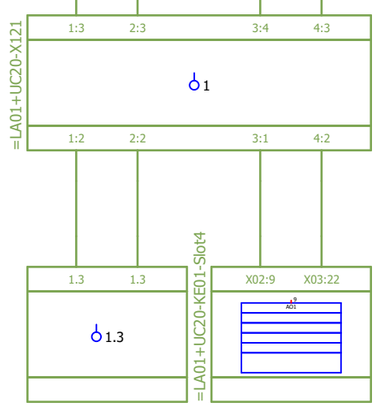
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-QM01-WD01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 135 CH						

External targets



Reference Item Number	Ballard Part # TBD		
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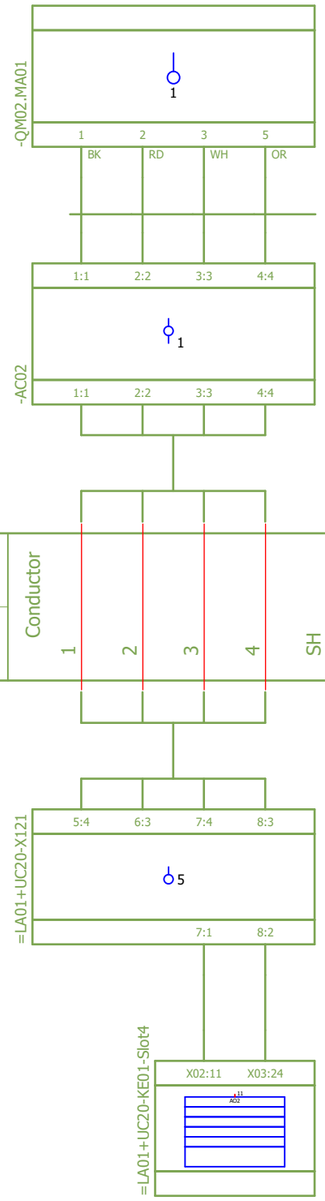
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 234 / 255

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-QM02-WD01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 135 CH						

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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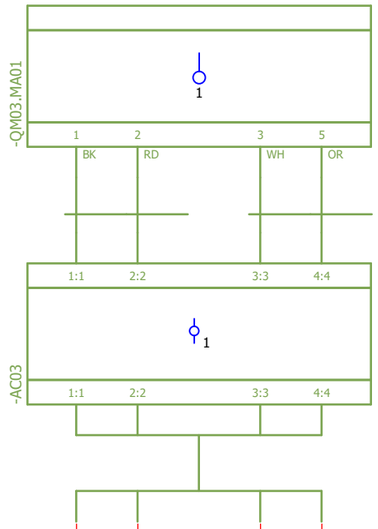
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Cable connection diagram

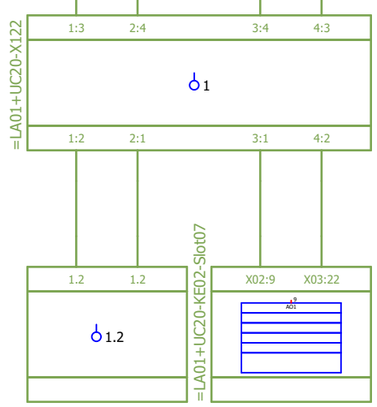
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PBL 29-Sep-25

Internal targets



=JA01+DA01-QM03-WD01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 135 CH						

External targets



Reference Item Number	Ballard Part # TBD		
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EPLAN Revision	12		
EPLAN Project Pages	627		
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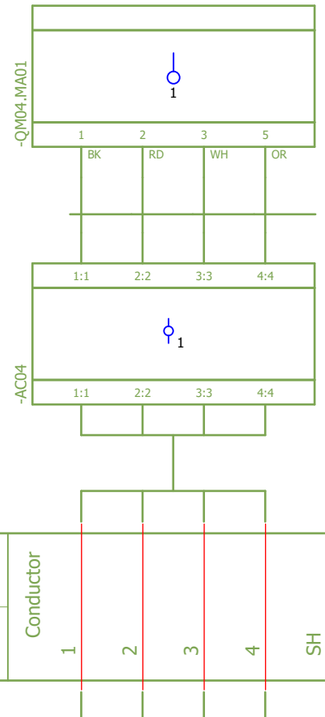
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Cable connection diagram

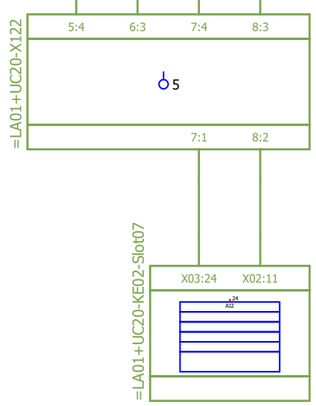
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-QM04-WD01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 135 CH						

External targets



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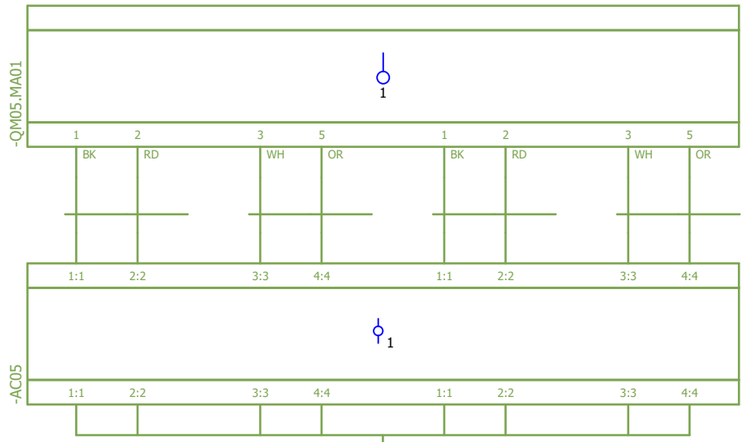
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Cable connection diagram

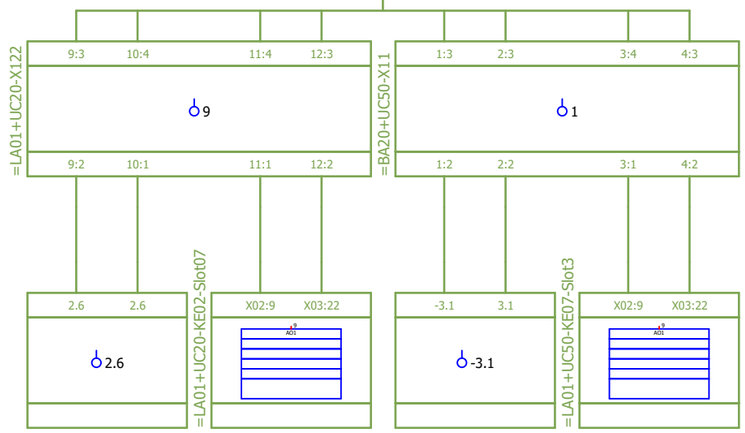
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PBL 29-Sep-25

Internal targets



=JA01+DA01-QM05-WD01	Conductor	1	2	3	4	SH	1	2	3	4	SH
ÖLFLEX® CLASSIC 135 CH											

External targets



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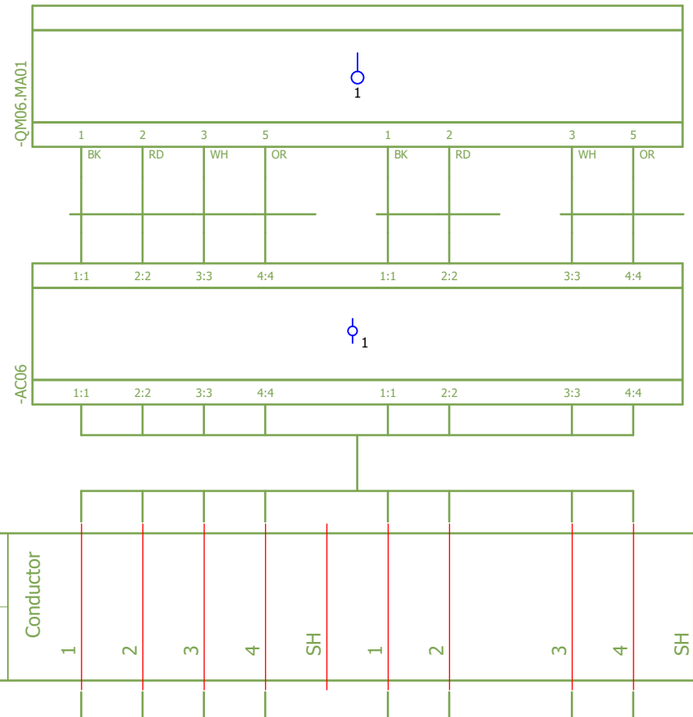
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FRM5103656/0B

Cable connection diagram

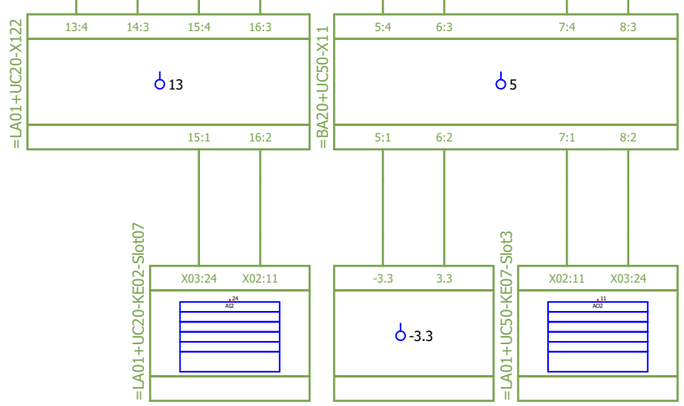
F07_001
PBL 29-Sep-25

Internal targets



=JA01+DA01-QM06-WD01	Conductor	1	2	3	4	SH	1	2	3	4	SH
ÖLFLEX® CLASSIC 135 CH											

External targets



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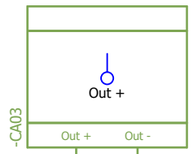
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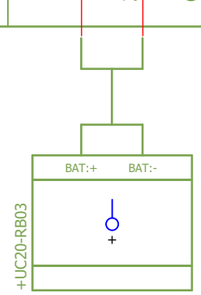
Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=LA01+DA01-RB03-WD01	Conductor	1	2	GNYE	SH
ÖLFLEX® CLASSIC 110 CH					



External targets

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =LA01+DA01-RB03-WD01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 240 / 255

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

=LA01+UC20-KE03-WG01	Conductor	WHBU	BU	WHOG	OG	WHGN	GN	WHBN	BN	SH
Profinet 4pair cabling Cat.6A FRNC flexi										

External targets

Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE			
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM		SHEET TYPE/DESC	Cable-connection diagram =LA01+UC20-KE03-WG01		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 241 / 255
=	++	+ UC20	& D01	29-Sep-25						

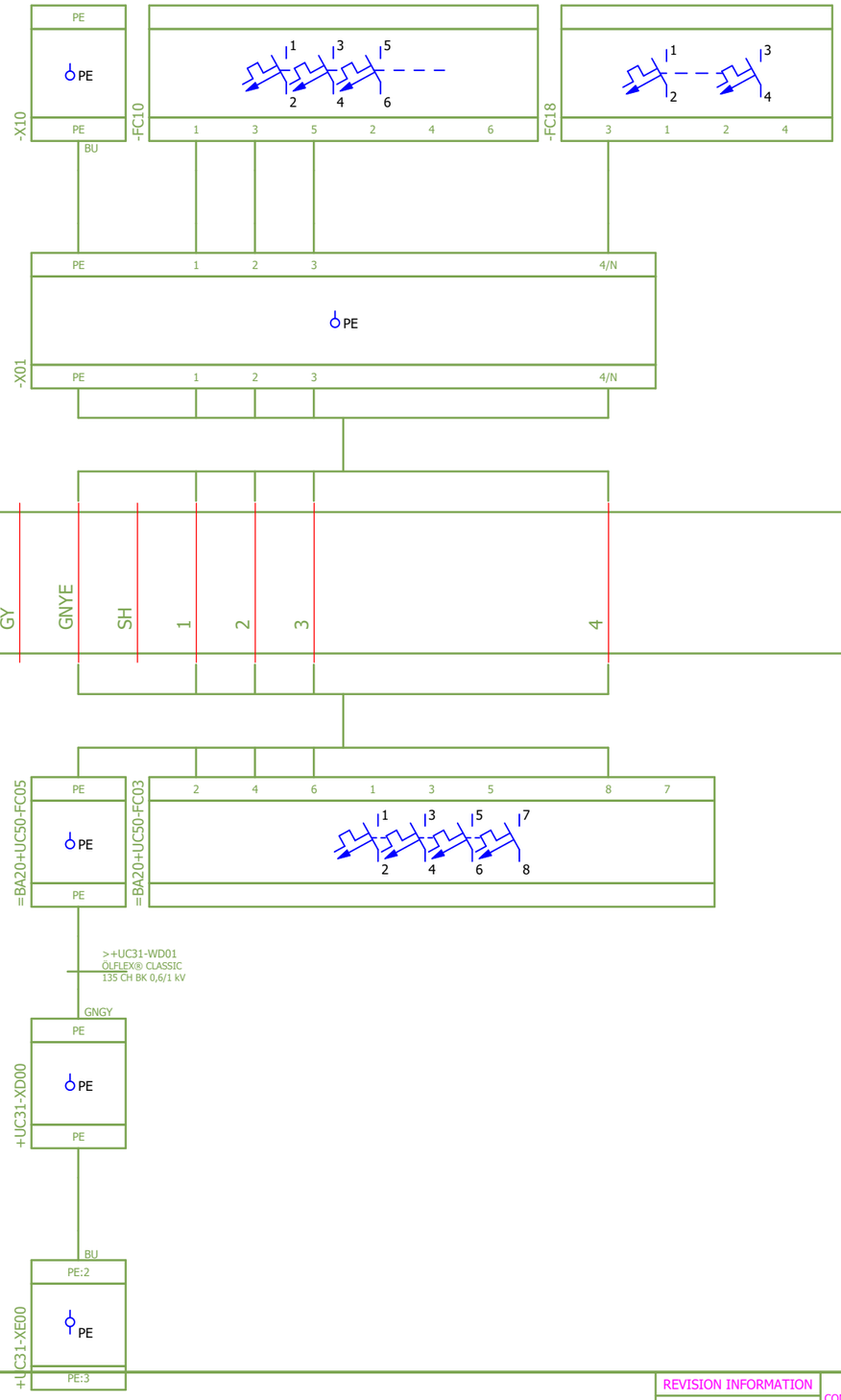
FRM5103656/0B

0	1	2	3	4	5	6	7	8

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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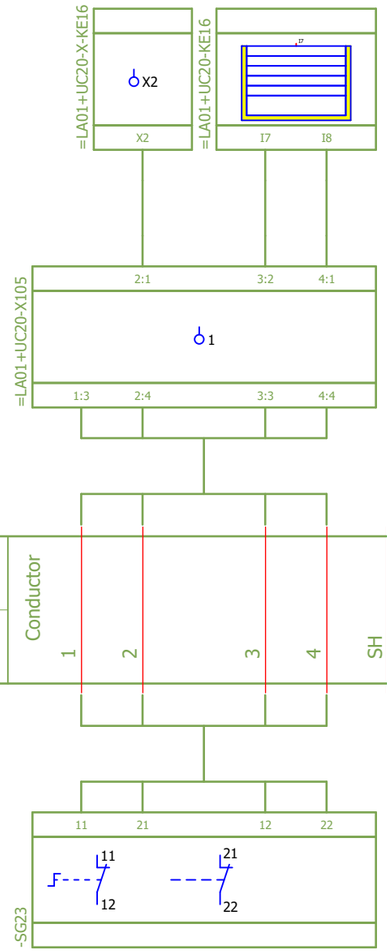
DRAWING	601456B UC20 40ft Control Cabinet	REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =LA01+UC20-WD01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 242 / 255

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



=LB02+DA01-SG23-WG01	Conductor	1	2	3	4	SH
ÖLFLEX® CLASSIC 110 CH						

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DESCRIPTION
DATE
29-Sep-25

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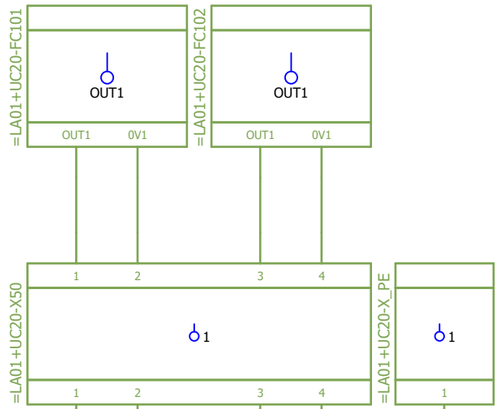
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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =LB02+DA01-SG23-WG01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 243 / 255

FRM5103656/0B

Cable connection diagram

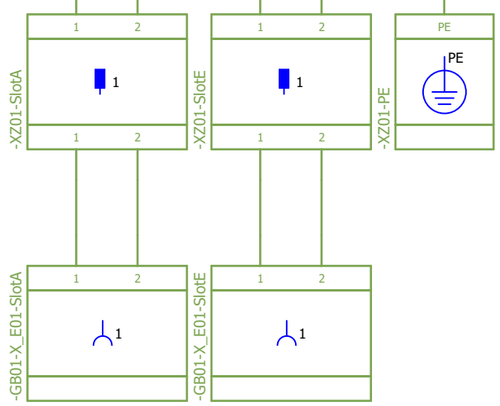
F07_001
PBL 29-Sep-25

Internal targets



=RE01+GB01-GB01-WD05	Conductor	1	2	3	4	GNYE	SH
CLASSIC 110 CH							

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DESCRIPTION
DATE
29-Sep-25

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB01-GB01-WD05		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 244 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

-GB01-XG01
1
1

=RE01+GB01-GB01-WG01
Cat.6A PUR

Conductor	WHBU	BU	WHOG	OG	WHGN	GN	WHBN	BN	SH

External targets

-XZ01-SlotC
1-8
1-8
1-8

-GB01-X_E01-SlotC
1-8
1-8

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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29-Sep-25

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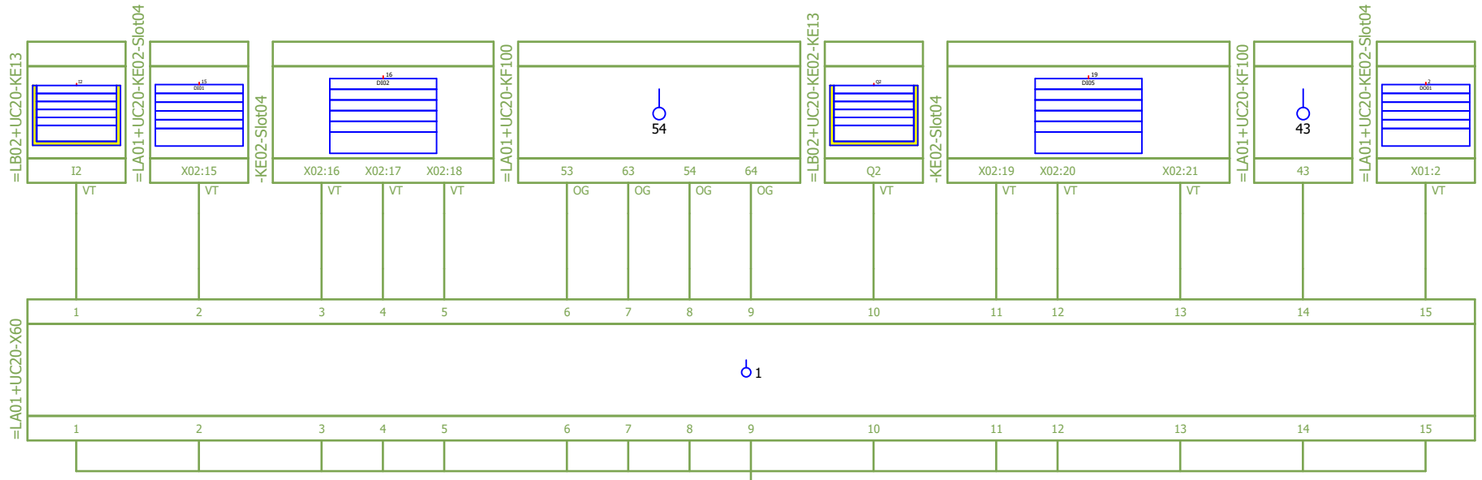
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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB01-GB01-WG01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 245 / 255

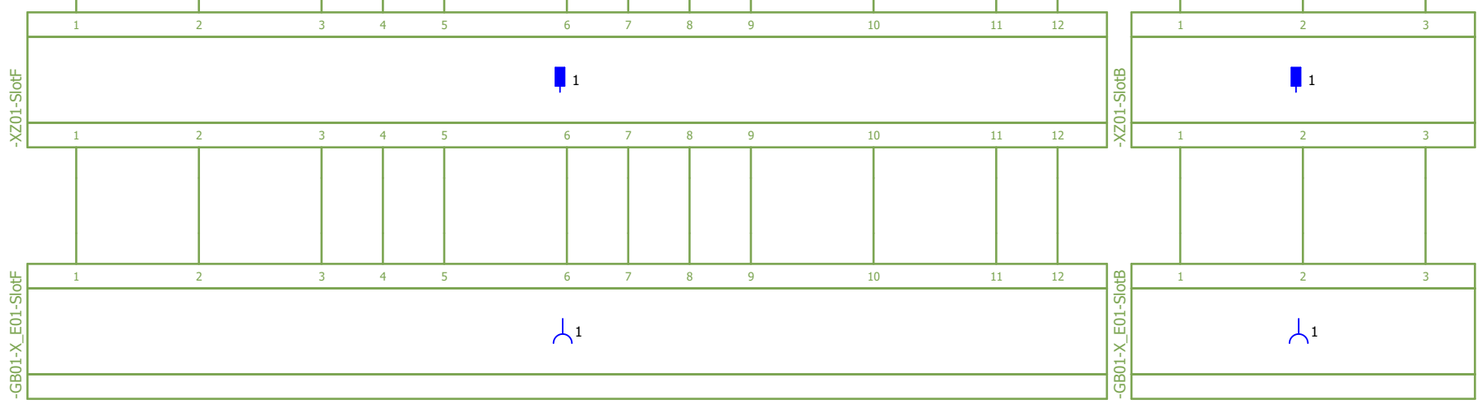
Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets



External targets



=RE01+GB01-GB01-WG02	Conductor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	GNYE	SH	1	2	3	4	5
ÖLFLEX® CLASSIC 110 CH																									

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB01-GB01-WG02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 246 / 255

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

=RE01+GB01-GB01-WG02	Conductor	6	7	8	9	10	11	12	13	14	15	16	17	GNYE	SH
ÖLFLEX® CLASSIC 110 CH															

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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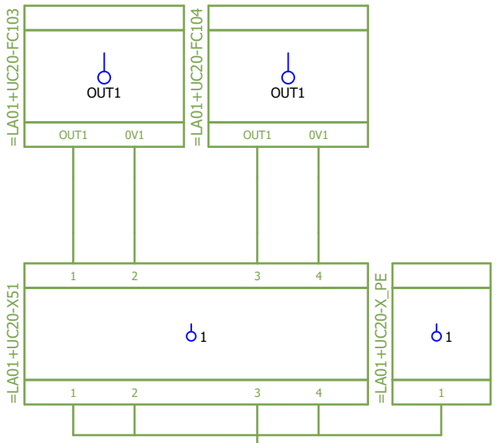
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DRAWING TITLE			
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 246.a /

FRM5103656/0B

Cable connection diagram

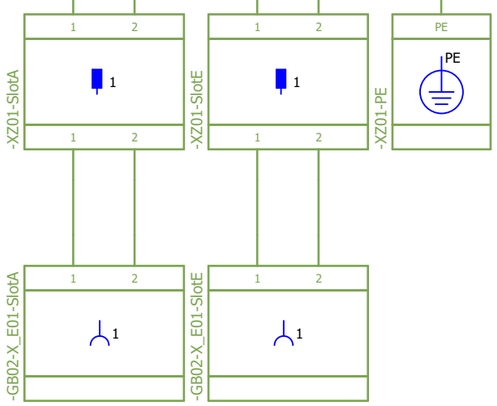
F07_001
PBL 29-Sep-25

Internal targets



=RE01+GB02-GB02-WD05	Conductor	1	2	3	4	GNYE	SH
CLASSIC 110 CH							

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DATE
29-Sep-25

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-GB02-WD05		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 248 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

-GB02-XG01
1
1

=RE01+GB02-GB02-WG01
Cat.6A PUR

Conductor	WHBU	BU	WHOG	OG	WHGN	GN	WHBN	BN	SH

External targets

-XZ01-SlotC
1-8
1-8
1-8

-GB02-X_E01-SlotC
1-8
1-8

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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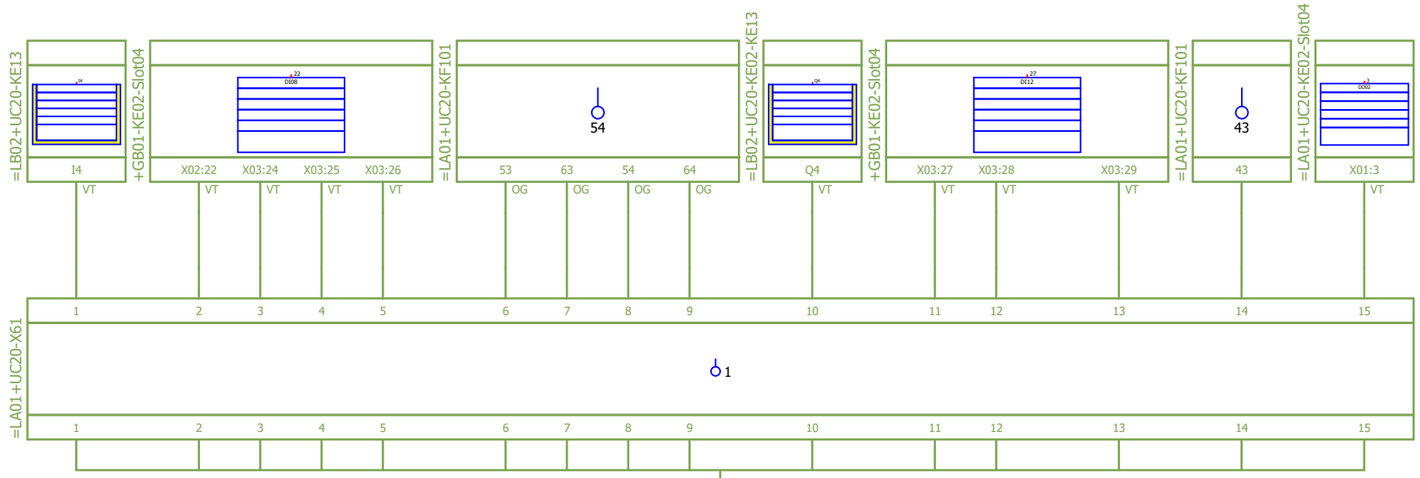
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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-GB02-WG01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 249 / 255

Cable connection diagram

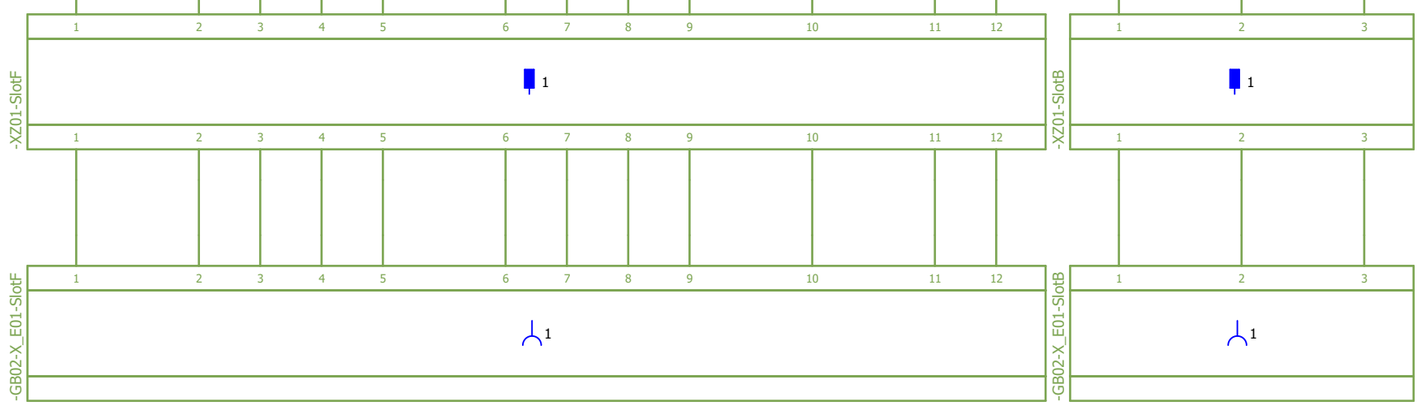
F07_001
PBL 29-Sep-25

Internal targets



=RE01+GB02-GB02-WG02	Conductor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	GNYE	SH	1	2	3	4	5	6
ÖLFLEX® CLASSIC 110 CH																										

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-GB02-WG02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 250 / 255

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

=RE01+GB02-GB02-WG02	Conductor	7	8	9	10	11	12	13	14	15	16	17	GNYE	SH
ÖLFLEX® CLASSIC 110 CH														

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DRAWING		REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-GB02-WG02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 250.a /

FRM5103656/0B

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

=BA01+UC02-X02
1
1

=RE01+GB02-WD01	Conductor	BK	SH
ÖLFLEX® FD 90 CP			

External targets

-XB01
1
1
1

-GB02-X_HV
1:A+
1
(empty)

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-WD01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 252 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

=BA01+UC02-X02
2
2

=RE01+GB02-WD02	Conductor	BK	SH
ÖLFLEX® FD 90 CP			

External targets

-XB02
1
1
1

-GB02-X_HV
3
3

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-WD02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 253 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

=BA01+UC02-X02
3
3

=RE01+GB02-WD03	Conductor	BK	SH
ÖLFLEX® FD 90 CP			

External targets

-XB03
1
1
1

-GB02-X_HV
2
2

Reference Item Number	Ballard Part # TBD		
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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-WD03		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 254 / 255

Cable connection diagram

F07_001
PBL 29-Sep-25

Internal targets

=BA01+UC02-X02
4
4

=RE01+GB02-WD04	Conductor	BK	SH
ÖLFLEX® FD 90 CP			

External targets

-XB04
1
1
1

-GB02-X_HV
4
4

Reference Item Number	Ballard Part # TBD		
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EPLAN Project Pages	627		
=	++	+ UC20	& D01

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DRAWING TITLE			
SHEET TYPE/DESC	Cable-connection diagram =RE01+GB02-WD04		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 255 / 255

Sub Section E03-003

UC30 Coolant Skid Control Cabinet

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	9/9/2025	Updated, as build

Document Title:	**BLPH Project - Panel Cabinet Layout: UC30 Coolant Skid Control Cabinet**
Document Number:	K559-2254-CWIWP4202202-E03-003
Revision:	Rev002
Sequence Number:	003
File Name:	K559-2254-CWIWP4202202-E03-003Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BALLARD™

+UC30

Ballard Power Systems Europe - Technology Solutions

Cabinet: Coolant Skid Control Cabinet
Location: Coolant Skid, Middle

Cabinet Supply:
- Vin = 400VAC, 3P+N+PE
- IKmax = 10kA
- I max = 160A
- IP 55x

Control circuit
- AC 230V
- DC 24V

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& A01

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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Front Page		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 82

Ballard Power Systems Europe - Technology Solutions, Cabinet Wiring Colors

Standard Basis: EN 61439

Required wire standard compliance:

Required: IEC Wire
Required: UL Recognized
Required: CSA/UL

Wire Numbering:

- Wires inside panels are to be numbered
- Wire number system is perferably "potential oriented with subnumber"
- All wires of the same potential (e.g. DC Common) have the same main number, with sequential subnumber.
- Potential numbers with fewer digits may be leading zero padded (e.g. 19 -> 019)
- Separator between main and subnumber is "."

Example: 019.1 BUWH 0.75mm²

- 019 — Wire potential number
- 1 — Wire sequential subnumber with separator
- BUWH — Wire color code (Dark Blue with White stripe)
- 0.75mm² — Wire dimension

AC Wiring Colors

AC Power Circuit (Generic)	Black (BK)
AC Phase L1	Brown (BN)
AC Phase L2	Black (BK)
AC Phase L3	Grey (GY)
AC Neutral	Light Blue (BU)
Externally supplied circuit	Orange (OG)

DC Wiring Colors

DC Power Circuit	Black (BK)
DC Control Voltage (24V)	Dark Blue (BU)
DC Control Voltage Refence (0V)	Dark Blue with White Stripe (BUWH)
Signal Wire (DI, DO)	White (WH)
Signal Wire (AI, AO)	Violet (VT)
Externally supplied circuit	Orange (OG)

PE Wiring Colors

Protective Earth (PE)	Green/Yellow (GNYE)

Conductor Colour Identification

IEC 60757:1983 Designation	Description
BK	Black
BN	Brown
RD	Red
OG	Orange
YE	Yellow
GN	Green
BU	Blue
VT	Violet
GY	Gray
WH	White
PK	Pink
GD	Gold
TQ	Turquoise
SR	Silver
GNYE	Green/Yellow
SH	Shield

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	11
EPLAN Project Pages	629
=	++ | + UC30 | & A01

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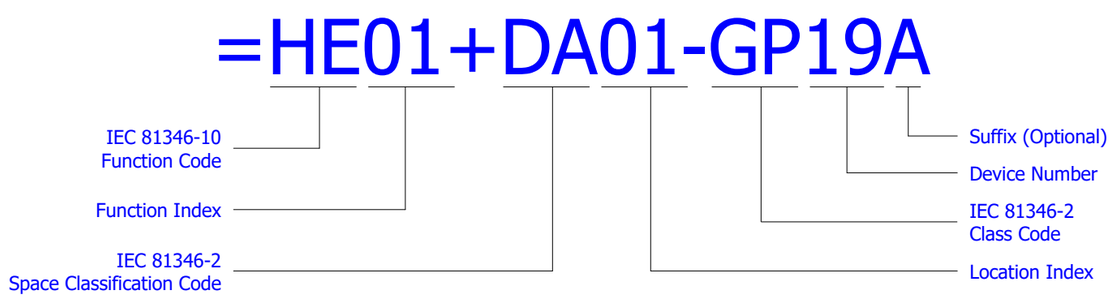
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Standard Wire Colors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 82

FRM5103656/0B

Ballard Power Systems Europe - Technology Solutions Device Tag Process

A Ballard Device Tagname consists of three parts:
- A function designation (=)
  - According to IEC81346-10, Table B.1 and B2.
  - Always two letters followed by two digits
- A location designation (+)
  - According to IEC81346-2, Table 4
  - Always two letters followed by two digits
- A class code (-)
  - According to IEC81346-2, Table 2
  - Always two letters followed by two or three digits plus optional suffix

Sample fully qualified Device Tag (DT) for a Coolant Pump



IEC81346-10 Function Examples

IEC 81346-10 Table B.1 and B.2 provide a class definition system, which provides a two letter code for the functional description
Table B.1 is used for power supply systems and table B.2 for other systems

IEC 81346-10 Table B.1 / B.2	Function Codes (Example)
=AA	Structural System, Load support (Frame)
=BA	Transporting Electrical Energy (Power Converters)
=HA	Supply System, Gaseous Matter (Gas Piping)
=HE	Supply System, Heating/Cooling (Radiator)
=JA	Distribution System, Gaseous Matter (Gas Handling Unit)
=JB	Distribution System, Liquid Matter (Fluid Drain)
=LA	Control System, Process (PLC, SCADA)
=LB	Control System, Safety (Safety PLC)
=QA	Storage System, Gaseous Matter (Gas Storage)
=RE	Energy Conversion System, Chemical to Electricity (Fuel cells, Batteries)

IEC81346-2 Space Classification

IEC 81346-2 Table 4 provide a classification scheme for spaces, which provides a two and three letter code for the space (location) classification.
Class code "1" and "1" is used for the location scheme

IEC 81346-2 Table 4	Location Codes (Example)
+GB	Space for power generation, Chemical (Fuel Cells)
+DA	Space for active technical equipment
+UC	Space for electrical equipment (Electrical Cabinet)

IEC81346-2 Class Code

IEC 81346-2 Class Codes is a scheme for defined objects for reference designations according to their inherent function

IEC 81346-2 Table 2	Class Codes (Example)
-BA	Sensing, electrical potential (Voltage Transducer)
-BC	Sensing, electrical current (Current Transducer)
-BP	Sensing, pressure (Pressure Transducer)
-BT	Sensing, temperature (Temperature Transducer)
-EA	Emitting, light (Light Fixture)
-FC	Protecting, overcurrent (Fuse, MCCB)
-GB	Generating, Chemical Reaction (Fuel Cell)
-GP	Generating, Liquid Flow (Pump)
-GQ	Generating, Gas Flow (Van, Ventilator)
-KE	Processing, Electrical signals (PLC)
-KF	Processing, Information (Network Switch)
-MA	Driving, Torque (AC Motor)
-QA	Controlling, Electric Current (Contactor, Motor Starter)
-QB	Controlling, Electric Separation (Disconnector)
-QM	Controlling, Fluid On/Off (Valve)
-QN	Controlling, Fluid Regulation (Damper, Gas Control Valve)
-WD	Guiding, Low Voltage Electric Energy (AC or DC power Cable)
-WE	Guiding, Reference Potential (Grounding Wire/Cable)
-WG	Guiding, Electric Signals (Control, Network Cable)

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	11
EPLAN Project Pages	629
= ++ + UC30 & A01	

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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Tagging Standard		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 3 / 82

FRM5103656/0B

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Ballard Power Systems Europe - Technology Solutions

Controller IO Overview Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C02

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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Controller IO Overview Introduction		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 7 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30-KE04
DEIF AMC300
Controller Extension Rack

-Slot1
DEIF PSM3.2
Power Supply Module 3.2

PSM3.2

	PE PE		Frame Ground	
	1 12-24V		Supply +	
	2 0V		Supply COM	
	3 R1 COM		Status OK Relay COM	
A52.4	4 DO1	DO1	Status OK Relay	
	5 R2 COM		Relay 2 COM	
A52.5	6 DO2	DO2	Relay 1 Out	
	7 R3 COM		Relay 3 COM	
A52.6	8 DO3	DO3	Relay 3 Out	

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.4:E X03 — Ethernet-1 IN

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.4:E X03 — Ethernet-2 OUT

Bus Follower
Multi-line 300

-Slot2
ACM3.1
Alternating Current Module 3.1

ACM3.1

1 L1			
2 L2			
3 L3			
4 N		Source - L1	
		Source - L2	
		Source - L3	
		Source - N	
5 L1	BA20-UC30-L1	Coolant Skid Supply Voltage - L1	
6 L2	BA20-UC30-L2	Coolant Skid Supply Voltage - L2	
7 L3	BA20-UC30-L3	Coolant Skid Supply Voltage - L3	
8 N	BA20-UC30-N	Coolant Skid Supply Voltage - N	
9 L1-S1	=BA20+UC30-BC01	Current transformer L1 - S1	
10 L1-S2	CH1-S2	Channel 1 - S2	
11 L2-S1	=BA20+UC30-BC02	Current transformer L2 - S1	
12 L2-S2	CH2-S2	Channel 2 - S2	
13 L3-S1	=BA20+UC30-BC03	Current transformer L3 - S1	
14 L3-S2	CH3-S2	Channel 3 - S2	
15 4-S1	CH4-S1	Channel 4 - S1	
16 4-S2	CH4-S2	Channel 4 - S2	

-Slot3
&C03/25.4
&C03/29.4
IOM3.2
IO Module 3.2

IOM3.2

1 R1 COM			Relay 1 In
2 DO1			Relay 1 out
3 R2 COM			Relay 2 COM
4 DO2			Relay 2 Out
5 R3 COM			Relay 3 In
6 DO3			Relay 3 Out
7 R4 COM			Relay 4 In
8 DO4			Relay 4 Out
9 AO1			Spare
10 AO1 COM			AO1 COM
11 AO2			Spare
12 AO2 COM			AO2 COM
13 AO3			Spare
14 AO3 COM			AO3 COM
15 AO4			Spare
16 AO4 COM			AO4 COM
17 DI1		IAH_FC4X	Fuse trip indication H2 Heat
18 DI2			Spare
19 DI3			Spare
20 DI4			Spare
21 DI1-4 COM			DI1-4 COM
22 AI1			HT1 Coolant Flow
23 AI1 COM			AI1 COM
24 AI2	&C03/25.4	HE01_BL01_LT	HT1 Level header tank
25 AI2 COM	&C03/25.4		AI2 COM
26 AI3			HT2 Coolant Flow
27 AI3 COM			AI3 COM
28 AI4	&C03/29.4	HE02_BL01_LT	HT2 Header Tank Level
29 AI4 COM	&C03/29.4		AI4 COM

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C02

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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Container Controller, Coolant Rack 1/4		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 8 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30-KE04

DEIF AMC300
Controller Extension Rack

-Slot4

&C03/28.3
&C03/32.3
IOM3.2
IO Module 3.2

IOM3.2

1	R1 COM			Relay 1 In	
2	DO1			Spare	
3	R2 COM			Relay 2 COM	
4	DO2			Spare	
5	R3 COM			Relay 3 In	
6	DO3			Relay 3 Out	
7	R4 COM			Relay 4 In	
8	DO4			Relay 4 Out	
9	AO1	&C03/28.3	HE01_QN01_SP	HT1 Bypass Valve Setpoint	
10	AO1 COM	&C03/28.3		AO1 COM	
11	AO2	&C03/28.6	HE01_QN02_SP	HT1 Cooler Valve Setpoint	
12	AO2 COM	&C03/28.6		AO2 COM	
13	AO3	&C03/32.3	HE02_QN01_SP	HT2 Bypass Valve Setpoint	
14	AO3 COM	&C03/32.3		AO3 COM	
15	AO4	&C03/32.6	HE02_QN02_SP	HT2 Cooler Valve Setpoint	
16	AO4 COM	&C03/32.6		AO4 COM	
17	DI1			Spare	
18	DI2			Spare	
19	DI3			Spare	
20	DI4			Spare	
21	DI1-4 COM			DI1-4 COM	
22	AI1	&C03/28.4	HE01_QN01_FB	HT1 Bypass Valve Feedback	
23	AI1 COM	&C03/28.4		AI1 COM	
24	AI2	&C03/28.7	HE01_QN02_FB	HT1 Cooler Valve Feedback	
25	AI2 COM	&C03/28.8		AI2 COM	
26	AI3	&C03/32.4	HE02_QN01_FB	HT2 Bypass Valve Feedback	
27	AI3 COM	&C03/32.4		AI3 COM	
28	AI4	&C03/32.7	HE02_QN02_FB	HT2 Cooler Valve Feedback	
29	AI4 COM	&C03/32.8		AI4 COM	

-Slot5

&C03/25.3
&C03/25.1
&C03/25.6
&C03/29.3
&C03/29.1
&C03/29.6
&C03/33.4
&C03/34.1
IOM3.3
IO Module 3.3

IOM3.3

1	AI1			Spare	
2	AI2	&C03/25.3	HE01_BF01_TT	Main HT Coolant Return Temperature	
3	AI3	&C03/25.3		Spare	
4	AI4			Spare	
5	AI5	&C03/25.1	HE01_BF01_FT	HT1 Coolant Flow	
6	AI6			Spare	
7	AI7	&C03/25.6	HE01_BT05_TT	HT1 Cooling Tower Return Temperature	
8	AI8	&C03/25.6		Spare	
9	AI9	&C03/25.6		Spare	
10	AI10	&C03/25.7	HE01_BT06_TT	HT1 Pump Inlet Temperature	
11	AI11	&C03/25.7		Spare	
12	AI12	&C03/25.8		Spare	
13	AI13			Spare	
14	AI14	&C03/29.3	HE02_BF01_TT	Main HT Coolant Return Temperature	
15	AI15			Spare	
16	AI16			Spare	
17	AI17	&C03/29.1	HE02_BF01_FT	HT2 Coolant Flow	
18	AI18			Spare	
19	AI19	&C03/29.6	HE02_BT05_TT	HT2 Cooling Tower Return Temperature	
20	AI20			Spare	
21	AI21			Spare	
22	AI22	&C03/29.7	HE02_BT06_TT	HT2 Pump Inlet Temperature	
23	AI23			Spare	
24	AI24			Spare	
25	AI25	&C03/33.4	HE03_BL01_PT	LT Coolant System Header Tank Level	
26	AI26			Spare	
27	AI27	&C03/33.4		Spare	
28	AI28	&C03/34.1	JA01_BT04_TT	Exterior Temperature	
29	AI29	&C03/34.1		Spare	
30	AI30	&C03/34.2		Spare	

-Slot6

IOM3.4
IO Module 3.4

IOM3.4

1	12-24V			Supply +
2	DO01	HA01_EA01		Hydrogen Heater 1
3	DO02	HA01_EA02		Hydrogen Heater 2
4	DO03	DO03		Digital Out 03
5	DO04	DO04		Digital Out 04
6	DO05	DO05		Digital Out 05
7	DO06	DO06		Digital Out 06
8	DO07	DO07		Digital Out 07
9	DO08	DO08		Digital Out 08
10	DO09	DO09		Digital Out 09
11	DO10	DO10		Digital Out 10
12	DO11	DO11		Digital Out 11
13	DO12	DO12		Digital Out 12
14	COM			Supply COM
15	DI03	IAH_FC3X		Fuse Trip Indication HT2
16	DI02	IAH_FC20X		Fuse Trip Indication 24V
17	DI03	IAH_FC2X		Fuse Trip Indication HT1
18	DI04	IAH_FC1X		Fuse Trip Indication LT
19	DI05	JT_RB30_BAT		UPS Battery Operation
20	DI06	JT_RB30_RDY		UPS Battery Ready
21	DI07	JT_RB30_SOH		UPS Battery Low SOH
22	DI08	HA01_BL01		Hydrogen Heater Level Swich
23	COM			Supply COM
24	DI09	DI09		Digital In 09
25	DI10	DI10		Digital In 10
26	DI11	DI11		Digital In 11
27	DI12	DI12		Digital In 12
28	DI13	DI13		Digital In 13
29	DI14	DI14		Digital In 14
30	DI15	DI15		Digital In 15
31	DI16	DI16		Digital In 16
32	COM			Supply COM

Reference Item Number	Ballard Part # TBD		
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EPLAN Project Pages	629		
=	++	+ UC30	& C02

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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Container Controller, Coolant Rack 2/4		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 9 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30-KE05
DEIF AMC300
Controller Extension Rack

-Slot1
DEIF PSM3.2
Power Supply
Module 3.2

PSM3.2

	PE PE			Frame Ground
	1 12-24V			Supply +
	2 0V			Supply COM
	3 R1 COM			Status OK Relay COM
A52.4	4 DO1	DO1		Status OK Relay
	5 R2 COM			Relay 2 COM
A52.5	6 DO2	DO2		Relay 1 Out
	7 R3 COM			Relay 3 COM
A52.6	8 DO3	DO3		Relay 3 Out

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.5:E X03 — Ethernet-1 IN

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.6:E X03 — Ethernet-2 OUT

Bus Slave
Multi-line 300

-Slot2
&C03/45.4
&C03/44.4
&C03/44.4
IOM3.3
IO Module 3.3

IOM3.3

1	AI1			Spare
2	AI2	&C03/45.4	=DA01+DA02+BP01	Hydrogen Inlet Pressure
3	AI3			Spare
4	AI4	&C03/44.4	HE01_DA02_BT01	Hydrogen heater temperature
5	AI5	&C03/44.4		Spare
6	AI6			Spare
7	AI7			Spare
8	AI3			Spare
9	AI9			Spare
10	AI10			Spare
11	AI11			Spare
12	AI12			Spare
13	AI13			Spare
14	AI14			Spare
15	AI15			Spare
16	AI16			Spare
17	AI17			Spare
18	AI18			Spare
19	AI19			Spare
20	AI20			Spare
21	AI21			Spare
22	AI22			Spare
23	AI23			Spare
24	AI24			Spare
25	AI25			Spare
26	AI26			Spare
27	AI27			Spare
28	AI28			Spare
29	AI29			Spare
30	AI30			Spare

Reference Item Number	Ballard Part # TBD		
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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 10 / 82

=LA01+UC40-KE04
DEIF AMC300
Controller Extension Rack

Reserved

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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SHEET TYPE/DESC	Container Controller, Coolant Rack 4/4		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 11 / 82

BALLARD™

Ballard Power Systems Europe - Technology Solutions

Multiline Documentation

Reference Item Number	Ballard Part # TBD		
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EPLAN Revision	11		
EPLAN Project Pages	629		
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DATE
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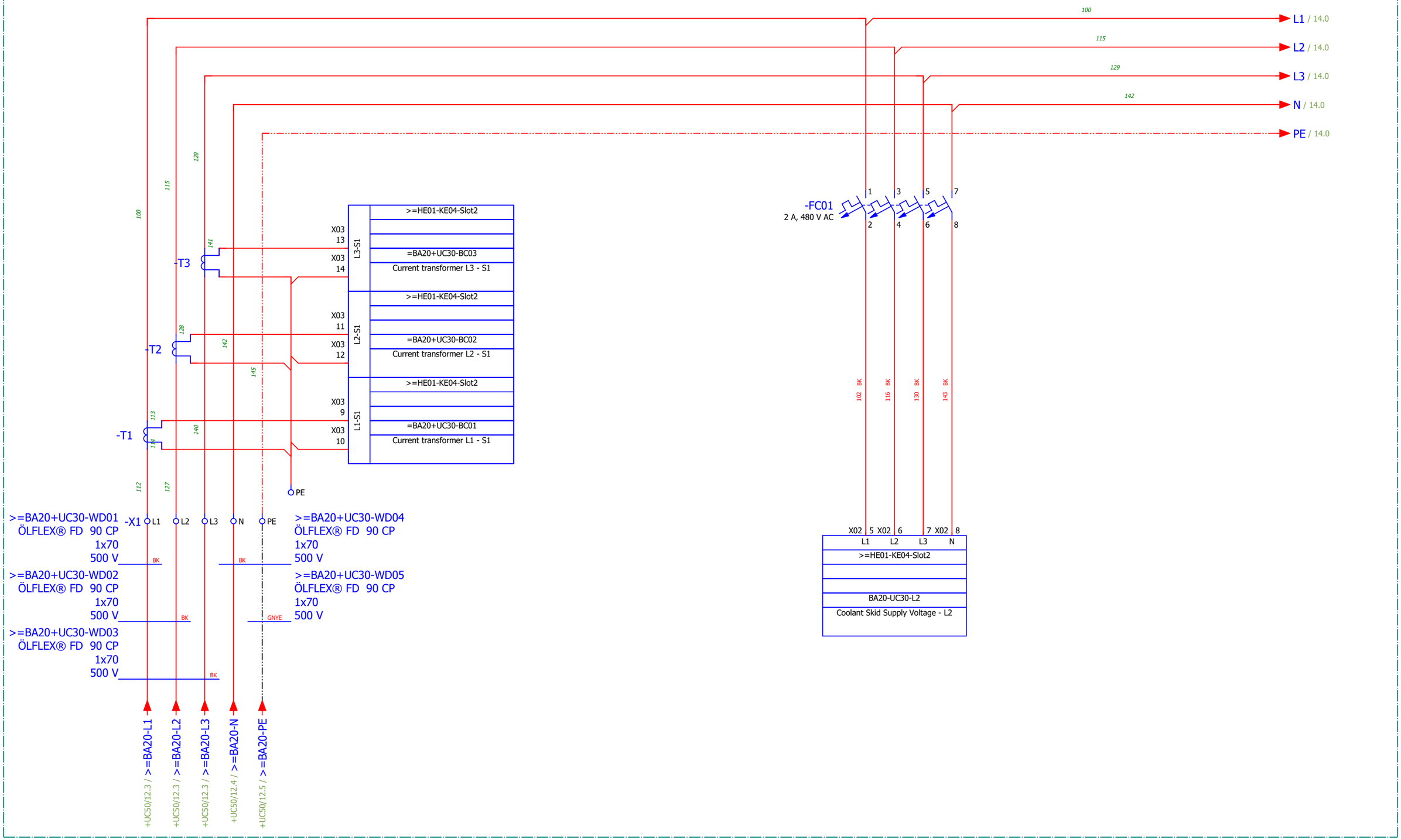
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Multiline Documentation Intro		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 12 / 82

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC30

Power conversion BOP Cooling skid cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

REVISION INFORMATION
DESCRIPTION
DATE
03-Sep-25

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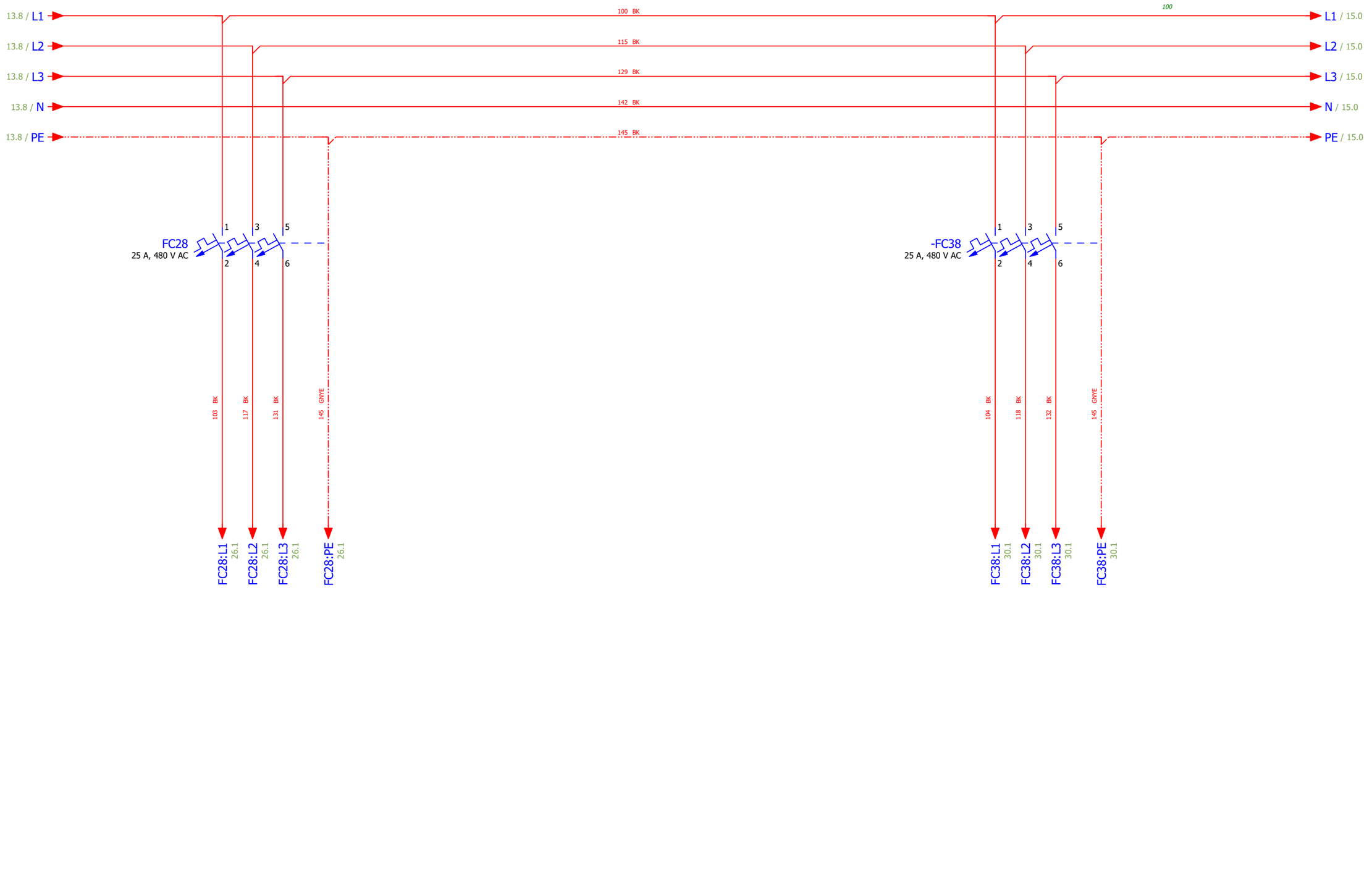
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Control Cabinet Supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 13 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

Power conversion BOP Cooling skid cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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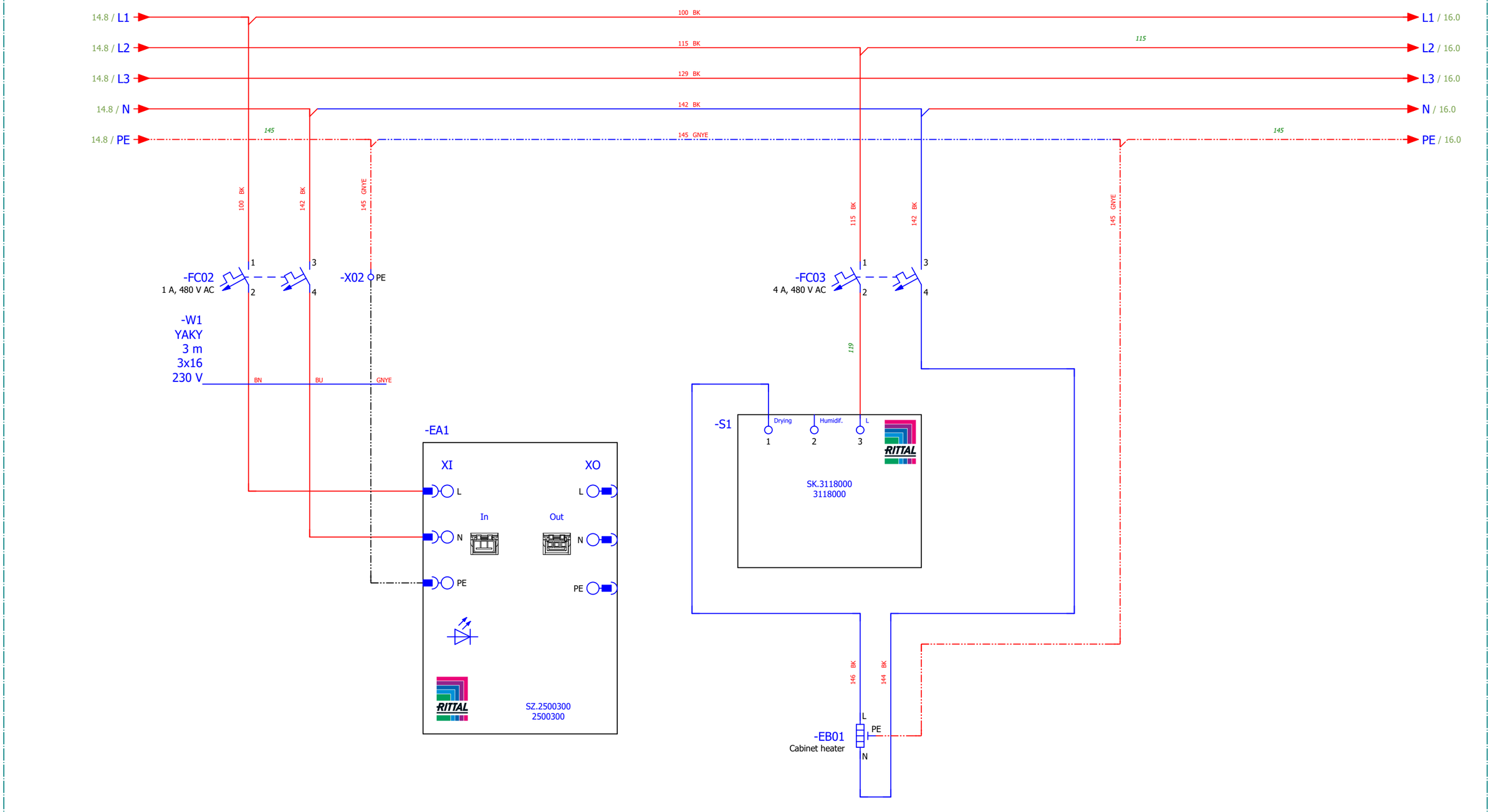
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT pump supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 14 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

Power conversion BOP Cooling skid cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Cabinet light and heater		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 15 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

15.8 / L1 → 100 → L1 / 35.0
15.8 / L2 → 115 → L2 / 35.0
15.8 / L3 → 129 → L3 / 35.0
15.8 / N → 46 → N /
15.8 / PE → 145 → PE / 35.0

-FC100
6 A
1 3 5
2 4 6
105 BK
120 BK
133 BK
145 GNYE

-TB30
24V, 20A
PSU
L1 L2 L3 PE
3AC 380-480V

PULS
Power Supply
QT20.241
24-28V
DC-OK
Overload

DC 24V, 20A, 480W/720W
Out + Out +' Out - Out -' 13 14
DC-OK

148
149
149
PE

-RB30
24V, 20A
UPS Module
In + In - In -'
DC 24V
Bat. + Bat. -
11 12 13
PT100 Temp. Sensor
PT100 Temp. Sensor
Battery Center Tap

PULS
DC-UPS Control Unit, 24V, 20A
UB20.21

DC 24V 20A
Out + Out -

Ready 1
Ready 2
Buffering 3
Buffering 4
Repl. Bat. 5
Repl. Bat. 6
Inhibit + 7
Inhibit - 8

153
153
153
153
19.5 / -X202:4B

-RB30+
18.0
-RB30-
18.1

152 → RB30:Bat+ / 17.0
154 → RB30:Bat- / 17.0
RB30:Temp_11 / 17.0
RB30:Temp_12 / 17.0

UPS Battery Ready
JT_RB30_RDY
>=HE01-KE04-Slot6
DI06
X02 20

UPS Battery Operation
JT_RB30_BAT
DI05
19

UPS Battery Low SOH
JT_RB30_SOH
DI07
21

155
157
158

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DRAWING	K559-2254-CWIWP4202202-E03-003		REVISION	11	
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet				
SHEET TYPE/DESC	40ft Coolant skid - 24 VDC Supply				
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	16 / 82	

0	1	2	3	4	5	6	7	8

=LA01+UC30

16.7 / RB30:Bat+

16.7 / RB30:Bat-

16.7 / RB30:Temp_11

16.7 / RB30:Temp_12

-CA30

PULS

Battery Module, 24V, 12Ah
UZK24.121

154

152

DC 24V
Out + Out -

PT100 Temp. Sensor 11

PT100 Temp. Sensor 12

Battery Center Tap 13

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
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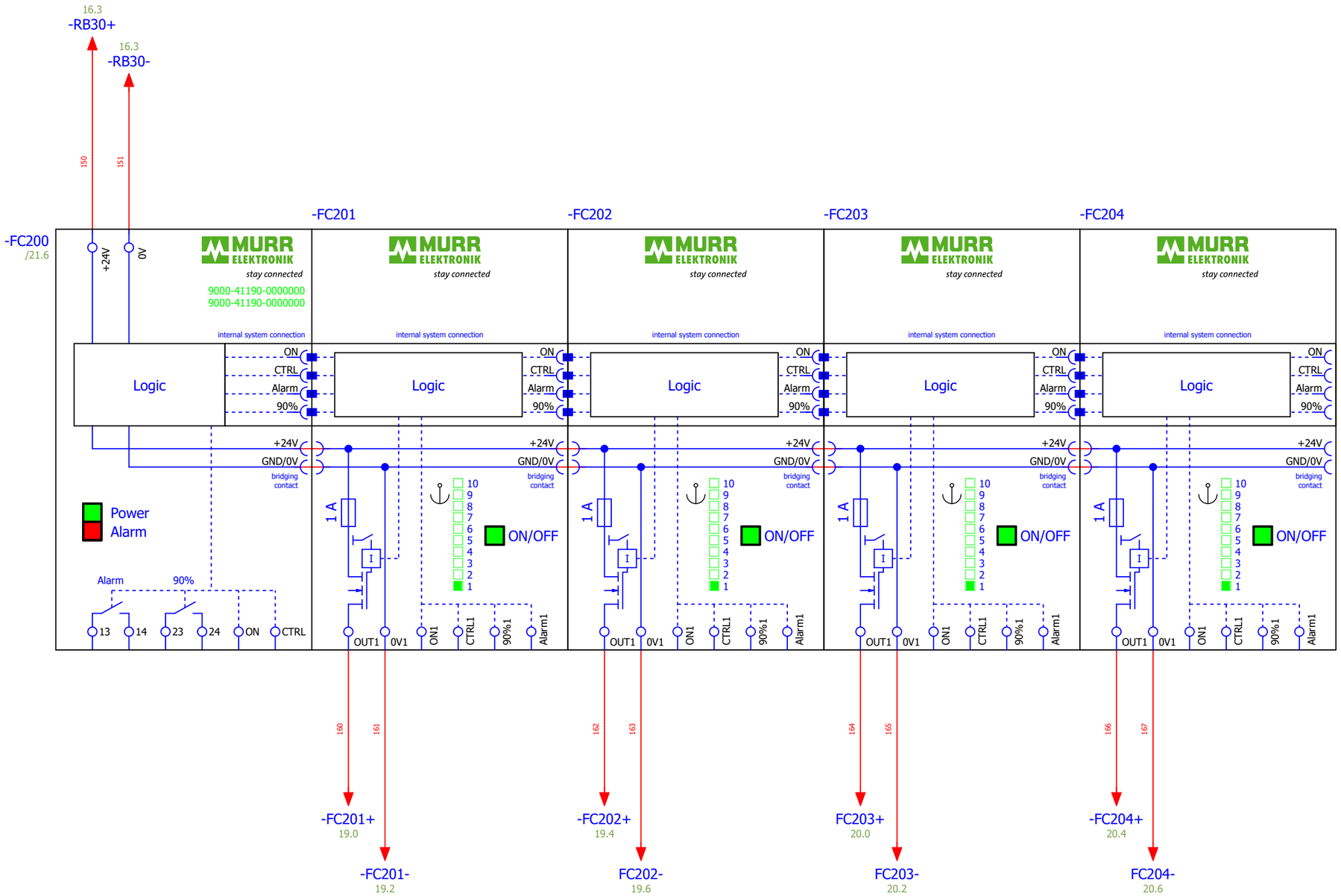
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant skid - 24 VDC Supply - Back up battery		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 17 / 82

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC30



Reference Item Number	Ballard Part # TBD		
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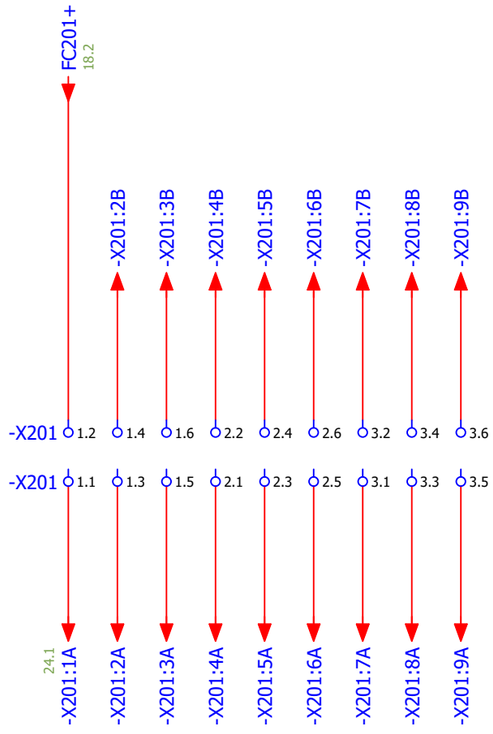
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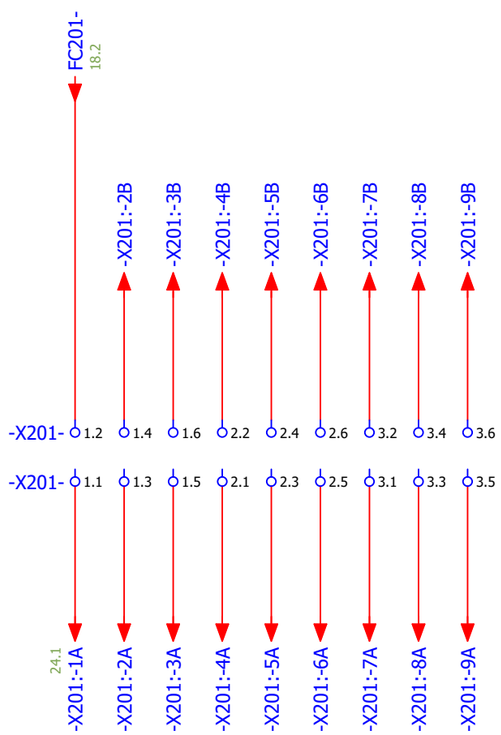
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant skid - 24 VDC Supply - fuses		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 18 / 82

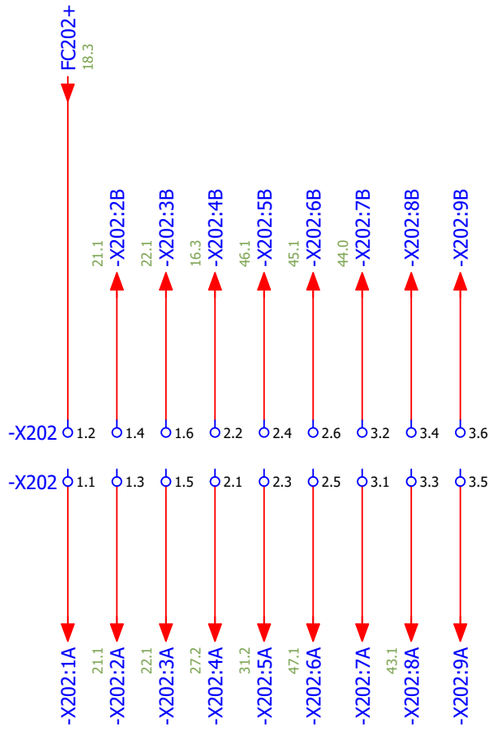
=LA01+UC30

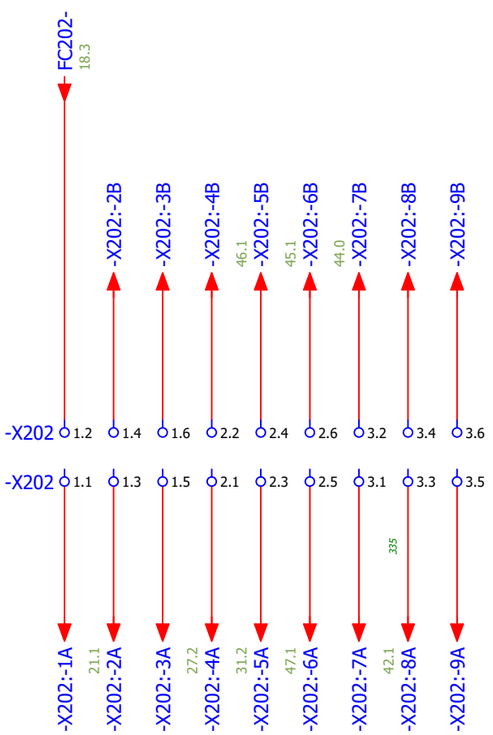
Safety





Internal 24VDC Supply





Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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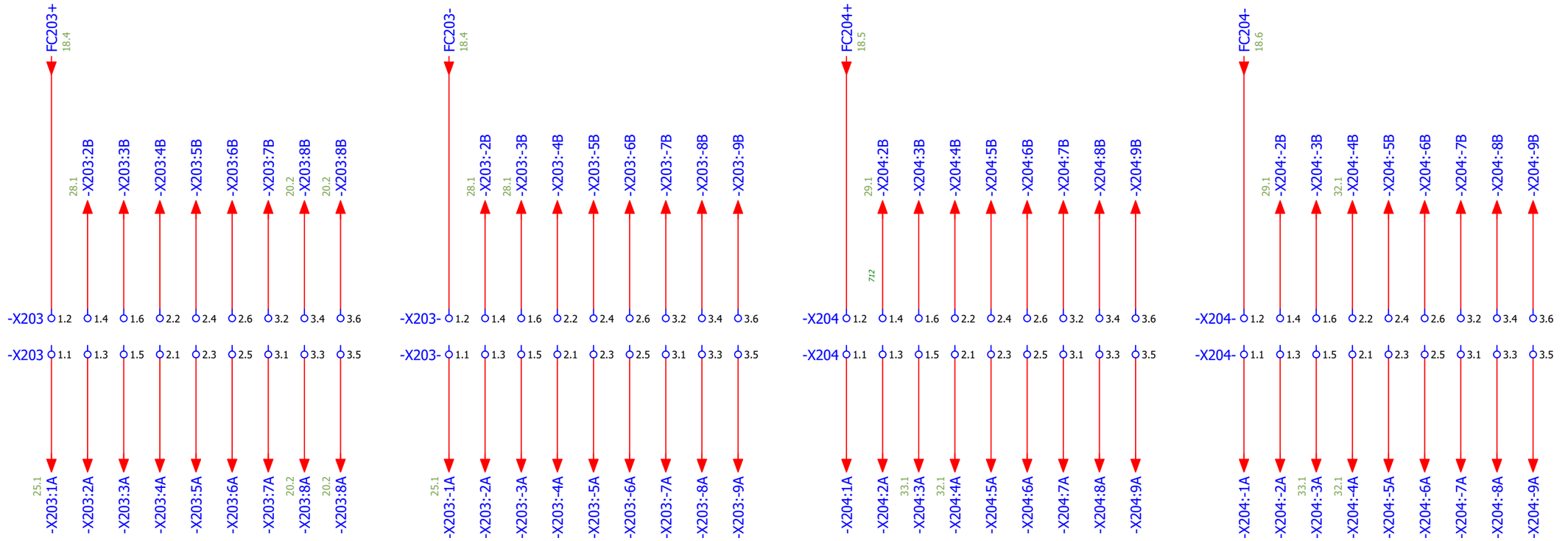
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant skid - 24 VDC Supply - Distribution		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 19 / 82

=LA01+UC30

External 24VDC Supply

External 24VDC Supply



Reference Item Number	Ballard Part # TBD		
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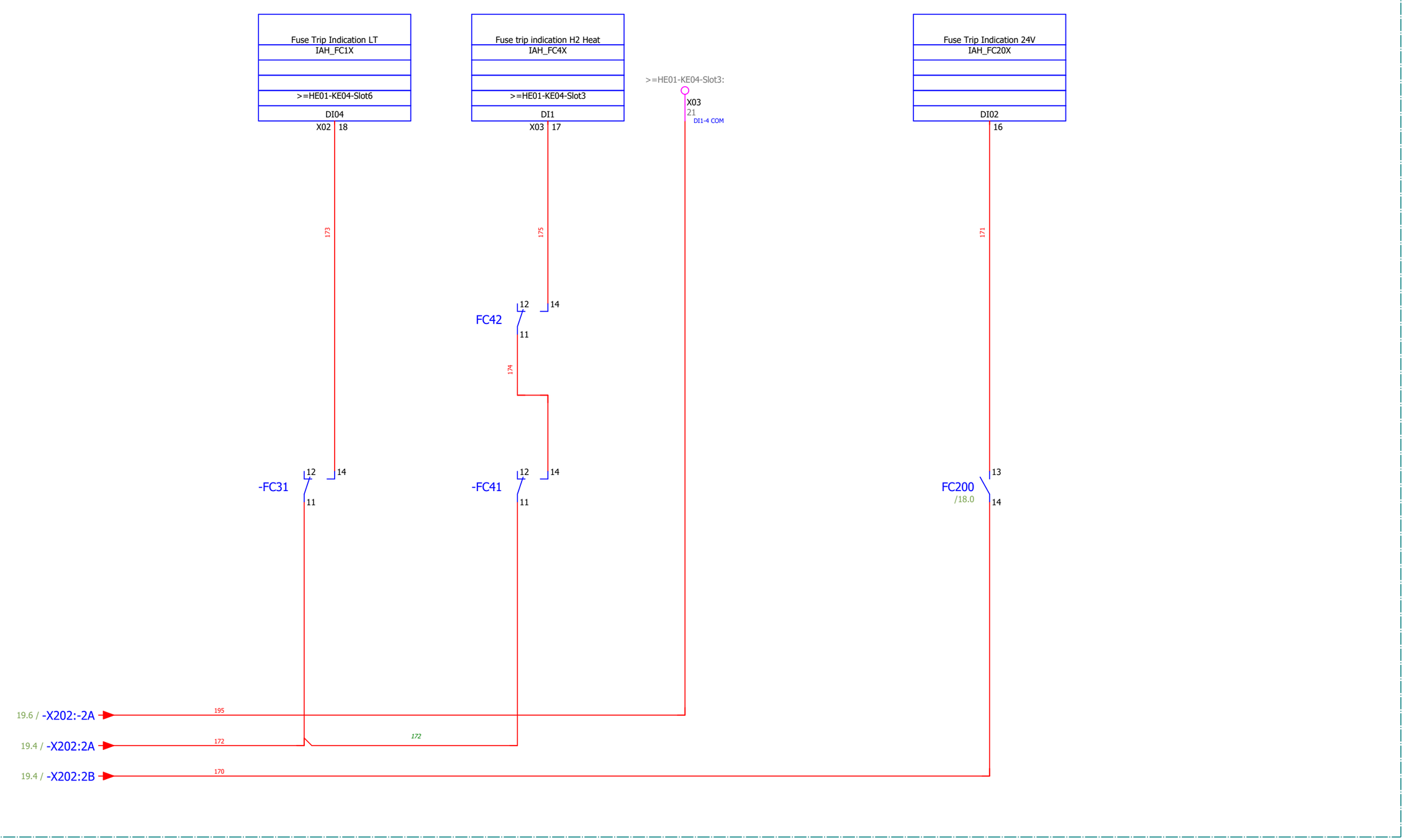
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant skid - 24 VDC Supply - Distribution		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 20 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

Power conversion BOP Cooling skid cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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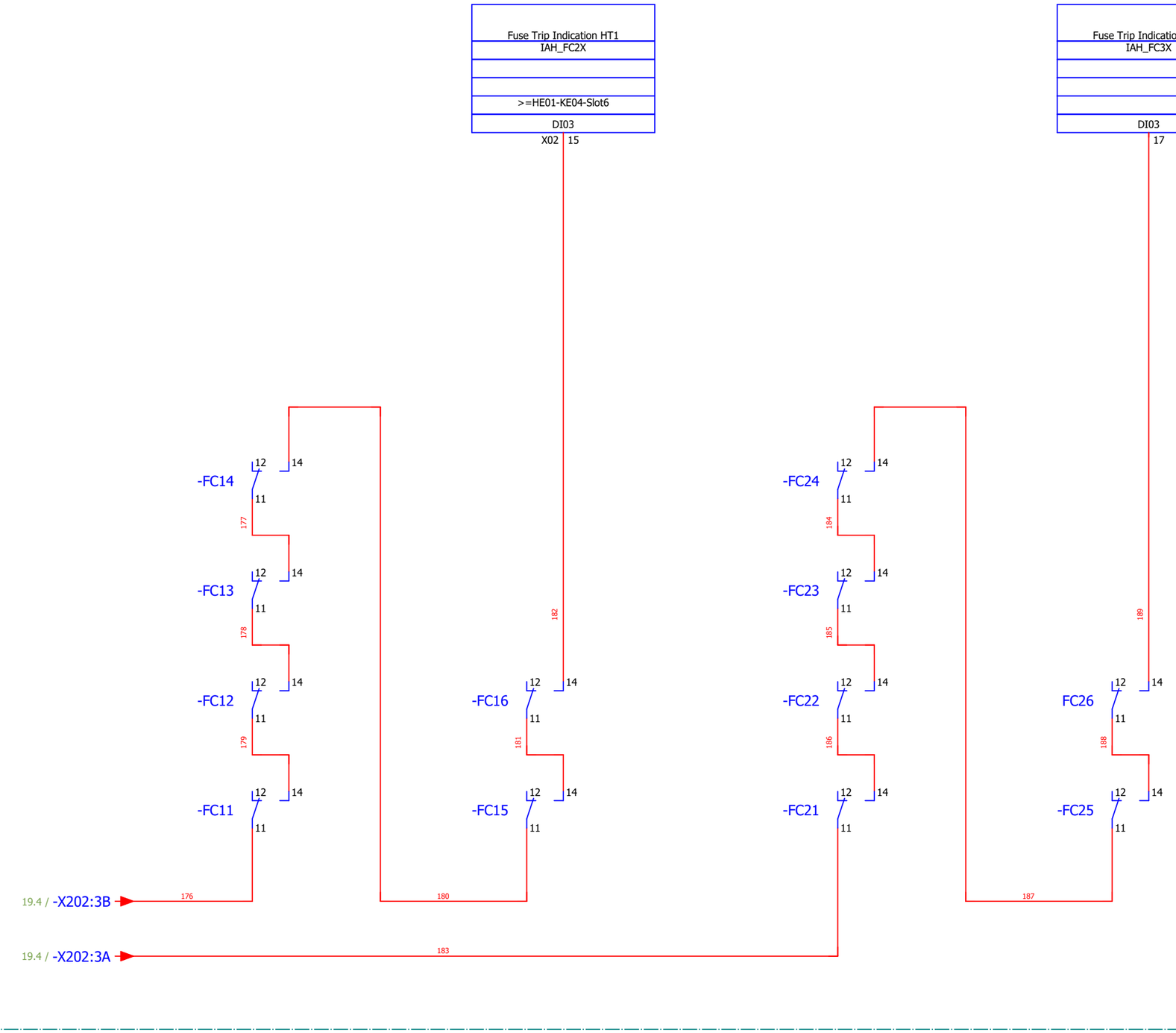
DRAWING	K559-2254-CWIWP4202202-E03-003		REVISION	11	
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet				
SHEET TYPE/DESC	40ft Coolant skid - MCCB Trip Indication 24V				
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	21 / 82	

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC30

Power conversion BOP Cooling skid cabinet



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EPLAN Revision	11		
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant skid - MCCB Trip Indication HT1+2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 22 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside

=LB02+DA04
Coolant System Power Distribution, Container #1 Outside

719
721
720
722

-SG01
Cabinet ESTOP
11 21
12 22

-S1
11 21
12 22

-WG01
Emergency stop
1 2 3 4

719 → KE12:X1 / 24.1
723 → KE12:3 / 24.1
724 → KE12:4 / 24.1
725 → KE12:7 / 24.1

-X100 X1 1 2 3 4 5 6 7 3' 4'

KF10 FB Forward
ESD CH1 Forward
ESD CH2 Forward
KF10 FB Return
KF10 Coil
ESD CH1 Return
ESD CH2 Return
KF10 DCCOM

-WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
Coolant Skid ESTOP

-WG02
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Coolant Skid Safety Relay

-WG01
+UC20/59.0

-WG02
+UC20/59.0

Reference Item Number	Ballard Part # TBD
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Safety circuit		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 23 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

Coolant System Power Distribution, Container #1 Outside

23.5 / KE12:X1 → 719

23.5 / KE12:4 → 724

726 → KF10:23 / 27.5

727 → KF10:33 / 27.5

KF10

PHOENIX CONTACT

PSR-MC82-5NO-1NC-1DO-24DC-SC

24V, A1, 11, 23, 33, 43, 53, 63

A1, A2

A1, A2

11, 12, 23, 24, 33, 34, 43, 44, 53, 54, 63, 64

M1, A2, 12, 24, 34, 44, 54, 64

19.0 / -X201:1A → 168

19.2 / -X201:-1A → 169

23.5 / KE12:7 → 725

23.5 / KE12:3 → 723

Reference Item Number	Ballard Part # TBD		
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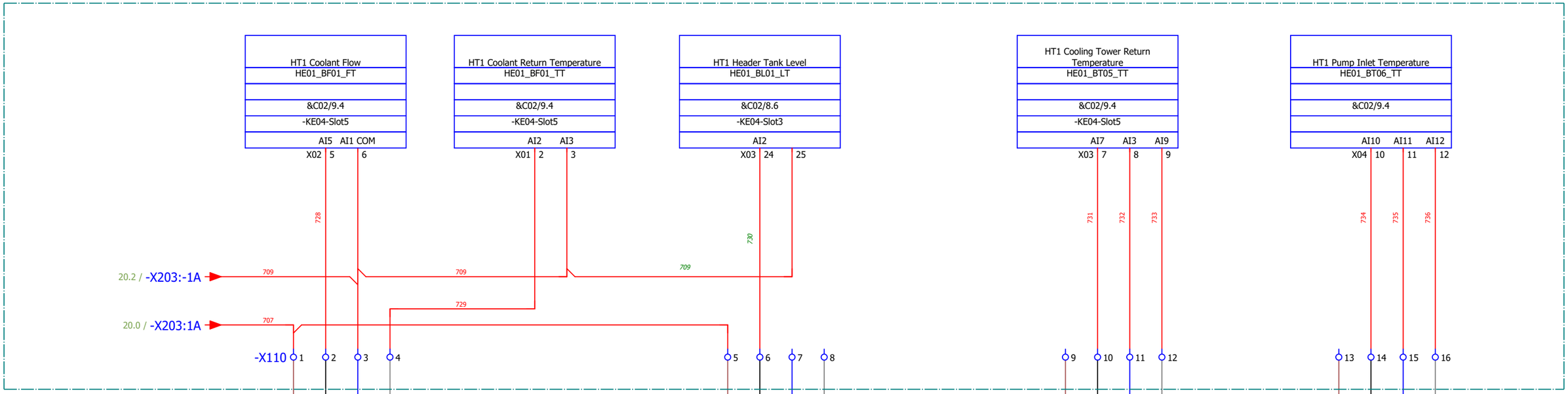
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Safety circuit		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 24 / 82

0	1	2	3	4	5	6	7	8

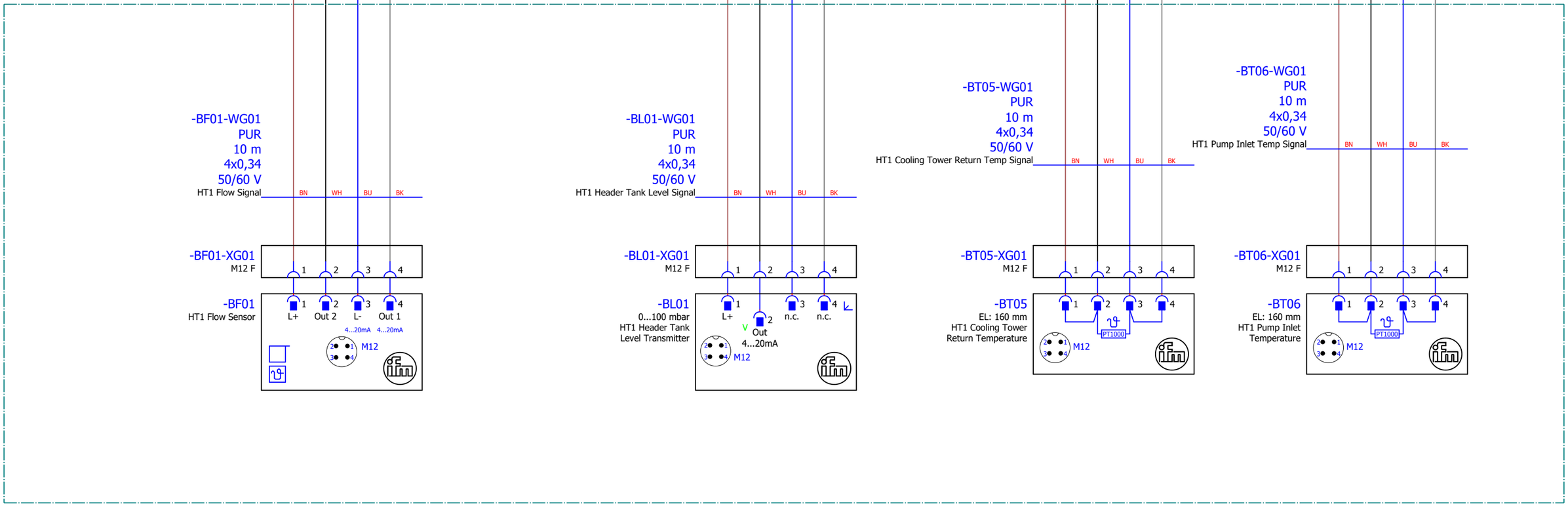
=LA01+UC30

Coolant System Power Distribution, Container #1 Outside



=HE01+DA02

HT#1 Coolant Sensor/Actuator, Coolant Skid



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03-Sep-25

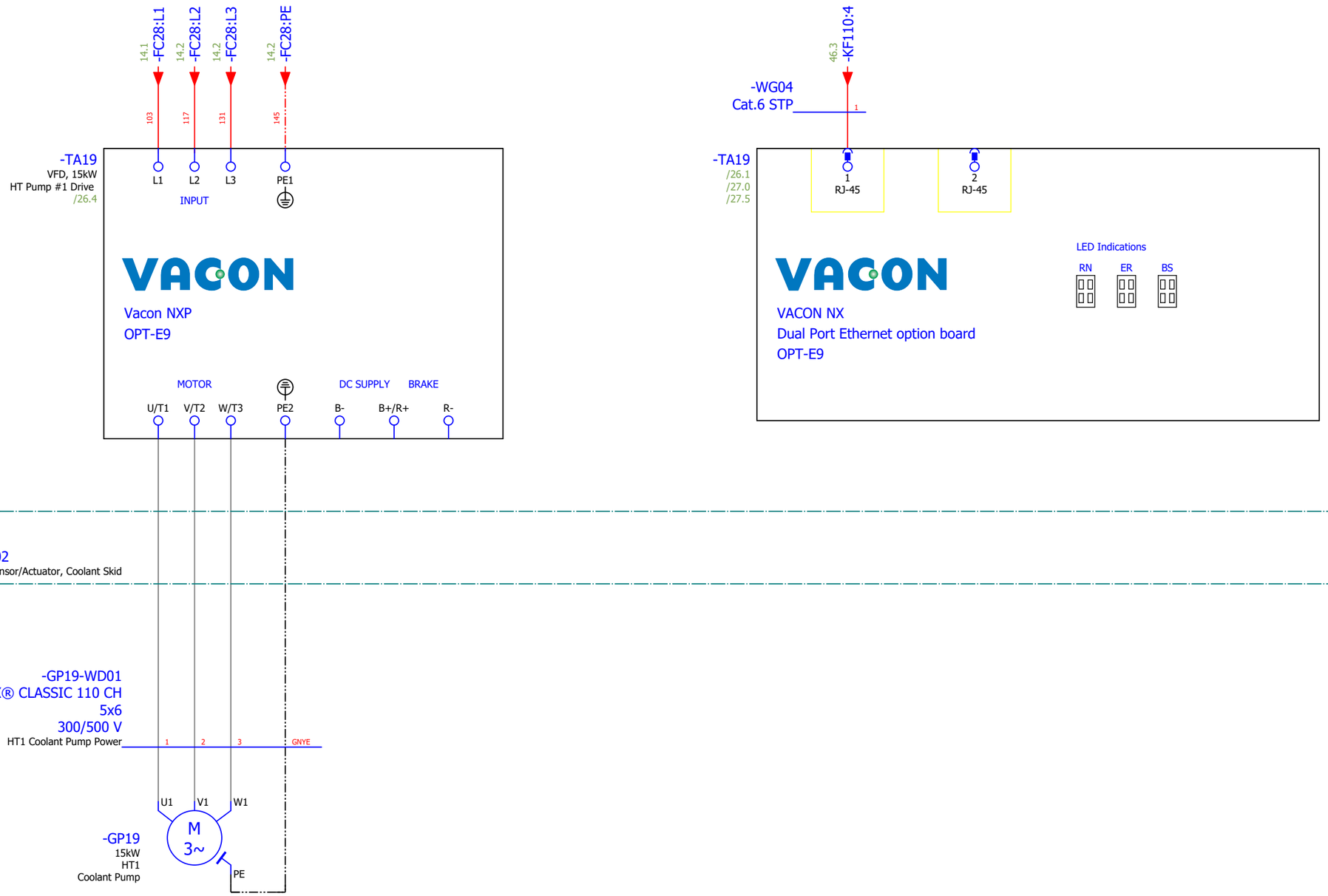
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #1 Sensors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 25 / 82

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside



=HE01+DA02
HT#1 Coolant Sensor/Actuator, Coolant Skid

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

REVISION INFORMATION
DESCRIPTION
DATE
03-Sep-25

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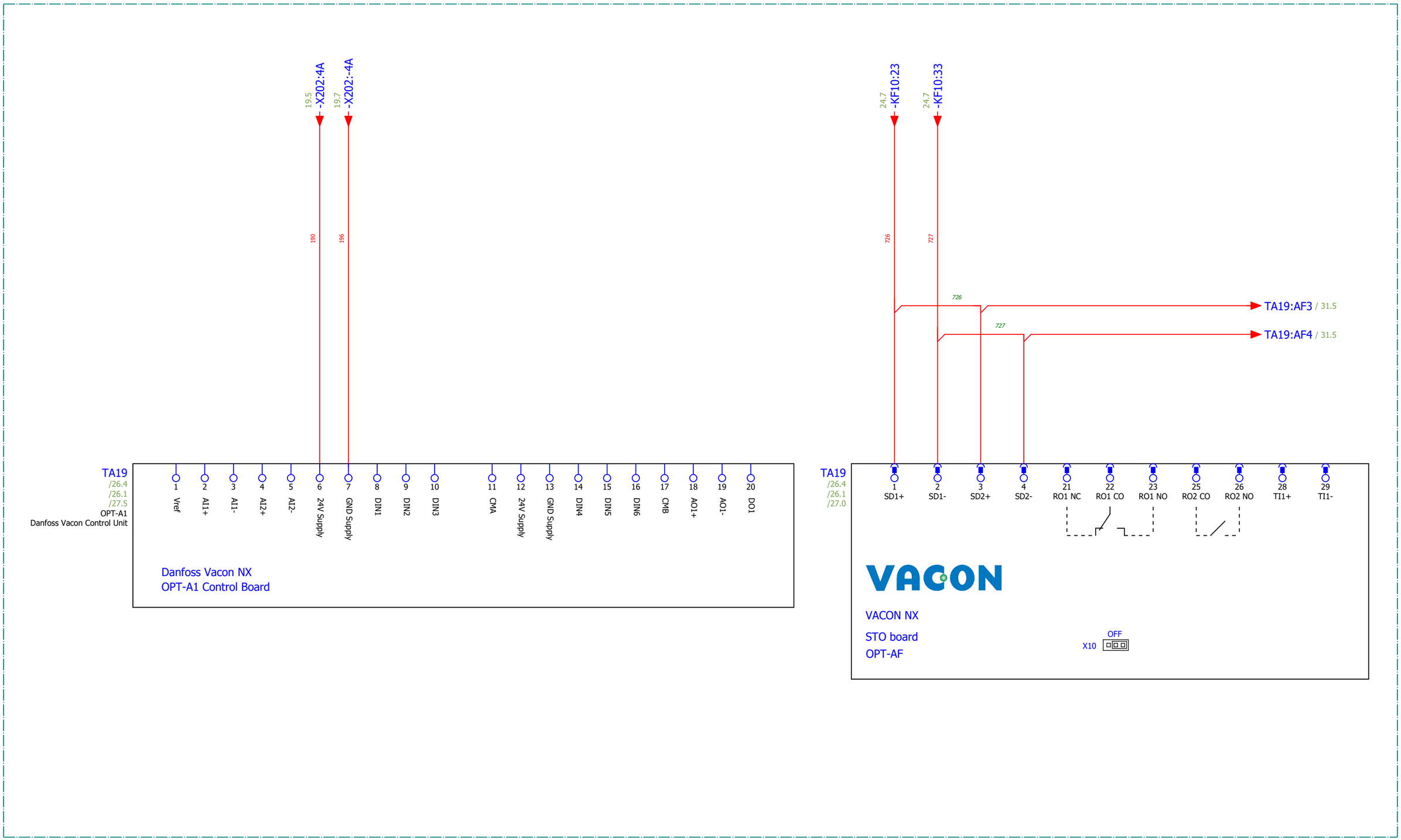
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #1 Coolant Pump		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 26 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

Coolant System Power Distribution, Container #1 Outside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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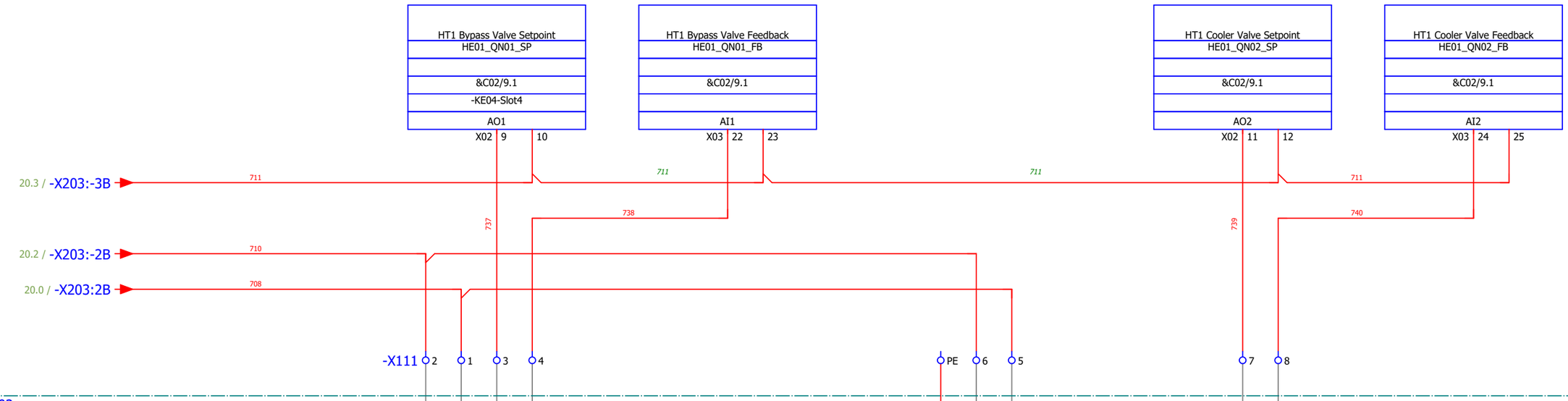
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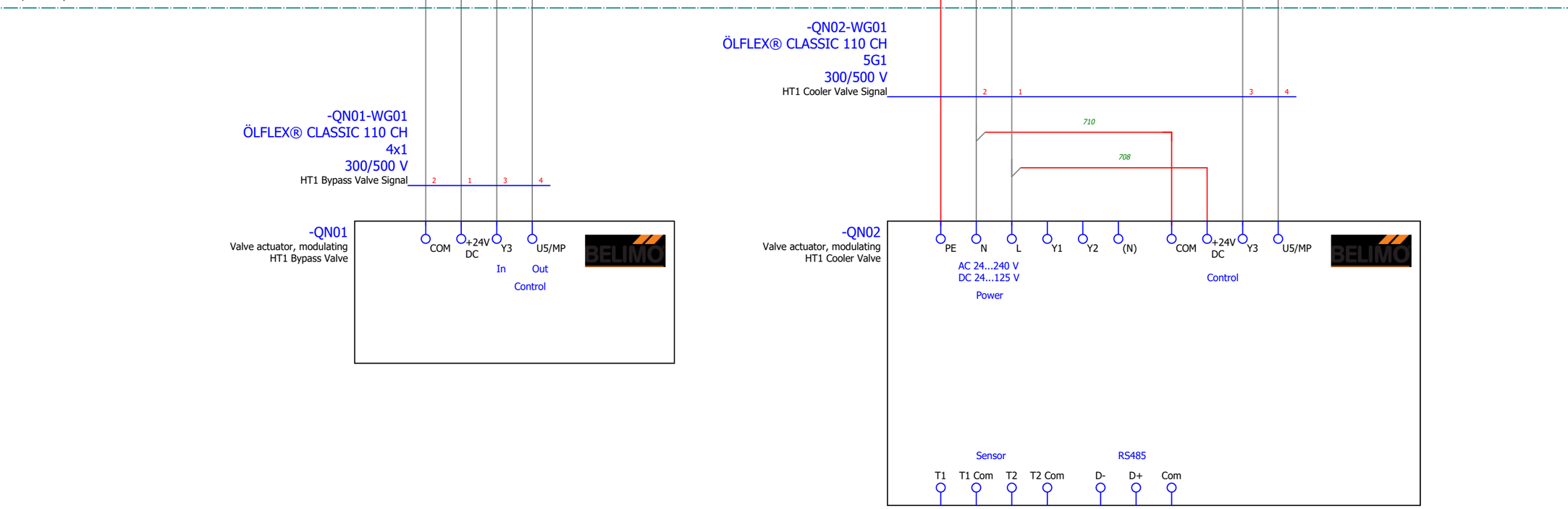
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #1 Coolant Pump VFD Interface		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 27 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside



=HE01+DA02
HT#1 Coolant Sensor/Actuator, Coolant Skid



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #1 Mixing Valves		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 28 / 82

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside

HT2 Coolant Flow
HE02_BF01_FT
&C02/9.4
-KE04-Slot5
AI17
X06 17 18

Main HT Coolant Return Temperature
HE02_BF01_TT
&C02/9.4
-KE04-Slot5
AI14
X05 14 15

HT2 Header Tank Level
HE02_BL01_LT
&C02/8.6
-KE04-Slot3
AI4
X03 28 29

HT2 Cooling Tower Return Temperature
HE02_BT05_TT
&C02/9.4
-KE04-Slot5
AI19
X07 19 20 21

HT2 Pump Inlet Temperature
HE02_BT06_TT
&C02/9.4
AI22
X08 22 23 24

20.6 / -X204:-2B
20.4 / -X204:2B
715
715
715
741
742
743
712
744
745
746
747
748
749

-X112 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

=HE02+DA02
HT#2 Coolant Sensor/Actuator, Coolant Skid

-BF01-WG01
PUR
10 m
4x0,34
50/60 V
HT2 Flow Signal
BN WH BU BK

-BF01-XG01
M12 F
1 2 3 4

-BF01
HT1 Flow Sensor
1 L+
2 Out 2
3 L-
4 Out 1
4...20mA 4...20mA
M12

-BL01-WG01
PUR
10 m
4x0,34
50/60 V
HT2 Header Tank Level Signal
BN WH BU BK

-BL01-XG01
M12 F
1 2 3 4

-BL01
0...100 mbar
HT1 Header Tank
Level Transmitter
1 L+
2 V Out 4...20mA
3 n.c.
4 n.c.
M12

-BT05-WG01
PUR
10 m
4x0,34
50/60 V
HT2 Cooling Tower Return Temp Signal
BN WH BU BK

-BT05-XG01
M12 F
1 2 3 4

-BT05
EL: 160 mm
HT1 Cooling Tower
Return Temperature
1 2 3 4
PT1000
M12

-BT06-WG01
PUR
10 m
4x0,34
50/60 V
HT2 Pump Inlet Temp Signal
BN WH BU BK

-BT06-XG01
M12 F
1 2 3 4

-BT06
EL: 160 mm
HT1 Pump Inlet
Temperature
1 2 3 4
PT1000
M12

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
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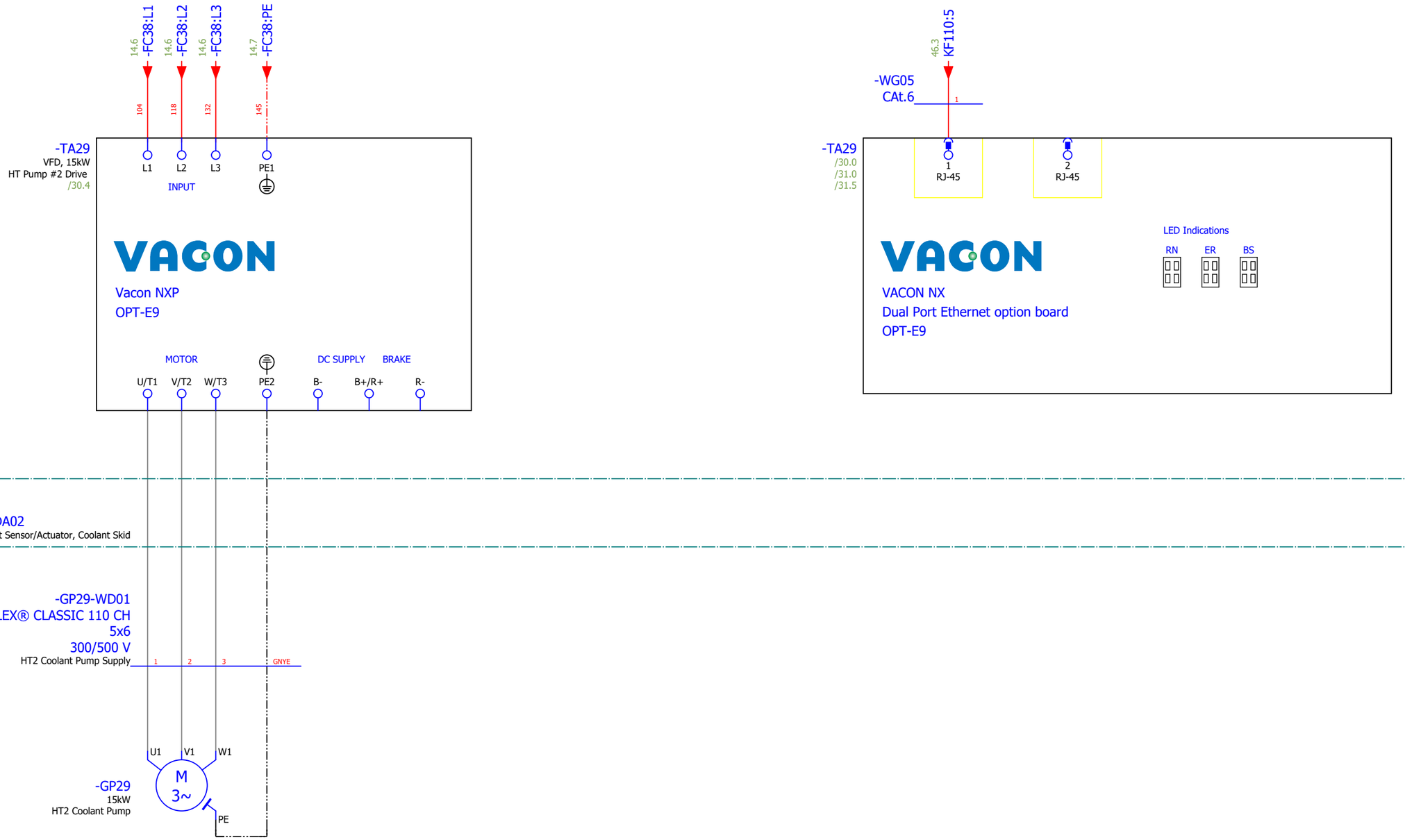
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #2 Sensors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 29 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside



=HE02+DA02
HT#2 Coolant Sensor/Actuator, Coolant Skid

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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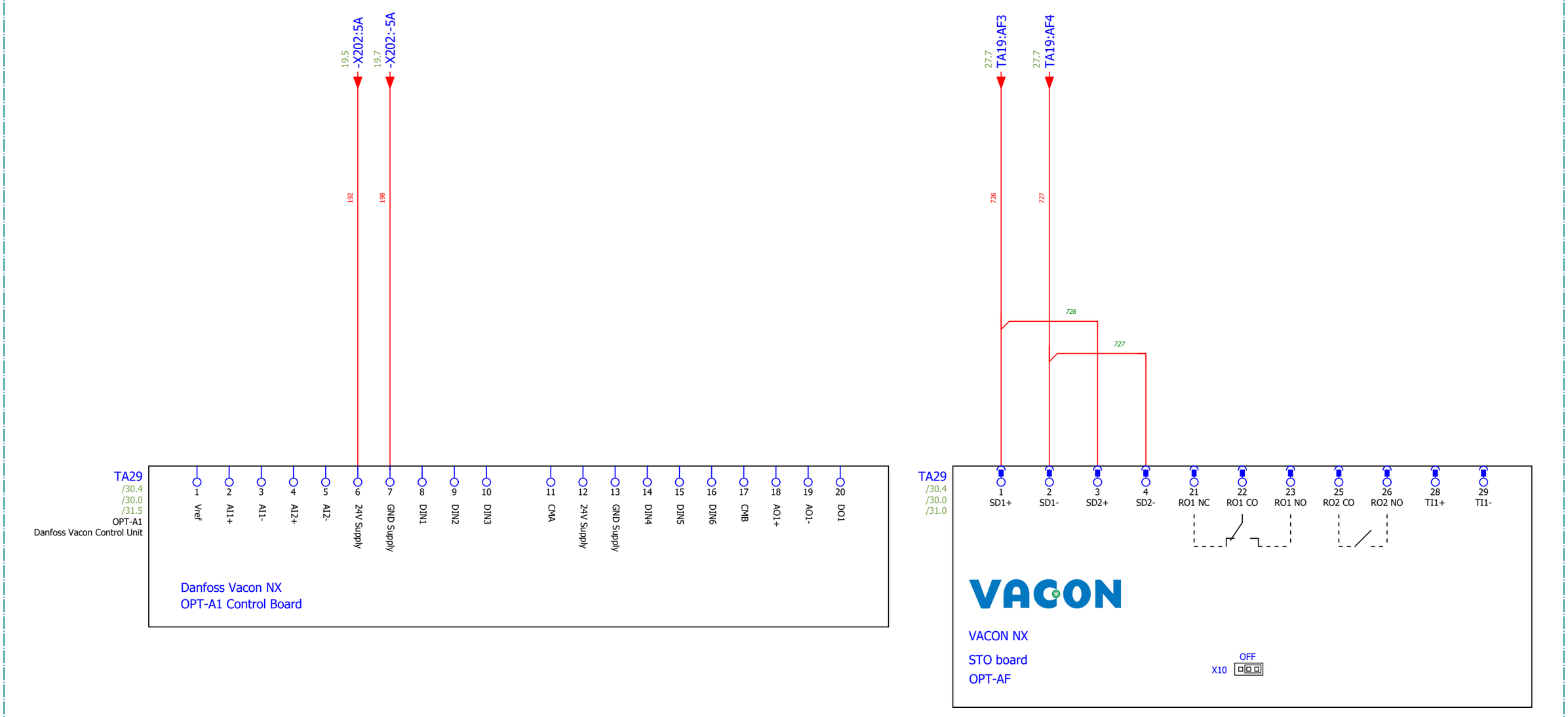
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #2 Coolant Pump		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 30 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

Coolant System Power Distribution, Container #1 Outside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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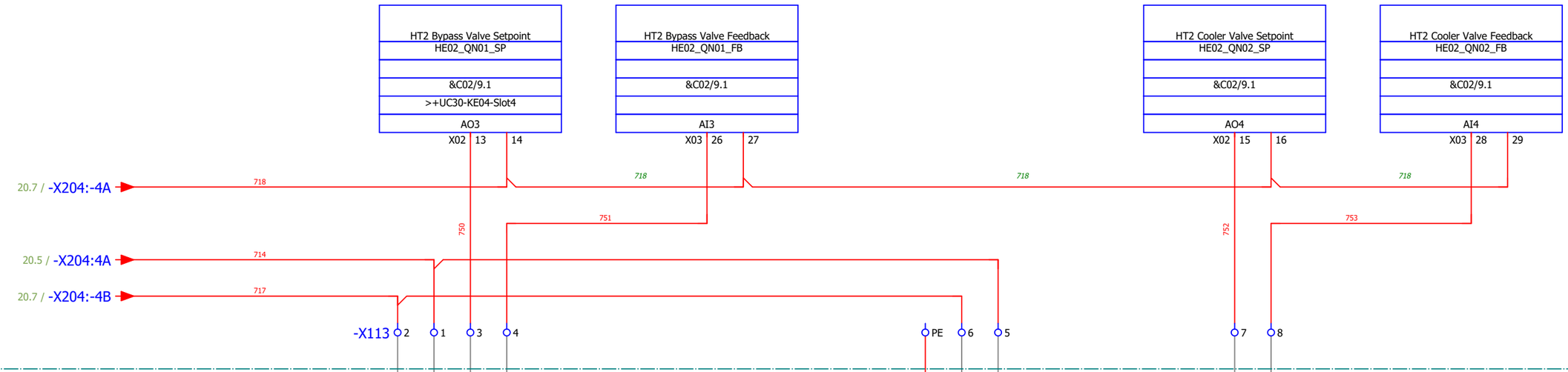
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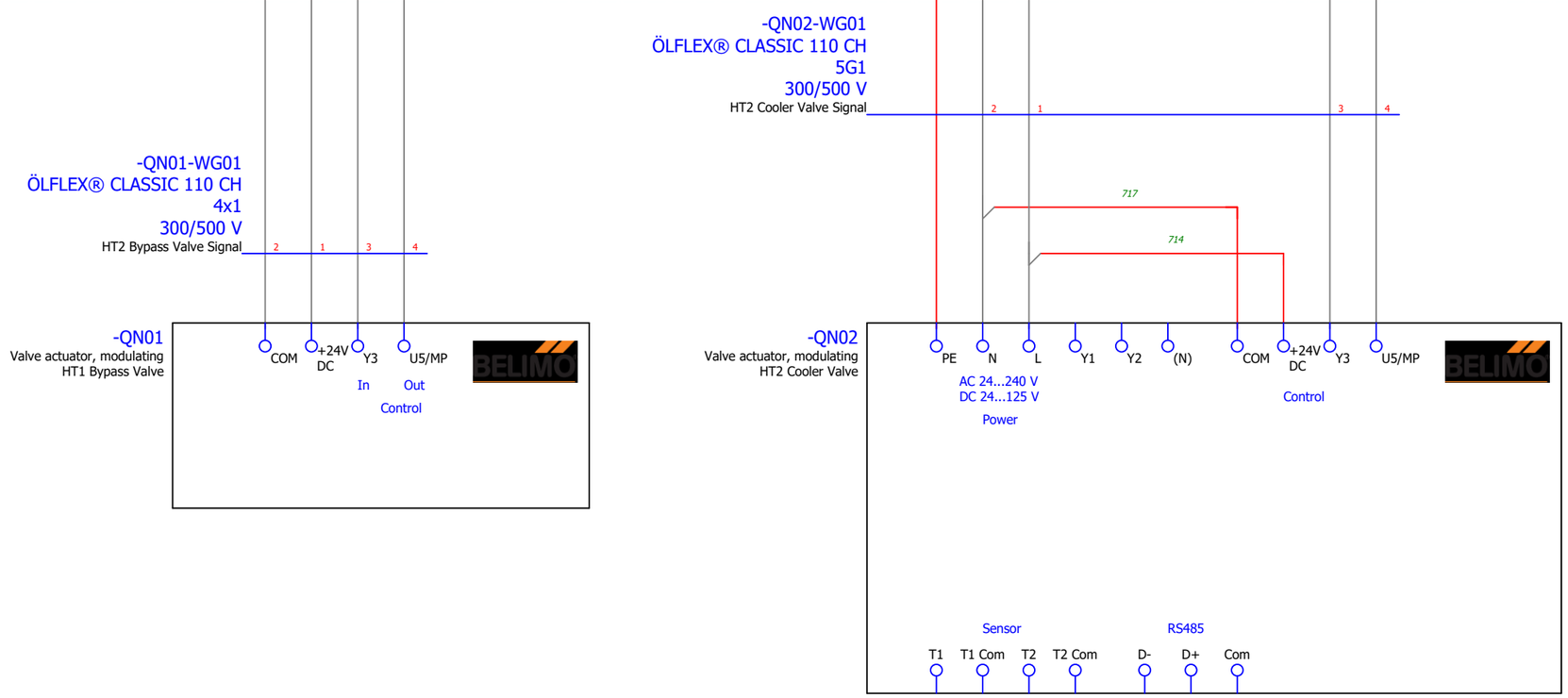
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #2 Coolant Pump VFD Interface		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 31 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside



=HE02+DA02
HT#2 Coolant Sensor/Actuator, Coolant Skid



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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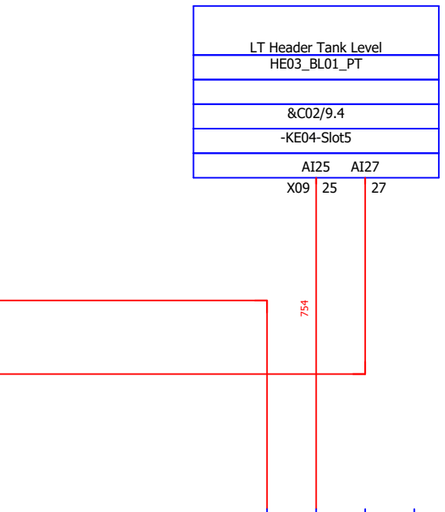
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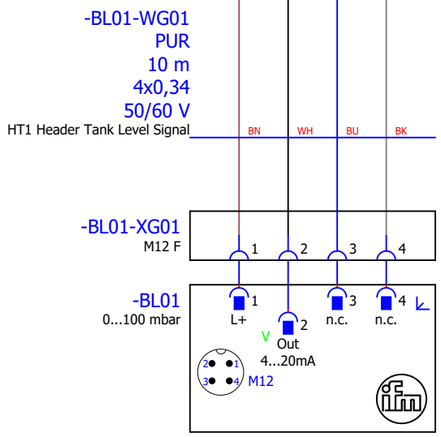
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT #2 Mixing Valves		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 32 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside



=HE03+DA02
LT Header Tank Coolant Sensor/Actuator, Coolant Skid



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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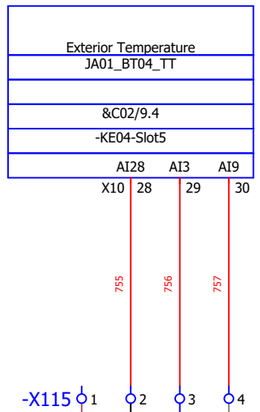
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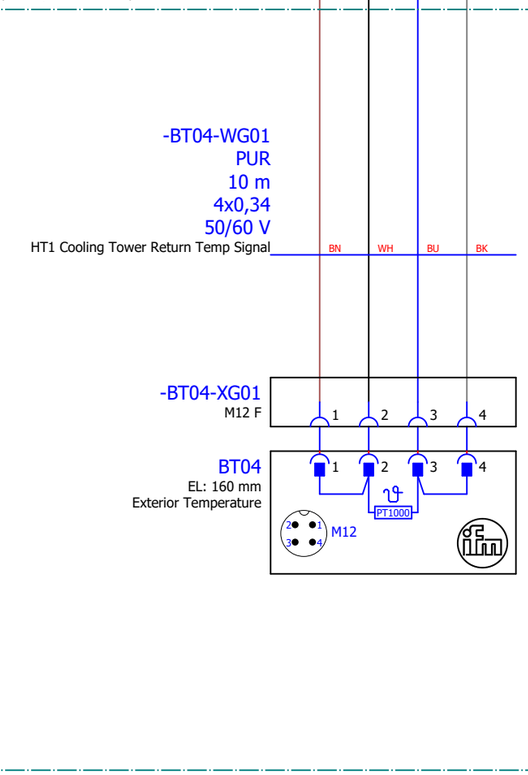
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - LT Header Tank		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 33 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
Coolant System Power Distribution, Container #1 Outside



=JA01+DA02
Ventilation systerm, Exterior Temperature



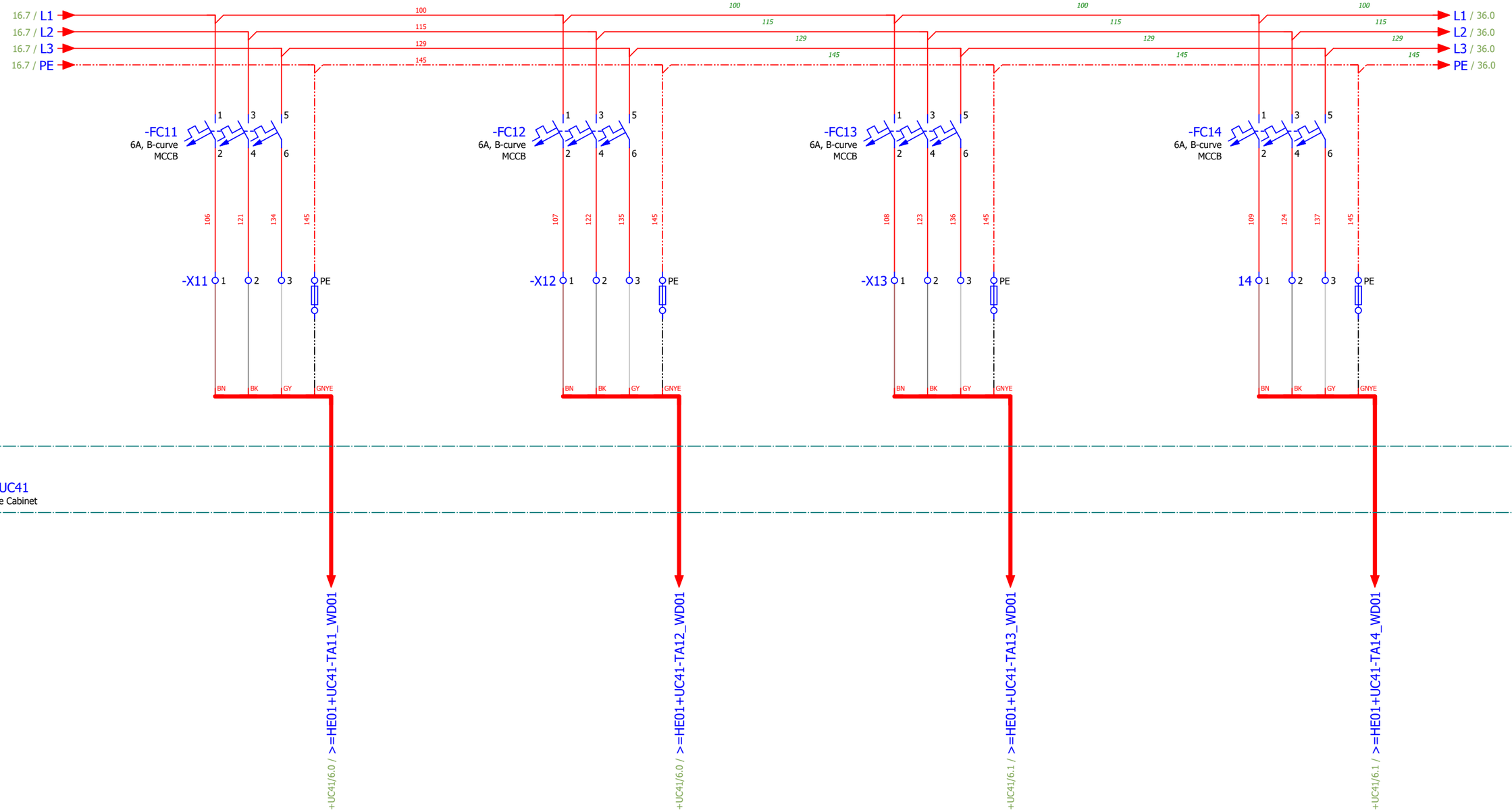
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EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
EPLAN Revision	11					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	40ft Coolant Skid - Exterior Temperature		
EPLAN Project Pages	629			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 34 / 82
=	++	+ UC30	& C03	03-Sep-25						

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01+UC30

40ft Coolant Skid - Control Cabinet



=HE01+UC41

HT Fan Drive Cabinet

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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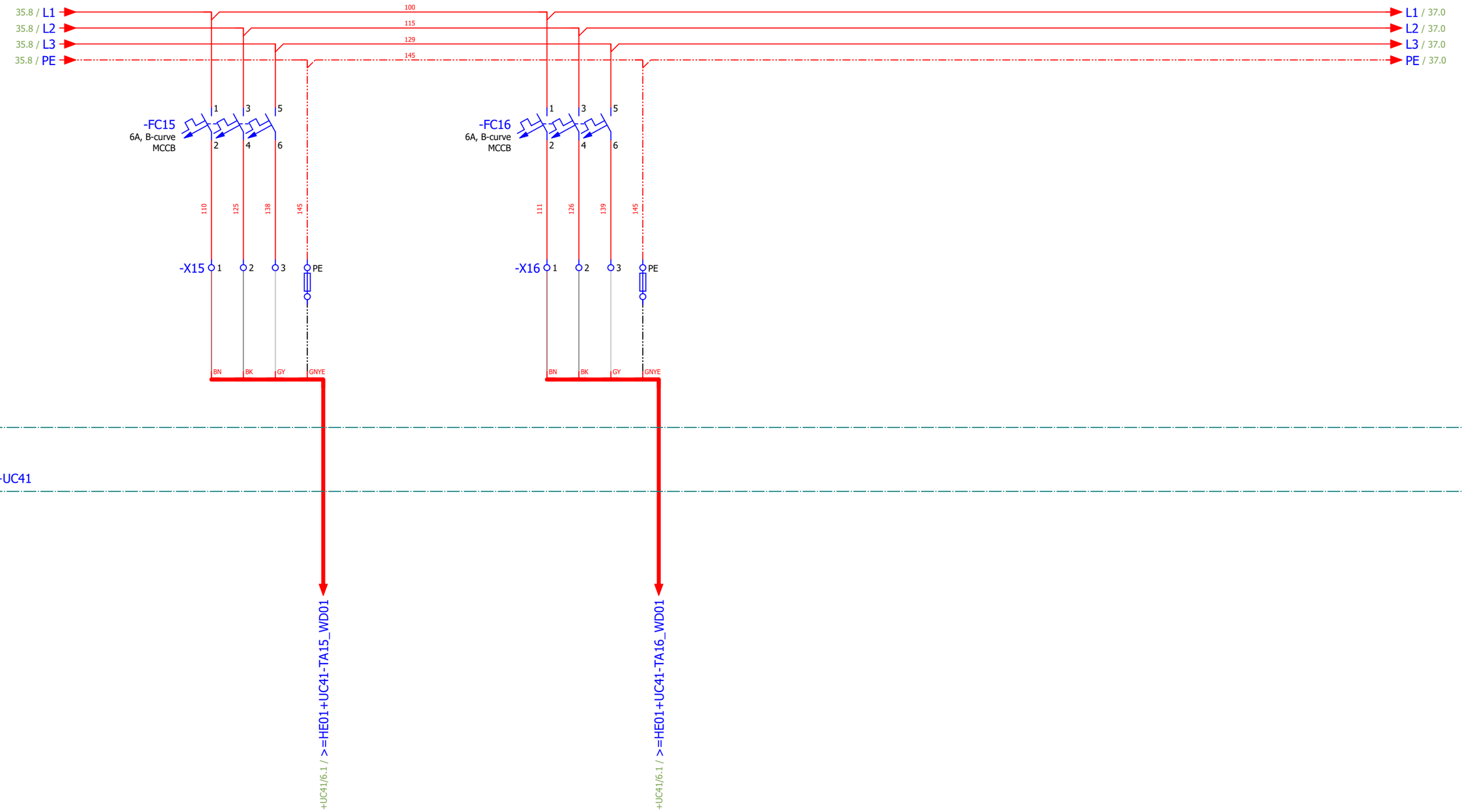
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT Cooler #1 Fan Power 1/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 35 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

40ft Coolant Skid - Control Cabinet



=HE01+UC41

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
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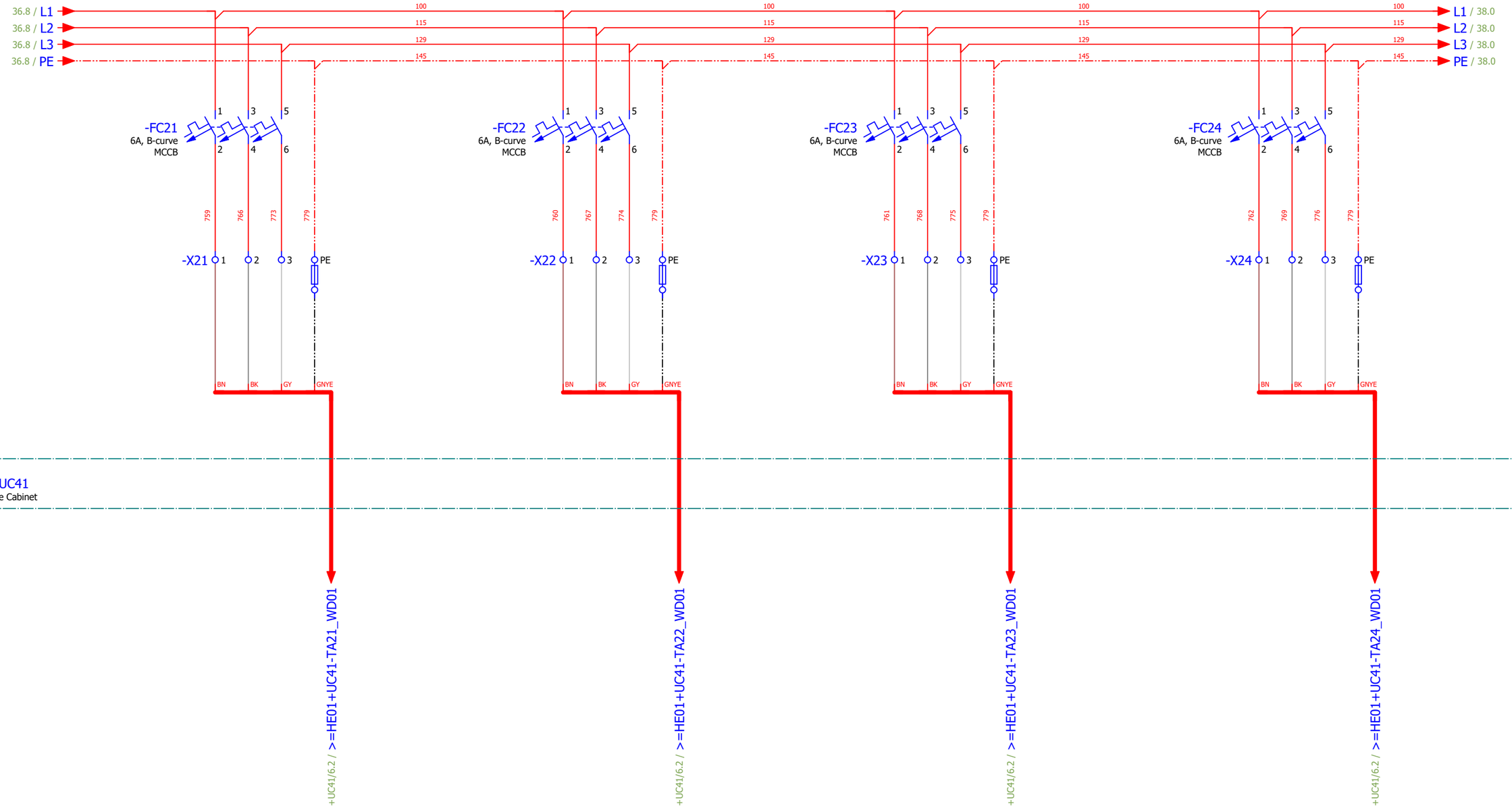
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT Cooler #1 Fan Power 2/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 36 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
40ft Coolant Skid - Control Cabinet



=HE01+UC41
HT Fan Drive Cabinet

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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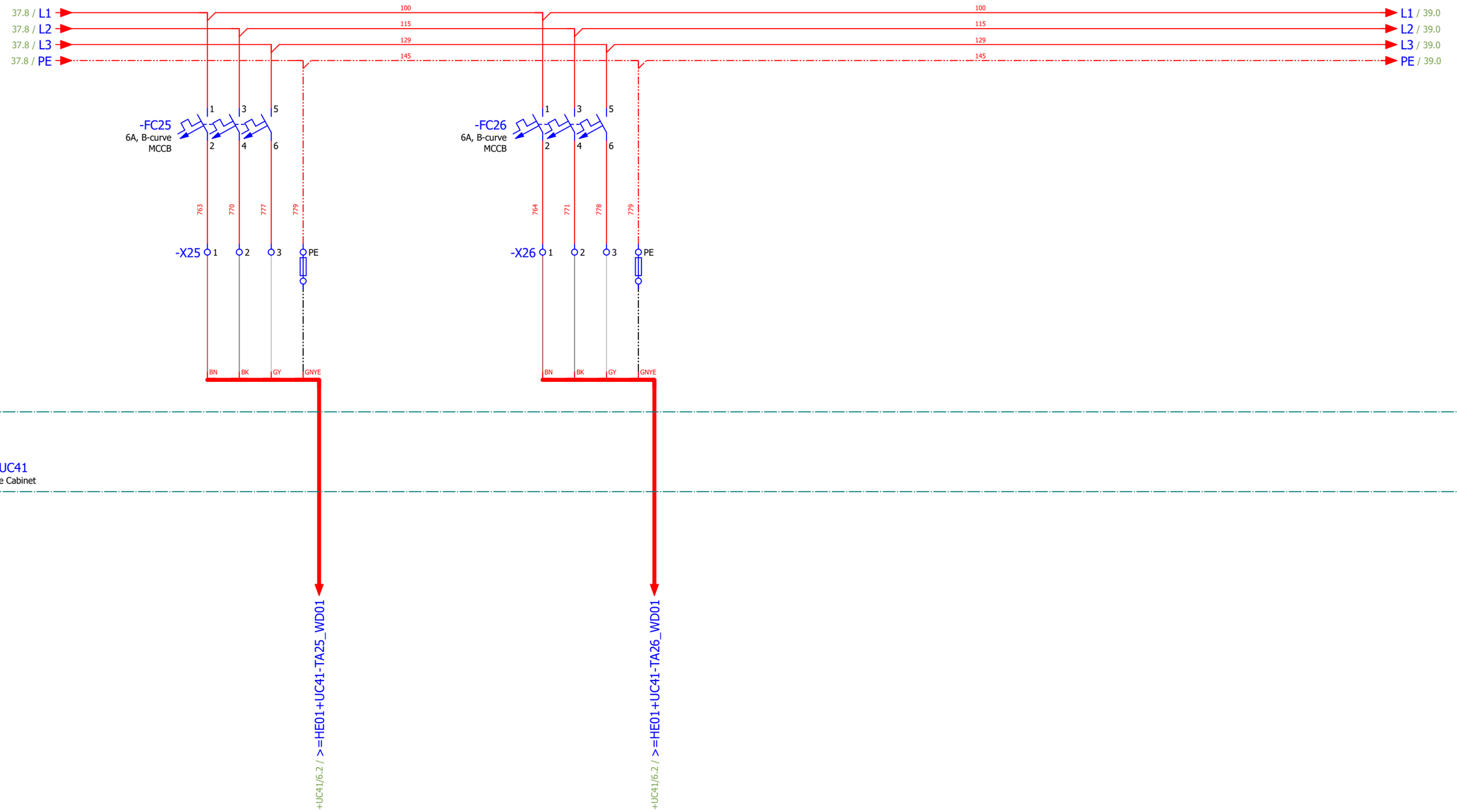
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT Cooler #2 Fan Power 1/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 37 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
40ft Coolant Skid - Control Cabinet



=HE01+UC41
HT Fan Drive Cabinet

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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DESCRIPTION	
DATE	
03-Sep-25	

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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - HT Cooler #2 Fan Power 2/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 38 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
40ft Coolant Skid - Control Cabinet



=HE01+UC41
HT Fan Drive Cabinet

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DESCRIPTION
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - LT Cooler Fan Power		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 39 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
40ft Coolant Skid - Control Cabinet



=HE01+UC41
HT Fan Drive Cabinet

+UC41/6.3 / >=HE01+UC41-EA40_WD01

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DESCRIPTION
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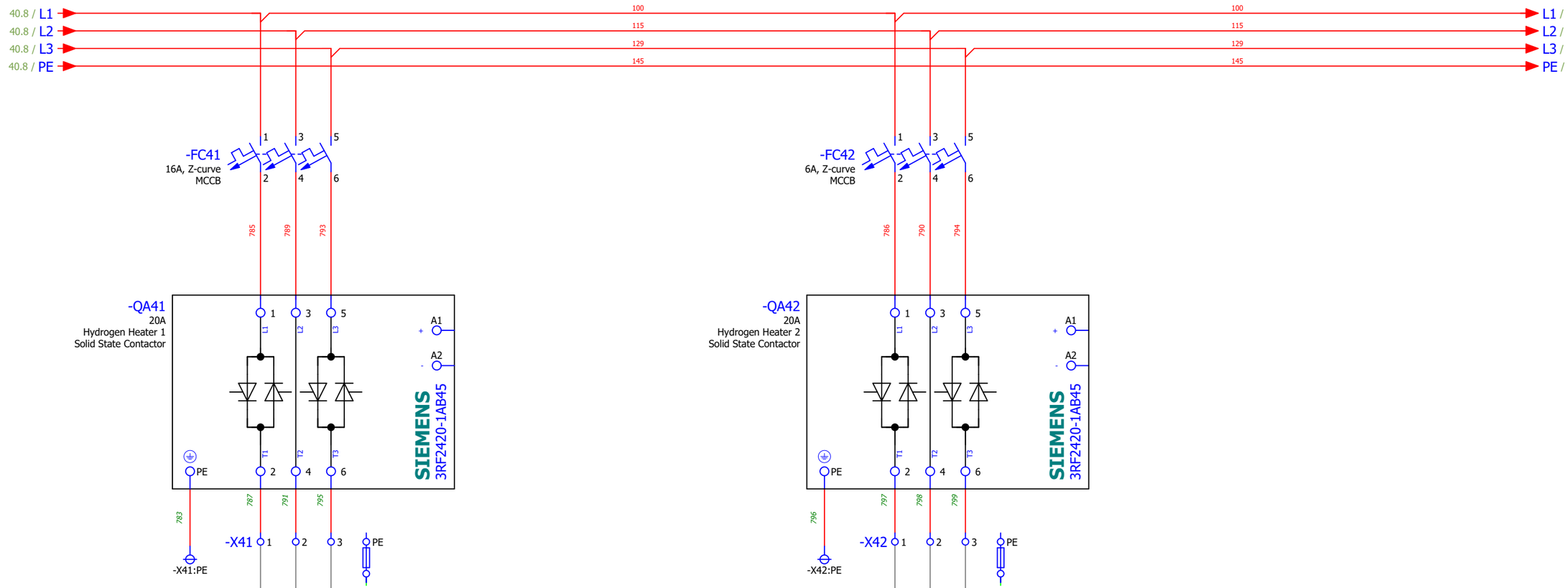
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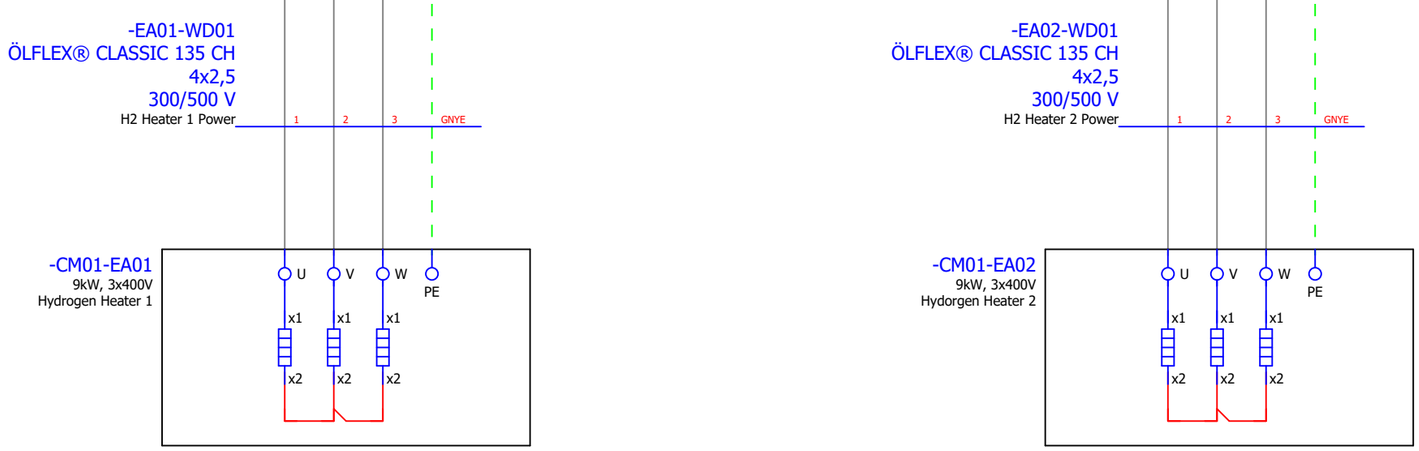
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - VFD Cabinet Airconditioning		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 40 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
40ft Coolant Skid - Control Cabinet



=HA01+DA02
Hydrogen Supply System, Outside Container #1



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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03-Sep-25	

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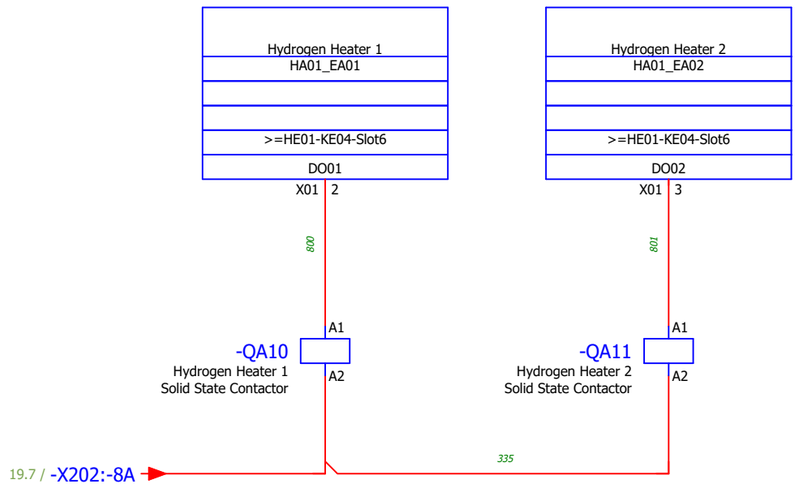
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Hydrogen Heater Power		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 41 / 82

FRM5103656/0B

=LA01+UC30
40ft Coolant Skid - Control Cabinet



=HA01+DA02
Hydrogen Heater

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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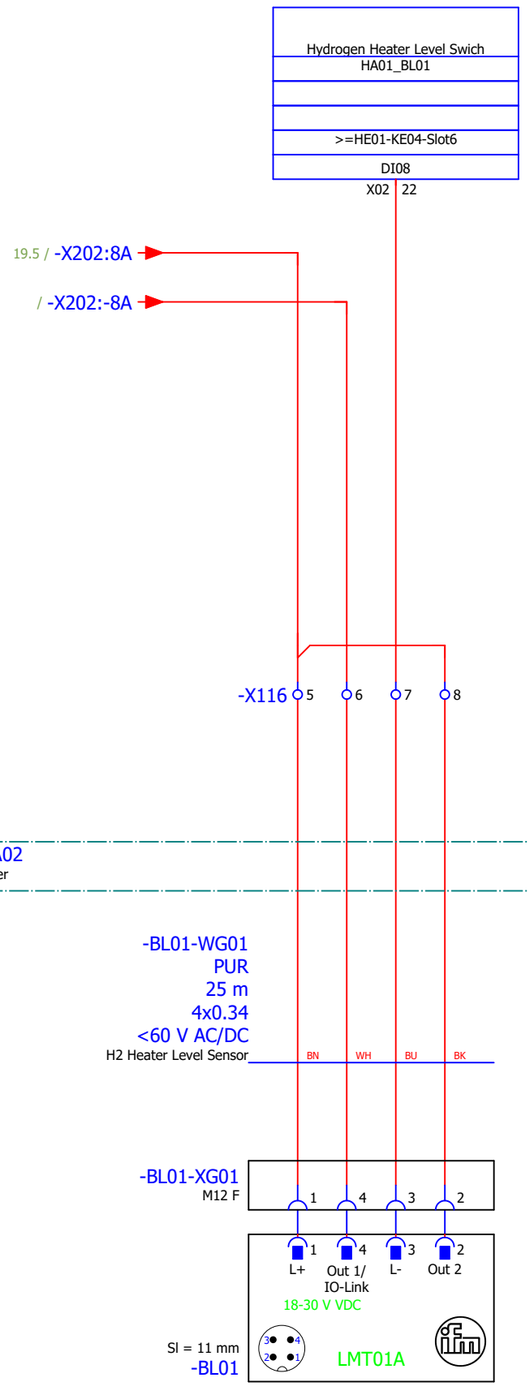
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Hydrogen Heater Control		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 42 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

40ft Coolant Skid - Control Cabinet



=HA01+DA02

Hydrogen Heater

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

REVISION INFORMATION
DESCRIPTION
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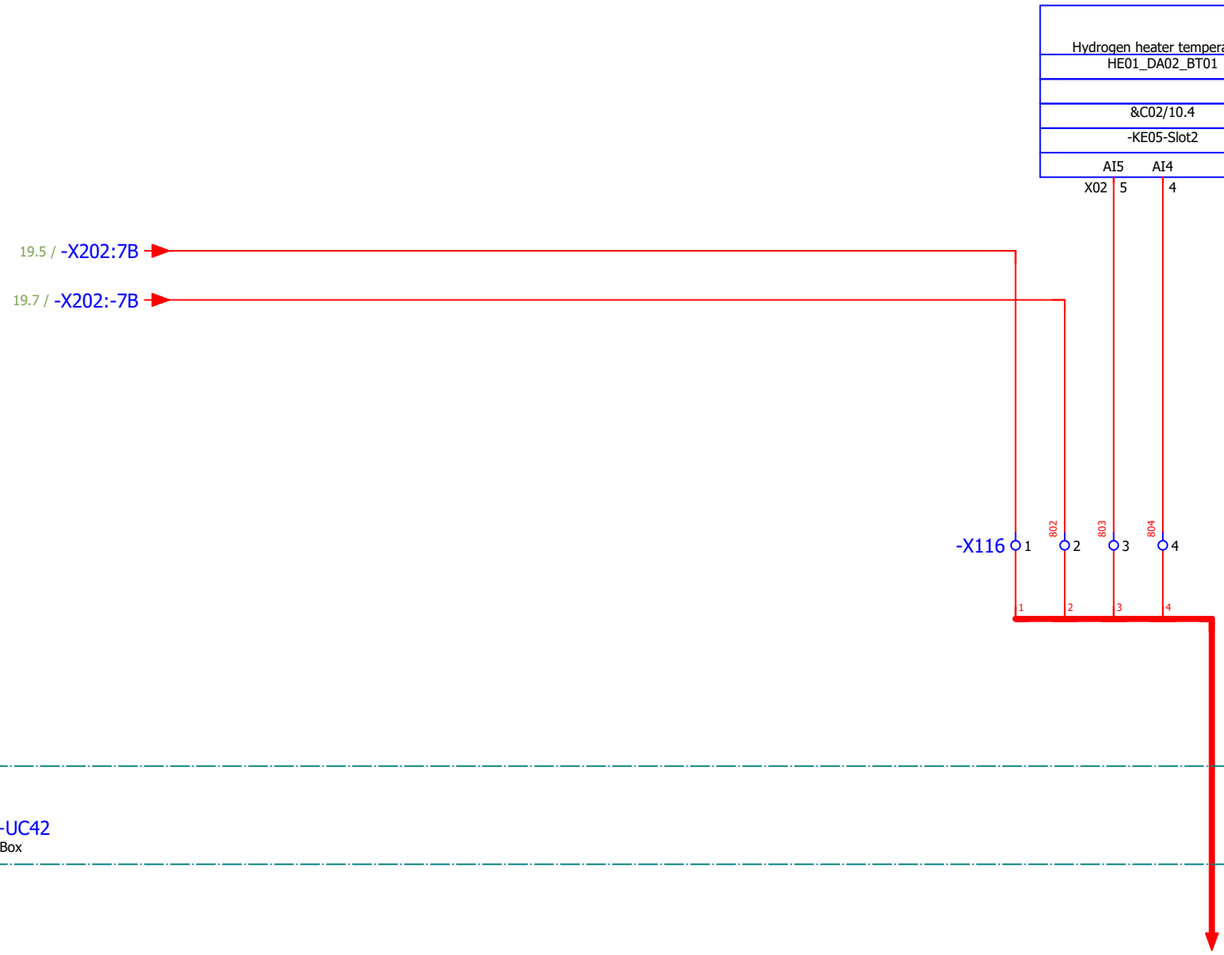
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Hydrogen Heater Control Level		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 43 / 82

=LA01+UC30
40ft Coolant Skid - Control Cabinet



=LA01+UC42
Ex Barrier Box

See document E03-008 for UC42 Ex Barrier Box Details

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Hydrogen Heater Control Temperature		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 44 / 82

=LA01+UC30
40ft Coolant Skid - Control Cabinet

Hydrogen Inlet Pressure
=DA01+DA02+BP01
&C02/10.4
-KE05-Slot2
AI2
3 X01 2

19.5 / -X202:6B
19.7 / -X202:-6B

-X116 9 10 11 12
1 2

>=LA01+UC30-BP01
+UC42/4.6

See document E03-008 for UC42 Ex Barrier Box Details

=HA01+UC42
Ex Barrier Box

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DATE
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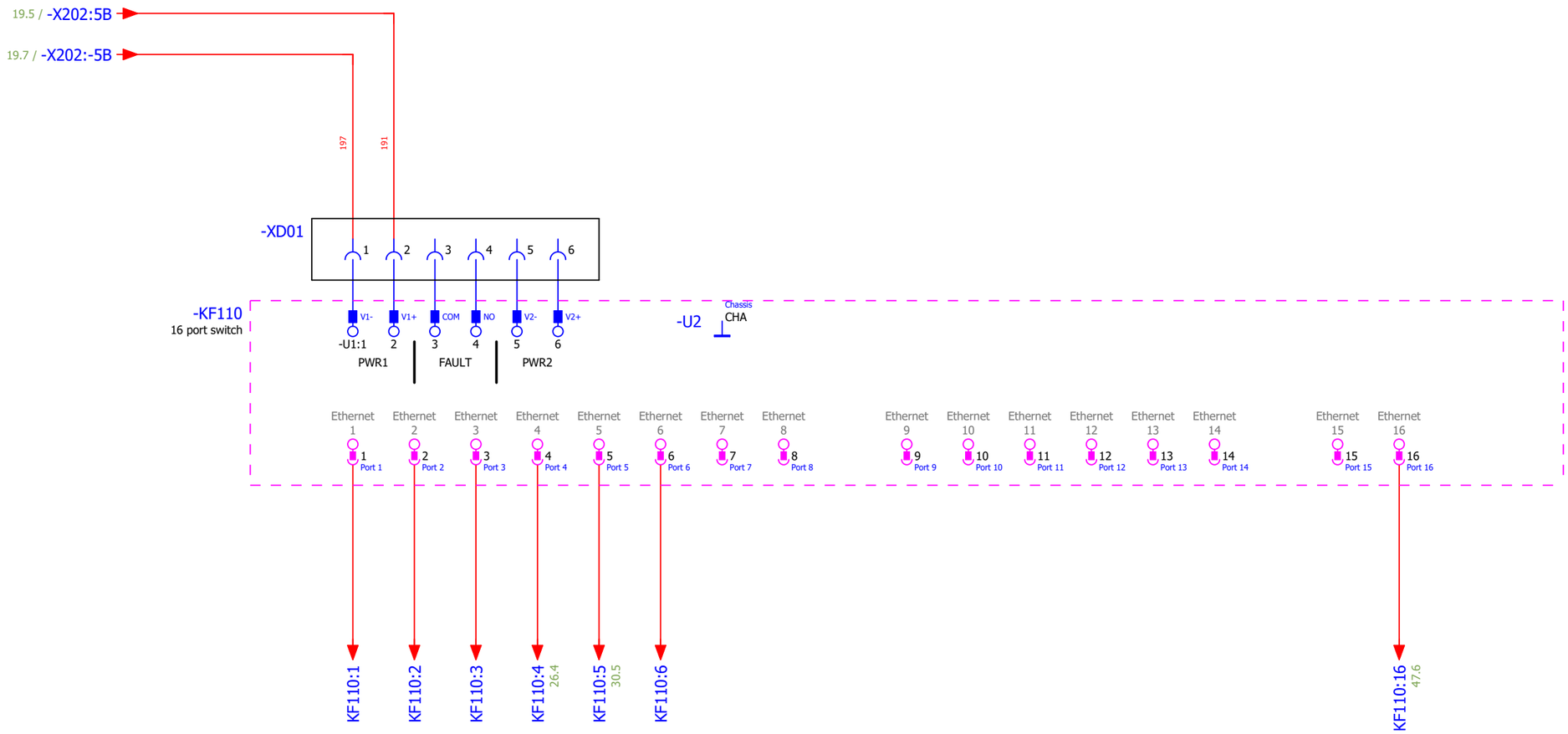
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Hydrogen Manifold pressure		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 45 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30

40ft Coolant Skid - Control Cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DESCRIPTION
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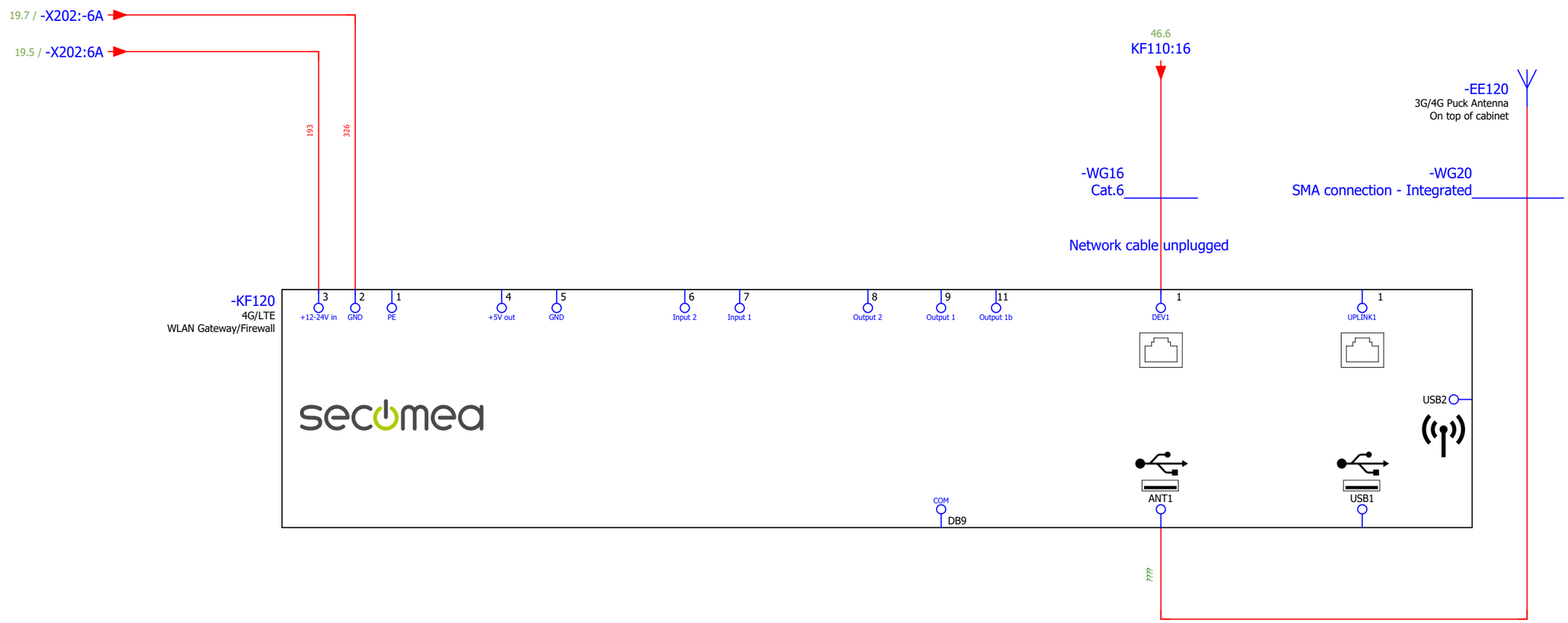
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Newtwork switch		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 46 / 82

0	1	2	3	4	5	6	7	8

=LA01+UC30
40ft Coolant Skid - Control Cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C03

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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	40ft Coolant Skid - Secomea		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 47 / 82

FRM5103656/0B

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Panel Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Panel Documentation and Layout		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 48 / 82

FRM5103656/0B

Terminal-strip overview

F14_001

Terminal strip	Terminal strip definition text	Terminals					Graphical page of terminal diagrams
		first	last	Total PE	Total N	Total number	
=LA01-14		1	PE	1	0	4	
=LA01-X1		L1	PE	0	0	5	
=LA01-X02		PE	PE	0	0	1	
=LA01-X11		1	PE	1	0	4	
=LA01-X12		1	PE	1	0	4	
=LA01-X13		1	PE	1	0	4	
=LA01-X15		1	PE	1	0	4	
=LA01-X16		1	PE	1	0	4	
=LA01-X21		1	PE	1	0	4	
=LA01-X22		1	PE	1	0	4	
=LA01-X23		1	PE	1	0	4	
=LA01-X24		1	PE	1	0	4	
=LA01-X25		1	PE	1	0	4	
=LA01-X26		1	PE	1	0	4	
=LA01-X31		1	PE	1	0	4	
=LA01-X41		1	PE	1	0	4	
=LA01-X42		1	PE	1	0	4	
=LA01-X50		1	PE	1	0	4	
=LA01-X100		1	X1	0	0	10	
=LA01-X110		1	16	0	0	16	
=LA01-X111		PE	8	0	0	9	
=LA01-X112		1	16	0	0	16	
=LA01-X113		PE	8	0	0	9	
=LA01-X114		1	4	0	0	4	
=LA01-X115		1	4	0	0	4	
=LA01-X116		1	12	0	0	12	
=LA01-X201		1.1	3.6	0	0	18	
=LA01-X201-		1.1	3.6	0	0	18	
=LA01-X202		1.1	3.6	0	0	36	
=LA01-X203		1.1	3.6	0	0	18	
=LA01-X203-		1.1	3.6	0	0	18	
=LA01-X204		1.1	3.6	0	0	18	
=LA01-X204-		1.1	3.6	0	0	18	
=LB02-XD03		1	1	0	0	1	

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

REVISION INFORMATION	
DESCRIPTION	
DATE	03-Sep-25

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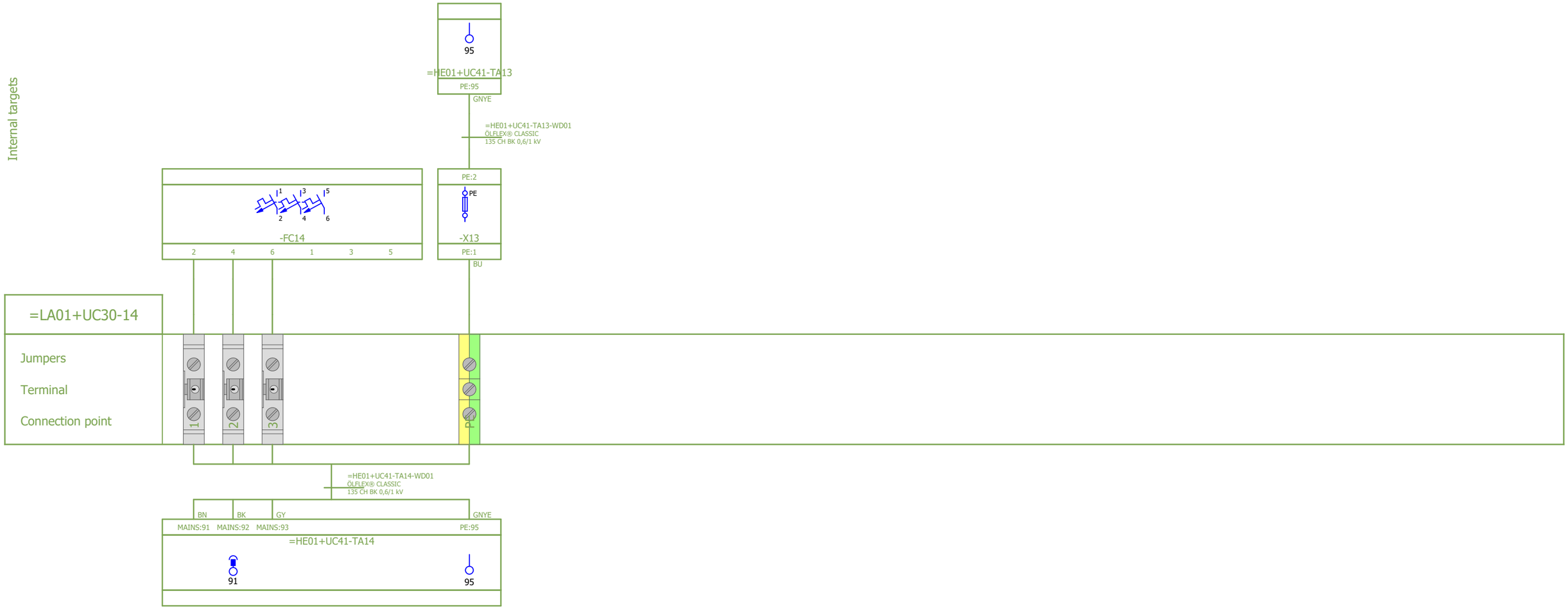
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-strip overview : =LA01+UC30-14 - =LB02+UC30-XD03		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 49 / 82

Terminal-connection diagram

F11_001
PETBLA 09-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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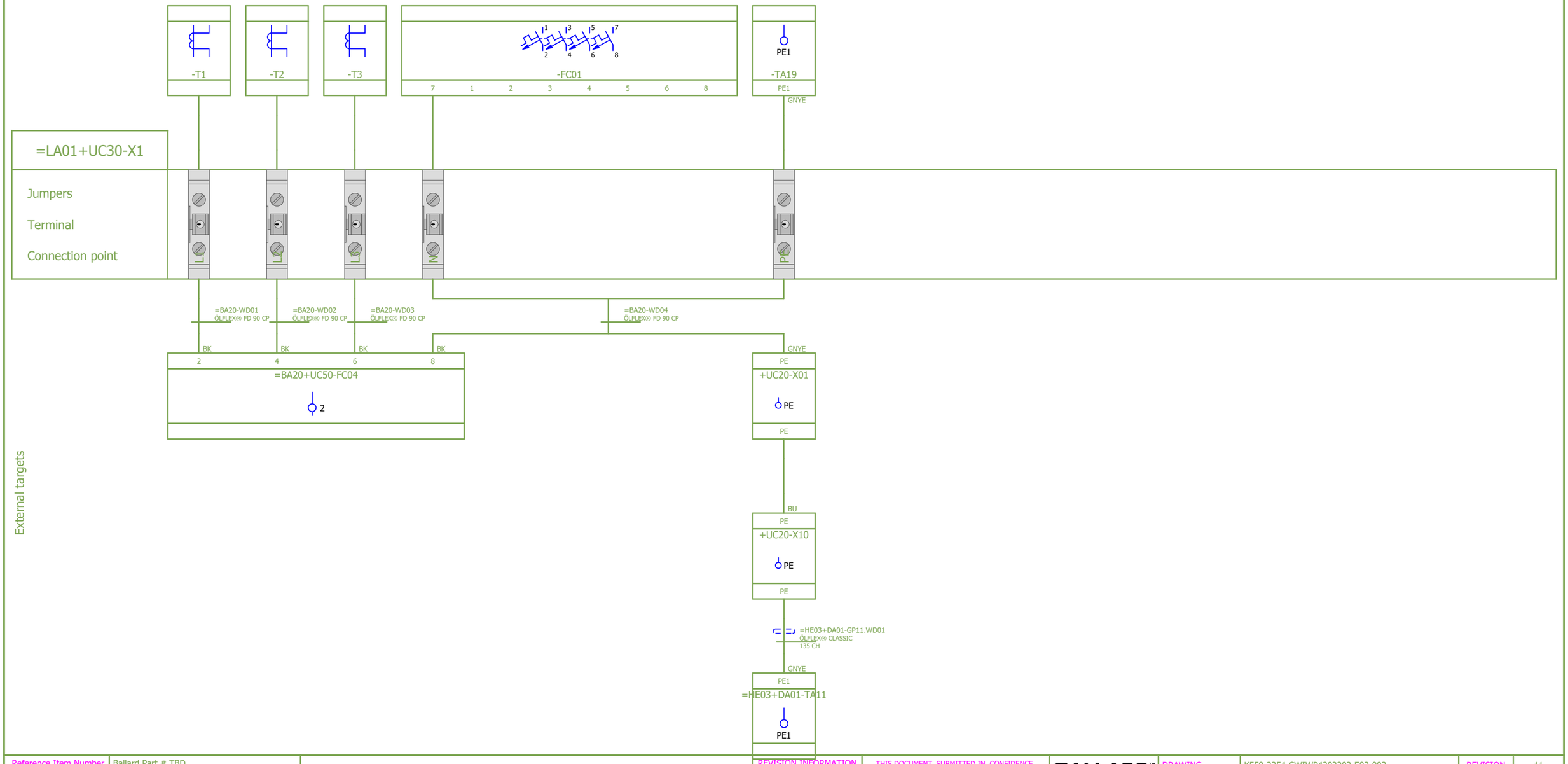
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-14		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 50 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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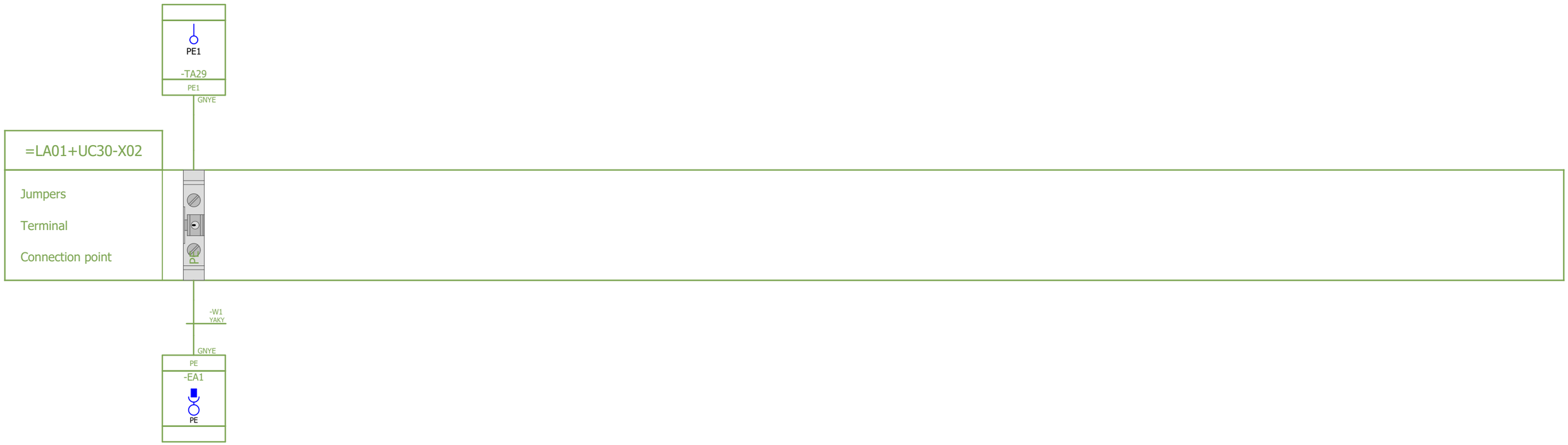
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X1		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 51 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

REVISION INFORMATION	
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DATE	03-Sep-25

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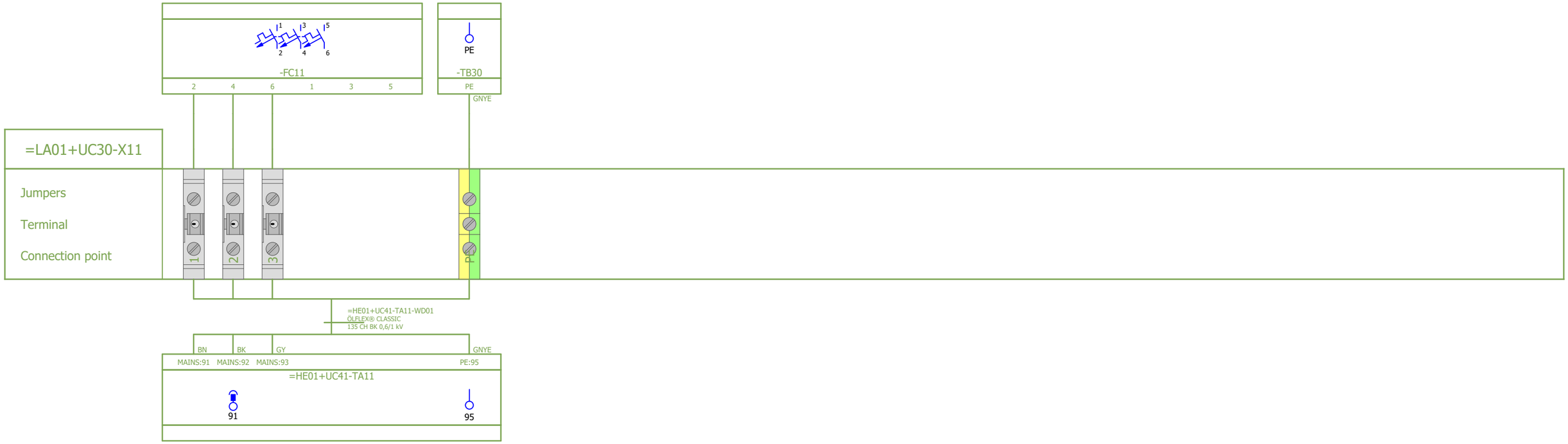
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 52 / 82

FRM5103656/0B

Terminal-connection diagram

F11_001
PETBLA 09-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

REVISION INFORMATION
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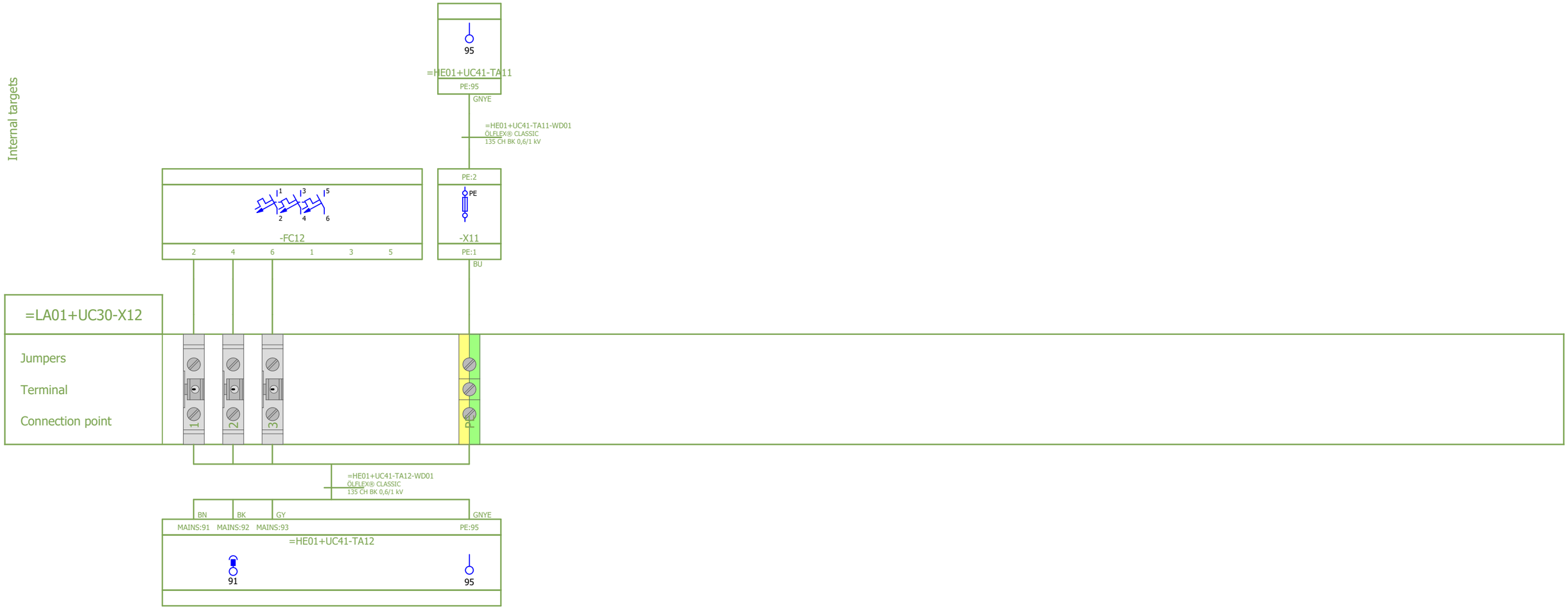
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X11		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 53 / 82

Terminal-connection diagram

F11_001
PETBLA 09-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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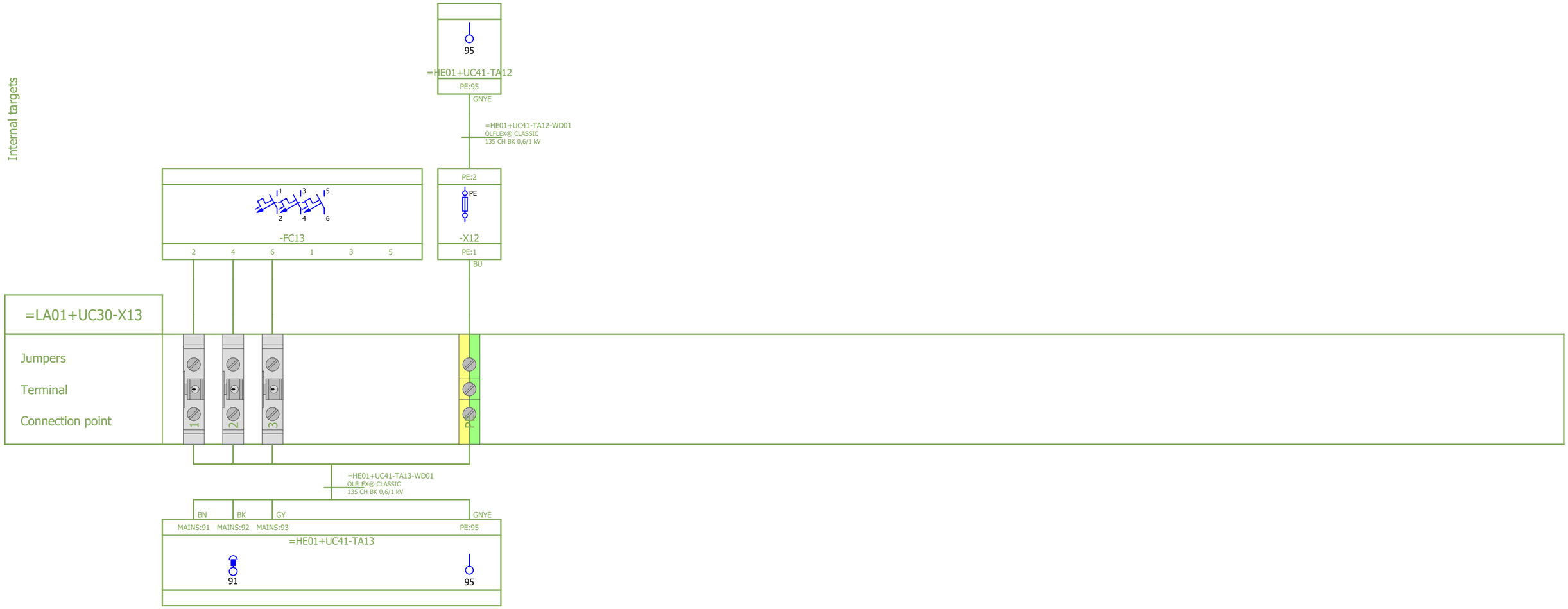
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X12		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 54 / 82

Terminal-connection diagram

F11_001
PETBLA 09-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

REVISION INFORMATION
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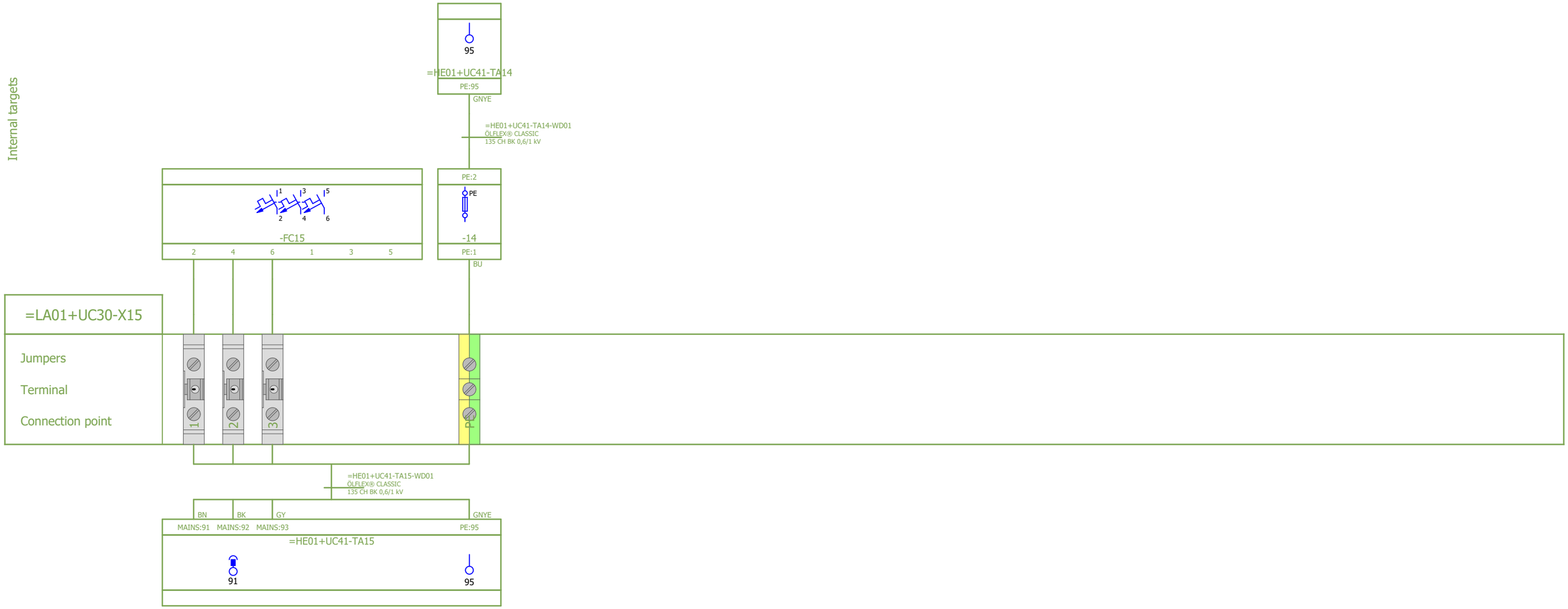
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X13		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 55 / 82

Terminal-connection diagram

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PETBLA 09-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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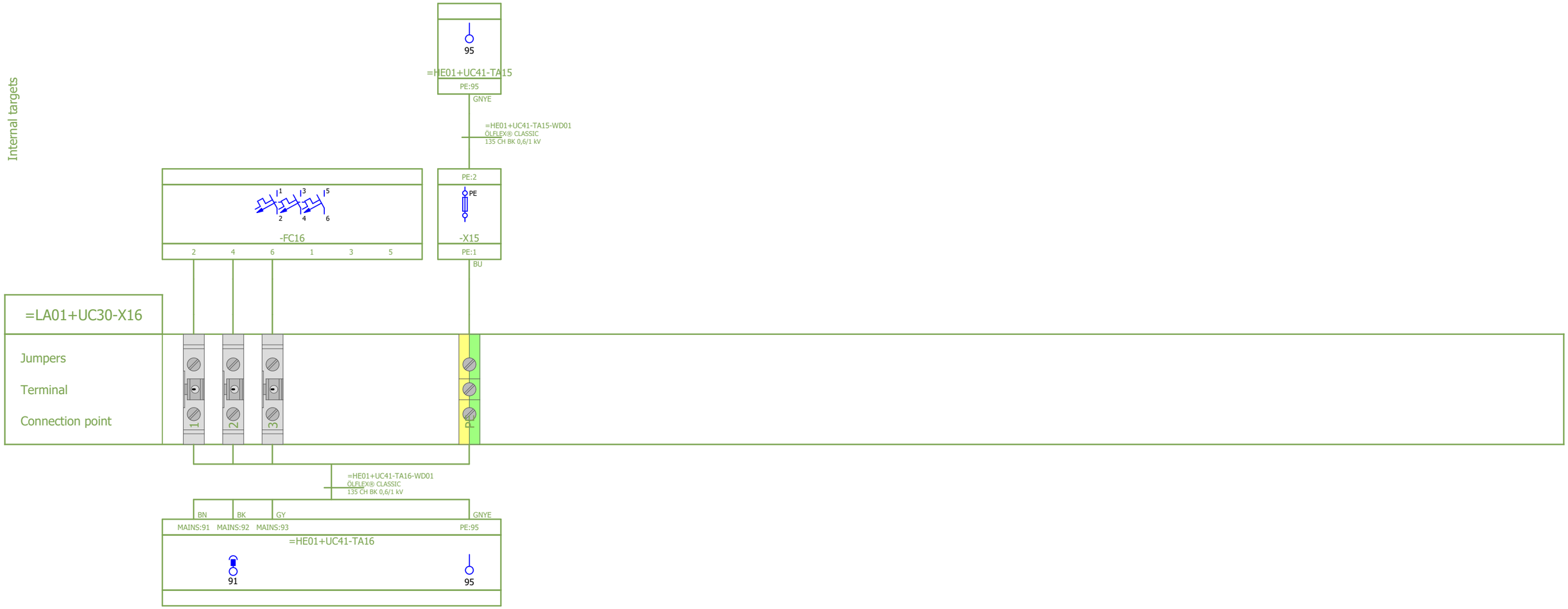
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X15		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 56 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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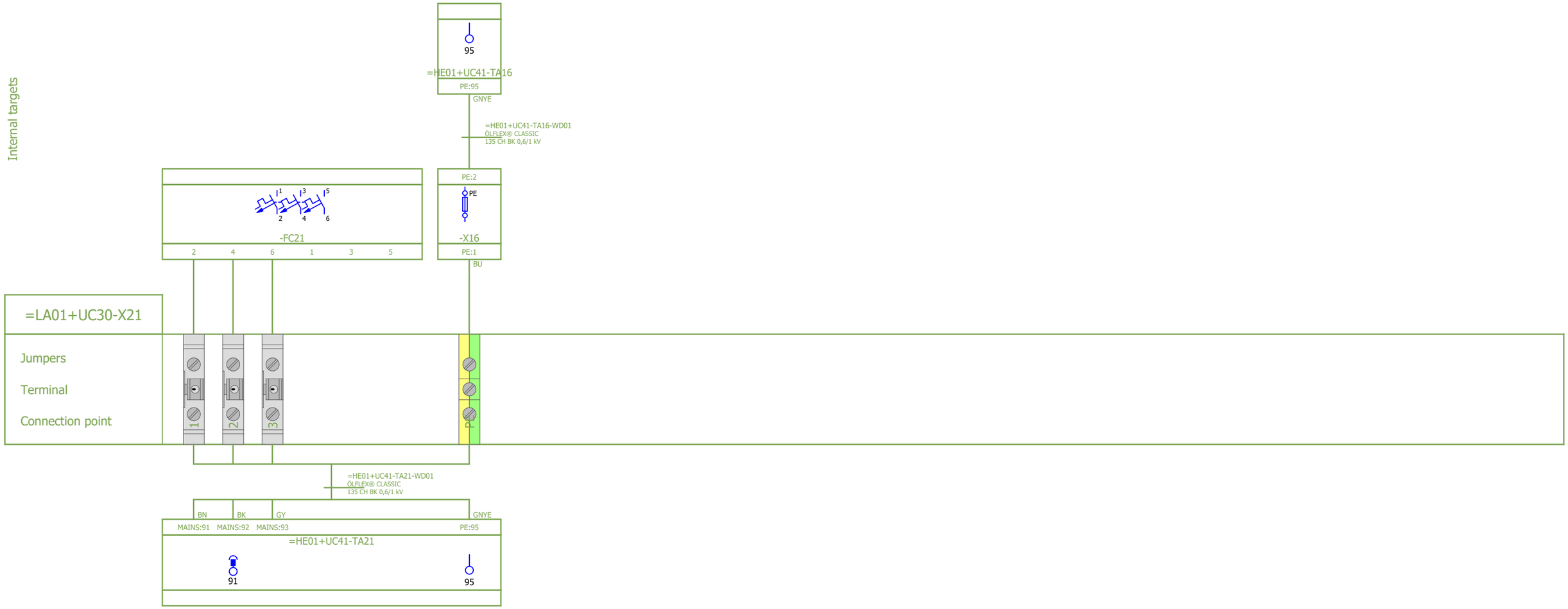
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X16		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 57 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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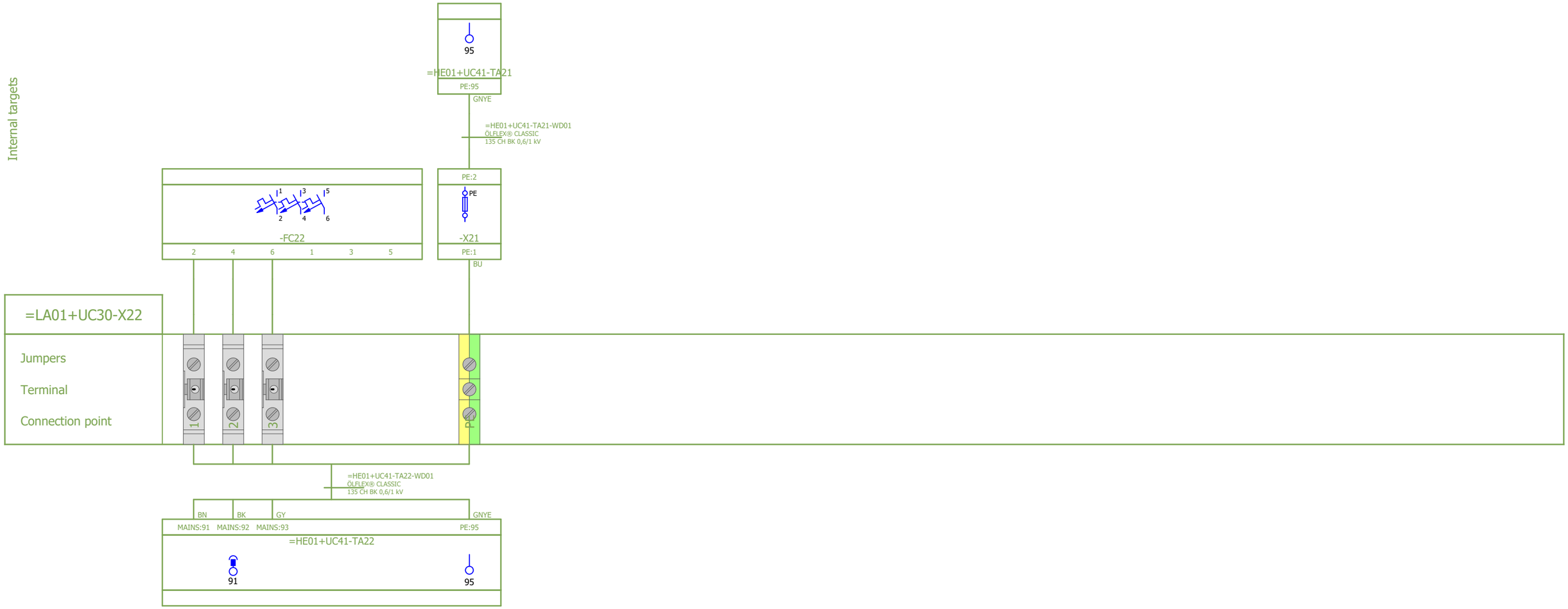
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X21		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 58 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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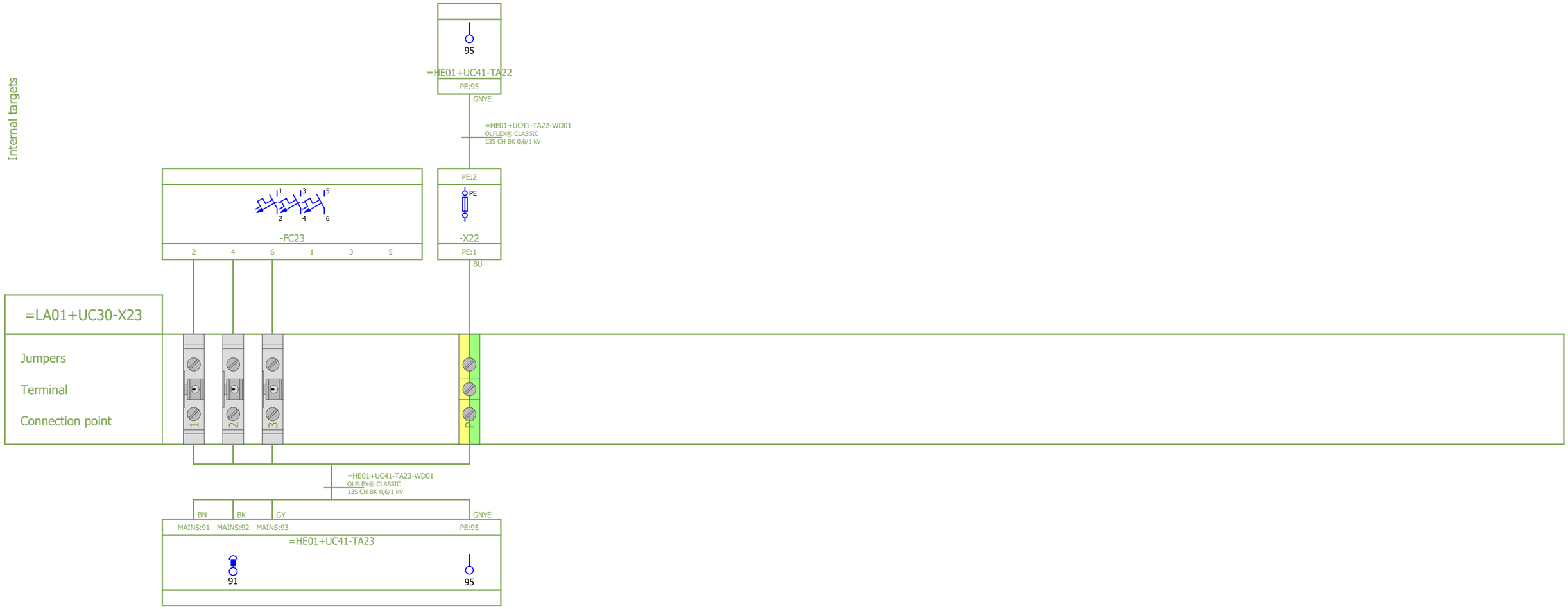
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X22		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 59 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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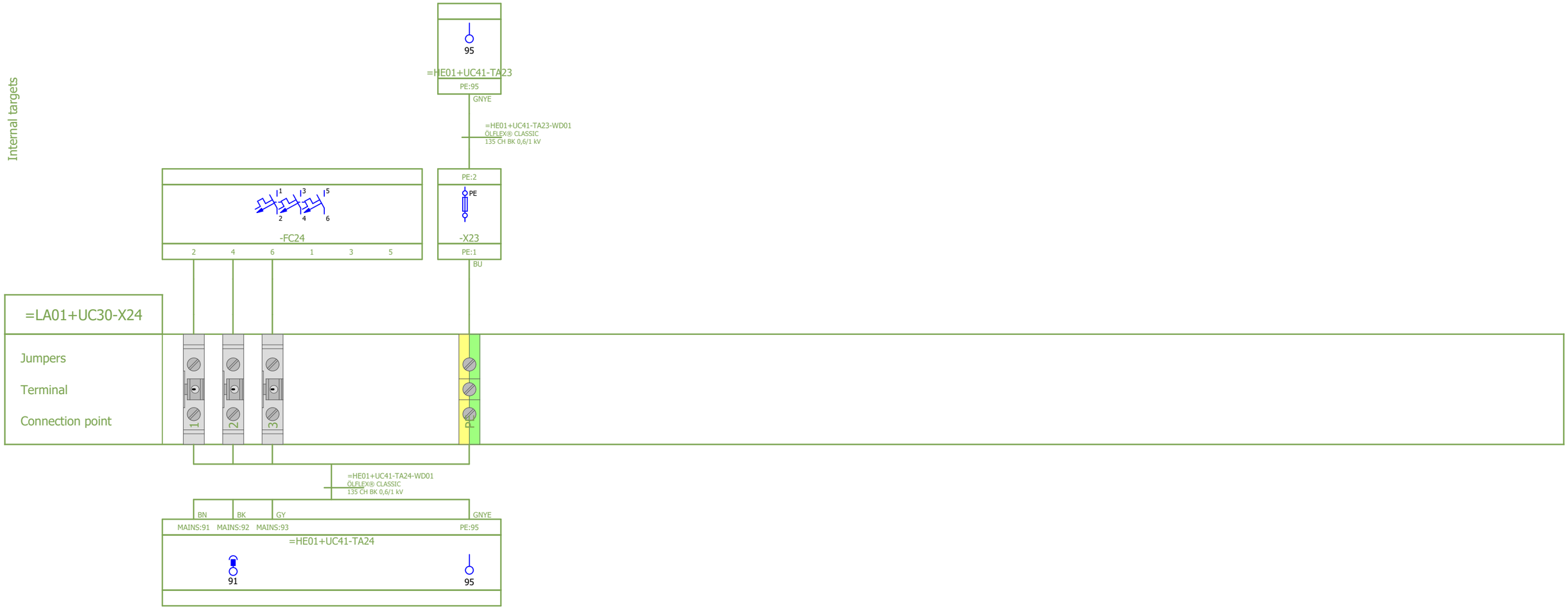
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X23		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 60 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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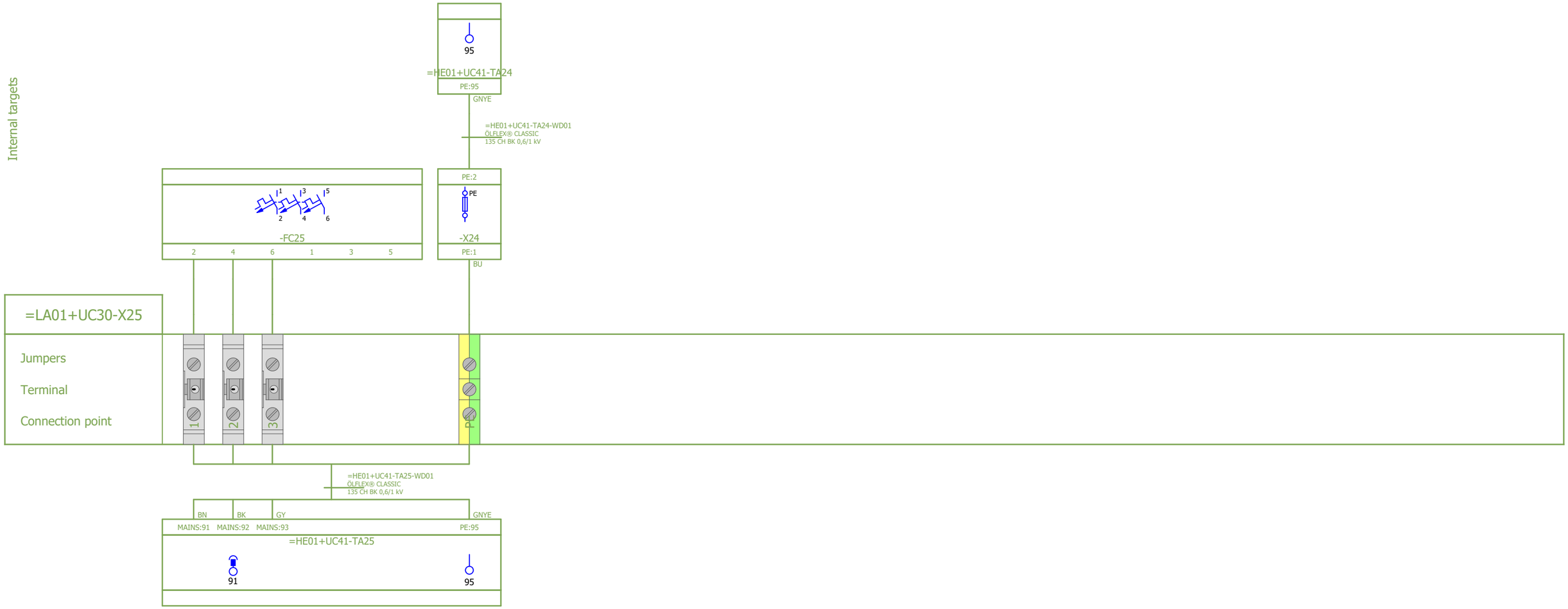
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X24		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 61 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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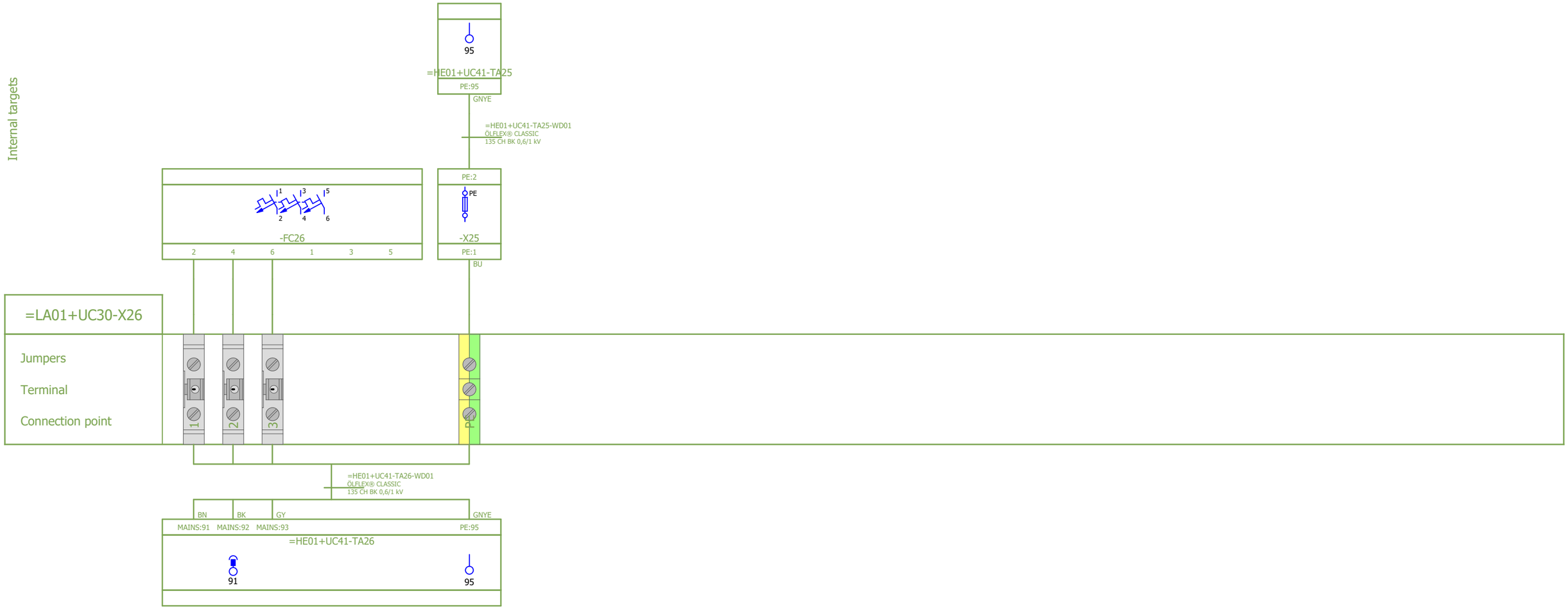
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X25		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 62 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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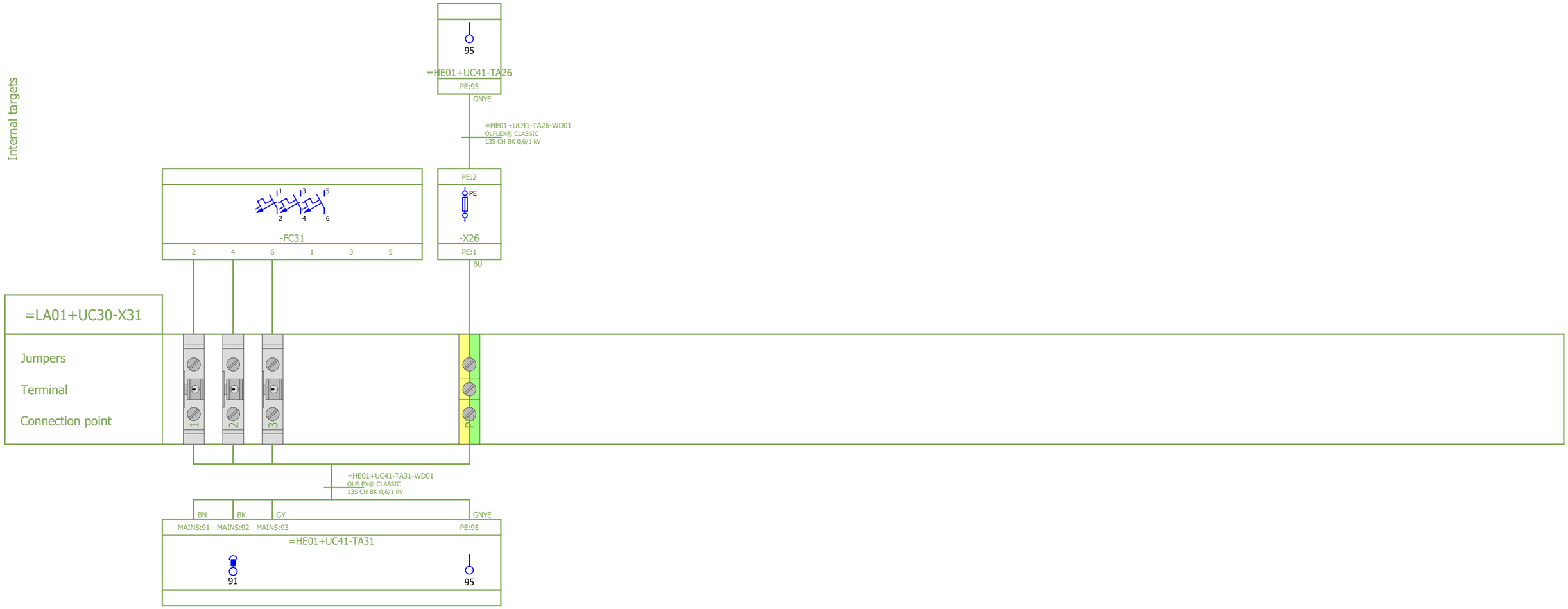
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X26		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 63 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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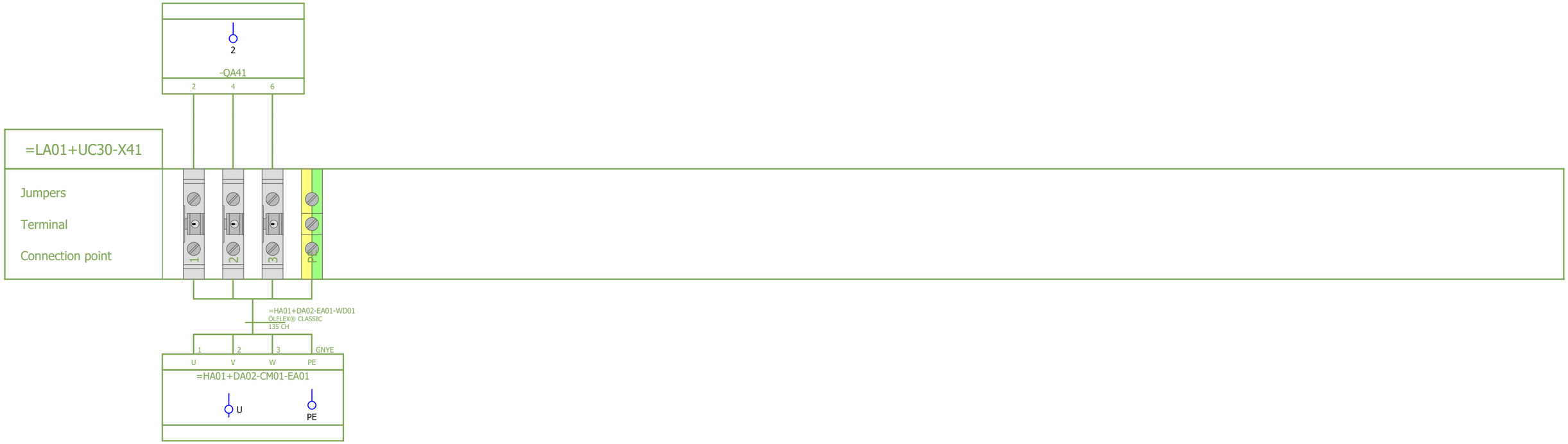
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X31		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 64 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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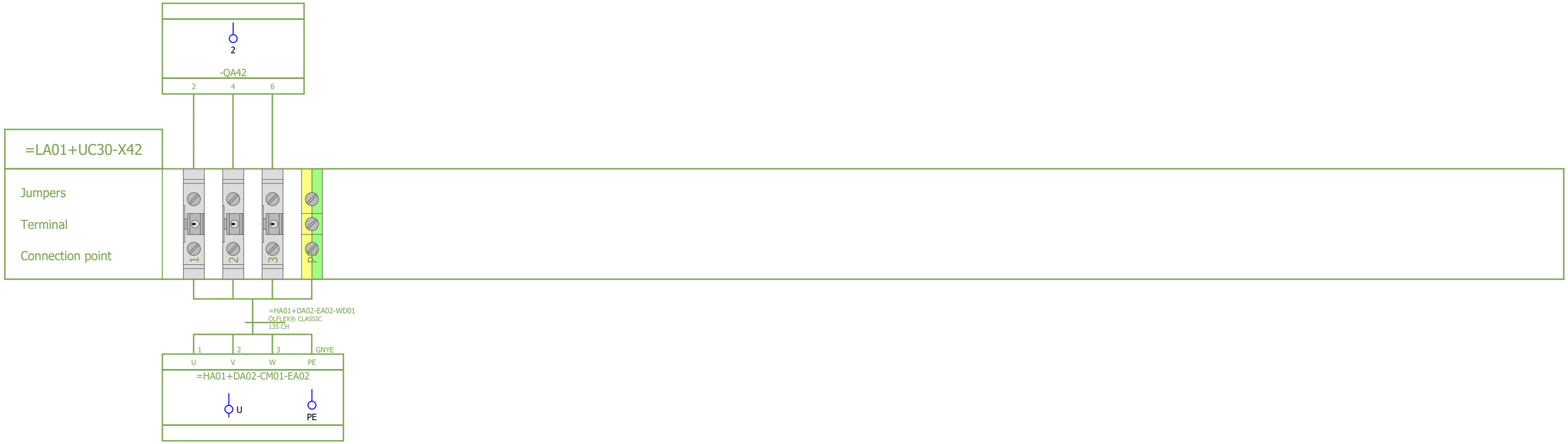
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X41		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 65 / 82

Terminal-connection diagram

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PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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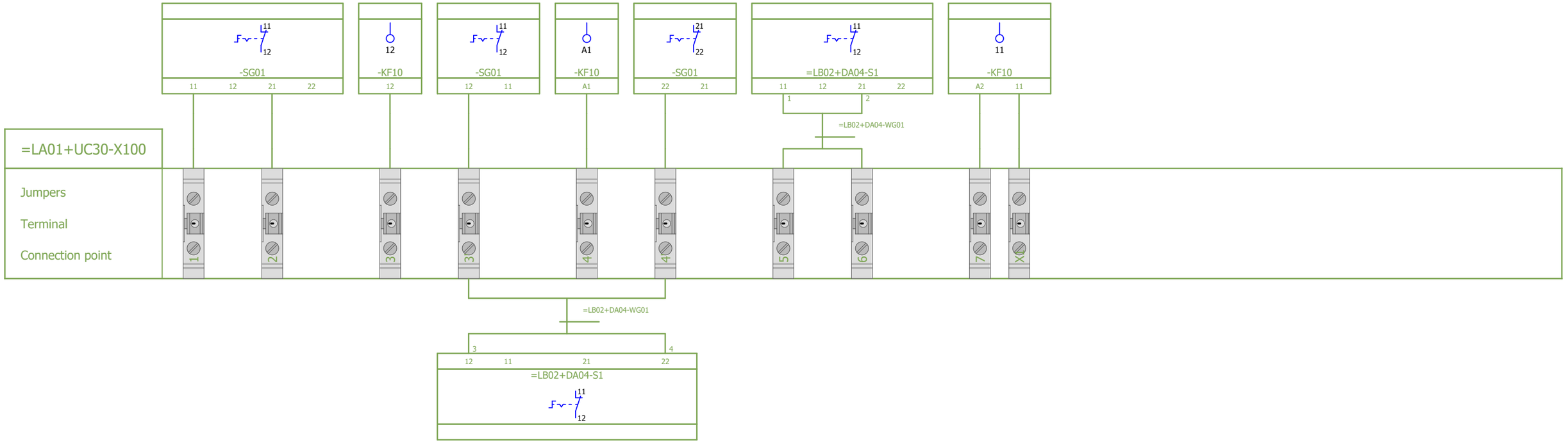
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X42		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 66 / 82

Terminal-connection diagram

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PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
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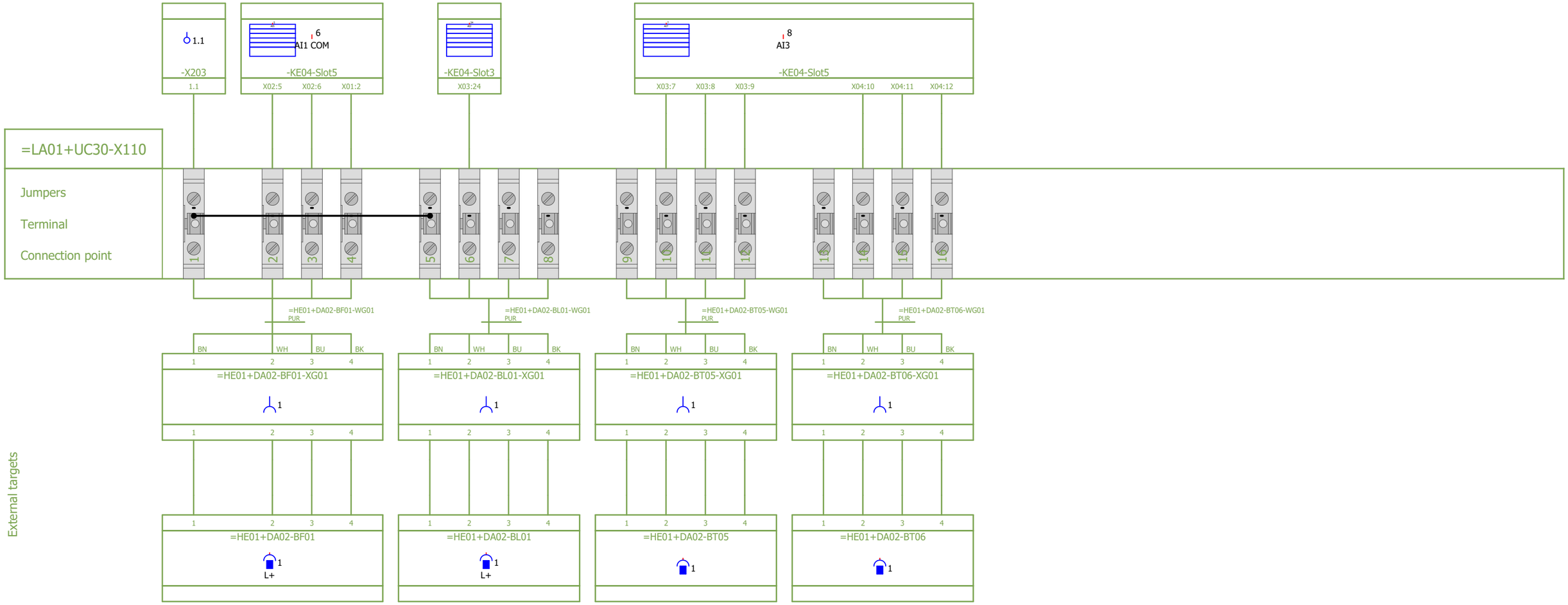
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X100		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 67 / 82

Terminal-connection diagram

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Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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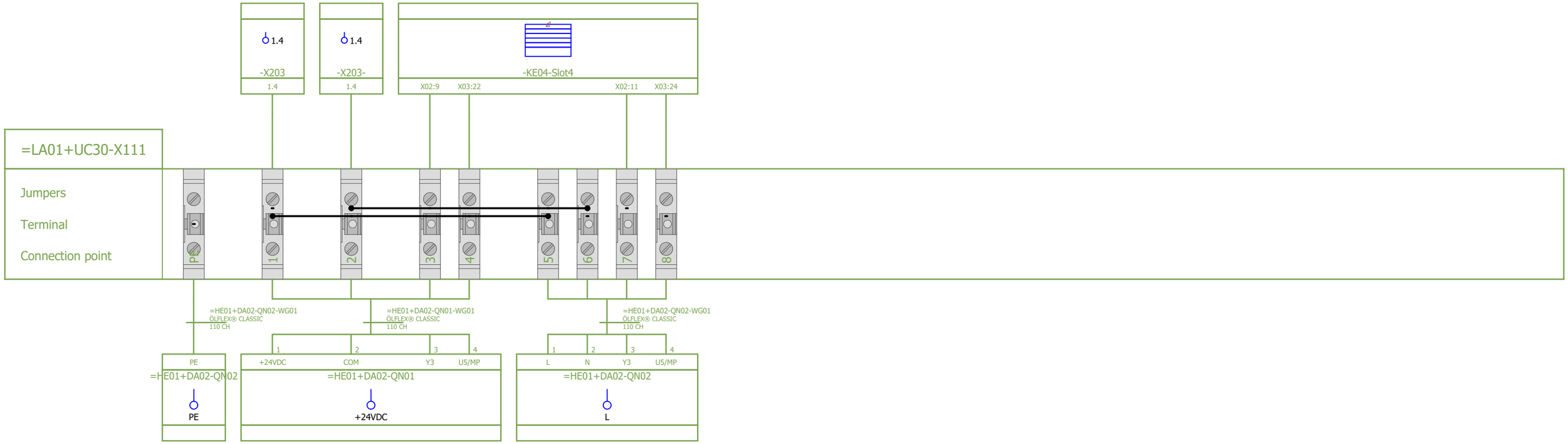
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X110		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 68 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

REVISION INFORMATION
DESCRIPTION
DATE
03-Sep-25

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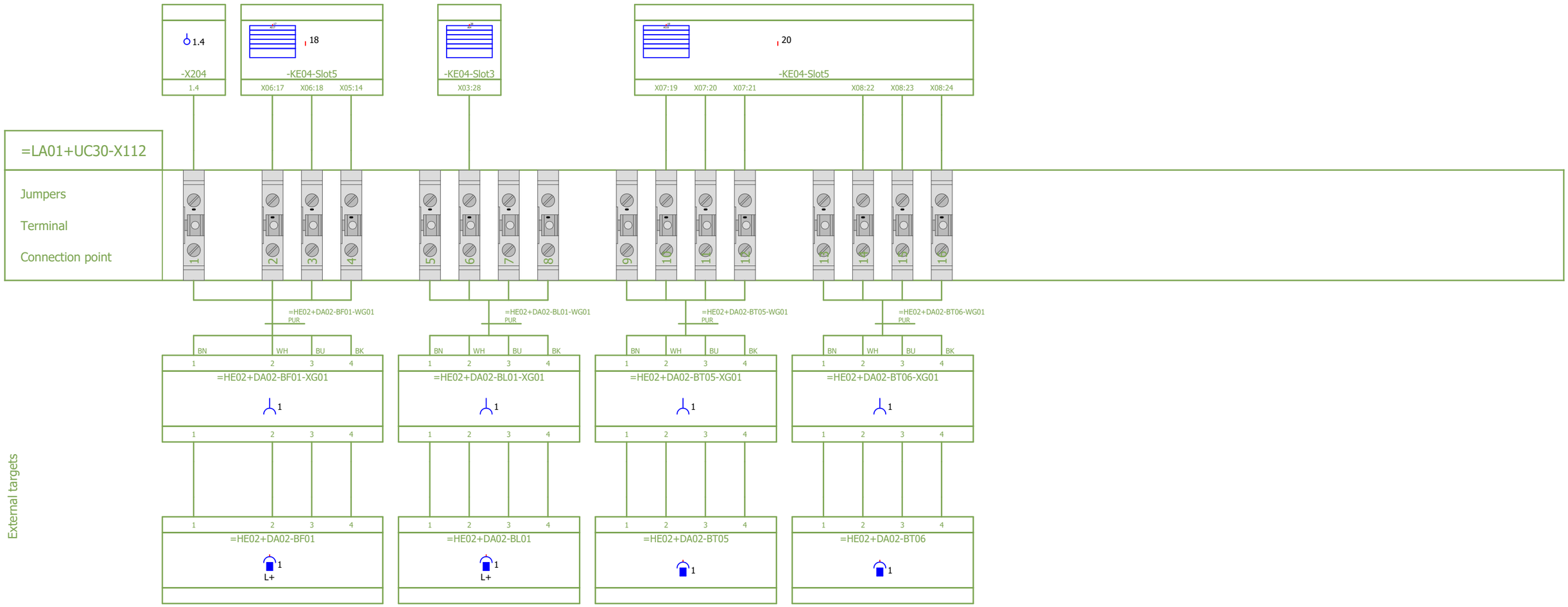
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DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X111		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 69 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
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EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X112		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 70 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets

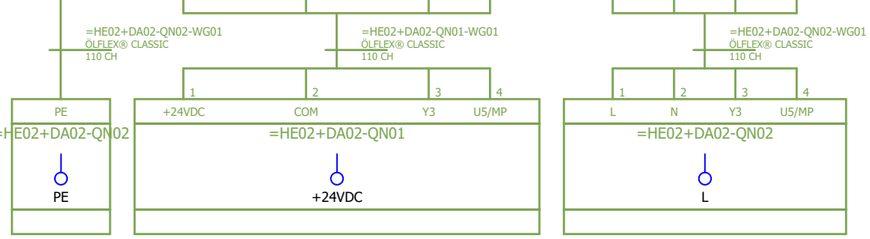
=LA01+UC30-X113

Jumpers

Terminal

Connection point





External targets

Reference Item Number	Ballard Part # TBD		
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EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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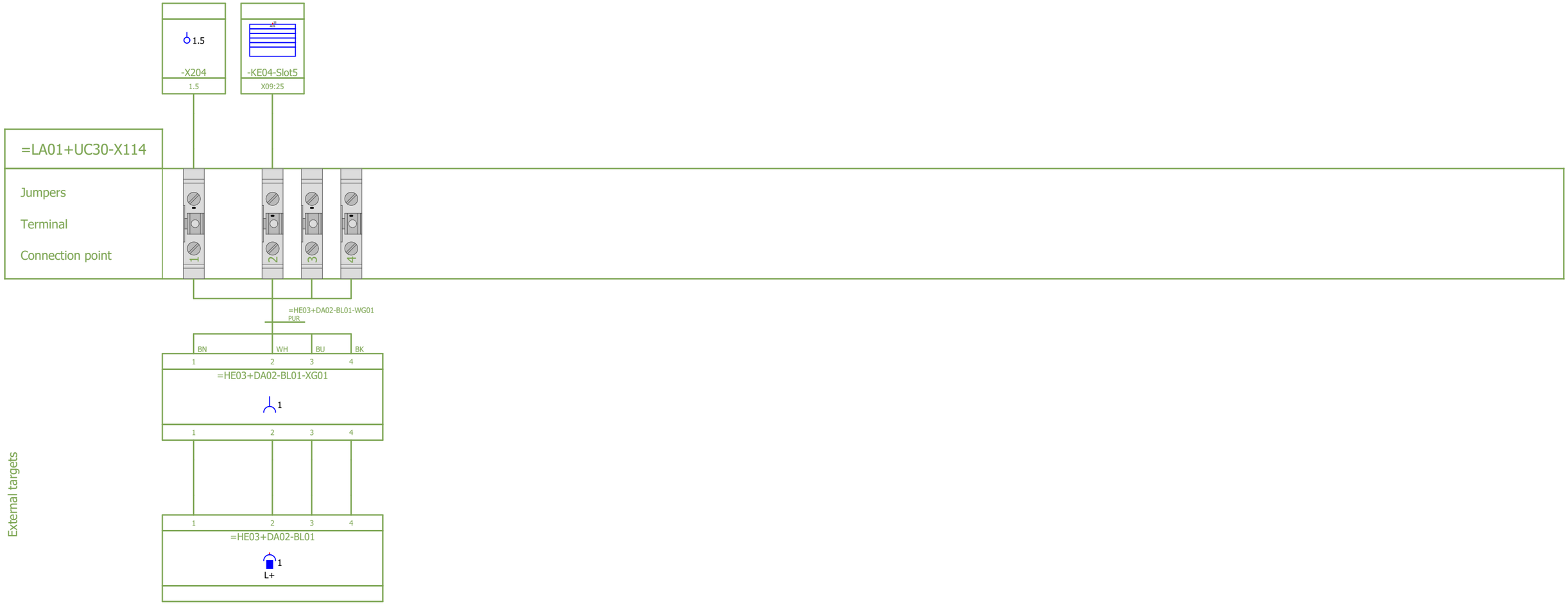
DRAWING	K559-2254-CWIWP4202202-E03-003	REVISION	11
DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X113		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 71 / 82

FRM5103656/0B

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

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EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

REVISION INFORMATION
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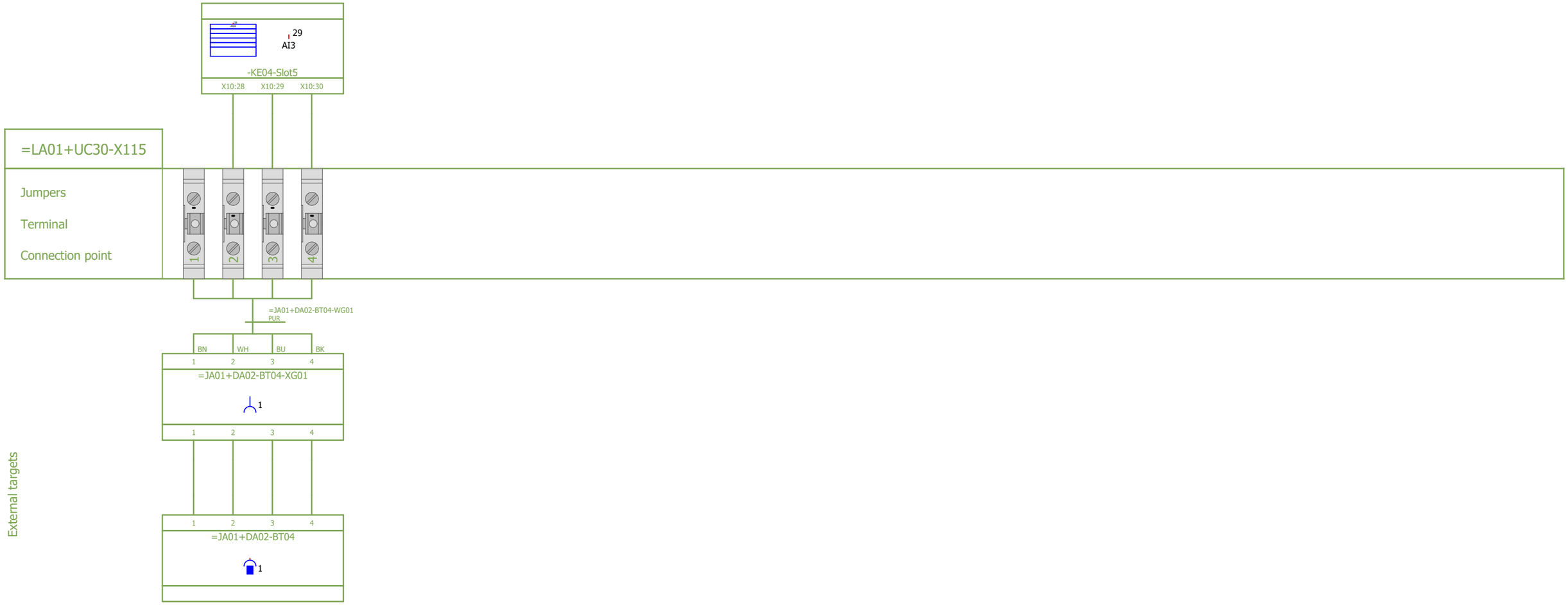
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X114		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 72 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X115		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 73 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets

OUT1
-FC201
OUT1

=LA01+UC30-X201

Jumpers
Terminal
Connection point



24
-KF10
24

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X201		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 74 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets

0V1
-FC201
0V1

=LA01+UC30-X201-

Jumpers
Terminal
Connection point



34
-KF10
34

External targets

Reference Item Number	Ballard Part # TBD		
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EPLAN Revision	11		
EPLAN Project Pages	629		
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SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X201-		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 75 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets

=LA01+UC30-X202

Jumpers

Terminal

Connection point

-FC202 (OUT1 / 0V1)

-FC200 (13 / 14)

-FC11 (12 / 14 / 11)

-RB30 (1)

-KF110-U1 (2) — U1:2 / U1:1

-XD01 (2) — 2 / 1 — 2:V1+ / 1:V1-

+UC42-TF01 (32) — 32 / 31

-X116 (1) — 1:3 / 2:4 — 1:2 / 2:1

External targets

-FC31 (12 / 14 / 11) — 11 / 12 / 14

=HE01-KE04-Slot3 (21) — X03:21

-FC21 (12 / 14 / 11) — 11 / 12 / 14

-TA19 (6) — 6 / 7

-TA29 (6) — 6 / 7

-KF120 (3) — X01:3 / X01:2

-X116 (5) — 5:2 / 5:3

=HA01+DA02-BL01-WG01
PUR
BN

=HA01+DA02-BL01-XG01 (1) — 1 / 1

=HA01+DA02-BL01 (1) — 1 — L+

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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EPLAN Project Pages	629		
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SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X202		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 76 / 82

FRM5103656/0B

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

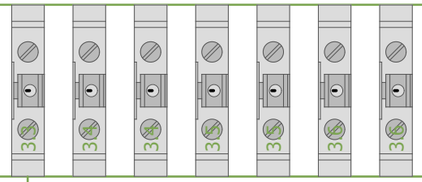
Internal targets

=LA01+UC30-X202

Jumpers

Terminal

Connection point



A2 A1

-QA10

A1

A2

External targets

Reference Item Number	Ballard Part # TBD		
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EPLAN Project Pages	629		
=	++	+ UC30	& C04

REVISION INFORMATION

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ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 77 / 82

FRM5103656/0B

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets

+24VDC
=HE01+DA02-QN01
+24VDC
1

=HE01+DA02-QN01-WG01
ÖLFLEX® CLASSIC
110 CH

OUT1
-FC203
OUT1

1:3
1
-X111
1:2

=LA01+UC30-X203

Jumpers
Terminal
Connection point

External targets

1:2
-X110
1
1:3

=HE01+DA02-BF01-WG01
PUR
BN

1
=HE01+DA02-BF01-XG01
1
1

1
=HE01+DA02-BF01
1
L+

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC30	& C04

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SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X203		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 78 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets

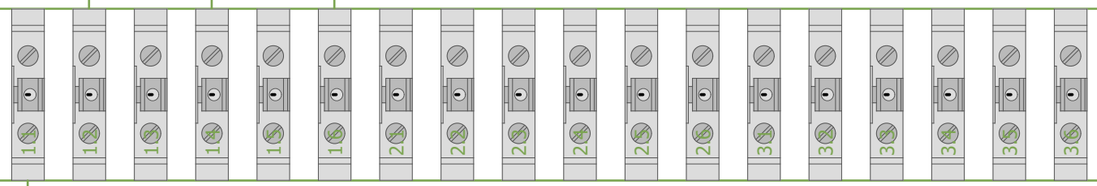
COM
=HE01+DA02-QN01
COM
2

=HE01+DA02-QN01-WG01
ÖLFLEX® CLASSIC
110 CH

0V1	2:4	2	10
-FC203	-X111		-KE04-Slot4
0V1	2:1		X02:10

=LA01+UC30-X203-

Jumpers
Terminal
Connection point



External targets

3:2
-X110
3
3:3

=HE01+DA02-BF01-WG01
PUR
BU

3
=HE01+DA02-BF01-XG01
3
3

3
=HE01+DA02-BF01
3
L-

Reference Item Number	Ballard Part # TBD		
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EPLAN Project Pages	629		
=	++	+ UC30	& C04

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SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X203-		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 79 / 82

FRM5103656/0B

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets

1
1
=HE02+DA02-BF01-XG01
1
BN
=HE02+DA02-BF01-WG01
PUR

OUT1
-FC204
OUT1

1:3
1
-X112
1:2

=LA01+UC30-X204

Jumpers
Terminal
Connection point

11 11 11 11 11 11 21 21 21 21 21 21 31 31 31 31 31 31

External targets

1:2
-X114
1
1:3

1:2
-X113
1
1:3

=HE03+DA02-BL01-WG01
PUR
=HE02+DA02-QN01-WG01
ÖLFLEX® CLASSIC
110 CH

BN
1
=HE03+DA02-BL01-XG01
1
1

1
+24VDC
=HE02+DA02-QN01
+24VDC

1
=HE03+DA02-BL01
1
L+

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
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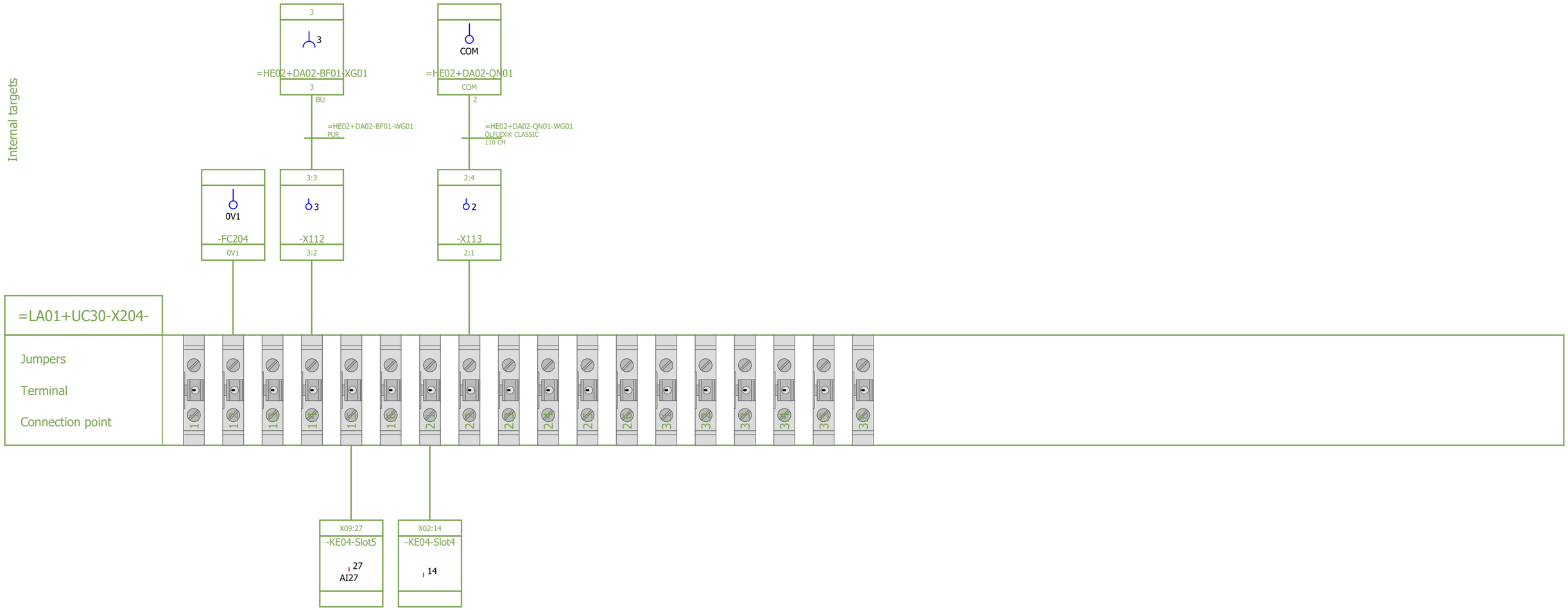
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DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC30-X204		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 80 / 82

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

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FRM5103656/0B

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



=HKN70-WG03

=LB02+UC30-XD03

Jumpers	
Terminal	
Connection point	1

External targets

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EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC30 Coolant Skid Control Cabinet		
EPLAN Revision	11					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM		SHEET TYPE/DESC	Terminal-connection diagram =LB02+UC30-XD03		
EPLAN Project Pages	629						ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 82 / 82
=	++	+ UC30	& C04	DATE						
				03-Sep-25						

FRM5103656/0B

Sub Section E03-004

UC31 10ft Control Cabinet

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	9/9/2025	Updated, as build
003	9/29/2025	Updated per comments from PK

Document Title:	**BLPH Project - Panel Cabinet Layout: UC31 10ft Control Cabinet**
Document Number:	K559-2254-CWIWP4202202-E03-004
Revision:	Rev003
Sequence Number:	004
File Name:	K559-2254-CWIWP4202202-E03-004Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BALLARD™

+UC31

Ballard Power Systems Europe - Technology Solutions

Cabinet: 10ft Container Control
Location: 10ft Container, Behind access hatch

Cabinet Supply:
Vin = 400VAC, 3P+N+PE
IKmax = 10kA
IP20

AC / DC Sense:
AC: Vin = 400VAC, 3ph
AC: IKmax = 25kA

DC: Vin = 750VDC
DC: IKmax = 10kA

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& A01

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Front Page		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 81

Ballard Power Systems Europe - Technology Solutions, Cabinet Wiring Colors

Standard Basis: EN 61439

Required wire standard compliance:

Required: IEC Wire
Required: UL Recognized
Required: CSA/UL

Wire Numbering:

- Wires inside panels are to be numbered
- Wire number system is perferably "potential oriented with subnumber"
- All wires of the same potential (e.g. DC Common) have the same main number, with sequential subnumber.
- Potential numbers with fewer digits may be leading zero padded (e.g. 19 -> 019)
- Separator between main and subnumber is "."

Example: 019.1 BUWH 0.75mm²

- 019 — Wire potential number
- 1 — Wire sequential subnumber with separator
- BUWH — Wire color code (Dark Blue with White stripe)
- 0.75mm² — Wire dimension

AC Wiring Colors

AC Power Circuit (Generic)	Black (BK)
AC Phase L1	Brown (BN)
AC Phase L2	Black (BK)
AC Phase L3	Grey (GY)
AC Neutral	Light Blue (BU)
Externally supplied circuit	Orange (OG)

DC Wiring Colors

DC Power Circuit	Black (BK)
DC Control Voltage (24V)	Dark Blue (BU)
DC Control Voltage Refence (0V)	Dark Blue with White Stripe (BUWH)
Signal Wire (DI, DO)	White (WH)
Signal Wire (AI, AO)	Violet (VT)
Externally supplied circuit	Orange (OG)

PE Wiring Colors

Protective Earth (PE)	Green/Yellow (GNYE)

Wire Color Abbreviations

BK	Black
BN	Brown
RD	Red
OG	Orange
YE	Yellow
GN	Green
BU	Blue
VT	Violet
GY	Gray
WH	White
PK	Pink
GD	Gold
TQ	Turquoise
SR	Silver
GNYE	Green/Yellow
SH	Shield

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC31 | & A01

REVISION INFORMATION
DESCRIPTION
DATE
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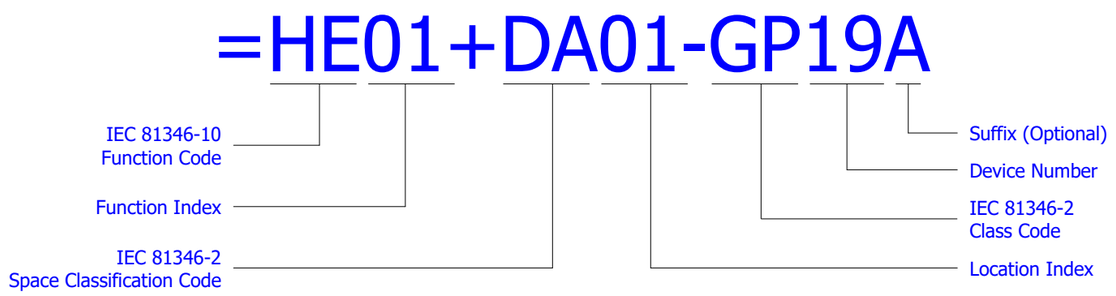
DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Standard Wire Colors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 81

FRM5103656/0B

Ballard Power Systems Europe - Technology Solutions Device Tag Process

A Ballard Device Tagname consists of three parts:
- A function designation (=)
  - According to IEC81346-10, Table B.1 and B2.
  - Always two letters followed by two digits
- A location designation (+)
  - According to IEC81346-2, Table 4
  - Always two letters followed by two digits
- A class code (-)
  - According to IEC81346-2, Table 2
  - Always two letters followed by two or three digits plus optional suffix

Sample fully qualified Device Tag (DT) for a Coolant Pump



IEC81346-10 Function Examples

IEC 81346-10 Table B.1 and B.2 provide a class definition system, which provides a two letter code for the functional description
Table B.1 is used for power supply systems and table B.2 for other systems

IEC 81346-10 Table B.1 / B.2	Function Codes (Example)
=AA	Structural System, Load support (Frame)
=BA	Transporting Electrical Energy (Power Converters)
=HA	Supply System, Gaseous Matter (Gas Piping)
=HE	Supply System, Heating/Cooling (Radiator)
=JA	Distribution System, Gaseous Matter (Gas Handling Unit)
=JB	Distribution System, Liquid Matter (Fluid Drain)
=LA	Control System, Process (PLC, SCADA)
=LB	Control System, Safety (Safety PLC)
=QA	Storage System, Gaseous Matter (Gas Storage)
=RE	Energy Conversion System, Chemical to Electricity (Fuel cells, Batteries)

IEC81346-2 Space Classification

IEC 81346-2 Table 4 provide a classification scheme for spaces, which provides a two and three letter code for the space (location) classification.
Class code "1" and "1" is used for the location scheme

IEC 81346-2 Table 4	Location Codes (Example)
+GB	Space for power generation, Chemical (Fuel Cells)
+DA	Space for active technical equipment
+UC	Space for electrical equipment (Electrical Cabinet)

IEC81346-2 Class Code

IEC 81346-2 Class Codes is a scheme for defined objects for reference designations according to their inherent function

IEC 81346-2 Table 2	Class Codes (Example)
-BA	Sensing, electrical potential (Voltage Transducer)
-BC	Sensing, electrical current (Current Transducer)
-BP	Sensing, pressure (Pressure Transducer)
-BT	Sensing, temperature (Temperature Transducer)
-EA	Emitting, light (Light Fixture)
-FC	Protecting, overcurrent (Fuse, MCCB)
-GB	Generating, Chemical Reaction (Fuel Cell)
-GP	Generating, Liquid Flow (Pump)
-GQ	Generating, Gas Flow (Van, Ventilator)
-KE	Processing, Electrical signals (PLC)
-KF	Processing, Information (Network Switch)
-MA	Driving, Torque (AC Motor)
-QA	Controlling, Electric Current (Contactor, Motor Starter)
-QB	Controlling, Electric Separation (Disconnector)
-QM	Controlling, Fluid On/Off (Valve)
-QN	Controlling, Fluid Regulation (Damper, Gas Control Valve)
-WD	Guiding, Low Voltage Electric Energy (AC or DC power Cable)
-WE	Guiding, Reference Potential (Grounding Wire/Cable)
-WG	Guiding, Electric Signals (Control, Network Cable)

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
= ++ + UC31 & A01	

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Tagging Standard		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 3 / 81

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Ballard Power Systems Europe - Technology Solutions

Controller IO Overview

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C02

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, 20ft Rack 1/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 4 / 81

0	1	2	3	4	5	6	7	8

=LA01+UC31-KE06
DEIF AMC300
Controller Extension Rack

-Slot1
DEIF PSM3.2
Power Supply
Module 3.2

PSM3.2

	PE	PE &C03/26.1		Frame Ground
	1	12/24V &C03/26.1		Supply +
	2	0V &C03/26.1		Supply COM
	3	R1 COM		Status OK Relay COM
A52.4	4	DO1	DO1	Status OK Relay
	5	R2 COM		Relay 2 COM
A52.5	6	DO2	DO2	Relay 1 Out
	7	R3 COM		Relay 3 COM
A52.6	8	DO3	DO3	Relay 3 Out

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.5:C +&C01/5.8:E X03 — Ethernet-1 IN

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.6:C +&C01/5.8:E X03 — Ethernet-2 OUT

Bus Follower
Multi-line 300

-Slot2
&C03/18.1
&C03/18.2
ACM3.1
Alternating Current Module 3.1

ACM3.1

1	L1	&C03/18.1	BA30_BA01_L1	Main Output (Busbar) - L1 Voltage
2	L2	&C03/18.1	BA30_BA01_L2	Main Output (Busbar) - L2 Voltage
3	L3	&C03/18.1	BA30_BA01_L3	Main Output (Busbar) - L3 Voltage
4	N	&C03/18.2	BA30_BA01_N	Main Output (Busbar) - N Voltage
5	L1	&C03/18.3	BA30_BA02_L1	Main Output (Customer) - L1 Voltage
6	L2	&C03/18.3	BA30_BA02_L2	Main Output (Customer) - L2 Voltage
7	L3	&C03/18.3	BA30_BA02_L3	Main Output (Customer) - L3 Voltage
8	N	&C03/18.4	BA30_BA02_N	Main Output (Customer) - N Voltage
9	L1	&C03/18.5	BA30_BC01_L1	Main Output (Busbar) - L1 Current
10	L1-S2	&C03/18.5	CH1-S2	Channel 1 - S2
11	L2	&C03/18.6	BA30_BC01_L2	Main Output (Busbar) - L2 Current
12	L2-S2	&C03/18.6	CH2-S2	Channel 2 - S2
13	L3	&C03/18.7	BA30_BC01_L3	Main Output (Busbar) - L3 Current
14	L3-S2	&C03/18.8	CH3-S2	Channel 3 - S2
15	4-S1		CH4-S1	Channel 4 - S1
16	4-S2		CH4-S2	Channel 4 - S2

-Slot3
&C03/32.2
&C03/49.2
&C03/19.3
&C03/19.2
&C03/20.2
IOM3.1
Input Output Module 3.1

IOM3.1

3 1 2	1	DO1.1	&C03/32.2	UC31_QA40_O	Precharge contactor coil
	2	R1 COM	&C03/32.2		Relay 1 Common
	3	DO1.2			Relay 1 NC
6 4 5	4	DO2.1	&C03/49.2	DA03_EA01	Container lighting
	5	R2 COM	&C03/49.2		Relay 2 Common
	6	DO2.2			Relay 2 NC
9 7 8	7	DO3.1			Relay 3 NO
	8	R3 COM			Relay 3 Common
	9	DO3.2			Relay 3 NC
12 10 11	10	DO4.1			Relay 4 NO
	11	R4 COM			Relay 4 Common
	12	DO4.2			Relay 4 NC
	13	DIO1	&C03/19.3	UC31_RB01_BAT	20ft PLC UPS Battery Operation
	14	DIO2	&C03/19.2	UC31_RB01_DIS	20ft PLC UPS Battery Discharged
	15	DIO3	&C03/19.4	UC31_RB01_RDY	20ft PLC UPS Battery Ready
	16	DIO4	&C03/20.3	UC31_RB02_BAT	20ft Breaker UPS Battery Operation
	17	DIO5	&C03/20.2	UC31_RB02_DIS	20ft Breaker UPS Battery Discharged
	18	DIO6	&C03/20.4	UC31_RB02_RDY	20ft Breaker UPS Battery Ready
	19	DIO7	&C03/32.6	UC31_FC40_I	Precharge MCCB feedback
	20	DIO8	&C03/32.5	UC31_QA40_I	Precharge contactor feedback
	21	DIO9			Spare
	22	DIO10			Spare
	23	COM	&C03/26.3		Supply COM

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, 20ft Rack 1/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 5 / 81

0	1	2	3	4	5	6	7	8

=LA01+UC31-KE06
DEIF AMC300
Controller Extension Rack

-Slot4
&C03/29.1
&C03/42.3
&C03/42.4
IOM3.2
IO Module 3.2

IOM3.2

1	R1 COM	&C03/26.5		Relay 1 In
2	DO1	&C03/29.1	FC30_YO	Breaker FC30 Opening Coil
3	R2 COM	&C03/26.5		Relay 2 COM
4	DO2	&C03/29.2	FC30_YC	Breaker FC30 Closing Coil
5	R3 COM	&C03/26.5		Relay 3 In
6	DO3	&C03/29.3	FC30_RY	Breaker FC30 Trip Reset Coil
7	R4 COM	&C03/26.5		Relay 4 In
8	DO4	&C03/29.4	FC30_UR	Breaker FC30 Undervoltage Coil
9	AO1	&C03/42.3	JA01_QM07_SP	Intake Damper Position Setpoint
10	AO1 COM	&C03/42.3		AO1 COM
11	AO2	&C03/42.5	JA01_QM08_SP	Outlet Damper Position Setpoint
12	AO2 COM	&C03/42.5		AO2 COM
13	AO3			Spare
14	AO3 COM			AO3 COM
15	AO4			Spare
16	AO4 COM			AO4 COM
17	DI1	&C03/29.5	FC30_SPR	Breaker Sping Charge FB
18	DI2	&C03/29.6	FC30_Q1	Breaker Auxillary Contact Q1
19	DI3	&C03/29.7	FC30_Q2	Breaker Auxillary Contact Q2
20	DI4			Spare
21	DI1-4 COM	&C03/26.5		DI1-4 COM
22	AI1	&C03/42.4	JA01_QM07_FB	Damper Position Feedback
23	AI1 COM	&C03/42.4		AI1 COM
24	AI2	&C03/42.6	JA01_QM08_FB	Outlet Damper Position Feedback
25	AI2 COM	&C03/42.6		AI2 COM
26	AI3			Spare
27	AI3 COM			AI3 COM
28	AI4			Spare
29	AI4 COM			AI4 COM

-Slot5
&C03/31.2
&C03/30.8
IOM3.2
IO Module 3.2

IOM3.2

1	R1 COM	&C03/26.6		Relay 1 In
2	DO1	&C03/31.2	UC31_EA01_FAN	20ft Heater Fan Enable
3	R2 COM	&C03/26.6		Relay 2 COM
4	DO2	&C03/31.4	UC31_EA01_HTR	20ft Heater Enable
5	R3 COM			Relay 3 In
6	DO3			Breaker FC30 Trip Reset Coil
7	R4 COM			Relay 4 In
8	DO4			Battery Simulator Enable
9	AO1			Spare
10	AO1 COM			AO1 COM
11	AO2			Spare
12	AO2 COM			AO2 COM
13	AO3			Spare
14	AO3 COM			AO3 COM
15	AO4			Spare
16	AO4 COM			AO4 COM
17	DI1	&C03/30.8	IAH_05	MCCB Trip Indication AC Customer
18	DI2			Breaker Auxillary Contact Q1
19	DI3			Breaker Auxillary Contact Q2
20	DI4			Spare
21	DI1-4 COM	&C03/26.6		DI1-4 COM
22	AI1			Spare
23	AI1 COM			AI1 COM
24	AI2			Spare
25	AI2 COM			AI2 COM
26	AI3			Spare
27	AI3 COM			AI3 COM
28	AI4			Spare
29	AI4 COM			AI4 COM

-Slot6
&C03/30.1
IOM3.2
IO Module 3.2

IOM3.2

1	R1 COM			Relay 1 In
2	DO1			Relay 1 out
3	R2 COM			Relay 2 COM
4	DO2			Relay 2 Out
5	R3 COM			Relay 3 In
6	DO3			Relay 3 Out
7	R4 COM			Relay 4 In
8	DO4			Relay 4 Out
9	AO1			Spare
10	AO1 COM			AO1 COM
11	AO2			Spare
12	AO2 COM			AO2 COM
13	AO3			Spare
14	AO3 COM			AO3 COM
15	AO4			Spare
16	AO4 COM			AO4 COM
17	DI1	&C03/30.1	IAH_01	MCCB Trip Indication PSU
18	DI2	&C03/30.3	IAH_02	MCCB Trip Indication Heating
19	DI3	&C03/30.5	IAH_03	MCCB Trip Indication Battery
20	DI4	&C03/30.6	IAH_04	MCCB Trip Indication AC Busbar
21	DI1-4 COM	&C03/26.7		DI1-4 COM
22	AI1			Spare
23	AI1 COM			AI1 COM
24	AI2			Spare
25	AI2 COM			AI2 COM
26	AI3			Spare
27	AI3 COM			AI3 COM
28	AI4			Spare
29	AI4 COM			AI4 COM

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C02

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, 20ft Rack 2/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 6 / 81

0	1	2	3	4	5	6	7	8

=LA01+UC31-KE06
DEIF AMC300
Controller Extension Rack

-Slot7
&C03/45.2
&C03/46.1
&C03/46.5
IOM3.3
IO Module 3.3

IOM3.3

1	AI1			Spare
2	AI2	&C03/45.2	HE03_BF02_FT	LT Coolant Flow Auxillary Sensor
3	AI3	&C03/45.2		Spare
4	AI4			Spare
5	AI5	&C03/45.3	HE03_BF02_TT	LT Coolant 20ft Temperature
6	AI6	&C03/45.3		Spare
7	AI7	&C03/45.4	HE03_BT07_TT	LT Coolant 20ft Forward
8	AI8	&C03/45.4		LT Coolant 20ft Forward
9	AI9	&C03/45.4		Spare
10	AI10	&C03/46.1	DA03_BT01	Container temperature
11	AI11	&C03/46.1		Spare
12	AI12	&C03/46.1		Spare
13	AI13		TA30_U_TT	TA30 U Primary Temp
14	AI14			Spare
15	AI15			Spare
16	AI16		TA30_V_TT	TA30 V Primary Temp
17	AI17			Spare
18	AI18			Spare
19	AI19		TA30_W_TT	TA30 W Primary Temp
20	AI20			Spare
21	AI21			Spare
22	AI22			Spare
23	AI23	&C03/46.5	DA03_BP01	Container Diff. Pressure
24	AI24	&C03/46.5		Spare
25	AI25			Spare
26	AI26			Spare
27	AI27			Spare
28	AI28			Spare
29	AI29			Spare
30	AI30			Spare

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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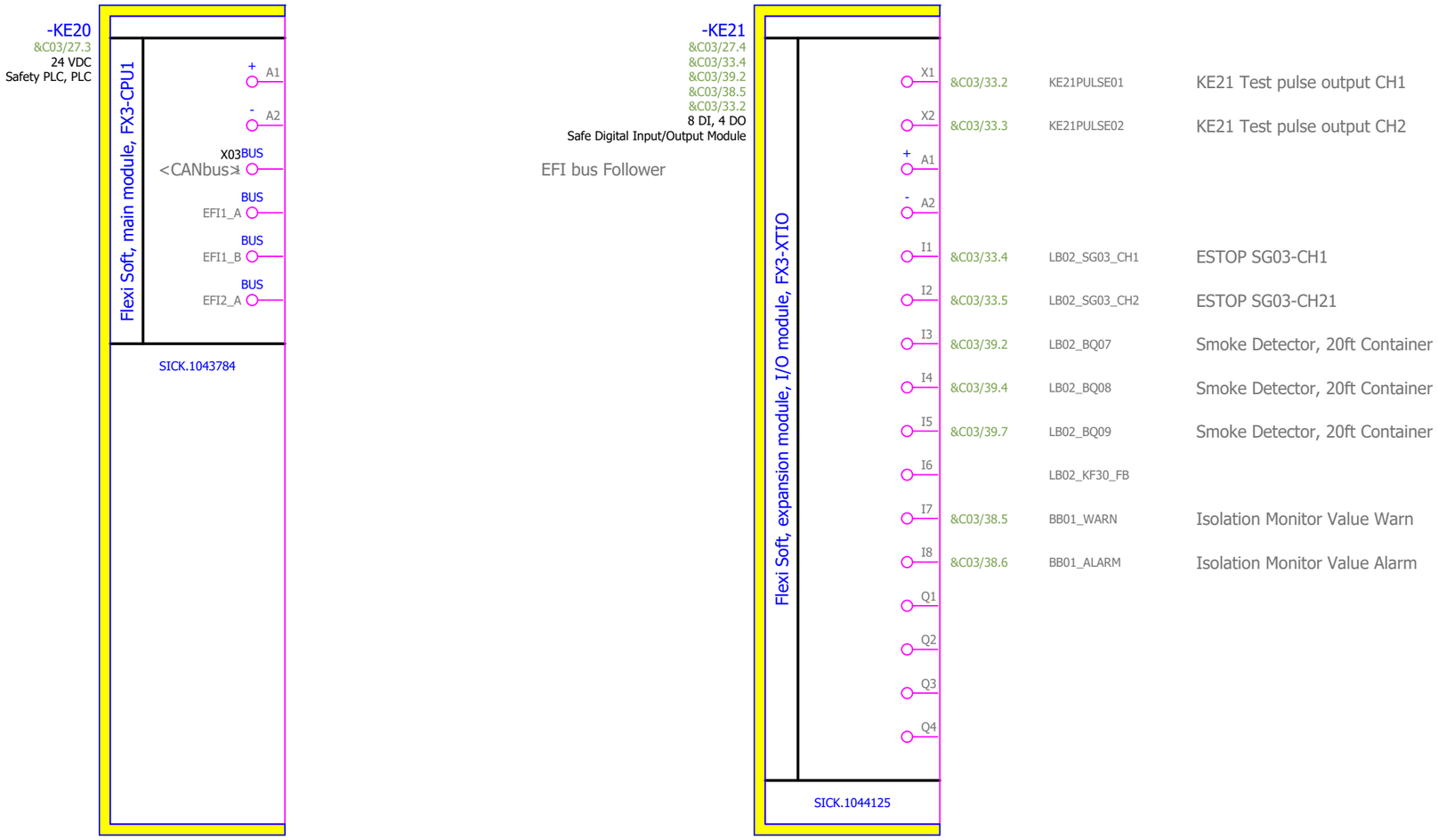
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Container Controller, 20ft Rack 3/3		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 7 / 81

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LB02+UC31
Container Safety System, Control Cabinet 20 ft



&C03/33.2	KE21PULSE01	KE21 Test pulse output CH1
&C03/33.3	KE21PULSE02	KE21 Test pulse output CH2
&C03/33.4	LB02_SG03_CH1	ESTOP SG03-CH1
&C03/33.5	LB02_SG03_CH2	ESTOP SG03-CH21
&C03/39.2	LB02_BQ07	Smoke Detector, 20ft Container 1/3
&C03/39.4	LB02_BQ08	Smoke Detector, 20ft Container 2/3
&C03/39.7	LB02_BQ09	Smoke Detector, 20ft Container 3/3
	LB02_KF30_FB	
&C03/38.5	BB01_WARN	Isolation Monitor Value Warn
&C03/38.6	BB01_ALARM	Isolation Monitor Value Alarm

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Controller, 20ft Container 1/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 8 / 81

0	1	2	3	4	5	6	7	8

=LB02+UC31

Container Safety System, Control Cabinet 20 ft

-KE22

&C03/27.5
&C03/34.3
&C03/35.4
&C03/37.1
&C03/36.3
&C03/34.3
&C03/35.4
&C03/36.1
8 DI, 4 DO
Safe Digital Input/Output Module

Flexi Soft, expansion module, I/O module, FX3-XTIO

SICK.1044125

X1				
X2				
+ A1				
- A2				
I1	&C03/37.3 &C03/34.3	LB02_KF30_I	Safety Relay KF30 Feedback
I2	&C03/37.4 &C03/35.4	LB02_KF31_I	Safety Relay KF31 Feedback
I3	&C03/37.1		Spare
I4			Spare
I5	&C03/36.3	LB02_BG01_CH1	Safety Door Sensor, Door A - CH1
I6	&C03/36.4	LB02_BG01_CH2	Safety Door Sensor, Door A - CH2
I7	&C03/36.6	LB02_BG02_CH1	Safety Door Sensor, Door B - CH1
I8	&C03/36.7	LB02_BG02_CH2	Safety Door Sensor, Door B - CH2
Q1	&C03/34.3 &C03/37.2	LB02_KF30_Q	Safety Relay KF30 Coil
Q2	&C03/35.4	LB02_KF31_Q	Safety Relay KF31 Coil
Q3			
Q4			

Safety IO - Battery Pack

-KE23

&C03/27.6
&C03/40.1
&C03/41.1

Flexi Soft, expansion module, I/O module, FX3-XTIO

SICK.1044125

X1	&C03/41.1
X2	&C03/41.2
+ A1	
- A2	
I1	&C03/40.1
I2	&C03/40.2
I3	&C03/40.3
I4	&C03/40.4
I5	&C03/40.4
I6	&C03/40.5
I7	&C03/40.6
I8	&C03/40.7
Q1	&C03/41.4
Q2	&C03/41.5
Q3	&C03/41.6
Q4	&C03/41.7

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C02

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Controller, 20ft Container 2/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 9 / 81

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Ballard Power Systems Europe - Technology Solutions

Multiline Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DATE	
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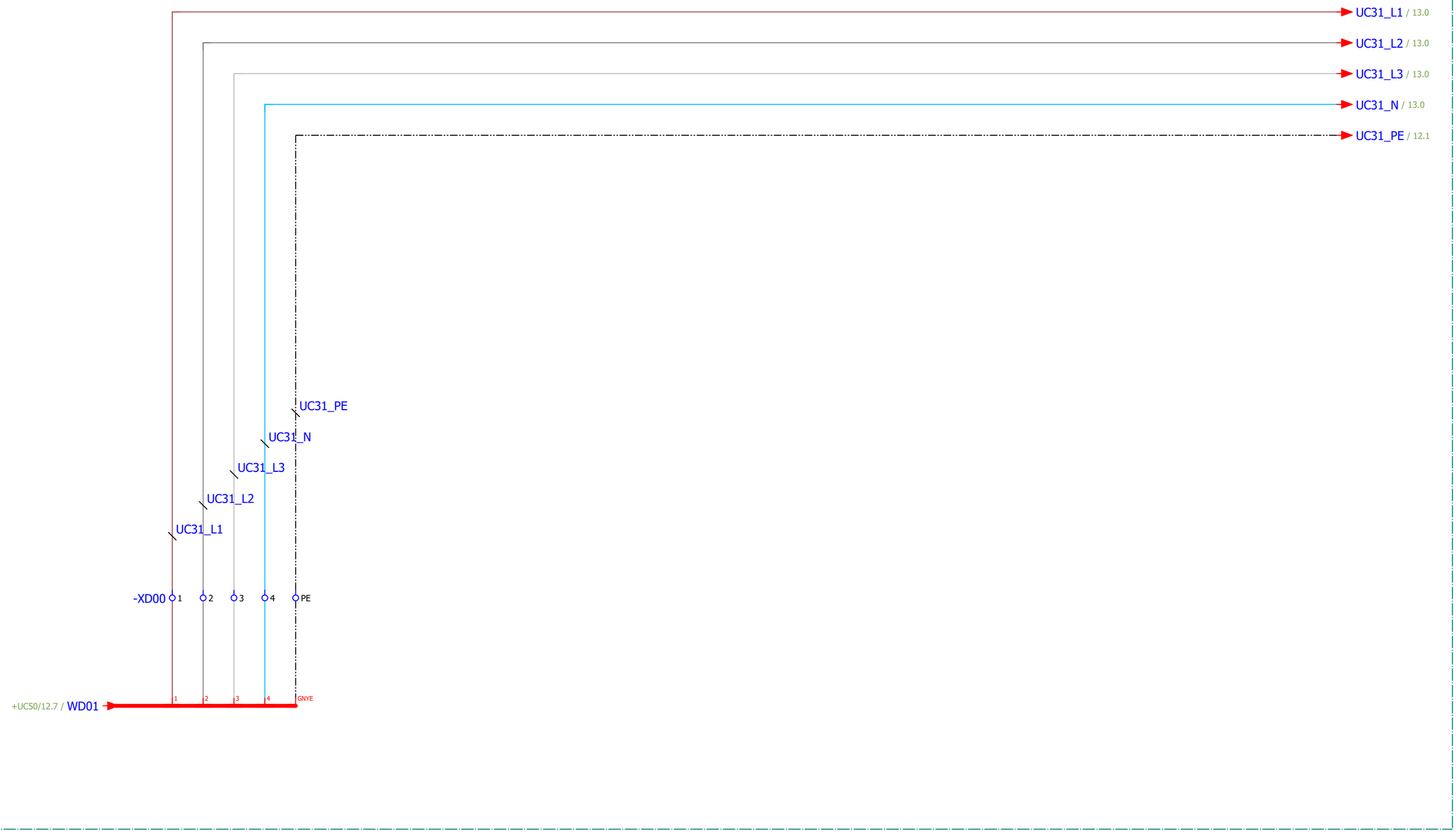
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Multiline Documentation Intro		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 10 / 81

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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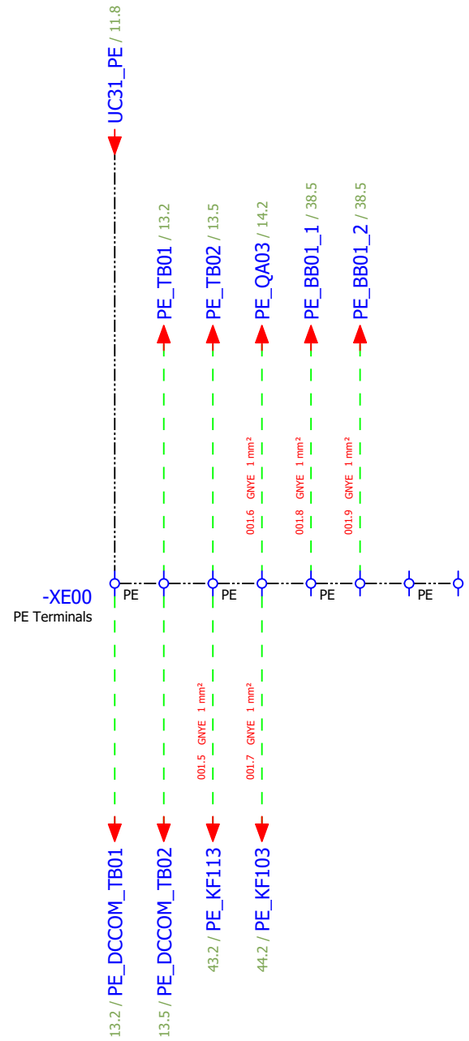
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC Input		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 11 / 81

FRM5103656/0B

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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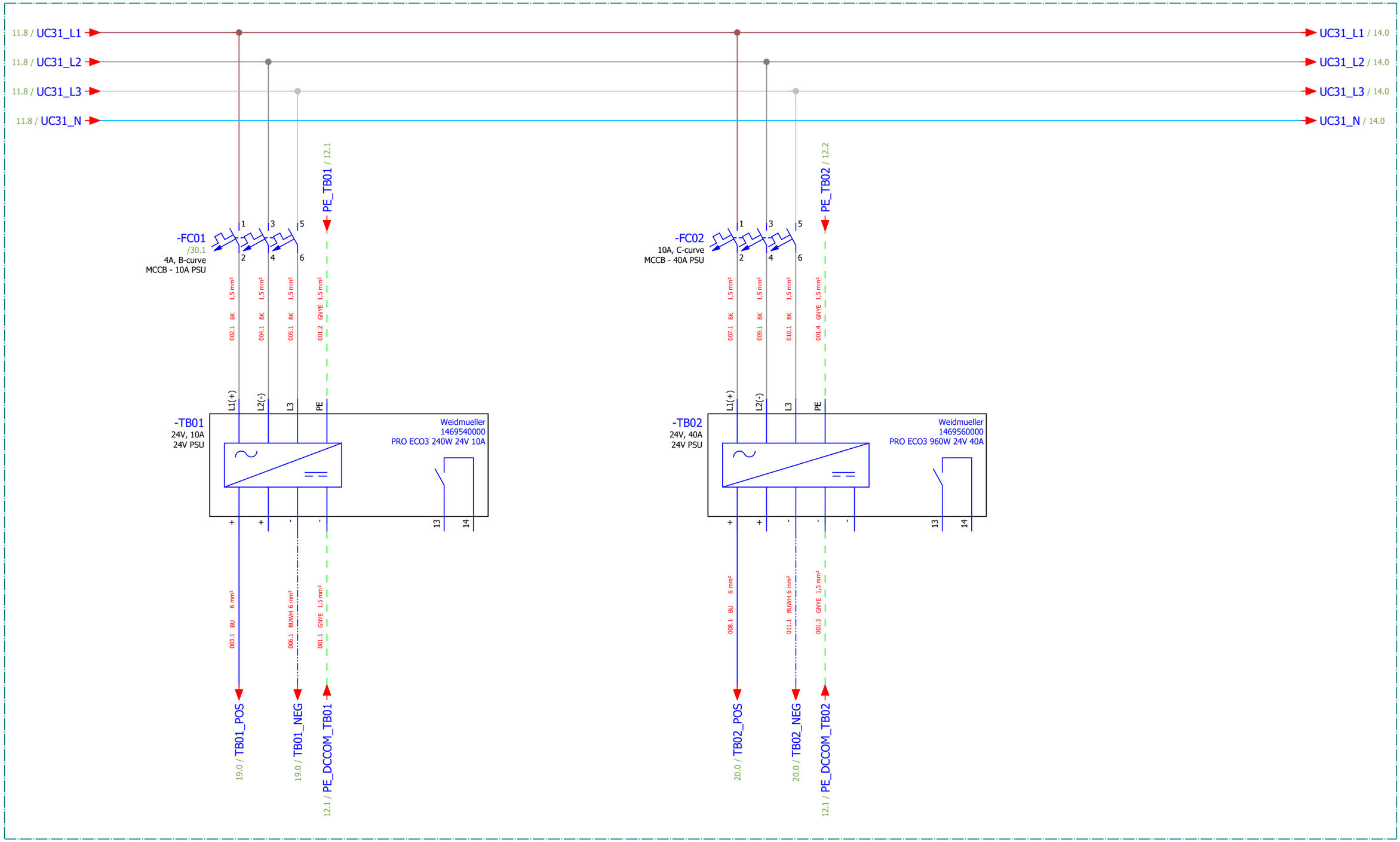
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	PE Distribution		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 12 / 81

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC - 24V Power Supplies		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 13 / 81

=LA01

13.8 / UC31_L1 → UC31_L1 / 15.0
13.8 / UC31_L2 → UC31_L2 / 15.0
13.8 / UC31_L3 → UC31_L3 / 15.0
13.8 / UC31_N → UC31_N / 15.0

PE_QA03 / 12.2

-FC03
/30.3
16A, B-curve
MCCB - 10ft Heating Fan

-FC04
/30.3
10A, B-curve
MCCB - 10ft Ventilation Fan

PE_QA03 /

-QA03
/31.4

-QA01
/31.2
Heater Fan Contactor

012.1 BK 1,5 mm²
014.1 BK 1,5 mm²
016.1 BK 1,5 mm²
001.6 GNYE 1,5 mm²
021.1 BK 1,5 mm²
013.1 BK 1,5 mm²
015.1 BK 1,5 mm²
017.1 BK 1,5 mm²
021.2 BK 1,5 mm²
022.2 BK 1,5 mm²
018.1 BK 1,5 mm²
019.1 BK 1,5 mm²
020.1 BK 1,5 mm²
001.6 GNYE 1,5 mm²

-XD01 1 2 3 4 PE 5 6 7 8 9 PE

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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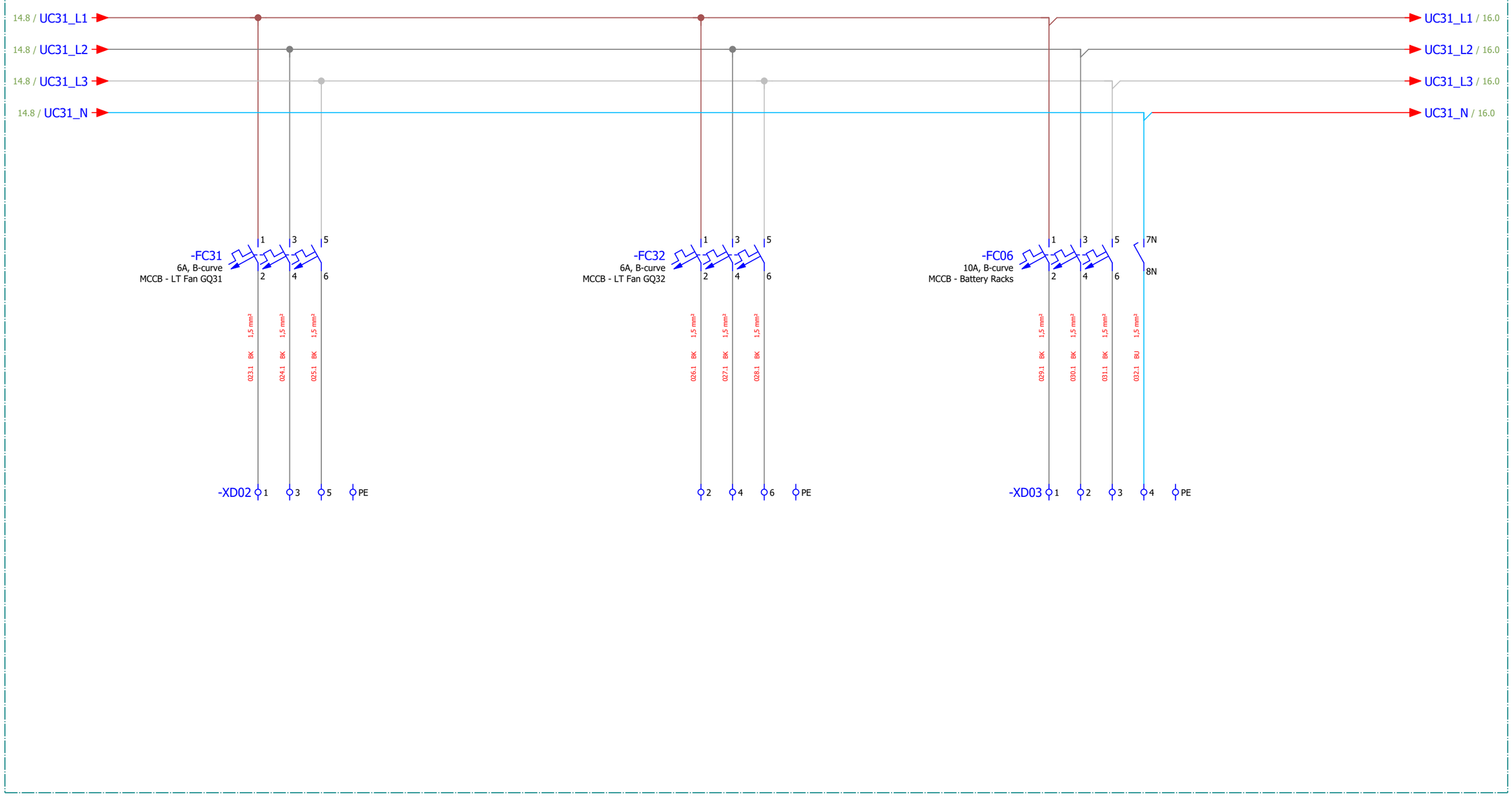
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC - Container Heating		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 14 / 81

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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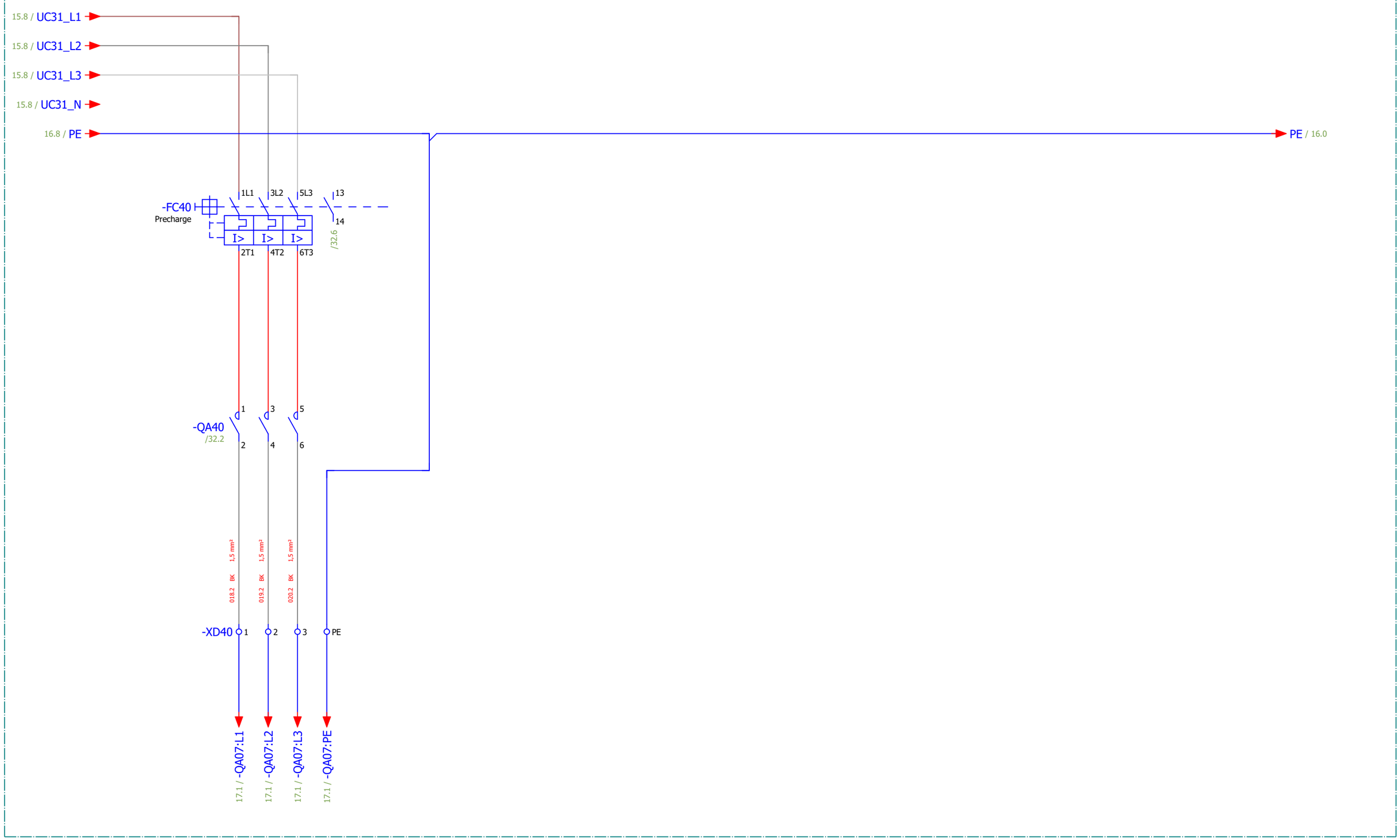
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC - LT Fans		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 15 / 81

FRM5103656/0B

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC - Precharge		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 16 / 81

=BA30

16.1 / >=LA01+UC31-QA07:L1
16.1 / >=LA01+UC31-QA07:L2
16.2 / >=LA01+UC31-QA07:L3
16.2 / >=LA01+UC31-QA07:PE

-TA40-WD01
ÖLFLEX® CLASSIC 130 H BK 0,6/1 kV
4x2,5
0,6/1,0 kV
Precharge transformer supply
1 2 3 GNYE

-TA40
Precharge Isolation Trafo
U V W PE
PRI
BLOCK
TT3 2,5-4-4
SEC
380U 380V 380W 400U 400V 400W 420U 420V 420W N

-TB40-WD01
ÖLFLEX® CLASSIC 130 H BK 0,6/1 kV
4x2,5
0,6/1,0 kV
Precharge Rectifier Supply
BN BK GY
BN BK GY

BN BK GY
-TB40
3p Diode Bridge
- +
-RA40.1
3.3Ω, 1000W
-RA40.2
3.3Ω, 1000W
-XD41 1 2
-RA40.3
3.3Ω, 1000W
-RA40.4
3.3Ω, 1000W
-FC41
20 A
1 1
>=BA20+DA03-WD01:1
>=BA20+DA03-WD01:2

>=BA20+DA03-L+ / 38.7
>=BA20+DA03-L- / 38.8
-WD02
ÖLFLEX® CLASSIC 130 H BK 0,6/1 kV
4x2,5
0,6/1,0 kV
Isolation monitoring
BN BK
-FC42
2 A
1 1
3
4

=BA30+
DC Bus

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

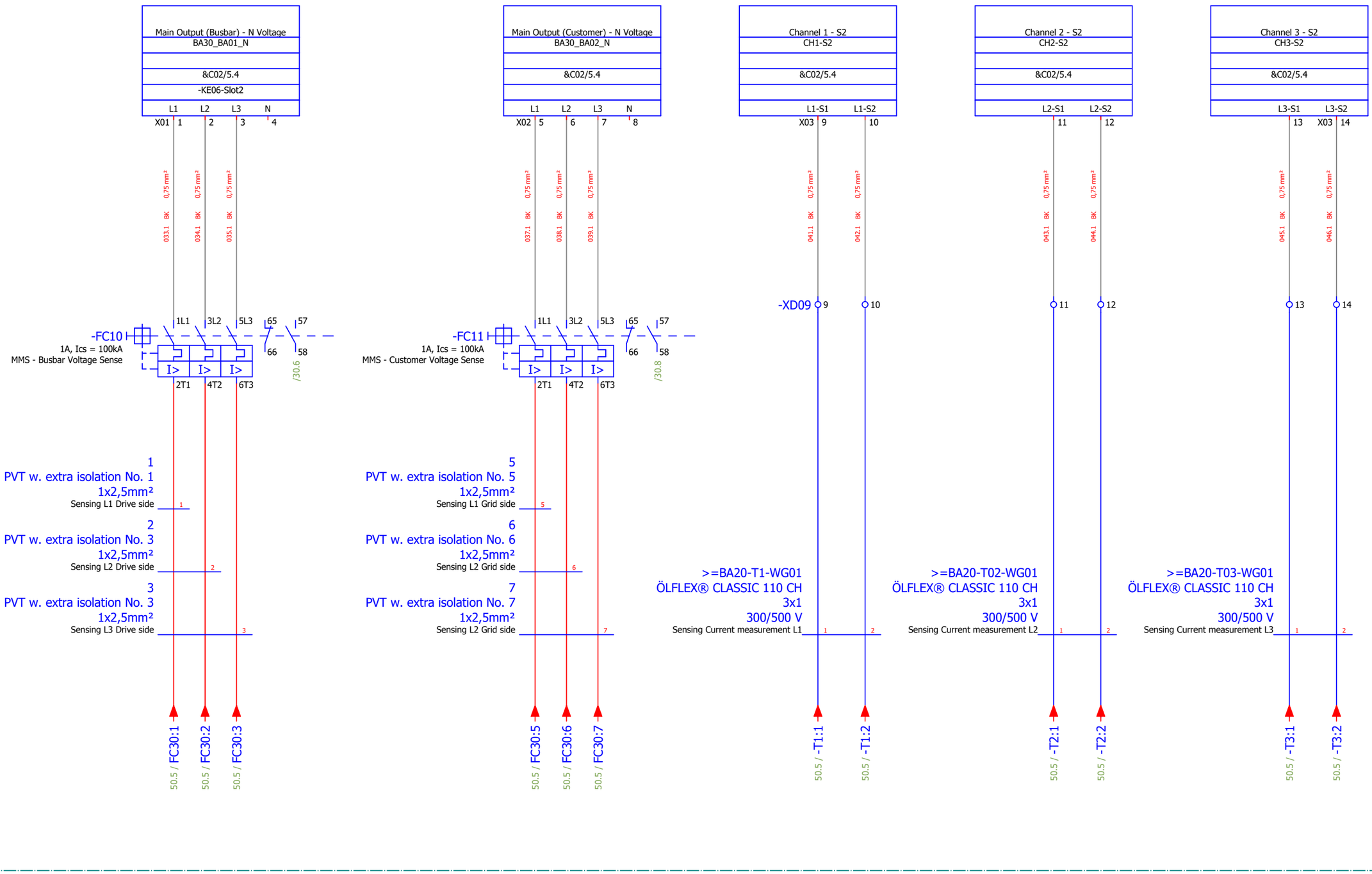
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC - Precharge		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 17 / 81

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC - Sensing		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 18 / 81

0	1	2	3	4	5	6	7	8

=LA01+UC31

=LA01+UC31
Main Breaker Cabinet

20ft PLC UPS Battery Discharged
UC31_RB01_DIS
&C02/5.7
-KE06-Slot3
DIO2
X02 14

20ft PLC UPS Battery Operation
UC31_RB01_BAT
&C02/5.7
-KE06-Slot3
DIO1
X02 13

20ft PLC UPS Battery Ready
UC31_RB01_RDY
&C02/5.7
DIO3
15

TB01_POS / 13.1
TB01_NEG / 13.2

052.1 WH 0,5 mm²
055.1 WH 0,5 mm²
056.1 WH 0,5 mm²
049.1 BU 6 mm²
050.1 BUWH 6 mm²

-RB01
24V, 10A
24V UPS Module
IN + IN - Input
B+ B- Battery
12 14 22 24 32 34
Alarm Buffering Charging
10A 20A
INV3 INV4 INV5 Temp.
H L
Time 0.5-45 min
Acid 1.3-17 Ah
Weidmüller CP DC UPS

Output OUT + OUT -
Interlock + Interlock - 1 2
Alarm 3
Buffering Charging 4 5
Temperature Sensor 6 7
11 21 31

-XD06
1
2

-CA01
PULS
Battery Module, 24V, 12Ah
UZK24.121
DC 24V
Out + Out -
PT100 Temp. Sensor 11
PT100 Temp. Sensor 12
Battery Center Tap 13

Battery Supply RB01
300/500 V
3x2,5
ÖLFLEX® CLASSIC 110 CH
-CA01-WD01

054.1 BU 0,5 mm² 054.3 BU 0,5 mm² 054.4 BU 0,5 mm² → 24V_DI4_2 / 20.2

047.1 BU 6 mm²
048.1 BUWH 6 mm²
051.1 VT 0,5 mm²
053.1 VT 0,5 mm²
054.2 BU 0,5 mm²

5 WH
6 BN

Battery Tempereature CA01
300/500 V
4x0,5
UNITRONIC®-FD CP (TP) PLUS
-CA01-WG01

21.2 / RB01_POS
21.0 / RB01_NEG
23.2 / 24V_DI4

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	10A UPS Module		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 19 / 81

0	1	2	3	4	5	6	7	8

=LA01

=LA01+UC31
Main Breaker Cabinet

20ft Breaker UPS Battery Discharged
UC31_RB02_DIS
&C02/5.7
-KE06-Slot3
DIO5
X02 17

20ft Breaker UPS Battery Operation
UC31_RB02_BAT
&C02/5.7
DIO4
16

20ft Breaker UPS Battery Ready
UC31_RB02_RDY
&C02/5.7
DIO6
18

TB02_POS / 13.4
TB02_NEG / 13.5

062.1 WH 0,5 mm²
064.1 WH 0,5 mm²
065.1 WH 0,5 mm²
059.1 BU 6 mm²
060.1 BUWH 6 mm²

-RB02
24V, 40A
40A UPS Module
IN + IN - Input
B+ B- Battery
12 14 22 24 32 34
Alarm Buffering Charging
Weidmüller CP DC UPS
INV3 INV4 INV5 Temp.
H L
Time 0.5-45 min
Acid 1.3-17 Ah
Output
OUT + OUT -
Interlock + Interlock - 1 2
Alarm 3
Buffering Charging 4 5
Temperature Sensor 6 7
11 21 31

-XD06
3
4

-CA02
PULS
Battery Module, 24V, 12Ah
UZK24.121
DC 24V
Out + Out -
PT100 Temp. Sensor 11
PT100 Temp. Sensor 12
Battery Center Tap 13

1
2
Battery Supply RB02
300/500 V
3x2,5
ÖLFLEX® CLASSIC 110 CH
-CA02-WD01

054.5 BU 0,5 mm²
054.6 BU 0,5 mm²
061.1 VT 0,5 mm²
063.1 VT 0,5 mm²
057.1 BU 6 mm²
058.1 BUWH 6 mm²

7
8
WH
BN
Battery Tempereature CA02
300/500 V
4x0,5
UNITRONIC®-FD CP (TP) PLUS
-CA02-WG01

28.5 / 24V_FC30
28.5 / DCCOM_FC30
19.4 / 24V_DI4_2

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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=	++	+ UC31	& C03

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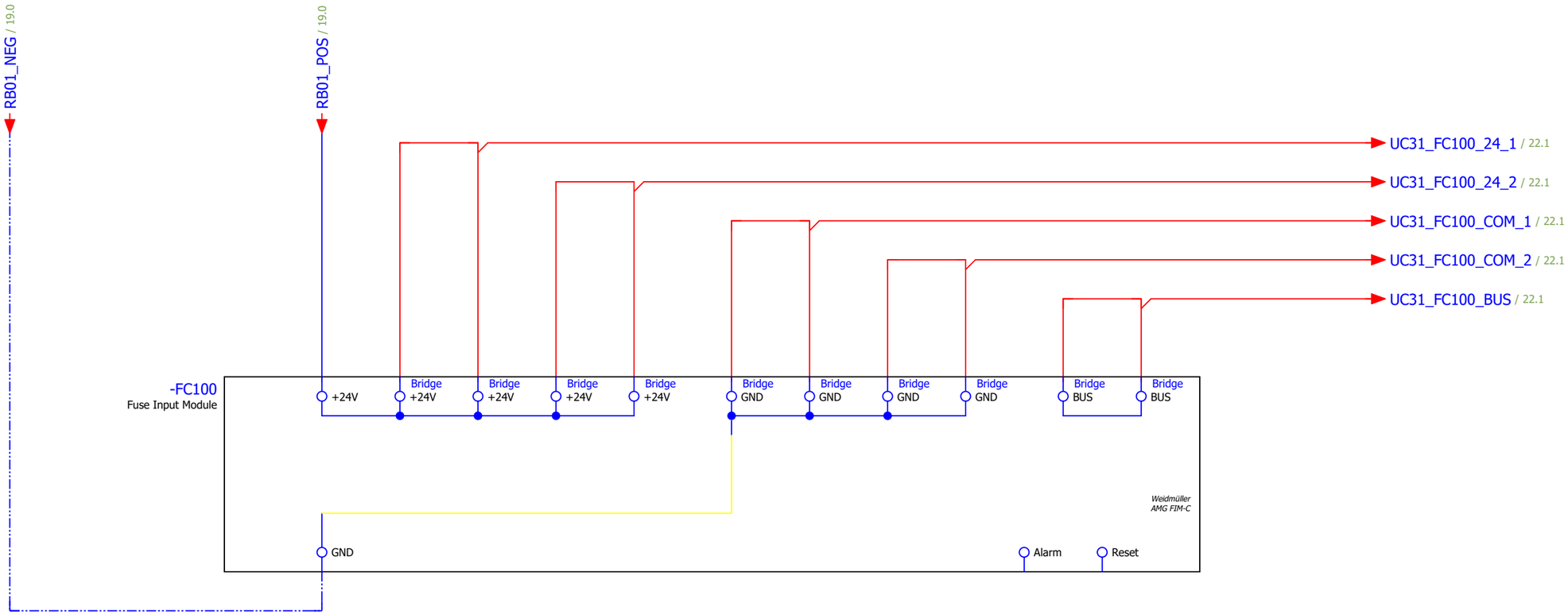
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	40A UPS Module		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 20 / 81

FRM5103656/0B

=LA01



Reference Item Number	Ballard Part # TBD		
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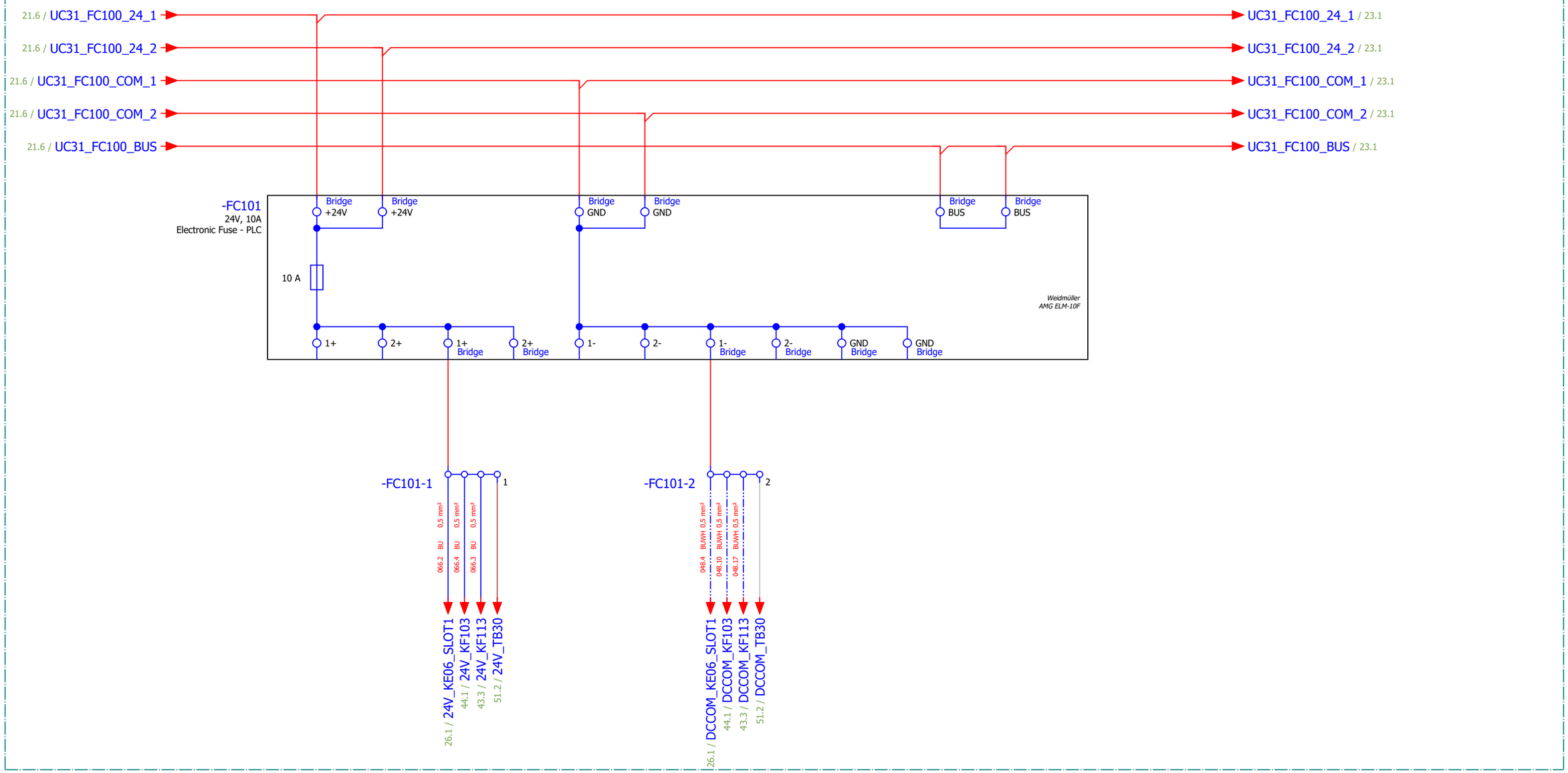
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	24V Fusing - FC100		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 21 / 81

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01



Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC31 | & C03

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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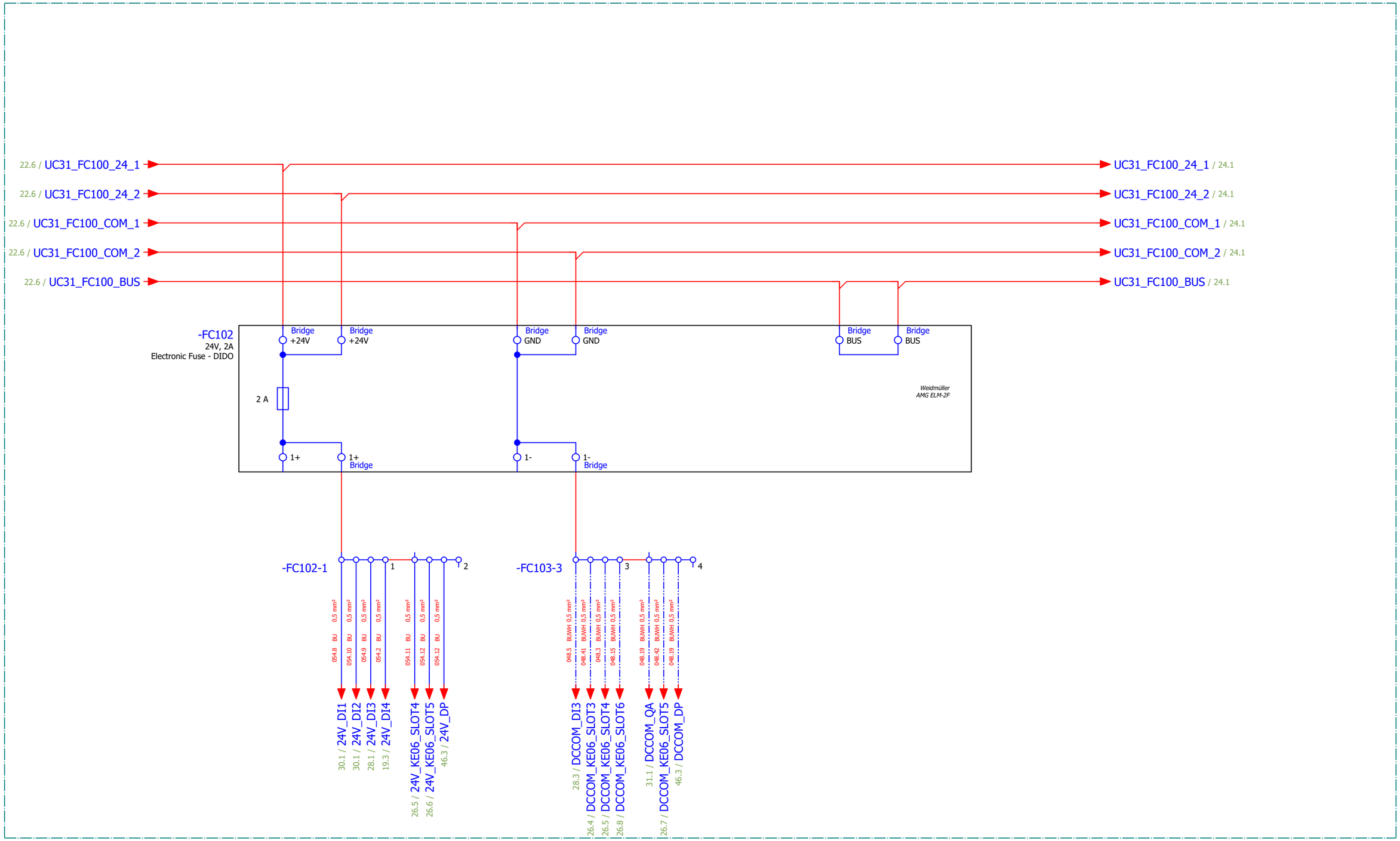
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	24V Fusing and Distribution - FC101		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 22 / 81

0	1	2	3	4	5	6	7	8

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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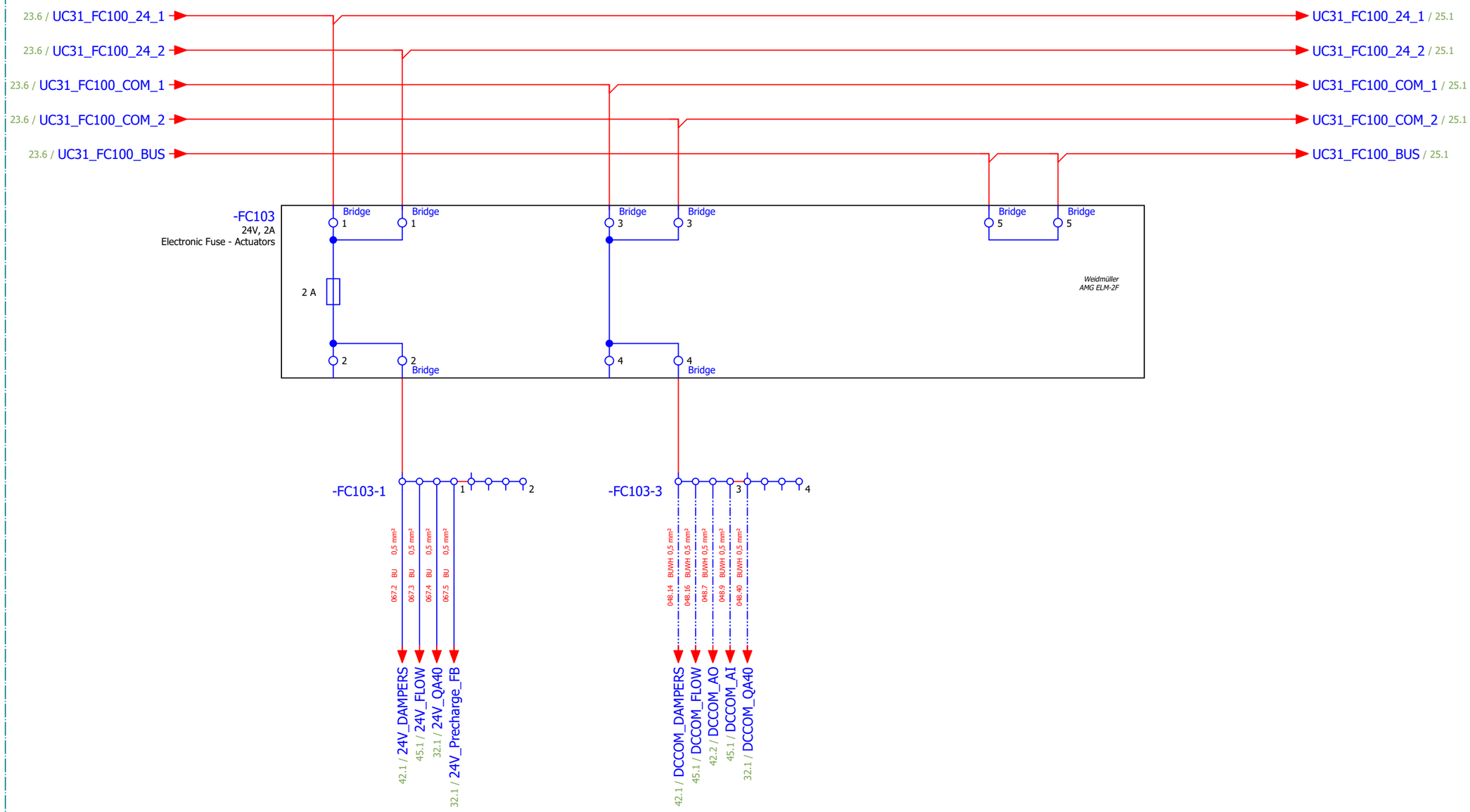
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	24V Fusing and Distribution - FC102		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 23 / 81

0	1	2	3	4	5	6	7	8

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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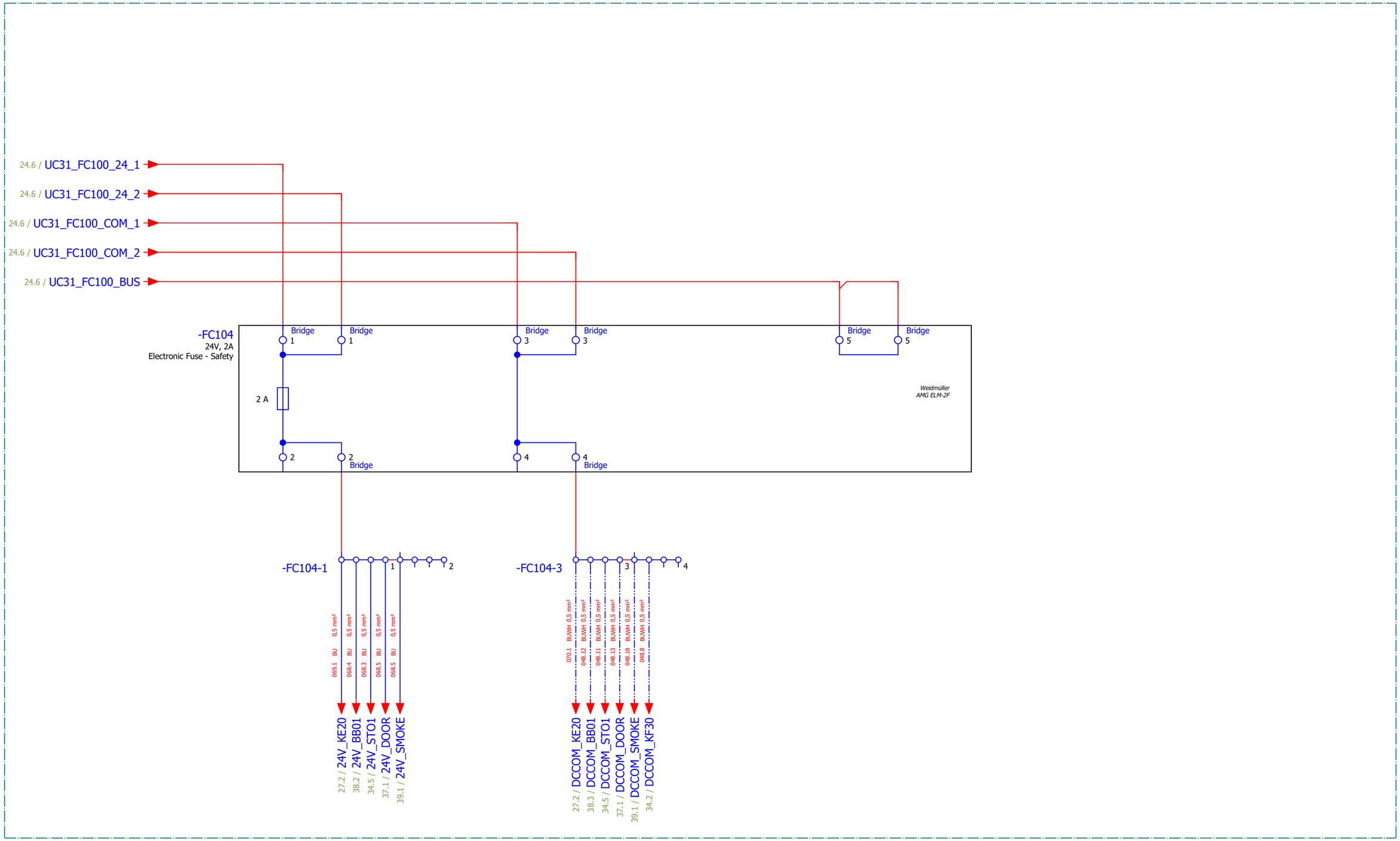
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	24V Fusing and Distribution - FC103		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 24 / 81

0	1	2	3	4	5	6	7	8

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	24V Fusing and Distribution - FC104		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 25 / 81

0	1	2	3	4	5	6	7	8

=LA01

-KE06
DEIF AMC300
Controller Extension Rack

-Slot1
DEIF PSM3.2

PE
PE
&C02/5.1

12-24V
1
&C02/5.1

0V
2
&C02/5.1

-Slot3

-Slot4

R1 COM
1
Relay 1 In &C02/6.1

R2 COM
3
Relay 2 COM &C02/6.1

R3 COM
5
Relay 3 In &C02/6.1

R4 COM
7
Relay 4 In &C02/6.1

-Slot5

R1 COM
1
Relay 1 In &C02/6.4

R2 COM
3
Relay 2 COM &C02/6.4

-Slot6

DI1-4 COM
21
DI1-4 COM &C02/6.1

DI1-4 COM
21
DI1-4 COM &C02/6.4

DI1-4 COM
21
DI1-4 COM &C02/6.6

COM
23
Supply COM &C02/5.7

22.4 / DCCOM_KE06_SLOT1

22.2 / 24V_KE06_SLOT1

23.3 / DCCOM_KE06_SLOT3

23.2 / 24V_KE06_SLOT4

23.3 / DCCOM_KE06_SLOT4

23.2 / 24V_KE06_SLOT5

23.4 / DCCOM_KE06_SLOT5

23.4 / DCCOM_KE06_SLOT6

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	PLC - 24V		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 26 / 81

0	1	2	3	4	5	6	7	8

=LA01+UC20
From 40ft Container

=LB02+UC31
Safety System, 20ft Control Cabinet

25.2 / >=LA01-24V_KE20

25.3 / >=LA01-DCCOM_KE20

032.2 BU 0,5 mm²

034.2 BUWH 0,5 mm²

035.2 BU 0,5 mm²

036.2 BUWH 0,5 mm²

037.2 BU 0,5 mm²

038.2 BUWH 0,5 mm²

-KE20
&C02/8.0
24 VDC
Safety PLC, PLC
+ A1
- A2

-KE21
&C02/8.3
Safe Digital
Input/Output Module
+ A1
- A2

-KE22
&C02/9.1
Safe Digital
Input/Output Module
+ A1
- A2

-KE23
&C02/9.5
Safe Digital
Input/Output Module
+ A1
- A2

+UC20/46.8 / EFI_CAN

BN — 1 — X03 Other bus systems

WH — 2 — X03 Other bus systems

GN — 3 — X03 Other bus systems

YE — EFI2_B — Other bus systems

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

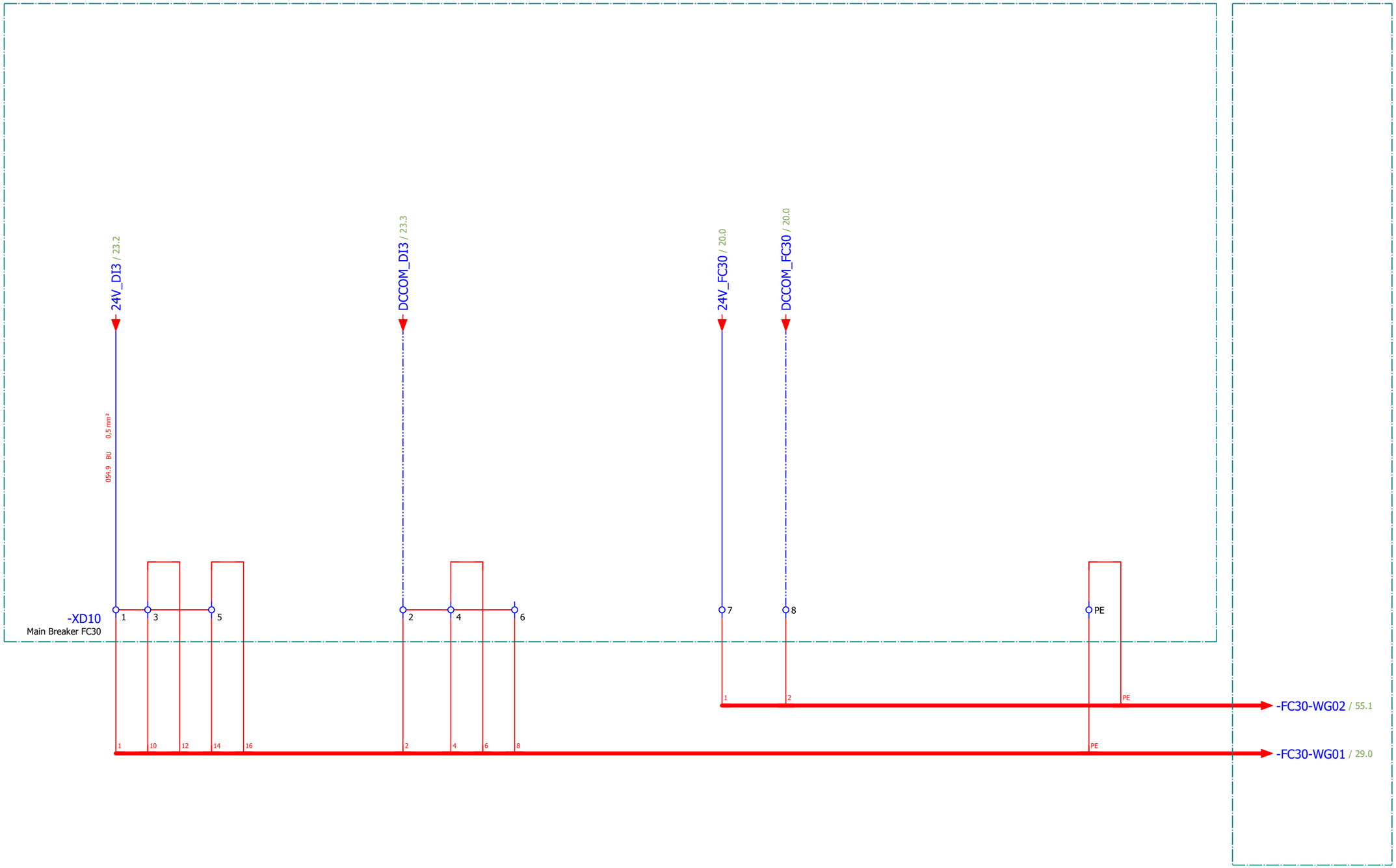
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety PLC - 24V		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 27 / 81



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	FC30 Breaker 24V		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 28 / 81

=BA30+DA01-LA01
AC Power Output, 20ft Container Inside

=BA30+DA03
AC Power Output, 20ft Container Inside

Breaker FC30 Opening Coil	Breaker FC30 Closing Coil	Breaker FC30 Trip Reset Coil	Breaker FC30 Undervoltage Coil	Breaker Sping Charge FB	Breaker Auxillary Contact Q1	Breaker Auxillary Contact Q2
FC30_YO	FC30_YC	FC30_RY	FC30_UR	FC30_SPR	FC30_Q1	FC30_Q2
&C02/6.1	&C02/6.1	&C02/6.1	&C02/6.1	&C02/6.1	&C02/6.1	&C02/6.1
-KE06-Slot4						
DO1	DO2	DO3	DO4	DI1	DI2	DI3
X01 2	4	6	X01 8	X03 17	18	19

0,5 mm² WH 074.1 → FC30_UR_1 34.6

34.6 FC30_UR_2

0,5 mm² WH 074.1

0,5 mm² WH 069.1

0,5 mm² WH 070.1

0,5 mm² WH 071.1

0,5 mm² WH 075.1

0,5 mm² WH 076.1

0,5 mm² WH 077.1

-XD10 10 11 12 13 14 15 16 17 18

28.8 / -FC30-WG01 → 3 5 7 1 2 17 9 11 → -FC30-WG01 / 53.0

-TA30-WG0X /

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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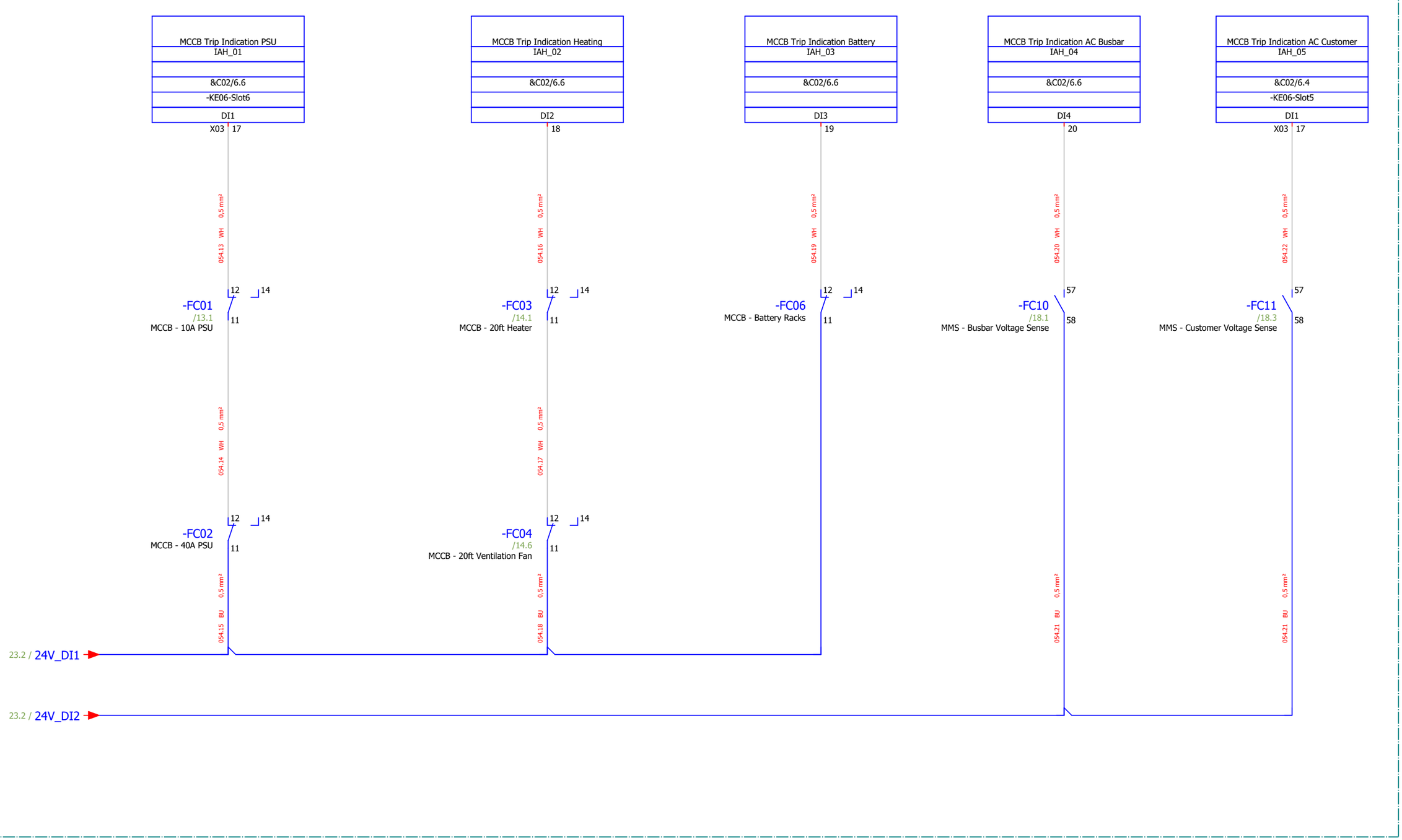
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	FC30 Breaker DI DO		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 29 / 81

=LA01



Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
=	++ | + UC31 | & C03

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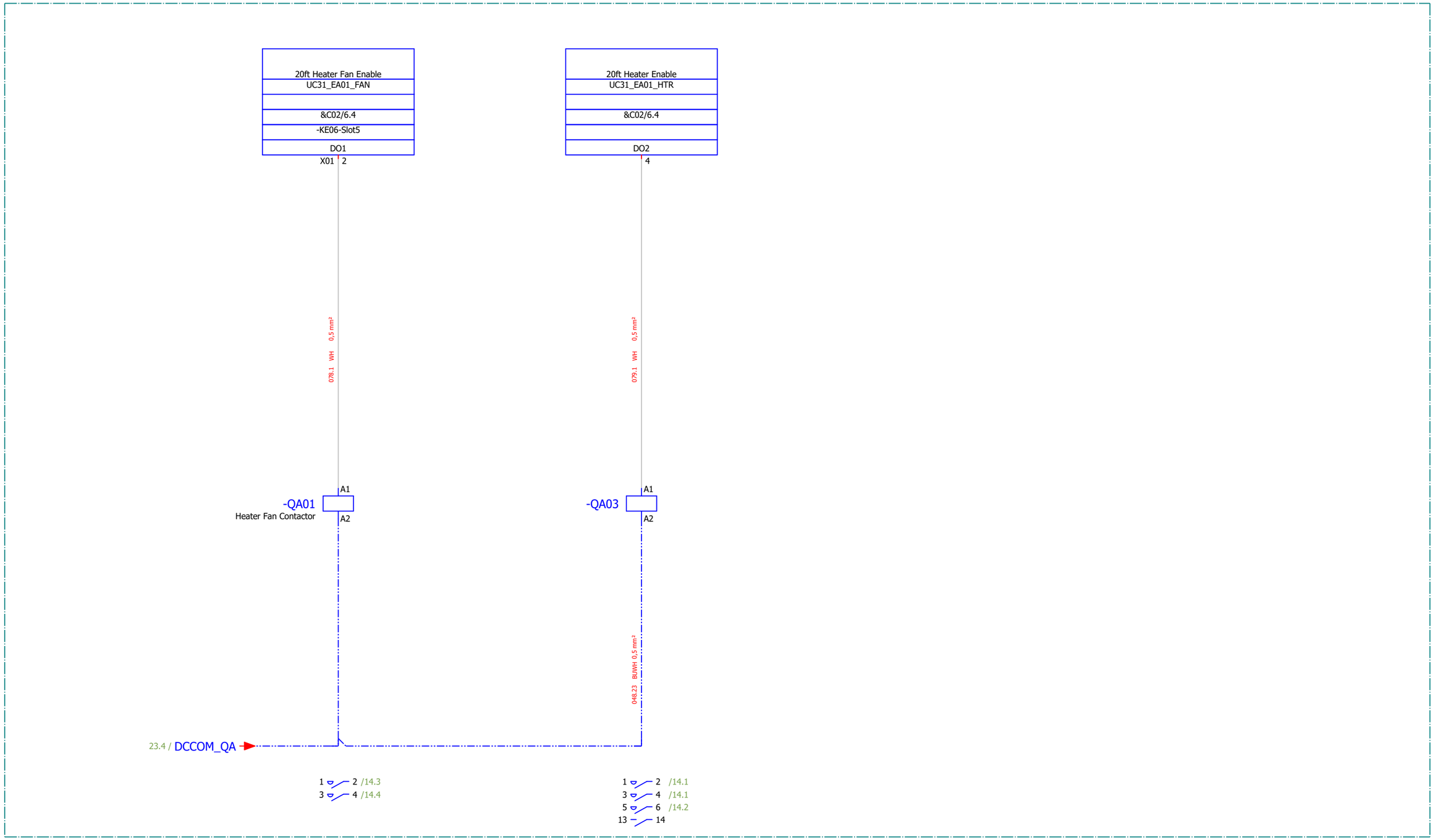
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	MCCB Trip Indicators		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 30 / 81

0	1	2	3	4	5	6	7	8

=LA01
Control System, 20ft Container



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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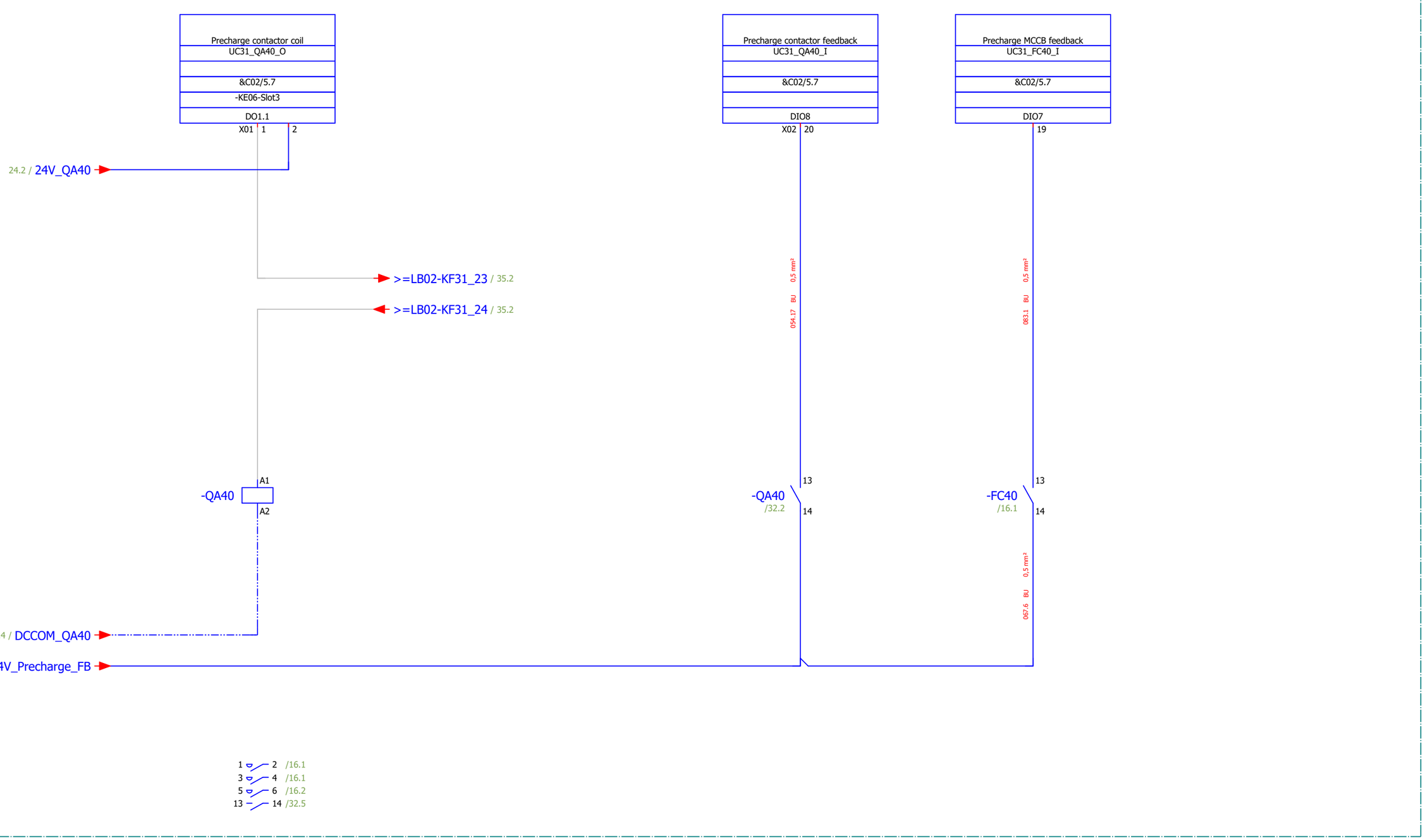
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	20ft Heating IO		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 31 / 81

0	1	2	3	4	5	6	7	8

=LA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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=	++	+ UC31	& C03

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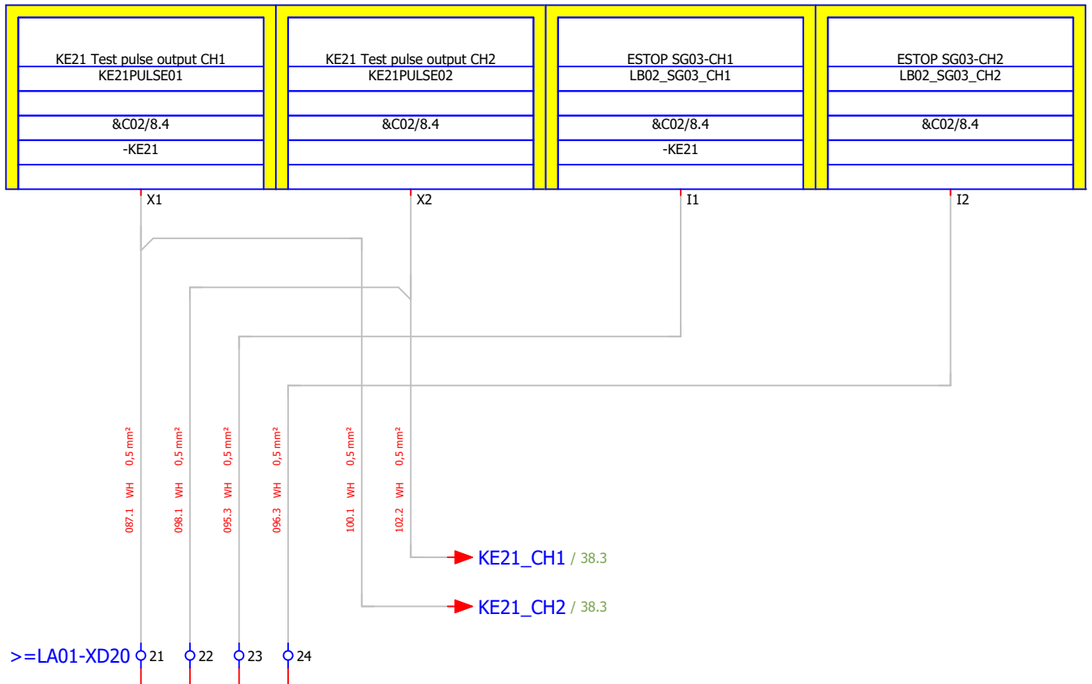
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	AC - Precharge IO		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 32 / 81

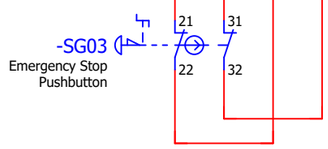
FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LB02+UC31
Safety System, 20ft Control Cabinet



=LB02+DA03
Safety System, 20ft Container, Breaker Panel Front



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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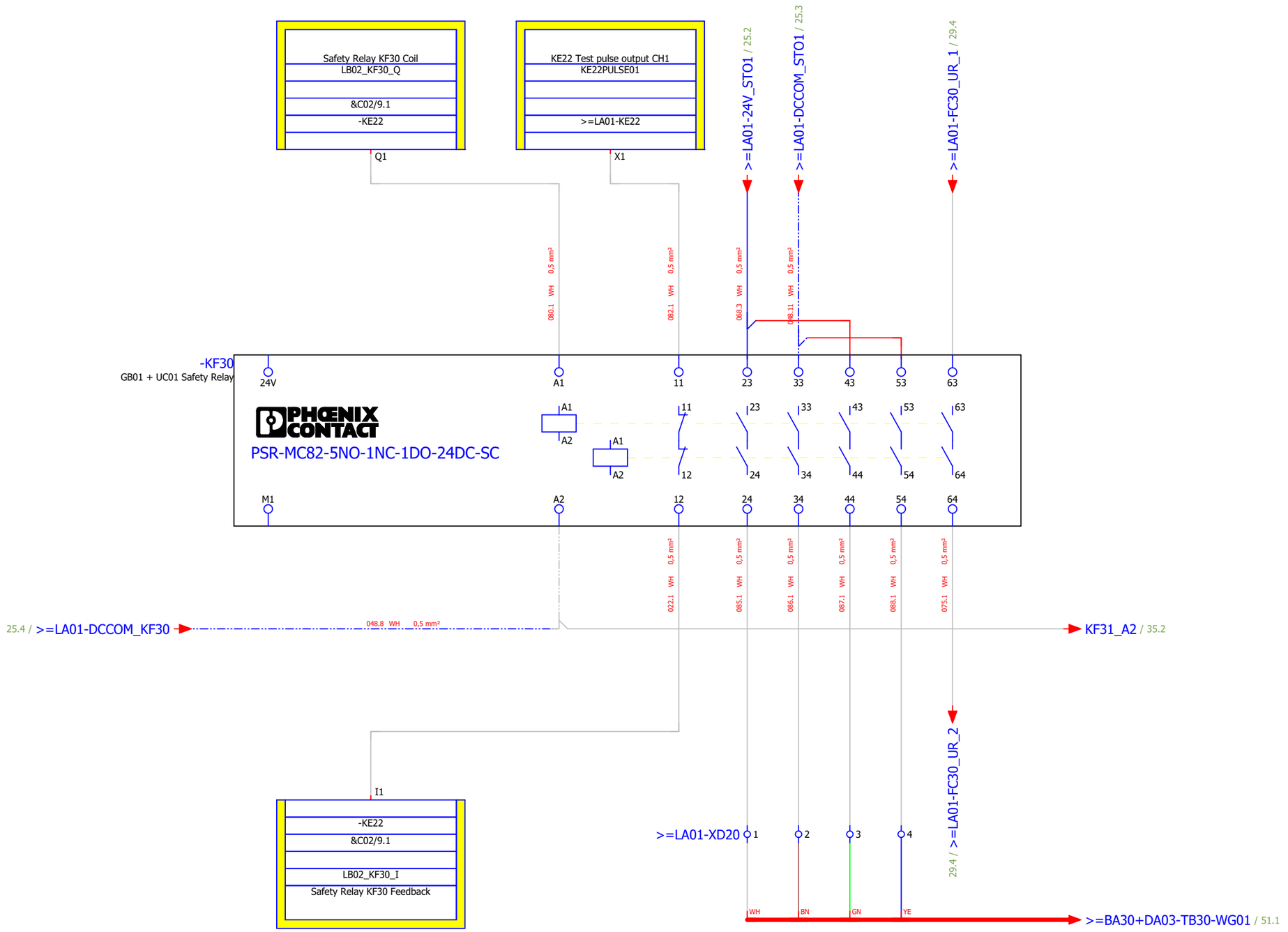
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety ESTOP		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 33 / 81

0	1	2	3	4	5	6	7	8

=LB02+UC31
Safety System, 20ft Control Cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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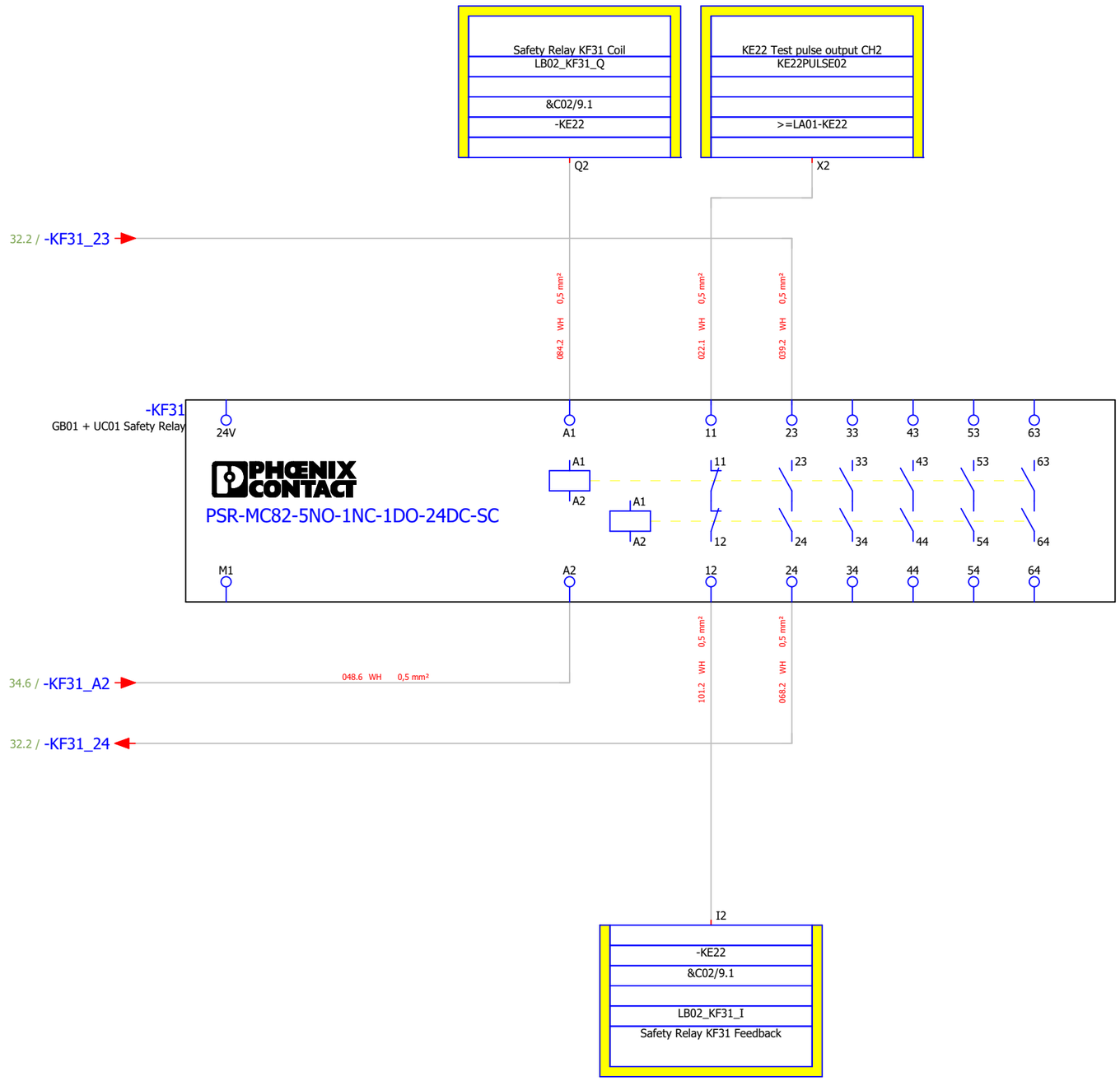
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Relay		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 34 / 81

0	1	2	3	4	5	6	7	8

=LB02+UC31
Safety System, 20ft Control Cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Relay KF31		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 35 / 81

=LB02+UC31
Safety System, 20ft Control Cabinet

KE22 Test pulse output CH1
KE22PULSE01
&C02/9.1
-KE22
X1

KE22 Test pulse output CH2
KE22PULSE02
&C02/9.1
X2

Safety Door Sensor, Door A - CH1
LB02_BG01_CH1
&C02/9.1
-KE22
I5

Safety Door Sensor, Door A - CH2
LB02_BG01_CH2
&C02/9.1
I6

Safety Door Sensor, Door B - CH1
LB02_BG02_CH1
&C02/9.1
I7

Safety Door Sensor, Door B - CH2
LB02_BG02_CH2
&C02/9.1
I8

200.1 WH 0,5 mm²
087.1 WH 0,5 mm²
201.1 WH 0,5 mm²
088.1 WH 0,5 mm²
089.1 WH 0,5 mm²
090.1 WH 0,5 mm²

>=LA01-XD20 5 6 7 8 9 10 11 12

=LB02+DA03
Safety System, 20ft Container, Inside

-BG01.WG01
20 m
4x0.25
300
Door A
BN WH BU BK

-BG01.XG01
M8 Female, A code
1 2 3 4

-BG01
IFM.MN502S
Door Switch - Door A
Out1 In1 Out2 In2
1 2 3 4

-BG02.WG01
20 m
4x0.25
300
Door B
BN WH BU BK

-BG02.XD01
M8 Female, A code
1 2 3 4

-BG02
IFM.MN502S
Door Switch - Door A
Out1 In1 Out2 In2
1 2 3 4

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

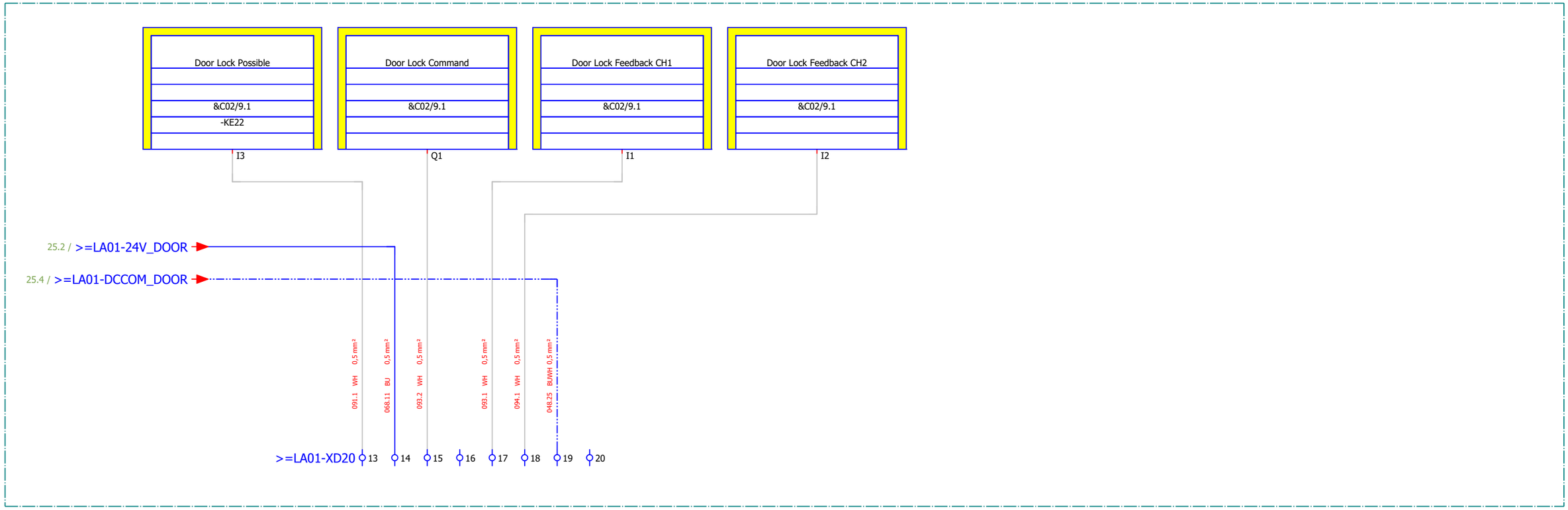
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DESCRIPTION
DATE
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Door Switches		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 36 / 81

=LB02+UC31
Safety System, 20ft Control Cabinet



=LB02+DA03
Safety System, 20ft Container, Inside

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

REVISION INFORMATION	
DESCRIPTION	
DATE	
29-Sep-25	

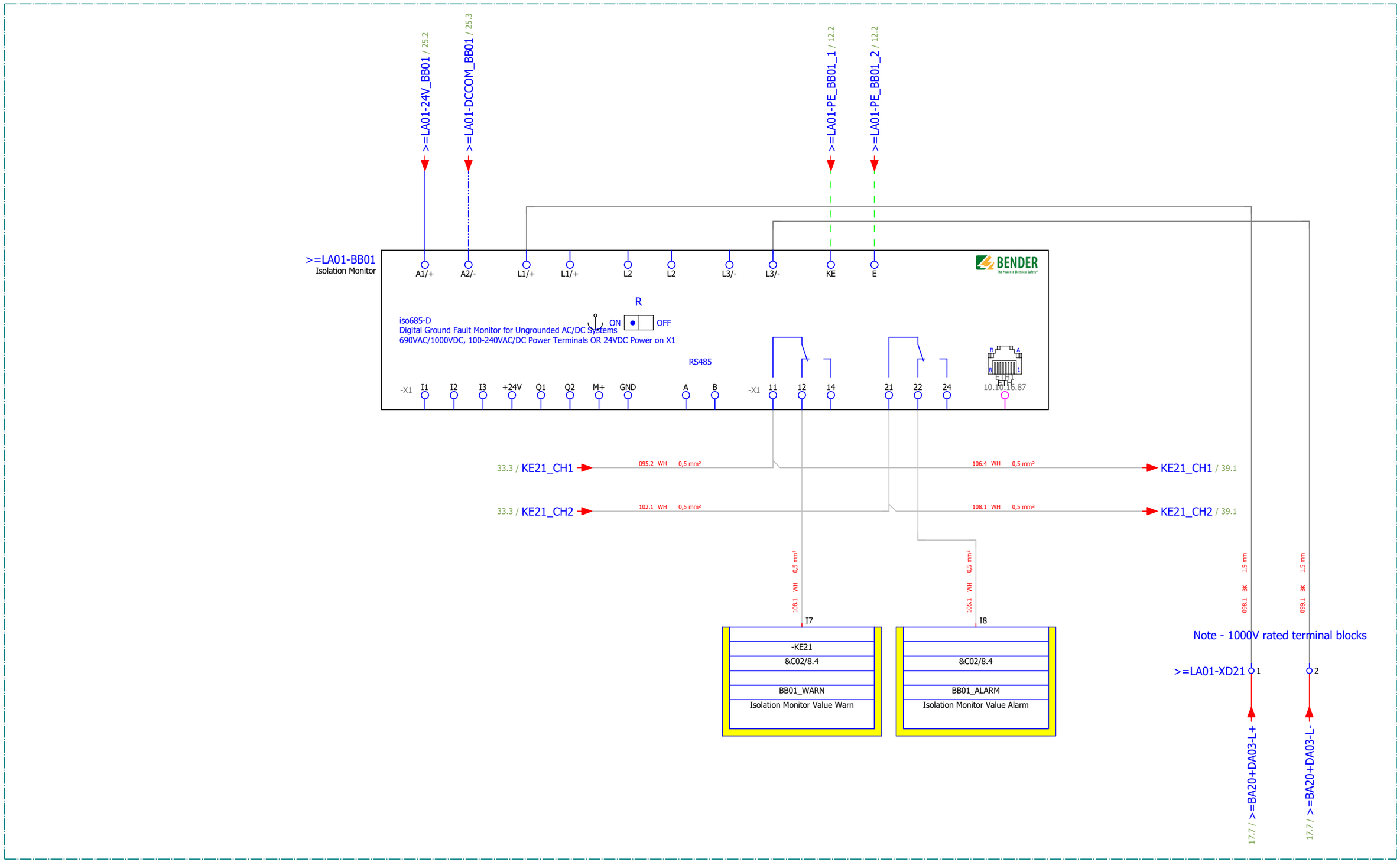
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Door Lock		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 37 / 81

=LB02+UC31
Safety System, 20ft Control Cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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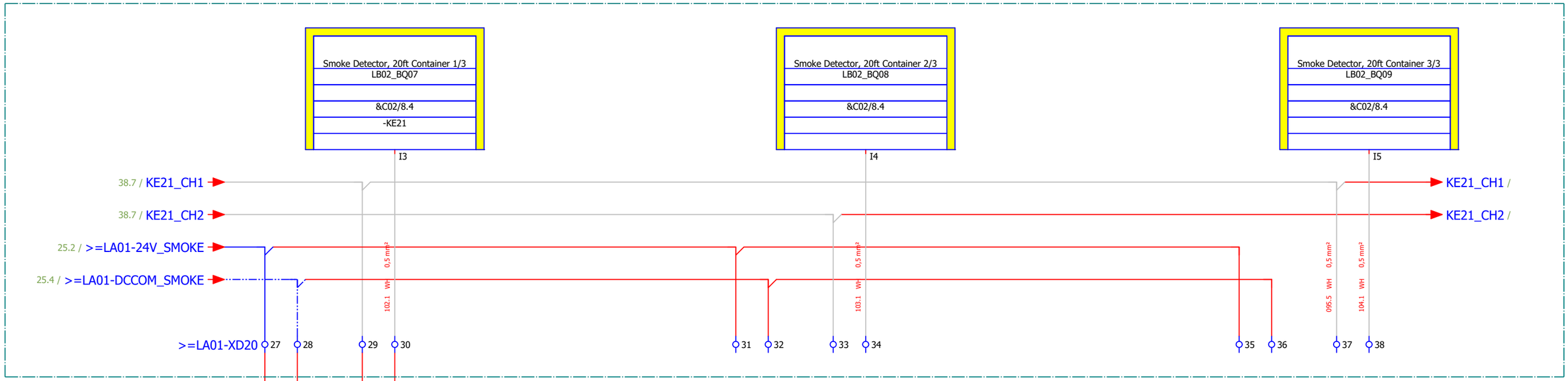
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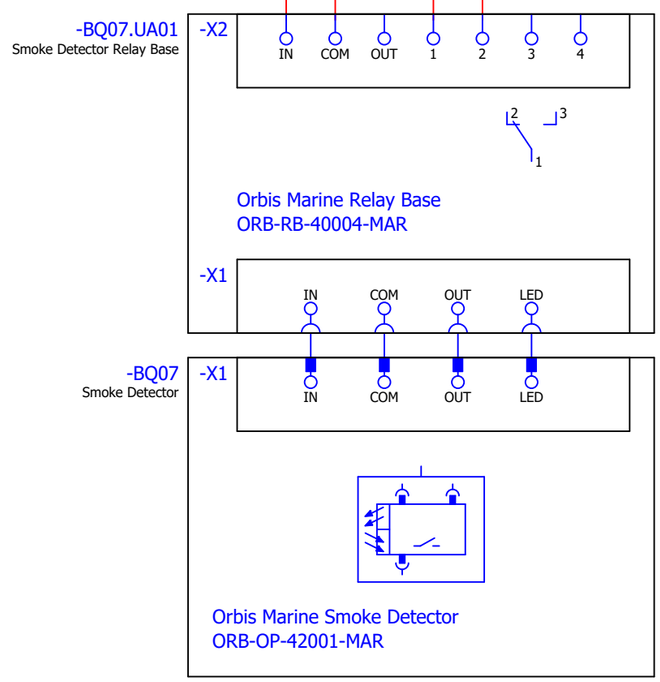
DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Isolation Monitor		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 38 / 81

0	1	2	3	4	5	6	7	8

=LB02+UC31
Safety System, 20ft Control Cabinet



=LB02+DA03
Safety System, 20ft Container, Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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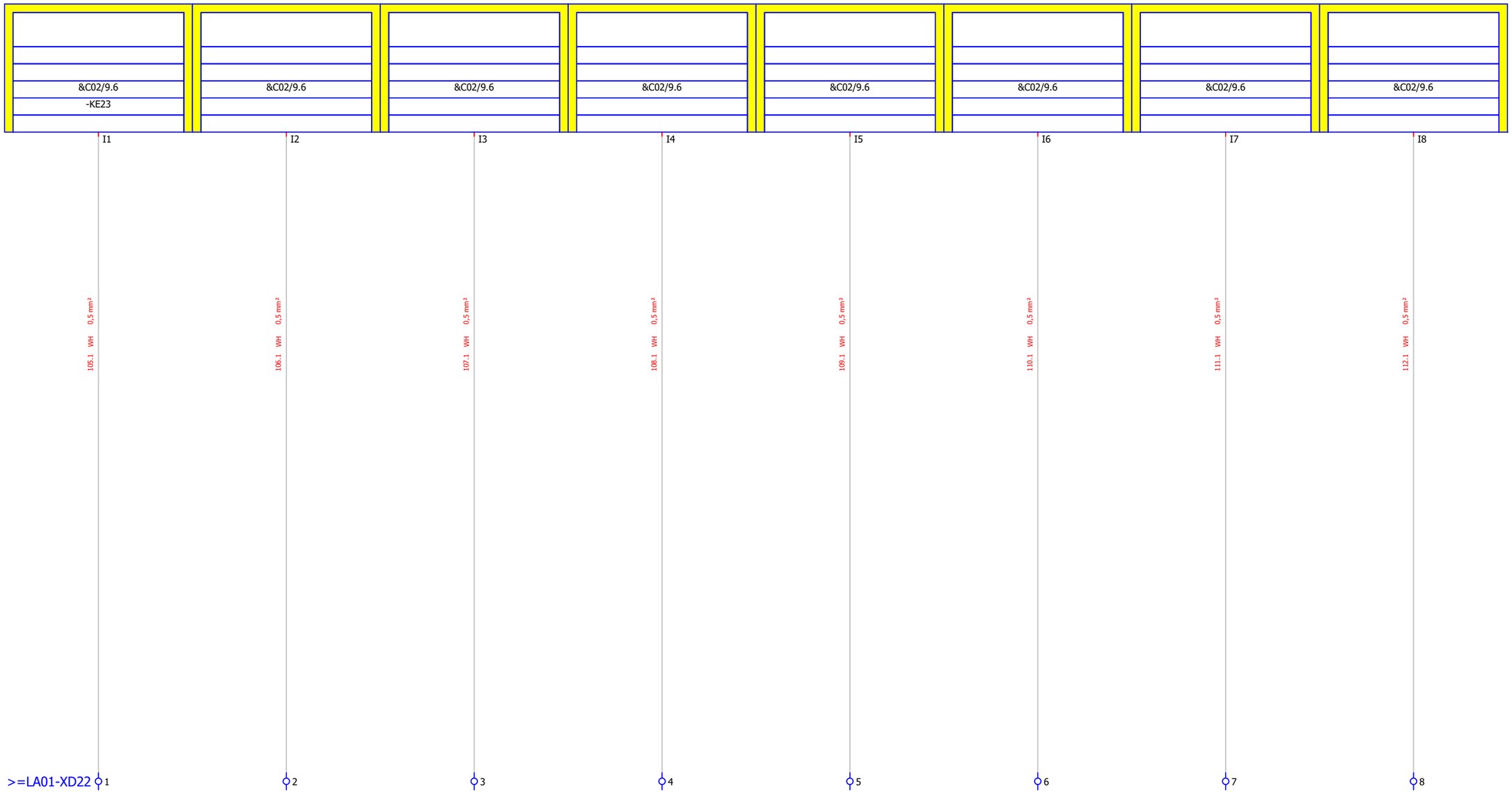
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Smoke Detector		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 39 / 81

=LB02+UC31

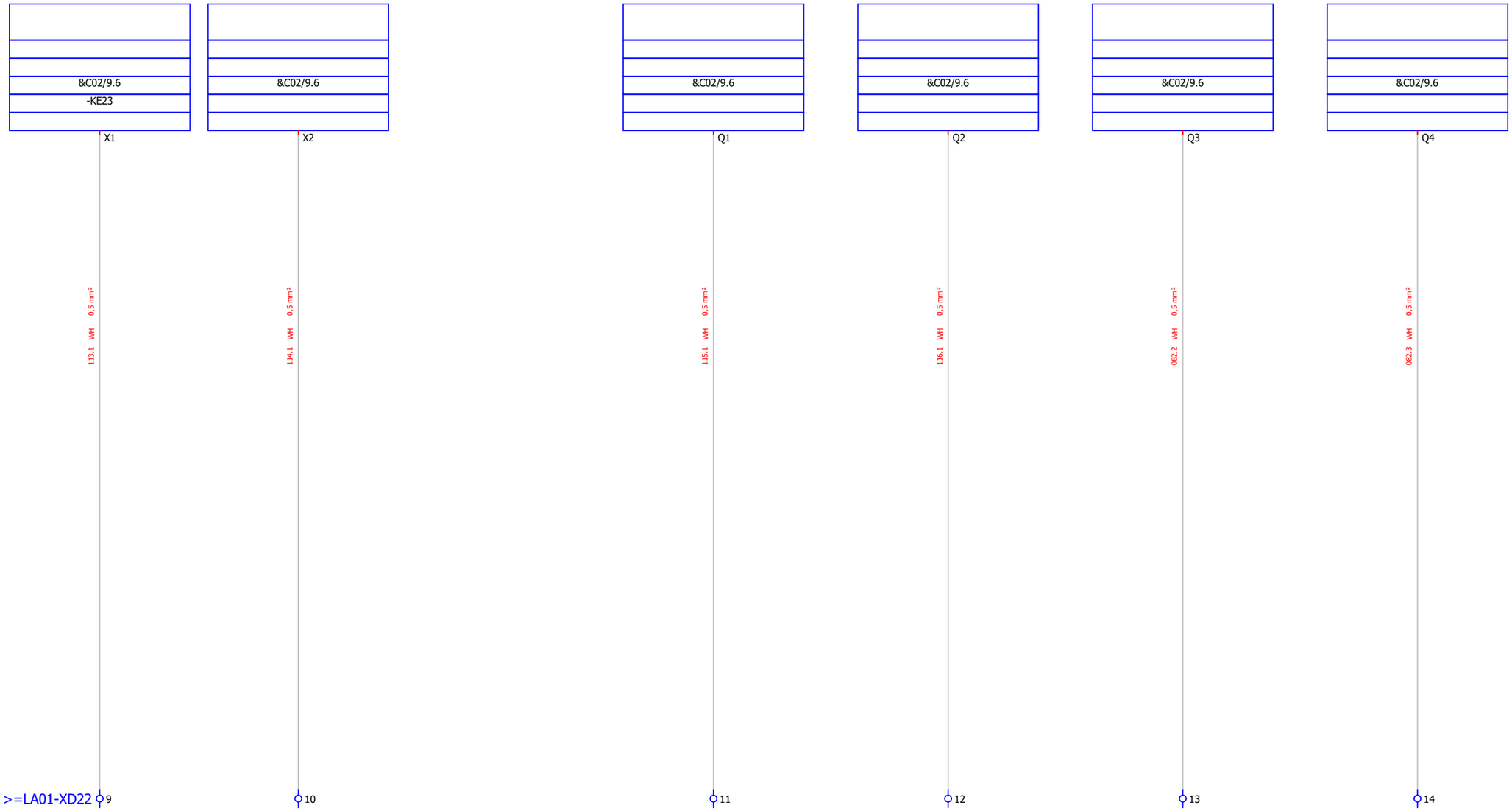
Safety System, 20ft Control Cabinet



Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	Safety Battery Pack Inputs		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 40 / 81
=	++	+ UC31	& C03	29-Sep-25						

=LB02+UC31

Safety System, 20ft Control Cabinet



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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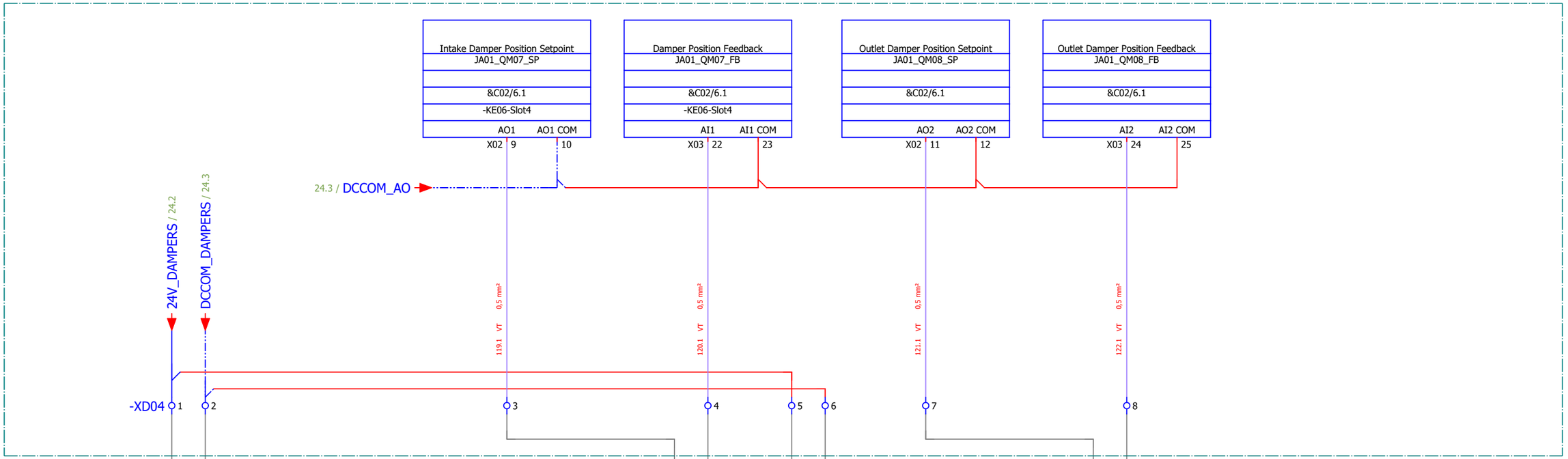
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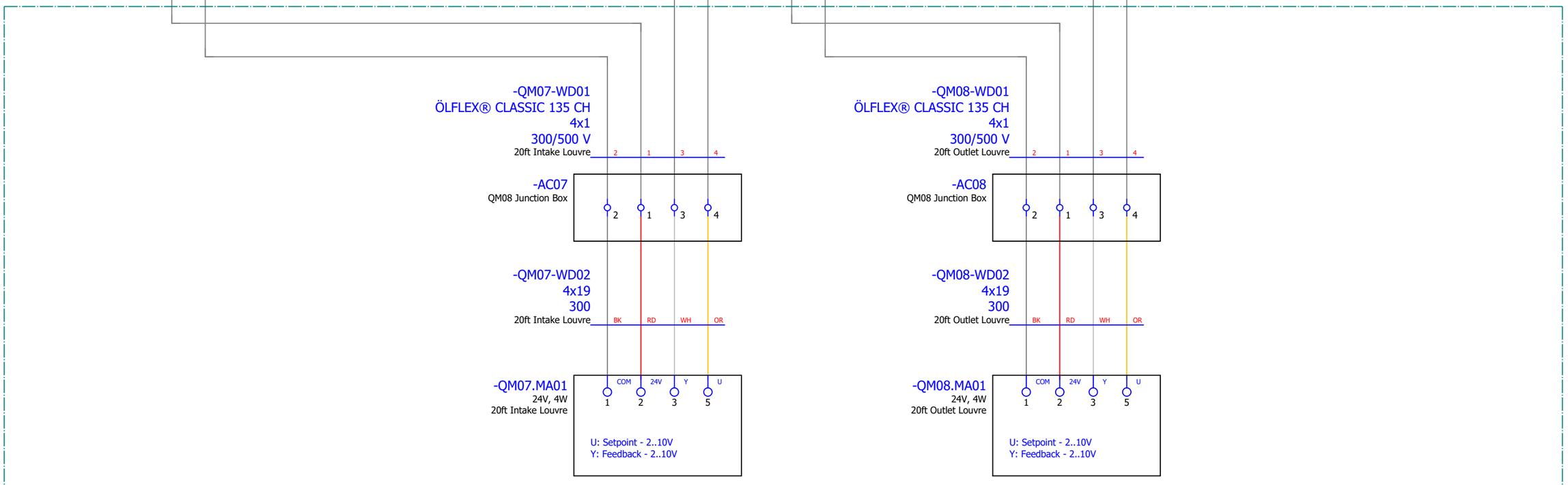
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Safety Battery Pack Outputs		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 41 / 81

=LA01
Control System, 20ft Container



=JA01+DA03



Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	12
EPLAN Project Pages	627
= ++ + UC31 & C03	

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DESCRIPTION
DATE
29-Sep-25

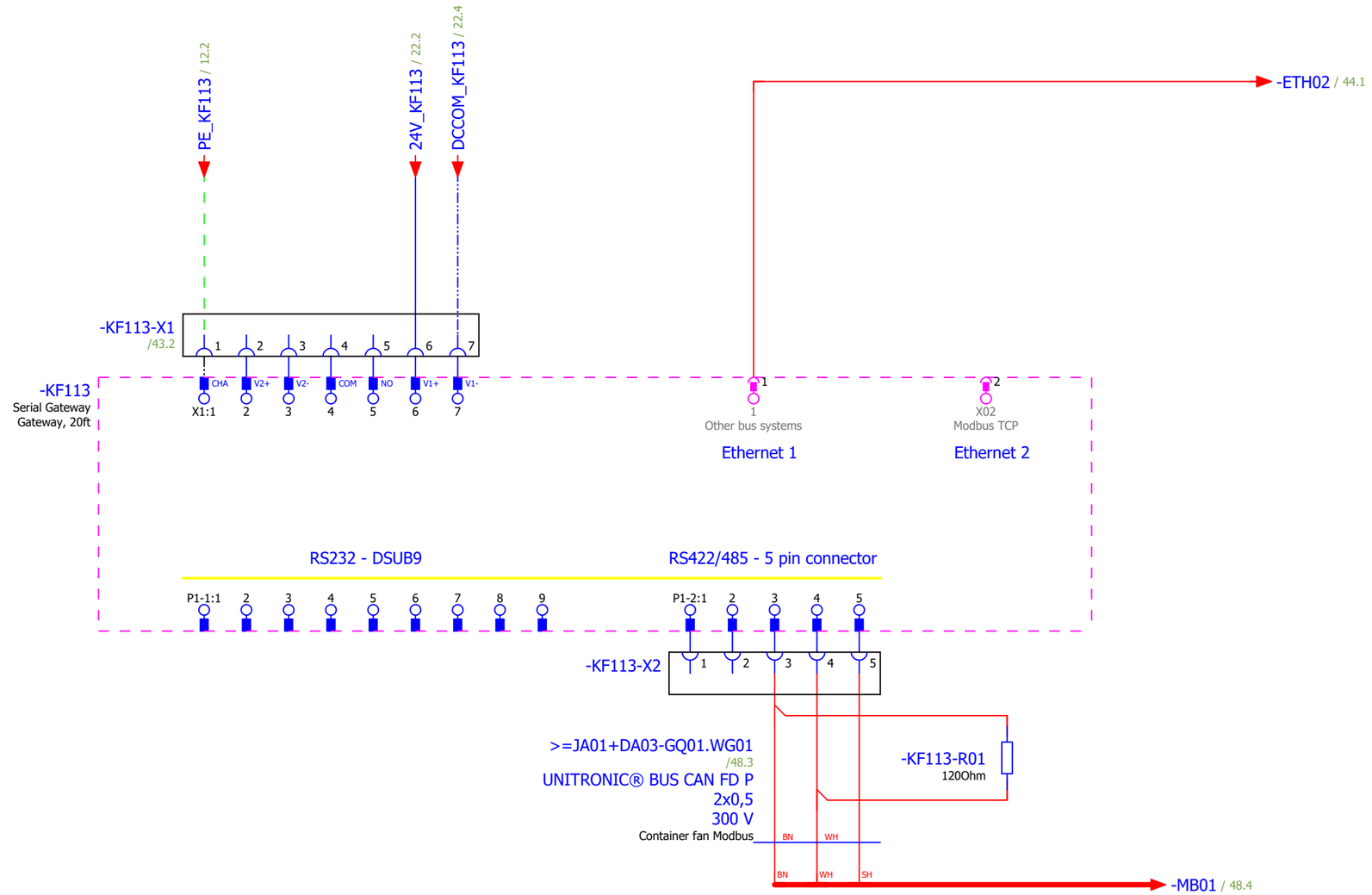
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Ventilation Damper IO		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 42 / 81

=LA01
Control System, 20ft Container



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DATE	29-Sep-25

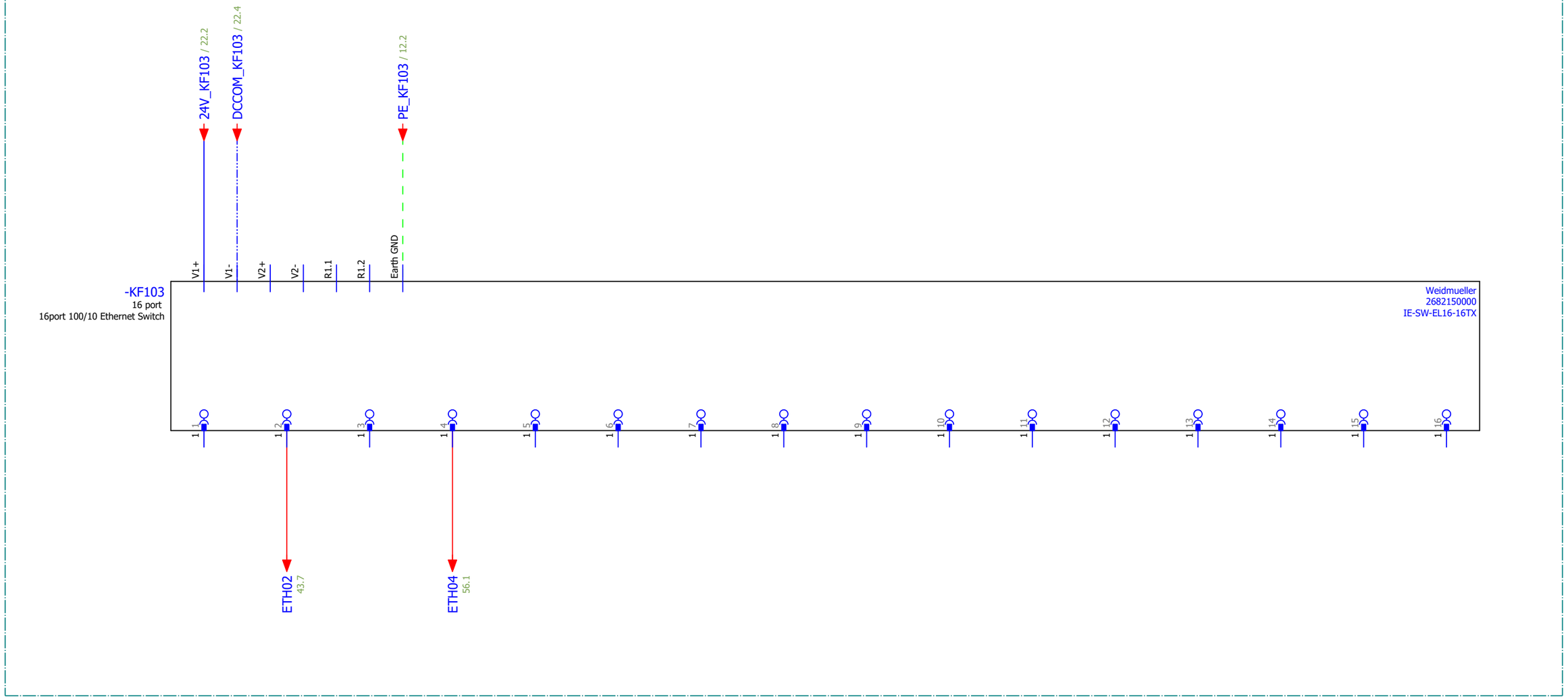
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Modbus Converter		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 43 / 81

=LA01
Control System, 20ft Container

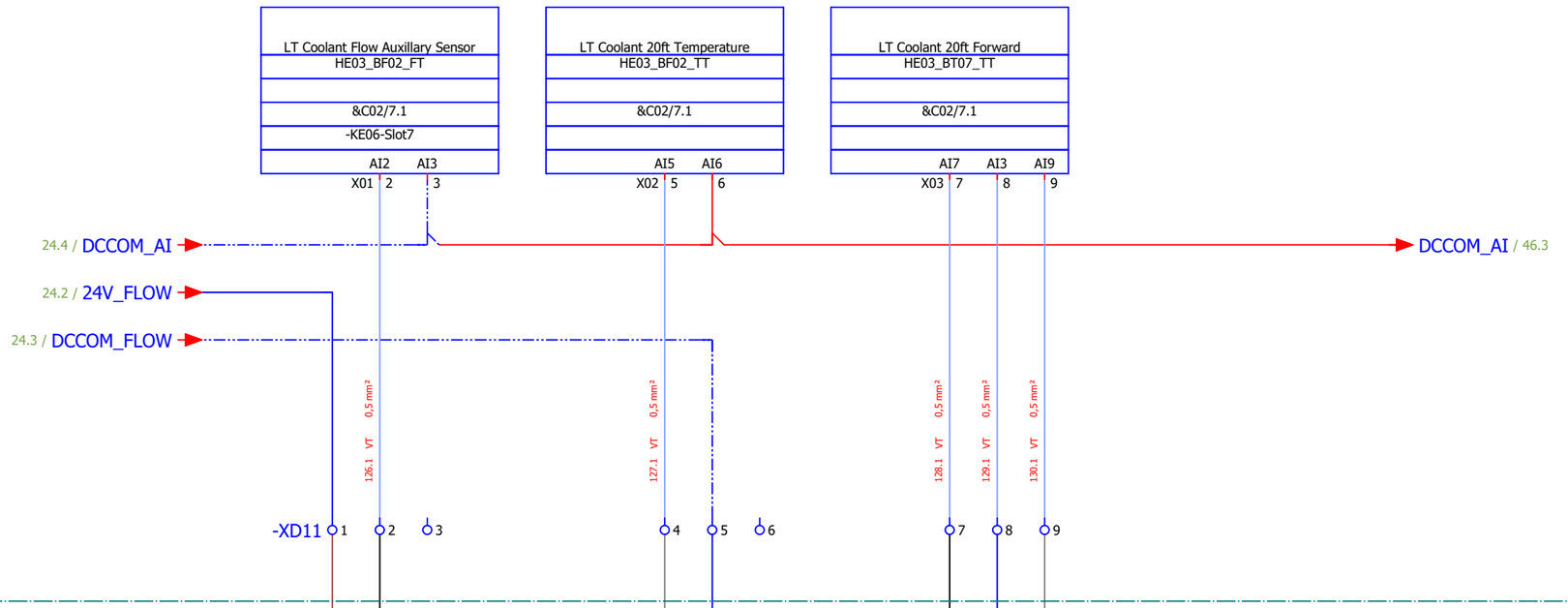


Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION			DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
EPLAN Revision	12					THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	SHEET TYPE/DESC	Network Switch		
EPLAN Project Pages	627			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 44 / 81
=	++	+ UC31	& C03	29-Sep-25						

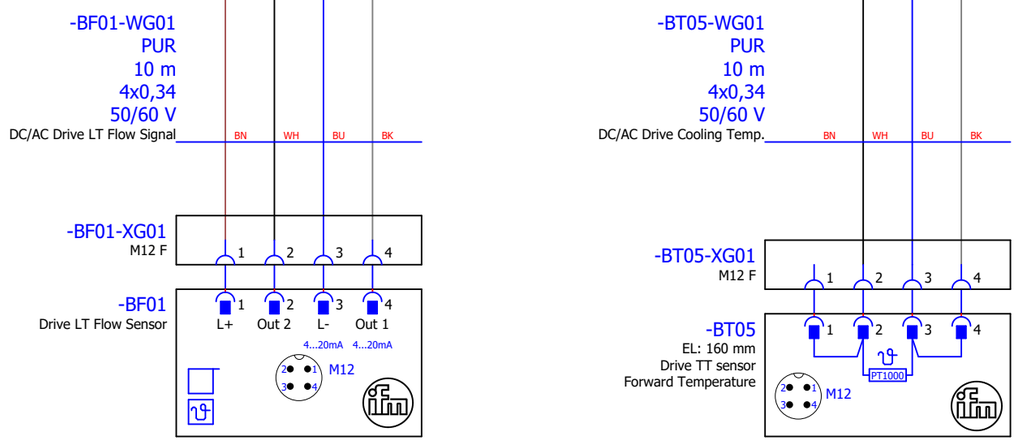
FRM5103656/0B

0	1	2	3	4	5	6	7	8

=LA01
Control System, 20ft Container



=HE03+DA03
Tempereature and flow sensors. Drive cooling



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	LT Measurements		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 45 / 81

0	1	2	3	4	5	6	7	8

=LA01
Control System, 20ft Container

Container temperature
DA03_BT01
&C02/7.1
-KE06-Slot7
AI10 AI11 AI12
X04 10 11 12

0,5 mm² VT 131.1
0,5 mm² VT 132.1
0,5 mm² VT 133.1

-XD11 10 11 12

Container Diff. Pressure
DA03_BP01
&C02/7.1
-KE06-Slot7
AI23
X08 23 24

45.6 / DCCOM_AI
23.4 / DCCOM_DP
23.2 / 24V_DP

-XD11 22 23 24

Klemmer skal monteres

=JA01+DA03
Control System, 20ft Container

-BT01-WG01
PUR
10 m
4x0,34
50/60 V
Container Temperature BN WH BU BK

-BT01-XG01
M12 F
1 2 3 4

-BT01
-25...80 °C
Container Temperature B
Transducer
1 2 3 4
PT1000
M12

-BP01.WG01
ÖLFLEX® CLASSIC 110 CH
4x1
300/500 V
Differential-pressure intake filter 1 2 3

-BP01
Container Indoor/Outdoor
Diffential Pressure Sensor
UB+ GND AOU1 AOI1
AC/DC 24 V
DC 0...5/10V
DC 4...20mA
ON 1 2 3 4 5 6
Setting: 0 to 500 Pa

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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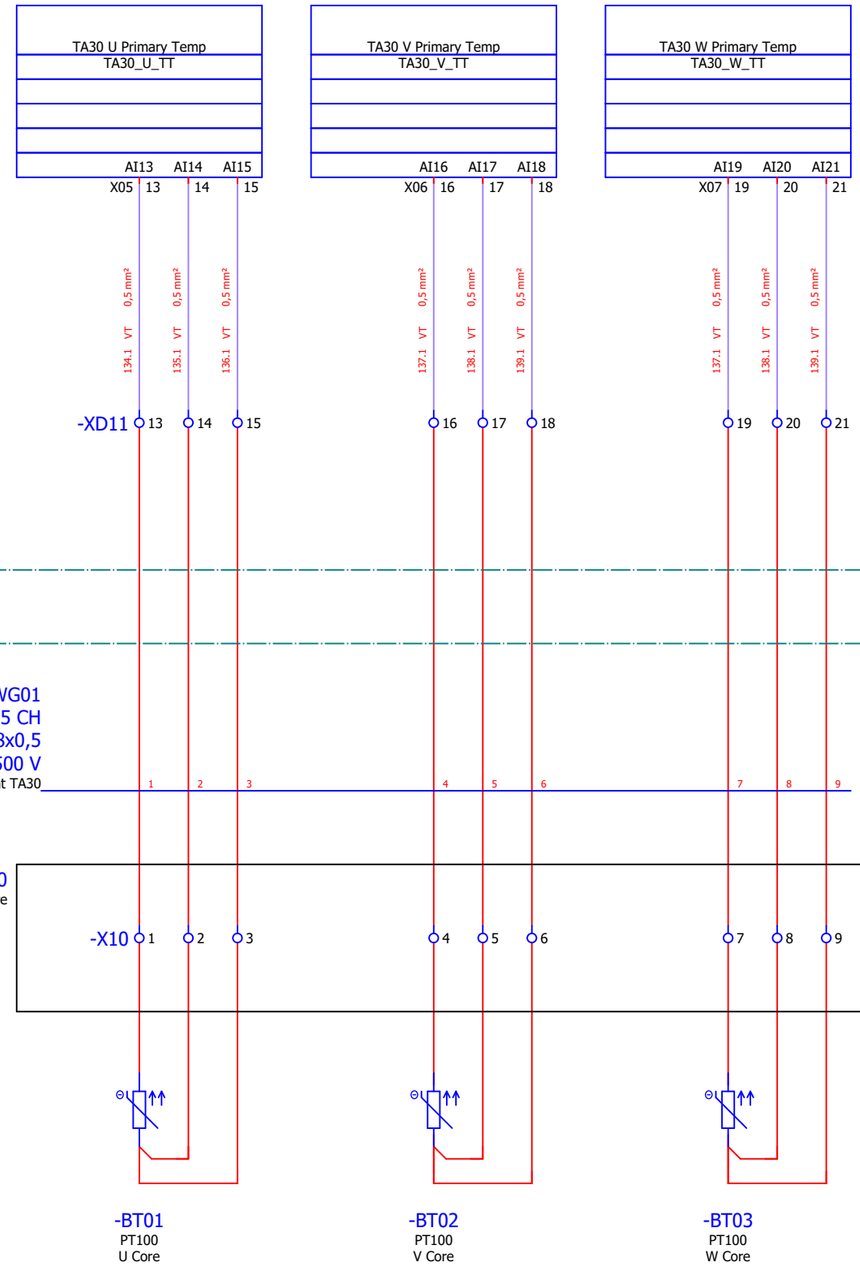
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Cont. Temp and Diff. Pressure		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 46 / 81

0	1	2	3	4	5	6	7	8

=LA01
Control System, 20ft Container



=BA20+DA03
Control System, 20ft Container

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Transformer Temperature Measurements		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 47 / 81

=JA01+DA03
Container ventilation fan

/ >+UC31-XD01:2
/ >+UC31-XD01:4
/ >+UC31-XD01:6
/ >+UC31-XD01:PE2

-GQ01.WD01
ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV
4x2,5
0,6/1,0 kV
Container fan supply
GN/YE 1 2 3

-GQ01.WG01
/43.4
UNITRONIC® BUS CAN FD P
2x0,5
300 V
Container fan Modbus
BN WH

>=LA01+UC31-MB01 / 43.6

-GQ01-R01
120Ohm

-GQ01
1kW
Container ventilation fan
PE PE L1 L2 L3 NC COM 0-10V RSB RSA GND 10V
1 2 3 4 5 6 7 8 10 11 12 13
M
3~
PE

>=LA01+UC31-XD01:1 /
>=LA01+UC31-XD01:3 /
>=LA01+UC31-XD01:5 /
>=LA01+UC31-XD01:N /
>=LA01+UC31-XD01:PE /

-EB02-WD01
ÖLFLEX® CLASSIC 110 CH
5x2,5
300/500 V
Container heater supply
1 2 3 4 GNYE

>=LA01+UC31-XD01:7 /
>=LA01+UC31-XD01:8 /

-EB02-WG01
ÖLFLEX® CLASSIC 110 CH
3x1
300/500 V
Container heater thermostat
1 2

-EB02
Container heating unit
L1 L2 L3 N PE T1 T2
1 2 3 4 5 6 7

11 kW Heater fan

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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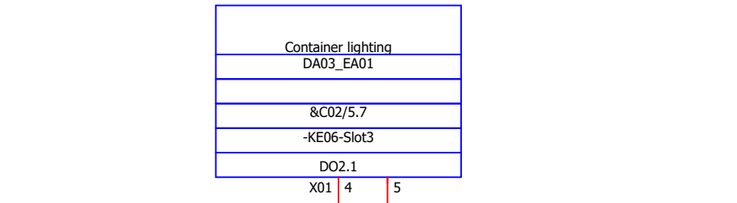
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Container ventilation and heating		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 48 / 81

=LA01+UC31
Container AUX control



/ 24VDC

/ 0VDC

-XD23 2 1 3 4

Klemmer skal monteres

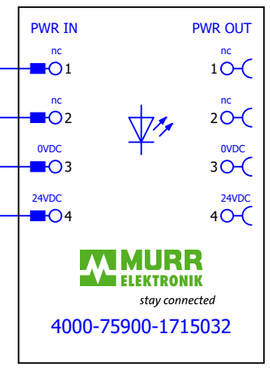
=JA01+DA03
Container Lighting

-EA01-WD01
PUR
20 m
4x0,25
50/60 V
LED Light strip EA01

BU BK WH BN

-EA01
24V, 32W
LED Light Strip

-EA01-XD01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DATE	29-Sep-25

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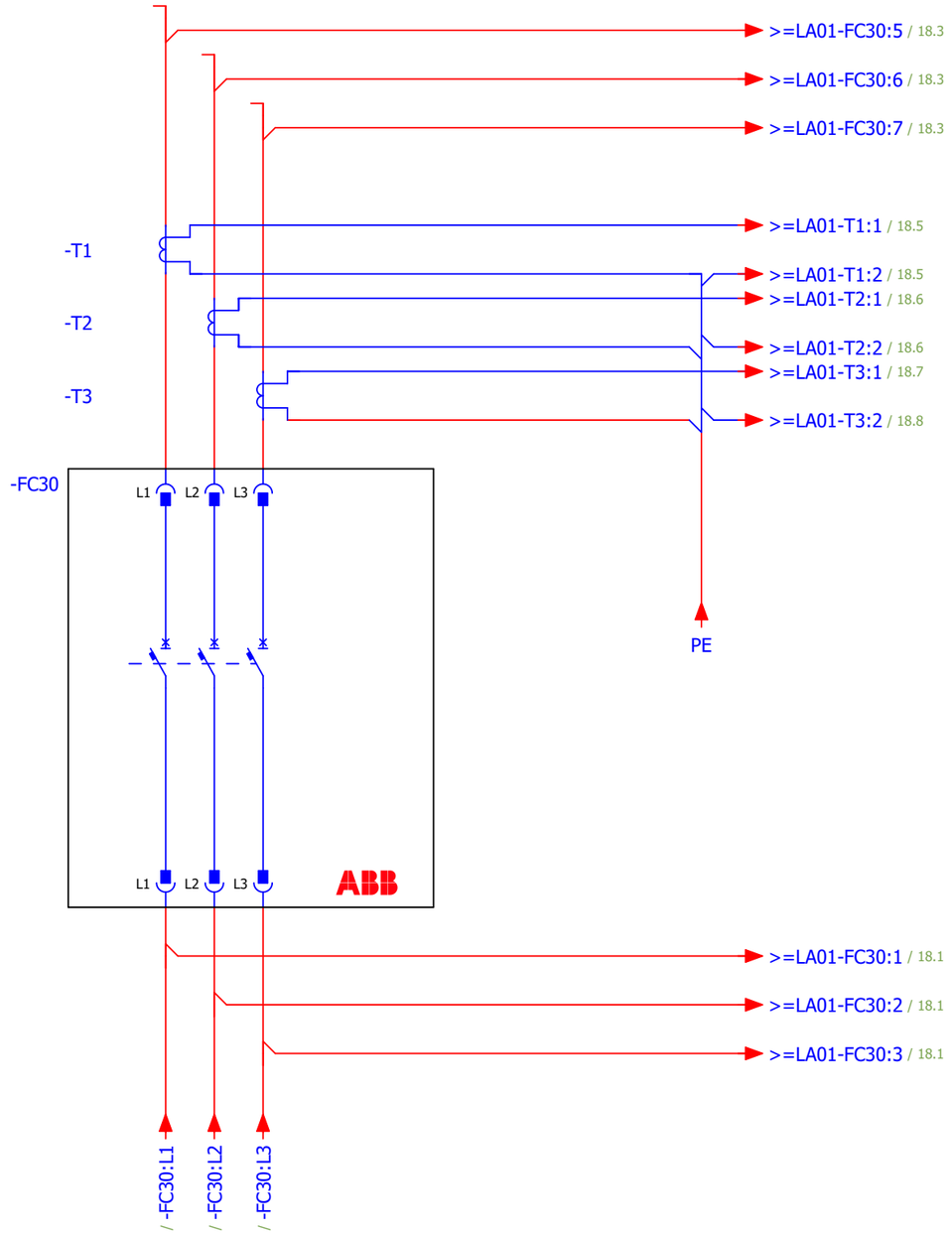
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Container Lighting		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 49 / 81

0	1	2	3	4	5	6	7	8

=BA30
Output Breaker



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

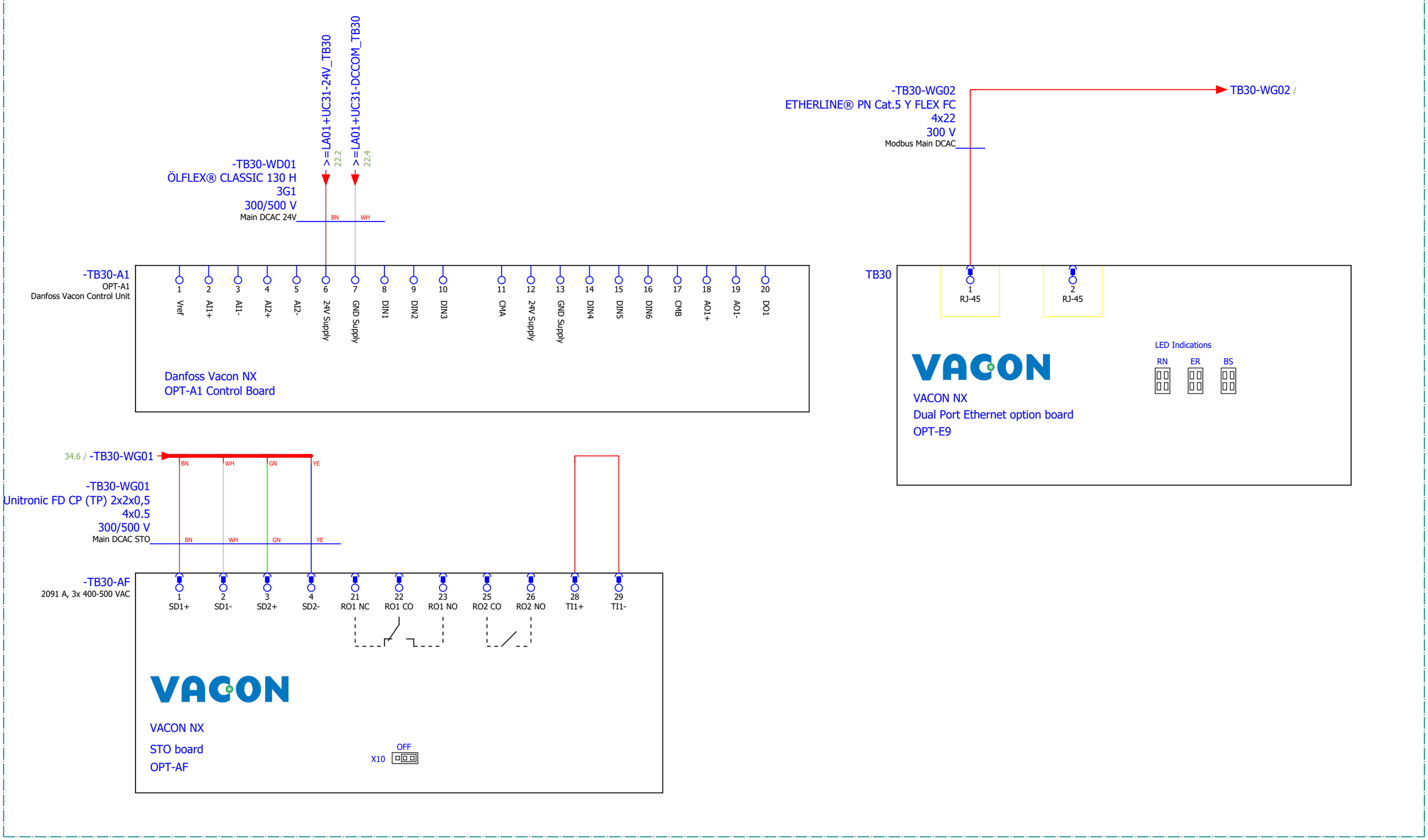
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Main output breaker		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 50 / 81

=BA30+DA03
20ft Container



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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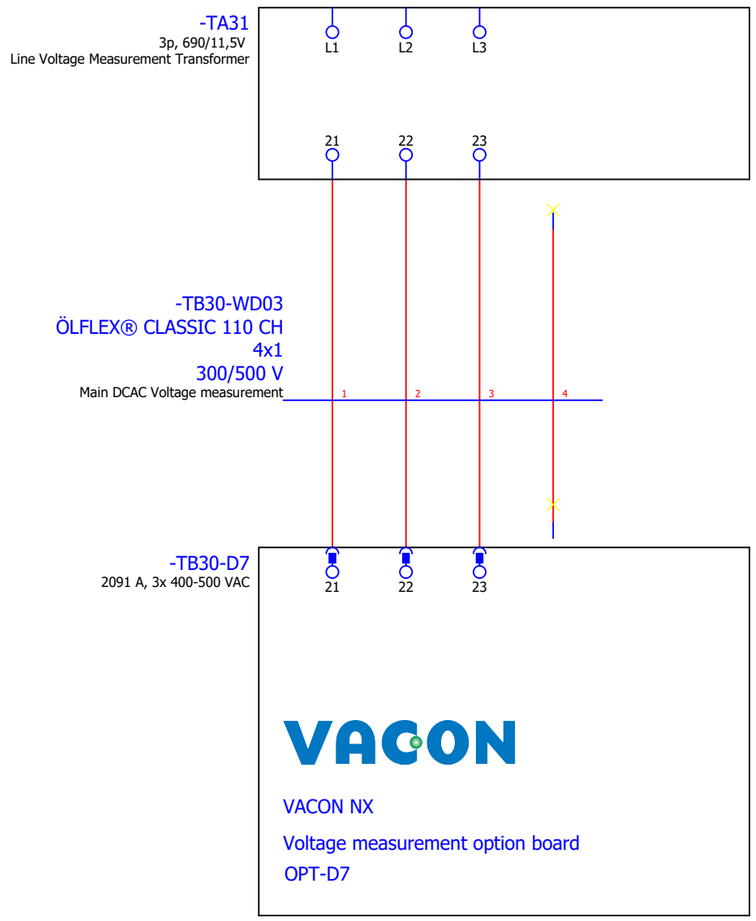
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Customer Interface Diagram, ???		
SHEET TYPE/DESC	DCAC Converter		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 51 / 81

0	1	2	3	4	5	6	7	8

=BA30+DA03
20ft Container



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DESCRIPTION
DATE
29-Sep-25

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Customer Interface Diagram, ???		
SHEET TYPE/DESC	DCAC Converter - Line Voltage Measurement		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 52 / 81

0	1	2	3	4	5	6	7	8

=BA30+DA03
AC Power Output, 20ft Container Inside

29.8 / -FC30-WG01

-FC30-WG01
/53.1
/54.2
/54.2
/55.3
/55.3
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Breaker IO Signals

-FC30-WG01 / 54.0

-FC30
Circuit Breaker, Fixed Part

12 14 22 24 32 34 42 44 96 98

-FC30
Circuit Breaker, 2000A

N L1 L2 L3

X:12 14 X:22 24 X:32 34 X:42 44 X:96 98

Q/1 Q/2 Q/3 Q/4 S51

X:Ne+ Ne- X:Rct Rca Ge+ Ge- X:Szi Szo Gzi Gzo

K51

EXTERNAL NEUTRAL

EKIP DIP
EKIP TOUCH
EKIP HI-TOUCH
EKIP LCD
EKIP HI-LCD
EKIP G TOUCH
EKIP G HI-TOUCH
EKIP G LCD
EKIP G HI-LCD

I >
I >>
I >>
I >>>
I >>

EKIP TOUCH
EKIP HI-TOUCH
EKIP LCD
EKIP HI-LCD
EKIP G TOUCH
EKIP G HI-TOUCH
EKIP G LCD
EKIP G HI-LCD

Szi (DFi) Szo (DFo) Gzi (DBi) Gzo (DBo)

N L1 L2 L3

X:11 X:21 X:31 X:41 X:95

X:Szc

ABB

-FC30
Circuit Breaker, Fixed Part

11 24V 21 24V 31 24V 41 24V 95

-FC30-WG01
/53.2
ÖLFLEX® CLASSIC 110 CH
18x0,75
300/500 V
Breaker IO Signals

10

10

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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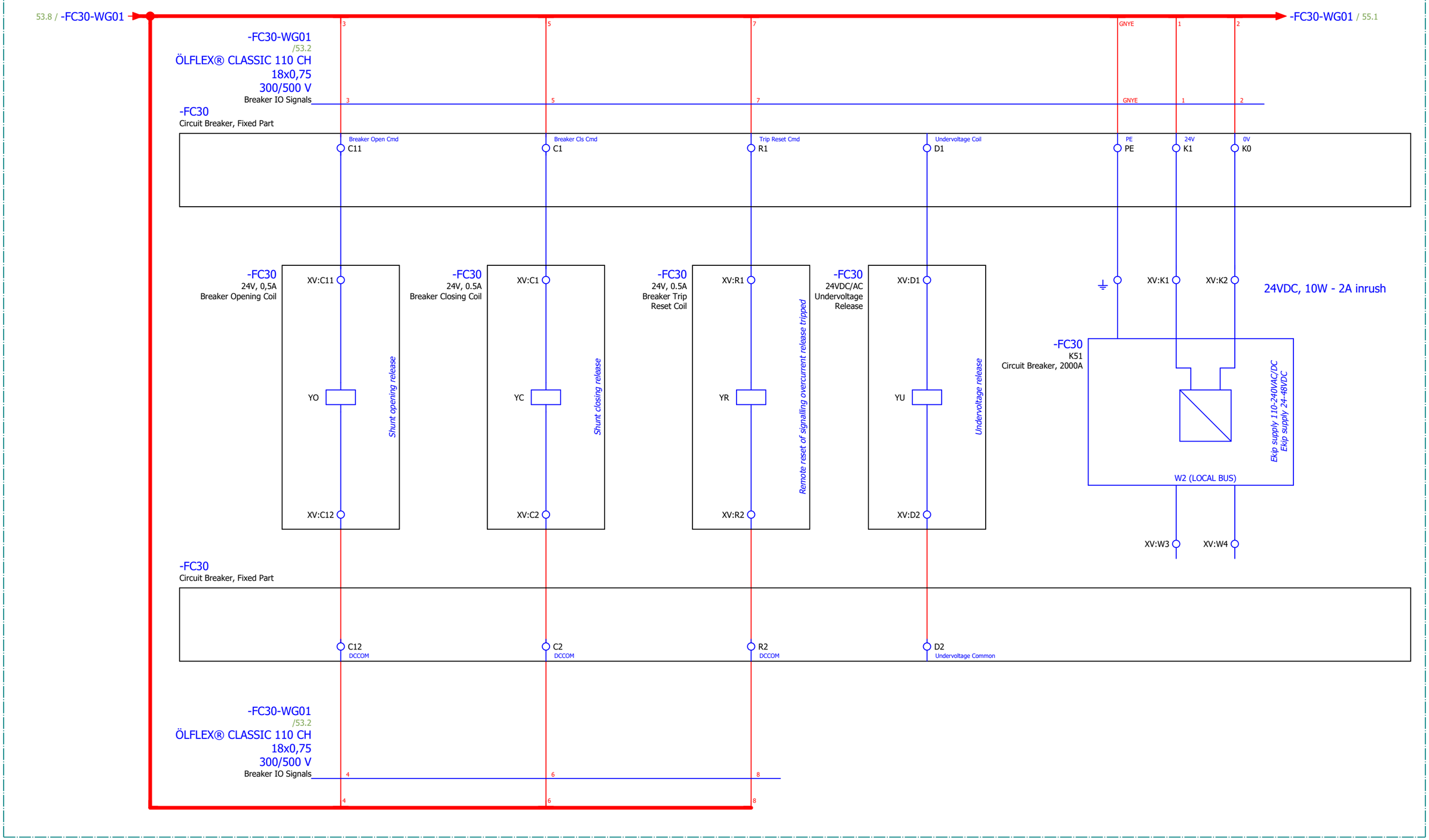
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Customer Interface Diagram, ???		
SHEET TYPE/DESC	10ft Container - Main Breaker and Aux Contacts		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 53 / 81

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=BA30+DA03
AC Power Output, 20ft Container Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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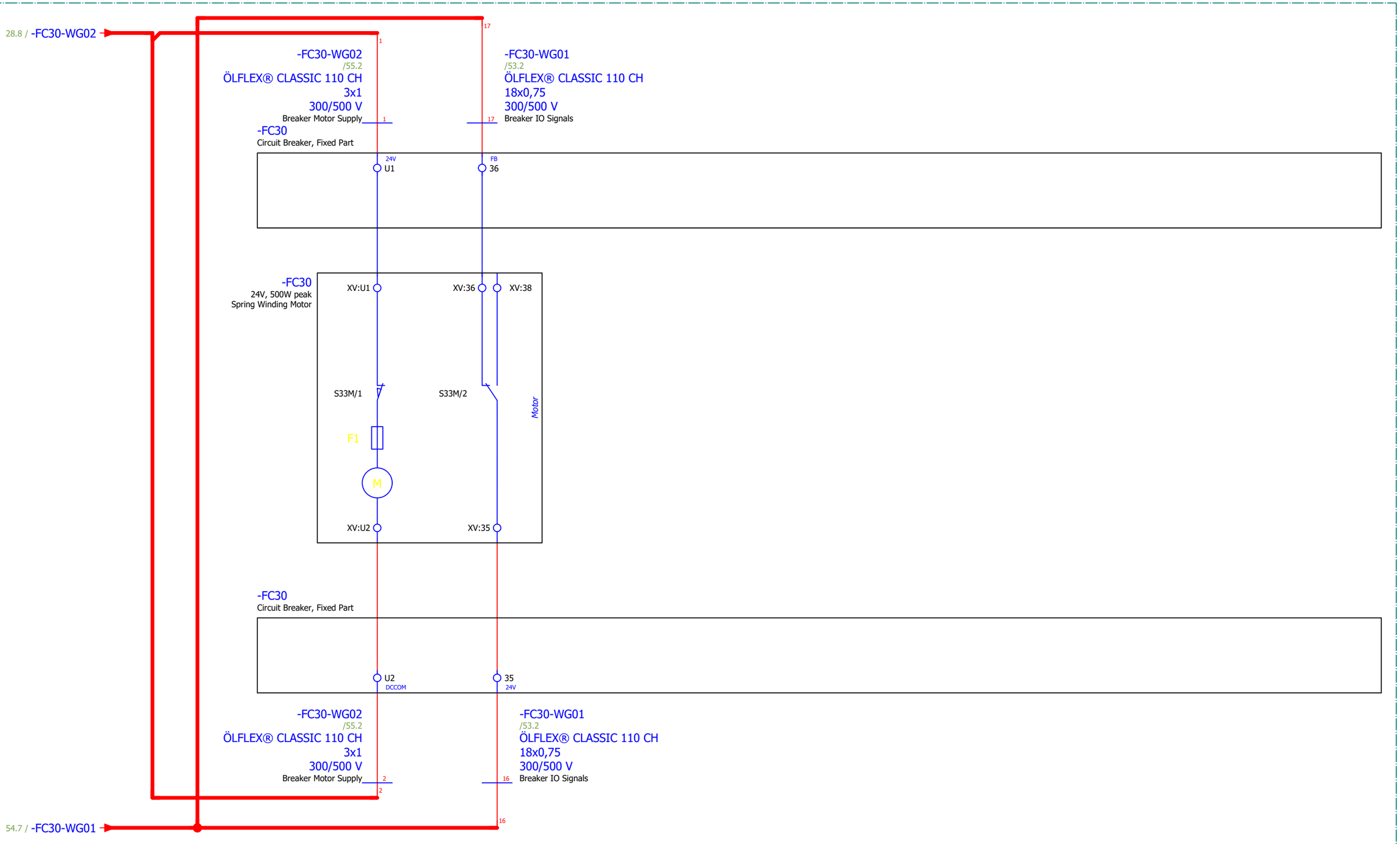
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Customer Interface Diagram, ???		
SHEET TYPE/DESC	10ft Container - Main Breaker Coils		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 54 / 81

0	1	2	3	4	5	6	7	8

=BA30+DA03
AC Power Output, 20ft Container Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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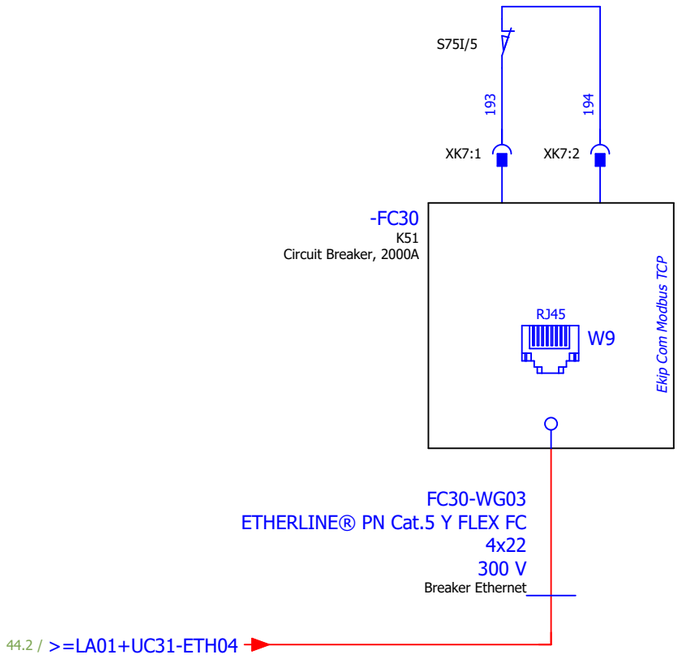
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Customer Interface Diagram, ???		
SHEET TYPE/DESC	10ft Container - Main Breaker, Motor		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 55 / 81

0	1	2	3	4	5	6	7	8

=BA30+DA03
AC Power Output, 20ft Container Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C03

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Customer Interface Diagram, ???		
SHEET TYPE/DESC	10ft Container - Main Breaker, Communication		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 56 / 81

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Ballard Power Systems Europe - Technology Solutions

Panel Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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DESCRIPTION	
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29-Sep-25	

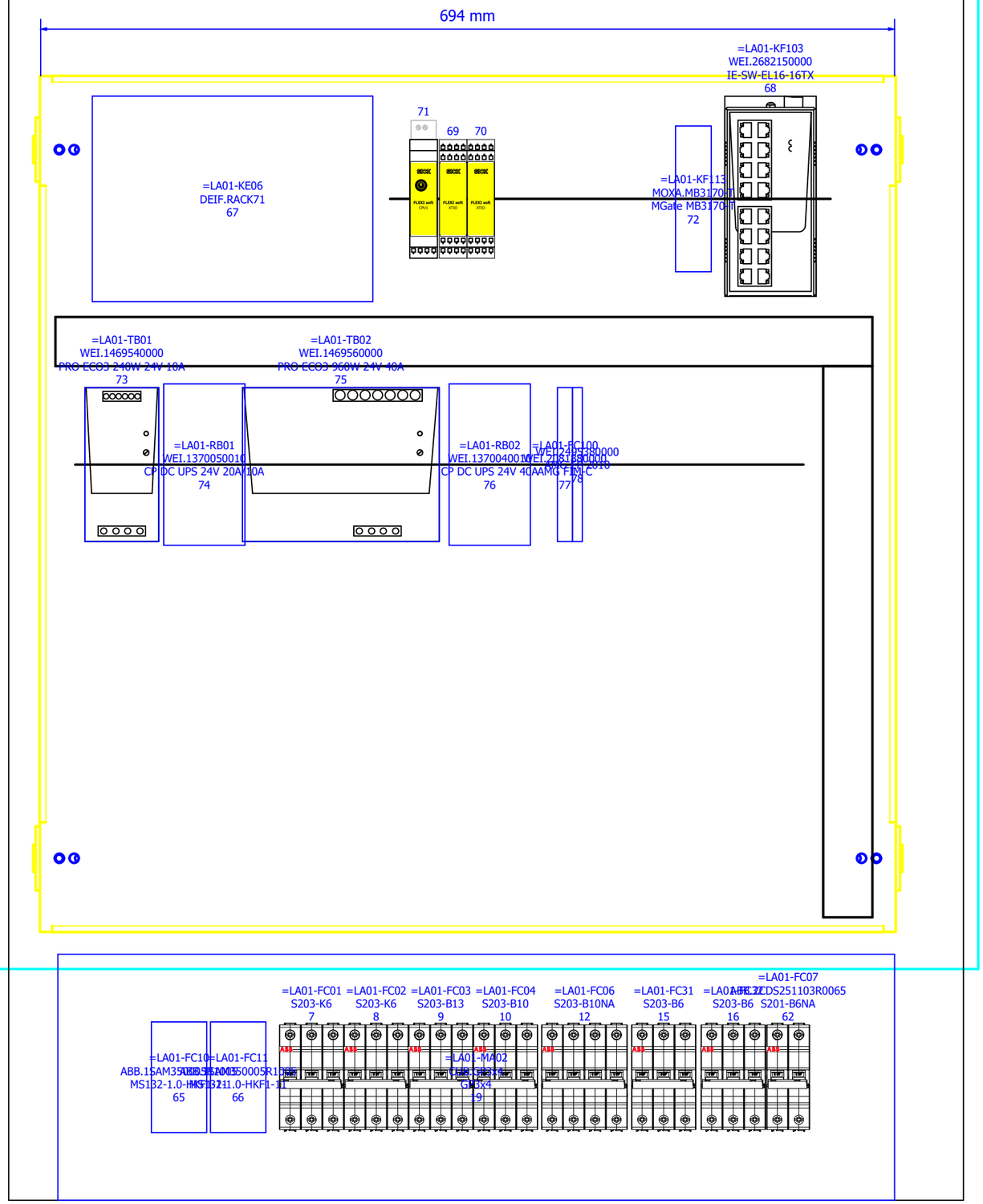
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Panel Documentation and Layout		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 57 / 81

FRM5103656/0B



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Panel Layout		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 58 / 81

Enclosure legend

Item number	Device tag	Type number	Part number	Manufacturer	Function text
7	FC01	S203-K6	ABB.2CDS253001R0377	ABB	
8	FC02	S203-K6	ABB.2CDS253001R0377	ABB	
9	FC03	S203-B13	ABB.2CDS253001R0135	ABB	
10	FC04	S203-B10	ABB.2CDS253001R0105	ABB	
12	FC06	S203-B10NA	ABB.2CDS253103R0105	ABB	
15	FC31	S203-B6	ABB.2CDS253001R0065	ABB	
16	FC32	S203-B6	ABB.2CDS253001R0065	ABB	
19	MA02	GP3x4	CUB.GP3x4	CUB	
62	FC07	S201-B6NA	ABB.2CDS251103R0065	ABB	
65	FC10	MS132-1.0-HKF1-11	ABB.1SAM350005R1005	ABB	MMS - Busbar Voltage Sense
66	FC11	MS132-1.0-HKF1-11	ABB.1SAM350005R1005	ABB	MMS - Customer Voltage Sense
67	KE06		DEIF.RACK71	DEIF	Controller Extension Rack
68	KF103	IE-SW-EL16-16TX	WEI.2682150000	WEI	16port 100/10 Ethernet Switch
69	KE21	FX3-XTIO84002	SICK.1044125	SICK	
70	KE22	FX3-XTIO84002	SICK.1044125	SICK	
71	KE20	FX3-CPU130002	SICK.1043784	SICK	
72	KF113	MGate MB3170-T	MOXA.MB3170-T	MOXA	Gateway, 20ft
73	TB01	PRO ECO3 240W 24V 10A	WEI.1469540000	WEI	24V PSU
74	RB01	CP DC UPS 24V 20A/10A	WEI.1370050010	WEI	24V UPS Module
75	TB02	PRO ECO3 960W 24V 40A	WEI.1469560000	WEI	24V PSU
76	RB02	CP DC UPS 24V 40A	WEI.1370040010	WEI	40A UPS Module

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Enclosure Legend		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 59 / 81

Terminal-strip overview

F14_001

Terminal strip	Terminal strip definition text	Terminals					Graphical page of terminal diagrams
		first	last	Total PE	Total N	Total number	
=BA30-XD41		1	2	0	0	2	
=LA01-FC101-1		1	1	0	0	1	
=LA01-FC101-2		2	2	0	0	1	
=LA01-FC102-1		1	2	0	0	2	
=LA01-FC103-1		1	2	0	0	2	
=LA01-FC103-3		3	4	0	0	4	
=LA01-FC104-1		1	2	0	0	2	
=LA01-FC104-3		3	4	0	0	2	
=LA01-XD00		1	PE	0	0	5	
=LA01-XD01		1	6	3	0	30	
=LA01-XD02		1	PE	2	0	8	
=LA01-XD03		1	PE	2	0	6	
=LA01-XD04		1	8	0	0	8	
=LA01-XD06		1	3	0	0	2	
=LA01-XD09		9	14	0	0	6	
=LA01-XD10		1	18	2	0	20	
=LA01-XD11		1	21	0	0	24	
=LA01-XD20		1	38	0	0	38	
=LA01-XD21		1	2	0	0	2	
=LA01-XD22		1	14	0	0	14	
=LA01-XD23		1	4	0	0	4	
=LA01-XD40		1	PE	3	0	12	
=LA01-XE00		PE		8	0	8	

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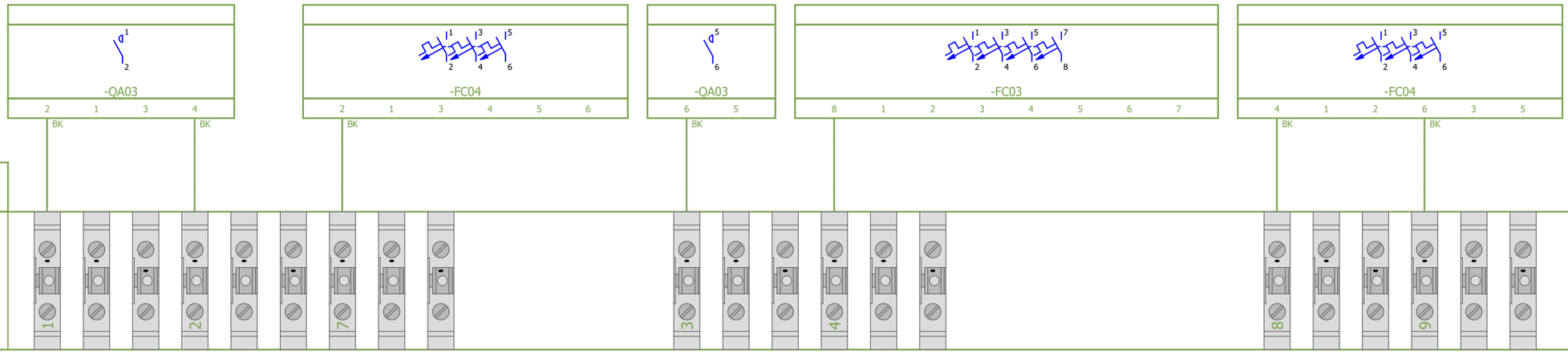
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Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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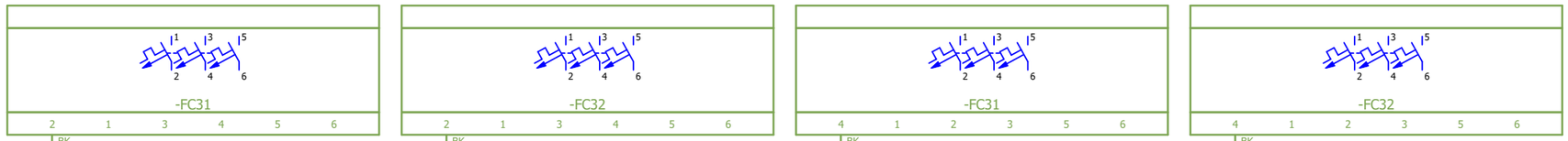
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 61 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



=LA01+UC31-XD02

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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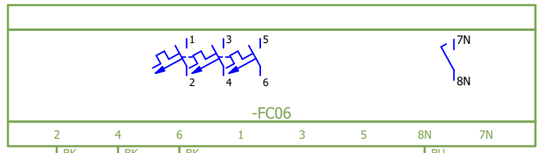
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 62 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



=LA01+UC31-XD03

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD03		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 63 / 81

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

-FC103
2
2 4
-FC103-1
1
1 BU
-FC103-3
3
3 BUWH
-KE06-Slot4
X02:9 X03:22 X02:11 X03:24
VT VT VT VT

=LA01+UC31-XD04

Jumpers

Terminal

Connection point

1 5 2 6 3 4 7 8

=JA01+DA03-QM07-WD01 =JA01+DA03-QM08-WD01 =JA01+DA03-QM07-WD01 =JA01+DA03-QM08-WD01 =JA01+DA03-QM07-WD01 =JA01+DA03-QM08-WD01
ÖLFLEX® CLASSIC 135 CH
1 1 2 2 3 4 3 4
1:2 1:2 2:1 2:1 3:3 4:4 3:3 4:4
=JA01+DA03-AC07 =JA01+DA03-AC08 =JA01+DA03-AC07 =JA01+DA03-AC08 =JA01+DA03-AC07 =JA01+DA03-AC08
1 1 2 2 3 3
RD RD BK BK WH OR WH OR
2 2 1 1 3 5 3 5
=JA01+DA03-QM07.MA01 =JA01+DA03-QM08.MA01 =JA01+DA03-QM07.MA01 =JA01+DA03-QM08.MA01 =JA01+DA03-QM07.MA01 =JA01+DA03-QM08.MA01
2 2 1 1 3 3

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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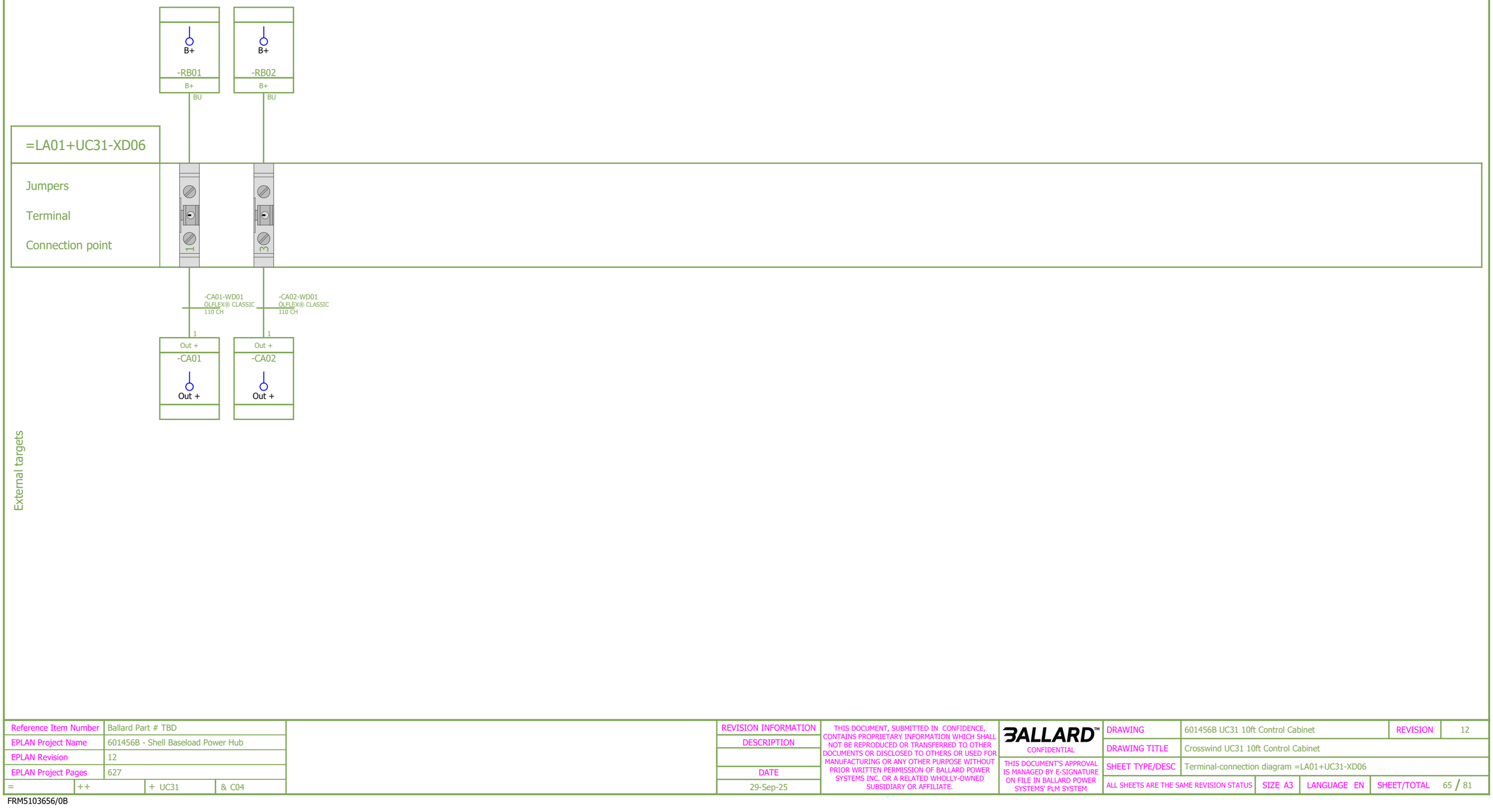
DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD04		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 64 / 81

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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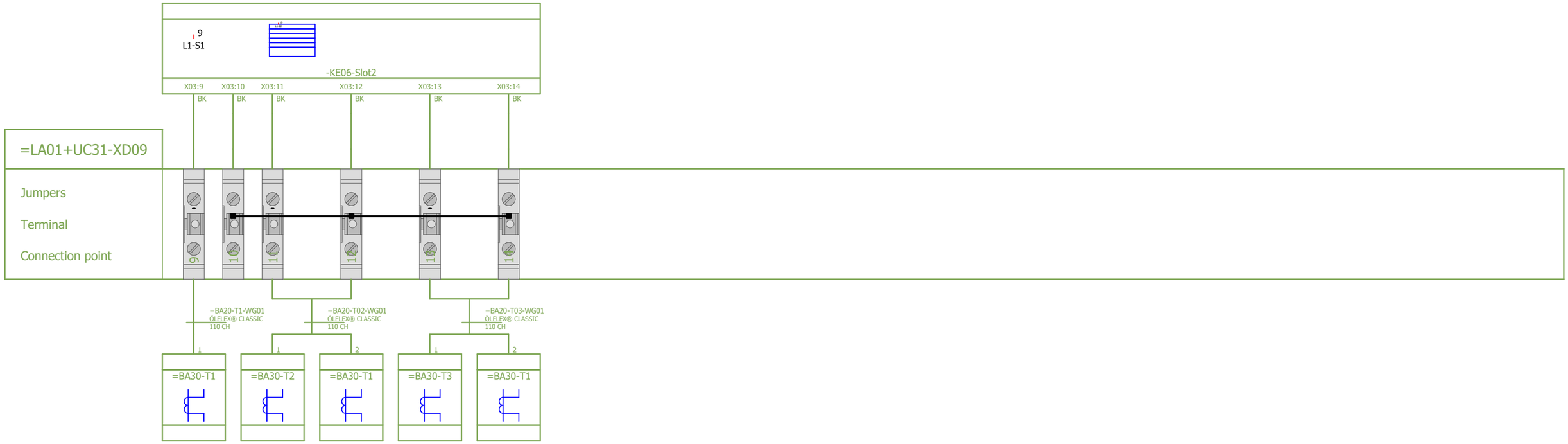
DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD06		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 65 / 81

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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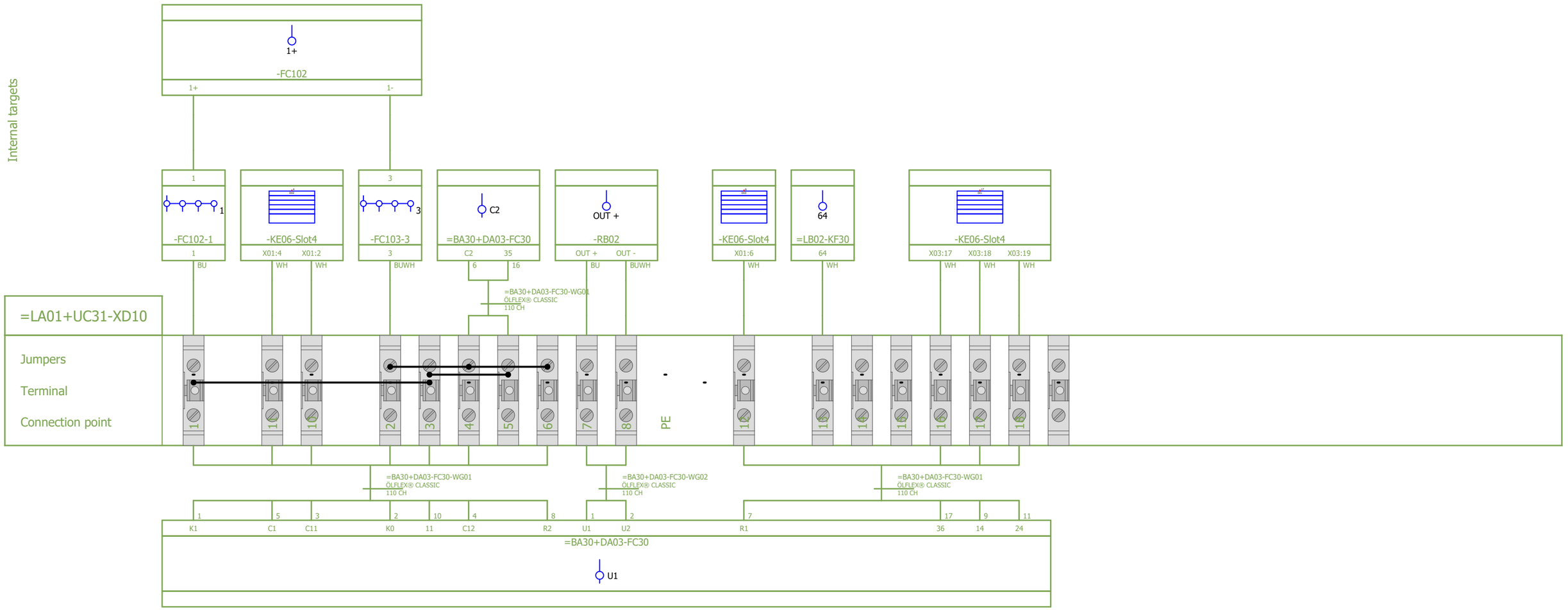
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD09		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 66 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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DESCRIPTION
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD10		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 67 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

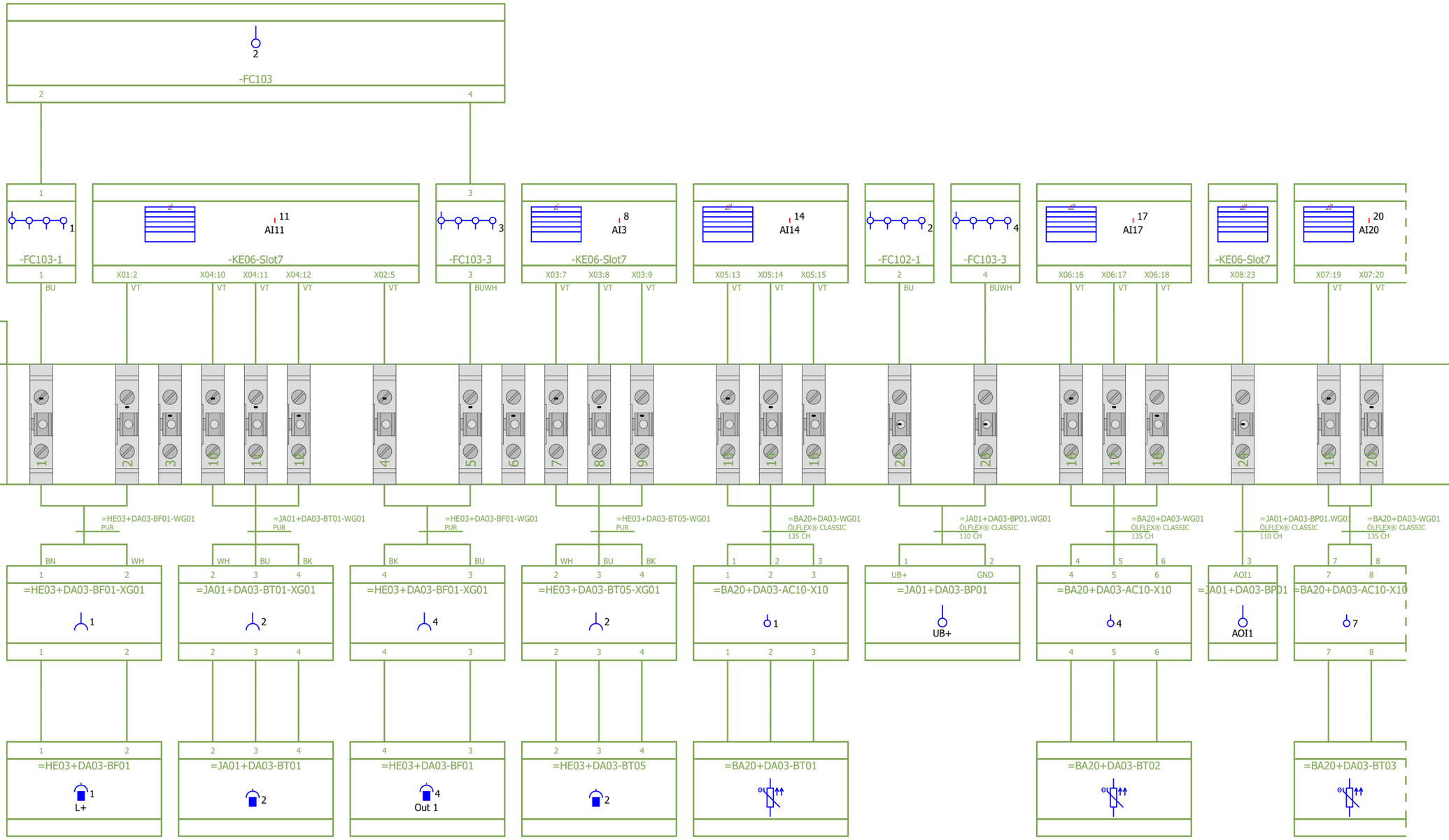
External targets

=LA01+UC31-XD11

Jumpers

Terminal

Connection point



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD11		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 68 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

=LA01+UC31-XD20

Jumpers

Terminal

Connection point

-FC104
2
2 4

=LB02-KF30
24
24 34 44 54
WH WH WH WH

=LB02-KE22
X1 I5 X2 I6 I7 I8 I3
WH WH WH WH WH WH WH

-FC104-1
1
1
BU

=LB02-KE22
Q1 I1 I2
WH WH WH

-FC104-3
3
3
BUWH

=LB02-KE21
X1
WH

-BB01
11
-X1:11
WH

=LB02-KE21
I1 I2
WH WH

=BA30+DA03-TB30-WG01
Unitronic FD CP (TP)
2x2x0,5
WH BN GN YE
AF:2 AF:1 AF:3 AF:4
=BA30+DA03-TB30-AF
2

=LB02+DA03-BG01.WG01
BN WH BU BK
1 2 3 4
=LB02+DA03-BG01.XG01
1
1 2 3 4
=LB02+DA03-BG01
1

=LB02+DA03-BG02.WG01
BN WH BU BK
1 2 3 4
=LB02+DA03-BG02.XD01
1
1 2 3 4
=LB02+DA03-BG02
1

21 31 22 32
=LB02+DA03-SG03
21 31
22 32

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD20		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 69 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets

External targets

=LA01+UC31-XD20

Jumpers

Terminal

Connection point

-FC104
2
2 4

=LB02-KF30
24
24 34 44 54
WH WH WH WH

=LB02-KE22
X1 I5 X2 I6 I7 I8 I3
WH WH WH WH WH WH WH

-FC104-1
1
1
1 BU

=LB02-KE22
Q1 I1 I2
WH WH WH

-FC104-3
3
3
3 BUWH

=LB02-KE21
X1
WH

-BB01
11
-X1:11
WH

=LB02-KE21
I1 I2
WH WH

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

=BA30+DA03-TB30-WG01
Unitronic FD CP (TP)
2x2x0,5
WH BN GN YE
AF:2 AF:1 AF:3 AF:4
=BA30+DA03-TB30-AF
2

=LB02+DA03-BG01.WG01
BN WH BU BK
1 2 3 4
=LB02+DA03-BG01.XG01
1
1 2 3 4
=LB02+DA03-BG01
1

=LB02+DA03-BG02.WG01
BN WH BU BK
1 2 3 4
=LB02+DA03-BG02.XD01
1
1 2 3 4
=LB02+DA03-BG02
1

21 31 22 32
=LB02+DA03-SG03
21 22 31 32

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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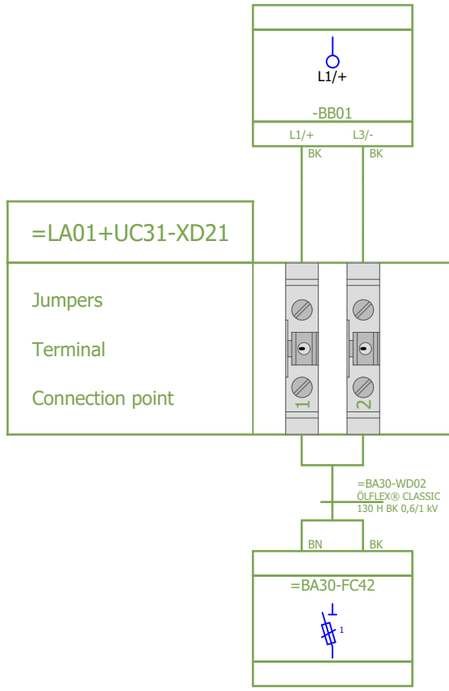
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD20		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 70 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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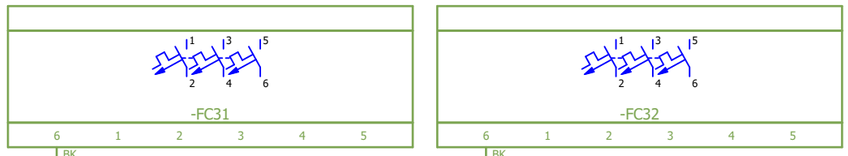
DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD21		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 71 / 81

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



=LA01+UC31-XD02

Jumpers	-	-
Terminal	-	-
Connection point	5	6 PE PE

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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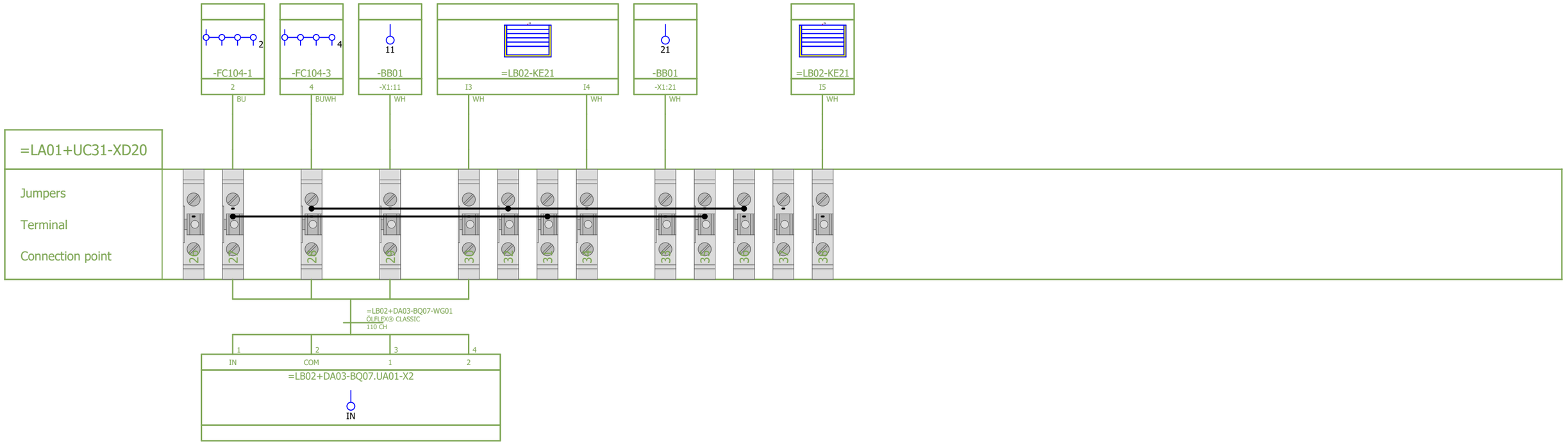
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 72 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
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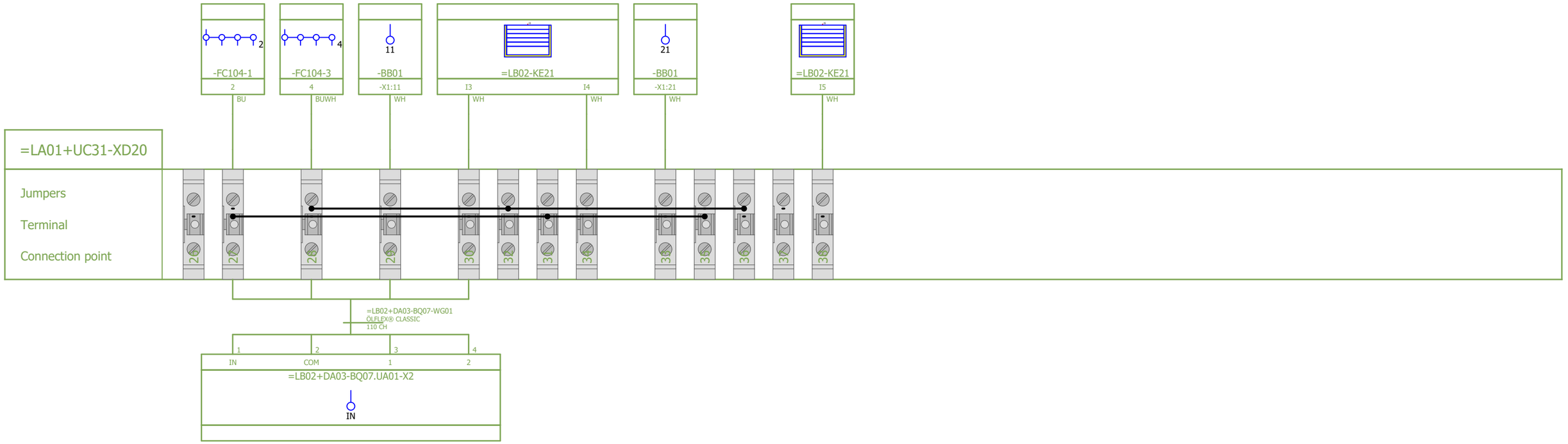
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD20		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 73 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
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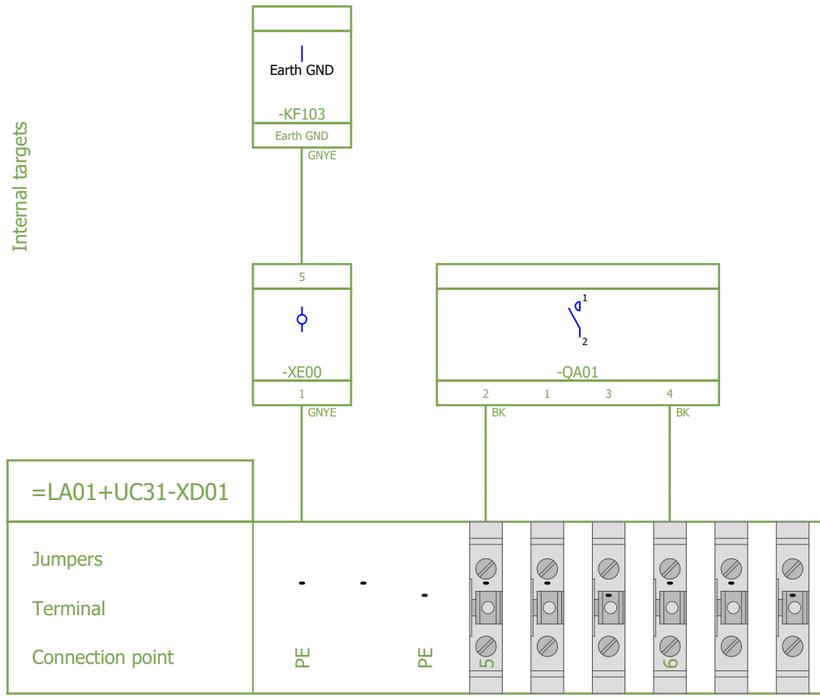
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DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD20		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 74 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
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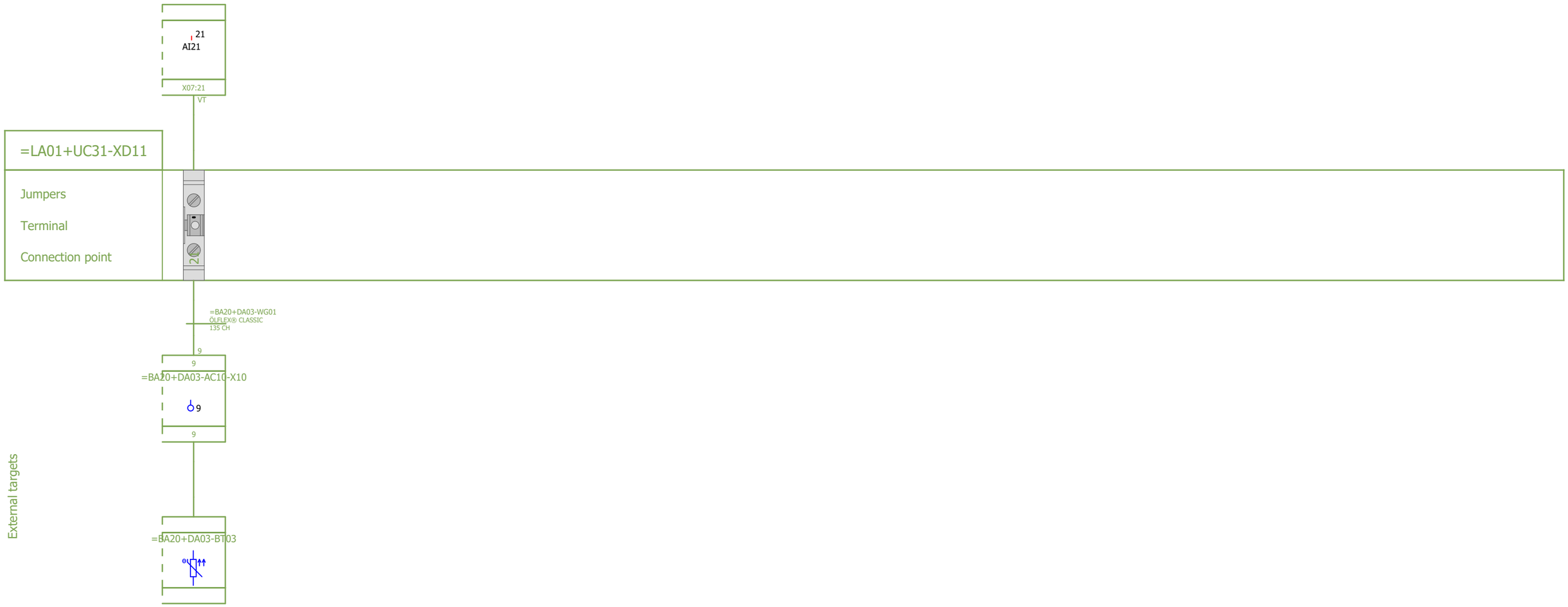
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DRAWING TITLE			
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FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



Reference Item Number	Ballard Part # TBD		
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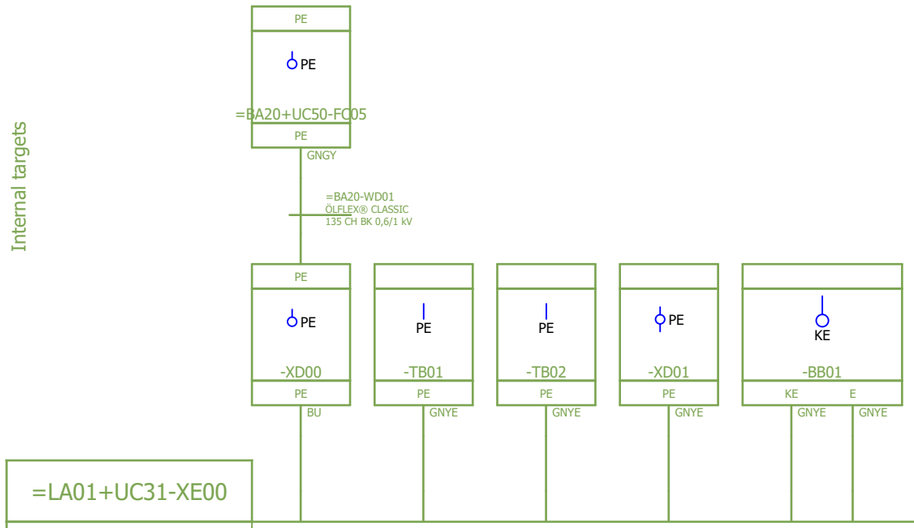
DRAWING		REVISION	12
DRAWING TITLE			
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD11		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 76 / 81

FRM5103656/0B

Terminal-connection diagram

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PBL 29-Sep-25

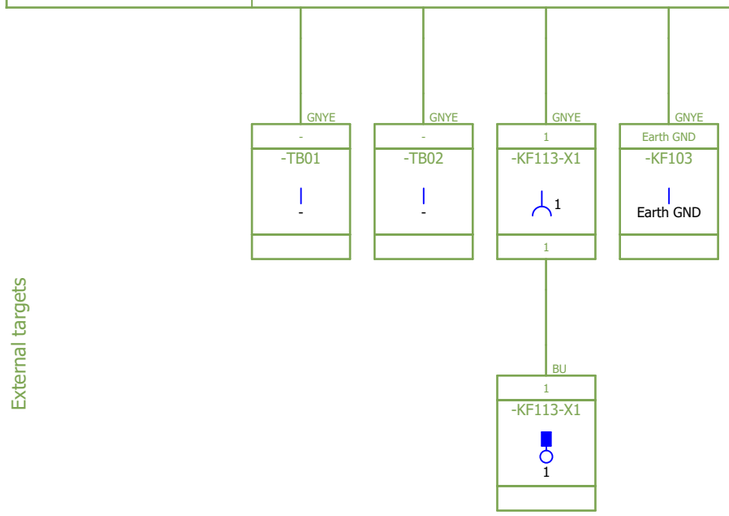
Internal targets



=LA01+UC31-XE00

Jumpers	-	-	-	-	-	-	-	-
Terminal								
Connection point	PE		PE		PE		PE	

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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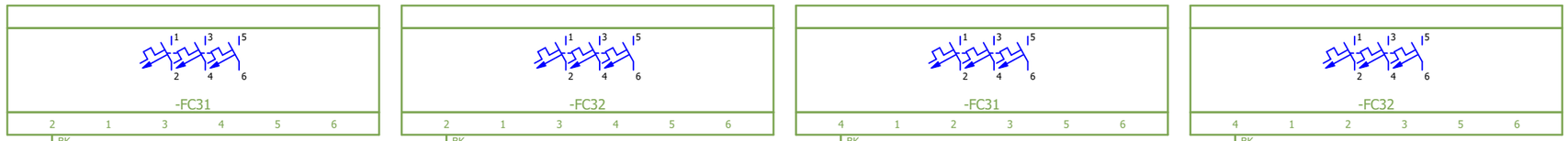
DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XE00		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 77 / 81

FRM5103656/0B

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



=LA01+UC31-XD02

Jumpers

Terminal

Connection point



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

REVISION INFORMATION
DESCRIPTION
DATE
29-Sep-25

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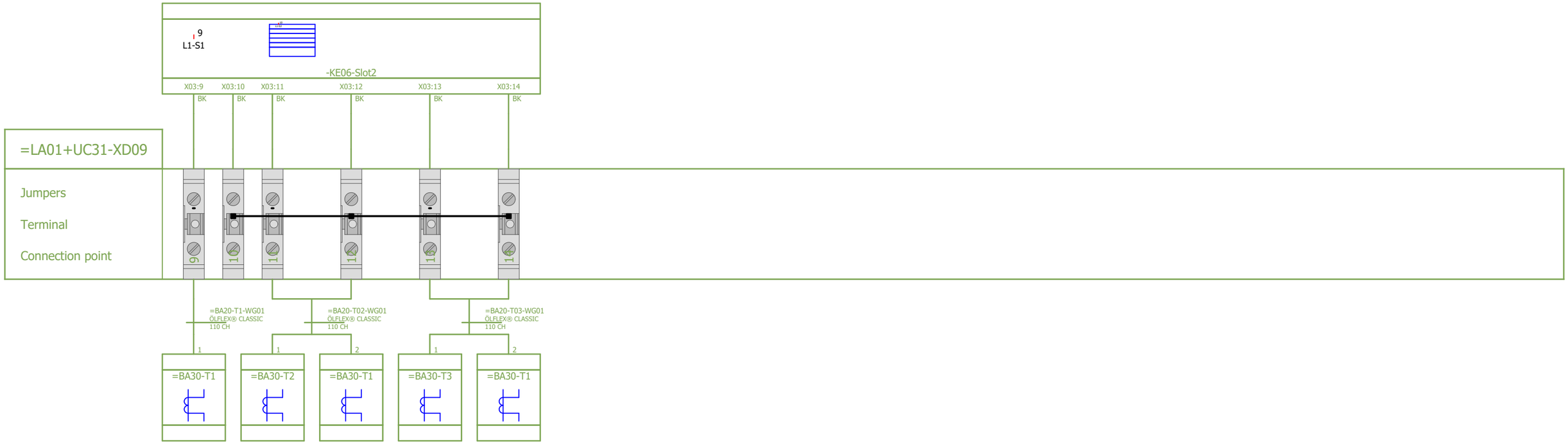
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 78 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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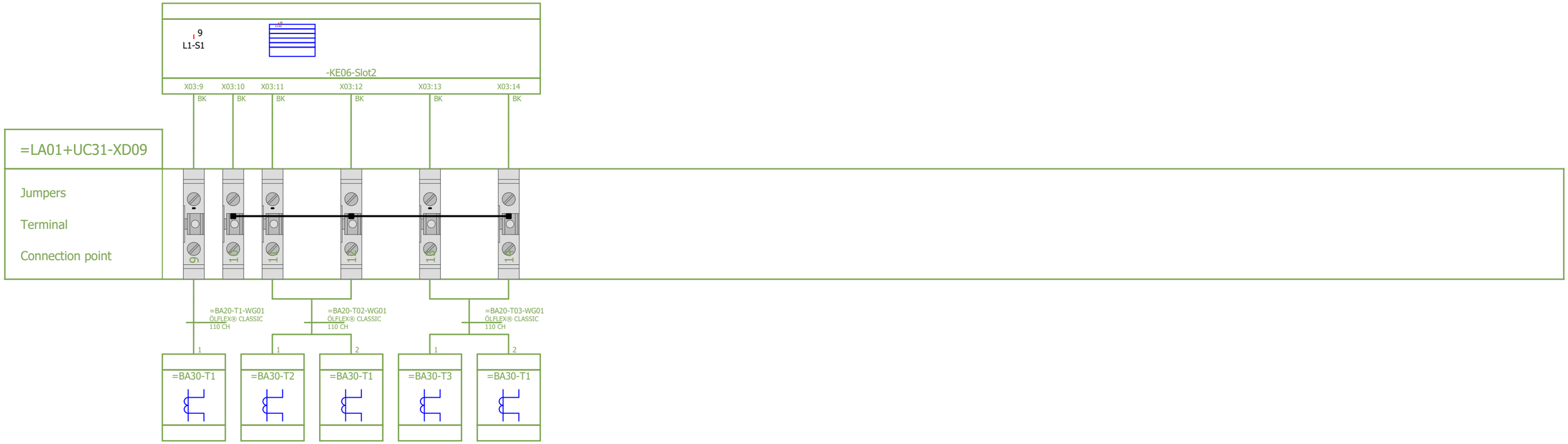
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD09		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 79 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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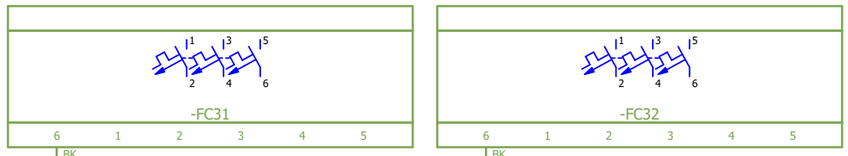
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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD09		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 80 / 81

Terminal-connection diagram

F11_001
PBL 29-Sep-25

Internal targets



=LA01+UC31-XD02

Jumpers	-	-
Terminal	5	6
Connection point		PE PE

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	12		
EPLAN Project Pages	627		
=	++	+ UC31	& C04

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DRAWING	601456B UC31 10ft Control Cabinet	REVISION	12
DRAWING TITLE	Crosswind UC31 10ft Control Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =LA01+UC31-XD02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 81 / 81

Sub Section E03-005

UC41 Coolant Skid VFD Cabinet

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	9/9/2025	Updated, as build

Document Title:	**BLPH Project - Panel Cabinet Layout: UC41 Coolant Skid VFD Cabinet**
Document Number:	K559-2254-CWIWP4202202-E03-005
Revision:	Rev002
Sequence Number:	005
File Name:	K559-2254-CWIWP4202202-E03-005Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8

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+UC41

Ballard Power Systems Europe - Technology Solutions

Cabinet: Coolant Skid Inverter Cabinet
Location: Coolant Skid, Middle Rear

Vin = 400VAC, 3ph

Ikmax = 6kA - AC Supply

IP56

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& A01

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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Front Page		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 27

FRM5103656/0B

Ballard Power Systems Europe - Technology Solutions, Cabinet Wiring Colors

Standard Basis: EN 61439

Required wire standard compliance:

Required: IEC Wire
Required: UL Recognized
Required: CSA/UL

Wire Numbering:

- Wires inside panels are to be numbered
- Wire number system is perferably "potential oriented with subnumber"
- All wires of the same potential (e.g. DC Common) have the same main number, with sequential subnumber.
- Potential numbers with fewer digits may be leading zero padded (e.g. 19 -> 019)
- Separator between main and subnumber is "."

Example: 019.1 BUWH 0.75mm²

- 019 — Wire potential number
- 1 — Wire sequential subnumber with separator
- BUWH — Wire color code (Dark Blue with White stripe)
- 0.75mm² — Wire dimension

AC Wiring Colors

AC Power Circuit (Generic)	Black (BK)
AC Phase L1	Brown (BN)
AC Phase L2	Black (BK)
AC Phase L3	Grey (GY)
AC Neutral	Light Blue (BU)
Externally supplied circuit	Orange (OG)

DC Wiring Colors

DC Power Circuit	Black (BK)
DC Control Voltage (24V)	Dark Blue (BU)
DC Control Voltage Refence (0V)	Dark Blue with White Stripe (BUWH)
Signal Wire (DI, DO)	White (WH)
Signal Wire (AI, AO)	Violet (VT)
Externally supplied circuit	Orange (OG)

PE Wiring Colors

Protective Earth (PE)	Green/Yellow (GNYE)

Conductor Colour Identification

IEC 60757:1983 Designation	Description
BK	Black
BN	Brown
RD	Red
OG	Orange
YE	Yellow
GN	Green
BU	Blue
VT	Violet
GY	Gray
WH	White
PK	Pink
GD	Gold
TQ	Turquoise
SR	Silver
GNYE	Green/Yellow
SH	Shield

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& A01

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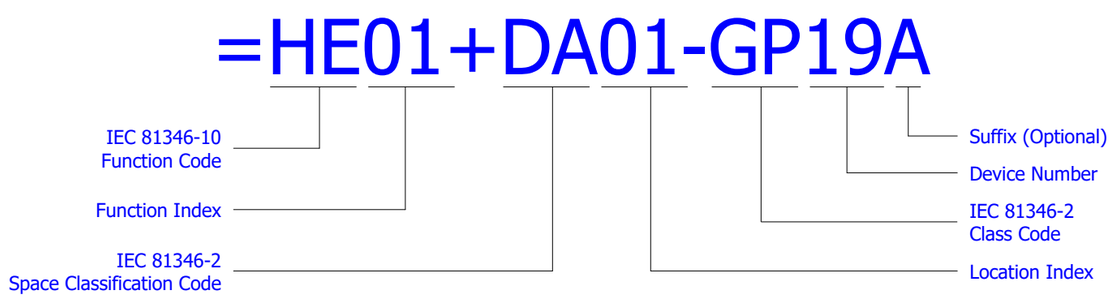
DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Standard Wire Colors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 27

FRM5103656/0B

Ballard Power Systems Europe - Technology Solutions Device Tag Process

A Ballard Device Tagname consists of three parts:
- A function designation (=)
  - According to IEC81346-10, Table B.1 and B2.
  - Always two letters followed by two digits
- A location designation (+)
  - According to IEC81346-2, Table 4
  - Always two letters followed by two digits
- A class code (-)
  - According to IEC81346-2, Table 2
  - Always two letters followed by two or three digits plus optional suffix

Sample fully qualified Device Tag (DT) for a Coolant Pump



IEC81346-10 Function Examples

IEC 81346-10 Table B.1 and B.2 provide a class definition system, which provides a two letter code for the functional description
Table B.1 is used for power supply systems and table B.2 for other systems

IEC 81346-10 Table B.1 / B.2	Function Codes (Example)
=AA	Structural System, Load support (Frame)
=BA	Transporting Electrical Energy (Power Converters)
=HA	Supply System, Gaseous Matter (Gas Piping)
=HE	Supply System, Heating/Cooling (Radiator)
=JA	Distribution System, Gaseous Matter (Gas Handling Unit)
=JB	Distribution System, Liquid Matter (Fluid Drain)
=LA	Control System, Process (PLC, SCADA)
=LB	Control System, Safety (Safety PLC)
=QA	Storage System, Gaseous Matter (Gas Storage)
=RE	Energy Conversion System, Chemical to Electricity (Fuel cells, Batteries)

IEC81346-2 Space Classification

IEC 81346-2 Table 4 provide a classification scheme for spaces, which provides a two and three letter code for the space (location) classification.
Class code "1" and "1" is used for the location scheme

IEC 81346-2 Table 4	Location Codes (Example)
+GB	Space for power generation, Chemical (Fuel Cells)
+DA	Space for active technical equipment
+UC	Space for electrical equipment (Electrical Cabinet)

IEC81346-2 Class Code

IEC 81346-2 Class Codes is a scheme for defined objects for reference designations according to their inherent function

IEC 81346-2 Table 2	Class Codes (Example)
-BA	Sensing, electrical potential (Voltage Transducer)
-BC	Sensing, electrical current (Current Transducer)
-BP	Sensing, pressure (Pressure Transducer)
-BT	Sensing, temperature (Temperature Transducer)
-EA	Emitting, light (Light Fixture)
-FC	Protecting, overcurrent (Fuse, MCCB)
-GB	Generating, Chemical Reaction (Fuel Cell)
-GP	Generating, Liquid Flow (Pump)
-GQ	Generating, Gas Flow (Van, Ventilator)
-KE	Processing, Electrical signals (PLC)
-KF	Processing, Information (Network Switch)
-MA	Driving, Torque (AC Motor)
-QA	Controlling, Electric Current (Contactor, Motor Starter)
-QB	Controlling, Electric Separation (Disconnector)
-QM	Controlling, Fluid On/Off (Valve)
-QN	Controlling, Fluid Regulation (Damper, Gas Control Valve)
-WD	Guiding, Low Voltage Electric Energy (AC or DC power Cable)
-WE	Guiding, Reference Potential (Grounding Wire/Cable)
-WG	Guiding, Electric Signals (Control, Network Cable)

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	11
EPLAN Project Pages	629
= ++ + UC41 & A01	

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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Tagging Standard		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 3 / 27

FRM5103656/0B

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Multiline Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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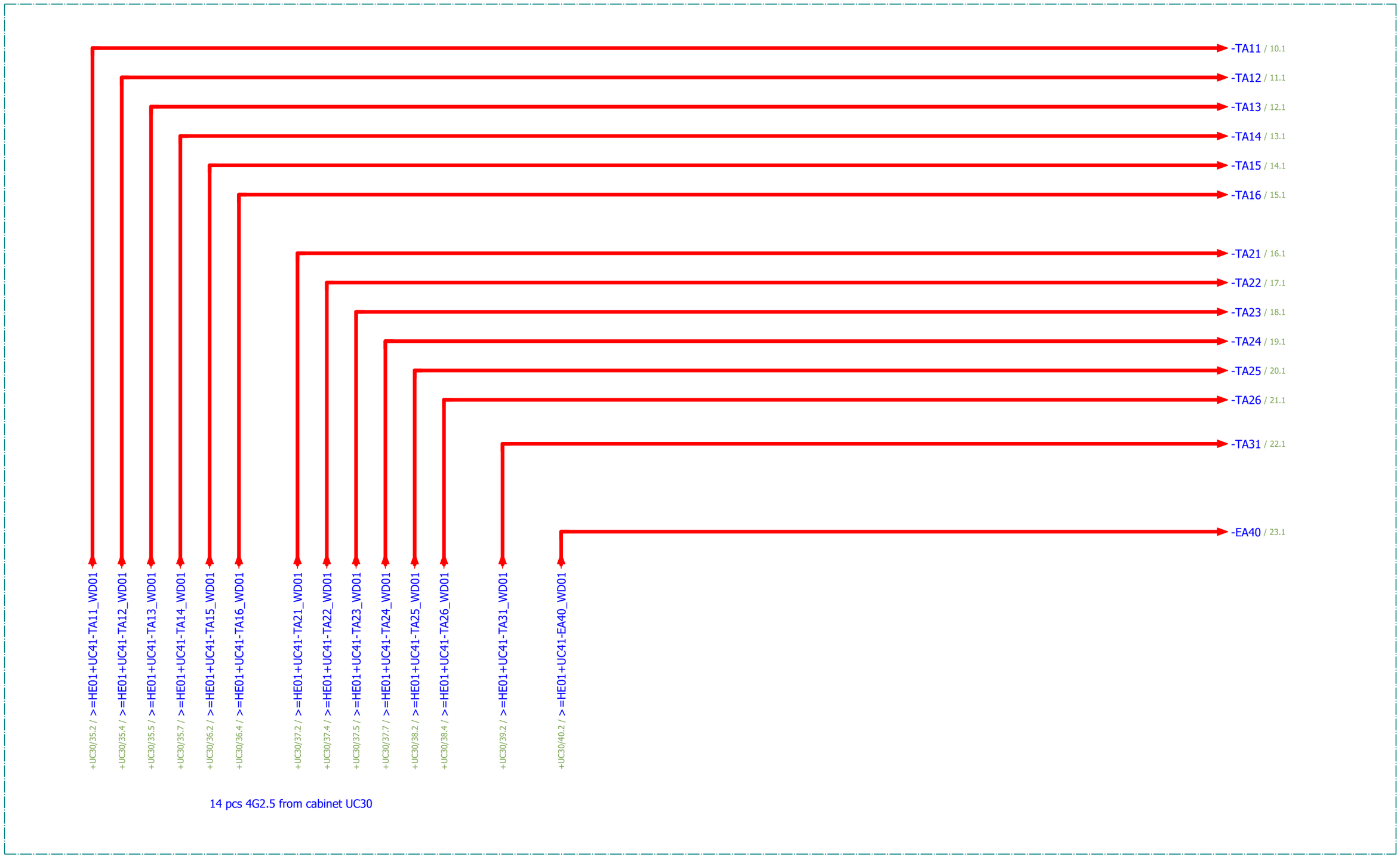
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DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Multiline Documentation Intro		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 5 / 27

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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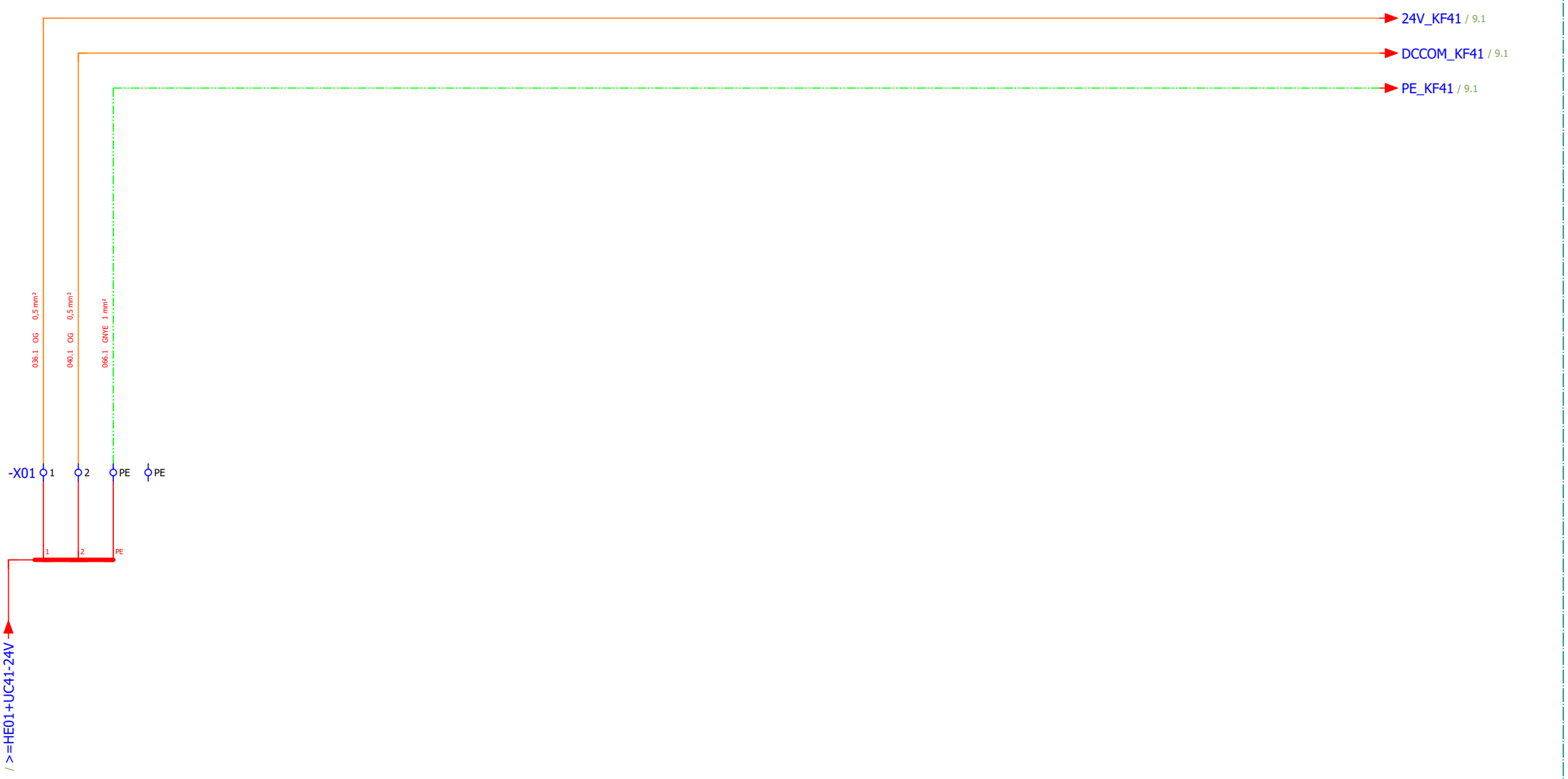
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - Incomming		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 6 / 27

0	1	2	3	4	5	6	7	8

=HE01



From Coolant Skid Control Cabinet (UC30)
3G1 - 24V Supply

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11		
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet				
SHEET TYPE/DESC	DC Supply - Incomming				
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	7 / 27	

0	1	2	3	4	5	6	7	8

=HE01

-KF41_WG01 / 9.1

-KF41_WG16 /

-EA40_WG01 / 23.1

-KF41-WG01
Cat.6A PUR
8x24
300 V
VFD Control Net

>=LA01+UC41-KF41-WG16
Cat.6A PUR
8x24
300 V
VFD Control Net

-EA40-WG01
UNITRONIC® BUS CAN UL/CSA
4x0,5
300 V
Air Chiller RS485 Bus

/ >=HE01+UC41-WG01

/ >=LA01+UC41-KF41-WG01

/ >=HE01+UC41-WG02

From Coolant Skid Control Cabinet (UC30)
1 pcs Ethernet
1 pcs RS485

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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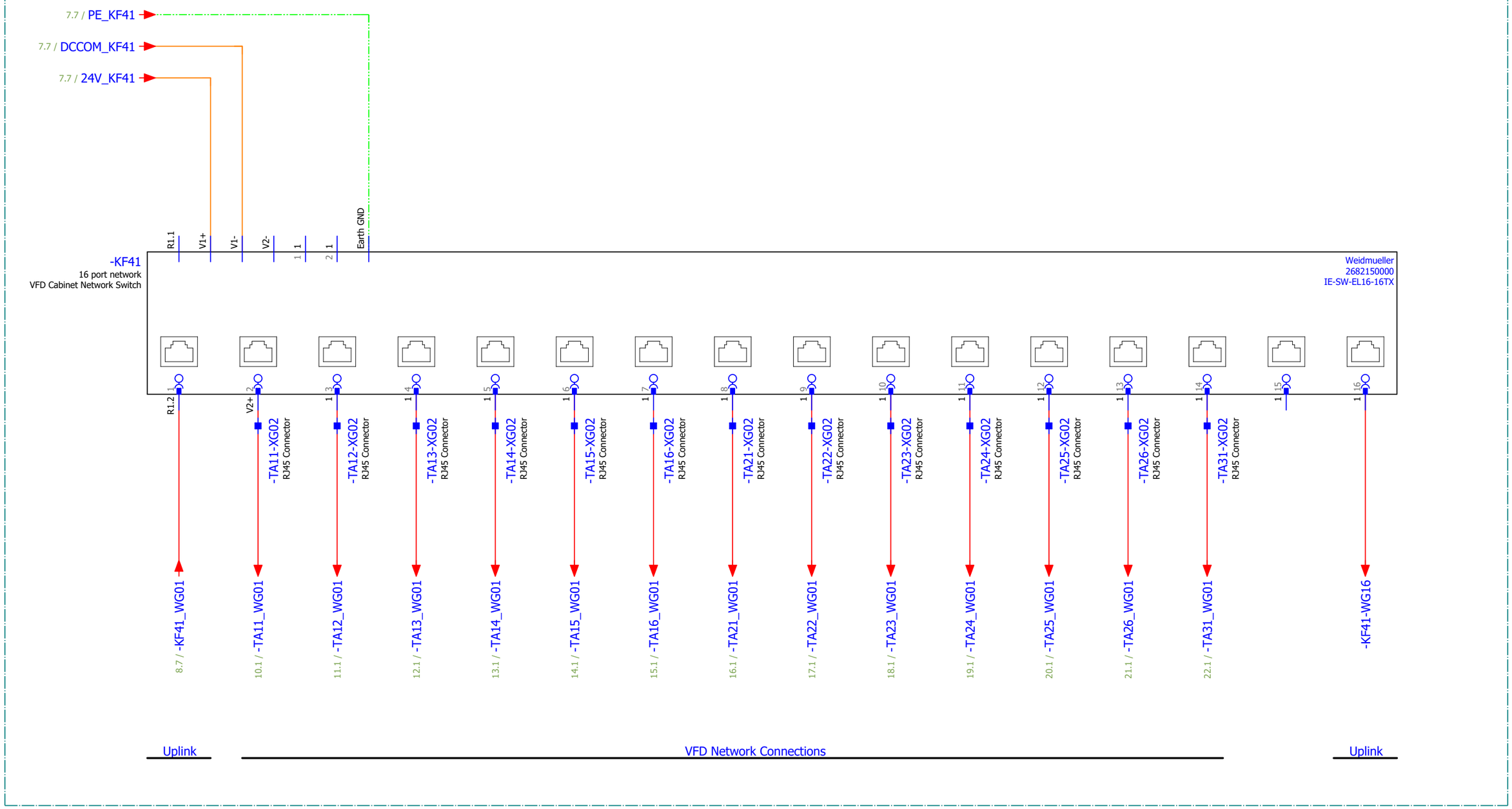
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Network - Incomming		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 8 / 27

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Network - Switch		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 9 / 27

0	1	2	3	4	5	6	7	8

=HE01

9.1 / TA11_WG01

6.7 / TA11

-TA11-WD01
4x2,5
0,6/1,0 kV
HT1 Drive TA11 Power

BN BK GY GNYE

-TA11-WG01
ETHERLINE® PN Cat.5 Y FLEX FC
4x22
300 V
HT1 Drive TA11 Com

-TA11-XG01
RJ45 Connector

-TA11
VFD - HT1 Fan 1
4.0kW / 5.5HP, 3x 380-480 VAC

INPUT
MAINS 91 L1
MAINS 92 L2
MAINS 93 L3
PE 95

RELAY1 01 R01 CO
RELAY1 02 R01 NO
RELAY1 03 R01 NC
RELAY 1

RELAY2 04 R02 CO
RELAY2 05 R02 NO
RELAY2 06 R02 NC
RELAY 2

RJ45-1 ETH01 Net1
RJ45-2 ETH02 Net2

VLT® HVAC Drive FC 102
FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX

MOTOR
U 96 MOTOR
V 97 MOTOR
W 98 MOTOR
99 PE

LOAD SHARING
DC (-) 88 LOAD
DC (+) 89 LOAD

=HE01+DA02
HT1 Cooler

-GQ11-WD01
4x2,5
0,6/1,0 kV
HT1 Fan GQ11 Power

BN BK GY GNYE

-GQ11
4kW
Ventilation Fan

M
3 ~

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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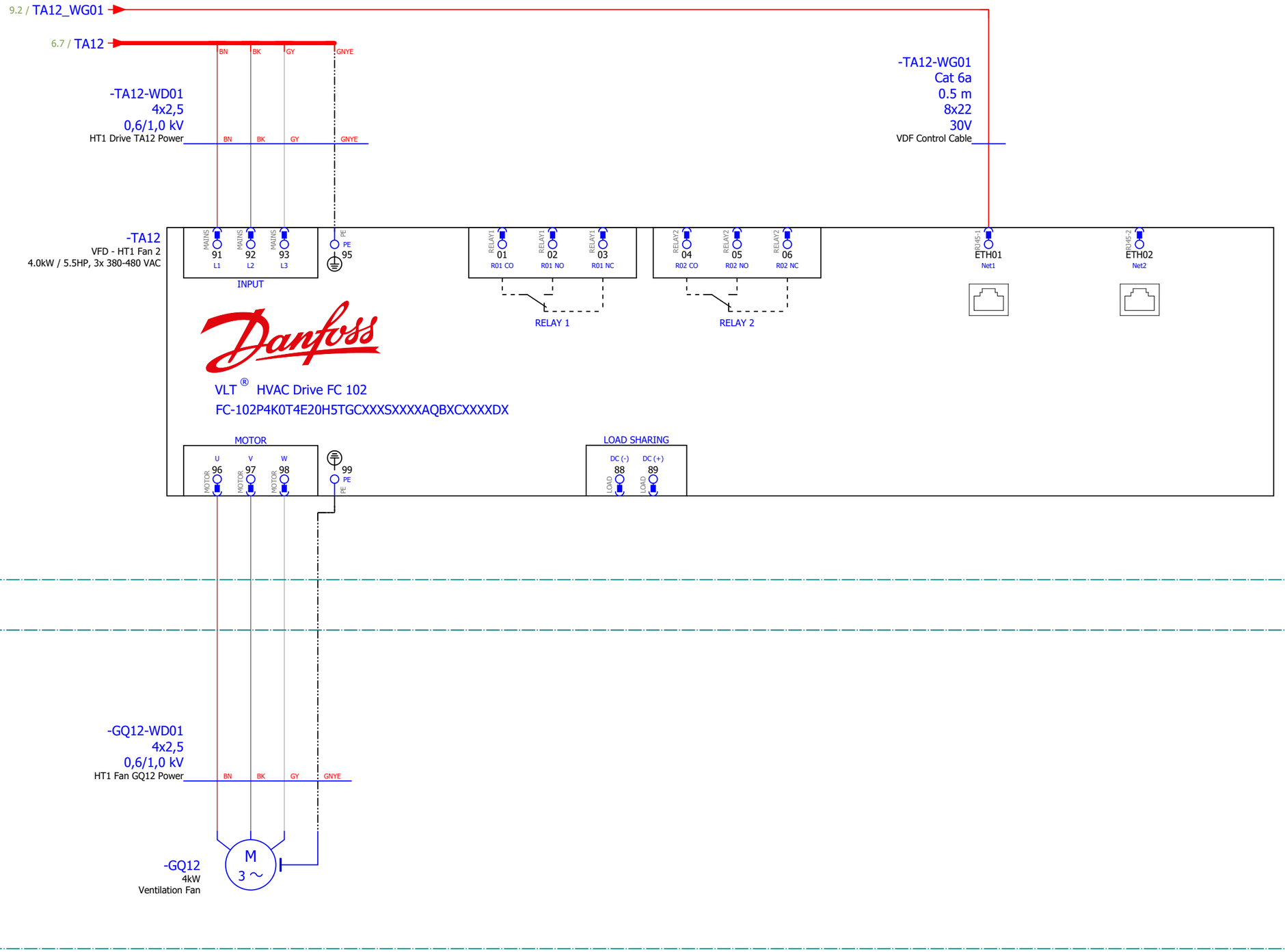
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA11		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 10 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

REVISION INFORMATION
DESCRIPTION
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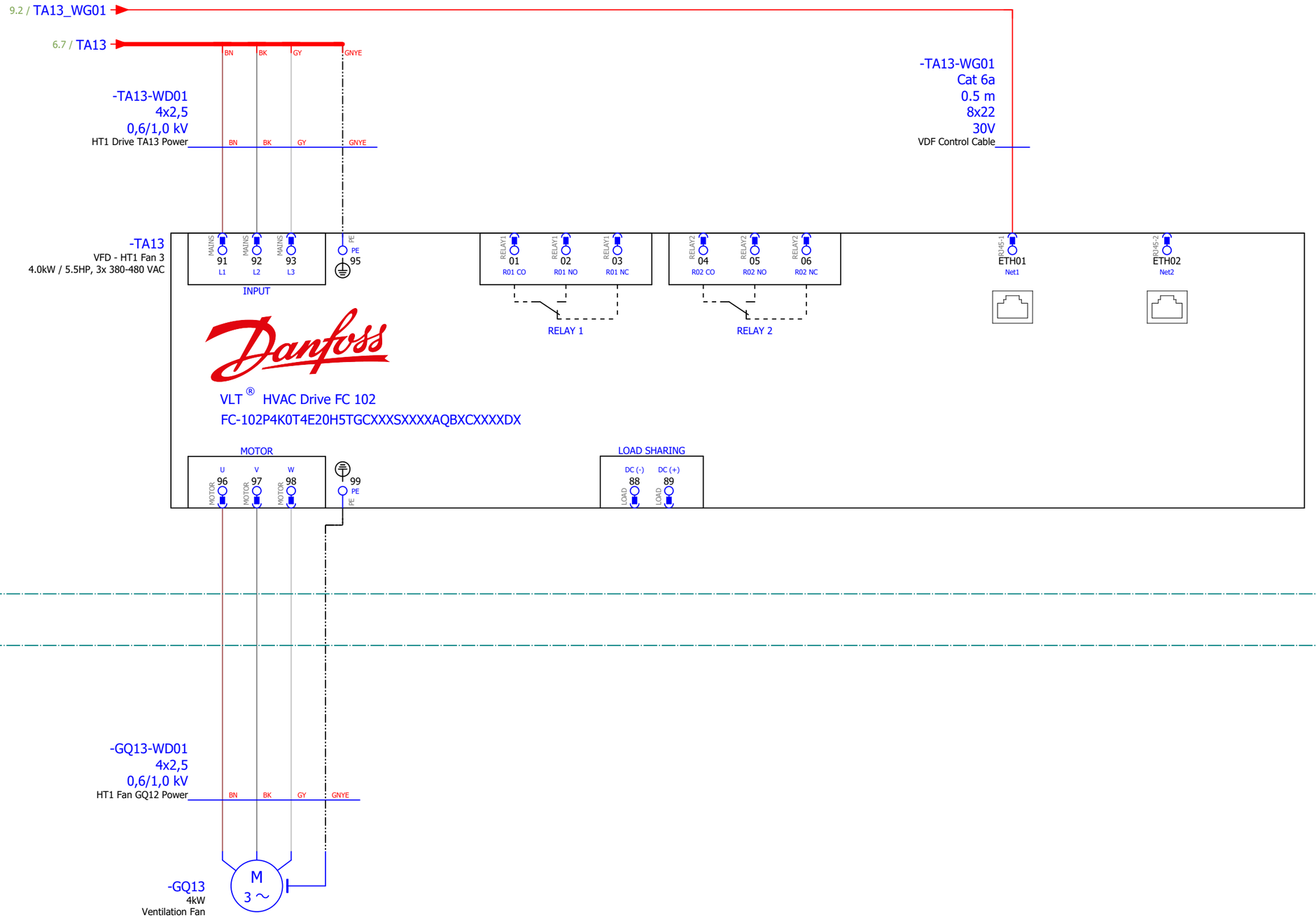
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA12		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 11 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

REVISION INFORMATION
DESCRIPTION
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA13		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 12 / 27

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=HE01

9.3 / TA14_WG01

6.7 / TA14

-TA14-WD01
4x2,5
0,6/1,0 kV
HT1 Drive TA14 Power

BN BK GY GNYE

-TA14-WG01
Cat 6a
0.5 m
8x22
30V
VDF Control Cable

-TA14
VFD - HT1 Fan 4
4.0kW / 5.5HP, 3x 380-480 VAC

INPUT
MAINS 91 L1
MAINS 92 L2
MAINS 93 L3
PE 95

RELAY1 01 R01 CO
RELAY1 02 R01 NO
RELAY1 03 R01 NC
RELAY 1

RELAY2 04 R02 CO
RELAY2 05 R02 NO
RELAY2 06 R02 NC
RELAY 2

RJ45-1 ETH01 Net1
RJ45-2 ETH02 Net2

VLT® HVAC Drive FC 102
FC-102P4K0T4E20H5TGCXXXSXXXXAQBXCXXXXDX

MOTOR
U 96 MOTOR
V 97 MOTOR
W 98 MOTOR
99 PE

LOAD SHARING
DC (-) 88 LOAD
DC (+) 89 LOAD

=HE01+DA02
HT1 Cooler

-GQ14-WD01
4x2,5
0,6/1,0 kV
HT1 Fan GQ12 Power

BN BK GY GNYE

-GQ14
4kW
Ventilation Fan

M
3 ~

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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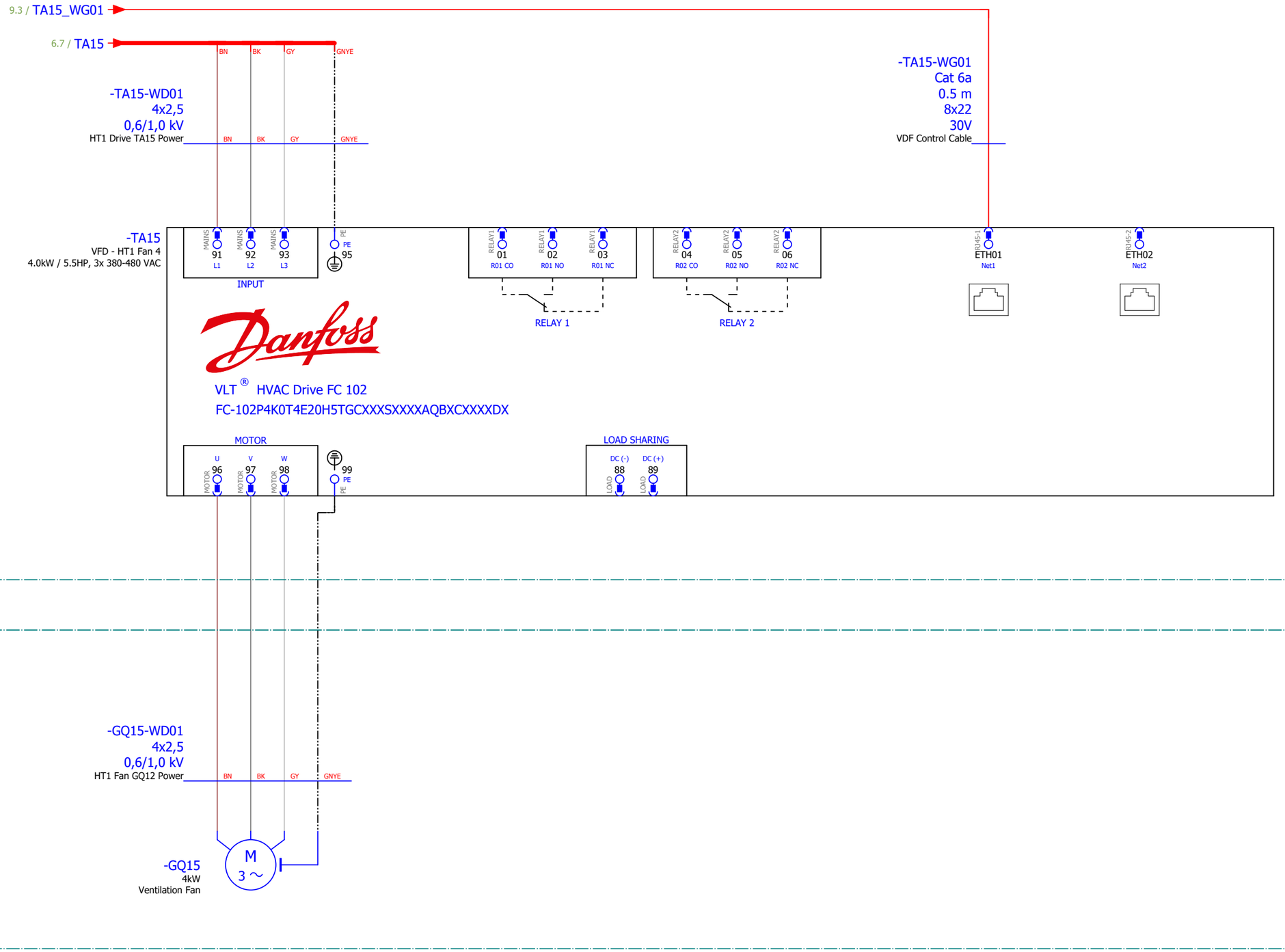
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA14		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 13 / 27

0	1	2	3	4	5	6	7	8

=HE01



=HE01+DA02
HT1 Cooler

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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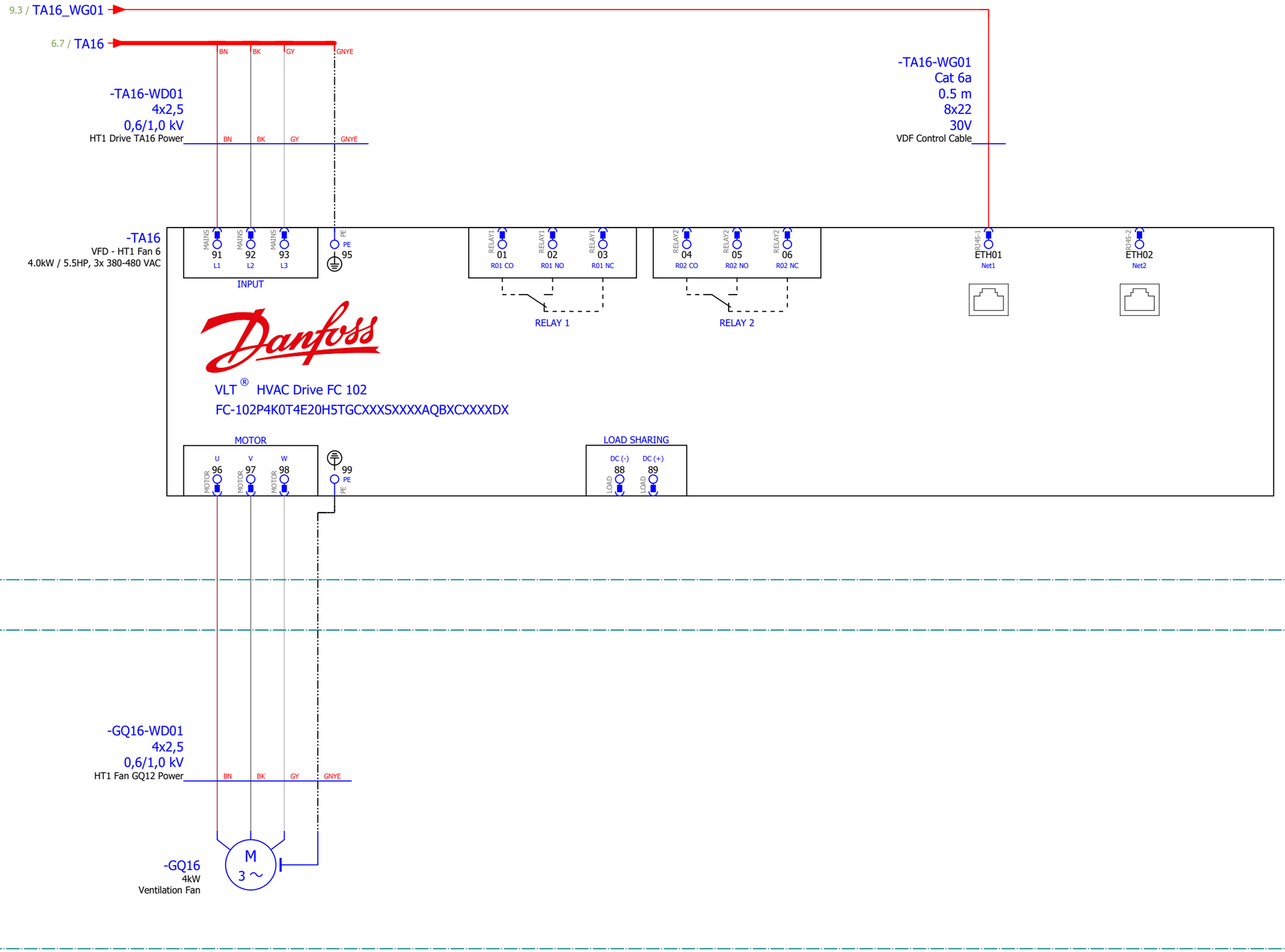
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA15		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 14 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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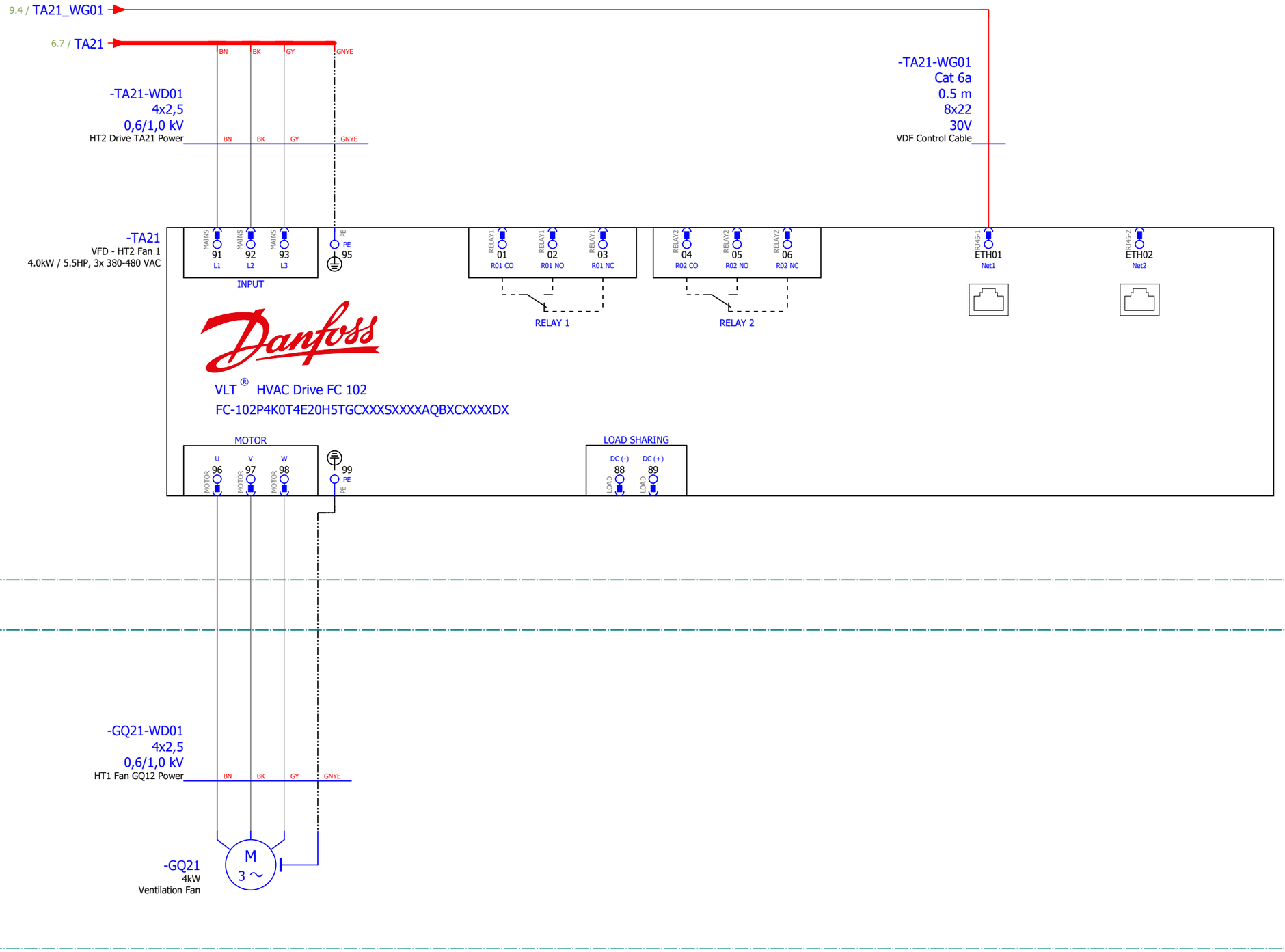
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA16		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 15 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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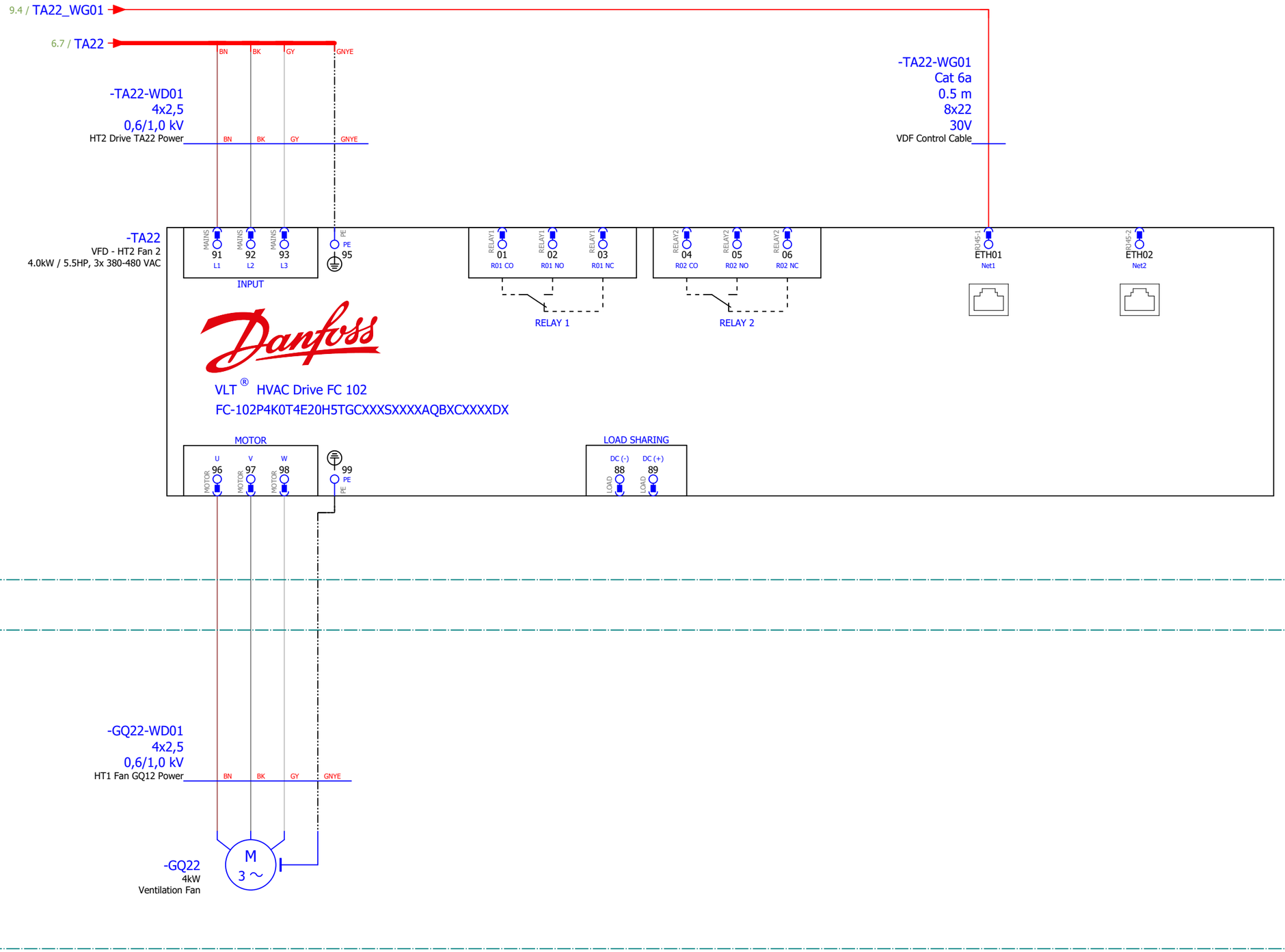
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA21		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 16 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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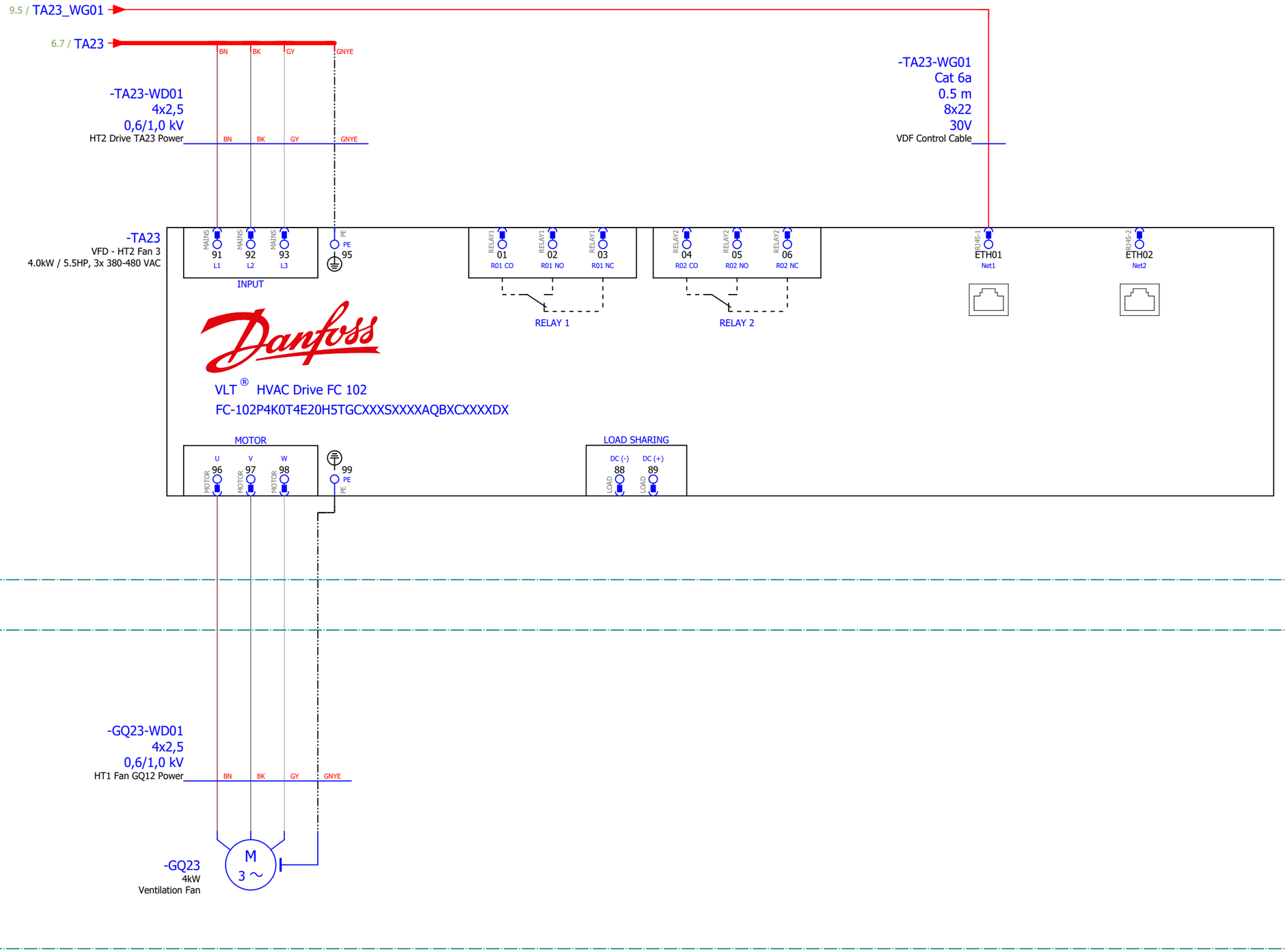
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA22		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 17 / 27

FRM5103656/0B

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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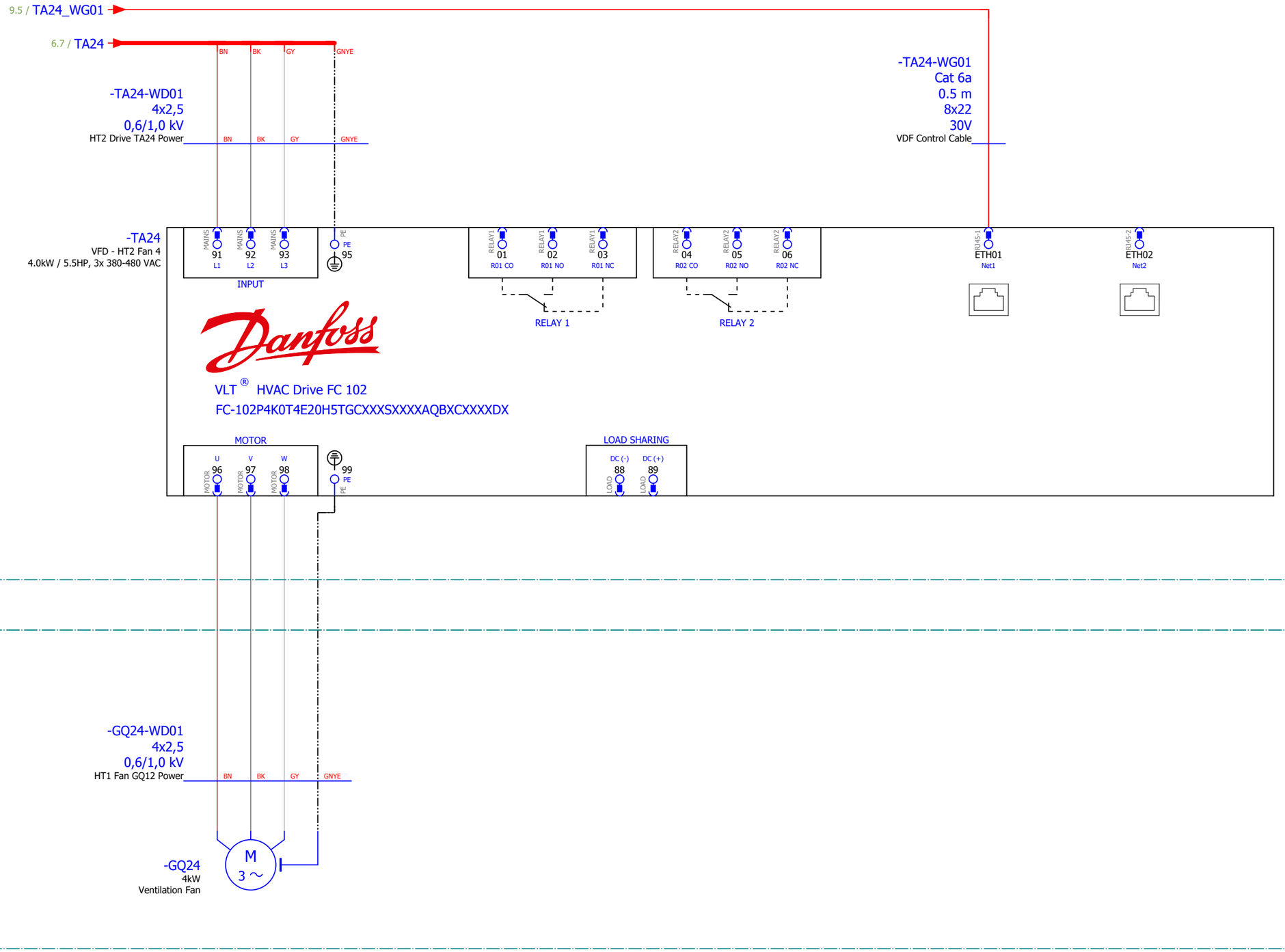
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA23		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 18 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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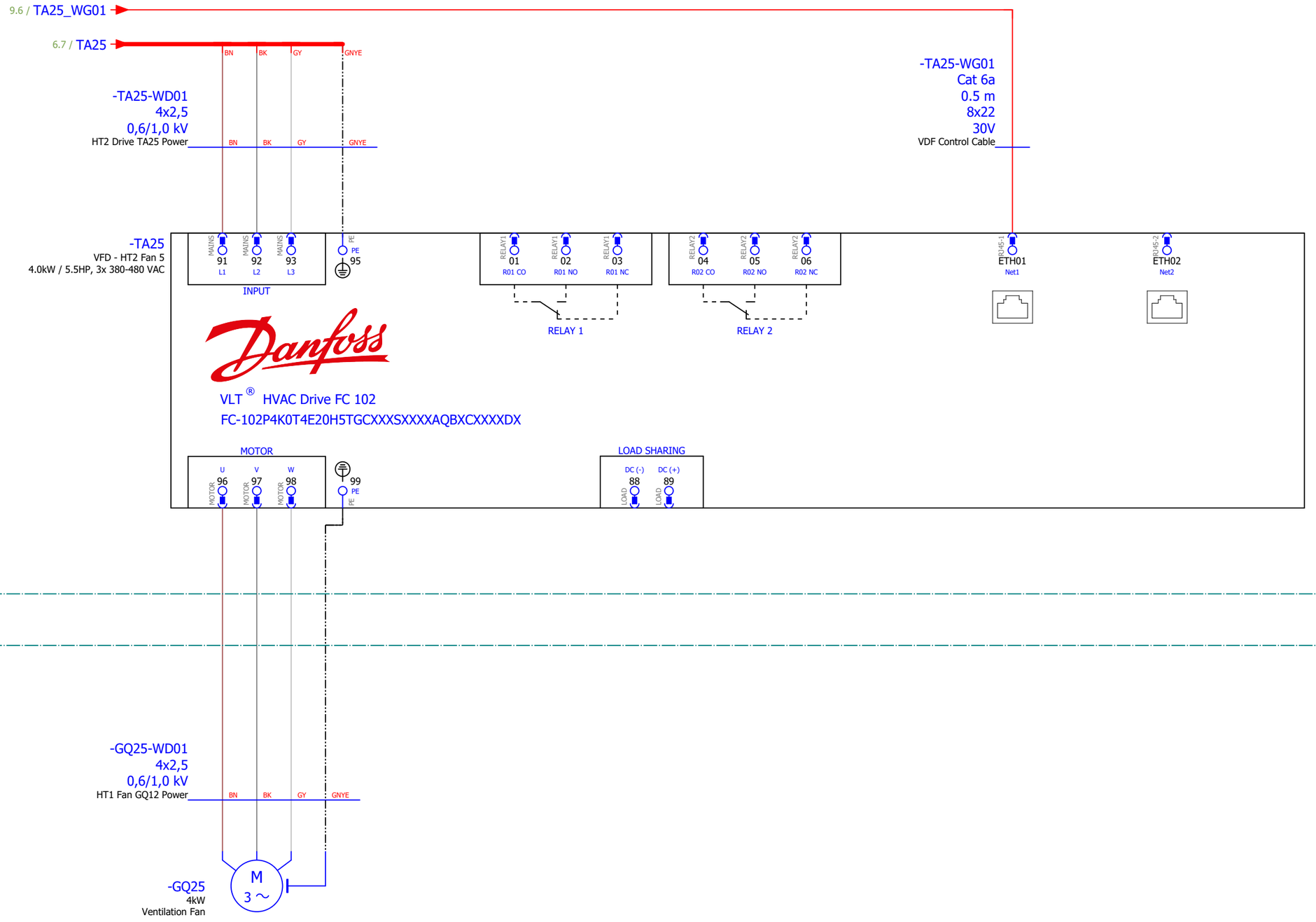
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA24		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 19 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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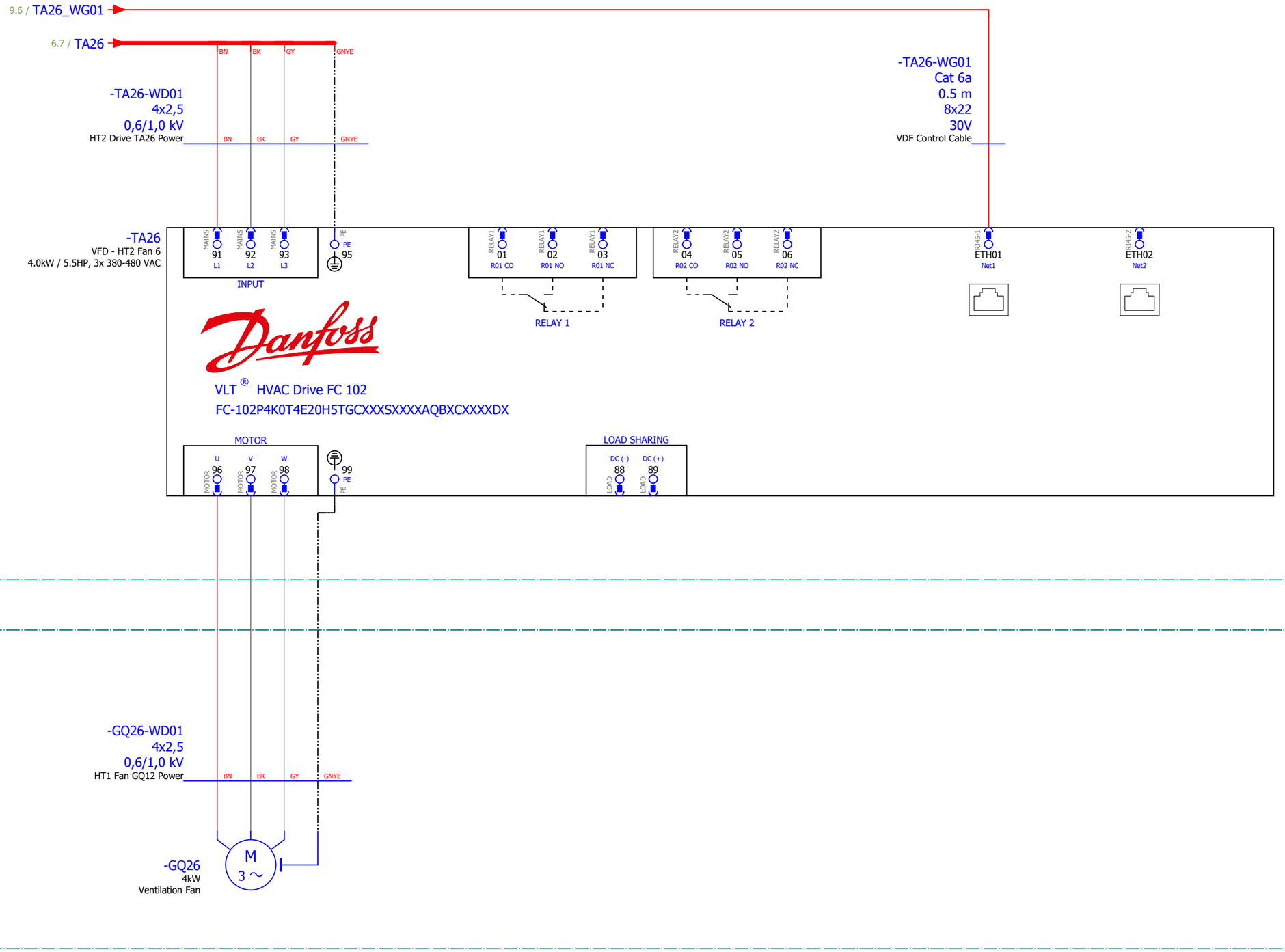
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA25		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 20 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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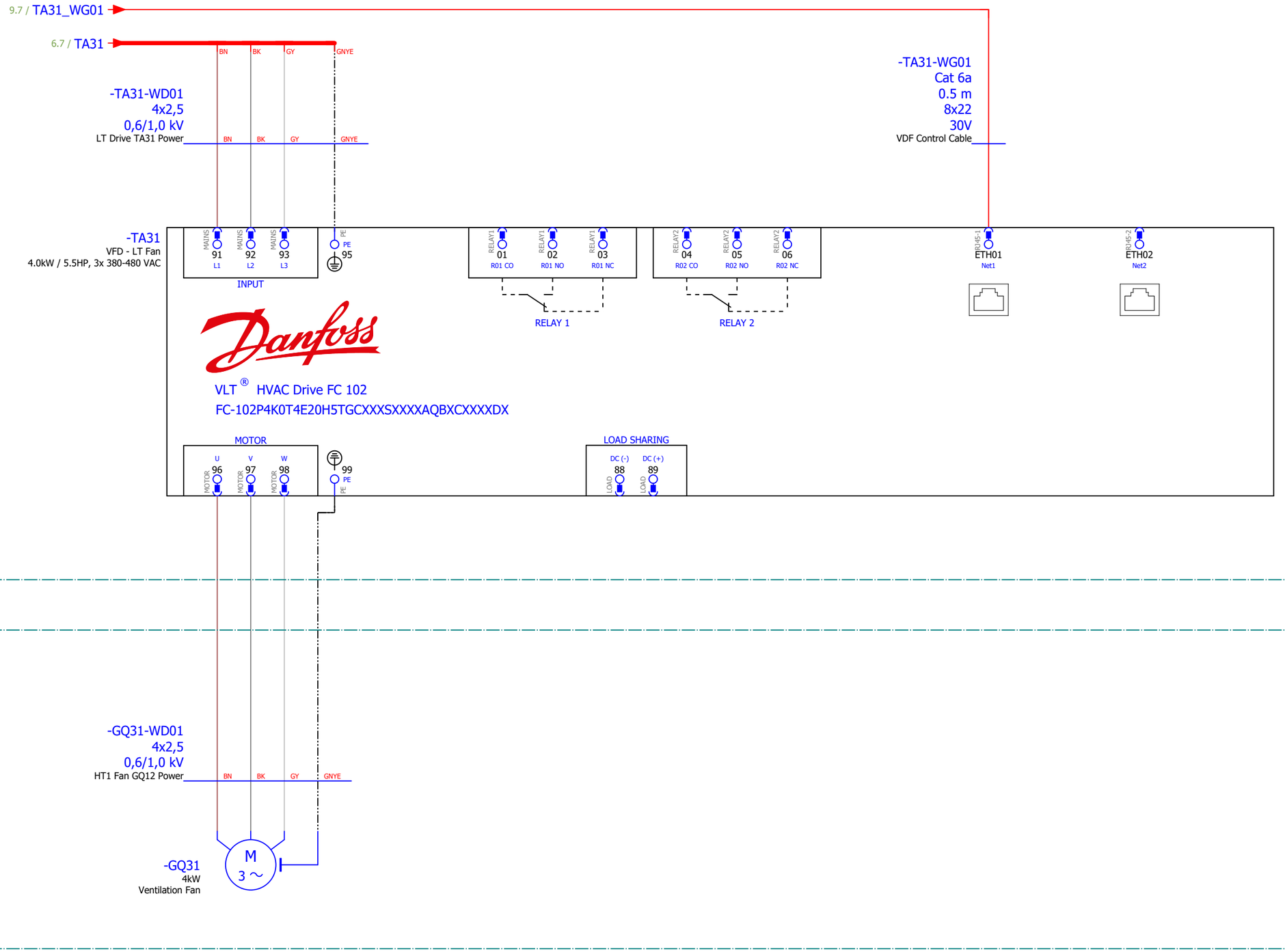
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA26		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 21 / 27

0	1	2	3	4	5	6	7	8

=HE01



=HE03+DA02
LT Cooler

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

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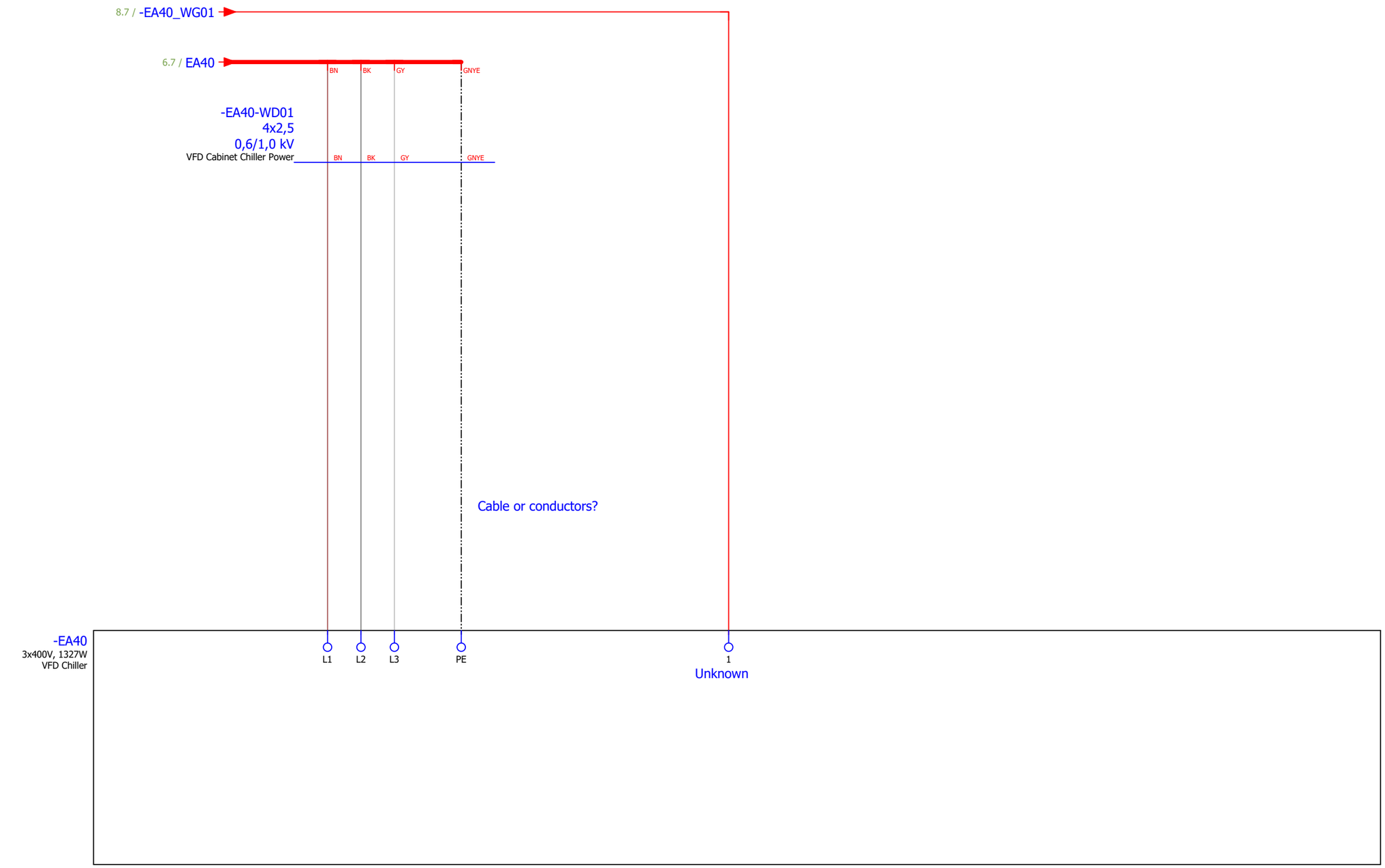
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - TA31		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 22 / 27

0	1	2	3	4	5	6	7	8

=HE01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C03

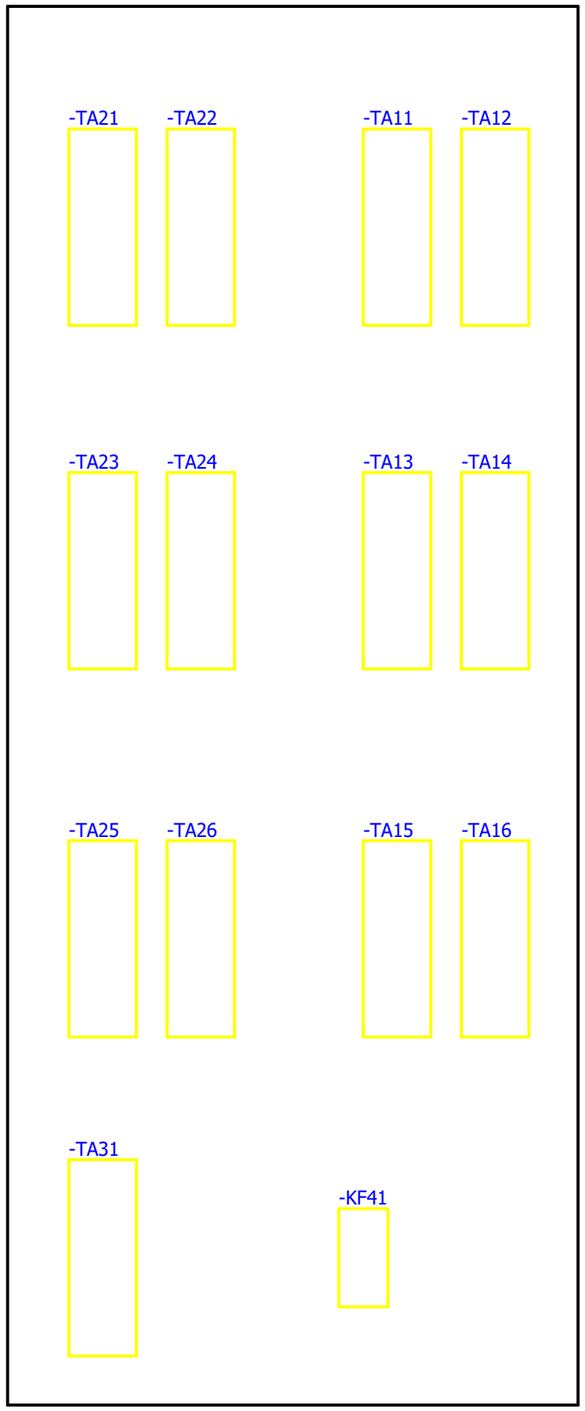
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	AC Power - Chiller		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 23 / 27



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C04

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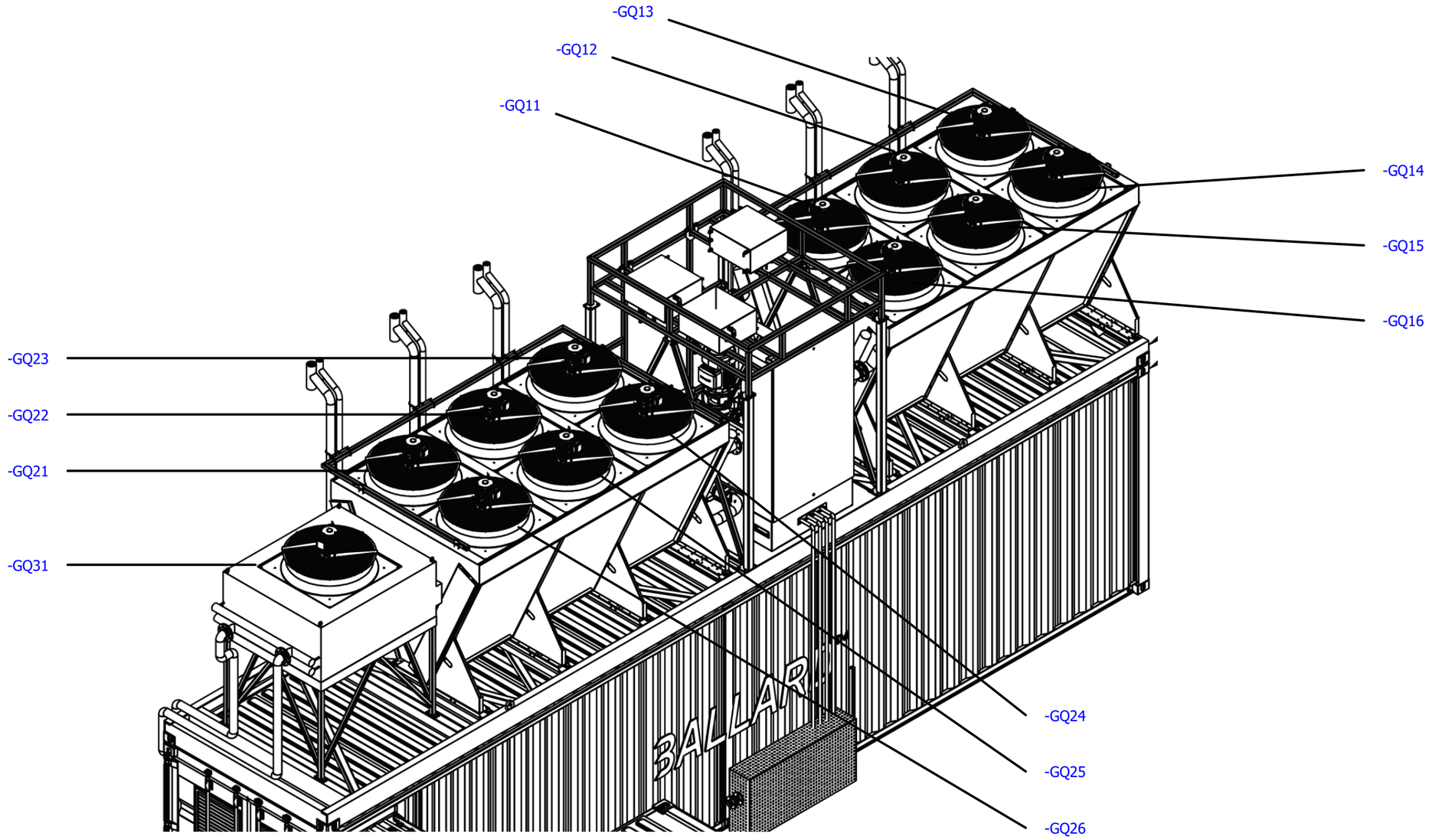
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Front Page		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 24 / 27

FRM5103656/0B

0	1	2	3	4	5	6	7	8



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C04

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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Fan Overview		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 25 / 27

FRM5103656/0B

Terminal-strip overview

F14_001

Terminal strip	Terminal strip definition text	Terminals					Graphical page of terminal diagrams
		first	last	Total PE	Total N	Total number	
=HE01-X01		1	PE	2	0	4	

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C04

REVISION INFORMATION	
DESCRIPTION	
DATE	
03-Sep-25	

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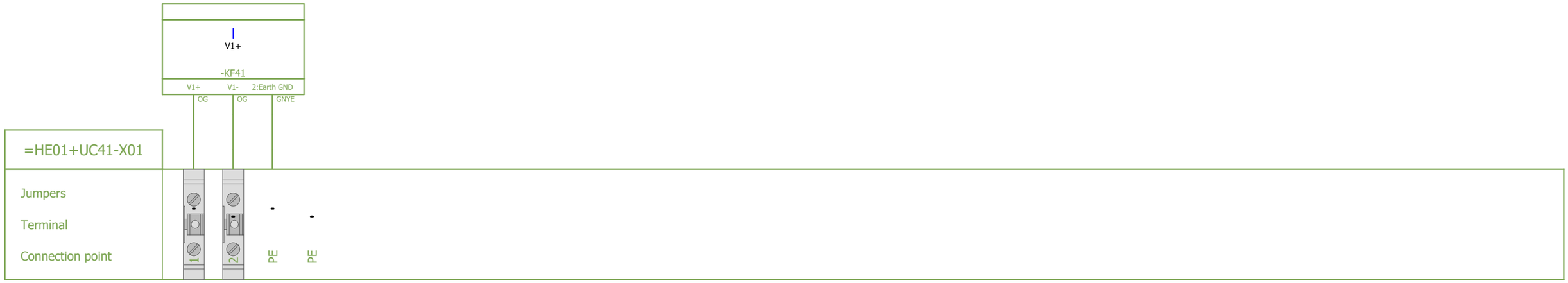
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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Terminal-strip overview : =HE01+UC41-X01 - =HE01+UC41-X01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 26 / 27

Terminal-connection diagram

F11_001
PETBLA 03-Sep-25

Internal targets



External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	629		
=	++	+ UC41	& C04

REVISION INFORMATION	
DESCRIPTION	
DATE	
03-Sep-25	

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DRAWING	K559-2254-CWIWP4202202-E03-005	REVISION	11
DRAWING TITLE	Crosswind UC41 Coolant Skid VFD Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =HE01+UC41-X01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 27 / 27

FRM5103656/0B

Sub Section E03-006

UC50 AC Power Distribution

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	28/03/2025	Update with network gateway PLC
003	28/10/2025	"reserved" empty page removed

Document Title:	**BLPH Project - Panel Cabinet Layout: UC50 AC Power Distribution**
Document Number:	K559-2254-CWIWP4202202-E03-006
Revision:	Rev003
Sequence Number:	006
File Name:	K559-2254-CWIWP4202202-E03-006Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BALLARD™

+UC50

Ballard Power Systems Europe - Technology Solutions

Cabinet: 40ft Container AC Distribution
Location: 40ft Container, next to access door

Vin = 400VAC, 3ph
Ikmax = 6kA - AC Supply
Ikmax

IP56

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& A01

REVISION INFORMATION
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DATE
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Front Page		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 28

Ballard Power Systems Europe - Technology Solutions, Cabinet Wiring Colors

Standard Basis: EN 61439

Required wire standard compliance:

Required: IEC Wire
Required: UL Recognized
Required: CSA/UL

Wire Numbering:

- Wires inside panels are to be numbered
- Wire number system is perferably "potential oriented with subnumber"
- All wires of the same potential (e.g. DC Common) have the same main number, with sequential subnumber.
- Potential numbers with fewer digits may be leading zero padded (e.g. 19 -> 019)
- Separator between main and subnumber is "."

Example: 019.1 BUWH 0.75mm²

- 019 — Wire potential number
- 1 — Wire sequential subnumber with separator
- BUWH — Wire color code (Dark Blue with White stripe)
- 0.75mm² — Wire dimension

AC Wiring Colors

AC Power Circuit (Generic)	———	Black (BK)
AC Phase L1	———	Brown (BN)
AC Phase L2	———	Black (BK)
AC Phase L3	———	Grey (GY)
AC Neutral	———	Light Blue (BU)
Externally supplied circuit	———	Orange (OG)

DC Wiring Colors

DC Power Circuit	———	Black (BK)
DC Control Voltage (24V)	———	Dark Blue (BU)
DC Control Voltage Refence (0V)	-·-·-·-	Dark Blue with White Stripe (BUWH)
Signal Wire (DI, DO)	———	White (WH)
Signal Wire (AI, AO)	———	Violet (VT)
Externally supplied circuit	———	Orange (OG)

PE Wiring Colors

Protective Earth (PE)	- - - - - - -	Green/Yellow (GNYE)

Conductor Colour Identification

IEC 60757:1983 Designation	Description
BK	Black
BN	Brown
RD	Red
OG	Orange
YE	Yellow
GN	Green
BU	Blue
VT	Violet
GY	Gray
WH	White
PK	Pink
GD	Gold
TQ	Turquoise
SR	Silver
GNYE	Green/Yellow
SH	Shield

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	11
EPLAN Project Pages	626
=	++ | + UC50 | & A01

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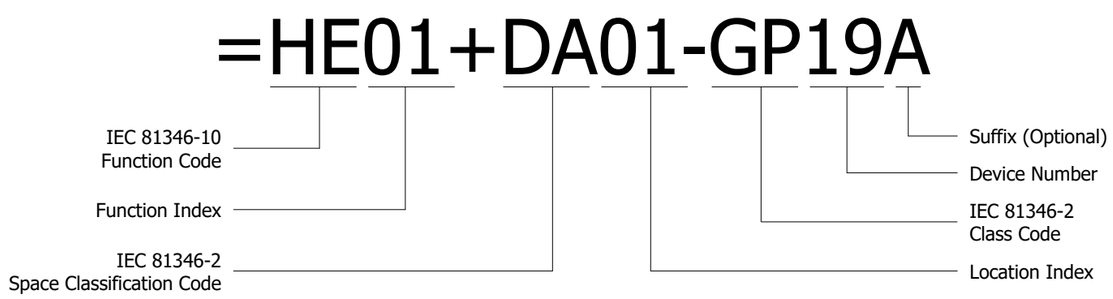
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Standard Wire Colors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 28

Ballard Power Systems Europe - Technology Solutions Device Tag Process

A Ballard Device Tagname consists of three parts:
- A function designation (=)
  - According to IEC81346-10, Table B.1 and B2.
  - Always two letters followed by two digits
- A location designation (+)
  - According to IEC81346-2, Table 4
  - Always two letters followed by two digits
- A class code (-)
  - According to IEC81346-2, Table 2
  - Always two letters followed by two or three digits plus optional suffix

Sample fully qualified Device Tag (DT) for a Coolant Pump



IEC81346-10 Function Examples

IEC 81346-10 Table B.1 and B.2 provide a class definition system, which provides a two letter code for the functional description
Table B.1 is used for power supply systems and table B.2 for other systems

IEC 81346-10 Table B.1 / B.2	Function Codes (Example)
=AA	Structural System, Load support (Frame)
=BA	Transporting Electrical Energy (Power Converters)
=HA	Supply System, Gaseous Matter (Gas Piping)
=HE	Supply System, Heating/Cooling (Radiator)
=JA	Distribution System, Gaseous Matter (Gas Handling Unit)
=JB	Distribution System, Liquid Matter (Fluid Drain)
=LA	Control System, Process (PLC, SCADA)
=LB	Control System, Safety (Safety PLC)
=QA	Storage System, Gaseous Matter (Gas Storage)
=RE	Energy Conversion System, Chemical to Electricity (Fuel cells, Batteries)

IEC81346-2 Space Classification

IEC 81346-2 Table 4 provide a classification scheme for spaces, which provides a two and three letter code for the space (location) classification.
Class code "1" and "1" is used for the location scheme

IEC 81346-2 Table 4	Location Codes (Example)
+GB	Space for power generation, Chemical (Fuel Cells)
+DA	Space for active technical equipment
+UC	Space for electrical equipment (Electrical Cabinet)

IEC81346-2 Class Code

IEC 81346-2 Class Codes is a scheme for defined objects for reference designations according to their inherent function

IEC 81346-2 Table 2	Class Codes (Example)
-BA	Sensing, electrical potential (Voltage Transducer)
-BC	Sensing, electrical current (Current Transducer)
-BP	Sensing, pressure (Pressure Transducer)
-BT	Sensing, temperature (Temperature Transducer)
-EA	Emitting, light (Light Fixture)
-FC	Protecting, overcurrent (Fuse, MCCB)
-GB	Generating, Chemical Reaction (Fuel Cell)
-GP	Generating, Liquid Flow (Pump)
-GQ	Generating, Gas Flow (Van, Ventilator)
-KE	Processing, Electrical signals (PLC)
-KF	Processing, Information (Network Switch)
-MA	Driving, Torque (AC Motor)
-QA	Controlling, Electric Current (Contactor, Motor Starter)
-QB	Controlling, Electric Separation (Disconnector)
-QM	Controlling, Fluid On/Off (Valve)
-QN	Controlling, Fluid Regulation (Damper, Gas Control Valve)
-WD	Guiding, Low Voltage Electric Energy (AC or DC power Cable)
-WE	Guiding, Reference Potential (Grounding Wire/Cable)
-WG	Guiding, Electric Signals (Control, Network Cable)

0	1	2	3	4	5	6	7	8

=LA01+UC50-KE07
DEIF AMC300
Controller Extension Rack

-Slot1
DEIF PSM3.2
Power Supply Module 3.2

PSM3.2

	PE PE		Frame Ground	
	1 12-24V		Supply +	
	2 0V		Supply COM	
	3 R1 COM		Status OK Relay COM	
A52.4	4 DO1	DO1	Status OK Relay	
	5 R2 COM		Relay 2 COM	
A52.5	6 DO2	DO2	Relay 1 Out	
	7 R3 COM		Relay 3 COM	
A52.6	8 DO3	DO3	Relay 3 Out	

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.10:E X03 — Ethernet-1 IN

EtherCAT Follower Ring Topology — EtherCAT +&C01/6.11:E X03 — Ethernet-2 OUT

Bus Follower
Multi-line 300

-Slot2
ACM3.1
Alternating Current Module 3.1

ACM3.1

1 L1	UC50_L1	Voltage measurement Nanogrid L1	
2 L2	UC50_L2	Voltage measurement Nanogrid L2	
3 L3	UC50_L3	Voltage measurement Nanogrid L3	
4 N	UC50_N	Voltage measurement Nanogrid N	
5 L1	UC50_L1'	Voltage measurement AUX L1	
6 L2	UC50_L2'	Voltage measurement AUX L2	
7 L3	UC50_L3'	Voltage measurement AUX L3	
8 N	UC50_N'	Voltage measurement AUX N	
9 L1-S1	UC50_BC01	Current measurement AUX L1	
10 L1-S2	CH1-S2	Channel 1 - S2	
11 L2-S1	UC50_BC02	Current measurement AUX L2	
12 L2-S2	CH2-S2	Channel 2 - S2	
13 L3-S1	UC50_BC03	Current measurement AUX L3	
14 L3-S2	CH3-S2	Channel 3 - S2	
15 4-S1	CH4-S1	Channel 4 - S1	
16 4-S2	CH4-S2	Channel 4 - S2	

-Slot3
&C03/19.1
IOM3.2
IO Module 3.2

IOM3.2

1 R1 COM			Relay 1 In
2 DO1			Relay 1 out
3 R2 COM			Relay 2 COM
4 DO2			Relay 2 Out
5 R3 COM			Relay 3 In
6 DO3			Relay 3 Out
7 R4 COM			Relay 4 In
8 DO4			Relay 4 Out
9 AO1	&C03/19.1	JA01_QM05.SP	Ventilation Outlet C Damper Postion SP
10 AO1 COM			AO1 COM
11 AO2	&C03/19.5	JA01_QM06.SP	Ventilation Outlet D Damper Postion SP
12 AO2 COM			AO2 COM
13 AO3		HE03_QN01.SP	LT Mixing valve SP
14 AO3	&C03/19.2		AO3 COM
15 AO4			Spare
16 AO4	&C03/19.5		AO4 COM
17 DI1			Spare
18 DI2			Spare
19 DI3			Spare
20 DI4			Spare
21 DI1-4 COM			DI1-4 COM
22 AI1	&C03/19.2	JA01_QM05.FB	Ventilation Outlet C Damper Postion FB
23 AI1 COM			AI1 COM
24 AI2	&C03/19.6	JA01_QM06.FB	Ventilation Outlet D Damper Postion FB
25 AI2 COM			AI2 COM
26 AI3			Spare
27 AI3 COM		HE03_QN01.FB	LT Mixing valve feedback
28 AI4			Spare
29 AI4 COM	&C08/19.6		AI4 COM

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C02

REVISION INFORMATION
DESCRIPTION
DATE
28-Oct-25

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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Container Controller, Coolant Rack 1/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 4 / 28

0	1	2	3	4	5	6	7	8

=LA01+UC50-KE07
DEIF AMC300
Controller Extension Rack

-Slot4
IOM3.4
IO Module 3.4

IOM3.4

	1 12-24V			Supply +
	2 DO01	+CU50_KF01	Control Nanogrid supply	
	3 DO02	+CU50_KF02	AUX Nanogrid supply	
A3.0	4 DO03	DO03	Digital Out 03	
A3.1	5 DO04	DO04	Digital Out 04	
A3.2	6 DO05	DO05	Digital Out 05	
A3.3	7 DO06	DO06	Digital Out 06	
A3.4	8 DO07	DO07	Digital Out 07	
A3.5	9 DO08	DO08	Digital Out 08	
A3.6	10 DO09	DO09	Digital Out 09	
A3.7	11 DO10	DO10	Digital Out 10	
A4.0	12 DO11	DO11	Digital Out 11	
A4.1	13 DO12	DO12	Digital Out 12	
	14 COM		Supply COM	
	15 DI01	+UC50_FC01	Nanogrid MCCB feedback	
	16 DI02	+UC50_FC02	AUX Supply MCCB feedback	
	17 DI03	+UC50_QA01	Nanogrid contactor QA01 feedback	
	18 DI04	+UC50_QA02	AUX Contactor QA02 feedback	
	19 DI05	+UC50_FC03 - 05	Distribution MCB feedback	
	20 DI06	+UC50_13 - 14	Control MCB feedback	
	21 DI07	+UC50_FC10	Nanogrid measurement MCB feedback	
	22 DI08	+UC50_FC11	AUX measurement MCB feedback	
	23 COM		Supply COM	
	24 DI09	+UC50_FC12	Surge protection MCB feedback	
	25 DI10	+UC50_FA	Surge protection feedback	
E7.7	26 DI11	DI11	Digital In 11	
E8.0	27 DI12	DI12	Digital In 12	
E8.1	28 DI13	DI13	Digital In 13	
E8.2	29 DI14	DI14	Digital In 14	
E8.3	30 DI15	DI15	Digital In 15	
E8.4	31 DI16	DI16	Digital In 16	
	32 COM		Supply COM	

-Slot5
IOM3.3
IO Module 3.3

IOM3.3

1 AI1		Spare
2 AI2	HE03_FT01	LT Cooling Circuit Flow Rate
3 AI3		Spare
4 AI4		Spare
5 AI5	HE03_TT02	LT Circuit Forward Temperature
6 AI6		Spare
7 AI7	HE03_TT01	LT Circuit Return Temperature
8 AI3		Spare
9 AI9		Spare
10 AI10	HE03_TT03	LT Circuit Radiator Outlet Temperature
11 AI11		Spare
12 AI12		Spare
13 AI13		Spare
14 AI14		Spare
15 AI15		Spare
16 AI16		Spare
17 AI17		Spare
18 AI18		Spare
19 AI19		Spare
20 AI20		Spare
21 AI21		Spare
22 AI22		Spare
23 AI23		Spare
24 AI24		Spare
25 AI25		Spare
26 AI26		Spare
27 AI27		Spare
28 AI28		Spare
29 AI29		Spare
30 AI30		Spare

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Container Controller, Coolant Rack 2/2		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 5 / 28

0	1	2	3	4	5	6	7	8

=LA01-KE10
DEIF AMC300
Network Separation PLC

-Slot1
DEIF PSM3.1
Power Supply
Module 3.1

PSM3.1

PE PE &C03/21.1 — Frame Ground
1 12&24V &C03/21.1 — Supply +
2 0V &C03/21.1 — Supply COM

3 R1 COM — Status OK Relay COM
A1.0 4 DO1 — DO1 — Status OK Relay

5 R2 COM — Relay 2 COM
A1.1 6 DO2 — DO2 — Relay 1 Out

7 R3 COM — Relay 3 COM
A1.2 8 DO3 — DO3 — Relay 3 Out

Note: Slot 2 and 3: Blanking plates

EtherCAT Master Ring Topology — Other bus systems X03 — Ethernet-1 IN

EtherCAT Master Ring Topology — Other bus systems X03 — Ethernet-2 OUT

Bus Master
Multi-line 300

-Slot4
DEIF PCM3.3
Processor and
Communication
Module 3.3
&C03/21.3

PCM3.3

X01 RS-483/232 — 1 2 3 4 5 6 7 8
X02 CAN-A / CAN-B — 9 10 11 12 13 14
X03 CAN-C / CAN-D — 15 16 17 18 19 20

ETH1 Other bus systems X04 — Ethernet-1 1
ETH1 Other bus systems &C03/21.4 X02 — Ethernet-3 1
ETH1 Other bus systems &C03/21.4 X02 — Ethernet-3 1
AGI Screen Connection Other bus systems X03 — Ethernet-4 1
ETH04 Other bus systems X04 — Ethernet-5 1

CPU
Multi-line 300

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Network Gateway, Rack 1/1		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 6 / 28

0	1	2	3	4	5	6	7	8

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Ballard Power Systems Europe - Technology Solutions

Multiline Documentation

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Multiline Documentation Intro		

ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 7 / 28

=BA20

L1 / 9.0
L2 / 9.0
L3 / 9.0
N / 9.0
PE / 9.0
-FC01.L1 / 12.1
FC01.N / 12.1

-QA01
/12.2
350A, 690V
MV Supply Isolator

-FC01
/14.1
MCCB - MV Supply

1SDA075465R1
XT4L 250 Ekip LSI In=250A 4p F F UL/CSA

Ekip LSI
K51
I>>>
I>
I>>
I>>
Y01

-FC10
/14.5
2A, C-curve
MCCB - MV Supply
Voltage Measurement

X01 1 X01 2 3 4
L1 L2 L3 N
-KE06-Slot2
UC50_L2
MV Supply L2

-X01 1 2 3

>=BA20+DA01-TA01.L1
>=BA20+DA01-TA01.L2
>=BA20+DA01-TA01.L3
>=BA20+DA01-TA01.N
>=BA20+DA01-TA01.PE

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C03

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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - AC distrbution Nanogrid supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 8 / 28

0	1	2	3	4	5	6	7	8

=BA20

8.8 / L1 → L1 / 11.0
8.8 / L2 → L2 / 11.0
8.8 / L3 → L3 / 11.0
8.8 / N → N / 11.0
8.8 / PE → PE / 10.0

-QA02
/12.4
55A, 4-pole
AUX Isolation Contactor
1 3 5 7
2 4 6 8

-FC02.L1 / 12.4
FC02.N / 12.4

-BC01
/9.1
/9.1
1
2

-BC02
+&C01/2.3:B
1
2

-BC03
/9.1
/9.1
1
2

X03 9	L1-S1	-KE06-Slot2	
		UC50_BC01	
10	L1-S2	Current measurement AUX L1	
X03 11	L2-S1	-KE06-Slot2	
		UC50_BC02	
12	L2-S2	Current measurement AUX L2	
X03 13	L3-S1	-KE06-Slot2	
		UC50_BC03	
14	L3-S2	Current measurement AUX L3	

PE

-FC11
/14.6
2A, C-curve
MCCB - Aux Voltage Measurement
1 3 5 7
2 4 6 8

X02 5 6 7 8
L1 L2 L3 N

-KE06-Slot2
UC50_L2'
Voltage measurement AUX L2

-FC02
/14.2
63A, C-curve
MCCB - Aux Supply
1 3 5 7
2 4 6 8

EXT-L1 EXT-L2 EXT-L3 EXT-N

-SG01
63 A
AUX Supply Disconnector
L1 1 | L2 3 | L3 5 | L4 (N)7
2 T1 | 4 T2 | 6 T3 | (N)8 T4

EXT-L1 EXT-L2 EXT-L3 EXT-N EXT-PE

EXT-L1 EXT-L2 EXT-L3 EXT-N

2L1 / 10.0
2L2 / 10.0
2L3 / 10.0
2N / 10.0

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C03

REVISION INFORMATION
DESCRIPTION
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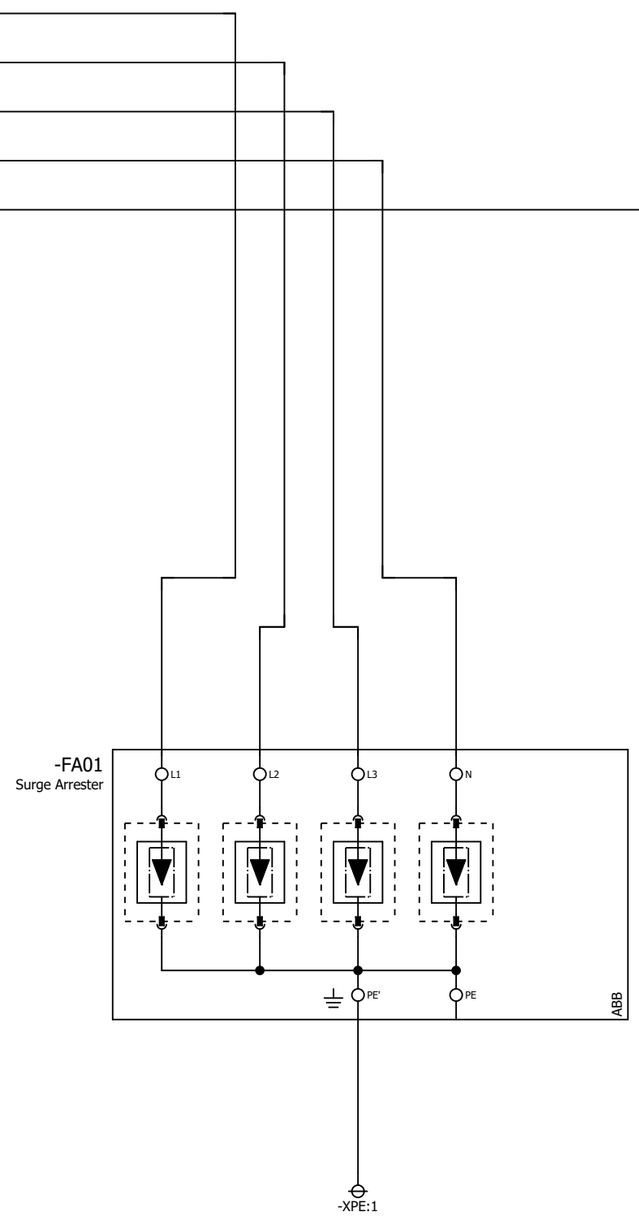
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - AC distrbution Nanogrid supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 9 / 28

0	1	2	3	4	5	6	7	8

=BA20

9.8 / 2L1
9.8 / 2L2
9.8 / 2L3
9.8 / 2N
9.8 / PE



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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DRAWING	601456B UC50 AC Distribution Cabinet		REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet			
SHEET TYPE/DESC	40ft Container - AC distrbution Surge Protection			
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	10 / 28

0	1	2	3	4	5	6	7	8

=BA20

9.8 / L1
9.8 / L2
9.8 / L3
9.8 / N
11.8 / PE

L1 /
L2 /
L3 /
N /
PE / 11.0

-FC04
/14.3
160A, Trip Curve
MCCB Cooling Skid
+UC30

1 3 5 7

Ekip LSI
K51

I> I> I> I>
I>> I>> I>> I>>

I>>>
I>
I>>
I>>

Y01

2 4 6 8

-FC03
/14.3
63A, B-curve
MCCB Control Cabinet
+UC20

1 3 5 7
2 4 6 8

>=LA01+UC20-WD01
ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV
5x16
0,6/1,0 kV
Supply UC20 MCU cabinet

1 2 3 4 GNYE
1 2 3 4 GNYE

+UC20/19.1 / >=LA01+UC20-WD01

-FC05
/14.3
32A, B-curve
MCCB - 10ft Container

1 3 5 7
2 4 6 8

PE

>+UC31-WD01
ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV
5x6
0,6/1,0 kV
Supply +UC31 10ft Cabinet

1 2 3 4 GNGY
1 2 3 4 GNYE

>=LA01+UC31-WD01 / +UC31/14.0

+UC30/13.1 / >=BA20+UC30-L1
+UC30/13.1 / >=BA20+UC30-L2
+UC30/13.1 / >=BA20+UC30-L3
+UC30/13.1 / >=BA20+UC30-N
+UC30/13.1 / >=BA20+UC30-PE

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
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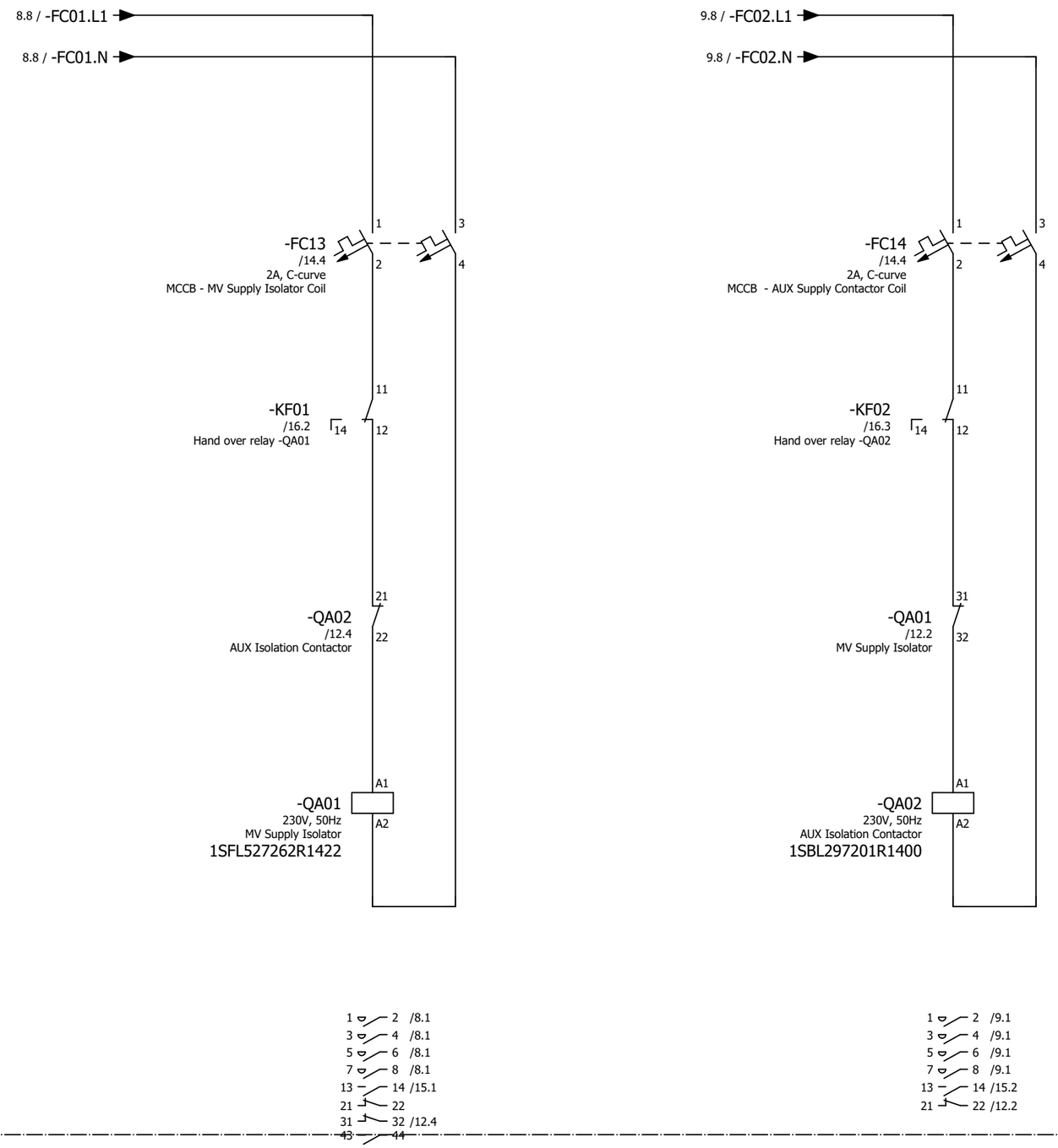
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - AC distrbution Nanogrid		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 11 / 28

0	1	2	3	4	5	6	7	8

=BA20



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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EPLAN Project Pages	626		
=	++	+ UC50	& C03

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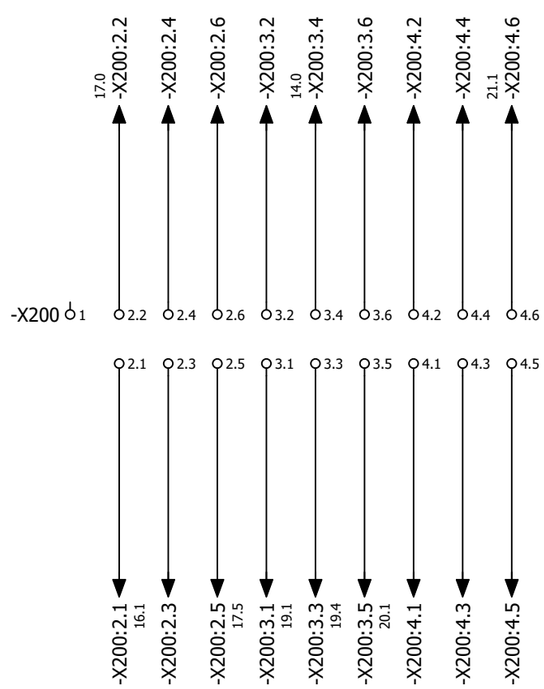
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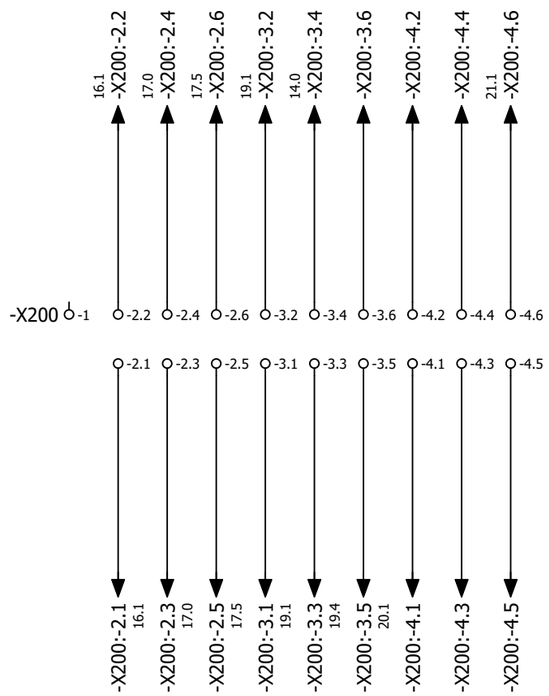
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - AC distrbution Control -QA01 & -QA02		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 12 / 28

0	1	2	3	4	5	6	7	8

=BA20





Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C03

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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - AC distribution - 24VDC		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 13 / 28

=BA20

MCCB Feedback - MV Supply FC01	MCCB Feedback - AUX Supply	MCCB Feedback - Control Cabinets Supply	MCCB Feedback - Contactor Supply	MCCB Feedback - MV Supply Measurement	MCCB Feedback - AUX Supply Measurement
+UC50_FC01	+UC50_FC02	+UC50_FC03 - 05	+UC50_13 - 14	+UC50_FC10	+UC50_FC11
-KE06-Slot4					
DI01	DI02	DI05	DI06	DI07	DI08
X02 15	16	19	20	21	22

-KE06-Slot4:
X2
23 COM
Supply com

-FC05 /11.6 MCCB - 10ft Container — 12 14 / 11
-FC04 /11.3 MCCB Cooling Skid +UC30 — 12 14 / 11
-FC14 /12.4 MCCB - AUX Supply Contactor Coil — 12 14 / 11
-FC01 /8.0 MCCB - MV Supply — 14 / 11
-FC02 /9.1 MCCB - Aux Supply — 12 14 / 11
-FC03 /11.1 MCCB Control Cabinet +UC20 — 12 14 / 11
-FC13 /12.2 MCCB - MV Supply Contactor Coil — 12 14 / 11
-FC10 /8.4 MCCB - MV Supply Voltage Measurement — 12 14 / 11
-FC11 /9.6 MCCB - Aux Voltage Measurement — 12 14 / 11

13.2 / -X200:3.4 →
13.4 / -X200:-3.4 →
→ -X200:3.4 / 15.0
→ -X200:-3.4 / 15.0

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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=	++	+ UC50	& C03

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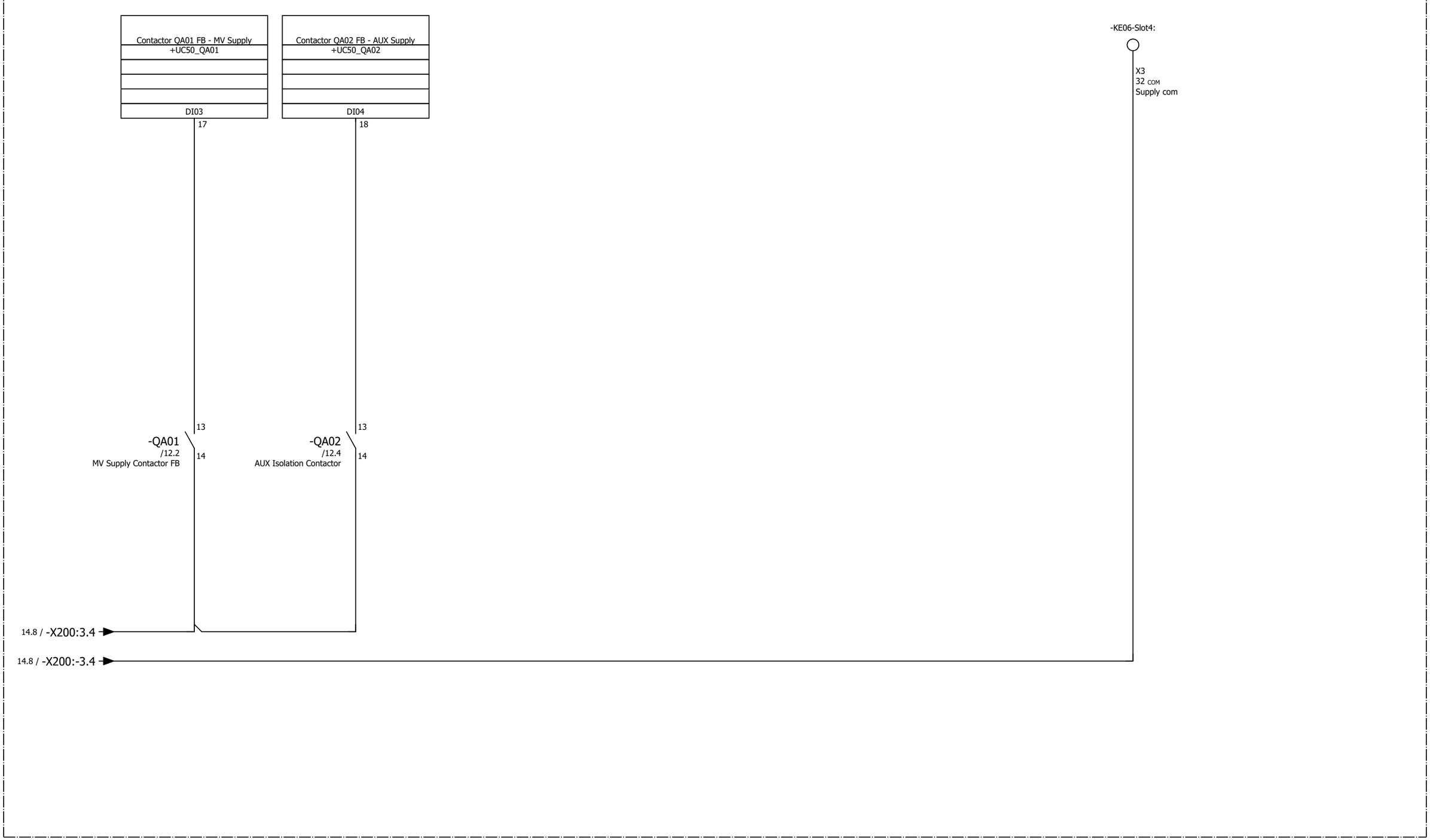
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - MCCB Feedback		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 14 / 28

=BA20



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
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=	++	+ UC50	& C03

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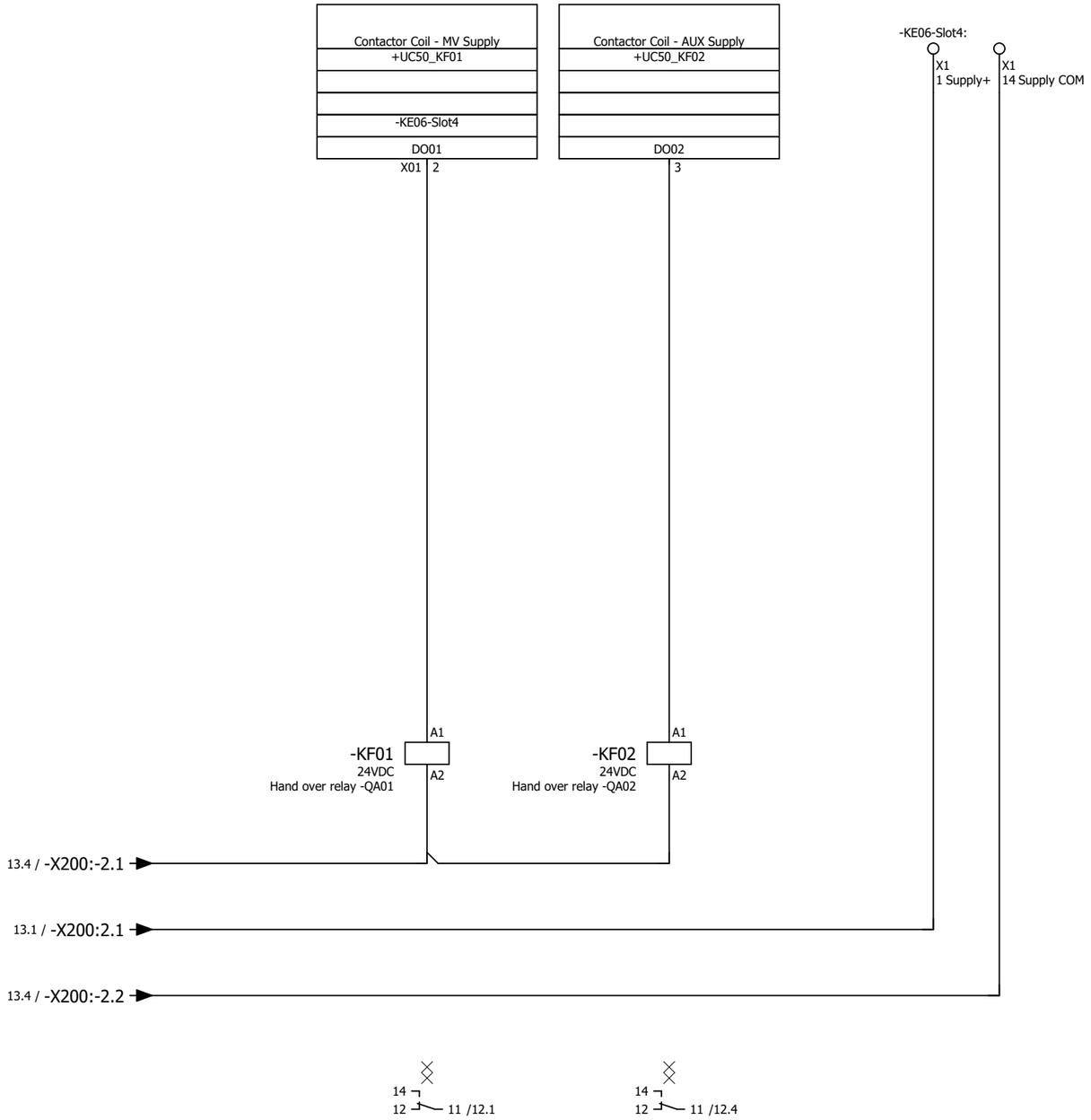
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - Contactor Feedback		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 15 / 28

0	1	2	3	4	5	6	7	8

=BA20



Reference Item Number	Ballard Part # TBD		
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=	++	+ UC50	& C03

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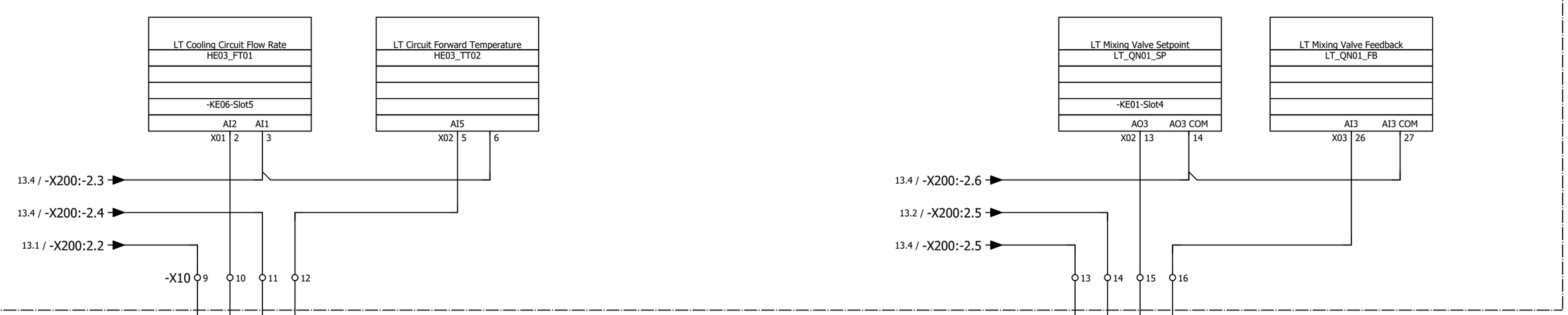
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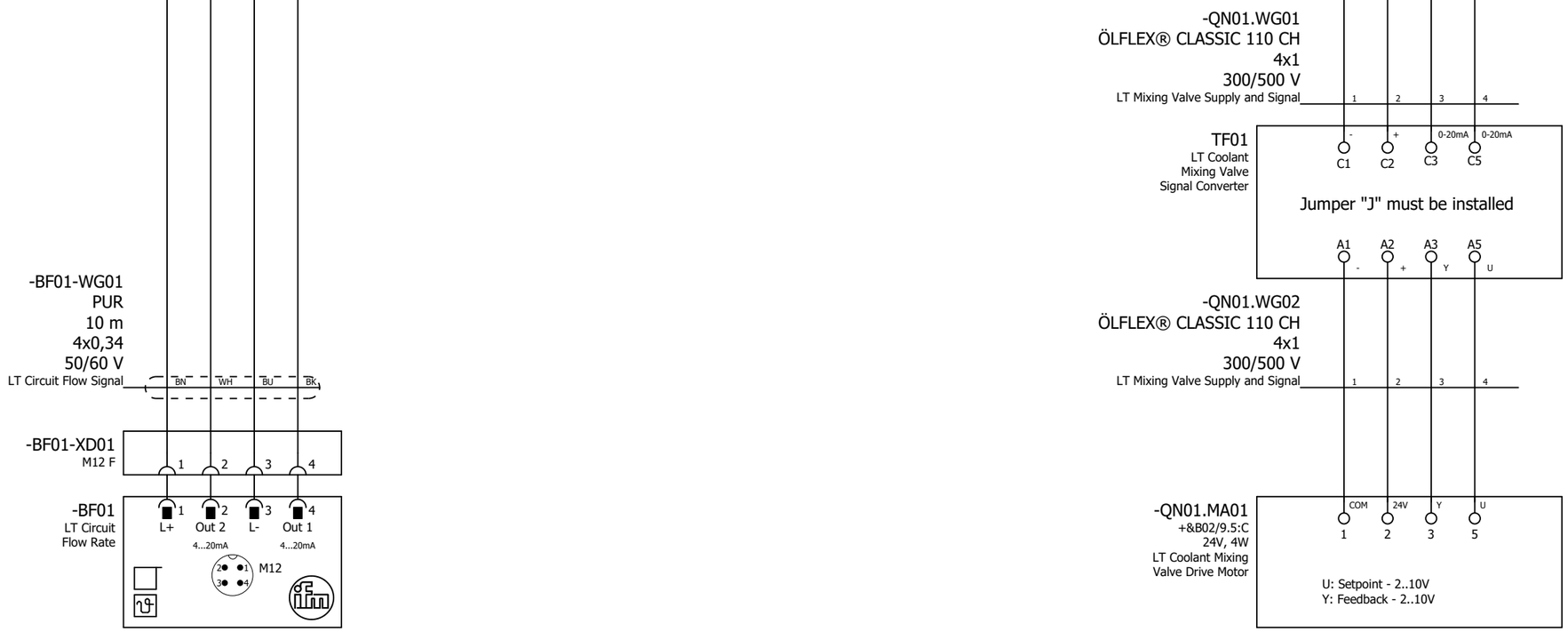
DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - Contactor Coils		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 16 / 28

0	1	2	3	4	5	6	7	8

=BA20



=HE03+DA01



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=	++	+ UC50	& C03

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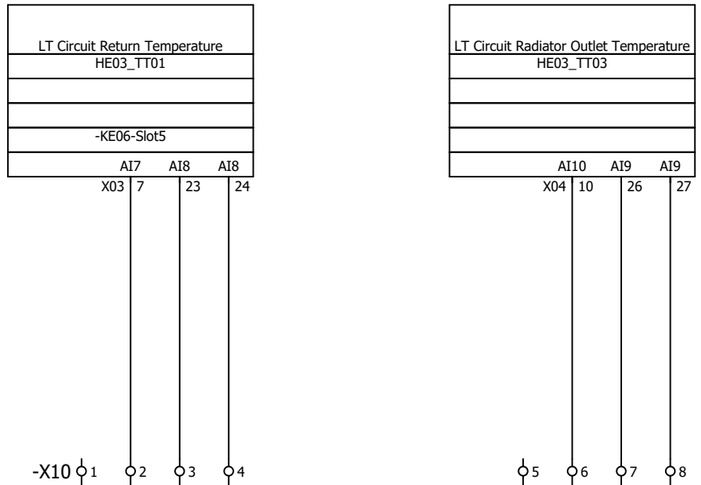
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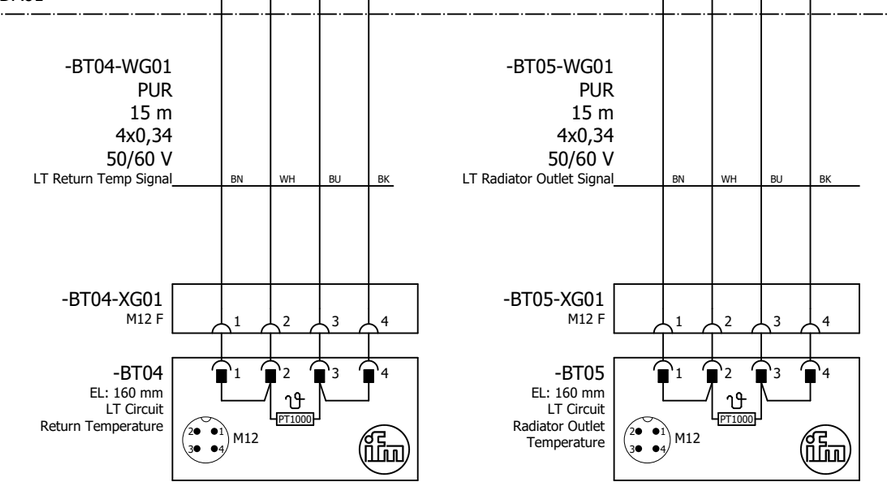
DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - LT Cooling System		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 17 / 28

0	1	2	3	4	5	6	7	8

=BA20



=HE03+DA01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
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=	++	+ UC50	& C03

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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - LT Cooling System		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 18 / 28

0	1	2	3	4	5	6	7	8

=BA20
Container Control System, Container #1 Inside

Ventilation Outlet C Damper Postion SP
JA01_QM05.SP
&C02/4.6
>=LA01-KE07-Slot3
AO1 AO3 COM
X02 9 14

Ventilation Outlet C Damper Postion FB
JA01_QM05.FB
&C02/4.6
AI1 AI3 COM
X03 22 27

Ventilation Outlet D Damper Postion SP
JA01_QM06.SP
&C02/4.6
AO2 AO4 COM
X02 11 16

Ventilation Outlet D Damper Postion FB
JA01_QM06.FB
&C02/4.6
AI2 AI2 COM
X03 24 29

13.4 / -X200:-3.2

13.2 / -X200:3.1
13.4 / -X200:-3.1
-X11 1 2 3 4

13.2 / -X200:3.3
13.4 / -X200:-3.3
5 6 7 8

=JA01+DA01
Ventilation System, Container #1 Inside

-QM05-WD01
+UC20/94.1
ÖLFLEX® CLASSIC 135 CH
4x1
300/500 V
Ventilation Outlet Louvre B1
1 2 3 4

-QM06-WD01
+UC20/94.4
ÖLFLEX® CLASSIC 135 CH
4x1
300/500 V
Ventilation Outlet Louvre B2
1 2 3 4

-AC05
+UC20/94.1
QM05 Junction Box
1 2 3 4

-AC06
+UC20/94.4
QM06 Junction Box
1 2 3 4

-QM05-WD02
4x19
300
Ventilation Outlet Louvre B1
BK RD WH OR

-QM06-WD02
4x19
300
Ventilation Outlet Louvre B2
BK RD WH OR

-QM05.MA01
24V, 4W
Louvre Drive Motor B1
COM 24V Y U
1 2 3 5
U: Setpoint - 2..10V
Y: Feedback - 2..10V

-QM06.MA01
24V, 4W
Louvre Drive Motor B2
COM 24V Y U
1 2 3 5
U: Setpoint - 2..10V
Y: Feedback - 2..10V

Reference Item Number	Ballard Part # TBD		
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=	++	+ UC50	& C03

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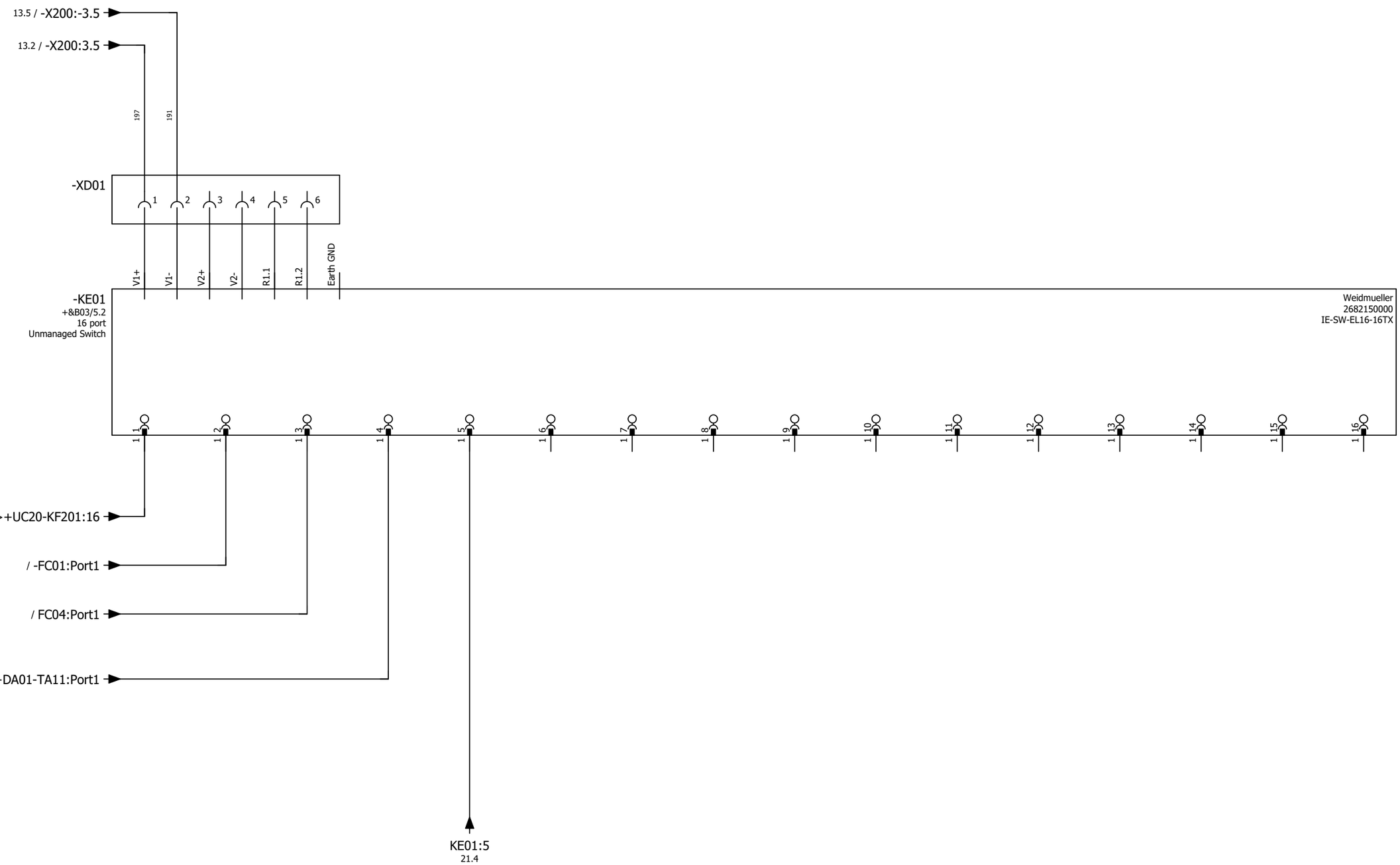
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - Container Exhaust Louvre B		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 19 / 28

0	1	2	3	4	5	6	7	8

=BA20
40ft Container - AUX distribution



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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container AUX distribution - Newtwork switch		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 20 / 28

0	1	2	3	4	5	6	7	8

=BA20
40ft Container - AUX distribution

20.3
KE01:5

>=LA01-KE10-Slot1
DEIF PSM3.1
Power Supply
Module 3.1

Supply +
&C02/6.1
1
12-24V

Supply COM
&C02/6.1
2
0V

Frame Ground
&C02/6.1
PE
PE

>=LA01-KE10-Slot4
&C02/6.5
DEIF PCM3.3
Processor and
Communication
Module 3.3

1
Top side of card
X02
Other bus systems
&C02/6.5
&C02/6.5

Other bus systems
X03
Bottom side of card
3

Connected to RM network cable - See sheet &B03:5

13.3
-X200:4.6

13.5
-X200:-4.6

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C03

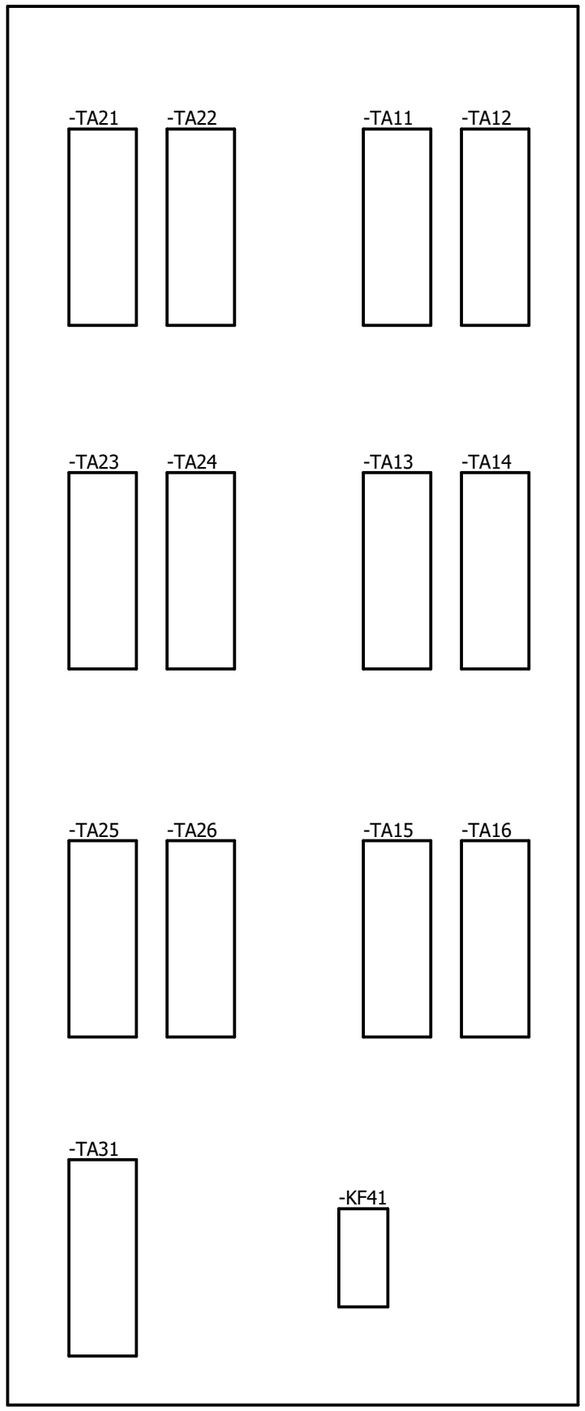
REVISION INFORMATION
DESCRIPTION
DATE
28-Oct-25

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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	40ft Container - Gateway PLC		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 21 / 28



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C04

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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Front Page		

ALL SHEETS ARE THE SAME REVISION STATUS | SIZE A3 | LANGUAGE EN | SHEET/TOTAL 22 / 28

Terminal-strip overview

F14_001

Terminal strip	Terminal strip definition text	Terminals					Graphical page of terminal diagrams
		first	last	Total PE	Total N	Total number	
=BA20-X01		1	3	0	0	3	
=BA20-X10		1	16	0	0	20	
=BA20-X11		1	8	0	0	10	
=BA20-X200		1	4.6	0	0	22	
=BA20-XB01		1	1	0	0	1	

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C04

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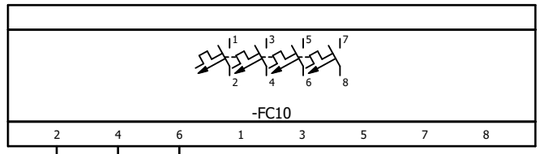
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Terminal-strip overview : =BA20+UC50-X01 - =BA20+UC50-XB01		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 23 / 28

Terminal-connection diagram

F11_001
PETBLA 28-Oct-25

Internal targets



=BA20+UC50-X01

Jumpers

Terminal

Connection point

External targets

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C04

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DESCRIPTION
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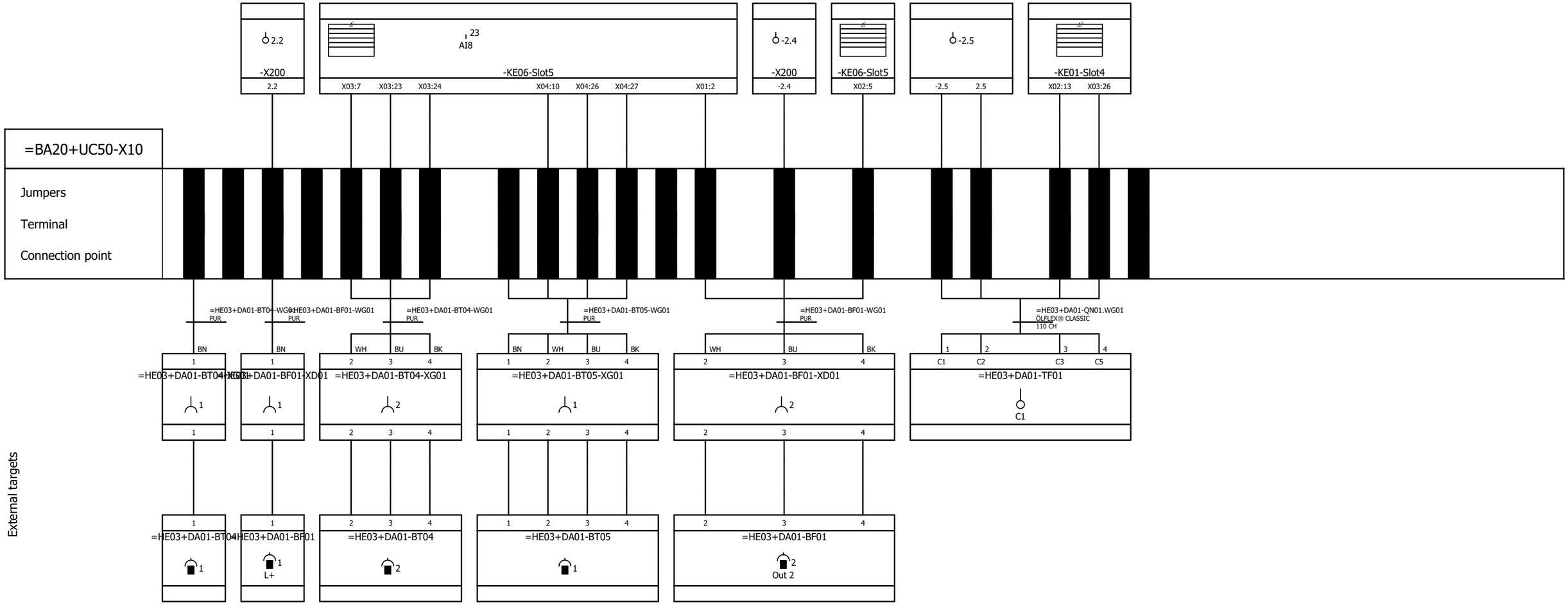
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DRAWING	601456B UC50 AC Distribution Cabinet		REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet			
SHEET TYPE/DESC	Terminal-connection diagram =BA20+UC50-X01			
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	24 / 28

Terminal-connection diagram

F11_001
PETBLA 28-Oct-25

Internal targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C04

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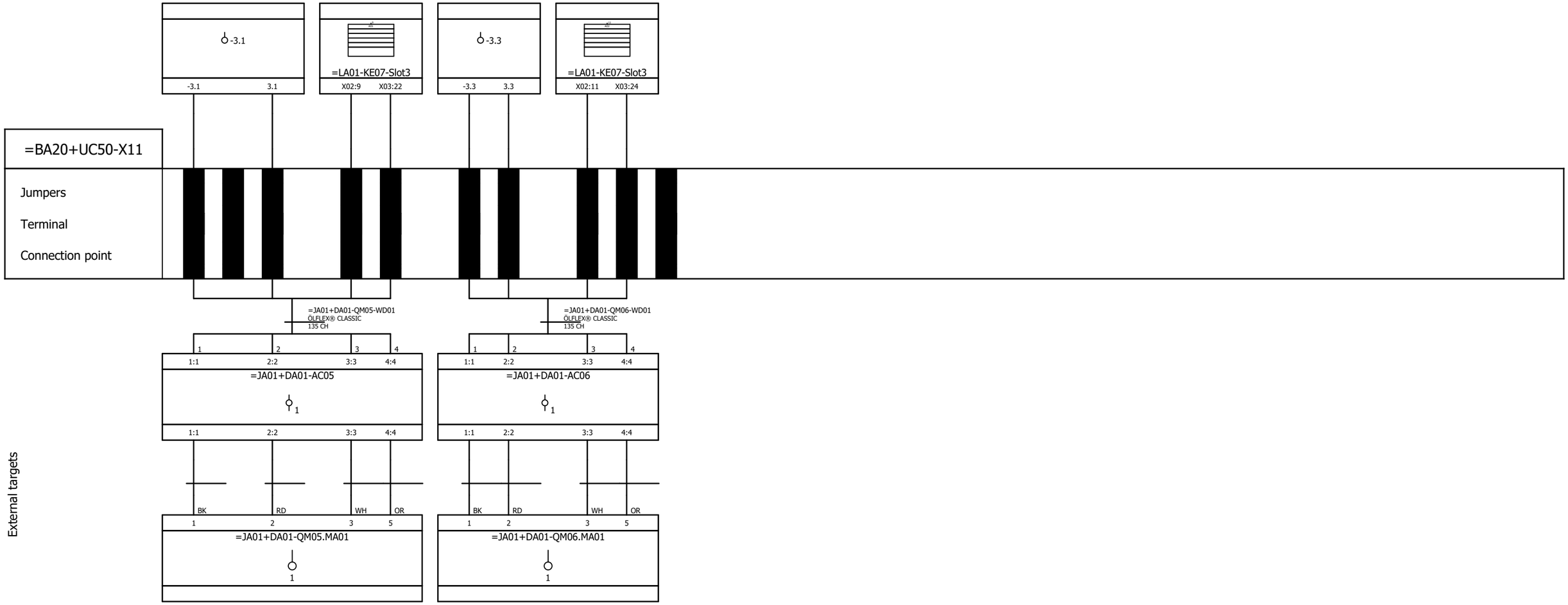
DRAWING	601456B UC50 AC Distribution Cabinet		REVISION	11	
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet				
SHEET TYPE/DESC	Terminal-connection diagram =BA20+UC50-X10				
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL	25 / 28	

Terminal-connection diagram

F11_001
PETBLA 28-Oct-25

Internal targets

External targets



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	11		
EPLAN Project Pages	626		
=	++	+ UC50	& C04

REVISION INFORMATION
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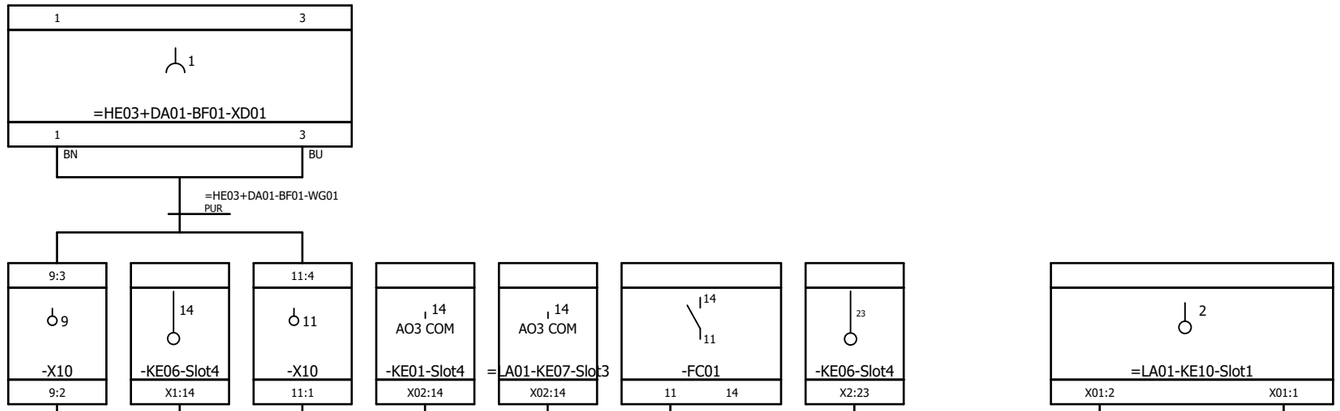
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DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
SHEET TYPE/DESC	Terminal-connection diagram =BA20+UC50-X11		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 26 / 28

Terminal-connection diagram

F11_001
PETBLA 28-Oct-25

Internal targets



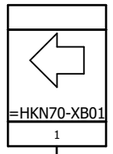
=BA20+UC50-X200

| | | |

Terminal-connection diagram

F11_001
PETBLA 28-Oct-25

Internal targets



=BA20+UC50-XB01	
Jumpers	
Terminal	
Connection point	1

External targets

Reference Item Number	Ballard Part # TBD			REVISION INFORMATION	THIS DOCUMENT, SUBMITTED IN CONFIDENCE, CONTAINS PROPRIETARY INFORMATION WHICH SHALL NOT BE REPRODUCED OR TRANSFERRED TO OTHER DOCUMENTS OR DISCLOSED TO OTHERS OR USED FOR MANUFACTURING OR ANY OTHER PURPOSE WITHOUT PRIOR WRITTEN PERMISSION OF BALLARD POWER SYSTEMS INC. OR A RELATED WHOLLY-OWNED SUBSIDIARY OR AFFILIATE.	BALLARD™ CONFIDENTIAL	DRAWING	601456B UC50 AC Distribution Cabinet	REVISION	11
EPLAN Project Name	601456B - Shell Baseload Power Hub			DESCRIPTION		THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM	DRAWING TITLE	Crosswind UC50 AC Distribution Cabinet		
EPLAN Revision	11						SHEET TYPE/DESC	Terminal-connection diagram =BA20+UC50-XB01		
EPLAN Project Pages	626			DATE			ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 28 / 28
=	++	+ UC50	& C04	28-Oct-25						

FRM5103656/0B

Sub Section E03-007

Electrical Interface RM

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	05/07/2024	First Issue
002	28/03/2025	Update after Comms Testing
003	28/03/2025	Reupload with cover page

Document Title:	**BLPH Project - Electrical Interface Documentation**
Document Number:	K559-2254-CWIWP4202202-E03-007
Revision:	Rev003
Sequence Number:	007
File Name:	K559-2254-CWIWP4202202-E03-007Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Electrical Interface Documentation for Rosetti Marino

Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	628		
=	++	+	& B03

REVISION INFORMATION
DESCRIPTION
DATE
05-Jul-24

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DRAWING	E03-007 Electrical Interfaces to RM	REVISION	06
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Electrical Interface Documentation Introduction		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 12

Electrical Interface - 6,6kV

Location: 10ft Container, Side Entry

Responsibility matrix: K559-2254-SWIWP4202202-E99-003Rev001

=BA30+DA03
Power Output, 10ft Container

-TA30
1250kVA
400/6600V Transformer
Dry-type

2W 2V 2U

1U 1V 1W

Ballard Scope
Rosetti Marino Scope

=HKN70
RM Scope

Ballard provides bulkhead plate

-X01
70mm2, M12
Angled Cable Lug

-X02
70mm2, M12
Angled Cable Lug

-X03
70mm2, M12
Angled Cable Lug

-82003-CEM-1-L1
LSZH
1x70
6,6kV

-82003-CEM-1-L2
LSZH
1x70
6,6kV

-82003-CEM-1-L3
LSZH
1x70
6,6kV

-82003-CEM-1-L1
6,6kV MV Power

-82003-CEM-1-L2
6,6kV MV Power

-82003-CEM-1-L3
6,6kV MV Power

SG-100D1

RM Information taken from "123A90-DDL-EL-LIS-20148_CPI"

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	06
EPLAN Project Pages	628
=	++ | + | & B03

REVISION INFORMATION
DESCRIPTION
DATE
29-Nov-24

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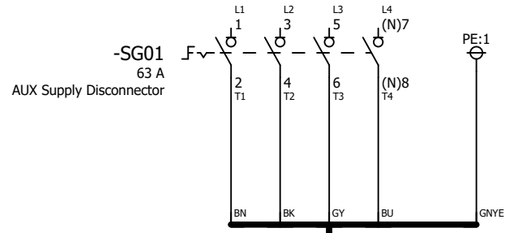
DRAWING	E03-007 Electrical Interfaces to RM	REVISION	06
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Electrical Interface - 6,6kV Connection		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 12

Electrical Interface - AUX Connection

Location: 40ft Container, Upper Left Corner

Responsibility matrix: K559-2254-SWIWP4202202-E99-003Rev001

=BA20+UC50
AC Distribution Cabinet, Inside 40ft Container



Cable length: 12 meters from interface point

Ballard Scope
Rosetti Marino Scope

=HKN70
RM Scope

-83012-CEL
LSZH
5x16
400V
Fuel Cell Auxillary Load

83012-CEL
AUX Power Supply

SG-200N1

RM Information taken from "123A90-DDL-EL-LIS-20148_CPI"

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	628		
=	++	+	& B03

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DRAWING	E03-007 Electrical Interfaces to RM	REVISION	06
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Electrical Interface - AUX Supply		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 3 / 12

Electrical Interface - Safety Connections

Location: 40ft Container,Top Side Entry

Responsibility matrix: K559-2254-SWIWP4202202-E99-003Rev001

=LB02+UC20
Control Cabinet, 40ft Container Inside

To Safety Control System

-KF52
24VDC
Customer Safety Input Relay

A1
A2

-R01
120 Ohm, 0,5W
Wire break
resistor
RM Scope

-KF51
+UC20&C03/55.6
Fire Detection
23
24
5
6

-KF53
+UC20&C03/55.7
Hydrogen Detection
23
24
7
8

-KF50
+UC20&C03/55.5
Safety Status
23
24
33
34
-X101
9
10
11
12

Cable length: 12 meters from interface point

Ballard Scope
Rosetti Marino Scope

>=EXT+
Customer Scope

C-80-XS-001
2x2.5
C-80-XS-001
1 2,5
2 2,5
4.1
4.1

C-80-XS-001 / B400-SIS-001

80-UCP-001
2x2x2.5
80-UCP-001
1 WH 2,5
2 WH 2,5
1 BK 2,5
2 BK 2,5
4.4
4.3
4.4
4.4

80-UCP-001 / B400-FGS-002

C-80-XA-003
1x2x2.5
C-80-XA-002
1 WH 2,5
1 BK 2,5
4.6
4.6

C-80-XA-003 / B400-SES-001

23 — 24 +UC20&C03/55.2
33 — 34 +UC20&C03/55.3

Expected behaviour:
- Conductor 1 24VDC, Conductor 2 0V - Safety OK, Relay ON
- Conductor 1 0V, Conductor 2 0V - Safety NOT OK, Relay OFF

KF51 Indicates Fire detection
KF53 Indicated Gas detection
Implemented with safety rated relay
- De-energized contacts (as shown): No Fire / Gas detection
- Energized contacts (opposite shown): Confirmed Fire/Gas

KF50 Indicates System Emergency Status
Implemented with safety rated relay
- Closed Contacts: FC Package OK
- Open Contacts: FC Package Safety Trip

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	628		
=	++	+	& B03

REVISION INFORMATION
DESCRIPTION
DATE
28-Mar-25

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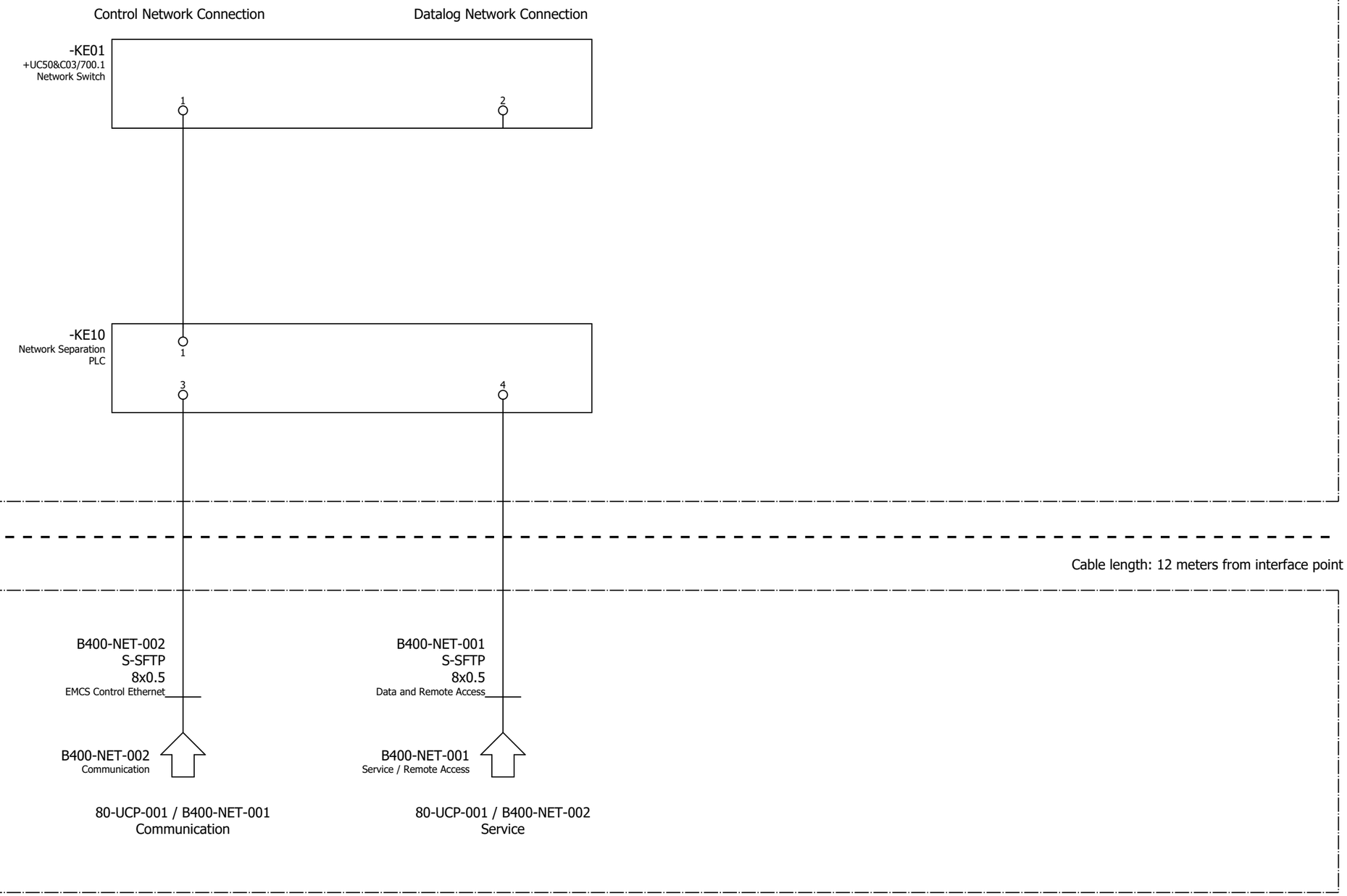
DRAWING	E03-007 Electrical Interfaces to RM	REVISION	06
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Electrical Interface - Safety		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 4 / 12

Electrical Interface - Network Connections

Responsibility matrix: K559-2254-SWIWP4202202-E99-003Rev001

Location: 40ft Container,Top Side Entry

=BA20+UC50
AC Distribution Cabinet, 40ft Container Inside



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	628		
=	++	+	& B03

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DRAWING	E03-007 Electrical Interfaces to RM	REVISION	06
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS		
SHEET TYPE/DESC	Electrical Interface - Network		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 5 / 12

Sub Section E03-008

UC42 EX Barrier

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	01/04/2025	First Issue

Document Title:	**BLPH Project - Panel Cabinet Layout: UC42 Ex Barrier Box**
Document Number:	K559-2254-CWIWP4202202-E03-008
Revision:	Rev001
Sequence Number:	008
File Name:	K559-2254-CWIWP4202202-E03-008Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

0	1	2	3	4	5	6	7	8

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+UC42

Ballard Power Systems Europe - Technology Solutions

Cabinet: Ex Barrier Box
Location: Outside 40ft Container, Right of H2 Manifold

Refer to K559-2254-CWIWP4202202-K02-003 ATEX Design Journal for ATEX Information

Vin = 24VDC

IP65

Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	628		
=	++	+ UC42	& A01

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DRAWING	601456B UC42 Ex Barrier Box			REVISION	06
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet				
SHEET TYPE/DESC	Front Page				
ALL SHEETS ARE THE SAME REVISION STATUS		SIZE A3	LANGUAGE EN	SHEET/TOTAL	1 / 18

Ballard Power Systems Europe - Technology Solutions, Cabinet Wiring Colors

Standard Basis: EN 61439

Required wire standard compliance:

Required: IEC Wire
Required: UL Recognized
Required: CSA/UL

Wire Numbering:

- Wires inside panels are to be numbered
- Wire number system is perferably "potential oriented with subnumber"
- All wires of the same potential (e.g. DC Common) have the same main number, with sequential subnumber.
- Potential numbers with fewer digits may be leading zero padded (e.g. 19 -> 019)
- Separator between main and subnumber is "."

Example: 019.1 BUWH 0.75mm²

- 019 — Wire potential number
- 1 — Wire sequential subnumber with separator
- BUWH — Wire color code (Dark Blue with White stripe)
- 0.75mm² — Wire dimension

AC Wiring Colors

AC Power Circuit (Generic)	———	Black (BK)
AC Phase L1	———	Brown (BN)
AC Phase L2	———	Black (BK)
AC Phase L3	———	Grey (GY)
AC Neutral	———	Light Blue (BU)
Externally supplied circuit	———	Orange (OG)

DC Wiring Colors

DC Power Circuit	———	Black (BK)
DC Control Voltage (24V)	———	Dark Blue (BU)
DC Control Voltage Refence (0V)	-·-·-·-	Dark Blue with White Stripe (BUWH)
Signal Wire (DI, DO)	———	White (WH)
Signal Wire (AI, AO)	———	Violet (VT)
Externally supplied circuit	———	Orange (OG)

PE Wiring Colors

Protective Earth (PE)	- - - - - - -	Green/Yellow (GNYE)

Conductor Colour Identification

IEC 60757:1983 Designation	Description
BK	Black
BN	Brown
RD	Red
OG	Orange
YE	Yellow
GN	Green
BU	Blue
VT	Violet
GY	Gray
WH	White
PK	Pink
GD	Gold
TQ	Turquoise
SR	Silver
GNYE	Green/Yellow
SH	Shield

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	06
EPLAN Project Pages	628
=	++ | + UC42 | & A01

REVISION INFORMATION
DESCRIPTION
DATE
28-Mar-25

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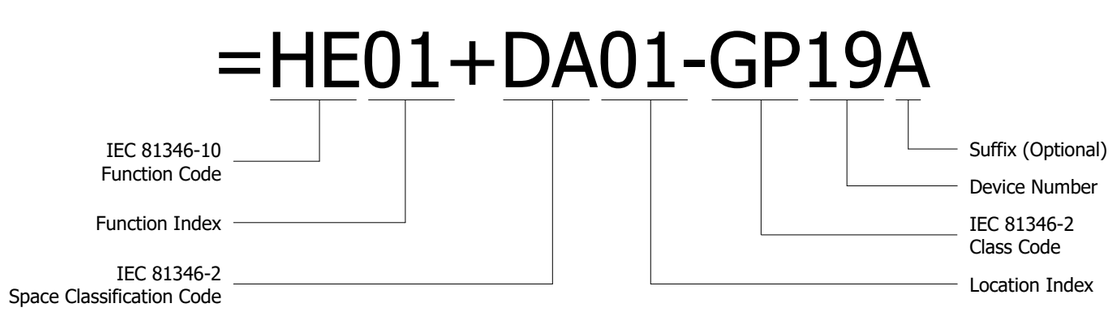
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DRAWING	601456B UC42 Ex Barrier Box	REVISION	06
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Standard Wire Colors		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 2 / 18

Ballard Power Systems Europe - Technology Solutions Device Tag Process

A Ballard Device Tagname consists of three parts:
- A function designation (=)
  - According to IEC81346-10, Table B.1 and B2.
  - Always two letters followed by two digits
- A location designation (+)
  - According to IEC81346-2, Table 4
  - Always two letters followed by two digits
- A class code (-)
  - According to IEC81346-2, Table 2
  - Always two letters followed by two or three digits plus optional suffix

Sample fully qualified Device Tag (DT) for a Coolant Pump



IEC81346-10 Function Examples

IEC 81346-10 Table B.1 and B.2 provide a class definition system, which provides a two letter code for the functional description
Table B.1 is used for power supply systems and table B.2 for other systems

IEC 81346-10 Table B.1 / B.2	Function Codes (Example)
=AA	Structural System, Load support (Frame)
=BA	Transporting Electrical Energy (Power Converters)
=HA	Supply System, Gaseous Matter (Gas Piping)
=HE	Supply System, Heating/Cooling (Radiator)
=JA	Distribution System, Gaseous Matter (Gas Handling Unit)
=JB	Distribution System, Liquid Matter (Fluid Drain)
=LA	Control System, Process (PLC, SCADA)
=LB	Control System, Safety (Safety PLC)
=QA	Storage System, Gaseous Matter (Gas Storage)
=RE	Energy Conversion System, Chemical to Electricity (Fuel cells, Batteries)

IEC81346-2 Space Classification

IEC 81346-2 Table 4 provide a classification scheme for spaces, which provides a two and three letter code for the space (location) classification.
Class code "1" and "1" is used for the location scheme

IEC 81346-2 Table 4	Location Codes (Example)
+GB	Space for power generation, Chemical (Fuel Cells)
+DA	Space for active technical equipment
+UC	Space for electrical equipment (Electrical Cabinet)

IEC81346-2 Class Code

IEC 81346-2 Class Codes is a scheme for defined objects for reference designations according to their inherent function

IEC 81346-2 Table 2	Class Codes (Example)
-BA	Sensing, electrical potential (Voltage Transducer)
-BC	Sensing, electrical current (Current Transducer)
-BP	Sensing, pressure (Pressure Transducer)
-BT	Sensing, temperature (Temperature Transducer)
-EA	Emitting, light (Light Fixture)
-FC	Protecting, overcurrent (Fuse, MCCB)
-GB	Generating, Chemical Reaction (Fuel Cell)
-GP	Generating, Liquid Flow (Pump)
-GQ	Generating, Gas Flow (Van, Ventilator)
-KE	Processing, Electrical signals (PLC)
-KF	Processing, Information (Network Switch)
-MA	Driving, Torque (AC Motor)
-QA	Controlling, Electric Current (Contactor, Motor Starter)
-QB	Controlling, Electric Separation (Disconnector)
-QM	Controlling, Fluid On/Off (Valve)
-QN	Controlling, Fluid Regulation (Damper, Gas Control Valve)
-WD	Guiding, Low Voltage Electric Energy (AC or DC power Cable)
-WE	Guiding, Reference Potential (Grounding Wire/Cable)
-WG	Guiding, Electric Signals (Control, Network Cable)

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	601456B - Shell Baseload Power Hub
EPLAN Revision	06
EPLAN Project Pages	628
= ++ + UC42 & A01	

REVISION INFORMATION
DESCRIPTION
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DRAWING	601456B UC42 Ex Barrier Box	REVISION	06
DRAWING TITLE	Crosswind UC20 40ft Control Cabinet		
SHEET TYPE/DESC	Tagging Standard		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 3 / 18

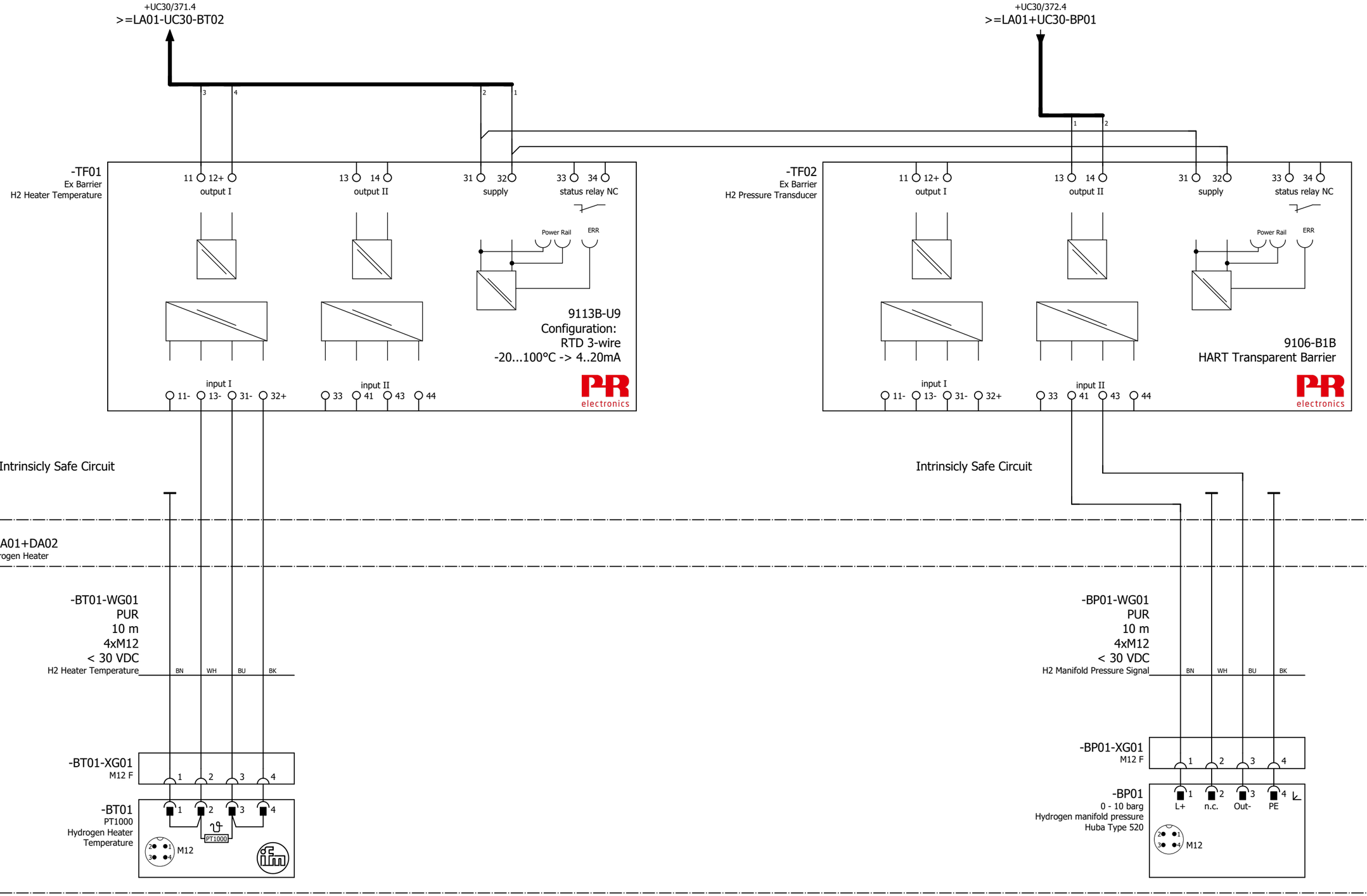
0	1	2	3	4	5	6	7	8

Refer to K559-2254-CWIWP4202202-K02-003 ATEX Design Journal for ATEX Information

=LA01
Ex Barrier Box

+UC30/371.4
>=LA01-UC30-BT02

+UC30/372.4
>=LA01+UC30-BP01



Reference Item Number	Ballard Part # TBD		
EPLAN Project Name	601456B - Shell Baseload Power Hub		
EPLAN Revision	06		
EPLAN Project Pages	628		
=	++	+ UC42	& C03

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DRAWING	601456B UC42 Ex Barrier Box	REVISION	06
DRAWING TITLE	40ft Container - DCDC Cabinets		
SHEET TYPE/DESC	EX Barrier Box		
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A3	LANGUAGE EN	SHEET/TOTAL 1 / 2

Sub Section E06

Computer System Documentation

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	2/17/2023	First Issue
002	3/24/2023	Re-issue according to comments
003	9/10/2025	Updated, As build

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DATE _____

Document Title:	**BLPH Project - Computer System Documentation**
Document Number:	K559-2254-CWIWP4202202-E06-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-E06-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E06
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	E06 – Computer System Documentation
Full Title	Computer system hardware documentation for Crosswind project. Contains internal segregation between process and safety systems, including component selection.

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Revision Record

Rev #	Description	Revised By	Date
2.0	Updated Release	PBL	March 2023
3.0	As build Release	PBL	Sept 2025

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1.0 Purpose

This document has two primary purposes:

- Outline the separation of duties between the process control system and safety system
- Hardware chosen to implement the duties for both process control system and safety system.

Please note that description of software implementing the process control is described in document C08.

Document C07 (Cause and effect charts) may be helpful in understanding the duties of the safety control system.

2.0 References

Table 1: Reference Documents

Document ID	Short ID	Document Title	Source
K559-2254-DM-PRO-001	n/a	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-C03-001	C03	Process and Instrumentation Diagrams	BPSE
K559-2254-CWIWP4202202-C06-001	C06	Single Line Diagram	BPSE
K559-2254-CWIWP4202202-C07-001	C07	Cause and Effect diagrams	BPSE
K559-2254-CWIWP4202202-C08-001	C08	Control Philosophy & Block Logic Diagrams	BPSE

3.0 Separation of duties between process control and safety control

3.1 Introduction

This section describes the overall functions inside the container and the separation of duties. Functions are listed with the tag given from the P&ID documentation, see C03, sheet 2.

3.2 List of functionalities and responsibilities

When reading the following table, please refer to Single Line Diagram (SLD, C06) and Process and Instrumentation Diagram (P&ID, C03).

The markings indicate the following:

- "Yes" - This system is responsible for this function.
- "-" - This system has no responsibility for this function.
- "STO" - The Safety system can initiate Safe Torque Off (STO) functionality on the drive or power converter.
- "Trip" - The Safety system can trip the breaker.

Table 2: List of functions in the 1MW container

Function (=) (See C03, Sheet 2)	Comment	Process Control	Safety System
=RE01, =RE02	Fuel Cell Module – Process Control	Yes	-
=RE01, =RE01	Fuel Cell Module – Safety	-	Yes
=BA01	Power Conversion Block #1 – DCDC Converter, Control	Yes	STO
=BA02	Power Conversion Block #2 – DCDC Converter, Control	Yes	STO
=BA20	Balance of Plant, DCAC Converter	Yes	STO
=BA30	Power Conversion Output – Main Breaker	Yes	Trip
=BA30	Power Conversion Output – DCAC Drive	Yes	STO

=HA01	Hydrogen Supply Valves	Yes	Yes (Override)
=HA01	Hydrogen Supply Pressure	Yes	-
=HE01	HT Coolant #1 – Temperature and flow	Yes	-
=HE01	HT Coolant #1 – Pump and Fans	Yes	STO (Pump)
=HE01	HT Coolant #1 – Valve control	Yes	-
=HE02	HT Coolant #2 – Temperature and flow	Yes	-
=HE02	HT Coolant #2 – Pump and Fans	Yes	STO (Pump)
=HE02	HT Coolant #2 – Valve control	Yes	-
=HE03	LT Coolant – Temperature and flow	Yes	-
=HE03	LT Coolant – Pump	Yes	STO Function
=HE03	LT Coolant – Fans	Yes	-
=HE03	LT Coolant – Valve control	Yes	-
=JA01	40ft Ventilation – Dampers and Fans	Yes	-
=JA01	40ft Ventilation - Temperature	Yes	-
=JA01	40ft Ventilation – Gas Detection	-	Yes
=JA01	40ft Ventilation – Smoke Detection	-	Yes
=LB02	40ft Container – Emergency Stop	-	Yes
=LB02	Customer – Emergency Stop	-	Yes
=JA02	10ft Ventilation – Dampers and Fans	Yes	-
=JA02	10ft Ventilation - Temperature	Yes	-
=JA02	10ft Ventilation – Smoke Detection	-	Yes
=LB02	10ft Container – Emergency Stop	-	Yes

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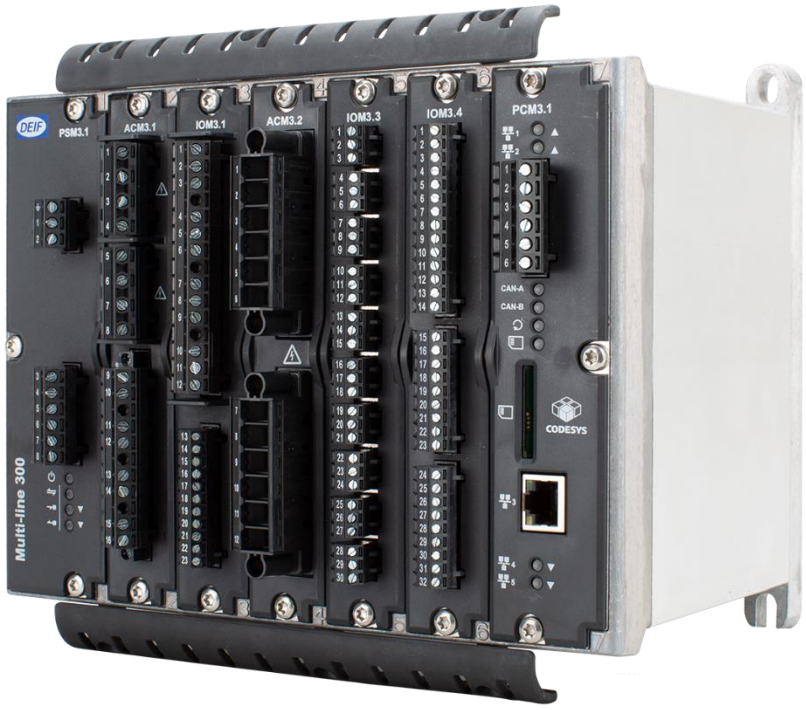
4.0 Hardware Selection for Process Control

This section describes the hardware used for process control for the FC Package process control system.

4.1 Controller Family

The chosen hardware family is the AMC (Advanced Modular Controller) 300 series by the manufacturer DEIF AS in Denmark, shown in Figure 1.

Figure 1: AMC300 Controller with option cards



DEIF AMC300 controller in 7-slot rack, with IO modules included. System CPU is located rightmost slot.

4.2 Controller Series Approvals

The DEIF AMC300 controller has a series of approvals, some of which are listed in Table 3.

Table 3: AMC300 Approvals (excerpt)

Approval	Issuing body	Approval Type
CE Marking	DEIF AS	EU Goods Marking
BV 42536/C0 BV	Bureau Veritas	Marine Type Approval
DNV TAA00002YK Rev 1	DNV	Marine Type Approval
UKCA	DEIF AS	UK Goods Marks

4.3 Controller Topology

The chosen topology for the controller is multiple racks with a single CPU. The racks communicate via an separate EtherCAT ring network.

4.4 Controller Modules (IO Cards)

Table 4: AMC300 IO Cards

IO Card	Purpose	IO on Card
PSM3.1	Rack power supply and EtherCAT Primary (Master)	2 NO Relay
PSM3.2	Rack power supply and EtherCAT Secondary (Follower)	2 NO Relay
ACM3.1	Alternating Current Module	2 x 3 phase voltage measurement, 4 current transducer inputs
ACM3.2	Differential Current Module	2 x 3 phase current transducer inputs

IOM3.1	Input Output Module, Relays and DI	4 Change over relays, 10 DI
IOM3.2	Input Output Module, Mixed Signals	4 NO Relay, 4 AO, 4 DI, 4 AI
IOM3.3	Input Output Module, Analogue Input	10 AI (V, mA, RTD)
IOM3.4	Input Output Module, Digital Input/Output	12 DO, 2 x 8 DI

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5.0 Hardware Selection for Safety Controller

This section describes the hardware used for process control for the FC Package Safety control system.

5.1 Controller Family

The chosen Safety controller is the FlexiSoft FX3 series produced by SICK AG.

The FlexiSoft series is a modular safety controller, programmed in software and capable of achieving very high safety ratings (PLe / SIL3)

Figure 2: SICK FlexiSoft FX3



Modular Safety Controller, CPU located leftmost with IO and network modules to the right.

5.2 Controller Series Approvals

The SICK FlexiSoft FX3 controller has a series of approvals, some of which are listed in

Table 3.

Table 5: SICK FlexiSoft FX3 Approvals (excerpt)

Approval	Issuing body	Approval Type
EU Declaration of Conformity	SICK AG	CE Marking
UK Declaration of Conformity	SICK AG	UKCE Marking
CULus	Underwriters Laboratory	UL508, CSA C22.2
TÜV Safe	TÜV Rheinland	UL508, CSA C22.2

5.3 Controller Series Safety Data

The manufacturer supplied Safety Data for the FlexiSoft FX3 series are listed in Table 6.

Table 6: SICK FlexiSoft FX3 Safety Data

Type	Performance	Standard
Safety Integrity Level	SIL3	IEC 61508
Category	Category 4	EN ISO 13849
Performance Level	PLe	EN ISO 13849
PFH_D	$1{,}69 * 10^{-9}$	EN ISO 13849
T_M	20 years	EN ISO 13849

5.4 Controller Topology

The chosen topology for the controller is two independent controllers, one located in the 40ft container and one located in the 20ft container. These two controllers are connected via a safety-rated EFI (CAN-bus based) connection, such that safety system trip in one container will guarantee activation of the safety system in the other container.

The controller in the 40ft container is connected via modbus to the process controller, such that the internal status of the controller can by communicated to the process control system. The communication is not safety rated. The process control system cannot influence the safety control system over the modbus connection.

5.5 Controller Modules (IO Cards)

Table 7: FlexiSoft FX3 IO Cards

IO Card	Purpose	IO on Card
CPU1	Controller CPU card with EFI bus	2 EFI bus channels
GMOD	Non-safe Modbus communication	2 RJ45 (Modbus TCP)
XTIO	Safe Digital Input/Output Module	8 DI 4 DO
XTDI	Safe Digital Input Module	8 DI with test outputs
ANA0	Safe Analog Module (4-20 mA)	2 AI / 1 AI (mirrored input)

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Sub Section E14

Load List

Ballard Power Systems Europe A/S
Majsmarken 1
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Revision history		
Rev.	**Date.**	**Description**
001	15/02/2023	First Issue
002	08/03/2024	Updated according to comments
003	13/08/2025	Updated according to comments

Document Title:	**BLPH Project - Load List**
Document Number:	K559-2254-CWIWP4202202-E14-001
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Code:	E14
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

1 MW Megablock Load List	
Date	13/08/2025
Responsible	RKN
Rev.	3

Note: With regards to BLPH platform modes, the Megablock Load List remains these 3 load cases for standby depending on the ambient temperature. During blackout the Megablock load is zero. When Megablock is running it covers its own BOP which equals zero load from BLPH.

													Case 1 - Hot Standby (-10 °C)			Case 2 - Hot Standby (10 °C)			Case 3 - Hot Standby (25 °C)		
Full DT	Pretty Name	Description	Location DT	Location Pretty Name	Nameplate Voltage [Vac]	Nameplate Current [A]	Nameplate Power [kW]	Control Method	Control DT (if applicable)	Fusing	Fusing DT	Fuse Characteristics	Comments	Load [%]	Duty Cycle [%]	Average Power Consumption [kW]	Load [%]	Duty Cycle [%]	Average Power Consumption [kW]	Load [%]	Duty Cycle [%]	Average Power Consumption [kW]
=JA01+UC07-EB01-1	Container Heater, Element 1/3	40ft Container Heating Element 1	+UC07	40ft Container HVAC System	400	13,0	9,00	Solid-State Contactor	=BA20+UC20-QB13	MCCB	=LA01+UC20-FC13	16A, B-curve	480V Heater operated at 400V	100	100	9,00	100	0	0,00	100	0	0,00
=JA01+UC07-EB01-2	Container Heater, Element 2/3	40ft Container Heating Element 2	+UC07	40ft Container HVAC System	400	13,0	9,00	Solid-State Contactor	=BA20+UC20-QB14	MCCB	=LA01+UC20-FC14	16A, B-curve	480V Heater operated at 400V	100	0	0,00	100	0	0,00	100	0	0,00
=JA01+UC07-EB01-3	Container Heater, Element 3/3	40ft Container Heating Element 3	+UC07	40ft Container HVAC System	400	13,0	9,00	Solid-State Contactor	=BA20+UC20-QB15	MCCB	=LA01+UC20-FC15	16A, B-curve	480V Heater operated at 400V	100	0	0,00	100	0	0,00	100	0	0,00
=JA01+UC07-GQ08	DCDC Cooling Fan A	Heater/Cooling Fan 40ft Container 1/2	+UC07	40ft Container HVAC System	400	1,4	1,00	EC Motor	n/a	MCCB	=BA20+UC20-FC16	6A, B-curve	Fan with EC motor	70	100	0,70	70	0	0,00	40	100	0,40
=JA01+UC07-GQ09	DCDC Cooling Fan B	Heater/Cooling Fan 40ft Container 2/2	+UC07	40ft Container HVAC System	400	1,4	1,00	EC Motor	n/a	MCCB	=BA20+UC20-FC17	6A, B-curve	Fan with EC motor	70	100	0,70	70	0	0,00	40	100	0,40
=JA01+DA01-GQ06	Ventilation Intake Fan A	Upper Fan	+DA01	40ft Container, Inside	400	5,1	3,50	EC Motor	n/a	MCCB	=BA20+UC20-FC11	6A, B-curve	Fan with EC motor	0	0	0,00	0	0	0,00	0	0	0,00
=JA01+DA01-GQ07	Ventilation Intake Fan B	Lower Fan	+DA01	40ft Container, Inside	400	5,1	3,50	EC Motor	n/a	MCCB	=BA20+UC20-FC12	6A, B-curve	Fan with EC motor	0	0	0,00	0	0	0,00	0	0	0,00
=BA20+UC20-TB01	FCwave1+2 PSU	24V PSU for FCwave 1+2 with UPS	+UC20	40ft Control Cabinet	400	1,4	0,96	n/a	n/a	MCCB	=BA20+UC20-FC20	6A, B-curve		20	100	0,19	20	100	0,19	20	100	0,19
=BA20+UC20-TB01	FCwave3+4 PSU	24V PSU for FCwave 3+4 with UPS	+UC20	40ft Control Cabinet	400	1,4	0,96	n/a	n/a	MCCB	=BA20+UC20-FC21	6A, B-curve		20	100	0,19	20	100	0,19	20	100	0,19
=BA20+UC20-TB01	FCwave5+6 PSU	24V PSU for FCwave 5+6 with UPS	+UC20	40ft Control Cabinet	400	1,4	0,96	n/a	n/a	MCCB	=BA20+UC20-FC23	6A, B-curve		20	100	0,19	20	100	0,19	20	100	0,19
=BA20+UC20-TB30	Control System PSU	24V PSU for Control System with UPS	+UC20	40ft Control Cabinet	400	0,7	0,48	n/a	n/a	MCCB	=BA20+UC20-FC30	6A, B-curve		80	100	0,38	80	100	0,38	80	100	0,38
=BA20+UC30-EA01	Cabinet Lighting	Cabinet Lighting for Coolant Control Cabinet	+UC30	Coolant Skid Cabinet	230	0,1	0,05	Integrated Movement Sensor	n/a	MCCB	=BA20+UC30-FC02	1A, C-curve		100	5	0,00	100	5	0,00	100	5	0,00
=BA20+UC30-EB01	Cabinet Heater	Cabinet Heater for Coolant Control Cabinet	+UC30	Coolant Skid Cabinet	230	0,4	0,15	Thermostat	=BA20+UC30-BT01	MCCB	=BA20+UC30-FC03	4A, C-curve		100	100	0,15	100	0	0,00	100	0	0,00
=BA20+UC30-TB30	Control System PSU	24V PSU for Control System with UPS	+UC30	Coolant Skid Cabinet	400	0,7	0,48	n/a	n/a	MCCB	=BA20+UC30-FC100	6A, B-curve		100	100	0,48	100	100	0,48	100	100	0,48
=HE03+DA01-GP11	Coolant Pump, LT	Electronics Cooling	+DA01	40ft Container, Inside	400	5,8	4,00	VFD	=HE03-DA01-TA11	MCCB	=BA20+UC30-FC11	10A, B-curve		80	0	0,00	80	0	0,00	80	0	0,00
=HE01+DA02-GP19	Coolant Pump, HT1	Coolant Pump for FCwave 1-3	+DA02	Coolant Skid	400	21,7	15,00	VFD	=HE01+UC30-TA19	MCCB	=BA20+UC30-FC28	25A, B-curve		60	0	0,00	60	0	0,00	60	0	0,00
=HE02+DA02-GP29	Coolant Pump, HT2	Coolant Pump for FCwave 4-6	+DA02	Coolant Skid	400	21,7	15,00	VFD	=HE01+UC30-TA29	MCCB	=BA20+UC30-FC38	25A, B-curve		60	0	0,00	60	0	0,00	60	0	0,00
=HE01+DA02-GQ11	HT1 Ventilation Fan 1		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA11	MCCB	=BA20+UC30-FC20	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE01+DA02-GQ12	HT1 Ventilation Fan 2		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA12	MCCB	=BA20+UC30-FC21	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE01+DA02-GQ13	HT1 Ventilation Fan 3		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA13	MCCB	=BA20+UC30-FC22	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE01+DA02-GQ14	HT1 Ventilation Fan 4		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA14	MCCB	=BA20+UC30-FC23	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE01+DA02-GQ15	HT1 Ventilation Fan 5		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA15	MCCB	=BA20+UC30-FC24	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE01+DA02-GQ16	HT1 Ventilation Fan 6		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA16	MCCB	=BA20+UC30-FC25	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE02+DA02-GQ21	HT2 Ventilation Fan 1		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA21	MCCB	=BA20+UC30-FC30	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE02+DA02-GQ22	HT2 Ventilation Fan 2		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA22	MCCB	=BA20+UC30-FC31	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE02+DA02-GQ23	HT2 Ventilation Fan 3		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA23	MCCB	=BA20+UC30-FC32	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE02+DA02-GQ24	HT2 Ventilation Fan 4		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA24	MCCB	=BA20+UC30-FC33	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE02+DA02-GQ25	HT2 Ventilation Fan 5		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA25	MCCB	=BA20+UC30-FC34	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE02+DA02-GQ26	HT2 Ventilation Fan 6		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA26	MCCB	=BA20+UC30-FC35	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HE03+DA04-GQ31	LT Ventilation Fan 1		+DA02	Coolant Skid	400	5,8	4,00	VFD	=HE01+UC41-TA31	MCCB	=BA20+UC30-FC10	6A, B-curve		70	0	0,00	70	0	0,00	70	0	0,00
=HA01+DA01-EA01	Hydrogen Heater, Heater 1/2		+DA02	40ft Container, Outside	400	13,0	9,00	Solid-State Contactor	=BA30+UC30-QA10	MCCB	=BA20+UC30-FC41	16A, Z-curve		100	40	3,60	100	20	1,80	100	0	0,00
=HA01+DA01-EA02	Hydrogen Heater, Heater 2/2		+DA02	40ft Container, Outside	400	13,0	9,00	Solid-State Contactor	=BA30+UC30-QA11	MCCB	=BA20+UC30-FC42	16A, Z-curve		100	0	0,00	100	0	0,00	100	0	0,00
=JA01+DA03-EB02	Container Heater, 10ft	Heating Element, 10ft container	+DA03	10ft Container, Inside	400	13,0	9,00	Integrated Thermostat	n/a	MCCB	=LA01+UC31-FC04	10A, B-curve		100	25	2,25	100	0	0,00	100	0	0,00
=JA01+DA03-EB02	Container Heater Fan, 10ft		+DA03	10ft Container, Inside	400	1,0	0,70	Contactor	=LA01+UC31-QA01	MCCB	=LA01+UC31-FC07	6A, B-curve		100	100	0,70	100	0	0,00	100	0	0,00
=JA01+DA03-GQ03	Ventilation Fan, 10ft		+DA03	10ft Container, Inside	400	8,2	5,70	EC Motor	n/a	MCCB	=LA01+UC31-FC04	10A, B-curve	Fan with EC motor	30	0	0,00	30	0	0,00	30	100	1,71
=LA01+UC31-TB01	Control System PSU	Control System	+UC31	10ft Control Cabinet	400	0,7	0,48	n/a	n/a	MCCB	=LA01+UC31-FC01	4A, B-curve		80	100	0,38	80	100	0,38	80	100	0,38
=LA01+UC31-TB02	Control System PSU	Breaker Supply PSU	+UC31	10ft Control Cabinet	400	1,4	0,96	n/a	n/a	MCCB	=LA01+UC31-FC02	4A, B-curve		80	1	0,01	80	1	0,01	80	1	0,01
													Summation:			**18,93 [kW]**			**3,63 [kW]**			**4,34 [kW]**

Sub Section E99-003

Cable Transits Schedule

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	3/8/2024	First Issue
002	10/28/2025	Released as Rev2

Document Title:	**BLPH Project - Specials: Cable Transits Schedule**
Document Number:	K559-2254-CWIWP4202202-E99-003
Revision:	Rev002
Sequence Number:	003
File Name:	K559-2254-CWIWP4202202-E99-003Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	FC Package Electrical and Comms Interfaces
Full Title	Crosswind/Baseload Power Hub Fuel Cell Package Eletrical and Communications Interfaces
Abstract	Note: This document have been available as “B99 – BLPH FC Package MV Interface” previously – it is now updated to include all the electrical and communication interfaces for the FC package.

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Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	PBL	16th Feb 2024
2	Update to include LV and Communications interfaces	PBL	07th Mar 2024

Checked by: n/a	Date: n/a
Approved by: n/a	Date: n/a

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1.0 Purpose and Scope

The purpose of this document is to outline the MV(Medium-voltage) interface between FC package to the Base Load Power Hub platform.

The document further includes the LV and controls interfaces between the BLPH platform and the FC package.

Drawings of the interface is presented, and details of the connection points is outlined.

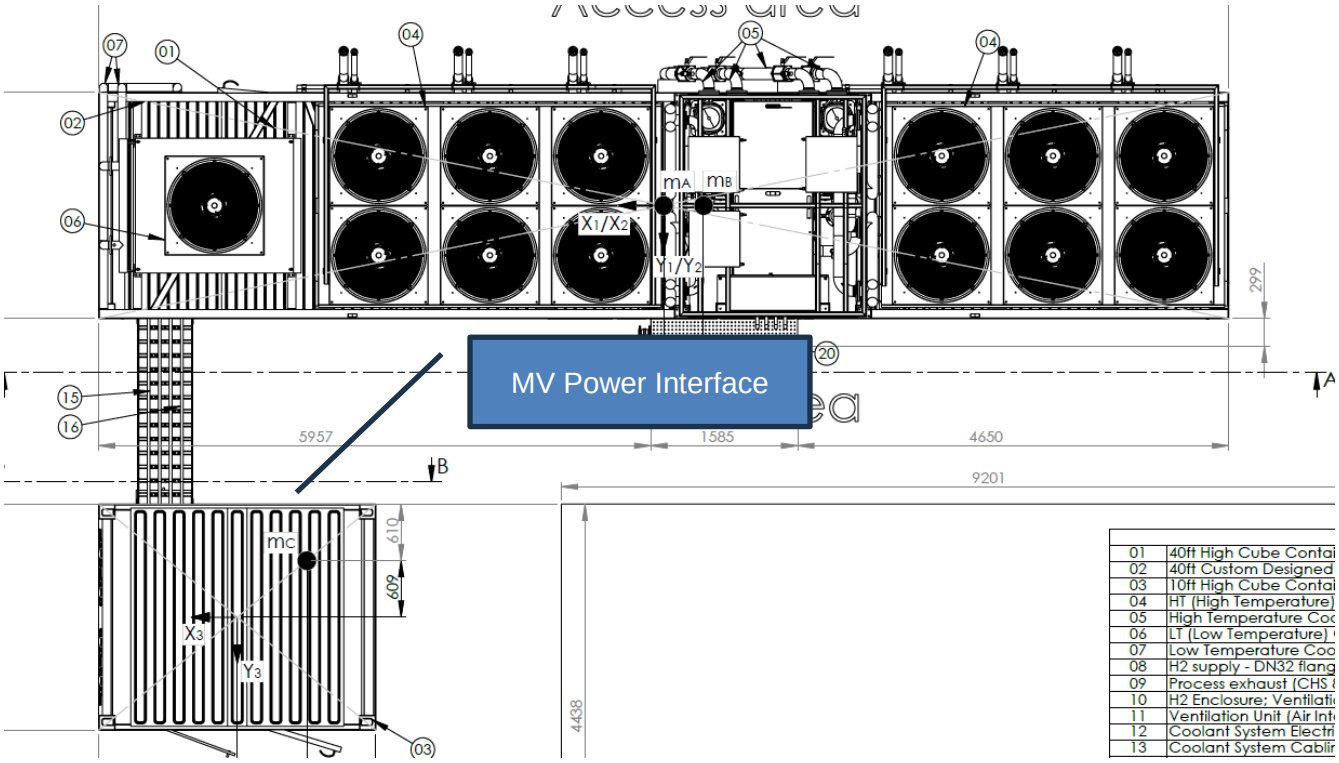
2.0 Connection Overview

2.1 List of Connections

Connection	Description	Physical Connection
MV Interface	Main power delivery interface – 3 phase 6,6kV AC 50Hz 100A connection	3 pcs single Conductor Cables
Auxiliary Supply	Container auxiliary supply – 3p+N+PE 400V 50Hz 32A supply	5G6 Cable (optionally 5G10)
Network Connection	Network cable carrying Modbus TCP control signals and SCADA data to BLPH	Fiber optic cable
Service Connection	Network cable carrying service and troubleshooting information to Ballard. Encrypted.	Fiber optic cable **OR** Copper ethernet (4x2x0,5mm^2)
Safety Signals	Multiconductor signal cable carrying safety signals between FC package and BLPH control system	Multiconductor cable (6x2x0,75mm^2)

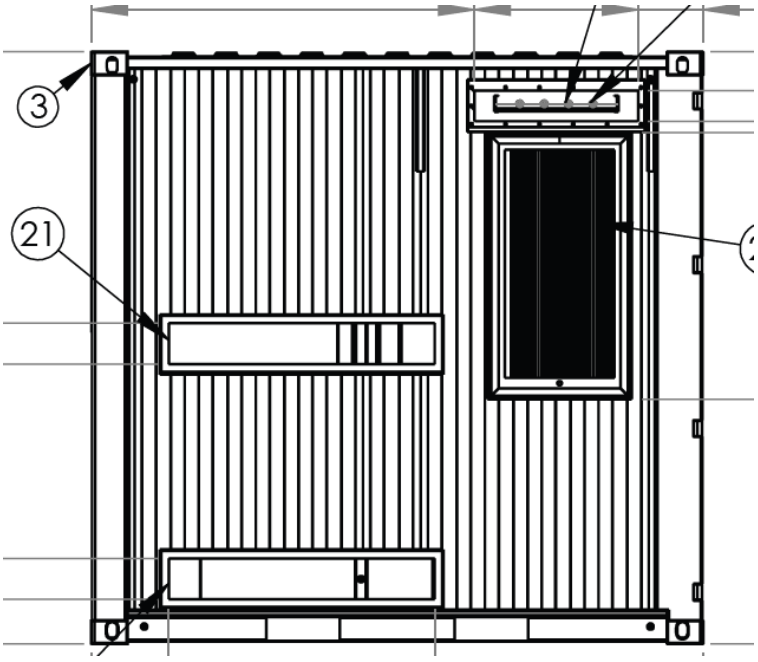
2.2 MV Interface (6,6kV Interface)

Figure 1: Location of the MV power interface



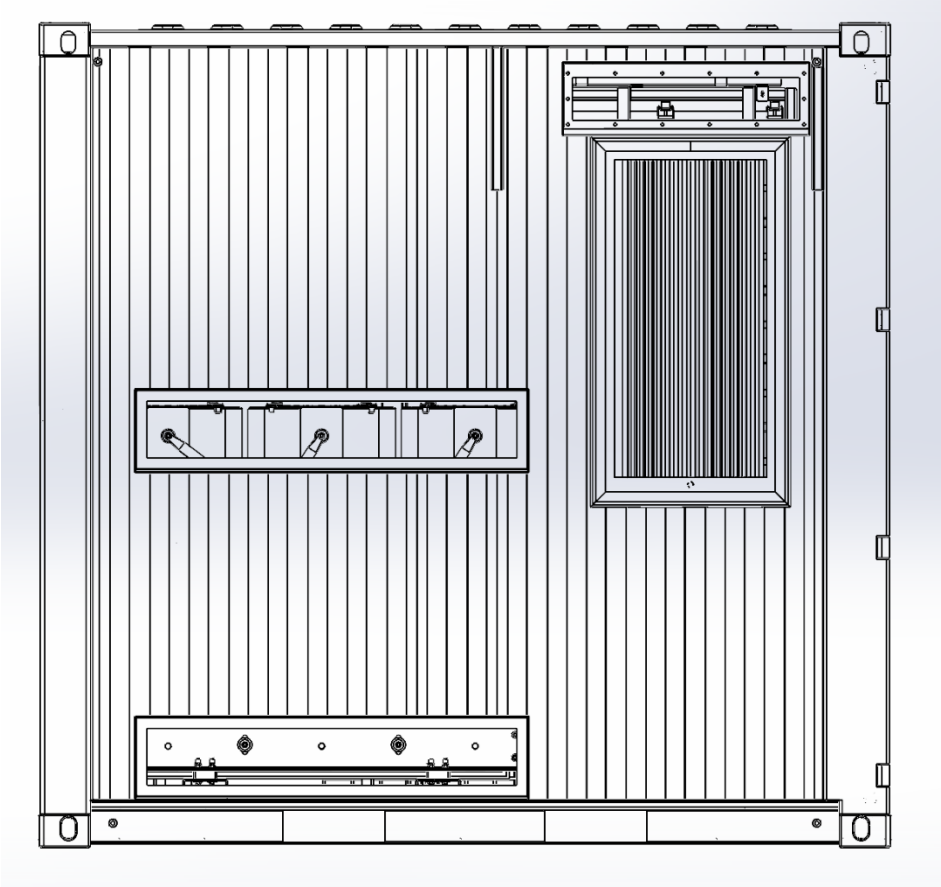
Location of the MV power interface shown on the General Arrangement (B01). The view is detailed in Figure 2*, which is section view "B".*

Figure 2: Section View “B”



Section view “B” of the 10ft container, showing the MV interface as item 21.

Figure 3: Transformer Connection Points

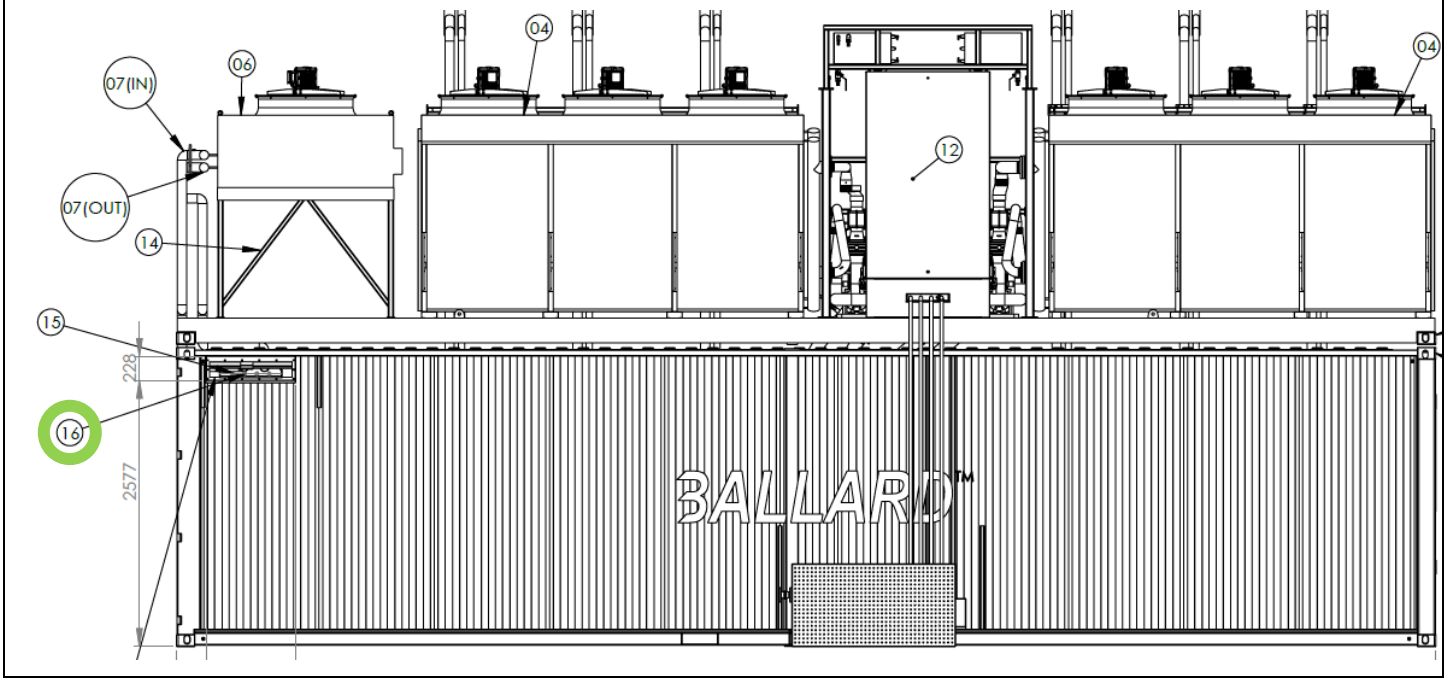


Rendering of transformer connection points as seen through the access ports. Access is possible through both upper and lower port. Both ports are covered by a sealing plate, the desired access plate is supplied with cable glands installed.

2.3 LV and Controls Interface

The physical location of the LV and controls interface is shown in document “K559-2254-CWIWP4202202-B01-001Rev005”, section view “A”, balloon 16.

Figure 4: Location of the LV and Controls Interface



Location of the LV and Control interface shown on the General Arrangement (B01). The view is detailed in Figure 2*, which is section view “A”. The Interface is shown as balloon “16”.*

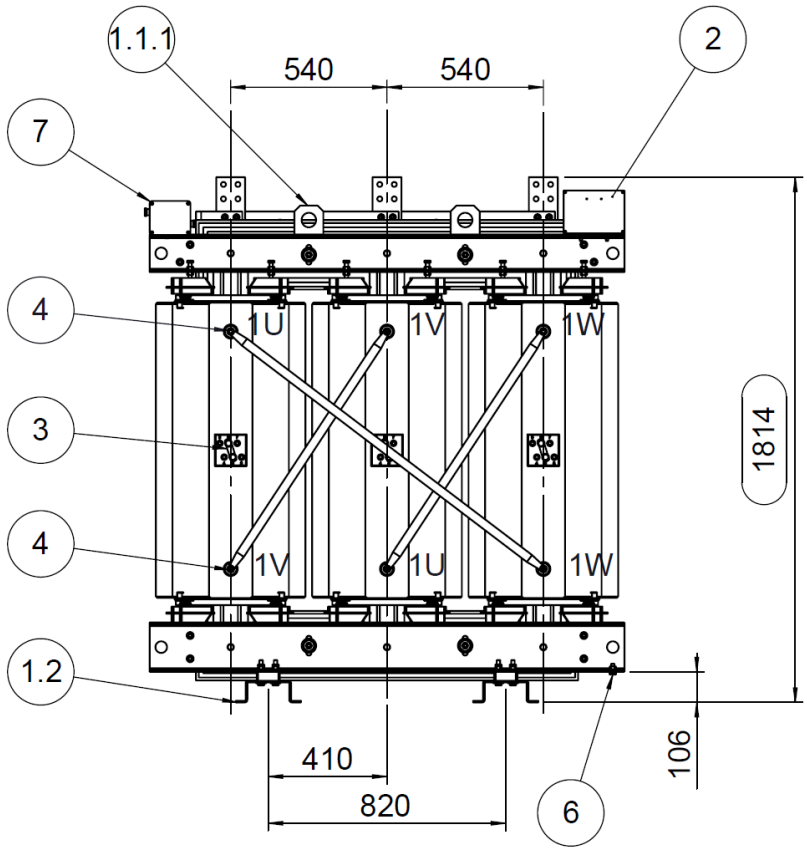
3.0 Electrical Overview – MV Connection

The MV connection between the FC package and the BLPH platform is a 3 phase 6,6kV 50Hz AC connection.

The power produced in the FC package is transmitted via this connection to the BLPH, which in turn provides power to start the fuel cell systems for a short period of time.

The interface point of the connection is on the MV connection points on the output transformer, as illustrated in Figure 5.

Figure 5: Output Transformer Drawing



Side view of the MV side of the output transformer, taken from transformer manufacturer general arrangement. Items are detailed in Table 1.

Table 1: Transformer GA Items

Item	Description	Quantity
1.1.1	Lifting Lug, 100x100x10	4
1.2	Truck	2
2	Plate A5 Al Black [Rating Plate]	1
3	Voltage Regulation Plate	3
4	HV Terminal M12 Brass Stud	6
5	LV Busbar Terminal 100x10 Al	3
6	Stainless Steel Earthing Stud M12 A2-70	2
7	Probes Marshalling Box, 3xPt100	1

3.1 Terminal Lugs

The MV terminal lugs on the transformer are bolts of size M12 with brass bolts present.

3.2 Connection Responsibility Matrix

The parties responsible for each part of the MV interface is outlined in the following table:

Table 2: Responsibility Matrix – MV Connection

Item	Description	Responsible
MV Connection Bolts	Transformer MV connection bolts	Ballard
Weather sealing plate	Cover plate for transformer connection points	Ballard
Cable Glands	3 pcs cable glands to mechanical fasten and weather seal MV AC cable	Ballard
MV Cable	3 pcs AC cable to carry power to/from FC package	RM
MV Cable lugs	3 pcs cable lugs to fit M12 brass bolts	RM
MV Cable Workmanship	Mounting, adjusting, cutting and crimping cable lugs to cables and mounting to transformer MV connection points	RM

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4.0 Electrical Overview – Auxiliary Connection

The Auxiliary connection to the FC package is the supply of AC power to the package when the fuel cells are not operating.

The expectation is that RM provides cable and mounting up to the interface point, with a specified additional length (see Table 5) that Ballard personnel will pull through the interface point, mount to the terminal blocks inside the package and coordinate with RM personnel for relevant electrical tests.

The expected cable coloring is described in Table 3.

Table 3: Cable Markings – Auxiliary Connection

Item	Electrical Connection
1 or BROWN	Phase L1
2 or BLACK	Phase L2
3 or GREY	Phase L3
4 or BLUE	Neutral
GREEN YELLOW	Protective Earth

Table 4: Responsibility Matrix – Auxiliary Connection

Item	Description	Responsible
Cable outside FC package	Provisioning and mounting the cable outside the FC package interface point	RM
Cable extra length	Specified extra length of cable above for routing inside FC package	RM
Cable Interface Plate and cable gland	Weather sealing for cable	Ballard
Cable routing	Routing cable inside FC package	Ballard
Cable connection and workmanship	Mounting cable inside FC package	Ballard

Table 5: Cable Extra Length – Auxiliary Connection

Item	Description	Length
Cable extra length	Extra length of auxiliary supply cable needed	12m

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5.0 Electrical Overview – Network and Service Connection

The Network connection to the FC package is the control connection between the FC package and the BLPH platform control system.

The service connection to the FC package is the service/troubleshooting/data transfer connection from the FC package to the Ballard OT infrastructure. It is expected that RM provides a routing through relevant firewalls of this connection to a specified IP for Ballard's SCADA. The data is secured against unauthorized access and malicious actors.

The expectation is that RM provides cable and mounting up to the interface point, with a specified additional length that Ballard personnel will pull through the interface point and route to the cabinet.

Ballard will raise a TQ on the specifics of the Fiber converter and material.

Table 6: Responsibility Matrix – Network and Service Connection

Item	Description	Responsible
Cable outside FC package	Provisioning and mounting the cable outside the FC package interface point	RM
Cable extra length	Specified extra length of cable above for routing inside FC package	RM
Cable Interface Plate and cable gland	Weather sealing for cable	Ballard
Cable routing	Routing cable inside FC package	Ballard
Cable splice	Splice of fiber inside FC package and mounting connector	RM

Table 7: Cable Extra Length – Network service Connection

Item	Description	Length
Cable extra length	Extra length of network fiberoptic cable needed	10m

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6.0 Electrical Overview – Safety Connection

The safety connection is a single multicore cable carrying the hardwired safety signals between the FC package safety controller and the BLPH safety system.

The expectation is that RM provides cable and mounting up to the interface point, with a specified additional length (see Table 9) that Ballard personnel will pull through the interface point and route to the cabinet.

Table 8: Responsibility Matrix – Safety Connection

Item	Description	Responsible
Cable outside FC package	Provisioning and mounting the cable outside the FC package interface point	RM
Cable extra length	Specified extra length of cable above for routing inside FC package	RM
Cable Interface Plate and cable gland	Weather sealing for cable	Ballard
Cable routing	Routing cable inside FC package	Ballard
Cable connection and workmanship	Mounting cable inside FC package	Ballard

Table 9: Cable Extra Length – Safety Connection

Item	Description	Length
Cable extra length	Extra length of multicore cable needed	25m

7.0 Assembly pictures

Figure 6: View of transformer connection points from outside



Picture taken of the transformer installed into the container, from approximately same angle as Figure 2*. Cover plate not installed on this picture.*

Figure 7: View of transformer connection points, inside



Picture of the transformer, as seen from inside the 10ft container. Both cover plates not installed.

Sub Section E99-004

Grounding Layout

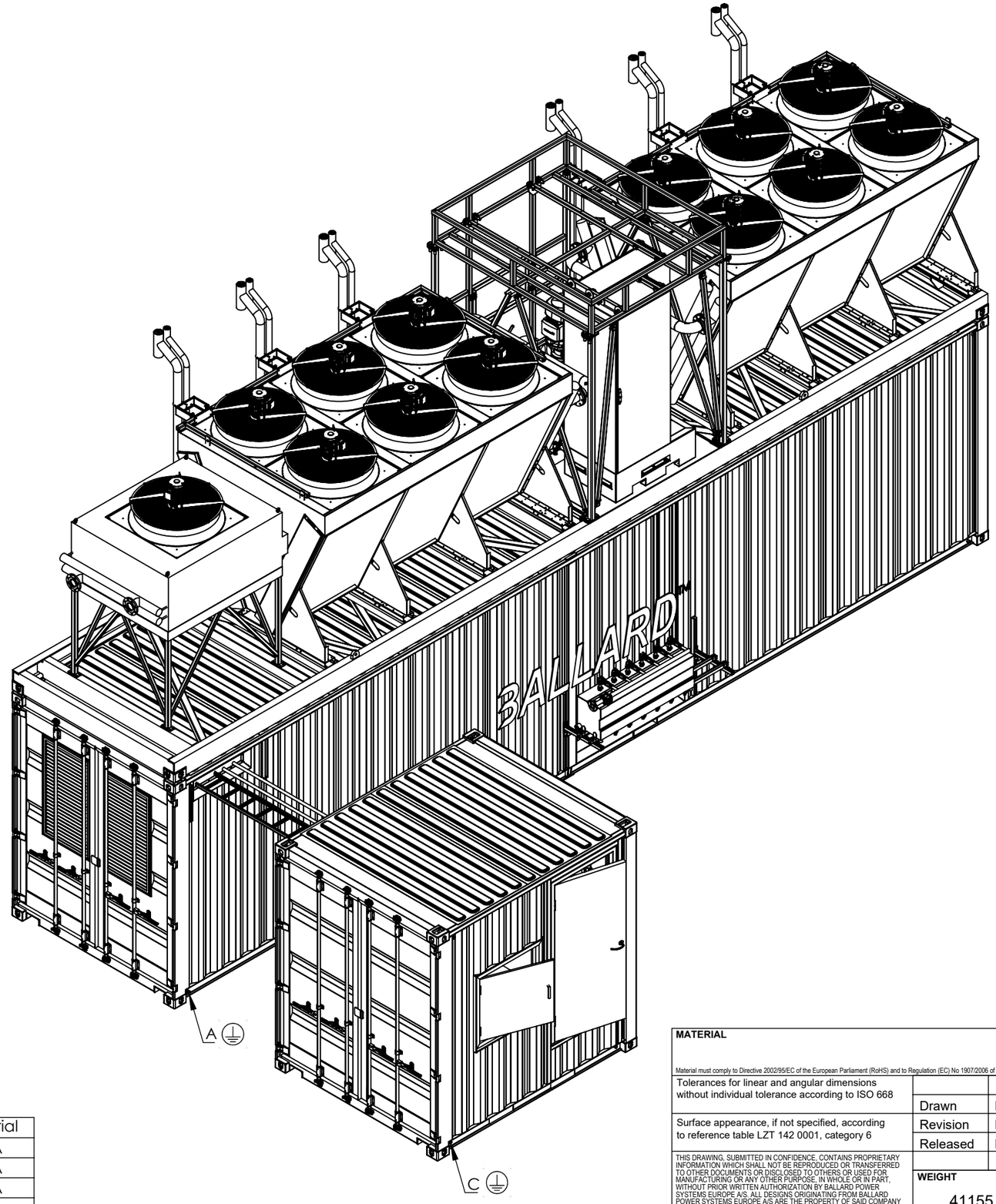
Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	03/03/2023	First Issue
002	11/04/2024	Updated/modified acc. to comments

Document Title:	**BLPH Project - Specials: Earthing Layout**
Document Number:	K559-2254-CWIWP4202202-E99-004
Revision:	Rev002
Sequence Number:	004
File Name:	K559-2254-CWIWP4202202-E99-004Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

ISOMETRIC VIEW

Revision Table				
ZONE	REV.	DESCRIPTION	DATE	REV. BY
0	0	RELEASE	09/04/2024	PSZ



Point	Bolt size	Bolt length	Torque	Material
A	M12x1.5	25 mm	65 Nm	V2A
B	M12x1.5	25 mm	65 Nm	V2A
C	M12x1.5	25 mm	65 Nm	V2A
D	M12x1.5	25 mm	65 Nm	V2A

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	PSZ	09-04-2024
Revision	PSZ	09-04-2024
Released	PSZ	09-04-2024

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WEIGHT 41155 kg

1st angle projection

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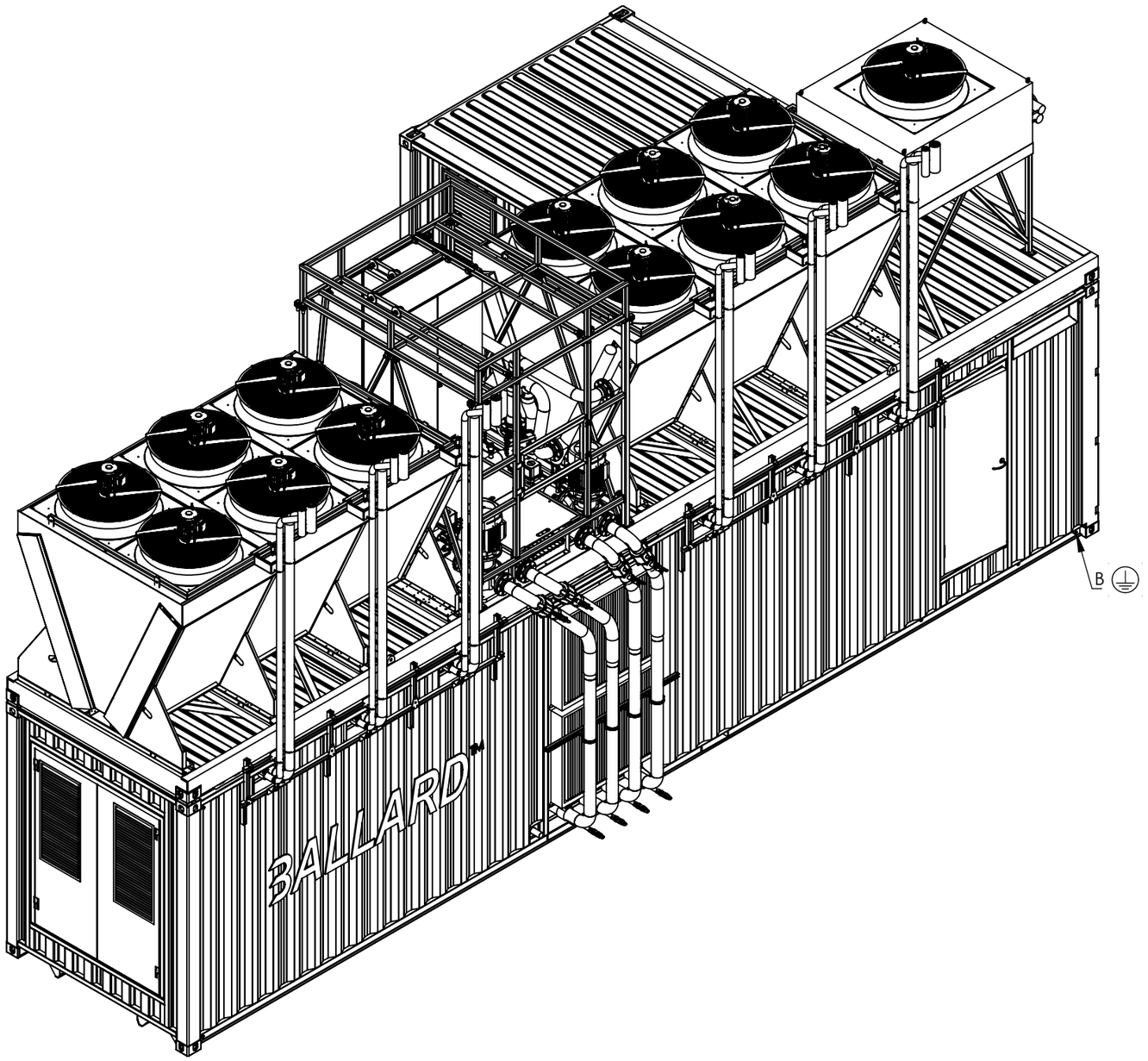
Ballard hydrogen system

ISOMETRIC VIEW

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	1/6	1:50	E99-004	0

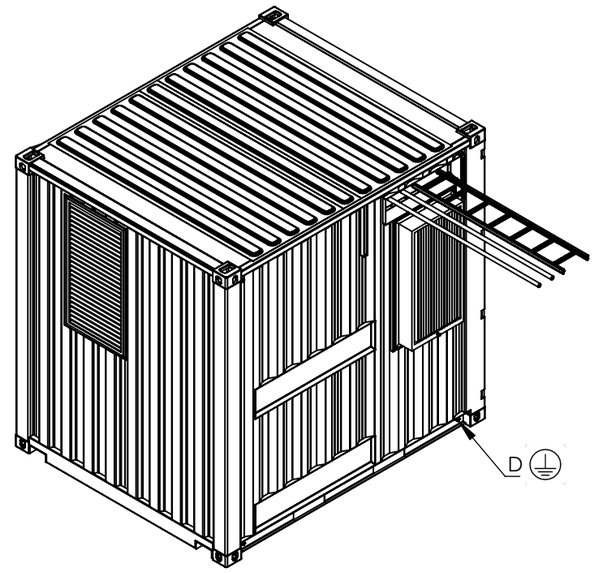
Revision Table				
ZONE	REV.	DESCRIPTION	DATE	REV. BY
0	0	RELEASE	09/04/2024	PSZ

ISOMETRIC VIEW - 40FT CONTAINER



ISOMETRIC VIEW - 10FT CONTAINER

(40ft container hidden)



Point	Bolt size	Bolt length	Torque	Material
A	M12x1.5	25 mm	65 Nm	V2A
B	M12x1.5	25 mm	65 Nm	V2A
C	M12x1.5	25 mm	65 Nm	V2A
D	M12x1.5	25 mm	65 Nm	V2A

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	PSZ	09-04-2024
Revision	PSZ	09-04-2024
Released	PSZ	09-04-2024

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WEIGHT 41155 kg

1st angle projection

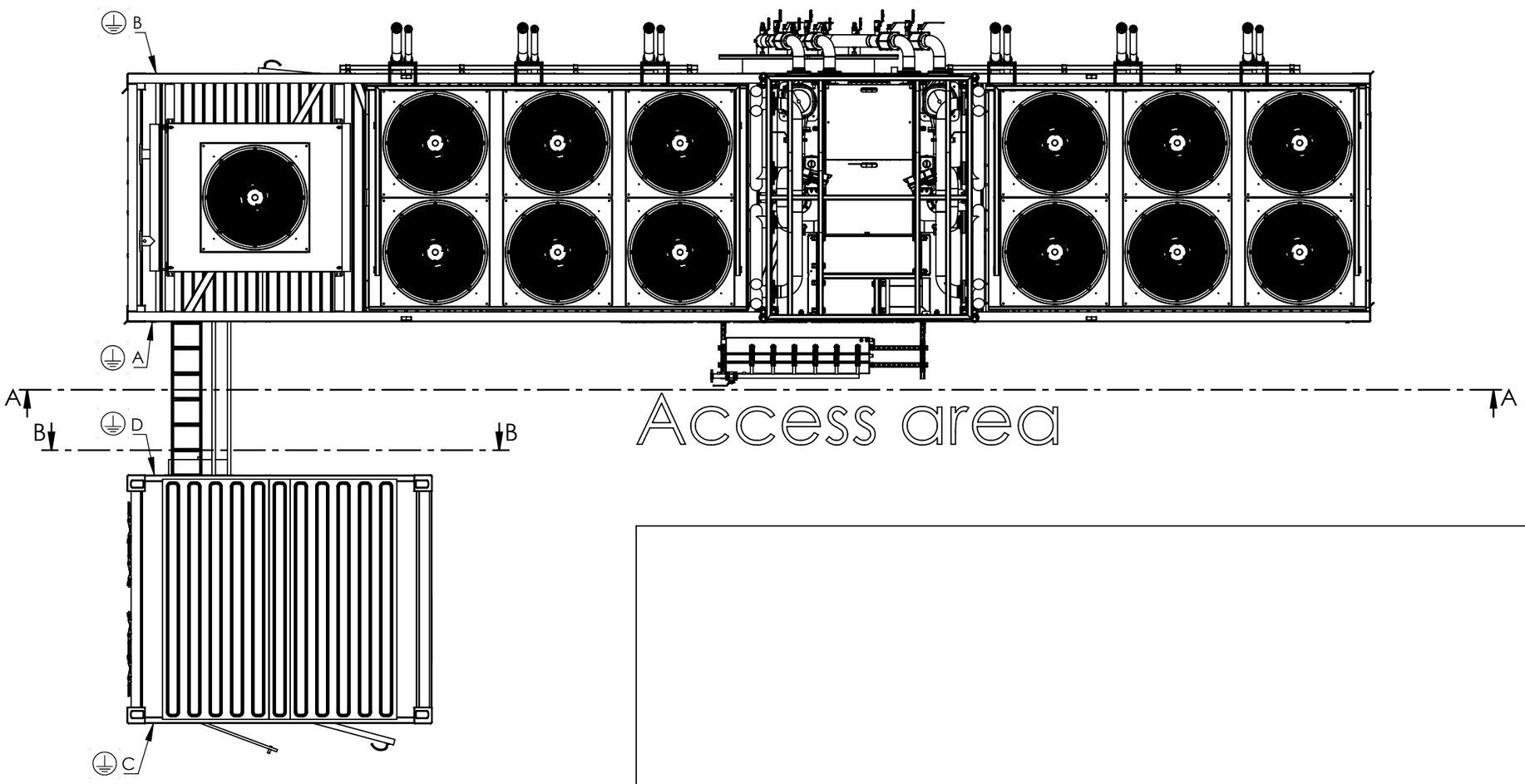
BALLARD™

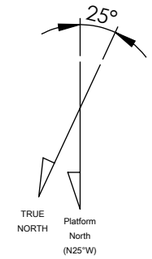
Ballard hydrogen system

ISOMETRIC VIEW - Back

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	2/6	1:50	E99-004	0

TOP VIEW - ACCESS AREA





Point	Bolt size	Bolt length	Torque	Material
A	M12x1.5	25 mm	65 Nm	V2A
B	M12x1.5	25 mm	65 Nm	V2A
C	M12x1.5	25 mm	65 Nm	V2A
D	M12x1.5	25 mm	65 Nm	V2A

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	PSZ	09-04-2024
Revision	PSZ	09-04-2024
Released	PSZ	09-04-2024

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WEIGHT 41155 kg

1st angle projection

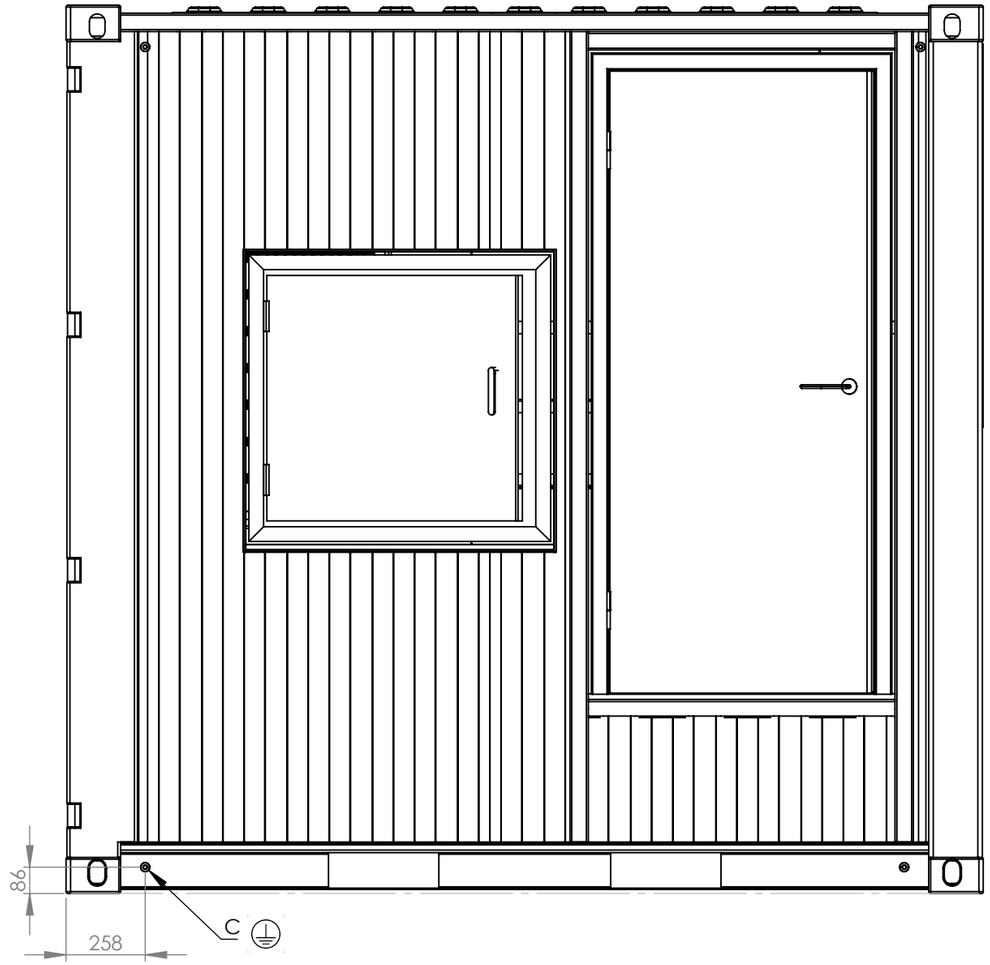
BALLARD

Ballard hydrogen system

Top - Access area

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	3/6	1:50	E99-004	0

FRONT VIEW - 10FT CONTAINER
(LOOKING SOUTH)



Point	Bolt size	Bolt length	Torque	Material
A	M12x1.5	25 mm	65 Nm	V2A
B	M12x1.5	25 mm	65 Nm	V2A
C	M12x1.5	25 mm	65 Nm	V2A
D	M12x1.5	25 mm	65 Nm	V2A

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	PSZ	09-04-2024
Revision	PSZ	09-04-2024
Released	PSZ	09-04-2024

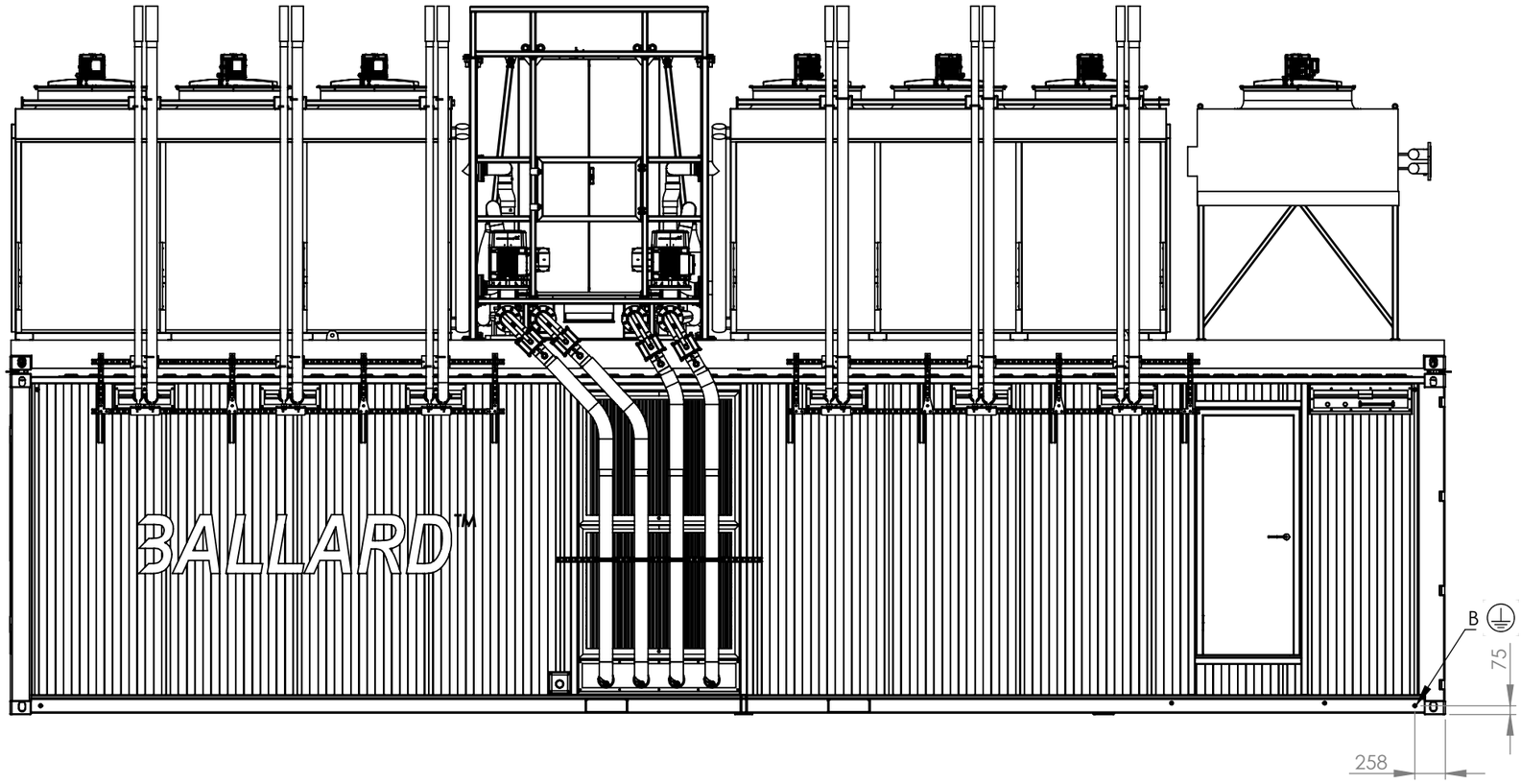
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BALLARD™

Ballard hydrogen system
FRONT

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
41155 kg	1st angle projection	A3	4/6	1:20	E99-004	0

BACK VIEW - 40FT CONTAINER
(LOOKING NORTH)



Point	Bolt size	Bolt length	Torque	Material
A	M12x1.5	25 mm	65 Nm	V2A
B	M12x1.5	25 mm	65 Nm	V2A
C	M12x1.5	25 mm	65 Nm	V2A
D	M12x1.5	25 mm	65 Nm	V2A

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

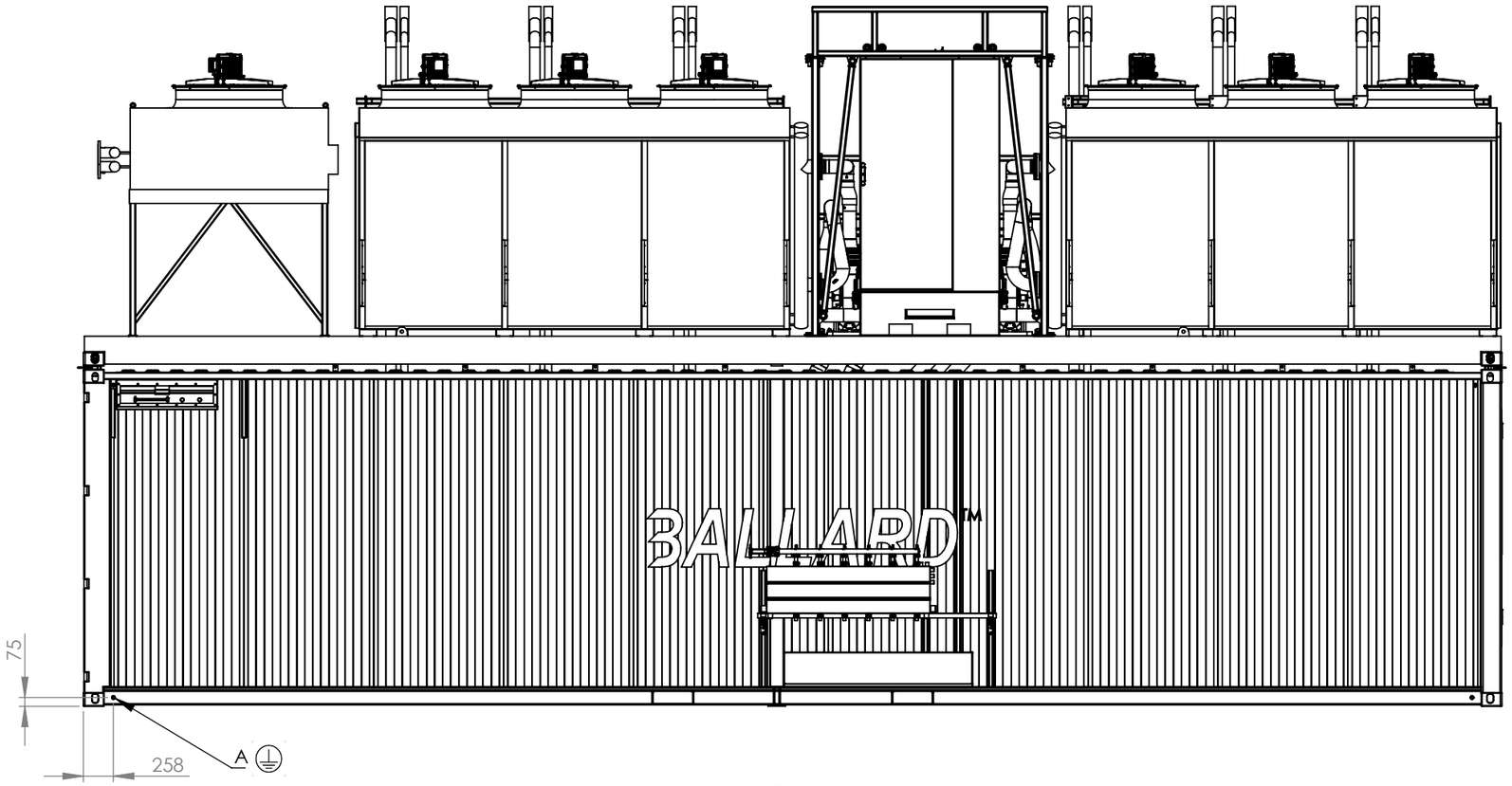
	By	Date
Drawn	PSZ	09-04-2024
Revision	PSZ	09-04-2024
Released	PSZ	09-04-2024

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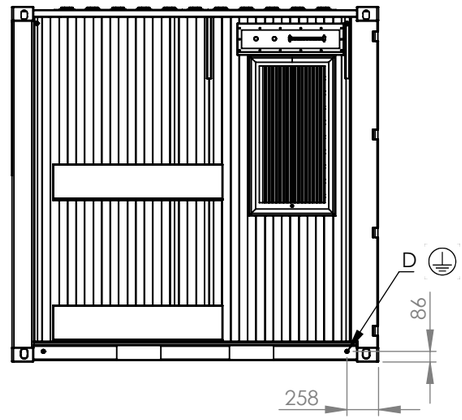
BALLARD™

Ballard hydrogen system
BACK

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
41155 kg	1st angle projection	A3	5/6	1:50	E99-004	0



SECTION A-A



SECTION B-B

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	PSZ	09-04-2024
Revision	PSZ	09-04-2024
Released	PSZ	09-04-2024

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Cross sections

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
41155 kg	1st angle projection	A3	6/6	1:50	E99-004	0

Sub Section E99-005

Secure Remote Access Proposal

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	28/08/2023	First Issue

Document Title:	**BLPH Project - Specials: Secure Remote Access**
Document Number:	K559-2254-CWIWP4202202-E99-005
Revision:	Rev001
Sequence Number:	005
File Name:	K559-2254-CWIWP4202202-E99-005Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	E99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Fuel Cell Package Secure Remote Access
Full Title	Fuel Cell Package Secure Remote Access
Abstract	*This document presents the fuel cell architecture for the secure remote access and data transfer from the OT systems within to Ballard data logging and monitoring systems.*

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Revision Record

Rev #	Description	Revised By	Date
1.0	PBL		**28-08-2023**

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1.0 Purpose and Scope

The purpose of this document is to outline the requirements and preferences of Ballard regarding remote access and operational and security data transfer from the fuel cell package controller to Ballard internal databases.

This document will describe the intent from Ballard both during the on-shore commissioning and work-up phase onshore at Rosetti Marinos facilities in Ravenna, Italy and when transported and installed at final location on the offshore monopile at the HKN wind farm.

The intent of the document is to be shared with project partners, covered by the project NDA.

2.0 External References

CWHKN-PMT-PJA-PLN-00009 – Crosswind Hollandse Kust Noord Site V - System Security Requirements, Rev 1.0

IEC 62443-2-4 – Security Program Requirements for IACS service providers

3.0 Terminology

Table 1: List of Terminology

Abbreviation	Full Name
OT	Operational Technology
IACS	Industrial Automation and Control Systems

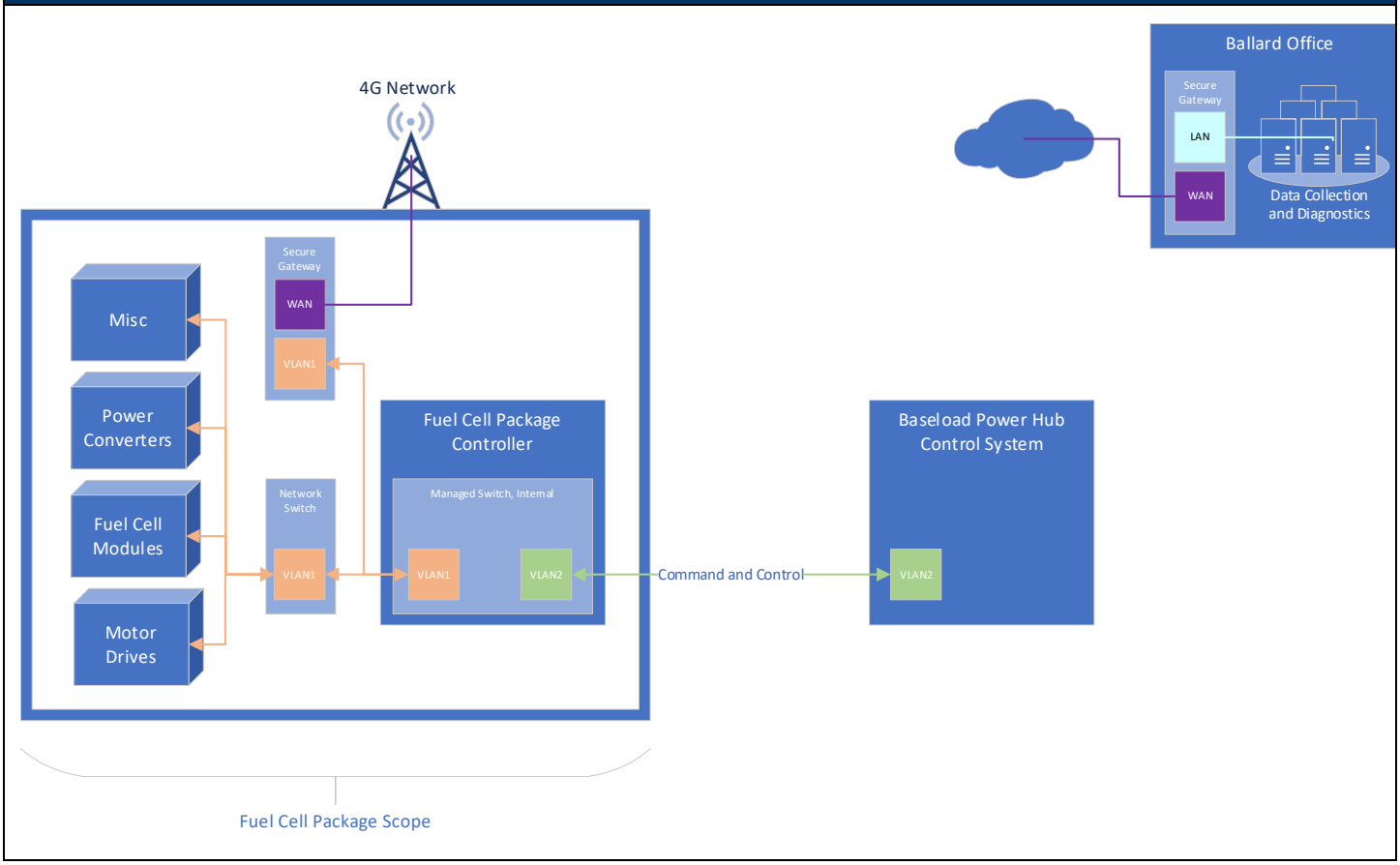
4.0 Fuel Cell Package OT Structure

The purpose of this section is to outline the OT architecture as designed in the fuel cell package for the Crosswind HKN project.

4.1 Proposed architecture during onshore commissioning

The Fuel Cell Package will be delivered with a Secure Remote Access gateway installed including a 4G wireless antenna, which allows troubleshooting, data collection and remote access.

Figure 1: Proposed Secure Remote Access architecture onshore



During onshore commissioning and work-up, Ballard proposes to have a 4G network connection from the fuel cell package container to Ballard main office, allowing rapid response from engineering back office support.

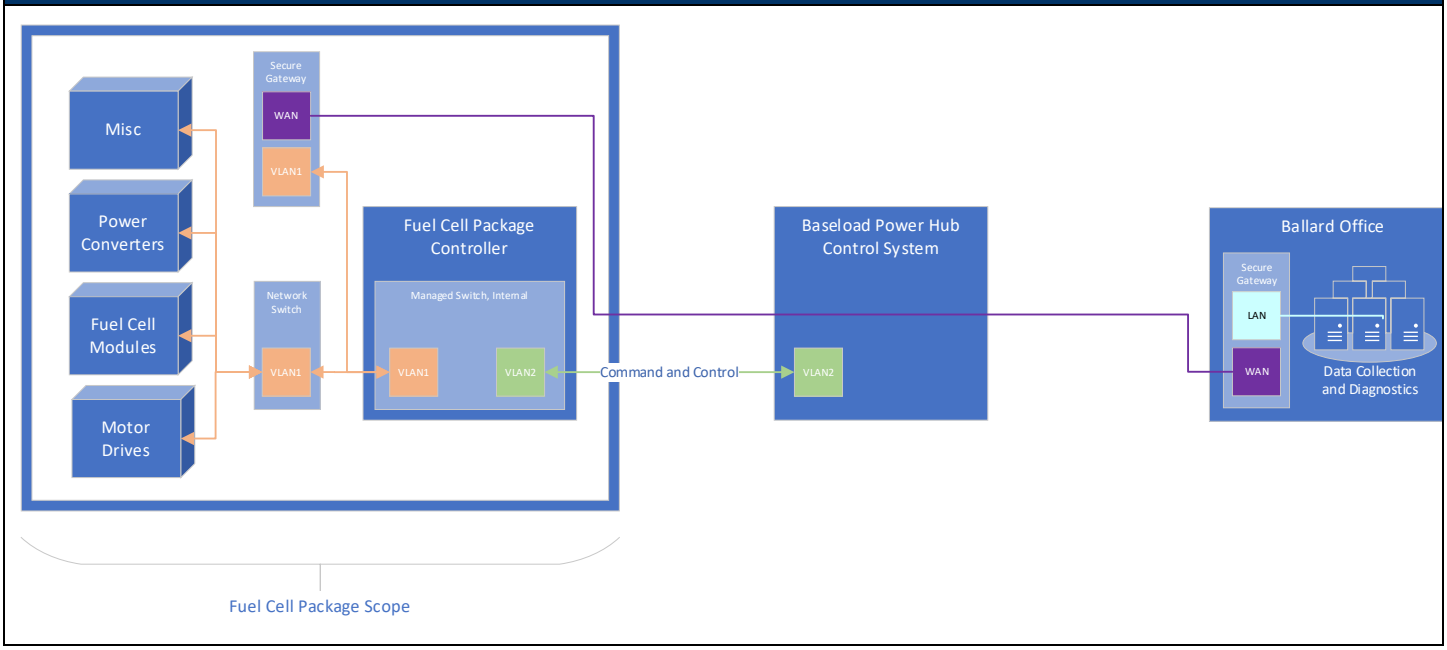
4.2 Proposed architecture during offshore operation

The Fuel Cell package can either continue with the setup from commissioning or be adapted to the architecture proposed in Figure 2.

As the 4G connection is expected to be non-existent at the final location, the solution with a secure access tunnel though the BLPH infrastructure to the internet would be preferred.

The secure access tunnel should be completely separated from the command and control system for the BLPH, in order to maintain the best possible separation between the OT network and data going to the internet.

Figure 2: Proposed Secure Remote Access architecture offshore



When the BLPH is completed and moved to the final offshore location, the proposed secure remoted access solution would be a pass-though the BLPH network infrastructure to Ballard.

5.0 Secure Remote Access Hardware

5.1 Crosswind Cybersecurity Requirements

The Crosswind project requirements for Secure Remote Access is given in document CWHKN-PMT-PJA-PLN-00009, section “Secure Remote Access”, page 11.

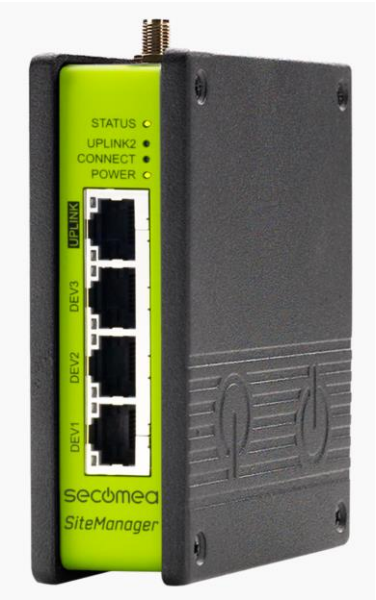
This section allows for the use of Secure Remote Access to OT systems and requires the use of a standard remote access solution.

There is no further explanation what this standard remote access solution is comprised of.

5.2 Ballard proposed Secure Remote Access solution.

The secure remote access solution proposed by Ballard is based on the SiteManager product line from the company Secomea.

Figure 3: Secomea Secure Remote Access Hardware



The Secomea SiteManager Secure Remote Access device. The OT side is the DEV1-3 ports with the WAN connection via the UPLINK port to the other end of the secure tunnel. The SiteManager can also connect via 4G connection

5.3 Security certifications of the proposed hardware and vendor

Table 2: IEC 62443 Certifications

Standard	Certificate	Authority
IEC62443-4-1	Link	TÜV SÜD
IEC62443-3-3	Link	TG alpha GmbH
IEC62443-4-2	Link	TG alpha GmbH
NIS2	Link	Secomea

Sub Section E99-006

Harmonic Study

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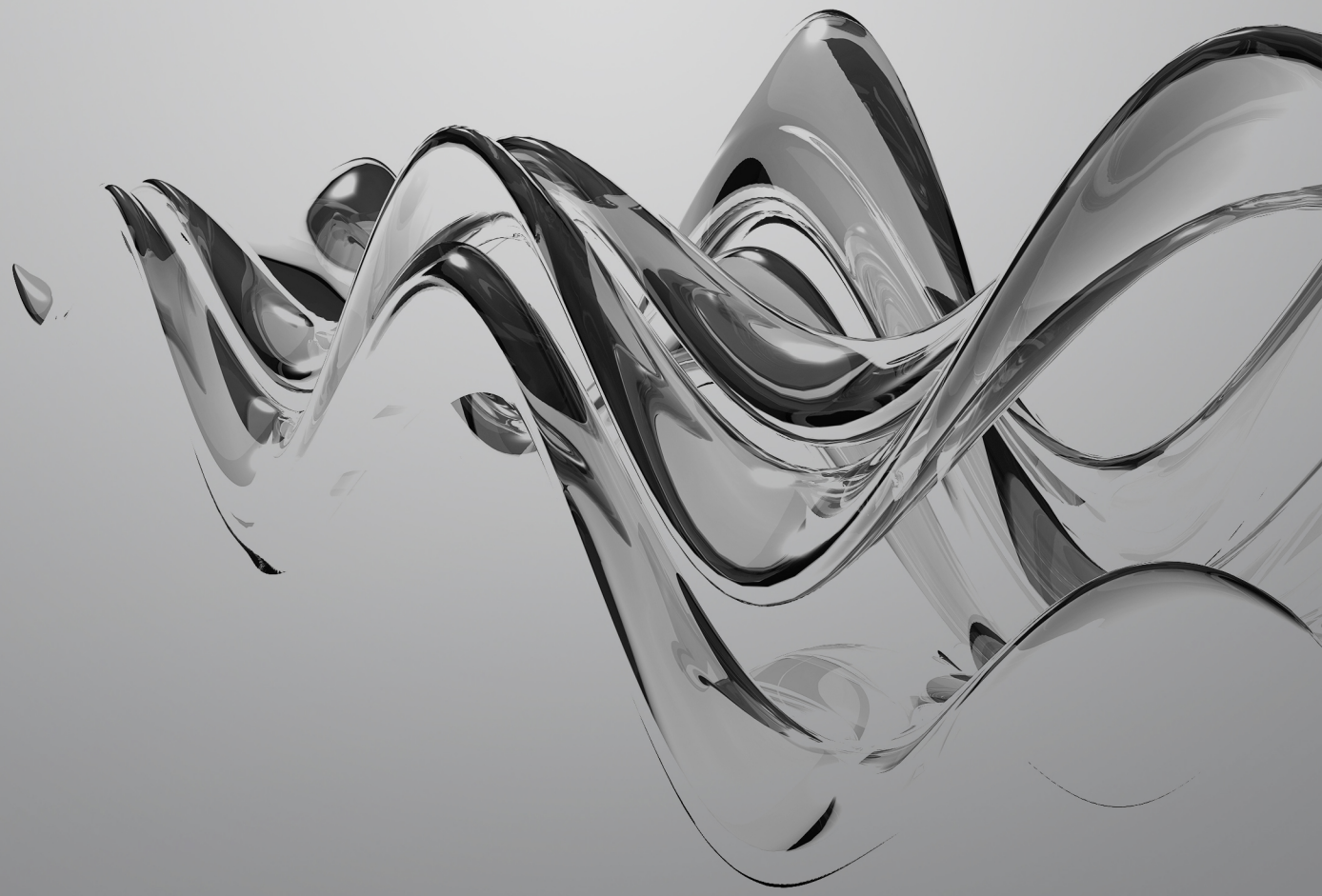
Revision history		
Rev.	**Date.**	**Description**
001	16/10/2023	First Issue

Document Title:	**BLPH Project - Specials: Harmonic Study Report**
Document Number:	K559-2254-CWIWP4202202-E99-006
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Purchase Order:	CWIWP4202202
Code:	E99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

ENGINEERING
TOMORROW

MyDrive® Harmonics Report

1MW Grid converter



Project name: 1MW Grid converter

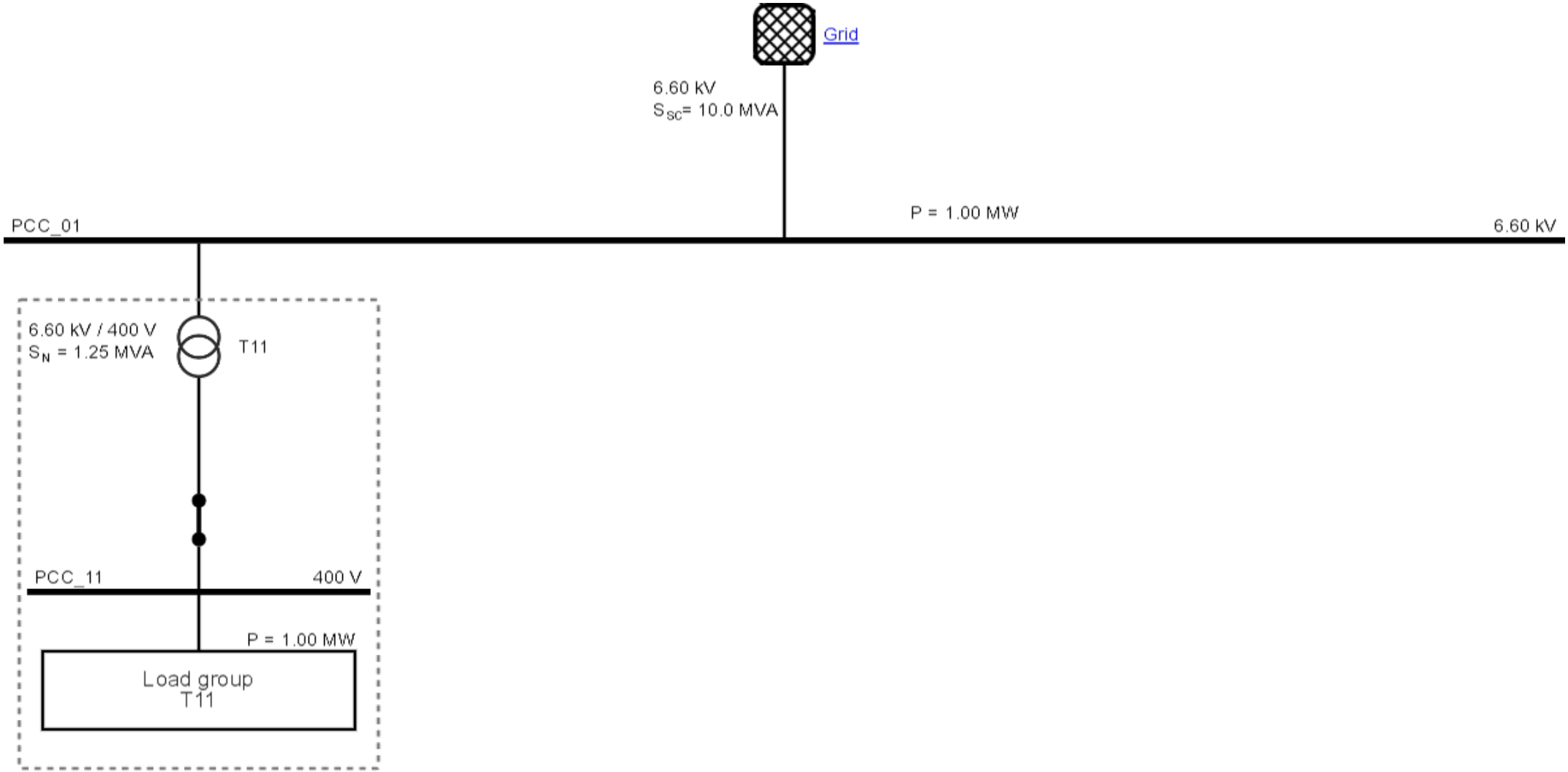
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Frequency	50
Created by	Richard Sørensen
Customer	Ballard
Version	v.1
Date	2023-10-16

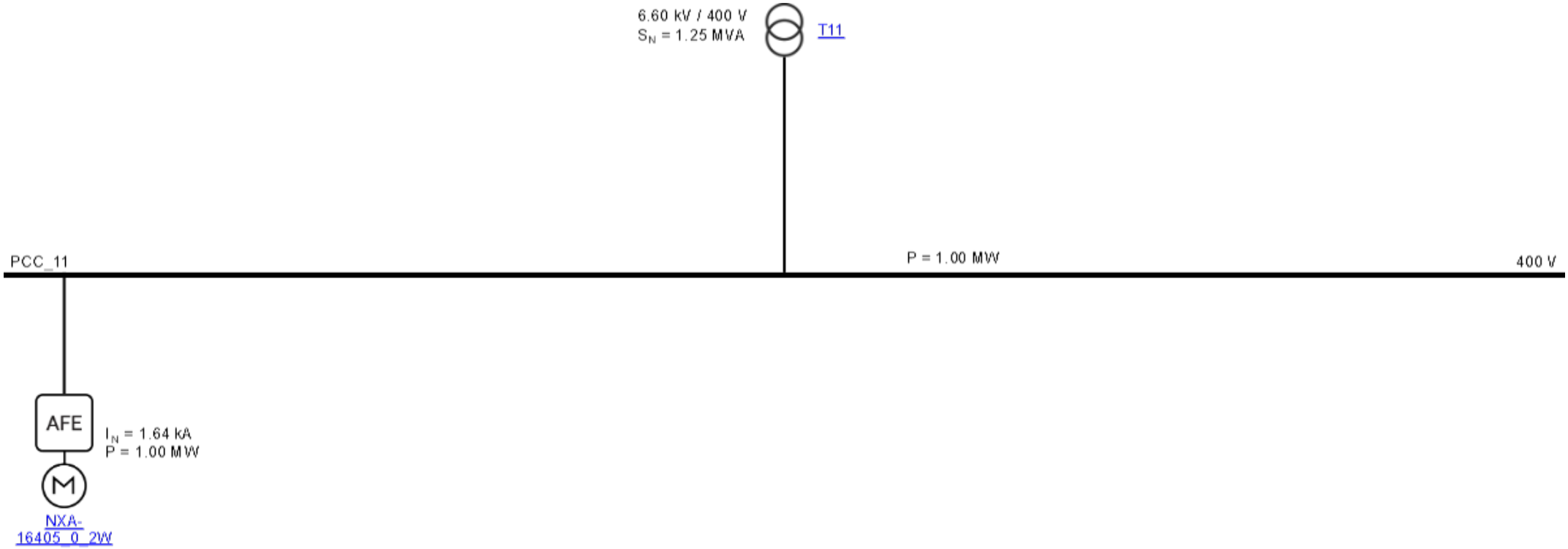
System (1)

Calculation overview

T11 primary side

Voltage THD	0.96 %
Current THD	1.38 %


Grid
6.60 kV
S_{sc}= 10.0 MVA
P = 1.00 MW
PCC_01
6.60 kV
6.60 kV / 400 V
S_N = 1.25 MVA
T11
PCC_11
400 V
P = 1.00 MW
Load group
T11


6.60 kV / 400 V
S_N = 1.25 MVA
T11
PCC_11
P = 1.00 MW
400 V
AFE
I_N = 1.64 kA
P = 1.00 MW
NXA-16405_0_2W

System components

Grid (Grid)

Bus voltage	6.6 kV
Short circuit power	10 MVA
Short circuit X/R ratio	10
Voltage predistortion	0 %
Demand current	80 %

Two winding transformer (T11)

Primary voltage	6.6 kV
Secondary voltage	400 V
Nominal power	1250 kVA
Short circuit voltage	6 %
Ohmic part of short circuit voltage	1.5 %
Primary demand current	80 %
Secondary demand current	80 %

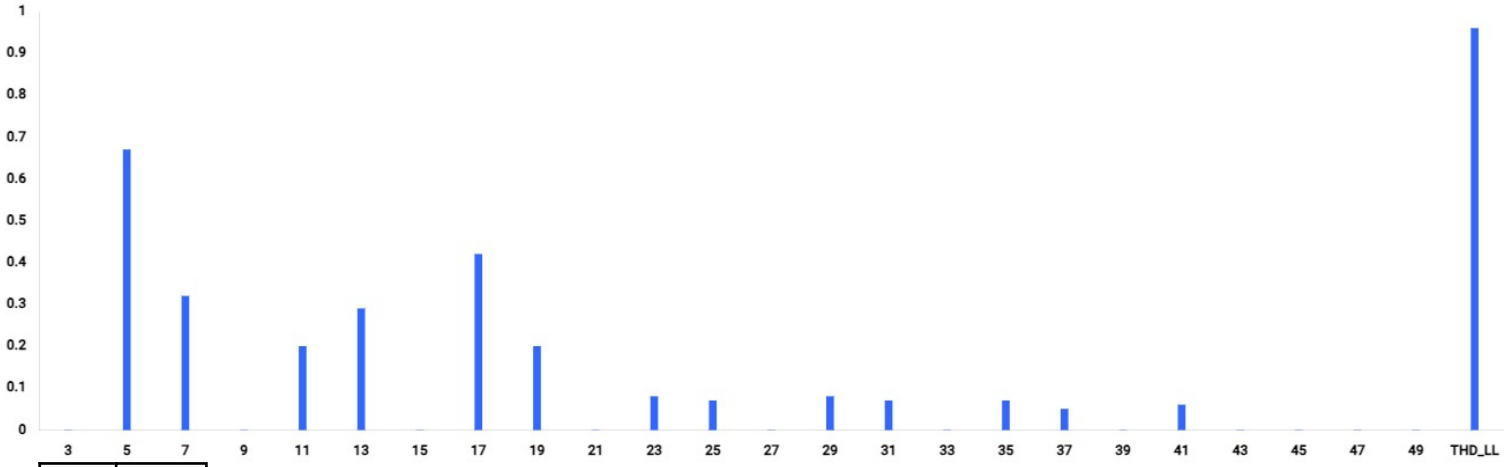
Load group T11

Active front-end (NXA-16405_0_2W)

Quantity	1
Model	NXA-16405_0_2W
Nominal input current	1640 A
DC load power	1000 kW

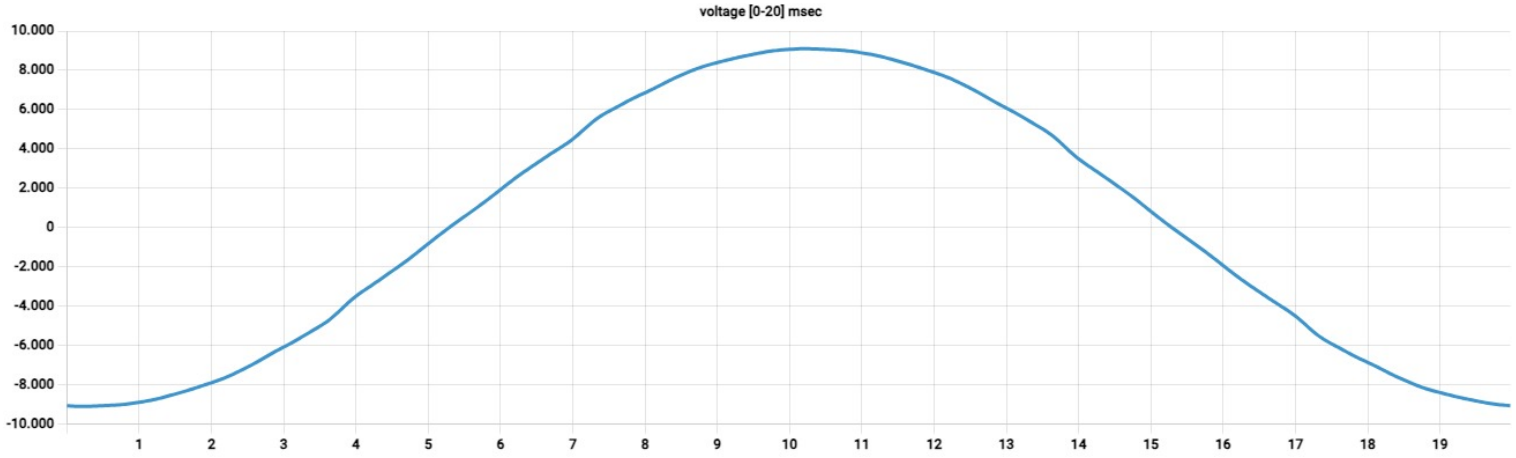
T11 primary side

Volt in % of fundamental



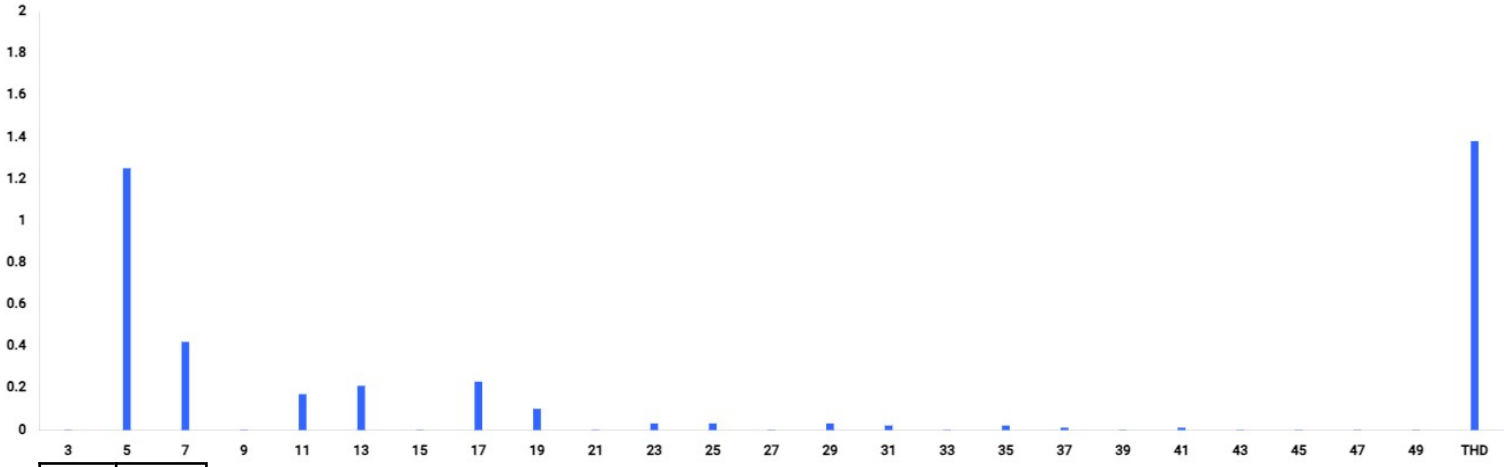
Key	Value
3	0.00
5	0.67
7	0.32
9	0.00
11	0.20
13	0.29
15	0.00
17	0.42
19	0.20
21	0.00
23	0.08
25	0.07
27	0.00
29	0.08
31	0.07
33	0.00
35	0.07
37	0.05
39	0.00
41	0.06
43	0.00
45	0.00
47	0.00
49	0.00
THD	0.96

U_{rms}=3728.22 THD_u=0.96 % (U_{1rms}= 3728.04 V)


voltage [0-20] msec
10.000
8.000
6.000
4.000
2.000
0
-2.000
-4.000
-6.000
-8.000
-10.000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

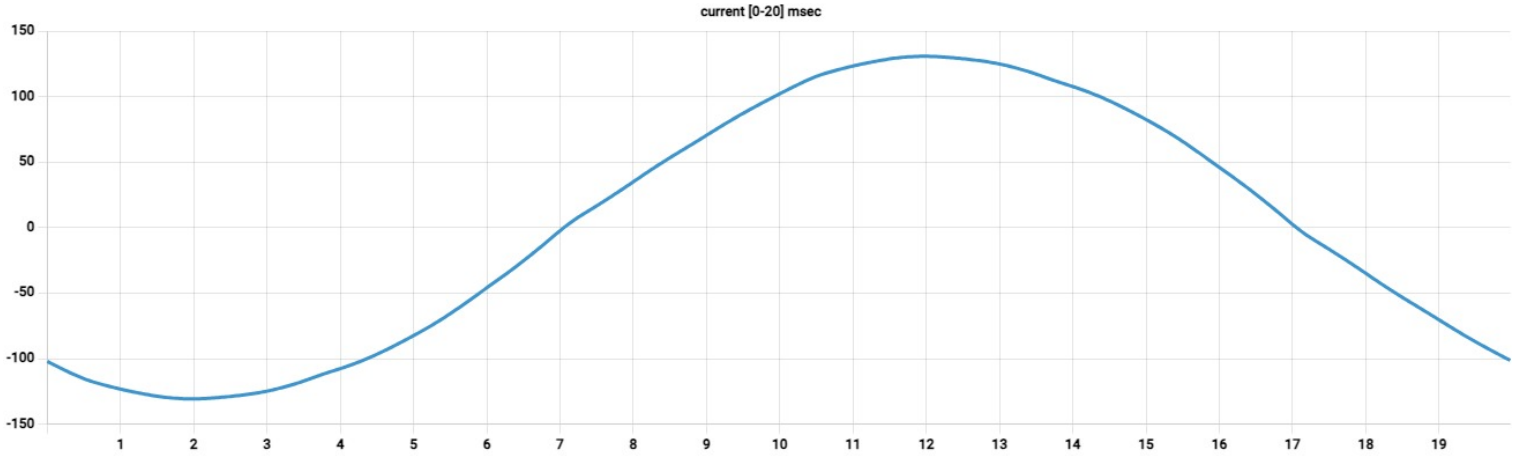
T11 primary side

Current in % of fundamental



Key	Value
3	0.00
5	1.25
7	0.42
9	0.00
11	0.17
13	0.21
15	0.00
17	0.23
19	0.10
21	0.00
23	0.03
25	0.03
27	0.00
29	0.03
31	0.02
33	0.00
35	0.02
37	0.01
39	0.00
41	0.01
43	0.00
45	0.00
47	0.00
49	0.00
THD	1.38

I_{rms}= 92.24THD_i= 1.38 %(I_{1rms}= 92.23 A)



Calculated values at T11 primary side

Displacement Power Factor	1
Fundamental Current RMS	92.23 A
Demand Current RMS	87.48 A
Short Circuit Current/Demand Current RMS ratio	10
Total Harmonic Current RMS	1.27 A
Total Current RMS	92.24 A
Average Active Power	1030.25 kW
Average Apparent Power	1031.7 kVA
Total Harmonic Current Distortion	1.38 %
Total Harmonic Voltage Distortion (Phase)	0.96 %
Total Harmonic Voltage Distortion (Line-to-Line)	0.96 %
True Power Factor (lambda)	1
Fundamental Voltage RMS (Phase)	3728.04 V
Fundamental Voltage RMS (Line-to-Line)	6457.16 V
Total Harmonic Voltage RMS (Phase)	35.92 V
Total Voltage RMS (Phase)	3728.22 V
Total Voltage RMS (Line-to-Line)	6457.46 V
Crest Factor	1.42

The compilation of information in this report (the "Information") relies upon the accuracy of the data entered by the user of MyDrive® Harmonics and of the actual operating and environmental conditions. Several outside factors can influence the harmonics measured on a power system, including other peripheral equipment within the plant and other neighbouring plants. This can include, but is not limited to, frequency converters, variable loads and/or other equipment. The calculated current and voltage harmonics shown may contain inaccuracies and is for estimation purposes only. It is provided "AS IS" without warranty of any kind and does not constitute a guarantee of that the information is complete, current, or correct, and Danfoss accepts no responsibility for unsuitable or inaccurate material that may be encountered. The use of this report does not relieve the user of any obligation or duty that might arise under any legislation covering the activities to which this document has been or is to be applied.

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Section G

Calculations

Sub Section G02

Process Utility Calculations

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Revision history		
Rev.	**Date.**	**Description**
001	17/02/2023	First Issue
002	21/09/2023	Mod. acc. to comments, new values
003	30/11/2023	Modified according to comments

Document Title:	**BLPH Project - Process/Utility Calculations**
Document Number:	TBD
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Purchase Order:	CWIWP4202202
Code:	G02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	G02 – Process/Utility Calculations
Full Title	Calculations demonstrating the sizing basis and criteria of equipment and the associated utilities for the hydrogen fuel cell container for Crosswind/Shell.
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	February 17th, 2023
2.0	Modified according to comments	EZE	September 21st, 2023
3.0	Modified according to comments	EZE	November 30th, 2023

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1.0 Introduction and Purpose

The calculations demonstrating the sizing basis and criteria of equipment and the associated utilities for the hydrogen fuel cell container for Crosswind/Shell are presented in this document.

2.0 References

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-D01-001	BLPH Project – Utilities Schedule	Ballard
K559-2254-CWIWP4202202-C06-001	BLPH Project – Electrical Single Line Diagrams	Ballard
K559-2254-CWIWP4202202-C08-001	BLPH Project – Control Philosophy and Logic Block Diagrams	Ballard
MAN002	FCwave™ Integration Manual v2.2.0	Ballard
Evapco – HT Cooler Datasheet	HT Cooler Datasheet	Evapco
Evapco – LT Cooler Datasheet	LT Cooler Datasheet	Evapco

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3.0 Inputs

3.1 Hydrogen Supply

- Pressure and temperature ranges are per design of FCwave™.
- Min. flow during operation of a single FCwave™ is 0.9 g/s (equivalent to 3.24 kg/h).
- Max. possible H2 flow per design of the FCwave™ is 4.9 g/s.

  → 6 x FCwave™ = 29.4 g/s (equivalent to 105.84 kg/h)

Note: There is no hydrogen consumption when the FCwave™ modules are not running.

3.2 AUX Supply

The AUX power interface supplies all necessary auxiliaries and controls within Ballard's scope while the fuel cells are not running.

The max. theoretical power consumptions for the AUX Supply is equal to 22 kW and is represented by two loads: 16 kW for Space Heating and 6 kW for the Control PSU. This max. possible power consumption occurs only during "keep warm" Standby mode (no operation) with space heating at max. power.

$$\rightarrow I = \frac{22{,}000\ W}{\sqrt{3} \times 400\ V} = 31.76\ A \approx 32\ A$$

The expected loads for the AUX Supply during the different operating modes are summarized as follows:

- Idle: 3 kW + Space Heating (according to table below)
- Standby: 6 kW + Space Heating (according to table below)
- Running: 0 kW
- Startup / Shutdown: 6 kW

Ambient Temperature	Expected Heating Loss (40 ft HC Container)	Expected Heating Loss (10 ft HC Container)	Total Heating Loss (Both Combined)
-20 °C	7.6 kW	2.3 kW	**9.9 kW**
-15 °C	6.2 kW	2.0 kW	**8.2 kW**
-10 °C	4.8 kW	1.4 kW	**6.2 kW**
-5 °C	3.4 kW	< 1 kW	**< 4.4 kW**
0 °C	2.0 kW	< 1 kW	**<3 kW**
5 °C	< 0.5 kW	< 0.5 kW	**<1 kW**
> 5 °C	0	0	**0**

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3.3 MV Link - Input

- This is a bi-directional interface.
- The voltage of 6.6 kV_{ac} and frequency of 50 Hz are the specified interface.
- Power is needed during the following modes:
  - "Startup": 10 kW – 150 kW (depending on number of FCwave™ modules starting at the same time)
  - "Rampdown": ~ 10 kW
  - "Aftercooling": ~ 5 kW

3.4 Total Air Intake (for Process and Ventilation of Container and H_2 Enclosures)

- Temperature and humidity ranges are per design.
- When in “Sleep” mode, where no FCwave™ is running and the container ventilation is OFF, the air intake is equal to 0 g/s.
- Min. air intake during “Standby”, where no FCwave™ is running and the container ventilation is ON, is equal to 135 g/s.
- Max. air intake assumes operation of all six FCwave™ modules at max. power and at a max. ambient temperature of 40 °C (*Ballard-internal design criterion*).
  - Process Air: 6 x 260 g/s = 1,560 g/s
  - H2E ventilation: 6 x 15 g/s = 90 g/s
  - Container ventilation: Rest of the 30,000 m^3/h max. flow (equivalent to ~10,000 g/s) needed to cool the inside of the container so it does not exceed 45 °C, which is the upper limit of the FCwave™ at max. *design* ambient temperature.

  Note: Actual mass flow at 25 °C (max. ambient temperature at project location) is not expected to exceed ~6,000 g/s.

3.5 Cooling Air (for HT and LT coolers)

Assumptions:

- Atmospheric pressure: 101,325 kPa
- Ambient temperature: 25 °C
- RH: 60%
  - Density of air = 1,184 g/m3

Calculations:

- Air flow of HT cooler fans at max. speed (according to manufacturer's datasheet): 47.86 m3/s (equivalent to ~56,500 g/s)
- Air flow of LT cooler fans at max. speed (according to manufacturer's datasheet): 8.81 m3/s (equivalent to ~10,500 g/s)
  - Total for 2 x HT coolers + LT cooler = ~123,500 g/s

4.0 Outputs

4.1 MV Link - Output

- The voltage of 6.6 kV_{ac} and frequency of 50 Hz are the specified interface.
- Max. power output for 6x FCwave™ after power conditioning losses and consumption of auxiliaries (assuming a max. of 12.5% combined) is 1.05 MW.

4.2 Water Drain

Assumptions:

- All hydrogen is electrochemically converted to water.
- All process water exits through the water drain.
- Max. hydrogen flowrate (design criteria) is 4.9 g/s per FCwave™
  - 29.4 g/s for 6 FCwave™ modules.

Calculations:

$$2H_2 + O_2 \rightarrow 2H_2O$$

- 1 mol of H_2 produces 1 mol of H_2O
- H_2 has a molecular weight of 2 g/mol, H_2O has a molecular weight of 18 g/mol
  - 29.4 g/s of H_2 produces 264.6 g/s of H_2O (equivalent to 15.9 L/min)
- Considering any additional water previously present along the process air exhaust and drain system due to changing ambient/operating conditions, a conservative design flowrate of **18 L/min** is assumed.

4.3 Process Air Exhaust

- For a single FCwave™, the process air exhaust mass flow during operation ranges from 100 g/s to 260 g/s.

  → For the container solution with 6x FCwave™, the range during operation is: 100 g/s – 1,560 g/s

4.4 Ventilation Air Exhaust (H_2 Enclosures)

- For a single FCwave™, the mass flow of the hydrogen enclosure ventilation during operation is 750 L/min (equivalent to ~15 g/s).

  → For the container solution with 6x FCwave™, the range during operation is: 15 g/s – 90 g/s

4.5 Ventilation Air Exhaust (Container)

- Outlet max. temperature is based on an estimated max. ΔT of 13 °C at max. ambient temperature of 40 °C (*Ballard-internal design criterion*) and max. fuel cell power with an assumed max. heat of 110 kW, composed mostly of losses that are not rejected by liquid cooling and radiant heat from direct sunlight.
- Max. mass flow is equal to the total max. *design* air intake minus the max. Process Air Exhaust and max. Ventilation Air Exhaust for the hydrogen enclosures:
  - 10,000 g/s - 1,560 g/s - 90 g/s = 8,350 g/s

Note: Actual mass flow at 25 °C (max. ambient temperature at project location) is not expected to exceed ~4,350 g/s.

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Sub Section G11

Reliability and Availability

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Revision history		
Rev.	**Date.**	**Description**
001	2/24/2023	First Issue
002	9/18/2025	Updated, As build

KBR
ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

ACCEPTED	(Code 1)
ACCEPTED WITH COMMENTS	(Code 2)
NOT ACCEPTED	(Code 3)
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DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - Reliability and Availability**
Document Number:	K559-2254-CWIWP4202202-G11-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-G11-001Rev002
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Code:	G11
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	G11 – Reliability and Availability
Full Title	Reliability and Availability for the Fuel Cell container (1MW) for Crosswind Baseload Power Hub

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Revision Record

Rev #	Description	Revised By	Date
1.0	NA,		
2.0	Comments and descriptions for data in Appendix 1 added	JTA	Sept 2025

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4.0 Appendix 1 Maintenance Plan for FCwave™ 200kW 3

1.0 Purpose

The purpose of this document is to give an impression of reliability and availability for the Fuel Cell container (1MW) for Crosswind Baseload Power Hub.

As the Fuel Cell container (1MW) for Crosswind Baseload Power Hub is a first of its kind system, there are no reliability or availability data covering the overall Fuel Cell container (1MW) system.

Most critical components regarding reliability are the FCwave™200kW fuel cell modules. Hence the data presented in appendix 1 is the maintenance plan including Preventive Maintenance intervals for this module.

2.0 Appendix

Table 1: Appendix Documents

Document ID	Short ID	Document Title	Source
SPC5114412-0A	Appendix 1	Maintenance Plan, FCwave™ 200kW	BPSE

3.0 Maintenance Plan for FCwave™ 200kW

The data presented in appendix 1 only coverers the FCwave™ module.

It is required to follow the maintenance plan to ensure trouble-free operation.

Maintenance intervals are influenced by the operating pattern for the system.

Background for the maintenance plan is that the system operates up to 6000 h/year (1500 hours quarterly) and that preventive service is carried out 4 times / year by trained service technicians.

4.0 Appendix 1 Maintenance Plan for FCwave™ 200kW

Maintenance Plan, FCwave™ 200kW

SPC5114412-0A

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Revision Record

Rev.	CO	Description	Date
0A	CO40908	Initial release	2024-01-03

Purpose of Document

The purpose of this document is to inform about the Preventive Maintenance intervals for the FCwave™ 200kW fuel cell module. It is required to follow the maintenance plan to ensure trouble-free operation during the lifetime of the FCwave™ module.

Conducting maintenance requires a certain level of competences. It is assumed that the owner or operator of the FCwave™ employs the right technical skills.
To ensure that the activities are carried out in a correct and safe manner, Ballard offers a dedicated FCwave™ training program consisting of several levels.
It is considered mandatory having participated in- and successfully passed such training prior to executing any work on the FCwave™.

The actual execution is governed by a task and interval reference, the Maintenance Plan, and supported by in-depth instructions collected in the always current version of the Fuel Cell System Service Manual, FCwave™ 200kW.

Conditional Inspections

In the Maintenance Plan below, several routine inspections are listed which shall be carried out according to the specified intervals.

These checks and inspections are intended to support an early-stage detection of any deviation of a condition, which later can cause a malfunction and/or need for intrusive corrective actions.

Conditional Inspection Plan

Covered by sensors in container system

Task	Interval *Whichever comes first		Comments
	Hours	Month(s)	
High Temperature Coolant Sub-system			
Check **coolant level indicator** on header tank.	250	1	Check HT coolant level is between minimum and maximum.
Check **cooling sub-system**.	250	1	Visual inspection for signs of coolant leaks.
Check **stack coolant** conductivity.	1.500	3	Replace **DI filter** (resin cartridge) if conductivity exceeds specification of 5 µS/cm @20°C.
Check **coolant tank level switch**.	6.000	12	Functional check. Replace if needed.
Check **coolant particulate filter** (wedge wire screen) for damage.	6.000	12	Clean filter. Replace if necessary.
H_2 Enclosure and Stack Sub-system			
Check **H_2 Enclosure water ingress sensor**.	3.000	6	Functional check as part of safety verification. Replace if necessary.
Check **differential pressure safety switch**.	3.000	6	Functionality check as part of safety verification.
Check **ventilation inlet flow switch**.	3.000	6	Functional check as part of safety verification.
Check **H_2 sensors**.	3.000	6	Functionality check as part of safety verification. Replace if necessary.
Check **enclosure ventilation fans**.	3.000	6	Functionality check as part of safety verification. Replace if necessary.

Process Air (Cathode) Sub-system			
Check **air filter w/ Mass Air Flow (MAF) meter**.	6.000	12	Replace if necessary.
H_2 Fuel (Anode) Sub-system			
Check **Hydrogen Recirculation Blower (HRB)** for oil leaks. Check elastic coupling element for wear.	6.000	12	Check HRB for oil leaks and replace if necessary. Inspect coupling for wear and replace if clear signs of damage to coupling material.
Check **HRB motor** for signs of wear to bearings, noticeable by wear on coupling element.	6.000	12	Check for vibration levels depending on RPM of the motor.
Cabinet Assembly			
Check **cabinet doors air filters**.	1.000	2	Check condition and replace if necessary.
Check **cabinet water ingress sensor**.	3.000	6	Functional check as part of safety verification. Replace if necessary.
Check **smoke detector**.	3.000	6	Functional check as part of safety verification. Replace if necessary.
Electrical Sub-system			
Check **electrical wire harness**.	6.000	12	Visual inspection of damage to insulation from rubbing against fixation or other objects.
Check **Linear Heat Detector (LHD) / fire wire**.	6.000	12	Visual inspection of visible fire wire. Check functionality. Replace if damage to insulation or lacking function.

Periodic Exchange of Components Due to Wear

Compared to other means of energy provision, the Ballard FCwave™ fuel cell only require a minimal number of components to be changed with fixed intervals in the, prolonged, period between the need for conducting a major overhaul.

Periodic Exchange Plan

Task	**Interval** *Whichever comes first		**Comments**
	Hours	**Month(s)**	
High Temperature Coolant Sub-system			
Change **DI filter** cartridge.	6.000	12	Replace DI filter cartridge.
H_2 Enclosure and Stack Sub-system			
Change **purge valve** due to wear as consequence of accumulated activations.	12.000	24	Replace purge valve.
Process Air (Cathode) Sub-system			
Change **humidifier assembly**.	5.000	10	Replace.
Change **cabinet door air filters**.	6.000	12	Replace filters.
Change **air filter w/ MAF meter**.	12.000	24	Replace filter and sensor.

Components Replaced Due to Safety

Given the FCwave™ module is operated on hydrogen, a corresponding number of dedicated hydrogen sensors are part of the safety system as well as the smoke detector installed in the FCwave™ module cabinet.

Safety Component Exchange Plan

Task	Interval *Whichever comes first		Comments
	Hours	Month(s)	
H_2 Enclosure and Stack Sub-system			
Change **H_2 sensors**.	6.000	12	Replace.
Cabinet Assembly			
Change **smoke detector**.	6.000	12	Replace.

Major Overhaul

Ballard scope

At a certain point of time, just like for any other type of machinery having operated for thousands and thousands of hours, the need for a Major Overhaul is present.
The indication of major overhaul is either by an increased consumption of hydrogen to produce a certain amount of energy, or the module can no longer output maximum energy according to the specification.
The Ballard Customer Care department can assist with evaluation of such need, as well as predict the activity in due time, if a service contract is established which include remote data monitoring.

The upper compartment containing the actual fuel cell stack can be removed by Ballard service technicians within a short period of hours and replaced with a 1-to-1 exchange unit containing a fully refurbished, tested, certified and trouble-free unit.

Owner scope or outsourced to Ballard

The lower unit is considered the BOP, Balance of Plant, for the fuel cell. It contains the systems required for the fuel cell to produce energy, such as air supply- and conditioning plus cooling system consisting of pump, valves, pipes, and heat exchanger.

The BOP components are standard heavy duty industrial designs which can be maintained and serviced by competences with a basic technical experience of marine, industry and/or automotive background, plus the specific training. As such, the required activities for these components at the time of Major Overhaul, can be scheduled in a way causing minimal intrusion of the operation. This is a recommendation however it will be based on owners preferred principle.

Major Overhaul Plan Owner Scope

Task	Interval *Whichever comes first		Comments
	Hours	Month(s)	
High Temperature Coolant Sub-system			
Change all HT coolant.	25.000	60	Replace cooling water as part of major overhaul and stack replacement.
Replace DI filter cartridge.	25.000	60	Replace DI filter.
Check coolant particulate filter (wedge wire screen).	25.000	60	Check for damage and clean. If damaged or perforated, replace with new.
HT coolant pump.	25.000	60	Replace shaft seal, O-rings, and gaskets or entire pump based on owners preferred principle.
HT coolant heat exchanger.	25.000	60	Evaluate the need for de-acidification or backflushing of customer side of heat exchanger.
Low Temperature Coolant Sub-system			
LT coolant condition – replace if necessary.	25.000	60	Evaluate the need for de-acidification or backflushing depending on visual signs of contamination or impurities.
Process Air (Cathode) Sub-system			
Replace cabinet doors air filters.	25.000	60	Replace filters.
Check air filter w/ MAF meter.	25.000	60	Replace filter and sensor.
Replace humidifier assembly.	25.000	60	Replace.
Electrical Sub-system			
Check electrical wire harness and power cables.	25.000	60	Visual inspection of damage to insulation from rubbing against fixation or other objects.
Check Linear Heat Detector / fire wire.	25.000	60	Visual inspection of fire wire in lower cabinet. Replace entire loop if damage to insulation.
Cabinet Assembly			
Check cabinet water ingress sensor.	25.000	60	Functional check, replace if necessary.
Clean cabinet.	25.000	60	Clean internal surface for collected dust and impurities.

Sub Section G24

Emergency Shut Down Valve

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Revision history		
Rev.	**Date.**	**Description**
001	5/31/2023	First Issue
002	9/18/2023	Modified according to comments
003	10/28/2025	Front page updated with Document number

Document Title:	**BLPH Project - Emergency Shut Down (ESD) Valve**
Document Number:	K559-2254-CWIWP4202202-G24-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-G24-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	G24
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	G24 – Emergency Shutdown Valve
Full Title	Calculations and documentation for the hydrogen emergency shutdown valve to be used in the hydrogen fuel cell container for Crosswind/Shell
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	31th of May, 2023
2.0	Modified to address review comments	EZE	18th of September, 2023

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2.0 References 5
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4.0 Appendix A – Datasheet of valve type 10
5.0 Appendix B – Datasheet of explosion proof operator 14

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1.0 Introduction and Purpose

All FCwave™ modules are connected to Emergency Shutdown (ESD) valves. These valves are normally closed and are intended to quickly and reliably stop the flow of hydrogen to the system during emergency situations. Additionally, since these valves are intended for use in potentially explosive atmospheres (ATEX Zone 2), they must also be explosion proof according to Directive ATEX 2014/34/EU.

Furthermore, to provide additional safety in the form of redundancy, each independent FCwave™ supply line is equipped with two identical ESD valves.

The location of the ESD valves can be seen in Figure 1 below.

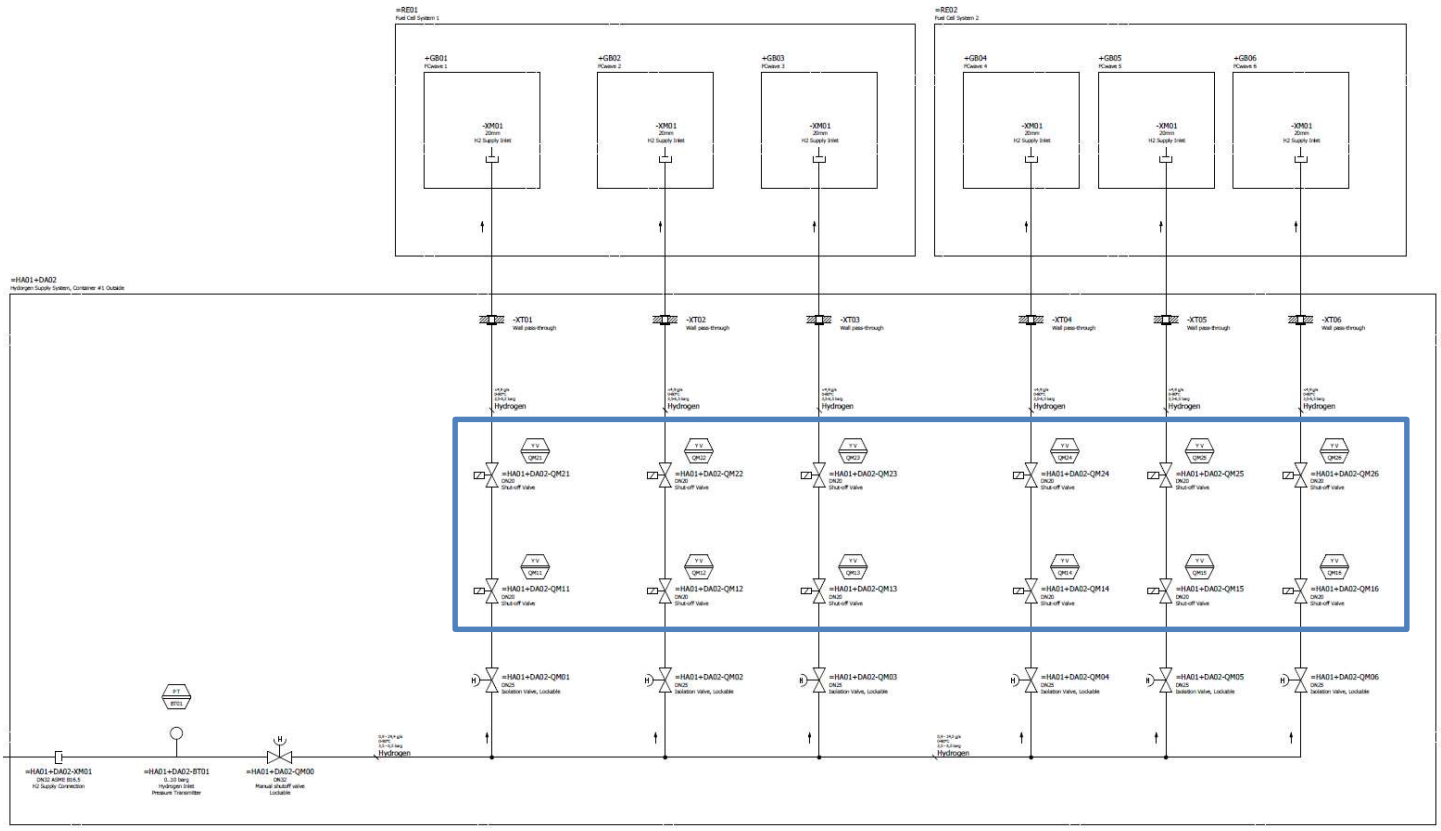


Figure 1. Excerpt of P&ID showing the hydrogen supply system; ESD valves are shown inside the blue rectangle.

The relevant sizing calculations and documentation for these valves are presented in this document.

2.0 References

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-C03-001	BLPH Project – P&IDs	Ballard
K559-2254-CWIWP4202202-E99-002	BLPH Project - Specials: Hazardous Area Layout	Ballard
IEC 60534-2-1:2011	Industrial-process control valves - Part 2-1: Flow capacity - Sizing equations for fluid flow under installed conditions	IEC
MAN002	FCwave™ Integration Manual v2.2.0	Ballard
Emerson – Control Valve Handbook	Control Valve Handbook – Fifth Edition	Emerson
Annex A	ASCO™ Solenoid Valves – Pilot Operated, Hung Diaphragm, 3/8” to 1 ½” (Series 210)	Emerson
Annex B	ASCO™ Operators for potentially explosive atmospheres flameproof enclosure, II 2 G/D Ex db IIC T6..T4 Gb / Ex tb IIIC Db IP66/67 aluminium, stainless steel (NF, WSNF Series)	Emerson

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3.0 Flow Capacity Calculations

In order to size an adequate emergency shutdown (ESD) valve for use in the individual supply lines of each of the six FCwave™ modules in the container solution, the norm IEC 60534-2-1 was used as the basis. The IEC 60534-2-1 specifies the use of the equation below (among other equivalent equations for use with different variables) to determine the minimum flow coefficient K_v required.

Note: *The equation is valid for non-choked turbulent flow without attached fittings.*

$$K_v = \frac{Q_n}{NP_1Y} \cdot \sqrt{\frac{G_g T_1 Z}{x}} \qquad (I)$$

where:

K_V is the flow coefficient for flow rates given in m^3/h.

Q_n is the normal volumetric flow rate of the gas [Nm^3/h].

According to the FCwave™ Integration Manual, the maximum flow rate to each fuel cell module should not exceed 4.9 g/s. Assuming a worst case, we can take 5 g/s (equivalent to **~190 Nm^3/h**) for the calculation.

N is the applicable numerical constant at normal conditions for units given in m^3/h, bar and K (for K_v).

In this case, the value is linearly extrapolated to the application-specific inlet absolute temperature (263 K, see below) from values given for different temperatures on Table 1 of the norm IEC 60534-2-1 and the manufacturer's Control Valve Handbook, and is equal to **439**.

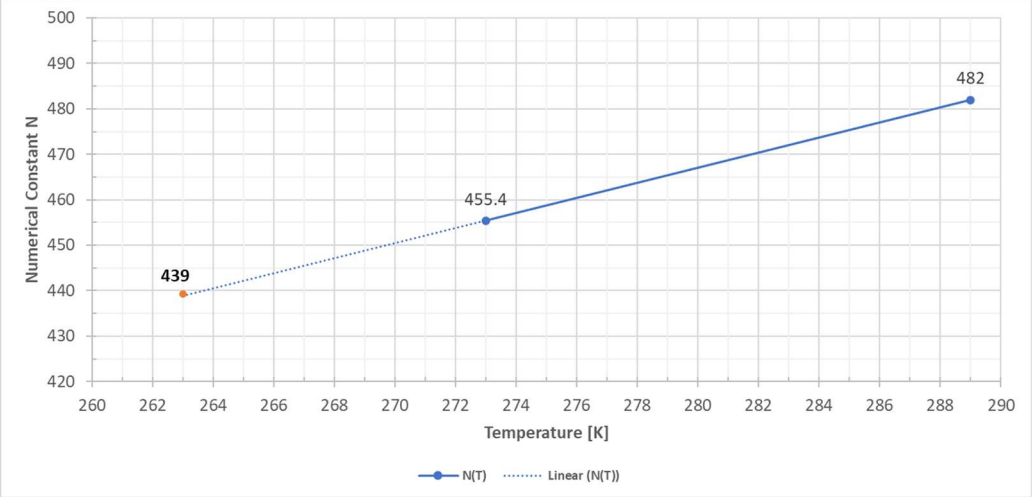


Figure 1. Extrapolation of numerical constant N for min. inlet temperature.

P_1 is the inlet absolute static pressure [bar].

Assuming a worst case in which the supply pressure is lower than the minimum required inlet pressure of 3.5 bar gauge, we can take 3.0 bar gauge for the calculation (**4.0 bar** absolute).

G_g is the gas specific gravity (ratio of density of flowing gas to density of air with both at standard conditions, which is considered in this practice to be equal to the ratio of the molecular weight of gas to molecular weight of air) [dimensionless].

For hydrogen gas, the gas specific gravity is equal to **0.07**.

T_1 is the inlet absolute temperature [K].

Assuming a worst case in which the supply temperature is somewhat below the required -8.4 °C, we can take -10 °C (equivalent to **263 K**) for the calculation.

Z is the compressibility factor at inlet conditions [dimensionless].

At the relative low pressure and temperature for this application, a value of **1.0** can be assumed.

x is the ratio of pressure differential to inlet absolute pressure ($\Delta P / P_1$) [dimensionless].

Assuming a maximum pressure drop of 0.15 bar (estimate based on expert assessment of the specific piping design) and an absolute inlet pressure of 4.0 bar, the ratio of pressure differential would be equal to **0.0375**.

Y is the expansion factor [dimensionless] and is given by:

$$Y = 1 - \frac{x}{3F_\gamma x_\tau} \qquad (II)$$

where:

F_γ is the specific heat ratio factor [dimensionless], as compared to air.

For hydrogen, the specific heat ratio at the given conditions is approx. 1.41 and that of air is 1.4, so the specific heat ratio factor can be assumed to be **1.0**.

x_τ is the pressure differential ratio factor of a control valve without attached fittings at choked flow [dimensionless].

This value is usually determined experimentally and is conservatively assumed here to be **0.5**, which in reality is likely to be considerably higher, giving the calculation an additional safety margin.

Filling in all values in equations *(I)* and *(II)*, we obtain:

$$Y = 1 - \frac{x}{3F_\gamma x_\tau} = 1 - \frac{0.0375}{3(1.0)(0.5)} = 0.975$$

$$Kv = \frac{Q_n}{NP_1Y} \cdot \sqrt{\frac{G_g T_1 Z}{x}} = \frac{190}{(439)(4.0)(0.975)} \cdot \sqrt{\frac{(0.07)(263)(1.0)}{0.0375}}$$

$$\boldsymbol{Kv = 2.46\ (m^3/h)}$$

Based on the calculation above, the valve that was selected is a ¾" direct acting hung diaphragm type valve with a K_v of 3.9 (m^3/h), which should provide a sufficient volume flow under the worst possible conditions assumed (see Appendix A and B for relevant datasheets).

Hung type diaphragms or pistons are mechanically held open (by a solenoid in this case) and are able to operate from the maximum pressure rating all the way down to zero, in that way, a safe closure of the valve can be guaranteed even during one of the most critical situations, which is when a fault is detected while the fuel cell module is on standby, with no hydrogen being consumed and, therefore, with no pressure differential across the valve.

For reference, the full catalog number of the valve selected is **NF X E210C488E 24/DC**. This valve has a metal plug and a metal seat (i.e. metal to metal type), and therefore can be expected to have a Class IV leakage class.

Moreover, rearranging factors of equation *(I)* and using the actual K_v value of the selected valve, we can calculate the pressure differential required to achieve the maximum flow of 190 Nm^3/h at an inlet pressure of 3 bar gauge:

$$\Delta P = \frac{G_g T_1 Z}{P_1}\left(\frac{Q_n}{NK_v Y}\right)^2 \qquad (III)$$

$$\Delta P = \frac{(0.07)(263)(1.0)}{4.0}\left[\frac{190}{(439)(3.9)(0.975)}\right]^2$$

$$\boldsymbol{\Delta P = 0.06\ bar}$$

Similarly, rearranging factors of equation *(I)* and using the actual K_v value of the selected valve together with the estimated maximum pressure drop of 0.15 bar, we can calculate the flow rate at an inlet pressure of 3 bar gauge:

$$Q_n = K_v N P_1 Y \sqrt{\frac{x}{G_g T_1 Z}} \qquad (IV)$$

$$Q_n = (3.9)(439)(4.0)(0.975)\sqrt{\frac{0.0375}{(0.07)(263)(1.0)}}$$

$$\boldsymbol{Q_n = 301\ Nm^3/h}$$

The summary of all three calculations can be found in the table below.

Table 1. Summary of calculations; results are highlighted in bold.

Inlet Pressure [bar_a]	Inlet Temperature [K]	Volumetric Flow [Nm^3/h]	Pressure Drop ΔP [bar]	Flow Coefficient K_v [m^3/h]
4.0	263	190	0.15	**2.46**
4.0	263	190	**0.06**	3.9
4.0	263	**301**	0.15	3.9

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4.0 Appendix A – Datasheet of valve type

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ASCO™ Solenoid Valves

Pilot Operated, Hung Diaphragm, 3/8" to 1 1/2"

2/2
Series
210

Features and Benefits

- *Two way shut-off valves for the control air, inert gas, water, oil and other gases/liquids compatible with the sealing material used*
- *Valves do not require a minimum operating pressure*
- *All products are covered by Pressure Equipment Directive 2014/68/EU and are suitable for group 1 and 2 fluids*
- *The solenoid valves satisfy all relevant EU directives*



General

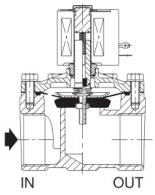
Differential pressure	See «SPECIFICATIONS» [1 bar =100 kPa]
Maximum viscosity	65 cSt (mm²/s)
Response time	15 - 120 ms

Fluids (∗)	Temperature range (TS)	Seal materials (∗)
air, inert gas, water, oil	-20°C to +85°C	NBR (nitrile)

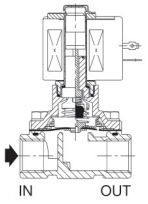
Materials of components in contact with fluid

(∗) Ensure that compatibility of materials in contact with fluids is verified.

	Brass body	Stainless steel body
Body	Brass	AISI 304 SS (AISI 316 SS on request)
Core tube	Stainless steel	Stainless steel
Core and plugnut	Stainless steel	Stainless steel
Springs	Stainless steel	Stainless steel
Seat	Brass	Stainless steel
Seals, diaphragm and disc	NBR	NBR
Disc holder (NO function)	PA	PA
Shading coil	Copper	Silver



NC function



NO function

Electrical characteristics

Coil insulation class	F or H
Connector	Spade plug (cable Ø 6-10 mm)
Connector specification	ISO 4400 / EN 175301-803, form A
Electrical safety	IEC 335
Electrical enclosure protection	Moulded IP65 (EN 60529)
Standard voltages	DC (=) : 24V - 48V
(Other voltages and 60 Hz on request)	AC (~) : 24V - 48V - 115V - 230V / 50 Hz

Prefix option	Power ratings				Operator ambient temperature range (TS) [1]	Replacement coil		Type [2]
	Inrush ~	Holding ~		Hot/cold =		~	=	
	(VA)	(VA)	(W)	(W)	(°C)	230 V/50 Hz	24 V DC	
SC	55	23	10.5	-	-20 to +75	400425-117	-	01
	78	35	16.7	-	-20 to +50	400425-217	-	01
	110	33.6	15.4	12/16.8	-20 to +75	400525-117	400625-142	02
	240	43	20	16.8/23	-20 to +50	400525-217	400625-242	02

[1] 3/8" up to 1" max. operator ambient temperature range (TS) 60°C.
[2] For dimensions, see drawing(s) for each construction type on the following page(s).

Specifications

Pipe size	Orifice size	Flow coefficient Kv		Operating pressure differential (bar) Min.	Max. (PS) Air (∗) ~	Air (∗) =	Water (∗) ~	Water (∗) =	Oil (∗) ~	Oil (∗) =	Power coil (W) ~	Power coil (W) =	Catalog number Brass	Catalog number Stainless steel	Options Maintained manual operator	FPM	EPDM	CR
	(mm)	(m³/h)	(l/min)															
NC - Normally closed																		
Rp 3/8"	16	2.6	43	0	16	16	16	16	-	-	10.5	16.8	**SCE210C493**	-	MO	V	E	J
Rp 1/2"	16	3.4	57	0	16	16	16	16	-	-	10.5	16.8	**SCE210C494**	-	MO	V	E	J
					16	16	16	16	16	-	16.7	16.8	-	**SCE210C487**	MO	V	E	J
Rp 3/4"	19	4.3	72	0	16	16	16	16	-	-	10.5	16.8	**SCE210D495**	-	MO	V	E	J
	16	3.9	65	0	16	16	16	16	16	-	16.7	16.8	-	**SCE210C488**	MO	V	E	J
Rp 1"	25	9.6	160	0	16	16	16	16	16	10	15.4	23	**SCE210B454** [3]	-	MO	V	E	J
													-	**SCE210D489**	-	V	E	J
Rp 1 1/4"	28	12.8	213	0	9	6	9	6	9	4	15.4	23	**SCE210B155** [3]	-	MO	V	E	J
Rp 1 1/2"	32	19.3	322	0	9	5	9	5	9	3	15.4	23	**SCE210B156** [3]	-	MO	V	E	J

[3] Mounting position, DC only: piping horizontal, solenoid upright.

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Series
210

ASCO™ Solenoid Valves

Specifications

Pipe size	Orifice size	Flow coefficient Kv		Operating pressure differential (bar) Min.	Max. (PS) Air (∗) ~	Air (∗) =	Water (∗) ~	Water (∗) =	Oil (∗) ~	Oil (∗) =	Power coil (W) ~	Power coil (W) =	Catalog number Brass	Catalog number Stainless steel	Options Maintained manual operator	FPM	EPDM	CR
	(mm)	(m³/h)	(l/min)															
NO - Normally open																		
Rp 3/8"	16	2.6	43	0	16	16	16	16	16	10	10.5	23	**SCE210C433**	-	-	V	E	J
Rp 1/2"	16	3.4	57	0	16	16	16	16	16	10	10.5	23	**SCE210C434**	-	-	V	E	J
		2.6	43	0	16	16	16	16	10	10	10.5	23	-	**SCE210B430**	-	V	E	J
Rp 3/4"	19	4.7	79	0	16	16	16	16	16	10	10.5	23	**SCE210C435**	-	-	V	E	J
	16	2.6	43	0	16	16	16	16	10	10	10.5	23	-	**SCE210B438**	-	V	E	J
Rp 1"	25	11.2	185	0	16	-	16	-	16	-	20	-	**SCE210B457** (1)	-	-	V	E	J
Rp 1 1/4"	28	12.8	213	0	9	-	9	-	9	-	20	-	**SCE210B058** (1)	-	-	V	E	J
Rp 1 1/2"	32	19.3	322	0	9	-	9	-	9	-	20	-	**SCE210B059** (1)	-	-	V	E	J

(∗) Ensure that compatibility of materials in contact with fluids is verified.
(1) Mounting position: piping horizontal, solenoid upright.

Options

- Valves can also be supplied with FPM (fluoroelastomer), EPDM (ethylene-propylene) and CR (chloroprene) diaphragms, seals and discs. Use the appropriate optional suffix letter for identification
- Waterproof enclosure with embedded screw terminal coil according to protection class IP67, CEE-10
- Explosionproof enclosures for use in zones 1/21-2/22, categories 2-3 to ATEX Directive 2014/34/EU
- Electrical enclosures according to "NEMA" standards are available
- Compliance with "UL", "CSA" and other local approvals available on request
- Mounting brackets for brass bodied valves, suffix MB (Except pipe size Rp 1, 1 1/4 and 1 1/2)
- For protection against corrosion caused by the environment or the fluid, contact us
- Other pipe connections are available on request
- Connector with visual indication and peak voltage suppression or with cable length of 2 m

Installation

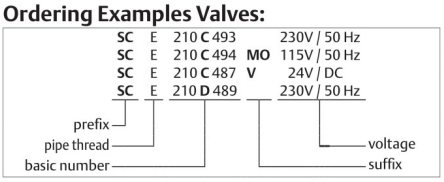
- The solenoid valves can be mounted in any position without affecting operation, unless indicated otherwise in the specifications table.
- Stainless steel valves are standard supplied with mounting brackets
- Pipe connection is E = Rp (ISO 7/1)
- Installation/maintenance instructions are included with each valve

Spare parts kit and accessories

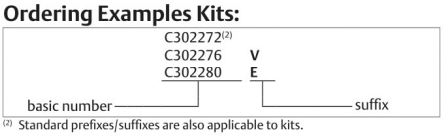
Catalog number	Spare parts kits no. ~	Spare parts kits no. =	Mounting bracket
SCE210C493/C494	**C302272**	**C326540**	**038713-000**
SCE210D495	**C302276**	**C326541**	**038713-000**
SCE210B454	**C302283**	**C326542**	-
SCE210B155	**C302283**	**C133801**	-
SCE210B156	**C302286**	**C133802**	-
SCE210C433/C434	**C326551**	**C326543**	**038713-000**
SCE210C435	**C326552**	**C326544**	**038713-000**
SCE210B457	**C302337**	-	-
SCE210B058	**C302339**	-	-
SCE210B059	**C302340**	-	-
SCE210C487/C488	**C302328**	**C326548**	**standard**
SCE210B430/B438	**C326553**	**C326550**	**standard**
SCE210D489	**C302329**	**C326549**	-

- Not available

Ordering Examples Valves:



Ordering Examples Kits:



(2) Standard prefixes/suffixes are also applicable to kits.

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ASCO™ Solenoid Valves

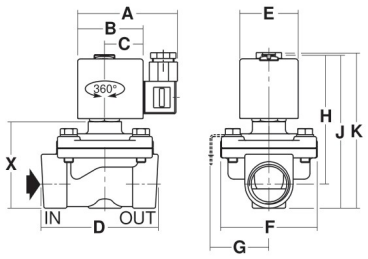
Series **210**

Dimensions (mm), Weight (kg)

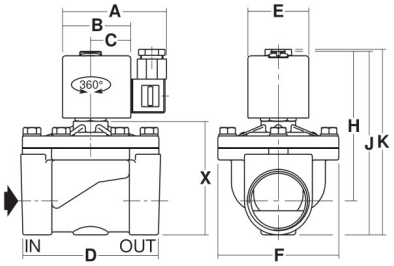


TYPE 01-02
Prefix "SC" Solenoid
Epoxy moulded
IEC 335 / ISO 4400
IP65

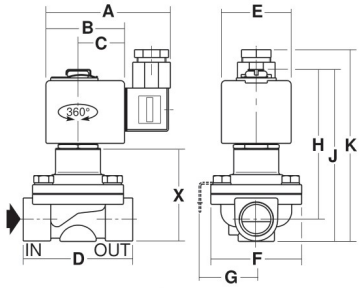
Type 01: SCE210C493/C494/D495 (AC)
SCE210C487/C488 (AC)
Type 02: SCE210C493/C494/D495/C487/C488 (DC)
SCE210D489/B454/B155 (AC/DC)

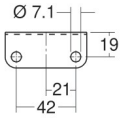


Type 02: SCE210B156 (AC/DC)



Type 01: SCE210C433/C434/C435 (AC)
SCE210B430/B438 (AC)
Type 02: SCE210B457/B058/B059 (AC/DC)





Mounting brackets for valves: (0.3 kg)
SCE210C493/C494/D495
SCE210C487/C488/D489
SCE210C433/C434/C435

Type	Prefix option	Catalog number	A	B	C	D	E	F	G	H	J	K	X	Weight [1]
01	SC	SCE210C493/C494	86	51	30	70	45	58	41	83	98	112	46	0.9
		SCE210D495	86	51	30	71	45	58	41	87	105	119	54	1.0
		SCE210C487/C488	86	51	30	71	45	58	41	87	105	119	55	1.0
		SCE210C433/C434	86	51	30	70	45	58	41	95	109	120	60	0.9
		SCE210C435	86	51	30	71	45	58	41	99	117	127	68	1.0
		SCE210B430/B438	86	51	30	71	45	58	41	98	116	127	67	1.0
02	SC	SCE210C493/C494	91	56	33	70	50	58	41	93	107	104	46	1.0
		SCE210D495	91	56	33	71	50	58	41	97	115	111	54	1.1
		SCE210C487/C488	91	56	33	71	50	58	41	97	116	112	55	1.1
		SCE210D489	91	56	33	95	50	98	41	112	134	134	75	2.2
		SCE210C433/C434	91	56	33	70	50	58	41	101	116	112	60	1.1
		SCE210C435	91	56	33	71	50	58	41	105	123	119	68	1.2
		SCE210B430/B438	91	56	33	71	50	58	41	105	123	119	67	1.1
		SCE210B454	91	56	33	95	50	83	-	114	134	131	75	2.0
		SCE210B457	91	56	33	95	50	83	-	155	176	160	98	2.1
		SCE210B155	86	56	33	95	50	83	-	112	143	148	86	2.0
		SCE210B156	86	56	33	111	50	99	-	125	153	158	96	2.8
		SCE210B058	86	56	33	95	50	83	-	161	187	187	130	2.0
		SCE210B059	86	56	33	111	50	99	-	167	194	194	137	2.5

[1] Incl. coil(s) and connector(s)

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5.0 Appendix B – Datasheet of explosion proof operator

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ASCO™

OPERATORS

for potentially explosive atmospheres
flameproof enclosure
II 2G/D Ex **d** IIC T6..T4 Gb / Ex **tb** IIIC Db IP66/IP67
aluminium or stainless steel enclosure

Series
NF
WSNF

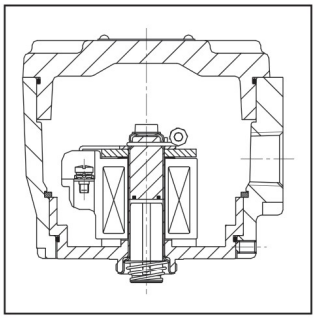
FEATURES

- *Explosionproof operator for use in potentially explosive atmospheres according to ATEX-Directive 2014/34/EU*
  EC type examination certificate no.: ***LCIE 00 ATEX 6008 X***
  IECEx Certificate of Conformity no.: ***IECEx LCI 07.0015X***
- *Compliance with the Essential Health and Safety Requirements has been assured by compliance with the International and European Standards EN-IEC 60079-0, EN-IEC 60079-1 and EN-IEC 60079-31*
- *Easy electrical installation by means of a screw terminal coil*
- *Enclosure provided with a 1/2 NPT threaded entry hole (M20 x 1,5 in option) for a broad range of cable entries*
- *Ingress protection degree IP66/67*
- *A wide range of valves can be supplied with the operator*



CONSTRUCTION

Solenoid enclosure	NF	Chromated aluminium, epoxy coated
	WSNF	Stainless steel (AISI 316L)
Bonnet	NF	Steel (zinc plated)
	WSNF	Stainless steel (nickel plated)
Core, core tube and plugnut	all	Stainless steel
Shading coil	all	Copper or silver
Nameplate	NF	Stainless steel
	WSNF	Stainless steel
Coil connection	all	Embedded screw terminals
Fasteners & screws	all	Stainless steel
Safety code		IECEx / Ex II 2G Ex d IIC T6..T4 Gb IECEx / Ex II 2D Ex tb IIIC 85°C..135°C Db IP66/67



ELECTRICAL CHARACTERISTICS

Standard voltages	DC (=) : 24V - 48V
(Other voltages and 60 Hz on request)	AC (~) : 24V - 48V - 115V - 230V[3] / 50 Hz

TEMPERATURE CLASSIFICATION TABLES

AC (~) solenoids

Pn (watt)	solenoid size MXX	solenoid size M12			maximum ambient °C [1] surface temperature T6 85°C	T5 100°C	T4 135°C	T3 200°C
insulation class F/H (155°C/180°C) 100% E.D.								
1,85[2][3]		●			75	80		
3,7 [2]		●			60	75	100	
5,8 [2]		●			60	75	100	
10,0 [2]	●				40	60	75	
10,0 [2]		●			40	60	100	
10,5	●				25	40	60	
13,4 [2]	●				40	60	75	
14,1 [2]		●			40	60	90	
15,4		●			25	40	60	
16,5		●			40	60	75	
16,7	●					25	40	
20,0		●				25	40	
20,5	●						25	
28,0		●					25	

DC (=) solenoids

Pn (watt)	solenoid size MXX	solenoid size M12			maximum ambient °C [1] surface temperature T6 85°C	T5 100°C	T4 135°C	T3 200°C
insulation class F/H (155°C/180°C) 100% E.D.								
1,8		●			75	80		
3,6		●			60	75	100	
5,7		●			60	75	100	
10,0		●			40	60	100	
11,2	●				40	60	75	
14,0		●			40	60	90	
16,8		●			40	60	75	
19,7	●				25	40	60	
23,0		●			25	40	60	
26,6		●			25	40	60	
29,5		●				25	40	
36,2		●				25	40	

Check the wattage compatibility with the product selected.
[1] **The minimum allowable ambient temperature is -60°C for the operator.** Actual temperature range can be limited depending on valve operation limits.
[2] AC (~): rectified coil construction.
[3] 230 V AC does not exist (Pn 1,85 W).

ORDERING INFORMATION

A valve supplied with the explosionproof operator will be identified with prefix NF or WSNF before the catalogue number.

Example: **NF** E 210D095 230V/50 Hz

- **NF** — operator
- E — pipe thread ISO 7/1
- 210D095 — basic number
- 230V/50 Hz — voltage

A valve supplied with the explosionproof operator will be identified with electrical interface FN, FS, FT or FU in the 15-digit product code.

15-DIGIT PRODUCT CODE

E 262 K 232 **FN** V00 H1

- E — Thread connection
- 262 — Product series
- K — Revision letter
- 232 — Valves version
- **FN** — **Electrical interface**
  - **FN** = NF
  - **FS** = WSNF
  - **FT** = NFET
  - **FU** = WSNFET
- V00 — Options
- H1 — Voltage - class

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Explosionproof equipment - 3

ASCO™

OPERATORS SERIES NF/WSNF

OPTIONS

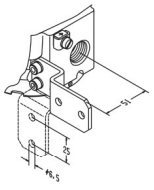
- Operators for mining, I M2 Ex d I, contact us

ORDERING EXAMPLES:

NF	B	327 B 001		230V / 50 Hz
NF	G	551 B 405		230V / 50 Hz
NFET	G	327 B 001	V	230V / 50 Hz
WSNF	E	272 A 047	MS	24V / DC
WSNF	B	320 A 184	E	24V / DC

prefix
pipe thread
basic number
voltage
suffix

MOUNTING BRACKET



Bracket kit no. **C139824**
contains: Stainless steel 304 SS screws and bracket

15-DIGIT PRODUCT CODE

E	262	K	232	**FN**	V00	H1
E	262	K	232	**FS**	V00	F8
E	262	K	232	**FT**	V00	FT
E	262	K	232	**FU**	V00	H9

Thread connection
Product series
Revision letter
Valves version
Electrical interface
Options
Voltage - class

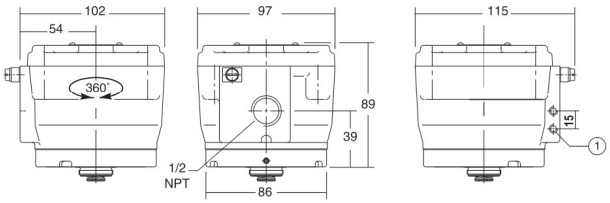
CONNECTIONS

- Any ATEX approved cable entry device can be fitted in the 1/2 NPT threaded entry hole (M20 x 1.5 in option). Refer to the nameplate for identification of the maximum cable temperature
- Internal and external earthing connection
- The operator can be rotated through 360° to select the most favourable position for cable entry

DIMENSIONS (mm), **WEIGHT** (kg)



TYPE NF-WSNF
Prefix "NF" , "WSNF" Solenoid / Electrical interface FN/FS/FT/FU
Aluminium, stainless steel
(NF, epoxy coated)
EN-IEC 60079-1 and EN-IEC 60079-31
II 2G Ex d IIC Gb, II 2D Ex tb IIIC Db IP66/67



series	weight
NF	1,4
WSNF	2,7

(1) 2 mounting holes M5, depth 9 mm

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4 - Explosionproof equipment

Sub Section G99-001

IEC60079-10 Analysis

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	Date.	Description
001	28/08/2024	First Issue
002	29/11/2024	Updated according to comments and implemented exhaust and drainage
003	19/03/2025	Corrected according to Code 2 comments
004	01/05/2025	Corrected rev 003 according to comments

Document Title:	BLPH Project - IEC60079-10 Analysis
Document Number:	K559-2254-CWIWP4202202-G99-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-G99-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	G99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

IEC 60079-10 Analysis 601456B Crosswind

Full Title: EN IEC 60079-10-1 Analysis, Crosswind 1MW MEGAblock

Abstract: EN IEC 60079-10-1:2021 is intended to be applied where there may be a presence of flammable gas or vapor mixed with air. This is done by classifying areas where gas/air mixtures may be present into zones. Suitable design choices can be made based on the analysis, to eliminate the ignition hazard in the identified zones.

In this report, two areas are evaluated: the fuel connection to FCwave and External hydrogen handling unit.

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1.0 Executive Summary

Two areas were evaluated using the methodology described in EN IEC 60079-10-1:2021:

1. Fuel connection to FCwave: due to the presence of continuous ventilation, and the quality of the ventilation as well as the ventilation speed surrounding the connection the area is considered non-hazardous. Those are discussed in further detail in this report.
2. External hydrogen handling unit: this area contains several fittings, flanges and valves fittings, which are considered potential sources of a secondary grade of release. Using natural ventilation present in the external location and the methodology in the standard, it is determined that the fuel connection area should be classified as Zone 2 for hydrogen gas with 1 meter radius.

2.0 Reference documents

Table 2-1: Reference documents

Document no.:	Document name:
ATEX 114	Directive 2014/34/EU – equipment and protective systems intended for potentially explosive atmospheres
K559-2254-CWIWP4202202-E99-002	BLPH Project - Specials: Hazardous Area Layout
EN IEC 60079-10-1:2021	Classification of areas - Explosive gas atmospheres
IEC 62282-3-100:2020	Stationary fuel cell power systems - Safety
K559-2254-CWIWP4202202-C03-001	BLPH Project - P&IDs
MAN002	Integration manual FCWave
K559-2254-CWIWP4202202-B01-001	General arrangement
K559-2254-CWIWP4202202-C99-001	Megablock Hydrogen Safety Concept
EX calc 0B	ATEX zone definition calculations

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3.0 Definitions and Acronyms

Table 3-1: Definitions and Acronyms

Document no.:	Document name:
AC	Alternating Current
BOP	Balance Of Plant
DC	Direct Current
GA	General arrangement
LFL	Lower flammability limit
LEL	Lower Explosion Limit
LT	Low Temperature
HT	High Temperature
PLC	Programmable logic controller
P&ID	Process and Instrumentation Diagram
SIS	Safety instrumented system
HAC	Hazardous area classification
Secondary grade of release (Grade: S)	*Release, which is not expected to occur in normal operation and, if it does occur, is likely to do so only infrequently and for short periods*[1].
Primary Grade of Release	Release which can be expected to occur periodically or occasionally under normal operation[2]
Continuous grade of release	Release which is continuous or is expected to occur frequently or for long periods[2].

4.0 Hydrogen Properties

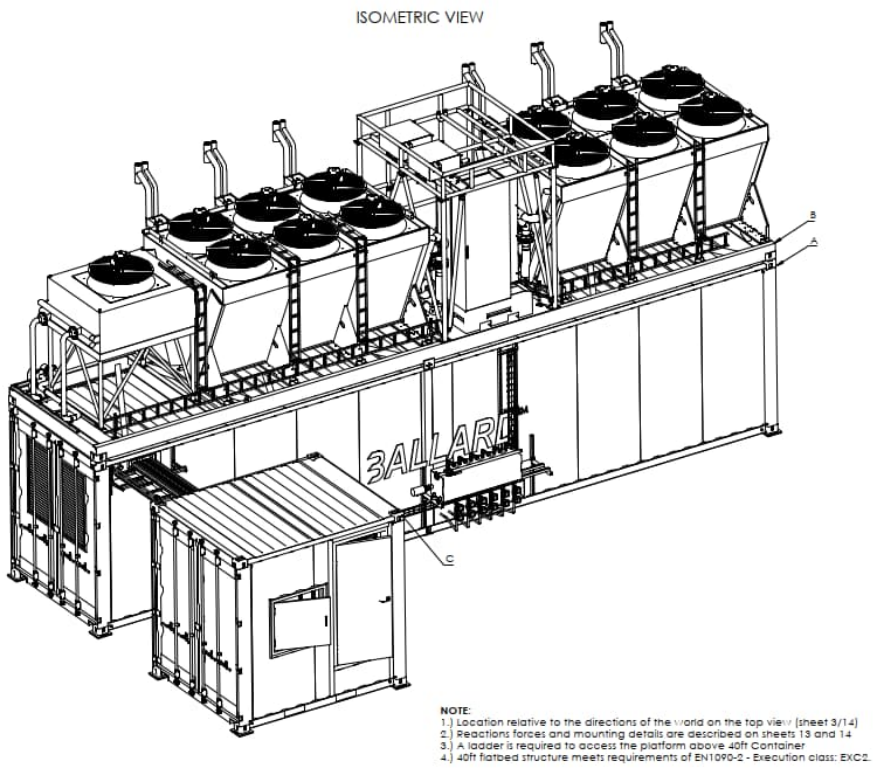
- Refer to Appendix A, Table 10-1
- Critical Pressure 192.1 kPa
- Hydrogen Density 0.08988 kg/m^3 @ 0 ℃

[1] From the definitions given in EN IEC 60079-10-1:2021.

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5.0 Background Information

Figure 1: System installation with auxiliary equipment



System overview of the complete assembled system

5.1 Crosswind 1MW MEGAblock

The FC PowerGen 1000kW® system is comprised of 3 main components:

1. Fuel cell container, 40ft: is an area for installation of the Ballard FCwave module and DCDC converters. Inside the container distribution of HT and LT cooling is done, as well as control system for all BOP components.
2. Power Converter container, 10ft: All the power electronic converting the DC from the FCwaves into AC to the customer, build up in a separate container. The Customer AC connections as well as switchgear and controls for equipment are included in this container.
3. Cooling Unit: An external skid frame containing dry coolers and pumps for cooling the FCwave and power electronic. The skid includes a control cabinet for controlling of valves and fans on the cooling.

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5.2 EN IEC 60079-10-1:2021

Specific terms used in this report are related to EN IEC 60079-10-1:2021, where a specific technical definition is given. Grade of release, zone type, and ventilation class are examples. Please refer to the standard for these definitions.

The standard provides a number of methods for classification of hazardous zones inside and outside of equipment containing flammable gases. The analysis performed and described through this report, follows the “classification by sources of release method” as described in Section 5.2 of the standard.

The general steps are:

- Is a flammable substance present (As described in Annex F, figure F.1.)
- Identify and specify grade of release sources (Continuously, Primary, Secondary).
- Determine the release rate for each source based on likely frequency and duration of release (as described in Annex F, figure F.4.).
- Assess ventilation or dilution conditions and effectiveness.
- Determine zone, based on grade of release and ventilation or dilution effectiveness.
- Determine extent of zone

For secondary grades of release, a process to determine the estimated leak rate and release characteristic is provided. The process relies on a number of calculations which are mentioned in this report but performed in a separate workbook. Results are shown in figures and tables included in this report.

5.3 Safety instrumented system

The safety instrumented system is comprised of a number of safety monitoring devices coupled with a safety controller which, in the event of a faulty condition being detected, stops the flow of hydrogen into the system. The monitoring devices include hydrogen detectors and smoke detectors, Further information on the Megablock Hydrogen Safety Concept referred to in document K559-2254-CWIWP4202202-C99-001.

5.4 P&ID

Several components are mentioned in this report that serve important functions with respect to hydrogen safety. These components and their relative location in the system can be found in the process and instrumentation diagram K559-2254-CWIWP4202202-C03-001 referenced in Section 2. For further details refer to the P&ID documentation.

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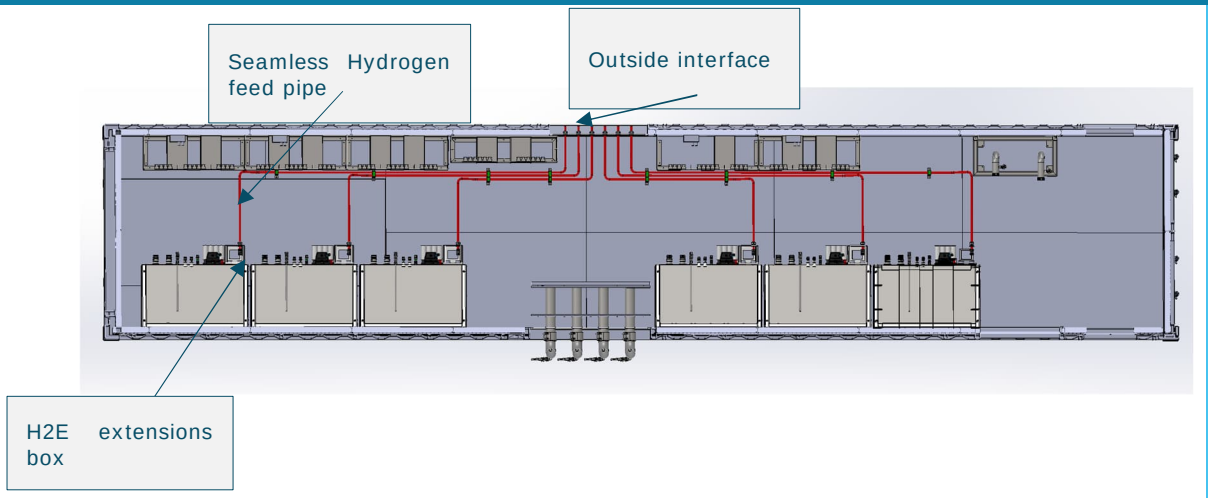
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6.0 Fuel connection to FCwave

Figure 2: Cross section of hydrogen extension box



Top view of the Fuel cell container. The red pipes are the unbroken seamless stainless-steel pipes, for hydrogen. The inlet connection is outside the container, and the outlet (inlet to FCwave) is enclosed in a ventilated space. See details in Figure 3.

6.1 Safety Approach

The hydrogen feed pipes are the connection pipes between the hydrogen interface pipe and the fuel cell module. All pipes are seamless stainless steel. The feed pipe is connected in both ends with a double-ferrule compression fitting. The pipe is a one-piece bended pipe with no welds or connections throughout the full length of the pipe, as illustrated on Figure 2 and Figure 3.

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Figure 3: Cross section of hydrogen extension box

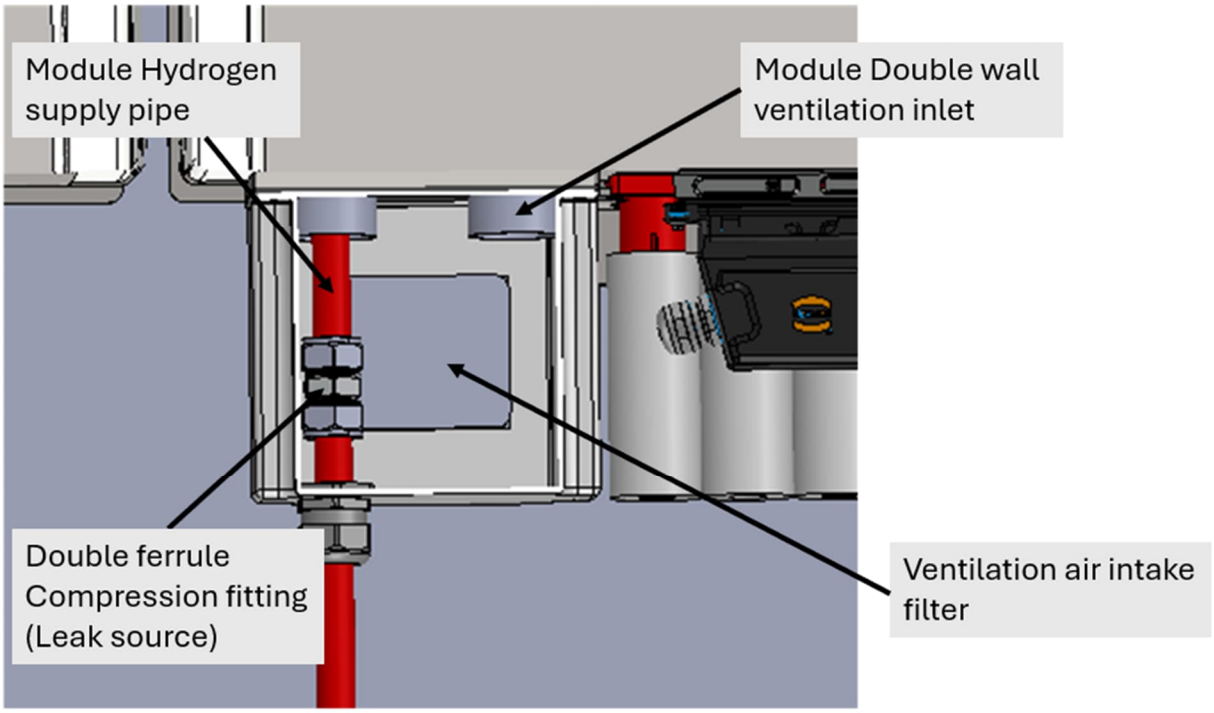


Figure shows a cross cut of the hydrogen enclosure extension. The prime component is the double ferrule compression fitting which is the potential leak

The connection to the fuel cell, from the hydrogen feed pipe, is made with a double-ferrule compression fitting, encapsulated in a ventilated space (box) as an extension of the fuel cell hydrogen ventilation system and the "double walled piping" approach, applied in the FCwave. Hereby transferring all the safety features from the module to this connection.

The FCwave module does not introduce any further risk of leakage due to the construction and certification on the product. For details on this refer to the safety Strategy for the FCwave in document MAN002.

Additionally, the container is equipped with 3 hydrogen sensors. 2 of these hydrogen sensors are located on the roof and near the point where the ventilated air from the container passes by to exhaust the container, so a leak anywhere in the container space will be detected here. The third is located next to the fresh air intake, making sure no hydrogen is introduced into the container from the outside.

The following chapter 6.2 to 6.6 are an assessment of the potential individual leak sources inside the container to determine if there is a local zone or area which requires further consideration.

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6.2 Sources of Release

There is one connection inside the container, hence this will be the only potential source of release. This potential leak will be defined as a secondary grade of release.

6.3 Degree of Dilution

The potential leak (1) in Table 6 1, on the connection to the FCwave module is inside the extension of the hydrogen enclosure, surrounded by forced ventilation. The air velocity in the enclosure surrounding the potential leak is defined: The area of the box is calculated to be: 0,0205m2, with the minimum ventilation flow from the FCwave integration manual (MAN002) being 0,0125m^3/s, resulting in a total air velocity of the ventilation surrounding the potential leak: 0,4062m/s.

Table B.1 from EN IEC 60079-10-1:2021 is used to determine the theoretical hole size (cross section) to estimate the release rate. Input data for the calculation and results are listed in Table 6-1.

Using the equations provided in the standard (ex. B.7.2.3.2 and B.7.2.3.3), release rates are determined for each group. Factoring in the lower flammability limit for hydrogen (4%), the release characteristics are calculated.

Based on the Ventilation velocity and the release characteristics, the degree of dilution is determined to be high, as shown in Figure 4, where the green square indicates the value from the leak source.

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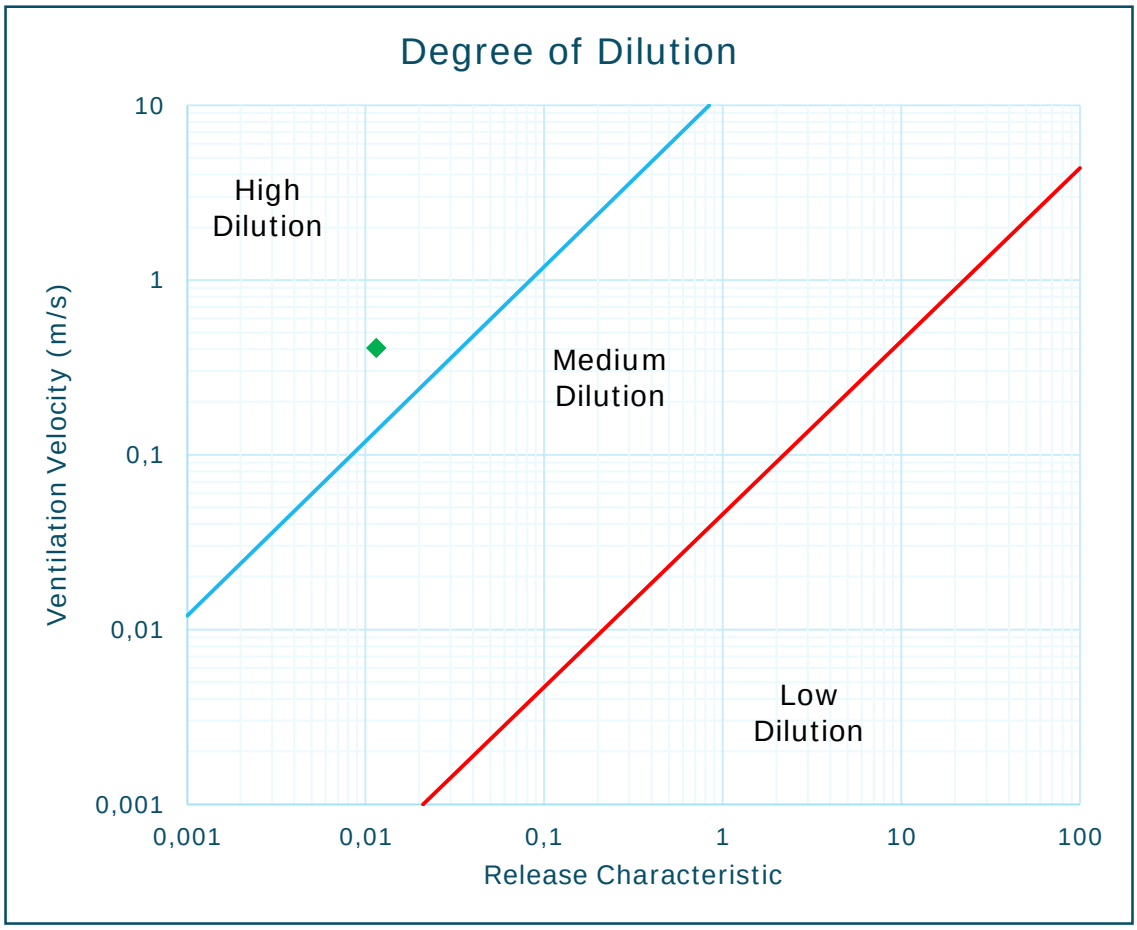
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Figure 4: Degree of Dilution Chart for release sources inside the container



The green point above corresponds to the data in Table 6-1. Points to the left of the blue line have a high degree of dilution, points between the blue and red lines have a medium degree of dilution.

6.4 Classification of Zone

Based on the schematic approach described in Figure F.4 of EN IEC 60079-10-1:2021, the zone classification of a *secondary grades of release* is assessed. The release characteristic and the degree of dilution, as described in Figure 4 and Table 6-1, “Leak 1”, results in a Non-Hazardous zone.

6.5 Extent of Zone

As the potential leak in “Leak 1” is classified to be a non-Hazardous zone, the extent is not calculated.

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6.6 Summary of Fuel connection to FCwave

The process fuel connection to the FCwave is considered non-hazardous due to the safety approach described in Table 6-1.

Table 6-1: *Release sources inside the container (not including FCwave).*

1	2	3	4	5	6	B.1	8	11	12	13	14
	Description	Location	Grade	Rate of Release (kg/s)	Release Characteristic (m^3/s)	Estimate Size of Hole (mm^2)	Operating Pressure (Barg)	Degree of Dilution	Availability	type	Extent (m)
1	M20-M25 Hy-lok double ferrule compression fitting reducer	Connection to FC wave module inside H2E extension box	S	3,62E-05	0,0115	0.1	10	High	Good	Non-Hazardous	none

The table is built up after the "Hazardous Area Classification data sheet" from Table A.2 – EN IEC 60079-10-1:2021. The data listed is equivalent to the "ATEX zone definition calculation document". Not all columns from Table A.2 are given in this table. Notes to columns:

1. The release source has reference "Leak 1" in the calculation document.

4. Grade: S. the Hy-lock connection is one of the tightest pipe connection methods on the market, hence only rare leakages are to be expected from this connection type.

5,6. Calculated based amongst others on the estimated hole size (after table B.1) and the maximum operation pressure in the pipes (8). (same as 6, but another unit)

B.1: from table B.1 in EN IEC 60079-10-1:2021 and based on sealing element type.

8. The maximum operating pressure is used in the calculations.

9. Releases are all "G" for gas type

10. Ventilation type is "Forced ventilation"

11. Based on the release characteristics and the available ventilation, figure C.1 from the standard, points to a "High" dilution.

12. The availability is specified as good, due to the safety/redundancy built into the ventilation pf the given space.

13. looking at table D.1 from the standard, the conditions: Secondary release, high dilution, good availability of ventilation points to "non-hazardous".

14. as the zone is classified to be "Non-hazardous", based on dilution and ventilation, the extend is Not applicable.

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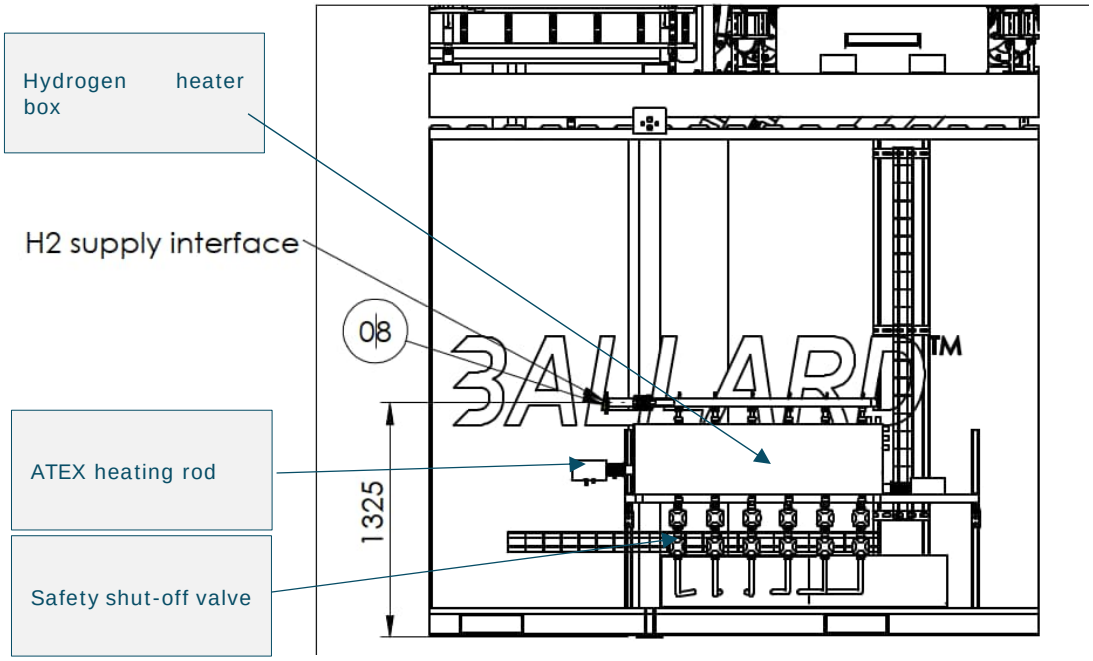
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7.0 External hydrogen handling unit

The fuel connection area is where the customer connects the hydrogen fuel supply to the fuel cell container. The external hydrogen handling unit also contains two in series safety shutoff valves as well as hydrogen heater for preheating the hydrogen in subzero conditions.

Figure 5: External hydrogen handling unit



The fuel connection area and safety shutoff valves are placed outside of the container, in free air.

The key elements of the "hydrogen handling unit" is pointed out in the figure.

7.1 Safety Approach

The fuel connection area outside the container contains a large number of fittings, flanges, and valves which may cause a secondary grade of release, at some point in the life of the product. As a hazardous zone is determined through the analysis, proper zone identification shall be made and the component and equipment in the area must be of the appropriate equipment category (EX approved). The extend and placement of the identified zone will be communicated to the integrator and end user in a general arrangement drawing K559-2254-CWIWP4202202-B01-001.

7.2 Sources of Release

There are three types of components which qualify as a potential source of release;

- fittings, flanges and valve stem packing.

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The Hydrogen handling unit consists of several individual fittings, flanges and connections, which are grouped in Table 7-1 below. Background hydrogen concentrations is not considered, as the system is not allowed to be installed in an already existing EX zone. All leaks are rated to be “secondary grade of release”, so according to EN IEC 60079-10-1:2021 Annex B section B4, one leak at a time is only considered.

7.3 Degree of Dilution

For outdoor locations where natural ventilation is available, a minimum ventilation velocity (for dilution) can be determined based on the location of the sources of release. Using Table C.1 from the standard, an estimated wind velocity or speed of buoyancy of worst case 0.5 m/s was determined based on:

- release of lighter than air gas.
- obstructed area less than 2 meters above ground.

Combined with the release characteristics from Table 7-1, the degree of dilution is determined to be “High” on “Leak 2,3”, and Medium at “Leak 4,5,6”, See Figure 6, where each leak source is plotted in to the diagram.

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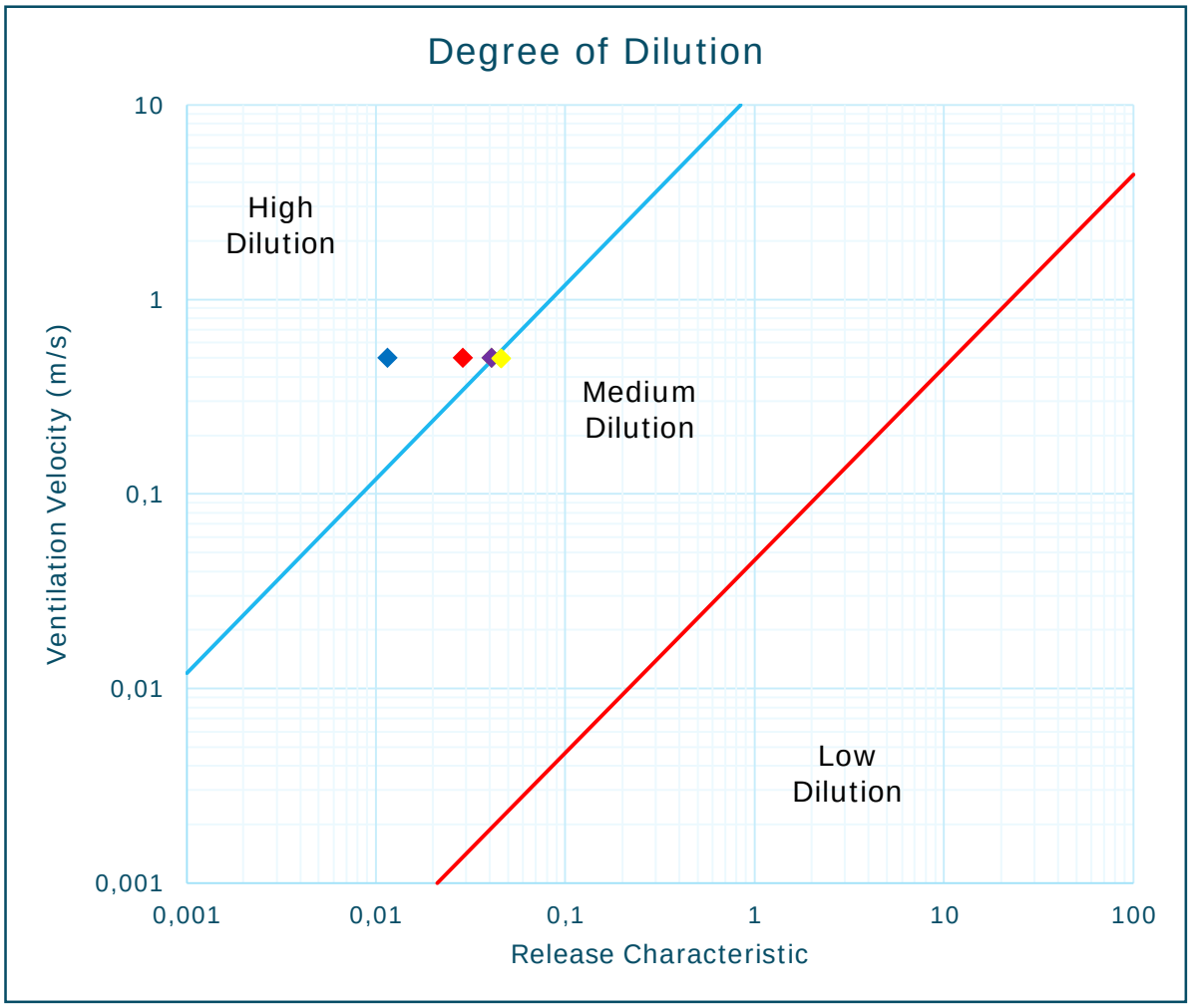
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Figure 6: Degree of dilution chart for connections on hydrogen handling unit.



The colored points in the chart correspond to the color groups in Table 7-1. Points to the left of the blue line have a high degree of dilution, points between the blue and red lines have a medium degree of dilution.

7.4 Classification of Zone

Based on the schematic approached described in Figure F.4 of EN IEC 60079-10-1:2021, the zone classification of a *secondary grades of release* is assessed. The release characteristic and the degree of dilution, as described in Figure 6 and Table 7-1, “Leak 2,3”, results in a Non-Hazardous zone and “Leak 4,5,6” result in a Zone 2, with max 1 m extend.

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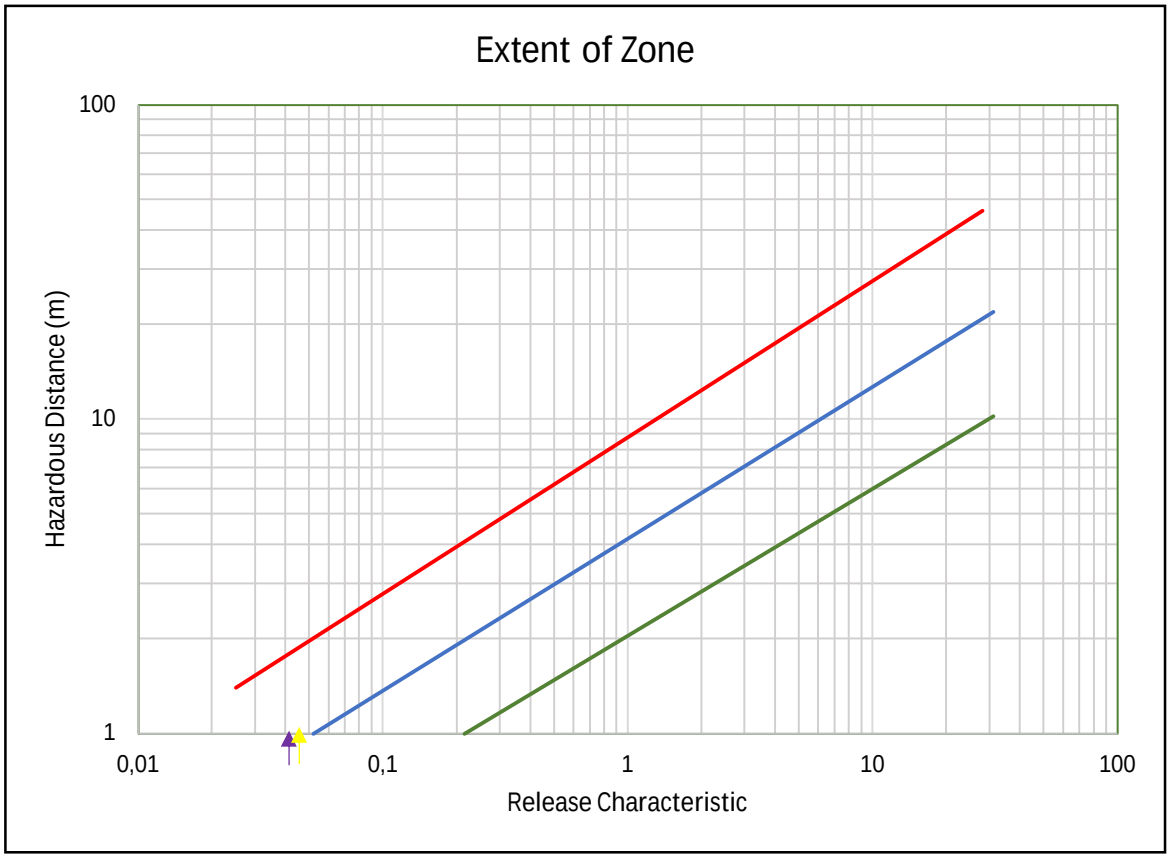
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7.5 Extent of Zone

Figure D.1 from EN IEC 60079-10-1:2021 is used as basics for the zone extend assessment. For the area around the "hydrogen handling unit", it is determined that all potential hydrogen releases will be jet type based, due to the high velocity of the modelled releases and the relative density of hydrogen to air. Based on the release characteristics specified in Table 7-1, it is found that the potential component releases from "Leak 5,6,7,8" would result in a zone that would be less than 1 meter in extent, see Figure 8. Since the minimum distance is 1 meter, the zone is defined to be 1m from the release source.

Figure 7: Extend of zone.



The colored points in the chart correspond to the color groups in Table 7-1. All points are below the line, determine the zone size.

7.6 Summary of External hydrogen handling unit

There are numerous fittings and valves (packing) that could leak at some point over the lifetime of the Fuel cell container. These leaks would generate jet plumes that would be relatively small and would dilute quickly. This analysis shows that adequate dilution would occur within 1 meter of the source. Therefore a 1 meter, Zone 2 setback should be

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established for the fuel connection area and components inside the zone should have the proper ATEX (Ex) rating.

Table 7-1: List of leak sources identified in the External hydrogen handling unit.

1	2	3	4	5	6	B.1	8	11	12	13	14
	Description	Location	Grade	Rate of Release (kg/s)	Release Characteristic (m^3/s)	Estimate Size of Hole (mm^2)	Operating Pressure (Barg)	Degree of Dilution	Availability	Zone type	Extent (m)
2	M25 Hy-lok double ferrule compression fitting	External connection to fuel cell container	S	3,62 E-05	0,0115	0,1	10	High	Fair	Non-Hazardous	<1
3	M25 to 3/4 BSPP + bonded seal Hy-lok double ferrule compression fitting	Connection to SOV	S	9,05 E-05	0,0288	0,25	10	High	Fair	Non-Hazardous	<1
4	Emerson Solenoid valve	Below H2 heater	S	0	0	0	10	NA	NA	Non-Hazardous	NA
5	Hy-lok Manual shut off valve	Above H2 heater	S	1,28 E-04	0,0409	0,25	10	Medium	Fair	Zone 2	<1
6	Flange connection	Customer interface	S	1,43 E-04	0,0457	0,25	10	Medium	Fair	Zone 2	<1
7	DVC main shutoff valve	Above H2 heater	S	1,28 E-04	0,0409	0,25	10	Medium	Fair	Zone 2	<1
8	DVC main shutoff flanges	Above H2 heater	S	1,43 E-04	0,0457	0,25	10	Medium	Fair	Zone 2	<1

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Table 7-1: List of leak sources identified in the External hydrogen handling unit.

The table is built up after the “Hazardous Area Classification data sheet” from Table A.2 – EN IEC 60079-10-1:2021. The data listed is equivalent to the “Atex zone definition calculation document”. Not all columns from Table A.2 are given in this table. Notes to columns:

1. The release source has reference “Leak 2-6” in the calculation document.

4. Grade: S. The Hy-lock connection, fittings and valves are selected due to their qualities in tightness, hence only rare leakages is connection with fault conditions are to be expected from this connection type.

5,6. Calculated based amongst others on the estimated hole size (after table B.1) and the maximum operation pressure in the pipes (8). (same as 6, but another unit)

7. No references used

B.1: from table B.1 in EN IEC 60079-10-1:2021 and based on sealing element type.

8: The maximum allowable operating pressure is applied in the calculations.

9. Releases are all “G” for gas type

10. Ventilation type is “Natural”

11. Based on the release characteristics and the available ventilation, figure C.1 from the standard, points to a “High” dilution from leak 2,3 and a medium dilution from leak 4,5,6.

12. The availability is specified as good, due to the ventilation being “natural”.

13. looking at table D.1 from the standard, the conditions: Secondary release, high dilution, good availability of ventilation points to “non-hazardous”. The conditions: Secondary release, medium dilution, good availability of ventilation points to “Zone 2”.

14. The extent of the zone is in all cases less than 1 m I radius from the leak point.

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8.0 Process exhaust and drain

8.1 Background for evaluation

As stated in the integration manual (MAN0002) for the FCwave module the maximum amount of hydrogen present at all scenarios in the process exhaust is 1%vol. This is equal to 25% LEL of hydrogen.

The composition of gas in the drain is the same as the process exhaust due to the fact that the process exhaust is by "fault" emptying the static air lock (previous referred to as water lock) within the module. This means the maximum content of hydrogen in the drain will be 1%vol equal to the process exhaust.

8.2 Definition of explosive gas atmosphere

Due to the concentration being so low (below LEL) the general foundation of the definition of an Explosive atmosphere is not met. According to the standard IEC 60079-10-1:2021 section 3.2 the definition is:

- *"Explosive gas atmosphere*

  Mixture of air, under atmospheric conditions, of flammable substances in the form of gas or vapor, which, after ignition, permits self-sustaining flame propagation"

As the composition of gas in the drain is below 25% of LEL the gas is not able to self-sustain a flame propagation, meaning it is by definition not an Explosive gas atmosphere. Additionally, the IEC 60079-10-1 section 4.4.2 has a clause for releases which is considered as negligible extend. Either due to the potential explosion being of a negligible consequence, or if the release rate or quantity is of a negligible extent in reference to the volume. Yet the clause still operates with the gas potentially being able to combust or explode, which is not the case for a mixture of 1% vol hydrogen.

Additionally, the mixture is also below 25% LEL making sure no clauses from IEC 60079-10-1 Annex I is applicable.

8.3 Risk mitigation considerations

As part of the IEC 60079-10-1 Zone classification procedure a risk assessment can determine to increase or decrease the zoning and EPL. For this installation, the mitigation for not increasing the zoning from e.g. a non-hazardous to a Zone 2 is mitigated by selection of components for the drain system. Which for this system is converted into gastight fittings, instrumentation and pipe with the weakest component being able to withstand a constant pressure of 69 Barg. In addition to this, the general design eliminates the risk of the hydrogen up-concentrating in unintended areas by making sure the exhaust is at the highest point and with a pressure less system securing hydrogen and steam from the process exhaust gas will be able to escape the system through normal buoyancy.

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9.0 Pressure testing according to IEC 62282-3-100

To make sure the Hazardous Area Classification is not exceeding the specified area of extent, release rate and frequency, the system within the Fuel cell container (from the hydrogen heating unit to the valve block (inside the FCwave)) has a build in function to automatically do a pressure decay test according to 62282-3-100:2020.

To maintain the specified HAC, the allowable maximum release of hydrogen is calculated in relation to the zone to make sure that the system is at all times within the boundaries provided in EN IEC 60079-10-1:2021.

The frequency at which this release can occur is still considered to be a “secondary grade of release” as *the release is not expected to occur in normal operation and, if it does occur, is likely to do so only infrequently and for short periods*[4]. Safety precautions describe in the document: *K559-2254-CWIWP4202202-C99-001 Megablock Hydrogen Safety Concept*, supports this assessment of the grade of release.

All leak sources mentioned in Table 7-1, are considered as a uniform leak, throughout this chapter.

9.1 Maximum release flow in respect to zone extend

As calculated in chapter 7.5, the minimum required extent of the zone 2 is 1m in radius. The maximum allowable leak, from the secondary leak source, is determined by the Figure 8 to have a release characteristic on 0,22m^3/s.

[4] From the definitions given in EN IEC 60079-10-1:2021.

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Figure 8: Extent of Zone

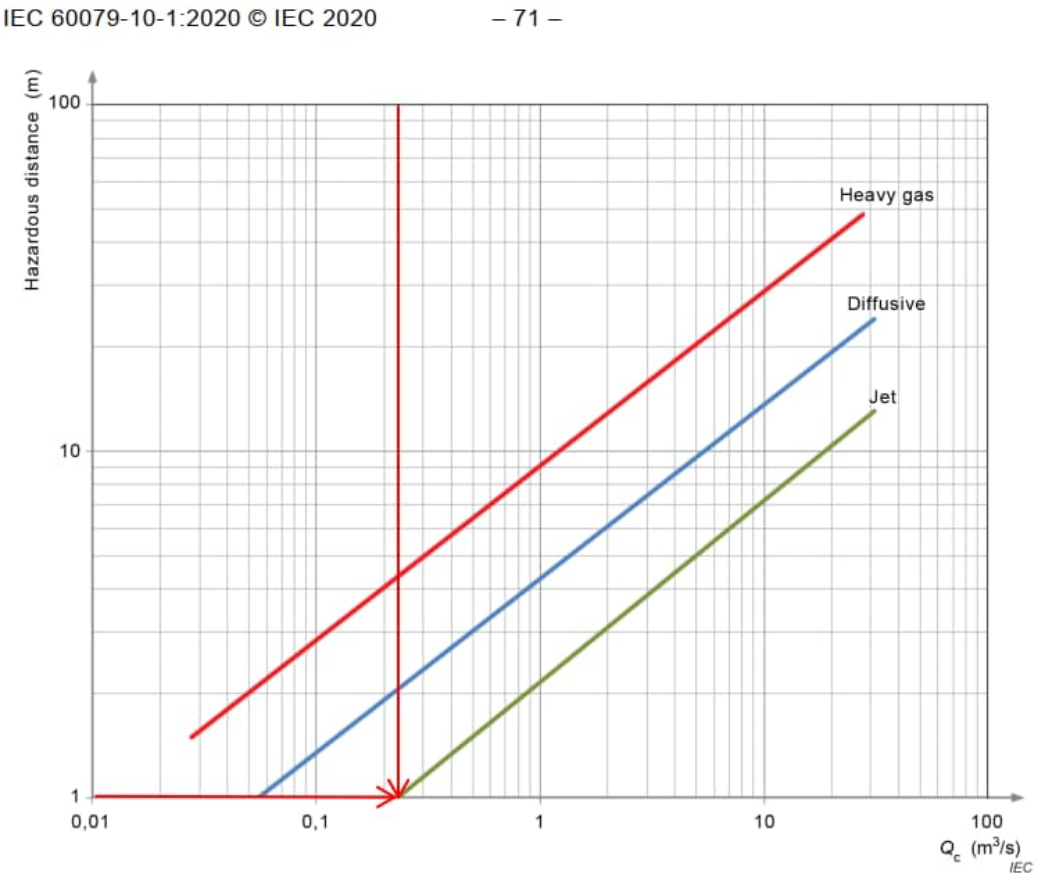


Figure D.1 – Chart for estimating hazardous area distances

Red lines show the assumptions for the minimum requirements to be measured

Converting this into the Release Flow (Wg) using the relative density and LFL, the maximum allowable Release Flow is 6,904x10-7 g/s to still maintain the applicable zone 2. However, considering the leak source a secondary grade of release, as under normal operation there is not expected to be a leak.

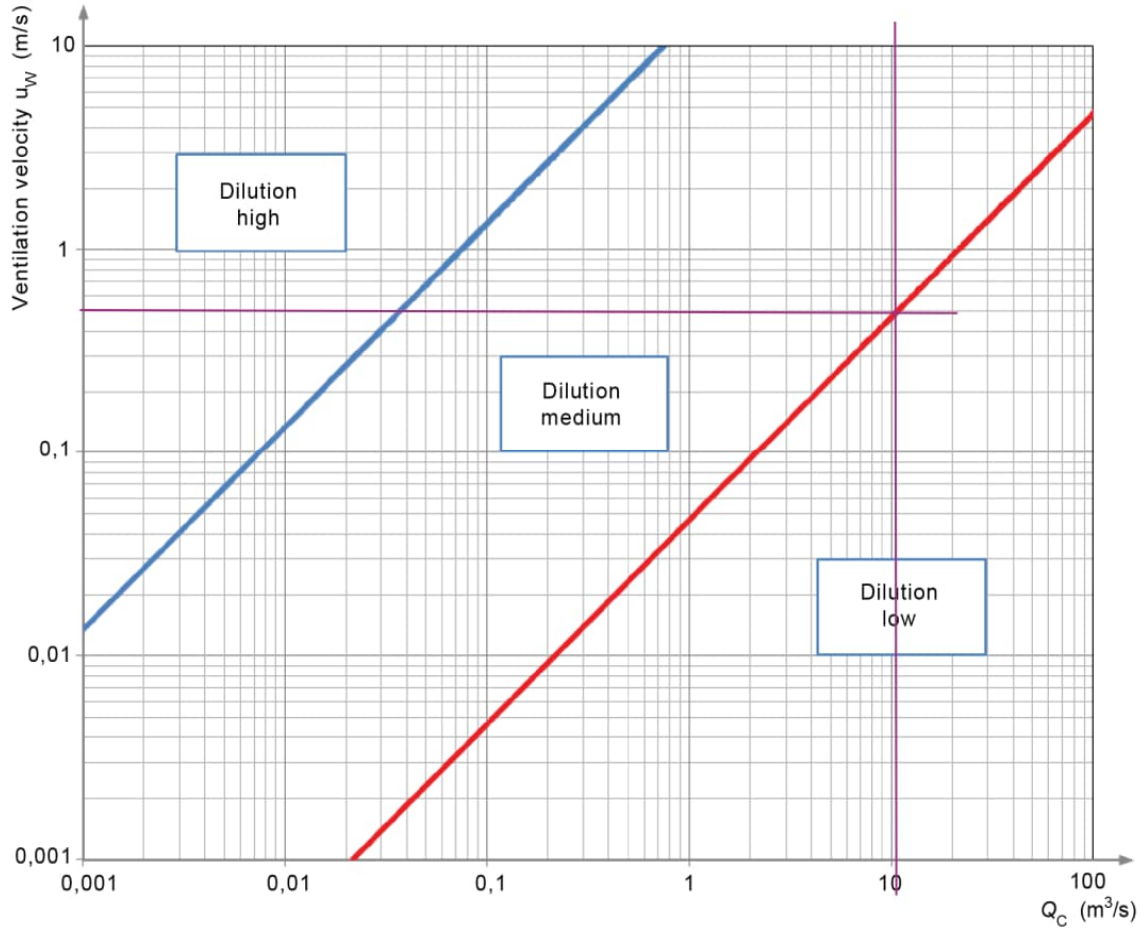
9.2 Maximum release flow in respect to effectiveness of ventilation

To maintain the same applicable zone 2 as calculated in chapter 7.4 the following criteria need to be met to maintain a Zone 2 according to Table D.1 and figure C.1 – EN IEC 60079-10-1:2021:

- Degree of dilution to be at least Medium Dilution
- Availability of ventilation to be at least Fair
- Ventilation speed is fixed by the physical installation to be 0,5m/s
- It is a prerequisite that the leak source is specified as secondary grade of release.

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Figure 9: Degree of dilution and maximum release flow accepted.



Based on C.1 from EN IEC 60079-10-1:2021. Chart for assessing the degree of dilution.

Converting this into the Release Flow (W_g) using the relative density and LFL we will get that the maximum allowable Release Flow is 3,169x10^{-5} g/s to still maintain the applicable zone 2

9.3 Summary of pressure testing value calculation

To make sure the Release Flow submitted to be the dimensioning value according to 60079-10. The value needs to be the one which will be equal or better than the worst Release Flow meaning but conditions for the calculation will be met. For the current installation this is equal to a maximum Release Flow of 6,904x10^{-7} g/s. To convert the value into a pressure, drop, which can be used to e.g. a pressure decay test, the volume, e.g. a pressure decay test, the volume and temperature need to be specified as part of the testing.

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10.0 Appendix

Table 10-1 *Hydrogen Properties*

1	2	3	4	5	6	8	9	11	13	14
	Name	Composition	Molar Mass (kg/kmol)	Relative density gas/air	Polytropic index of adiabatic expansion	Ignition temperature (℃)	Boiling Point (℃)	Vol (%)	Equipment Group	Temperature Class
1	Hydrogen gas (H2)	SAE J2719 ≥99.97%	2.01 (H2)	0.0696 (STP)	1.405	560	-252,8	4%	IIC	T1

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Sub Section G99-002

Intrinsically Safe Calculations

Ballard Power Systems Europe A/S
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Revision history		
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001	25/10/2024	First Issue
002	12/02/2025	Updated and corrected according to agreement during meetings
003	19/03/2025	Corrected according to code 2 comments

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1.0 Purpose

The purpose of this document is to highlight the safe design of the simple apparatus circuit on the FC PowerGen 1000kW®. The document will be formed on background of IEC 60079-25.

2.0 Analysis

The following system contains only a pressure transmitter and a temperature transmitter. Since they are connected to different complete independent barriers, two analyses will be made following the Annex A in IEC 60079-25.

Table 2-1: Simple system analysis pressure transmitter.

Step	Item	I.S. interface PR electronic 9106B1B	Pressure sensor HUBA control 520 Series	System
A	Equipment group	IIC	IIC	IIC
B	Level of protection	ic	ia	ic
C	Temperature classification	NA	T4	T4
D	Ambient temperature	-20 to 60°C	-25 to 85°C	-20 to 60°C
E	Parameter comparison			
	Voltage	U_0=27,5V	U_i≤30V	OK
	Current	I_0=92,6mA	I_i≤100mA	OK
	Power	P_0=0,64W	P_i≤0,75W	OK
F	Cable parameters			
	Capacitance	C_0=0,084µF	C_{cabel}=1nF Max	C_0=0,083µF
	Inductance	L_0=4,15mH	L_{cabel}=20µH Max	L_0=4,13mH
	L/R ratio	- µH/Ω	NA	NA
G	Earthing	Isolated	Isolated	Isolated

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Table 2-2: Simple system analysis pressure transmitter.

Step	Item	I.S. interface PR electronic 9113B	IFM 1050 Temperatur transmitter	System
A	Equipment group	IIC	NA[1]	
B	Level of protection	ic	NA[2]	
C	Temperature classification	NA	T4[3]	
D	Ambient temperature	-20 to 60°C	-25 to 80°C	-20 to 60°C
E	Parameter comparison			
	Voltage	U_0=8,7V	NA[4]	Ok
	Current	I_0=18,4mA	NA[4]	Ok
	Power	P_0=40mW	NA[4]	Ok
F	Cable parameters			
	Capacitance	C_0=5nF	C_{cabel}=1nF Max	C_0=4nF
	Inductance	L_0=100mH	L_{cabel}=20µH Max	L_0=98mH
	L/R ratio	892 µH/Ω	NA	892 µH/Ω
G	Earthing	Isolated	Isolated	Isolated

[1]Not applicable for simple apparatus.

[2]Not applicable for simple apparatus.

[3]Acordingly to IEC 60079-25 annex F the temperature rating will be T4 if the power does not exceed 1,2W at the ambient temperature of 60°C, which is applicable for this application. Further explanation is described in IEC 60079-0 section 5.3.3 Table 3 and 4.

[4]As it is a RTD type temperature sensor those values are not applicable.

2.1 Simple apparatus requirements

There are some requirements to apply for a component to be classified as a simple apparatus. The IEC 60079-11 section 5.7 describes the following requirements:

a) *Passive components, for example switches, junction boxes, resistors and simple semiconductor devices;*

b) *Sources of stored energy consisting of single components in simple circuits with well defined parameters, for example capacitors or inductors, whose values shall be considered when determining the overall safety of the system;*

c) *sources of generated energy, for example thermocouples and photocells, which do not generate more than 1.5 V, 100 mA and 25 mW.*

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Sins this temperature sensor is based on the RTD technology the sensor will not be able to induce any current nor voltage to make this a potential ignition source. Hence relying on the associated apparatus being the EX Barriere.

The barrier is built and approved for connection to RTD type of temperature sensors. The following data from the barrier is included in the Table 2-2.

3.0 Conclusion

According to this analysis of both the Pressure transmitter HUBA520 and the corresponding EX barrier PR electronic 9106B1B the conditions for intrinsically safe circuit are being met accordingly to the IEC 60079-25.

Furthermore, the analysis of Temperature transmitter IFM TT1050 and the corresponding EX barrier PR electronic 9113B does also comply with the requirements form intrinsically safe according to the IEC 60079-25. Since this is a simple apparatus the conditions for this are met accordingly to IEC 60079-11.

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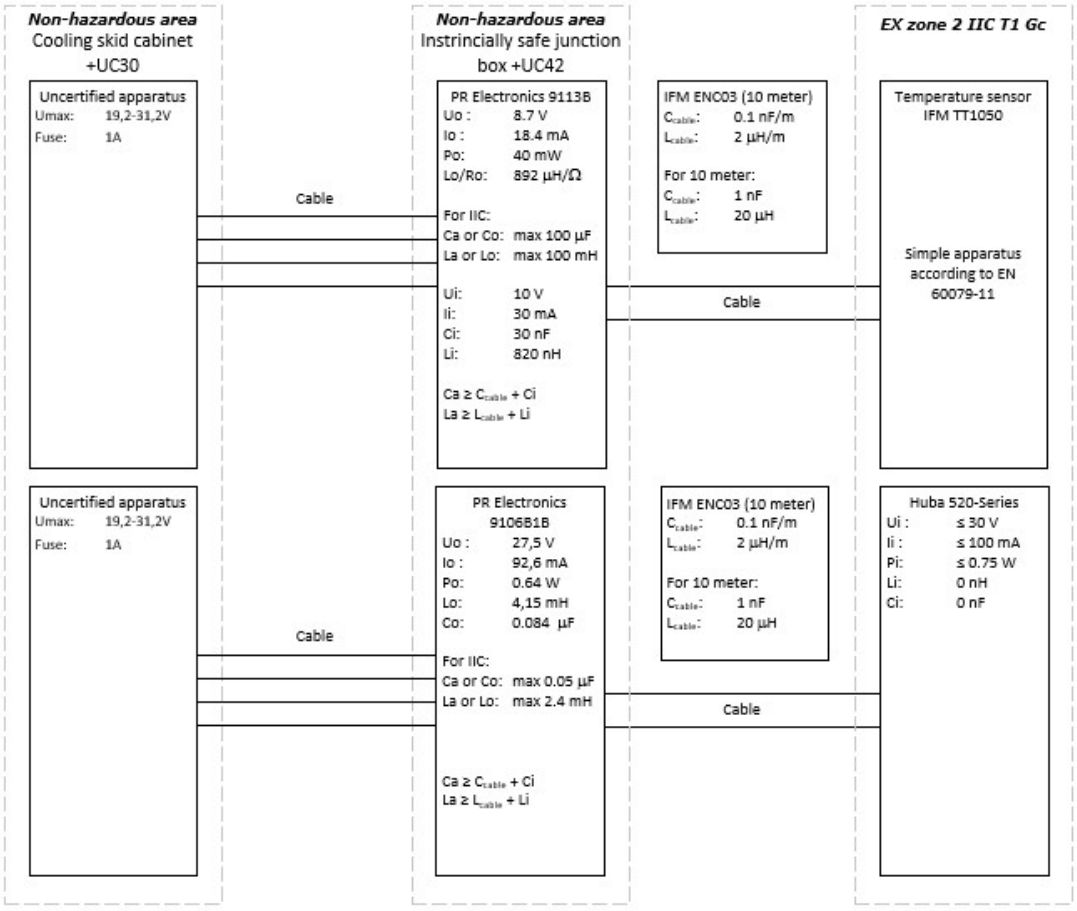
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Figure 1: Intrinsically safe calculations



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Section H

Performance Data

Sub Section H09

General Performance Curves

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Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	H09 – General Performance Curves
Full Title	General performance curves of the hydrogen fuel cell container for Crosswind/Shell
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	September 22, 2023

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5.0 Heat Rejection 7

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1.0 Introduction and Purpose

The present document contains relevant performance data for the 1 MW fuel cell container solution provided by Ballard Power Systems Europe to CrossWind.

Note: The data provided is for BoL (Begin of Life) conditions and an ambient temperature of 20 °C.

2.0 References

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
MAN002	FCwave™ Integration Manual v2.2.0	Ballard
K559-2254-ME-SPE-003	Equipment Specification – Fuel Cell System	Shell / KBR

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3.0 Electrical Efficiency

The electrical efficiency of a single FCwave™ module directly at its DC output is shown below:

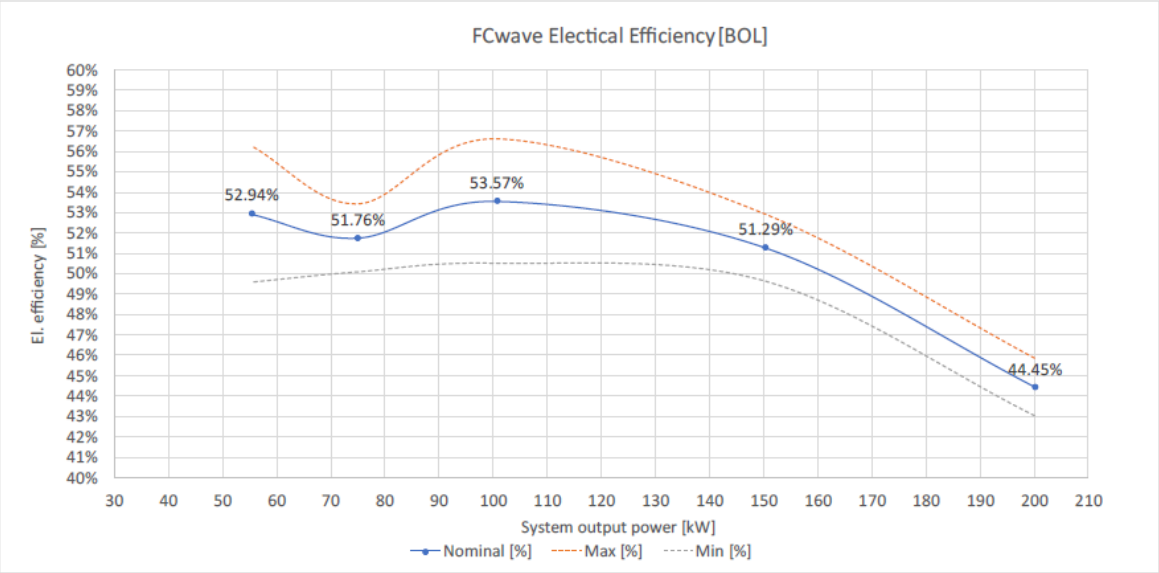


Figure 1. Electrical efficiency of a single FCwave™ module.
(Test done according to IEC62282-3-200:2016 using 95 confidence interval)

Including system losses caused by power conditioning, the overall electrical efficiency of the 1 MW container solution at the 6.6 kV AC output is shown below:

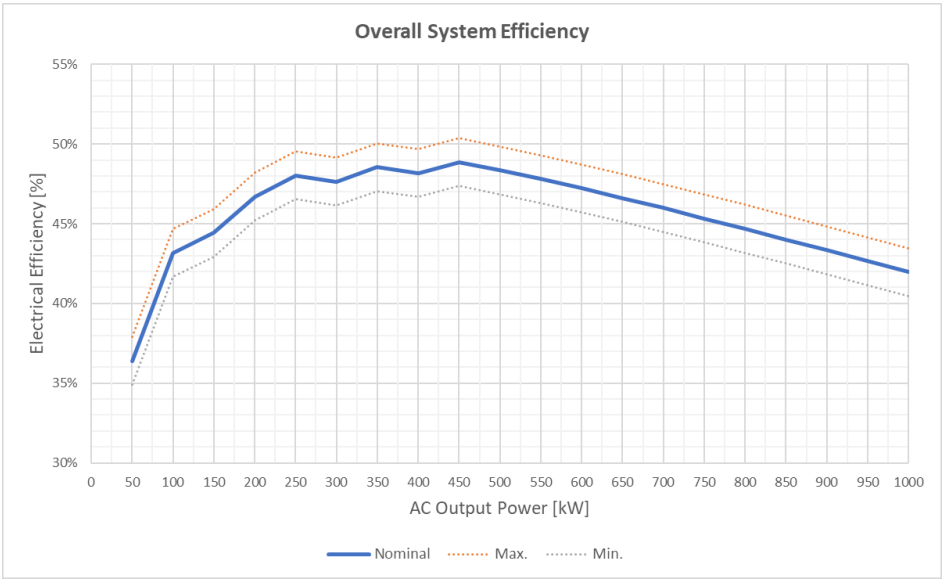


Figure 2. Electrical efficiency as a function of net output (AC) power of 1 MW container solution.

4.0 Hydrogen Consumption

The hydrogen consumed by the 1 MW container solution along its entire power range is shown below:

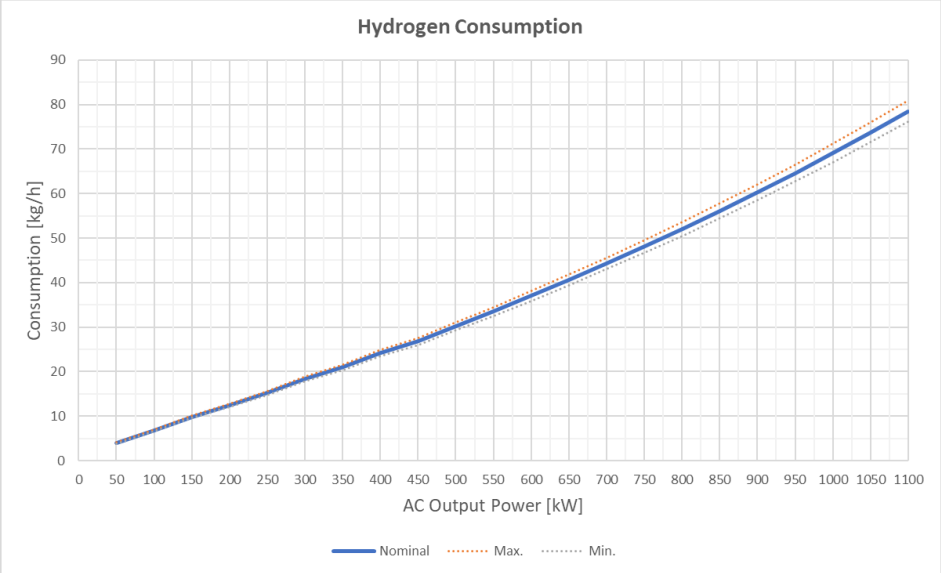


Figure 3. Hydrogen consumption as a function of net output (AC) power of 1 MW container solution.

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5.0 Heat Rejection

The overall heat rejection of the 1 MW container solution results from the energy content of the consumed hydrogen (based on the lower heating value, LHV) that is not transformed into electrical energy.

The heat rejection chart shown below includes all heat that is generated by the components of the container solution and dissipated through the HT coolers, LT cooler, process air exhaust, and ventilation air (both actively as well as passively).

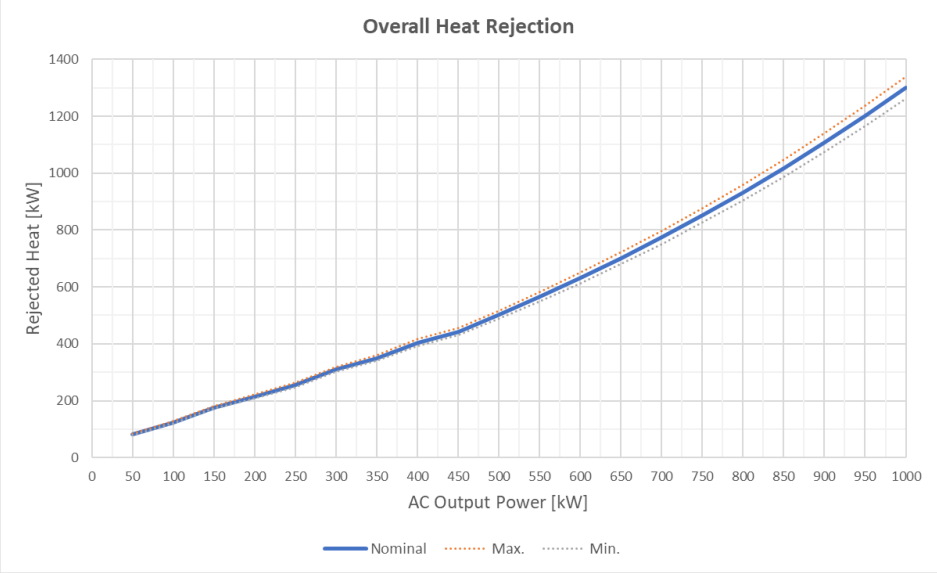


Figure 4. Overall heat rejection as a function of net output (AC) power of 1 MW container solution.

Section J

Materials Engineering

Sub Section J02

WPS and PQR Records

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Svejseprocedureprøvedokumentation

Welding Procedure Qualification Record

Complete documentation

DS/EN ISO 15613:2005

WPQR nr.:	141 T/T BBW 8.1 01
Dimension:	Rør: Ø20x3,0 - Ø50x2 mm
Materiale:	1.4301 - 1.4301

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For

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Indholdsfortegnelse / Table of contents

Svejseprocedureprøveattest / Welding procedure qualification record

141 T/T BBW 8.1 01

Visuel Kontrol 2015554-VT 01

Ikke Destruktiv Kontrol / Non Destructive Testing
Radiographic testing 78961-116-20219
Penetrant testing 78961-116-20219

Destruktiv Kontrol / Destructive Testing
Mechanical test report M026517:1

Materialecertifikater / Material Certificates
Chandan Steel Limited EN 10204, 3.1: Heat No: CH-2861
Siderinox S.p.a. EN 10204, 3.1: Heat No: 0440628

Tilsatsmateriale / Consumables
Hyundai SMT-316LSi, Ø1,6 mm EN 10204, 3.1: Lot No: V9988

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WELDING PROCEDURE QUALIFICATION RECORD

Kvalifikation i henhold til: Qualification i according to: DS/EN ISO 15613:2005
Standard/Norm: Standard/Code:
Kundens specifikation: Client's specification:

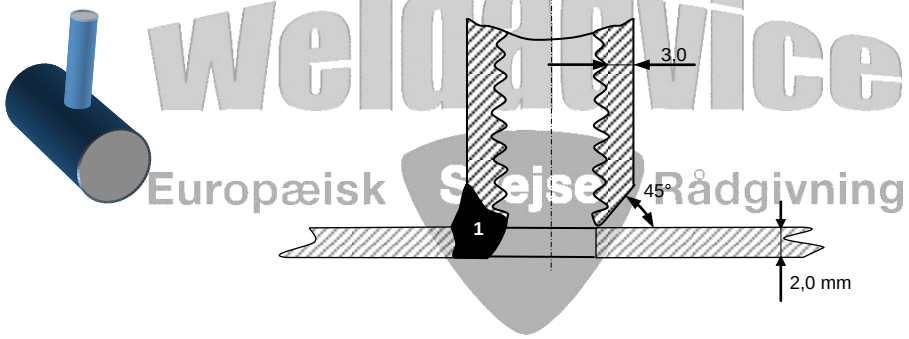
WPQR NO. 141 T/T BBW 8.1 01
Date: 15/01-2016
Blad/Sheet 1/ 1
Side/Page 1 / 2

Kunde/Client | Projekt/Project

Svejsning udført af /Welding carried out by: Brian Ravn | Mærke nr./Stamp no.

Standard/Code: EN 10217-7			Grundmaterialer/Base Materials	Standard/Code: EN 10088-3		
Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -		Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -
Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8	til/to	Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 3,0	Dia. mm: 20,0

Fugedetaljer og sømopbygning (Skitse)
Joint details and welding sequence (Sketch)



weldadvice
Europæisk Svejse Rådgivning

Svejsestilling/ Welding position: PC

Hæftning/Tacking:	Som Streng 1 / As run no. 1
Min. Forvarmetemp.: Min. preheat temp.:	16 °C
Længde: Length:	2 stk. af 4 mm
Antal strenge: No of runs:	1
Andre data: Other data:	
2. side: Fugning/Gouging:	☐ Ja Yes ☒ Nej No
Forvarmetemp.: Preheat temp.:	°C
Elektrode dia.: Electrode dia.:	mm
Lufttryk: Air pressure:	bar
2. side: Slibning/Grinding:	☐ Ja Yes ☒ Nej No

Streng No. / Run No.	Svejse-proces / Weld. proces	G Gas, T Tråd/Wire, P Pulver/Flux, E Electrode; ∇ Fabrikat og betegnelse / Manufacture and trade mark	Dimension: Diameter -Længde/ Diameter -Length mm	Standard: Klassifikation/ Classification (G EN ISO 14175:2008, T EN ISO 14343-A, E EN ISO 6848)	H_2 Skala/ Scale EN 1011	Beskyttelsesgas Shielding Gas: l/min	Dyse/ Nozzle mm Ø	Baggas Back shielding gas: Type/ l/min	Bem. Note No.
1	141	G *Strandmøllen, Pro Line H_2*	-	*R1*	-	*9*	*7*	*Formier* / *10*	-
1	141	T *Hyundai SMT-316LSi*	*1,6*	*G 19 12 3 L Si*	*D*	-	-	- / -	-
1	141	E *Wolframelektrode LaO_2*	*1,6*	*WL20*	-	-	-	- / -	-
								/	
								/	
								/	

Streng No. / Run No.	Program nr. / Program No.	AC DC / Pol.	Strøm/Current Amp	Tråd-hast. / Wire speed m/min	mm	Svejsehast mm/min. eller strækkelængde mm / Travel speed mm/min. or run-out length mm: Volt		S: XX: ∇ U.pendling/stringer pendling/weaving Strengbredde/ run width Max. mm	Heat input KJ/mm	Forvarme/ Preheat °C / Interpass-temp.	Bem. Note No.
1	-	*DC-*	*75*	-	-	*9,0*	*40*	*5,6*	*0,61*	*16* / -	-
										/	
										/	
										/	
										/	
										/	
										/	

Efterfølgende varmebeh./PWHT: ☒ Nej No ☐ Ja, se bilag nr.: Yes, see enclosure No.:

Bemærkninger-andre oplysninger/Notes-other informations

Vi bekræfter, at de givne oplysninger er korrekte og at prøven er tildannet, svejst og varmebehandlet i.h.t. ovennævnte standard/norm og/eller kundens specifikation./We confirm that the statements in this record are correct and that the test was prepared, welded and heat treated according to the above specified standard/code and/or client's specification.

Sted/Place | Dato/Date

Producentens underskrift
Contractor's signature

Prøvesvejsningen var mærket: The test coupon was marked: 2015544-01A, PC H.H. 15/01-2016

Charge/Heat: CH-2861
Charge/Heat: 0440628
Filler metal Lot: V9988

weldadvice
Europæisk Svejse Rådgivning
Messingvej 32 B DK 8940 Randers SV
Tlf.: +45 8640 6805 - Fax: +45 8640 6807

Gennemgået/bevidnet
Reviewed/witnessed by

Repræsenterende
Representing

Prøvningsresultat og godkendelse; Se bagside / Test results and approvals; See revers side

NON-DESTRUCTIVE EXAMINATION	WPQR No.: 141 T/T BBW 8.1 01	Blad/Sheet 1/1	Side/Page 2/2

Metode/ Method - resultat / result	Standard	Rapport nr./ Report no.
1. Visual examination Result: ***Accepteret/ Accepted***	Procedure standard: ***DS/EN ISO 17637:2011*** according to: ***DS/EN ISO 5817, Level B (C)***	***2015544-VT-01***
2. Radiographic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17636-1:2013 Class B*** according to: ***EN ISO 10675-1:2013, Level 1***	***78961-116-20219***
3. Ultrasonic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17640:2011 class B*** according to: ***EN 11666:2011- level 2***	
4. Magnetic particle testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17638:2009*** according to: ***DS/EN ISO 23278:2009 Level 2x***	
5. Dye penetrant testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 3452-1:2013*** according to: ***DS/EN 23277:2009- Level 2x***	***78961-116-20219***
6. Other examination Procedure: Result:	Type: according to:	

Place Randers	Date 19/01-2016	Witnessed/reviewed by (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature		Representing (Examiner or Notified Body)

Heino Harstad

MECHANICAL TESTING

According to DS/EN ISO 15614-1:2004/A1:2008/A2:2012; PED 97/23/EC

1. Tensile tests

EN ISO 6892-1:2009; EN ISO 4136:2012

Specified Y.S. min. *N/mm²* Specified U.T.S. min. *N/mm²*

Test no.	Dim.	Area	Gauge length	Yield Load	$R_{P0,2}$ N/mm²	$R_{P1,0}$ Load	R_{eH} N/mm²	R_m N/mm²	Elong A %	Remarks

2. Bend tests

DS/EN ISO 5173:2010 / EN ISO 7438:2005

Specified degr. 180° Former dia. mm

Type and dimensions	Bend angel	Results	Type and dimensions	Bend angel	Results

3. Impact tests

EN ISO 148-1:2013/ ISO 9016

Dim.: mm Specified type of test : V-notch Specified: J Testing temp. °C

Test no. VWT	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J
Average WM		Average FL		Average FL+2		Average FL+5		Average FL		Average FL+2		Average FL+5	

4. Macro Examination

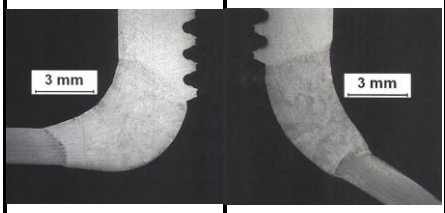
Separate sheet with picture ☐ Yes ☒ No Results:

5. Hardness tests

ISO 9015-1, EN ISO 6507-1:2006

Specified type of test: HV10 Req. max.

Sketch showing indentations



	Base metal (2mm)			HAZ (0,5 mm)				Weld metal			HAZ (0,5mm)				Base metal (2mm)		
A																	
B																	
C																	
D																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

6. Other/Supplementary Tests.

☒ No ☐ Yes See enclosures:

7. Further enclosures:

M026517:1

Place Randers	22/01-2016	Witnessed/reviewed (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature		Representing (Examiner or Test Body)

Heino Harstad

Vi godkender herved denne svejseprocedure til svejsning på omtalte projekt under de begrænsninger, der er givet i standarden/normen og/eller kundens specifikation.

We hereby approve this welding procedure for welding on the referring projekt within the limitations given in the standard/code and/or client´s specifikation.

Place Date

Underskrift af kunde/kunderepræsentant
Client´s or representative´s signature

Markrapport
Visuel kontrol af svejsesømme

Rekvirent TJ Technology, Ågade 65, 7850 Stoholm	**Sag nr.** 2015544	**Rapport nr.** VT-01
Entreprenør	**Dato.** 15/01-2016	**side af** 1 / 1
Emne Branch Connection Ø20x3 mm – Ø50,8x2 mm	**Tegning ref.:** 222446-D1324559	
Mrk. 2015544-01A	**Materiale:** X5 CrNi18-10	

Fugetype ☒ Stumpsøm	☐ Kantsøm	☐ Andet	☐ Slebet	**PWHT** ☐ Ja	☒ Nej	**Timer efter svejsning**
Undersøgelsesprocedure / klasse ☒ EN ISO 17637	☐ NS 10250	☐ ASME Sect. V	☐ Andet:			
Kvalitetskrav ☒ EN ISO 5817 Level B (C)	☐ ASME Sect.	☐ Andet:				
Udstyr ☒ Hulspejl	☒ Lygte	☐ Skydelære	☐ Kantsømlære	☐ Andet:		
Undersøgelsesomfang ☒ Kontrol før svejsning	☒ Kontrol under udførelse	☒ Kontrol efter svejsning	☐			
Omfang ☐ Visuel besigtigelse %	☒ Visuel kontrol 100 %	☐ Tilfældigt udvalgt	☐ Udpeget			

Undersøgelsens resultat

Accepteret / Accepted

Rep. opmærkning. ☐ På emne ☐ På skitse	**Kontrol af** ☐ Opslibning ☐ Reparation	**Bilag vedlagt** ☐ Ingen ☐ Stk.	**Inspektø**	**Certifikat type. / nr.** IWT-NO/0147

Attestationer	**Tekniker**	**Certifikat type / nr.**
	Tekniker	**Certifikat type / nr.**

9-11-01-L

Weldadvice I/S · Messingvej 32B · DK-8940 Randers SV · Tlf.: +45 8640 6805 · Fax: +45 8640 6807
CVR nr.: 2768 9620 · E-Mail: mail@weldadvice.dk ·Internet: www.weldadvice.dk/ www.weldadvice.com

Prøvningsrapport - Ikke-destruktiv Prøvning

KUNDE Weldadvice, Europæisk Svejse Rådgivning I/S, Messingvej 32 B, 8940 Randers SV, Denmark

KONTAKT Heino Harstad, Weldadvice, Europæisk Svejse Rådgivning I/S, Messingvej 32 B, 8940 Randers SV, Denmark

ENTREPRENØR

BYGHERRE

ARBEJDSSTED Force - Lab.

REKVISITIONS ID. 2015544-01

Rekvisitions Beskrivelse	Specifik Job Information
	6. Stk. svejseprøver/ kantsømme

78961-KHC A

Sammenfatning

Svejsninger, ingen sporbarhed, EN ISO 15614-1:2006/A2:2012

NDT Metode	Prøvningsspecifikation	Acceptkriterie	Andre krav
Penetrant (PT)	EN/ISO 3452-1:2013	EN/ISO 23277:2009 - 2X	
Radiografi (RT)	EN/ISO 17636-1:2013 - B	EN/ISO 10675-1:2013 - 1	

PRØVNINGSRESULTAT

	Svejsning Status	
	Acceptkriterie opfyldt	6 svejsninger

Detaljer om prøvningsresultat kan findes i "PRØVNINGSRESULTAT DETALJER" sektionen.

Tekniske data, NDT informationer, identifikation af udstyr, kalibreringsdata for udstyr, og andre relevante data, er registreret for hver NDT-metode i sektionen for Prøvningsmetode Detaljer. Uddrag fra Prøvningsrapporten må kun gengives efter skriftlig tilladelse fra FORCE Technology. Den elektroniske version af Prøvningsrapporten, som er gemt i "FORCE NDT Online", er defineret som originalen. Prøvningsresultaterne gælder kun for de emner som er testet. FORCE Technology - Almindelige betingelser er en integreret del af aftalen, medmindre andet er skriftligt aftalt.

PRØVNINGSRESULTAT - DETALJER

	Svejsninger hvor acceptkriterie er opfyldt		
Reference	**Svejsning Id. (Rep./Udv.)**	**Svejser(e)**	**Prøvningsmetode(r)**
2015544-01	01A-1	-	PT, RT
	01A-2	-	PT, RT
	02B-1	-	PT, RT
	02B-2	-	PT, RT
	03C	-	PT, RT
	04D	-	PT, RT

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PRØVNINGSOMFANG

RT. og PT. af 6. stk. svejseprøver, i muligt omfang.

SVEJSNING DETALJER

Reference	Svejsning Id. (Rep./Udv.)	Materialer	Overfladebeskaffenhed	Varmebehandling
		Dimensioner	Tidspunkt for prøvning	Temperatur (ca.)
		Nominel tykkelse	Timer efter sidste fremstillingstrin	Svejsningstype-fugeform-metode(r)
2015544-01	01A-1, 01A-2	Rustfrit stål	Som svejst	Ingen information
		20 mm	Ingen information	-
		3 mm	-	Ingen information-Ingen information-Ingen information
	02B-1, 02B-2	Rustfrit stål	Som svejst	Ingen information
		50 mm	Ingen information	-
		2 mm	-	Ingen information-Ingen information-Ingen information
	03C	Rustfrit stål	Som svejst	-
		50 mm	Ingen information	-
		2-2 mm	-	Ingen information-Ingen information-Ingen information
	04D	Rustfrit stål	Som svejst	-
		50 mm	Ingen information	-
		1,6-15 mm	-	Ingen information-Ingen information-Ingen information

Ovenstående oplysninger er til information og angives kun i den udstrækning, de er tilgængelige og relevante. Deres angivelse i denne prøvningsrapport kan ikke betragtes som en verifikation af deres rigtighed og de er ikke omfattet af nogen akkreditering.

PRØVNINGSMETODE - DETALJER

Penetrant Prøvning (PT) **Prøvningstidspunkt 19-01-2016 - 19-01-2016**

Personale

Navn (Tekniker Nr.)	Certifikattype	Certifikat nr.	Reference [Svejsning Ids]
Keld Hald Christensen (1)	EN ISO 9712 PT (EN 473) Level 2	0063-N2-P	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]

Produkter

Type	Parti Nr.	Produkt	Prøvningstekniske oplysninger Nr.
Halogenfri Opløsningsmiddel Fremkalder		Spotcheck SKD-S2	1
Vandafvaskelig/Opløsningsmiddel Rød Penetrant		Spotcheck SKL-WP	1
Halogenfri Rensevæske/Afrensning af Overskudspenetrant		Spotcheck SKC-S	1

Prøvningstekniske oplysninger

Nr.	Reference [Svejsning Ids]	For-rengøring	Penetreringstid	Fremkaldertid	Lysforhold
		Betegnelse	Emulgeringstid	-	Lys intensitet
1	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]	Penetrant Rensemiddel	15 min.	15 min.	Hvidt lys - kunstig
		IICd2	-	-	> 1000 LUX

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Radiografi Prøvning (RT) **Prøvningstidspunkt 19-01-2016 - 19-01-2016**

Personale

Navn (Tekniker Nr.)	Certifikattype	Certifikat nr.	Reference [Svejsning Ids]
Keld Hald Christensen (1)	EN ISO 9712 RT (EN 473) Level 2 (incl. aluminium)	0063-N2-R	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]

Udstyr

Type	Id.	Andre data	Prøvningstekniske oplysninger Nr.
RT X-RAY TUBE, SMART 225	XRL-10	FOCAL SPOT 3 MM, EN 12543, (DIRECT BEAM), 70-225 kV, 4,0 mA	1-4
RT FILM VIEWING UNIT, WILNOSOL	VGA-110	H UNIVERSAL, DENSITY D UP TO 3,7	1-4
RT DENSITOMETER, WILNOS LCD 51	PDE-21	MAXIMUM DENSITY D = 5,0	1-4

Prøvningstekniske oplysninger

Nr.	Optageteknik	Fremkaldelse	IQI (Certifikat nr.)	Spænding
	Antal film per svejsning/objekt	Folietype (tykkelse)	IQI placering	Strøm / Aktivitet
	Filmtype	Kilde/Brændplet størrelse	Gennemstrålet tykkelse	Eksponeringstid
	Kilde / detektor eller film afstand (SFD / SDD)	Kilde / objekt afstand (f/D)	Objekt / film afstand (b/d)	Opløsning
1	Dobbeltvæg/Enkeltbillede - Rør, Kontakt (DV/EB)	Maskine	10 FE EN ()	140 kV
	1	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	750.0 mm	50.0 mm	-
2	Dobbeltvæg/Dobbeltbillede - Rør, Ellipse (DV/DB)	Maskine	10 FE EN ()	140 kV
	2	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	750.0 mm	50.0 mm	-
3	Enkeltvæg/Enkeltbillede - Plade (EV/EB)	Maskine	10 FE EN ()	140 kV
	4	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	790.0 mm	10.0 mm	-
4	Enkeltvæg/Enkeltbillede - Plade (EV/EB)	Maskine	13 FE EN ()	200 kV
	4	Pb (0.02 / 0.02 mm)	Filmside	4.0 mA
	Foma / Indux R5	3.0 mm	15.0 mm	90 sek
	800.0 mm	785.0 mm	15.0 mm	-

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Film

Film id.	Prøvningstekniske oplysninger Nr.	Sværtning	IQI Nr.	Følsomhed	Ug
01, 02, 05	1	2,5	16	5.00 %	0.20 mm
03, 04	2	2,5	16	5.00 %	0.20 mm
06-09	3	2,5	16	5.00 %	0.04 mm
10-13	4	2,5	13	1.33 %	0.06 mm

Svejsning på film

Reference	Svejsning Id [Film Id'er]
2015544-01	01A-1 [01], 01A-2 [02], 02B-1 [03,04], 02B-2 [05], 03C [06-09], 04D [10-13]

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PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

SWEDAC ACKREDITERING 5622 ISO/IEC 17025

SAFE CONTROL MATERIALTEKNIK

Beställare / Ordered by Weldadvice Messingvej 32B DK-8940 Randers SV	**Orderdatum / Date of order** 2016-01-20	**Reg. nummer / Reg. number** M026517:1
Er referens / Your reference Heino Harstad	**Inlämningsdatum / Object (-s) received** 2016-01-20	**Sidnummer / Page** 1(2)
Ordernummer / Order number 2015544-02	**Rapportdatum / Date of report** 2016-01-25	**Vår referens / Our reference** Johan Ageryd

Assignment:	Procedure qualification test according to EN ISO 15 614-1:2004.	
Test object(s):	Branch connection. Half V- groove.	
Material:	1.4301/ 1.4307	1.4301/ 1.4307
Group:	8.1	8.1
Dimension:	Ø 20 x 3.0 mm	Ø 50 x 2.0 mm
Heat number:	CH-2861	0440628
pWPS:	WPS TJ Tech 02	
Procedure number:	2015544-01A	
Identification mark:	2015544-01A	
Weld method:	141	
Position:	PC	
Filler metal:	Hyundai SMT-316LSi, Ø 1.6 mm	
Note:	-	
Result:	Accepted according to referenced standard.	
Signature:	SAFE CONTROL Johan Ageryd	

"Laboratorier ackrediteras av Styrelsen för ackreditering och teknisk kontroll (SWEDAC) enligt svensk lag. Den ackrediterade verksamheten vid laboratoriet uppfyller kraven i SS-EN ISO/IEC 17 025 (2005). Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänner annat". Provningsresultaten i denna rapport avser endast provade objekt.

"Laboratories are accredited by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC) under the terms of Swedish legislation. The accredited laboratory activities meet the requirements in SS-EN ISO/IEC 17 025 (2005). This report may not be reproduced other than in its full, except with the prior written approval of the issuing laboratory". The test results in this report refer only to tested objects.

Safe Control Materialteknik AB • Tillgängligheten 1 • S-417 01 Göteborg
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E-mail: info@safecontrol.se • www.safecontrol.se

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

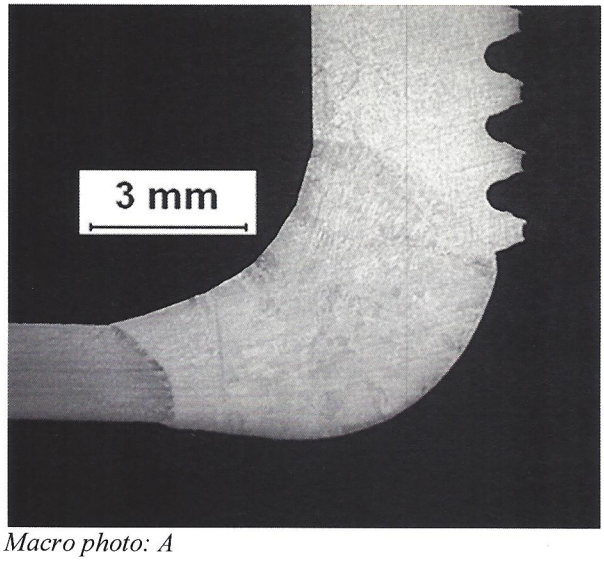
Teknisk instruktion / Technical instruction	Märkning / Marking	Reg. nummer / Reg. number
Macroscopic and microscopic examination of welds	2015544-01A	M026517:1
TI Dokumentnr./ TI Document no.	**Provningsutrustning / Testing equipment**	**Sidnummer / Page**
SCMM1	SCM 9	2(2)
Provning enligt / Testing according to	**Provningsdatum / Testing date**	**Utfört av / Performed by**
SS-EN 1321	2016-01-22	Johan Ageryd

Macroscopic examination:

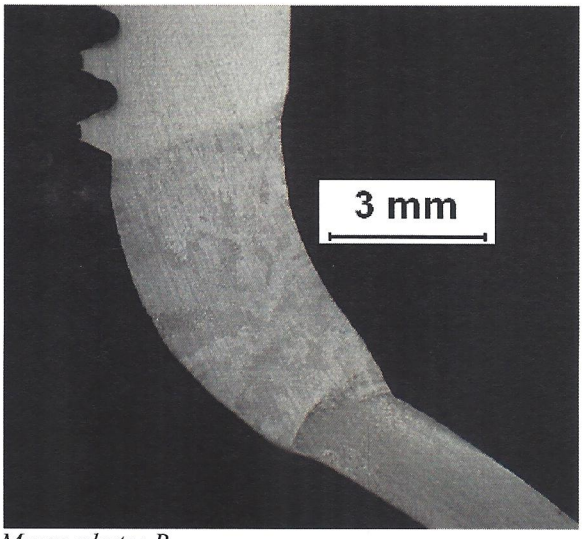
Two macro samples were cut out for macroscopic examination of weld metal, HAZ and base metal. The macro samples were ground (to 2000- paper) and examined in not etched and etched condition at magnification of 1× - 20×.

Macro sample			Base metal		Filler metal	Etchant *(acc. to SIS-CEN/CR 12361:1996)*
ID / No	Position	Orientation	Horizontal	Vertical		
2015544-01A	PC	Perpendicular to the weld direction	1.4301/ 1.4307	1.4301/ 1.4307	Hyundai SMT-316LSi	B.5 (Kalling´s)
Examined macro samples are assessed to fulfil the requirements in EN ISO 5817:2014. See macro photos below.						

Macro photos:



Macro photo: A



Macro photo: B

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurement: ± 1.5 %

Not.: Avsteg från punkt 10 i SS-EN 1321 har gjorts. Beteckning har ej redovisats i enlighet med exemplifierade versioner.
Note: Deviation from clause 10 in SS-EN 1321 has been done. Description has not been presented in accordance with exemplified versions.

Signatur/ Signature:

SAFE CONTROL
Johan Ageryd

CHANDAN STEEL LIMITED

(GOVT. OF INDIA RECOGNISED EXPORT HOUSE)

ISO 9001 : 2008 CERTIFICATE No. 04 100 011022-E3

ADM. OFFICE: 504, SUKH SAGAR, N. S. PATKAR MARG, MUMBAI 400 007, INDIA

Tel.: 91-22- 66290600. Fax.: 91-22-66290633/34

Website : www.chandansteel.net

Email : csl@chandansteel.net

WORKS: Plot No. 35, G. I. D. C., Umbergaon

Dist Valsad, Gujarat - 396 171.

Tel.: 91-260- 308 9999 Fax.: 91-260 308 9872

E-mail : exports@chandansteel.net

CE 0045 14 0045-CPR-1394

L/c. No.:

L/c. Date:

F824 QC 09A / 02 / 10.12.2012

MILL TEST /INSPECTION CERTIFICATE 3.1

ACCORDING TO EN 10204 : 2005

Consignee		Test Certificate No.	: EXP/00645 - 09/2015-2016
DACAPO STAINLESS A/S		Date of Issue	: 22.09.2015
NEPTUNVEJ 1		P. O. No.	: 45060220
8600 SILKEBORG		SC_No. & Date	: 15-16/00345, Dt.01.08.2015
DENMARK		Invoice No. & Date	: EXP/00645/2015-16 Dt.22.09.2015
PRODUCT DESCRIPTION		LENGTH	Net Wt.
STAINLESS STEEL ROUND BARS		Ordered	Actual
[CONDITION - 1D & 2D]		6.0 - 6.1 Mtrs.	6.0 - 6.1 Mtrs.
			2731 Kgs.

Article No.	Item No.	Heat No.	Material/Grade	Size mm	Tolerance	Process Route
-	5000200006	CH-2861	1.4301/1.4307	20.00 mm	h9	Electric Melting, A.O.D. Refining, Continuous Casting

CHEMICAL COMPOSITION (Weight %)

	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Ti	Co	N
Min.	-	-	-	-	-	18.00	-	8.00	-	-	-	-
Max.	0.030	1.00	2.00	0.045	0.030	19.50	-	10.50	-	-	-	0.1000
Results	0.029	0.43	1.65	0.045	0.028	18.30	-	8.03	-	-	-	0.0650

MECHANICAL PROPERTIES

Specified Values	Test Method :- EN ISO 6892-1					Hardness EN ISO 6506-1	Test Method :- DIN EN ISO 148 - 1 Charpy (V) Impact Test (2mm) at 20 °C (Joules) Sample Size - 10 x 10 x 55 mm			
	Proof Strength N/mm² /MPa		Tensile Strength N/mm²/MPa (Rm)	Elongation after Fracture A %	Reduction of Area %					
	0.2%(Rp0.2)	1%(Rp1.0)				(BHN)	I	II	III	Avg.
Results	448	485	715	44	65	222-225	230	240	245	238

Remarks:

1. Condition : 1D & 2D (Bright drawn & Polished).
2. Solution annealed at 1050 °C.
3. PMI test done 100% & found Satisfactory.
4. Both ends Chamfered.
5. The material is fully killed and calcium treated.
6. Material has improved machinability.
7. Material is free from radio-active contamination.
8. Intergranular Corrosion test carried out as per EN/ISO 3651-2-1998 (Test method A) found satisfactory.
9. Surface Defects found satisfactory as per EN 10277-1 Class 3.
10. The material conforms to DIN EN 10088-3:2005, EN 10088-5:2009, EN 10272-2008, AD2000 W2/W10, ASTM A276-13/A182-13/A479-13a, ASME SA276-10/ SA182-10/SA 479- 2010 SECTION II, PART A Specification.
11. Location of sample - off centre, Direction - Longitudinal, Test Temp - Room Temp., Shape of Test Piece - Round.
12. Marking details - Company Logo, Size, Grade & Heat No.
13. The material is manufactured /melt in Chandan Steel Mill and is of Indian Origin.

BUNDLE NO.: 64, 65, 67 to 69 COLOUR : BLUE

Intended use : Building construction or civil engineering.

Regulated substance : No performance determined.

It is hereby certified that the above results are true and correct in every details and are meeting the requirements of specification & purchase order.

D.O.P. No.: 1.4301/ROUND BAR

D.O.P. can be seen here: www.chandansteel.net

BSR

B. S. RAUTELA

MANAGER - Q.A./WORKS INSPECTOR

SIDERINOX

Siderinox S.p.a. Frazione Caselle 20081 Morimondo (MI) Italia
Ufficio Commerciale: Tel. 02 9498151 - Fax 02 949815250/251
Ufficio Amministrativo: Tel. 02 9498161 - Fax 02 949816350
Ufficio Spedizioni: Tel. 02 949816222 - Fax 02 949815350
Ufficio Acquisti : Tel. 02 949816345 - Fax 02 949816350
Casella e-mail: sx@siderinox.it Sito web: www.siderinox.it

Capitale Sociale Euro 3.300.000 i.v.
Cod. Fiscale e Reg. Imp. MI N. 01825510157
R.E.A. Milano N. 878116
Centro Meccanografico n. MI074282
Partita IVA 01825510157

AZIENDA CON SISTEMA
DI GESTIONE QUALITÀ
CERTIFICATO DA DNV GL
=ISO 9001=

INSPECTION CERTIFICATE EN 10204 3.1 N° 424885 of 02.02.2015

Purchaser **INOX STAAL A/S**

DDT	SIDERINOX order number	Customer's order
N 8 of 02.02.2015	N 5 of 22.01.2015	N 15836-1 of 22.01.2015

Product description

Stainless steel round pipe Ø 50,8 x 2 mm AISI 304/304L brushed EN 10217-7 Longitudinally welded

Dimension	Steel type	Quantity (m)	Weight (kg)
50,8 x 2 mm	EN 1.4301/1.4307 / AISI 304/304L	366	815

Production Norm	Rolling	Tolerances	Welding factor
EN 10217-7	Hot rolled	D3 \ T3	V=1

Marking MANUFACTURER'S MARK - DIMENSION - STEELGRADE - HEAT N. - PRODUCTION NORM - EXECUTION - E.C. INSPECTOR - WORK INSPEKTOR

Manufacturing process — Surface finishing W0

CHEMICAL COMPOSITION

Heat	% C	%Mn	%P	% S	%Si	%Cr	% Ni	% Mo	% Ti
	0,000 - 0,030	0,000 - 2,000	0,000 - 0,040	0,000 - 0,010	0,000 - 1,000	17,500 - 19,500	8,000 - 10,000	0,000 - 0,000	0,000 - 0,000
0440628	0,022	1,680	0,027	0,001	0,380	18,240	8,090		

The chemical values refer to the certificate issued by the steel mill according to EN 10088 / 10028-7 / ASTM A 240 and stored at our office.

TEST RESULTS

* (D) Direction: (L) Longitudinal, (T) Transverse - ** (P) Position: (W) Welding, (M) Material

Test unit	Test Class	(D) *	(P) **	TENSILE TEST in Nmm2=MPa				HARDNESS
				Yield Strength		Tensile Strength	Elongation	
				Rp 0,2%	Rp 1%	Rm	A %	HRB
				195 -	230 -	500 - 740	40 -	
T14100996	TC1	L	M	246	330	658	48	
T14100998	TC1	L	M	235	314	627	49	

Visual inspection	OK	Drift expanding test		Sealing test	
		UNI EN ISO 8493	OK	UNI EN ISO 10893-1	OK
Check on dimensions	OK	Flattenning test		Non destructive Eddy Current test	
		UNI EN ISO 8492	OK	UNI EN ISO 10893-2	OK
Antimixing test	OK	Weld bend test		Intergranular corrosion test	
		EN 910	OK	N. P.	N. P.

WE CERTIFY THAT THE MATERIAL SUPPLIED COMPLIES WITH THE REQUIREMENTS AGREED ON THIS ORDER

Remarks:

Cerfications:
UNI EN ISO 9001
Dir. PED 97/23/EC Encl. 1, Point 4.3, Comma 3
AQUAP from Nr. 7293-06-TU to Nr 7298-06-TU

Qualifications:
WPS/WPAR: UNI EN ISO 15609-1/UNI EN ISO 15614-11
WLD: UNI EN ISO 14732 operator
NDT: UNI EN ISO 9712 operator

Document issued by the mill's Inspector
D. Ricco

Document confirmed by the authorized company responsible
W. Amodeo

CERTIFIED MATERIAL REPORT

CMR No. : 1502253500015 Date of Issue : 2015-02-25

Customer	HYUNDAI WELDING EUROPE OFFICE		
Trade Name	SMT-316LSi Inox	Size	1.6mm*1000mm*5kg
Lot No.	V9988	Purchaser's Order No.	
Applicable Specification	AWS A5.9 ER316LSi	* According to EN 10204-2004 : 3.1	

Welding Current		Shielding Gas		Post Weld Heat Treatment (℃ × hr.)	

Mechanical Properties	Tensile Test			Impact Test (CVN - Joule)				
	YS(MPa)	TS(MPa)	EL(%)	Temp.(℃)	X1	X2	X3	Avg.
	-	-	-		-	-	-	-
Spec.								

Chemical Composition (%)

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo		
(WIRE)	0.021	0.97	1.71	0.027	0.011	0.20	11.33	18.30	2.57		
Spec.	≤0.03	0.65 ~1.00	1.0 ~2.5	≤0.03	≤0.03	≤0.75	11.0 ~14.0	18.0 ~20.0	2.0 ~3.0		

We hereby certifies that the material covered by this report has been inspected in accordance with and been found to meet the applicable requirements of specification and customer's requirements.

Approved by

K.W. Park

QA Manager Park K. W.

HYUNDAI HYUNDAI WELDING CO., LTD.
Head Office #507,Teheran-ro,Gangnam-gu,Seoul,Republic of Korea
Pohang Plant #100,Daesong-ro,Nam-gu,Pohang,Republic of Korea

Svejseprocedureprøvedokumentation

Welding Procedure Qualification Record

Complete documentation

DS/EN ISO 15614-1:2006/A1:2008/A:2:2012

WPQR nr.:	141 T BW 8.1 02
Dimension:	Rør: Ø50,8x2,0 mm
Materiale:	1.4301 - 1.4301

Udarbejdet af

weldadvice

Europæisk Svejse Rådgivning

For

TJ TECHNOLOGY

Ågade 65
7850 Stoholm

Indholdsfortegnelse / Table of contents

Svejseprocedureprøveattest / Welding procedure qualification record

141 T BW 8.1 02

Visuel Kontrol 2015554-VT 02

Ikke Destruktiv Kontrol / Non Destructive Testing
Radiographic testing 78961-116-20219
Penetrant testing 78961-116-20219

Destruktiv Kontrol / Destructive Testing
Mechanical test report M026517:2

Materialecertifikater / Material Certificates
Siderinox S.p.a. EN 10204, 3.1: Heat No: 0440628

Tilsatsmateriale / Consumables
Hyundai SMT-316LSi, Ø1,6 mm EN 10204, 3.1: Lot No: V9988

weldadvice Europæisk Svejse Rådgivning

TJ TECHNOLOGY
Ågade 65
7850 Stoholm

SVEJSEPROCEDUREPRØVEATTEST
WELDING PROCEDURE QUALIFICATION RECORD

Kvalifikation i henhold til: Qualification i according to: DS/EN ISO 15614-1:2006/A1:2008/A:2:2012
Standard/Norm: Standard/Code:
Kundens specifikation: Client's specification:

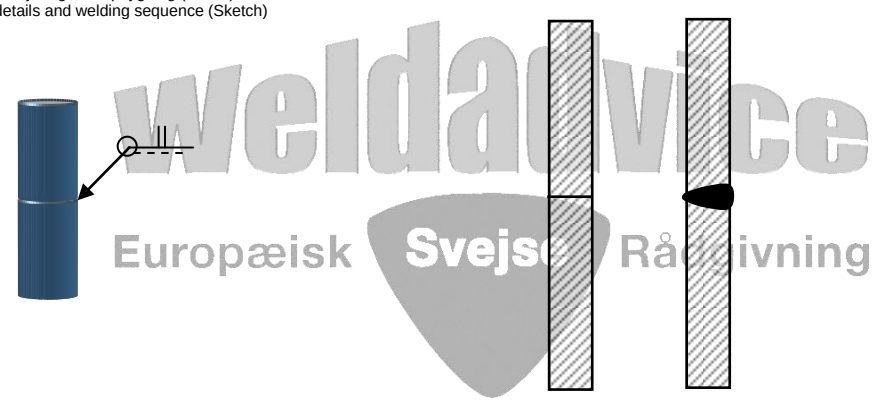
WPQR NO. 141 T BW 8.1 02
Date: 15/01-2016
Blad/Sheet 1/ 1
Side/Page 1 / 2

Kunde/Client | Projekt/Project

Svejsning udført af /Welding carried out by: Brian Ravn | Mærke nr./Stamp no.

Standard/Code: EN 10217-7			Grundmaterialer/Base Materials	Standard/Code: EN 10217-7		
Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -		Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -
Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8	til/to	Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8

Fugedetaljer og sømopbygning (Skitse)
Joint details and welding sequence (Sketch)



weldadvice Europæisk Svejse Rådgivning

Svejsestilling/Welding position: PC

Hæftning/Tacking:	Som Streng 1 / As run no. 1
Min. Forvarmetemp.: Min. preheat temp.:	16 °C
Længde: Length:	4 stk. 2-4 mm
Antal strenge: No of runs:	1
Andre data: Other data:	
2. side: Fugning/Gouging:	☐ Ja Yes ☒ Nej No
Forvarmetemp.: Preheat temp.:	°C
Elektrode dia.: Electrode dia.:	mm
Lufttryk: Air pressure:	bar
2. side: Slibning/Grinding:	☐ Ja Yes ☒ Nej No

Streng No. / Run No.	Svejse-proces / Weld. proces	G T P E ∇	Gas, Tråd/Wire, Pulver/Flux, Electrode; Fabrikat og betegnelse / Manufacture and trade mark	Dimension: Diameter -Længde/ Diameter -Length mm	Standard: Klassifikation/ Classification G T E	H_2 Skala/ Scale EN 1011	Beskyttelsesgas Shielding Gas: l/min	Dyse/ Nozzle mm Ø	Baggas Back shielding gas: Type/ l/min	Bem. Note No.
1	141	G	Strandmøllen, Pro Line H_2	-	EN ISO 14175:2008 / EN ISO 6848: R1	-	9,0	7	Formier / 10	-
1	141	E	Wolframelektrode LaO_2	1,6	WL20	-	-	-	- / -	-
									/ -	-
									/	
									/	
									/	

Streng No. / Run No.	Program nr. / Program No.	AC DC Pol.	Strøm/Current Amp	Tråd-hast. Wire speed m/min	mm	Svejsehast mm/min. eller strækkelængde mm. Travel speed mm/min. or run-out length mm	Volt	S: XX: ∇ U.pendling/stringer pendling/weaving Strengbredde/ run width Max. mm	Heat input KJ/mm	Forvarme/ Preheat /Interpass-temp. °C	Bem. Note No.
1	Pulsed		82	-	-	9,0	99		0,27	16 / -	1*)
										/	
										/	
										/	
										/	
										/	
										/	

Efterfølgende varmebeh./PWHT: ☒ Nej No ☐ Ja, se bilag nr.: Yes, see enclosure No.:

Bemærkninger-andre oplysninger/Notes-other informations
1*) Welding without filler metal

Vi bekræfter, at de givne oplysninger er korrekte og at prøven er tildannet, svejst og varmebehandlet i.h.t. ovennævnte standard/norm og/eller kundens specifikation./We confirm that the statements in this record are correct and that the test was prepared, welded and heat treated according to the above specified standard/code and/or client's specification.

Sted/Place | Dato/Date

Producentens underskrift
Contractor's signature

Prøvesvejsningen var mærket: The test coupon was marked: 2015544-02B, PC H.H. 15/01-2016

Charge/Heat:
Charge/Heat: 0440628
Filler metal Lot: Welded without filler metal

weldadvice Europæisk Svejse Rådgivning
Messingvej 32 B DK 8940 Randers SV
Tlf.: +45 8640 6805 - Fax: +45 8640 6807

Gennemgået/bevidnet
Reviewed/witnessed by

Repræsenterende
Representing

Prøvningsresultat og godkendelse; Se bagside / Test results and approvals; See revers side

NON-DESTRUCTIVE EXAMINATION	WPQR No.: 141 T BW 8.1 02	Blad/Sheet 1/1	Side/Page 2/2

Metode/ Method - resultat / result	Standard	Rapport nr./ Report no.
1. Visual examination Result: ***Accepteret/ Accepted***	Procedure standard: ***DS/EN ISO 17637:2011*** according to: ***DS/EN ISO 5817, Level B (C)***	***2015544-VT-02***
2. Radiographic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17636-1:2013 Class B*** according to: ***EN ISO 10675-1:2013, Level 1***	***78961-116-20219***
3. Ultrasonic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17640:2011 class B*** according to: ***EN 11666:2011- level 2***	
4. Magnetic particle testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17638:2009*** according to: ***DS/EN ISO 23278:2009 Level 2x***	
5. Dye penetrant testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 3452-1:2013*** according to: ***DS/EN 23277:2009- Level 2x***	***78961-116-20219***
6. Other examination Procedure: Result:	Type: according to:	

Place Randers	Date 19/01-2016	Witnessed/reviewed by (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature Heino Harstad		Representing (Examiner or Notified Body)

MECHANICAL TESTING

According to DS/EN ISO 15614-1:2004/A1:2008/A2:2012; PED 97/23/EC

1. Tensile tests

EN ISO 6892-1:2009; EN ISO 4136:2012

Specified Y.S. min. *≥195; ≥230 N/mm²* Specified U.T.S. min. *500 - 700 N/mm² - 470 670 N/mm²*

Test no.	Dim.	Area mm²	Gauge length	Yield Load	$R_{P0,2}$ N/mm²	$R_{P1,0}$ Load	R_{eH} N/mm²	R_m N/mm²	Elong A %	Remarks
TT/1	12.01x1.58	19.16						638		HAZ
TT/2	12.02x1.77	21.49						632		HAZ

2. Bend tests

DS/EN ISO 5173:2010 / EN ISO 7438:2005

Specified degr. 180° Former dia. 4x2 mm

Type and dimensions	Bend angel	Results	Type and dimensions	Bend angel	Results
TFBB/1 (2x18 mm)	180	Accepteret / Accepted	TRBB/1 (2x19 mm)	180	Accepteret / Accepted
TFBB/2 (2x21 mm)	180	Accepteret / Accepted	TRBB/2 (2x19 mm)	180	Accepteret / Accepted

3. Impact tests

EN ISO 148-1:2013/ ISO 9016

Dim.: mm Specified type of test : V-notch Specified: J Testing temp. °C

Test no. VWT	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J
Average WM		Average FL		Average FL+2		Average FL+5		Average FL		Average FL+2		Average FL+5	

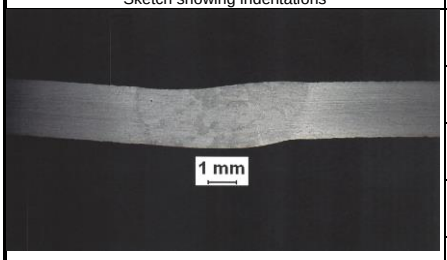
4. Macro Examination

Separate sheet with picture ☒ Yes ☐ No Results: Accepteret / Accepted

5. Hardness tests

ISO 9015-1, EN ISO 6507-1:2006

Specified type of test: HV10 Req. max.

Sketch showing indentations		Base metal (2mm)			HAZ (0,5 mm)				Weld metal			HAZ (0,5mm)				Base metal (2mm)		
	A																	
	B																	
	C																	
	D																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

6. Other/Supplementary Tests.

☒ No ☐ Yes See enclosures:

7. Further enclosures:

M026517:2

Place Randers	25/01-2016	Witnessed/reviewed (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature Heino Harstad		Representing (Examiner or Test Body)

Vi godkender herved denne svejseprocedure til svejsning på omtalte projekt under de begrænsninger, der er givet i standarden/normen og/eller kundens specifikation.

We hereby approve this welding procedure for welding on the referring projekt within the limitations given in the standard/code and/or client´s specifikation.

Place Date

Underskrift af kunde/kunderepræsentant
Client´s or representative´s signature

Markrapport
Visuel kontrol af svejsesømme

Rekvirent TJ Technology, Ågade 65, 7850 Stoholm	**Sag nr.** 2015544	**Rapport nr.** VT-02
Entreprenør	**Dato.** 15/01-2016	**side af** 1 / 1
Emne Rør: Ø50,8x2 mm	**Tegning ref.:** 222446-D1324560	
Mrk. 2015544-02B	**Materiale:** X5 CrNi18-10	

Fugetype
☒ Stumpsøm ☐ Kantsøm ☐ Andet ☐ Slebet

PWHT
☐ Ja ☒ Nej

Timer efter svejsning

Undersøgelsesprocedure / klasse
☒ EN ISO 17637 ☐ NS 10250 ☐ ASME Sect. V ☐ Andet:

Kvalitetskrav
☒ EN ISO 5817 Level B (C) ☐ ASME Sect. ☐ Andet:

Udstyr
☒ Hulspejl ☒ Lygte ☐ Skydelære ☐ Kantsømlære ☐ Andet:

Undersøgelsesomfang
☒ Kontrol før svejsning ☒ Kontrol under udførelse ☒ Kontrol efter svejsning ☐

Omfang
☐ Visuel besigtigelse % ☒ Visuel kontrol 100 % ☐ Tilfældigt udvalgt ☐ Udpeget

Undersøgelsens resultat

Accepteret / Accepted

Rep. opmærkning.	**Kontrol af**	**Bilag vedlagt**	**Inspektør**	**Certifikat type. / nr.**
☐ På emne ☐ På skitse	☐ Opslibning ☐ Reparation	☐ Ingen ☐ Stk.		IWT-NO/0147

Attestationer	**Tekniker**	**Certifikat type / nr.**
	Tekniker	**Certifikat type / nr.**

9-11-01-L

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

SWEDAC ACKREDITERING 5022 ISO/IEC 17025

SAFE CONTROL MATERIALTEKNIK

Beställare / Ordered by
Weldadvice
Messingvej 32B
DK-8940 Randers SV

Orderdatum / Date of order
2016-01-20

Reg. nummer / Reg. number
M026517:2

Er referens / Your reference
Heino Harstad

Inlämningsdatum / Object (-s) received
2016-01-20

Sidnummer / Page
1(4)

Ordernummer / Order number
2016544-02

Rapportdatum / Date of report
2016-01-25

Vår referens / Our reference
Johan Ageryd

Assignment:	Procedure qualification test according to EN ISO 15 614-1:2004.
Test object(s):	Butt weld. Two welded pipes.
Material:	1.4301/1.4307
Group:	8.1
Dimension:	Ø 50.8 x 2 mm
Heat number:	0440628 – C1309304
pWPS:	WPS TJ Tech 01
Procedure number:	2015544-02B
Identification mark:	2015544-02B
Weld method:	141
Position:	PC
Filler metal:	Hyundai SMT-316LSi, Ø1,6 mm.
Note:	-
Result:	Accepted according to referenced standard.
Signature:	SAFE CONTROL Johan Ageryd

"Laboratorier ackrediteras av Styrelsen för ackreditering och teknisk kontroll (SWEDAC) enligt svensk lag. Den ackrediterade verksamheten vid laboratoriet uppfyller kraven i SS-EN ISO/IEC 17 025 (2005). Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänner annat". Provningsresultaten i denna rapport avser endast provade objekt.

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Safe Control Materialteknik AB • Tillgängligheten 1 • S-417 01 Göteborg
Tel. +46 (0)31 65 64 70 • Fax +46 (0)31 65 64 80
E-mail: info@safecontrol.se • www.safecontrol.se

SWEDAC ACKREDITERING 5622 ISO/IEC 17025

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

Teknisk instruktion / Technical instruction
Tensile testing

Märkning / Marking
2015544-02B

Reg. nummer / Reg. number
M026517:2

TI Dokumentnr./ TI Document no.
SCDR1

Provningsutrustning / Testing equipment
SCM 1, 39, UTM V.2.10.02
SCM 107 extensometer L_e 50 mm

Sidnummer / Page
2(4)

Provning enligt / Testing according to
SS-EN ISO 6892-1:2009B10

Provningsdatum / Testing date
2016-01-21

Utfört av / Performed by
Harald Fredriksson

Tensile testing:

Pipe strip acc. to ISO 4136 / No	Dimensions		Square-area	Yield strength				Tensile strength	Elongation	Location of fracture
	Diameter/ width	Thickness		$R_{p0.2}$	$R_{p1.0}$	R_{eL}	R_{eH}	R_m	A_5	
	mm		mm^2	MPa					%	
TT/1	12.01	1.58	19.16	-	-	-	-	638	-	HAZ
TT/2	12.02	1.77	21.49	-	-	-	-	632	-	HAZ
SS-EN 10217-7:2005 1.4307:				≥180	≥215	-	-	470-670	≥35 T ≥40 L	-
SS-EN 10217-7:2005 1.4301:				≥195	≥230	-	-	500-700	≥35 T ≥40 L	-

Result: Satisfactory according to the requirement for the base material.

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

R_m: 2.0 % *$R_{p0.2}$ / $R_{p1.0}$:3.0 %* *R_{eH} / R_{eL}: 2.0 %*

Signatur/ Signature:

SAFE CONTROL Harald Fredriksson

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

Teknisk instruktion / Technical instruction	Märkning / Marking	Reg. nummer / Reg. number
Bend testing	2015544-02B	M026517:2
TI Dokumentnr./ TI Document no.	**Provningsutrustning / Testing equipment**	**Sidnummer / Page**
SCSP1	SCM 1 and mandrel Ø 8mm	3(4)
Provning enligt / Testing according to	**Provningsdatum / Testing date**	**Utfört av / Performed by**
SS-EN ISO 7438:2005	2016-01-21	Harald Fredriksson

Bend testing:

Sample type acc. to SS-EN ISO 5173 / No	Dimensions		Bending-angle	Diameter of mandrel	Observations and result
	Thickness (a)	Width (b)			
	mm	mm	°		
TFBB/1	2	18	180	4 x Test thickness (a)	Satisfactory, without remarks.
TFBB/2	2	21	180	4 x Test thickness (a)	Satisfactory, without remarks.
TRBB/1	2	19	180	4 x Test thickness (a)	Satisfactory, without remarks.
TRBB/2	2	19	180	4 x Test thickness (a)	Satisfactory, without remarks.

Result: Satisfactory according to the requirement in EN ISO 15614-1.

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurment: ± 0.2mm

Signatur/ Signature: SAFE CONTROL Harald Fredriksson

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

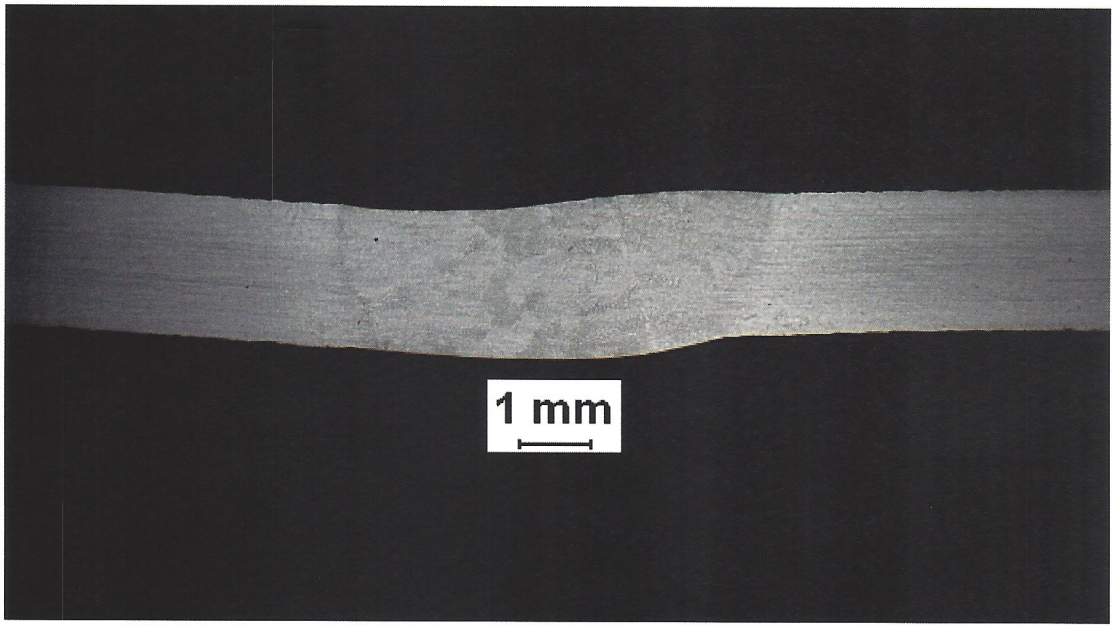
Teknisk instruktion / Technical instruction Macroscopic and microscopic examination of welds	**Märkning / Marking** 2015544-02B	**Reg. nummer / Reg. number** M026517:2
TI Dokumentnr./ TI Document no. SCMM1	**Provningsutrustning / Testing equipment** SCM 9	**Sidnummer / Page** 4(4)
Provning enligt / Testing according to SS-EN 1321	**Provningsdatum / Testing date** 2016-01-21	**Utfört av / Performed by** Johan Ageryd

Macroscopic examination:

One macro sample was cut out for macroscopic examination of weld metal, HAZ and base metal. The macro sample was ground (to 2000- paper) and examined in not etched and etched condition at magnification of 1× - 20×.

Macro sample			Base metal		Filler metal	Etchant *(acc. to SIS-CEN/CR 12361:1996)*
ID / No	Position	Orientation	Left	Right		
2015544-02B	PC	Perpendicular to the weld direction	1.4301/1.4307	1.4301/1.4307	Hyundai SMT-316LSi	B.5 (Kalling´s)
Examined macro sample is assessed to fulfil the requirements in EN ISO 5817:2014. See macro photo below.						

Macro photo:



Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurement: ± 1.5 %

Not.: Avsteg från punkt 10 i SS-EN 1321 har gjorts. Beteckning har ej redovisats i enlighet med exemplifierade versioner.
Note: Deviation from clause 10 in SS-EN 1321 has been done. Description has not been presented in accordance with exemplified versions.

Signatur/ Signature:

SAFE CONTROL
Johan Ageryd

SIDERINOX

Siderinox S.p.a. Frazione Caselle 20081 Morimondo (MI) Italia
Ufficio Commerciale: Tel. 02 9498151 - Fax 02 949815250/251
Ufficio Amministrativo: Tel. 02 9498161 - Fax 02 949816350
Ufficio Spedizioni: Tel. 02 949816222 - Fax 02 949815350
Ufficio Acquisti : Tel. 02 949816345 - Fax 02 949816350
Casella e-mail: sx@siderinox.it Sito web: www.siderinox.it

Capitale Sociale Euro 3.300.000 i.v.
Cod. Fiscale e Reg. Imp. MI N. 01825510157
R.E.A. Milano N. 878116
Centro Meccanografico n. MI074282
Partita IVA 01825510157

AZIENDA CON SISTEMA
DI GESTIONE QUALITÀ
CERTIFICATO DA DNV GL
=ISO 9001=

INSPECTION CERTIFICATE EN 10204 3.1 N° 424885 of 02.02.2015

Purchaser **INOX STAAL A/S**

DDT	SIDERINOX order number	Customer's order
N 8 of 02.02.2015	N 5 of 22.01.2015	N 15836-1 of 22.01.2015

Product description

Stainless steel round pipe Ø 50,8 x 2 mm AISI 304/304L brushed EN 10217-7 Longitudinally welded

Dimension	Steel type	Quantity (m)	Weight (kg)
50,8 x 2 mm	EN 1.4301/1.4307 / AISI 304/304L	366	815

Production Norm	Rolling	Tolerances	Welding factor
EN 10217-7	Hot rolled	D3 \ T3	V=1

Marking MANUFACTURER'S MARK - DIMENSION - STEELGRADE - HEAT N. - PRODUCTION NORM - EXECUTION - E.C. INSPECTOR - WORK INSPEKTOR

Manufacturing process — Surface finishing W0

CHEMICAL COMPOSITION

Heat	% C	%Mn	%P	% S	%Si	%Cr	% Ni	% Mo	% Ti
	0,000 - 0,030	0,000 - 2,000	0,000 - 0,040	0,000 - 0,010	0,000 - 1,000	17,500 - 19,500	8,000 - 10,000	0,000 - 0,000	0,000 - 0,000
0440628	0,022	1,680	0,027	0,001	0,380	18,240	8,090		

The chemical values refer to the certificate issued by the steel mill according to EN 10088 / 10028-7 / ASTM A 240 and stored at our office.

TEST RESULTS

* (D) Direction: (L) Longitudinal, (T) Transverse - ** (P) Position: (W) Welding, (M) Material

Test unit	Test Class	(D) *	(P) **	TENSILE TEST in Nmm2=MPa				HARDNESS
				Yield Strength		Tensile Strength	Elongation	
				Rp 0,2%	Rp 1%	Rm	A %	HRB
				195 -	230 -	500 - 740	40 -	
T14100996	TC1	L	M	246	330	658	48	
T14100998	TC1	L	M	235	314	627	49	

Visual inspection	OK	Drift expanding test		Sealing test	
		UNI EN ISO 8493	OK	UNI EN ISO 10893-1	OK
Check on dimensions	OK	Flattenning test		Non destructive Eddy Current test	
		UNI EN ISO 8492	OK	UNI EN ISO 10893-2	OK
Antimixing test	OK	Weld bend test		Intergranular corrosion test	
		EN 910	OK	N. P.	N. P.

WE CERTIFY THAT THE MATERIAL SUPPLIED COMPLIES WITH THE REQUIREMENTS AGREED ON THIS ORDER

Remarks:

Cerfications:
UNI EN ISO 9001
Dir. PED 97/23/EC Encl. 1, Point 4.3, Comma 3
AQUAP from Nr. 7293-06-TU to Nr 7298-06-TU

Qualifications:
WPS/WPAR: UNI EN ISO 15609-1/UNI EN ISO 15614-11
WLD: UNI EN ISO 14732 operator
NDT: UNI EN ISO 9712 operator

Document issued by the mill's Inspector
D. Ricco

Document confirmed by the authorized company responsible
W. Amodeo

CERTIFIED MATERIAL REPORT

CMR No. : 1502253500015 Date of Issue : 2015-02-25

Customer	HYUNDAI WELDING EUROPE OFFICE		
Trade Name	SMT-316LSi Inox	Size	1.6mm*1000mm*5kg
Lot No.	V9988	Purchaser's Order No.	
Applicable Specification	AWS A5.9 ER316LSi	* According to EN 10204-2004 : 3.1	

Welding Current		Shielding Gas		Post Weld Heat Treatment (℃ × hr.)	

Mechanical Properties	Tensile Test			Impact Test (CVN - Joule)				
	YS(MPa)	TS(MPa)	EL(%)	Temp.(℃)	X1	X2	X3	Avg.
	-	-	-		-	-	-	-
Spec.								

Chemical Composition (%)

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo		
(WIRE)	0.021	0.97	1.71	0.027	0.011	0.20	11.33	18.30	2.57		
Spec.	≤0.03	0.65 ~1.00	1.0 ~2.5	≤0.03	≤0.03	≤0.75	11.0 ~14.0	18.0 ~20.0	2.0 ~3.0		

We hereby certifies that the material covered by this report has been inspected in accordance with and been found to meet the applicable requirements of specification and customer's requirements.

Approved by

K.W. Park

QA Manager Park K. W.

HYUNDAI HYUNDAI WELDING CO., LTD.
Head Office #507,Teheran-ro,Gangnam-gu,Seoul,Republic of Korea
Pohang Plant #100,Daesong-ro,Nam-gu,Pohang,Republic of Korea

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 P/T FW 5.1 FM3 S t2 D21.3 PH sl

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242580 Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør	
Sømtype Type of joint	FW		FW:Kantsøm	
Materialegruppe(r) Material group(s)	5.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM3		FM1, FM2, FM3	
Type og betegnelse Type and designation Tabel/table 4 Tabel/table 5	 S	DS EN ISO 21952-A W CrMo1 Si	S, M	
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)				
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW				
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4	
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6	
Svejseposition Welding position BW tabel/table 9 FW tabel/table 10	 PH		all FW positions, except vertical dowr	
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)	

Svejseproceduresspecifikations-nr.:
Welding procedure specification No.: SP141-075

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):
13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242580

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s2 D21.3 H-L045 ss gb

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242582

Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	T		T:Rør	
Sømtype Type of joint	BW		BW:Stumpsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar	
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	2		2-4	
Materialetykkelse i mm for FW Material thickness in mm for FW				
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6	
Svejseposition Welding position BW tabel/table 9	H-L045		all BW positions, except vertical down	
FW tabel/table 10				
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)	

Svejseprocedurespecifikations-nr.: SP141-199
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):
13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242582

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 P/T FW 8.1 FM5 S t2 D50 PH sl

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec
H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 25350
Welding passport No.:

Svejserens navn: Morten Pedersen
Welder's name:

Fødselsdato: 21-4-1988
Birth date:

Adresse: Bækkevej 6
Address: 9500 Hobro

Prøvningsinstans: Nordisk Svejse Kontrol A/S
Examining body: Stejlundvænget 4 6870 Ølgod

Reference-nr./Reference No. 241393

Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør	
Sømtype Type of joint	FW		FW:Kantsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)				
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW				
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4	
Rørdiameter i mm Pipe diameter in mm	50		>=25	
Svejseposition Welding position BW tabel/table 9			all FW positions, except vertical dowr	
FW tabel/table 10	PH			
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)	

Svejseprocedurespecifikations-nr.:
Welding procedure specification No.: SP141-123

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 17-03-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift): 18-03-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 17-03-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 241393

Prøveemne undersøgt (dato):
Test piece examined (date): 18-03-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 18-03-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 17-03-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 17-03-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 21-03-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
14/9-22	CEO	
16/3-23	CEO	
11/9-23	CEO	

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 238073

Prøveemne undersøgt (dato):
Test piece examined (date): 29-10-2021

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 29-10-2021 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 28-10-2021

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 28-10-2024

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 01-11-2021 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	~~Underskrift~~/Signature
27/4 - 22	CEO	
24/10 - 22	CEO	
28/4 - 23	CEO	
23/10 - 23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s1.5 D76 H-L045 ss gb

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 25350
Welding passport No.:

Svejserens navn: Morten Pedersen
Welder's name:

Fødselsdato: 21-4-1988
Birth date:

Adresse: Bækkevej 6, 9500 Hobro
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 238073

Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	T		P:Plade T:Rør	
Sømtype Type of joint	BW		BW:Stumpsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar	
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	1.5		1.5-3,0	
Materialetykkelse i mm for FW Material thickness in mm for FW				
Rørdiameter i mm Pipe diameter in mm	76		>=38	
Svejseposition Welding position BW tabel/table 9	H-L045		all BW positions, except vertical down	
FW tabel/table 10				
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)	

Svejseprocedurespecifikations-nr.: SP141-189
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED

Svejsning af prøveemne udført/Welding of test piece terminated: 28-10-2021

NSK NB 2735

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):

29-10-2021 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 28-10-2021 Brian Gravgaard

Sub Section J04

Surface Preparation & Painting Specification

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	14/04/2023	First Issue
002	09/02/2024	Updated to include painting specifications from suppliers
003	16/07/2024	Updated and expanded according to comments

Document Title:	**BLPH Project - Surface Preparation & Painting Specification**
Document Number:	K559-2254-CWIWP4202202-J04-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-J04-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J04
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	J04 – Surface Preparation & Painting Specification
Full Title	Surface Preparation & Painting Specification

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	RGL	April 14, 2023
2.0	Updated to include painting specifications from suppliers	EZE	February 9, 2024
3.0	Updated according to comments: -Added data sheets from paint manufacturers -Added details on the Coating Procedure Tests -Added Inspection & Test Tables -Added details on qualification testing -Added reference to NORSOK M501	EZE	July 16, 2024

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1.0 General

In terms of obtaining the required level of antirust protection of surfaces that are to be provided with such protection by painting depends greatly on the condition of the surfaces and physical elements of their design. It is therefore very important that the material and surface treatment and pre-treatment prior to the painting of the parts can be carried out in the prescribed manner. The recommendations will be found in this document.

Any and all weld spatter, slag must be removed before the item is painted. It is important that the manufacturing document clearly indicates which surfaces are to be painted and what type of treatments are to be given. If areas are not to be painted, the item document should also indicate which surfaces are NOT to be treated.

Parts or objects which, after assembly or installation, have surfaces that are not accessible for technically correct pre-treatment and painting must be finished before they are assembled or installed. If not done correctly, the antirust protection will NOT be achieved.

Painting of bolts and nuts with the intention to protect them against rust must be avoided, since painting does not provide good rust protection. If nevertheless, painting is prescribed, it is essential that the thickness of the paint applied to nuts and bolt heads does not prevent the appropriate spanners/wrenches from correctly fitting and tightening them.

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2.0 References

Table 1. Reference Documents

Document ID	Document Title	Source
ISO 2811	Paints and varnishes — Determination of density	ISO
ISO 3251	Paints, varnishes and plastics — Determination of non-volatile-matter content	ISO
ISO 4624	Paints and varnishes — Pull-off test for adhesion	ISO
ISO 4628	Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance	ISO
ISO 8501	Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness	ISO
ISO 8502	Preparation of steel substrates before application of paints and related products	ISO
ISO 8503	Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates	ISO
ISO 12944	Paints and varnishes — Corrosion protection of steel structures by protective paint systems	ISO
ISO 19840	Paints and varnishes — Corrosion protection of steel structures by protective paint systems Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces	ISO
NORSOK M501	Surface preparation and protective coating	NORSOK

3.0 Surface Preparation and Painting Specifications

The applicable corrosion environment category for the containers according to ISO 12944-9 is defined as **CX**; for Offshore areas of high salinity or industrial areas of extremely high humidity and aggressive atmosphere or subtropical and tropical areas.

The requirements of a coating system for category CX are (for a zinc-rich primer):

- Primer Dry Film Thickness: ≥ 40 µm
- Minimum Number of Coats: 3
- Total Dry Film Thickness: ≥ 280 µm

3.1 Containers

The surface preparation and painting specifications used by the supplier of the containers are detailed in the table below.

Table 2. Coating System Specification (Containers).

Manufacturer		Type of Substrate	Type of Environment
Name:	PPG Industries, Inc.	Uncoated carbon steel	CX (offshore)
Address:	One PPG Place Pittsburgh, PA 15272 USA		
Surface Preparation:	ISO 8501-3 P3 ISO 8501-1 Sa 2½ ISO 8503-1 40-70 µm ISO 8502-6 <50 mg/m^2 NaCl ISO 8502-3 Rate 2		

	Trade Name	Color Shade	Generic Type	NDFT (µm)
1st coat	SigmaZinc™ 68 GP	Grey	Zinc Epoxy	60
2nd coat	SigmaFast™ 278	Div. Ral	Epoxy	170
3rd coat	SigmaDur™ 550	Div. Ral	Acrylic PU	50
			Total NDFT (µm)	280

3.2 Cooling Platform and LT Cooler Support Structure

The surface preparation and painting specifications used by the supplier of the cooling platform and LT cooler support structure are categorized as No. 1A based on the NORSOK M501 standard, which also fulfill the requirements of ISO 12944-9 CX, and are detailed in the table below.

Table 3. Coating System Specification No. 1A (Cooling Platform and LT Cooler Support Structure).

Manufacturer		Type of Substrate	Type of Environment
Name:	Hempel A/S	Uncoated carbon steel	CX (offshore)
Address:	Lundtoftegårdsvej 91 2800 Kgs. Lyngby Denmark		
Surface Preparation:	ISO 8501-1 Sa 2½ ISO 8501-3 Grade P3 ISO 8502-3 Rate 2 ISO 8502-6 and ISO 8502-9 ≤20 mg/m^2 NaCl ISO 8503-1 Medium G (50-85 µm) ISO 2801 Surface control between layers		

	Trade Name	Color Shade	Generic Type	NDFT (µm)
1st coat	Hempadur Avantguard 750	Grey	Zinc Epoxy	60
2nd coat	Hempadur 4774D	Ral 7035	Epoxy	170
3rd coat	Hempadur 4774D	Ral 9001	Epoxy	
4th coat	Hempathane HS 5610	Ral 7035	Acrylic PU	50
			Total NDFT (µm)	280

3.3 Performance (Pre-qualification) Testing

The requirements for pre-qualification are applicable to both coating systems specified above.

Acceptance criteria in the pre-qualification testing are considered as minimum performance requirements.

Table 4. Performance tests requirements and acceptance criteria for coating systems.

Activity Description	**Environment corrosivity to ISO 12944-2**	**Verification Method**	**Acceptance Criteria**
Fingerprinting	All environments	ISO 12944-9 Annex C	ISO 12944-9 Annex C
Cyclic ageing test	CX (Offshore and coastal atmospheric zone) and CX + Im4 (splash zone and tidal zone), seawater filled compartments and Im3 (buried items)	ISO 12944-9 Clause 9	ISO 12944-9 Clause 9 Supplementary requirements: Chalking to ISO 4628-6, maximum rating 2. Pull-off test to ISO 4624, minimum 5.0 MPa and maximum 50% reduction from value measured before ageing.

3.4 Coating Procedure Test (CPT)

The Coating Procedure Test (CPT) is a systematic and controlled evaluation process used to verify the effectiveness and performance of a coating system under the defined conditions. The purpose of the CPT is to ensure that the coating procedure meets the desired quality standards and performs as expected while in service.

The table below shows the initial activities that form part of the CPT and are responsibility of the coating manufacturers.

Table 5. Coating procedure testing (partial).

Test Type	Method	Frequency	Acceptance Criteria	Consequence
Routine batch testing of painting material	a) Density ISO 2811-1 or ASTM D1475 b) Non-volatile matter (solid content) ISO 3251 or ASTM D2369	Each batch of paint	a1) For density ≤ 2.0 g/cm^3, ±0,05 g/cm^3 from fingerprint of paint used for CPT. a2) For density > 2.0 g/cm^3 , ±0,10 g/cm^3 from fingerprint of paint used for CPT. b) ±2 % wt from fingerprint of paint used for CPT.	Unused painting material shall be quarantined. Fingerprinting check shall be carried out to verify material against CPT material. If the fingerprint does not match the material used for the CPT, the entire batch shall be rejected and the areas coated with the non-compliant material shall be re-blasted and re-coated with a coating that meets the specification.
Fingerprinting	ISO 12944-9 Annex C	CPT paint material only, unless required to verify a paint batch.	ISO 12944-9 Annex C	Paint material to be rejected. Re-blast and re-coat with material compliant with CPT.

The CPT then follows all activities listed in the Inspection and Testing section below, which are responsibility of the coating applicators.

3.5 Inspection and Testing

Testing and inspection is carried out in accordance with the table below.

Table 6. Inspection and testing.

Test Type	Method	Frequency	Acceptance Criteria	Consequence
Environmental conditions	Ambient and metal temperature, relative humidity, and dew point.	At the start of each shift and minimum of twice per shift	In accordance with specified requirements (see data sheets)	No blasting or coating
Visual examination	Visual for sharp edges, weld spatter slivers, rustgrade, etc.	100% of all surfaces	No defects	Defects to be removed or repaired
Cleanliness	a) ISO 8501-1 b) ISO 8502-3	a) 100% visual of all surfaces b) Spot checks	a) In accordance with specified requirements b) Maximum quantity and size rating 2	a) Re-blasting b) Re-cleaning and retesting of non-conforming area until acceptable
Salt test	ISO 8502-6 and ISO 8502-9	Spot checks	Maximum conductivity corresponding to specification	Repeated washing of non-conforming area with potable water and retesting until acceptable followed by re-blasting
Roughness	ISO 8503-5	Each component or once per 10 m^2	As specified	Re-blasting non-conforming area with abrasive of suitable grade to achieve desired surface profile
Visual examination of coating	Visual to determine curing, contamination, solvent retention, pinholes/popping, sagging and surface defects	100% of surface after each coat	According to specified requirements	Repair of defects

Film thickness	ISO 19840. Calibration on a smooth surface	ISO 19840	ISO 19840, and coating system data sheet	Repair, additional coats or re-coating as appropriate
Adhesion	ISO 4624 (method A or B) using equipment with an automatic centred pulling force, and carried out when coating system are fully cured.	Spot checks	See notes below	Coating to be rejected. Re-blast and re-coat.
Notes: 1. 50 % reduction of average adhesion value from the CPT is acceptable as minimum adhesion during production coating. Absolute minimum value is 5 MPa.				

3.6 Field Painting Procedure / Repairs to Damaged Finishes

During handling, turning and assembly, damage to edges and to surfaces by the use of sharp-toothed clamps must be avoided by taking precautionary measures, such as the use of lifting devices with soft renewable contact surfaces or properly designed lifting cleats. If damage does occur, it must be carefully blended out by grinding (and the full protective treatment restored, with specified overlaps between coats).

Just as surface cleanliness before first coating is fundamental to performance of the system, so is the cleanliness of painted surfaces prior to the application of subsequent coats. On site, thorough cleaning shortly before painting is always necessary to remove contamination accumulated over time and from construction activities including dust, grout leaks from concreting, and the products of blast cleaning, bolting and welding.

3.7 Data Sheets

3.7.1 PPG Sigmazinc 68 GP

PRODUCT DATA SHEET

March 2, 2023 (Revision of January 4, 2023)

SIGMAZINC™ 68 GP

DESCRIPTION

Two-component, high solids polyamine adduct cured zinc rich epoxy primer

PRINCIPAL CHARACTERISTICS

- Designed as a system primer in various paint systems for aggressive environments
- Suitable for use in offshore and onshore environments with ISO 12944-2 corrosivity categories of C5 and CX (offshore)
- Meets the requirements of Norsok M-501 rev. 6, System 1
- Quick-drying, can be overcoated after a short interval
- Complies with the compositional requirements of ISO 12944–5
- Complies with the compositional requirements of SSPC-Paint 20, Level 2
- The zinc dust used in this product complies with minimum ASTM D520 Type II

COLOR AND GLOSS LEVEL

- Gray, reddish gray
- Flat

BASIC DATA AT 20°C (68°F)

Data for mixed product	
Number of components	Two
Mass density	2.4 kg/l (20.0 lb/US gal)
Volume solids	68 ± 2%
VOC (Supplied)	Directive 2010/75/EU, SED: max. 130.0 g/kg max. 310.0 g/l (approx. 2.6 lb/US gal)
Recommended dry film thickness	50 - 150 µm (2.0 - 6.0 mils) depending on system
Theoretical spreading rate	13.6 m^2/l for 50 µm (545 ft^2/US gal for 2.0 mils) See spreading rate tables
Dry to touch	20 minutes
Overcoating Interval	Minimum: 1.5 hours See overcoating tables
Full cure after	7 days
Shelf life	Base: at least 24 months when stored cool and dry Hardener: at least 24 months when stored cool and dry

Note: See ADDITIONAL DATA – Curing time

RECOMMENDED SUBSTRATE CONDITIONS AND TEMPERATURES

Substrate conditions

- Steel; blast cleaned to ISO-Sa2½ (SSPC SP-10), blasting profile 40 – 70 µm (1.6 – 2.8 mils)

Ref. P844

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PRODUCT DATA SHEET

March 2, 2023 (Revision of January 4, 2023)

SIGMAZINC™ 68 GP

Substrate temperature

- Substrate temperature during application should be at least 0°C (32°F)
- Substrate temperature during application and curing should be at least 3°C (5°F) above dew point

INSTRUCTIONS FOR USE

Mixing ratio by volume: base to hardener 90:10 (9:1)

- The temperature of the paint should preferably be above 15°C (59°F), otherwise extra thinner may be required to obtain application viscosity
- Adding too much thinner results in reduced sag resistance
- Thinner should be added after mixing the components

Induction time

None

Pot life

6 hours at 20°C (68°F)

Air spray

Recommended thinner
THINNER 91-92 or THINNER 91-82 (AMERCOAT T-10)

Volume of thinner
0 - 5%, depending on required thickness and application conditions

Nozzle orifice
1.5 – 2.5 mm (approx. 0.060 – 0.100 in)

Nozzle pressure
0.3 - 0.6 MPa (approx. 3 - 6 bar; 44 - 87 p.s.i.)

Airless spray

Recommended thinner
THINNER 91-92 or THINNER 91-82 (AMERCOAT T-10)

Volume of thinner
0 - 5%, depending on required thickness and application conditions

Nozzle orifice
Approx. 0.43 – 0.53 mm (0.017 – 0.021 in)

Nozzle pressure
15.0 MPa (approx. 150 bar; 2176 p.s.i.)

PPG

Ref. P844

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PRODUCT DATA SHEET

March 2, 2023 (Revision of January 4, 2023)

SIGMAZINC™ 68 GP

Brush/roller

Recommended thinner
THINNER 91-92 or THINNER 91-82 (AMERCOAT T-10)

Volume of thinner
0 – 5%

Cleaning solvent
THNNER 90-53, THINNER 90-58 (AMERCOAT 12) OR THINNER 21-06 (AMERCOAT 65)

ADDITIONAL DATA

Spreading rate and film thickness	
DFT	**Theoretical spreading rate**
50 µm (2.0 mils)	13.6 m^2/l (545 ft^2/US gal)
60 µm (2.4 mils)	11.3 m^2/l (454 ft^2/US gal)
75 µm (3.0 mils)	9.1 m^2/l (364 ft^2/US gal)
100 µm (4.0 mils)	6.8 m^2/l (273 ft^2/US gal)

Overcoating interval for DFT up to 100 µm (4.0 mils)						
Overcoating with...	**Interval**	**0°C (32°F)**	**10°C (50°F)**	**20°C (68°F)**	**30°C (86°F)**	**40°C (104°F)**
subsequent coating	Minimum	6 hours	3 hours	1.5 hours	1 hour	30 minutes
	Maximum	3 months	3 months	3 months	3 months	3 months

Notes:
- Zinc rich primers can form zinc salts on the surface; preferably they should not be weathered for long periods before overcoating
- Before overcoating visible surface contamination must be removed by high-pressure water cleaning, sweep blasting or mechanical cleaning

Curing time for DFT up to 100 µm (4.0 mils)			
Substrate temperature	**Dry to touch**	**Dry to handle**	**Full cure**
0°C (32°F)	1.5 hours	6 hours	20 days
10°C (50°F)	1 hour	3 hours	15 days
15°C (59°F)	40 minutes	2 hours	10 days
20°C (68°F)	20 minutes	1.5 hours	7 days
30°C (86°F)	10 minutes	1 hour	5 days

Notes:
- Adequate ventilation must be maintained during application and curing
- In case of application at air or surface temperature below 5°C (41°F), the temperature of the mixed paint is recommended to be higher than 10°C (50°F)

PPG

Ref. P844

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PRODUCT DATA SHEET

March 2, 2023 (Revision of January 4, 2023)

SIGMAZINC™ 68 GP

SAFETY PRECAUTIONS

- See Safety Data Sheet and product label for complete safety and precaution requirements
- This is a solvent-borne paint and care should be taken to avoid inhalation of spray mist or vapor, as well as contact between the wet paint and exposed skin or eyes

WORLDWIDE AVAILABILITY

It is always the aim of PPG Protective and Marine Coatings to supply the same product on a worldwide basis. However, slight modification of the product is sometimes necessary to comply with local or national rules/circumstances. Under these circumstances an alternative product data sheet is used.

REFERENCES

• EXPLANATION TO PRODUCT DATA SHEETS	INFORMATION SHEET	1411

WARRANTY

PPG warrants (i) its title to the product, (ii) that the quality of the product conforms to PPG's specifications for such product in effect at the time of manufacture and (iii) that the product shall be delivered free of the rightful claim of any third person for infringement of any U.S. patent covering the product. THESE ARE THE ONLY WARRANTIES THAT PPG MAKES AND ALL OTHER EXPRESS OR IMPLIED WARRANTIES, UNDER STATUTE OR ARISING OTHERWISE IN LAW, FROM A COURSE OF DEALING OR USAGE OF TRADE, INCLUDING WITHOUT LIMITATION, ANY OTHER WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR USE, ARE DISCLAIMED BY PPG. Any claim under this warranty must be made by Buyer to PPG in writing within five (5) days of Buyer's discovery of the claimed defect, but in no event later than the expiration of the applicable shelf life of the product, or one year from the date of the delivery of the product to the Buyer, whichever is earlier. Buyer's failure to notify PPG of such non-conformance as required herein shall bar Buyer from recovery under this warranty.

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3.7.2 PPG Sigmafast 278

PRODUCT DATA SHEET

March 2, 2023 (Revision of November 16, 2022)

SIGMAFAST™ 278

DESCRIPTION

Two-component, high solids, zinc phosphate epoxy primer and buildcoat

PRINCIPAL CHARACTERISTICS

- Epoxy primer or buildcoat in protective coating systems
- Excellent corrosion resistance in atmospheric exposure
- Cures at temperatures down to -5°C (23°F)
- Speed curing in steel fabrication
- Easy application by airless spray
- Wide application range
- ACQPA 27752-certified

COLOR AND GLOSS LEVEL

- Redbrown, gray and a selected range of (MIO) colors
- Semi-gloss

Notes:
- Epoxy coatings will chalk and fade upon exposure to sunlight, elevated temperatures, or chemical exposure. Discoloration and normal chalking do not impact performance. Light colors will darken over time. Some batch-to-batch variation in color is to be expected. Color matches are approximate.
- The addition of a UV stable topcoat should be considered when using epoxy coatings in cosmetic areas

BASIC DATA AT 20°C (68°F)

Data for mixed product	
Number of components	Two
Mass density	1.5 kg/l (12.5 lb/US gal)
Volume solids	80 ± 2%
VOC (Supplied)	Directive 2010/75/EU, SED: max. 153.0 g/kg UK PG 6/23(92) Appendix 3: max. 230.0 g/l (approx. 1.9 lb/US gal) EPA Method 24: 220.0 g/ltr (1.8 lb/USgal) China GB 30981-2020 (tested) 198.0 g/l (approx. 1.7 lb/gal)
Recommended dry film thickness	75 - 250 µm (3.0 - 10.0 mils)
Theoretical spreading rate	6.4 m^2/l for 125 µm (257 ft^2/US gal for 5.0 mils)
Dry to touch	2 hours
Overcoating Interval	Minimum: 2 hours Maximum: Extended
Full cure after	4 days

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PRODUCT DATA SHEET

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SIGMAFAST™ 278

Data for mixed product	
Shelf life	Base: at least 24 months when stored cool and dry Hardener: at least 24 months when stored cool and dry

Notes:
- See ADDITIONAL DATA – Spreading rate and film thickness
- See ADDITIONAL DATA – Overcoating intervals
- See ADDITIONAL DATA – Curing time

RECOMMENDED SUBSTRATE CONDITIONS AND TEMPERATURES

- Apply this product to the specified thickness as soon as possible after the surface is prepared

Substrate conditions

- Steel; blast cleaned to ISO-Sa2½ or minimum SSPC SP-6, blasting profile 40 – 70 µm (1.6 – 2.8 mils) or power tool cleaned to minimum ISO-St3 / SSPC SP3

Primed steel or previous coat

- Previous suitable coat must be dry and free from any contamination
- Surface of previous coat should be sufficiently roughened if necessary
- When applied to zinc silicate, a mist coat and full coat technique is required

Galvanized steel

- The surface must be properly prepared, dry, clean and free of any contamination
- The surface should be sufficiently roughened by sweep blasting to achieve a uniform matt appearance
- Sweep blast in accordance with the SSPC SP-16 guidelines

Stainless steel

- The surface must be properly prepared, dry, clean and free of any contamination
- The surface should be sufficiently roughened by sweep blasting with inert non-metallic abrasives
- Sweep blast in accordance with the SSPC SP-16 guidelines

Thermal Sprayed Metallization (TSM)

- Surface must be dry and free from any contamination
- The mist coat / full coat technique is required. See mist coat thinning recommendation in the Instructions For Use part below

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PRODUCT DATA SHEET

March 2, 2023 (Revision of November 16, 2022)

SIGMAFAST™ 278

Substrate temperature and application conditions

- Substrate temperature during application and curing should be at least 3°C (5°F) above dew point
- Substrate temperature during application and curing down to -5°C (23°F) is acceptable; provided the substrate is free from ice and dry

INSTRUCTIONS FOR USE

Mixing ratio by volume: base to hardener 75:25 (3:1)

- The temperature of the paint should preferably be above 15°C (59°F), otherwise extra thinner may be required to obtain application viscosity
- Adding too much thinner results in reduced sag resistance and slower cure
- Thinner should be added after mixing the components

Induction time
None

Pot life
1 hour at 20°C (68°F)

Air spray

Recommended thinner
THINNER 91-92

Volume of thinner
0 - 10%, depending on required thickness and application conditions

Nozzle orifice
1.7 – 2.0 mm (approx. 0.070 – 0.079 in)

Nozzle pressure
0.3 - 0.4 MPa (approx. 3 - 4 bar; 44 - 58 p.s.i.)

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SIGMAFAST™ 278

Airless spray

Recommended thinner
THINNER 91-92

Volume of thinner
0 - 10%, 30 - 50% when mist coat applied

Nozzle orifice
Approx. 0.46 – 0.53 mm (0.018 – 0.021 in)

Nozzle pressure
20.0 - 25.0 MPa (approx. 200 - 250 bar; 2901 - 3626 p.s.i.)

Brush/roller

Recommended thinner
THINNER 91-92

Volume of thinner
0 – 5%

Notes:
- Application by roller will leave roller marking and is suitable for minimum DFT requirements only
- A roller suitable for epoxy application must be used
- Application by brush may show brush marking, due to the thixatropic nature of the paint and is most suitable to small areas, tight angle areas or for stripe coating or touch-up

Cleaning solvent
THINNER 90-53

ADDITIONAL DATA

Spreading rate and film thickness	
DFT	**Theoretical spreading rate**
75 µm (3.0 mils)	10.7 m^2/l (428 ft^2/US gal)
125 µm (5.0 mils)	6.4 m^2/l (257 ft^2/US gal)
250 µm (10.0 mils)	3.2 m^2/l (128 ft^2/US gal)

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Overcoating interval for DFT up to 125 µm (5.0 mils)						
Overcoating with...	**Interval**	**-5°C (23°F)**	**0°C (32°F)**	**10°C (50°F)**	**20°C (68°F)**	**30°C (86°F)**
various epoxy coatings, polyurethane coatings, and PSX	Minimum Maximum	24 hours Extended	14 hours Extended	4 hours Extended	2 hours Extended	1 hour Extended

Notes:
- Actual maximum overcoating times will be influenced by local conditions
- A detergent wash with PREP 88 or equivalent is recommended prior to application of topcoats after 30 days of exposure if chalking or contamination is present
- To ensure optimal adhesion of the next coat, the surface must be dry and free from all contaminations (oil, grease, chalking, etc...) which would require cleaning and/or abrading

Curing time for DFT up to 125 µm (5.0 mils)			
Substrate temperature	**Dry to touch**	**Dry to handle**	**Full cure**
-5°C (23°F)	16 hours	38 hours	N/A
0°C (32°F)	11 hours	24 hours	21 days
10°C (50°F)	4 hours	8 hours	8 days
20°C (68°F)	2 hours	4 hours	4 days
30°C (86°F)	1 hour	2 hours	3 days

Note: Adequate ventilation must be maintained during application and curing

Pot life (at application viscosity)	
Mixed product temperature	**Pot life**
0°C (32°F)	10 hours
10°C (50°F)	3 hours
20°C (68°F)	1 hour
30°C (86°F)	30 minutes

SAFETY PRECAUTIONS

- See Safety Data Sheet and product label for complete safety and precaution requirements
- This is a solvent-borne paint and care should be taken to avoid inhalation of spray mist or vapor, as well as contact between the wet paint and exposed skin or eyes

WORLDWIDE AVAILABILITY

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PRODUCT DATA SHEET

March 2, 2023 (Revision of November 16, 2022)

SIGMAFAST™ 278

REFERENCES

- EXPLANATION TO PRODUCT DATA SHEETS — INFORMATION SHEET 1411

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3.7.3 PPG Sigmadur 550

PRODUCT DATA SHEET

August 8, 2022 (Revision of November 3, 2021)

SIGMADUR™ 550

DESCRIPTION

Two-component, aliphatic acrylic polyurethane finish

PRINCIPAL CHARACTERISTICS

- Unlimited recoatable
- Excellent resistance to atmospheric exposure conditions
- Good color and gloss retention
- Cures at temperatures down to -5°C (23°F)
- Resistant to splash of mineral and vegetable oils, paraffins, aliphatic petroleum products and mild chemicals
- Can be recoated even after long atmospheric exposure
- Good application properties

COLOR AND GLOSS LEVEL

- White and various other colors (see also SIGMACARE shade card)
- Gloss

Note: Certain colors, especially red, orange, and yellow may require additional coats for adequate hiding, especially if applied over primers with a significant color contrast

BASIC DATA AT 20°C (68°F)

Data for mixed product	
Number of components	Two
Mass density	1.3 kg/l (10.8 lb/US gal)
Volume solids	55 ± 2%
VOC (Supplied)	Directive 2010/75/EU, SED: max. 334.0 g/kg EUR Directive: 2004/42/IIA(i)(500) 459 g/l max. 430.0 g/l (approx. 3.6 lb/US gal) China GB 38469-2019 (tested) 409.0 g/l (approx. 3.4 lb/gal)
Recommended dry film thickness	50 - 60 µm (2.0 - 2.4 mils) depending on system
Theoretical spreading rate	11.0 m^2/l for 50 µm (441 ft^2/US gal for 2.0 mils)
Dry to touch	1 hour
Overcoating Interval	Maximum: 6 hours Maximum: Unlimited
Full cure after	4 days
Shelf life	Base: at least 36 months when stored cool and dry Hardener: at least 24 months when stored cool and dry

Ref. 7537

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PRODUCT DATA SHEET

August 8, 2022 (Revision of November 3, 2021)

SIGMADUR™ 550

RECOMMENDED SUBSTRATE CONDITIONS AND TEMPERATURES

Substrate conditions

- Previous coat (epoxy or polyurethane) must be dry and free from any contamination
- Previous coat: surface should be sufficiently roughened if necessary

Substrate temperature and application conditions

- Substrate temperature during application at -5°C (23°F) is acceptable; provided the substrate is free from ice and dry
- Substrate temperature during application and curing should be at least 3°C (5°F) above dew point
- Relative humidity during application and curing should not exceed 85%
- Should condensation on the surface occur during, or soon after application, this could result in color and gloss change

INSTRUCTIONS FOR USE

Mixing ratio by volume: base to hardener 88:12

- The temperature of the mixed base and hardener should be above 10°C (50°F), otherwise extra thinner may be required to obtain application viscosity
- Thinner should be added after mixing the components
- Adding too much thinner results in reduced sag resistance

Induction time

None

Pot life

5 hours at 20°C (68°F)

Note: See ADDITIONAL DATA – Pot life

Air spray

Recommended thinner
THINNER 21-06

Volume of thinner
3 - 5%, depending on required thickness and application conditions

Nozzle orifice
1.0 - 1.5 mm (approx. 0.040 - 0.060 in)

Nozzle pressure
0.3 - 0.4 MPa (approx. 3 - 4 bar; 44 - 58 p.s.i.)

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SIGMADUR™ 550

Airless spray

Recommended thinner
THINNER 21-06

Volume of thinner
3 - 5%, depending on required thickness and application conditions

Nozzle orifice
Approx. 0.43 – 0.48 mm (0.017 – 0.019 in)

Nozzle pressure
20.0 MPa (approx. 200 bar; 2901 p.s.i.)

Brush/roller

Recommended thinner
THINNER 21-06

Volume of thinner
0 – 5%

Cleaning solvent
THINNER 90-53

ADDITIONAL DATA

Spreading rate and film thickness	
DFT	**Theoretical spreading rate**
50 µm (2.0 mils)	11.0 m^2/l (441 ft^2/US gal)
60 µm (2.4 mils)	9.2 m^2/l (368 ft^2/US gal)

Overcoating interval for DFT up to 50 µm (2.0 mils)							
Overcoating with...	**Interval**	**-5°C (23°F)**	**0°C (32°F)**	**10°C (50°F)**	**20°C (68°F)**	**30°C (86°F)**	**40°C (104°F)**
itself	Minimum	24 hours	16 hours	8 hours	6 hours	5 hours	3 hours
	Maximum	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited

Note: Surface should be dry and free from any contamination

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PRODUCT DATA SHEET

August 8, 2022 (Revision of November 3, 2021)

SIGMADUR™ 550

Curing time for DFT up to 60 µm (2.4 mils)		
Substrate temperature	**Dry to handle**	**Full cure**
-5°C (23°F)	24 hours	15 days
0°C (32°F)	16 hours	11 days
10°C (50°F)	8 hours	6 days
20°C (68°F)	6 hours	4 days
30°C (86°F)	5 hours	3 days
40°C (104°F)	3 hours	48 hours

Notes:
- Adequate ventilation must be maintained during application and curing
- Premature exposure to early condensation and rain may cause color and gloss change

Pot life (at application viscosity)	
Mixed product temperature	**Pot life**
10°C (50°F)	7 hours
20°C (68°F)	5 hours
30°C (86°F)	3 hours
40°C (104°F)	2 hours

SAFETY PRECAUTIONS

- This is a solvent-borne paint and care should be taken to avoid inhalation of spray mist or vapor, as well as contact between the wet paint and exposed skin or eyes
- Contains a toxic polyisocyanate curing agent
- Avoid at all times inhalation of aerosol spray mist

WORLDWIDE AVAILABILITY

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REFERENCES

- EXPLANATION TO PRODUCT DATA SHEETS — INFORMATION SHEET — 1411

Ref. 7537

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PRODUCT DATA SHEET

August 8, 2022 (Revision of November 3, 2021)

SIGMADUR™ 550

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3.7.4 Hempel Hempadur Avantguard 750

Product Data Sheet

Hempadur Avantguard 750

Product characteristics

Description
Hempadur Avantguard 750 is an activated zinc-rich epoxy primer in compliance with the requirements of Level 2, type II in SSPC Paint-20, 2019 and ISO 12944 Part 5, 2018. The product is in full compliance with ASTM D520 type II and EU Directive 2004/42/EC, the Paints Directive on the limitation of volatile organic compounds: subcategory j.

Recommended use
Hempadur Avantguard 750 is recommended as a versatile primer for long-term protection of steel in severely corrosive environments including offshore.

Service temperature:
- Maximum, dry exposure only: 160°C [320°F].

Certificates / Approvals
- Meets requirements to NORSOK M-501 when used as part of a predefined paint system. Edition 6, System 1. Edition 7, System 1B
- Reaction to fire tested (as part of a coating system with approved primer and topcoat) according to EN13501-1 B-s1, d0.

Features
- Reduces the effect of corrosion and provides excellent galvanic protection.
- Fast drying primer with short minimum overcoating intervals.
- Excellent mechanical strength, also in cyclic temperatures, with improved tolerance to high film thickness through high flexibility and self-healing effect.
- Superior tolerance to high relative humidity during application.
- Cures down to -10°C [14°F].

Product safety

Flash point 25°C [77°F]

VOC content mixed product

Legislation	Value	5% thinning, by volume	Limit value, phase II (2010)[a]
EU	330 g/L [2.75 lb/US gal]	356	500
US (coatings)	330 g/L [2.75 lb/US gal]		
US (regulatory)	330 g/L [2.75 lb/US gal]		
China	330 g/L [2.75 lb/US gal]		

VOC values may vary with shade, please consult the Safety Data Sheet, section 9. According to specific legislation, see details in the Explanatory Notes available at Hempel website, hempel.com or at your local Hempel website. [a]EU Directive 2004/42/CE.

Handling
Handle with care. Before and during use, observe safety labels on packaging and paint containers and follow all local and national safety regulations. Always consult Hempel's Safety Data Sheet for this product along with the Product Data Sheet.

For professional use only.

Product data

Product code
1736G

Product components
Base 1736U
Curing Agent 97043

Standard shade / code
Grey 19840

Gloss
Flat

Volume solids
65 ± 2%

Issued by Hempel A/S - June 2024
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Product Data Sheet

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Hempadur Avantguard 750

Specific gravity
2.3 kg/L [19 lb/US gal]

Reference dry film thickness
60 micron [2.4 mils]

Surface preparation

Cleanliness
- Remove oil, grease and other contaminants by suitable detergent cleaning.
- Remove salts, detergents and other contaminants by high pressure fresh water cleaning.

New build:
- Abrasive blasting to min. Sa 2½ (ISO 8501-1) / SP 10 (SSPC).
- Remove dust, blast media and loose materials.

Roughness
- Surface profile Medium (G) (ISO 8503-2).

Consult Hempel's separate Surface Preparation Guidelines for more details.

Application

Mixing ratio
Base 1736U : Curing Agent 97043
(8.5 : 1.5 by volume)

Products containing floating or settling particles/pigments need to be continuosly stirred during application. This is especially important in case of heavy thinning.

Thinner
Above 20°C [68°F] Hempel's Thinner 08450
Below 20°C [68°F] Hempel's Thinner 08510

Cleaner
Hempel's Tool Cleaner 99610

Pot life

Product temperature	0°C [32°F]	20°C [68°F]	40°C [104°F]
Pot life	5 hours	4 hours	1½ hours

Application method

Tool	Thinning max vol.	Application parameters
Airless spray	5%	Nozzle pressure: 220 bar [3200 psi] Nozzle orifice: 0.017-0.021"

If brush or roller application is used, more coats will be necessary to achieve the specified dry film thickness. Spray data are indicative and subject to adjustment. Pressure is for a material temperature of 20°C [68°F].

Film thickness

Specification range	Low	High	Recommended
Dry film thickness	40 micron [1.6 mils]	100 micron [4.0 mils]	60 micron [2.4 mils]
Wet film thickness	60 micron [2.4 mils]	150 micron [6.0 mils]	90 micron [3.6 mils]
Theoretical spreading rate	16 m²/L [652 sq ft/US gal]	6.5 m²/L [265 sq ft/US gal]	11 m²/L [448 sq ft/US gal]

Overthickness must be closely controlled and never locally exceed 200 micron [8.0 mils] DFT. On irregular surfaces it is recommended to employ special care in avoiding over application.

Application conditions
- Temperature of product must be above 15°C [59°F] during application.
- To avoid condensation, apply on a clean and dry surface with a temperature that is at least 3°C [5°F] above the dew point.
- Surface temperature must be above -10°C [14°F] during application and curing.
- Surface temperature must be below 40°C [104°F] during application and curing.

Relative Humidity:
- Relative humidity must be below 95% during curing.
- Relative humidity must be below 95% during application.

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Product Data Sheet

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Hempadur Avantguard 750

Drying and overcoating

Product compatibility
- Previous coat: None.
- Subsequent coat: According to Hempel's Specification.

Drying time

Surface temperature		-10°C [14°F]	0°C [32°F]	20°C [68°F]	40°C [104°F]
Touch dry	min	50	30	10	5
Hard dry	hours	4½	3	1½	½

Determined for dry film thickness 60 micron [2.4 mils] at standard conditions, see Hempel's Explanatory Notes for details.

Overcoating

Hempel's specification supersedes any guidelines indicated in the overcoating table

Quality name		-10°C [14°F]	0°C [32°F]	20°C [68°F]	40°C [104°F]
Atmospheric medium					
Hempaprime Multi 500 Winter	Min	3 h	90 min	45 min	25 min
	Max	Ext*	Ext	Ext	Ext
Hempathane HS 55610	Min	3 h	90 min	45 min	25 min
	Max	56 d	42 d	14 d	3½ d
Atmospheric severe					
Hempaprime Multi 500 Winter	Min	3 h	90 min	45 min	25 min
	Max	90 d	90 d	30 d	7 d
Hempathane HS 55610	Min	3 h	90 min	45 min	25 min
	Max	20 d	15 d	5 d	28 h

Overcoating times are indicative for products of the same generic chemistry. Consult Hempel's specification for more information.

Drying conditions
- To obtain the drying time stated, it is important to maintain sufficient ventilation during application, drying and curing.

Overcoating details
- If the maximum overcoating interval is exceeded, roughening of the surface is necessary to ensure intercoat adhesion.
- Remove zinc salts or other contamination before overcoating.
- The surface must be dry and clean prior to application.

Other remarks
- Hempel's Specification supersedes any recommendations given in the Product Data Sheets.

Storage

Shelf life

Ambient temperature	25°C [77°F]
Base	12 months
Curing Agent	36 months

Shelf life from date of production, when stored in original, unopened containers. Thereafter, the product quality must be re-inspected. Storage at elevated temperatures may reduce shelf life. For advice, please consult Hempel.

Storage conditions
- Product must be stored according to local legislation, at maximum 40°C [104°F], without direct sunlight and protected from rain and snow.

Carbon Footprint

Dry film thickness	1 µm	1 mil
GWP (Global Warming Potential)	18.9 g CO_2e/m^2	0.098 lb CO_2e/ft^2

The carbon footprint is for 1 square meter / square foot of surface area with a dry film thickness of 1 micron / mil.

The scope includes raw materials, in-bound transport to the Hempel factory, Hempel manufacturing processes, and any Volatile Organic Compounds emitted during and after the application of the product.

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Product Data Sheet

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Hempadur Avantguard 750

It is calculated based on the standard shade defined in this PDS.
Values may vary with shade.

Additional documents

Additional information is available at the Hempel website
https://www.hempel.com/service-and-support/technical-guidelines
or at your local Hempel website:

- Explanatory Notes for Product Data Sheet.
- Application methods.
- Substrates.
- Surface Preparation.
- Application Instruction for this product.
- Repair & maintenance.
- Inspection & quality control.

This Product Data Sheet ("**PDS**") relates to the supplied product ("**Product**") and is subject to updating from time-to-time. Accordingly, the buyer/applicator should have regard to the PDS supplied together with the relevant batch of the Product (and not an earlier version). In addition to the PDS, the buyer/applicator may receive some or all of the following specifications, statements and/or guidelines as listed below or as are available from the Hempel website under 'Products' at www.hempel.com (the "**Additional documents**"):

No.	Document description	Location/comments
1.	Technical Statement	One-off specific advice provided on request for specific projects
2.	Specification	Only issued for specific projects
3.	PDS	This document
4.	Explanatory Notes to the PDS	Available at www.hempel.com and contain relevant information about the Product testing parameters
5.	Application Instruction	Where available, at www.hempel.com
6.	Generic technical guidelines (e.g. on application and surface preparation)	Where available, at www.hempel.com

In the event of a conflict of information between the PDS and the Additional documents, the order of priority of information shall be in the order as set out above. In such event you should also contact your representative at Hempel for clarification. Furthermore, the buyer/applicator must have full regard to the relevant Safety Data Sheet provided with each Product and which can also be downloaded from www.hempel.com.

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3.7.5 Hempel Hempadur 4774D

Product Data Sheet

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Hempadur 4774D

Product characteristics

Description
Hempadur 4774D is a self-priming, high-build, pure epoxy paint providing both abrasion and corrosion resistance.

Recommended use
Hempadur 4774D is recommended as a high-build primer, intermediate and/or self-primed finish for high performance, heavy-duty coating systems. Hempadur 4774D is fast curing and therefore suitable when high productivity is key - such as in the Wind segment.

Service temperature:
- Maximum, dry exposure only: 120°C [248°F].

Certificates / Approvals
- Meets requirements to ISO 12944 when used as part of a predefined paint system. Part 6 C5.
- Meets requirements to NORSOK M-501 when used as part of a predefined paint system. Edition 6, System 1. Edition 7, System 1B.

Features
- Heavy duty, abrasion resistant coating.
- Overcoatable by a wide range of epoxy- and polyurethane coatings.
- Low VOC.
- Applicable by standard heavy duty airless spray equipment in a wide range of film thicknesses.

Product safety

Flash point 34°C [93°F]

VOC content mixed product

Legislation	Value
EU	217 g/L [1.81 lb/US gal]
US (coatings)	217 g/L [1.81 lb/US gal]
US (regulatory)	217 g/L [1.81 lb/US gal]
China	217 g/L [1.81 lb/US gal]

According to specific legislation, see details in the Explanatory Notes available at Hempel website, hempel.com or at your local Hempel website. VOC values may vary with shade, please consult the Safety Data Sheet, section 9.

Handling
Handle with care. Before and during use, observe safety labels on packaging and paint containers and follow all local and national safety regulations. Always consult Hempel's Safety Data Sheet for this product along with the Product Data Sheet.

For professional use only.

Product data

Product code
4774D

Product components
Base 4774M
Curing Agent 9874D

Standard shade* / code
Light cream 20450 **

Gloss
Semi-gloss

Volume solids
76 ± 2%

Specific gravity
1.5 kg/L [12 lb/US gal]

Reference dry film thickness
150 micron [6.0 mils]

* Other shades are available, please contact your local Hempel representative.
** Slight discolouration may occur. This does not affect the performance of the coating.

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1/4

Product Data Sheet

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Hempadur 4774D

Surface preparation

Cleanliness
- Remove oil, grease and other contaminants by suitable detergent cleaning.
- Remove salts, detergents and other contaminants by high pressure fresh water cleaning.

New build:
- Abrasive blasting to min. Sa 2½ (ISO 8501-1) / SP 10 (SSPC).
- Remove dust, blast media and loose materials.
- All damage of shopprimer and contamination from storage and fabrication should be thoroughly mechanically/chemically cleaned prior to final painting.

Maintenance and Repair
- Abrasive blasting to min. Sa 2 (ISO 8501-1) / SP 6 (SSPC).
- Minor areas can be cleaned by power tool to St 3 provided the surface is roughened and not polished.
- Remove dust, blast media and loose materials.

Roughness
- Surface profile Medium (G) (ISO 8503-2).

Consult Hempel's separate Surface Preparation Guidelines for more details.

Application

Mixing ratio
Base 4774M : Curing Agent 9874D
(4 : 1 by volume)

Stir well before use.

Thinner
Hempel's Thinner 08450

Cleaner
Hempel's Tool Cleaner 99610

Pot life

Product temperature	15°C [59°F]	20°C [68°F]	30°C [86°F]
Pot life	60 min	45 min	20 min
Pot life (spray)	60 min	45 min	20 min
Pot life (brush)	60 min	45 min	20 min

Application method

Tool	Thinning max vol.	Application parameters
Airless spray	5%	Nozzle pressure: 250 bar [3600 psi] Nozzle orifice: 0.021-0.025"
Brush	5%	Not Applicable.

If brush or roller application is used, more coats will be necessary to achieve the specified dry film thickness. Spray data are indicative and subject to adjustment. Pressure is for a material temperature of 20°C [68°F].

Film thickness

Specification range	Low	High	Recommended
Dry film thickness	100 micron [4.0 mils]	250 micron [10 mils]	150 micron [6.0 mils]
Wet film thickness	130 micron [5.2 mils]	330 micron [13 mils]	200 micron [8.0 mils]
Theoretical spreading rate	7.6 m²/L [310 sq ft/US gal]	3 m²/L [122 sq ft/US gal]	5.1 m²/L [208 sq ft/US gal]

For best performance, avoid excessive film thickness. Product may be specified in another film thickness than indicated depending on purpose and area of use. This will alter spreading rate, drying and curing time and overcoating interval.

Application conditions
- Temperature of product must be above 15°C [59°F] during application.
- To avoid condensation, apply on a clean and dry surface with a temperature that is at least 3°C [5°F] above the dew point.
- Surface temperature must be above 5°C [41°F] during application and curing.
- Surface temperature must be below 60°C [140°F] during application and curing.

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Product Data Sheet

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Hempadur 4774D

Relative Humidity:
- Relative humidity must be below 85% during application.
- Relative humidity must be below 85% during curing.

Application remarks
- Product requires heavy duty spray equipment; spray hoses shall be as short as possible.
- The practical consumption factor may vary depending on application conditions, equipment and workmanship.

Drying and overcoating

Product compatibility
- Previous coat: None or according to Hempel's specification.
- Subsequent coat: None or according to Hempel's specification. Recommended products are: Hempadur, Hempathane

Drying time

Surface temperature		10°C [50°F]	20°C [68°F]	30°C [86°F]	40°C [104°F]
Touch dry	min	30	15	15	15
Hard dry	hours	5	2½	2	1½
Fully cured	days	-	7	-	-

Determined for dry film thickness 150 micron [6.0 mils] at standard conditions, see Hempel's Explanatory Notes for details.

Overcoating

Hempel's specification supersedes any guidelines indicated in the overcoating table

Quality name		10°C [50°F]	20°C [68°F]	30°C [86°F]	40°C [104°F]
Atmospheric medium					
Hempadur 4774D	Min	4 h	2 h	90 min	60 min
	Max	60 d	30 d	22 d	15 d
Hempathane HS 55610	Min	4 h	2 h	90 min	60 min
	Max	14 d	7 d	5½ d	3½ d
Atmospheric severe					
Hempadur 4774D	Min	4 h	2 h	90 min	60 min
	Max	60 d	30 d	22 d	15 d
Hempathane HS 55610	Min	4 h	2 h	90 min	60 min
	Max	14 d	7 d	5½ d	3½ d

Overcoating times are indicative for products of the same generic chemistry. Consult Hempel's specification for more information.

Drying conditions
- To obtain the drying time stated, it is important to maintain sufficient ventilation during application, drying and curing.

Overcoating details
- If the maximum overcoating interval is exceeded, roughening of the surface is necessary to ensure intercoat adhesion.
- The surface must be clean before overcoating.
- The surface must be dry and clean prior to application.

Other remarks
- Epoxy coats have an inherent tendency of chalking in outdoor exposure. This does not affect the performance of the coating.
- Hempel's Specification supersedes any recommendations given in the Product Data Sheets.

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Hempadur 4774D

Storage

Shelf life

Ambient temperature	25°C [77°F]
Base	36 months
Curing Agent	36 months

Shelf life from date of production, when stored in original, unopened containers. Thereafter, the product quality must be re-inspected. Storage at elevated temperatures may reduce shelf life. For advice, please consult Hempel.

Storage conditions

- Product must be stored according to local legislation, at maximum 40°C [104°F], without direct sunlight and protected from rain and snow.

Carbon Footprint

Dry film thickness	1 µm	1 mil
GWP (Global Warming Potential)	7 g CO_2e/m^2	0.036 lb CO_2e/ft^2

The carbon footprint is for 1 square meter / square foot of surface area with a dry film thickness of 1 micron / mil.

The scope includes raw materials, in-bound transport to the Hempel factory, Hempel manufacturing processes, and any Volatile Organic Compounds emitted during and after the application of the product.

It is calculated based on the standard shade defined in this PDS. Values may vary with shade.

Additional documents

Additional information is available at the Hempel website https://www.hempel.com/service-and-support/technical-guidelines or at your local Hempel website:

- Explanatory Notes for Product Data Sheet.
- Application methods.
- Substrates.
- Surface Preparation.
- Application Instruction for this product.
- Repair & maintenance.
- Inspection & quality control.

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1.	Technical Statement	One-off specific advice provided on request for specific projects
2.	Specification	Only issued for specific projects
3.	PDS	This document
4.	Explanatory Notes to the PDS	Available at www.hempel.com and contain relevant information about the Product testing parameters
5.	Application Instruction	Where available, at www.hempel.com
6.	Generic technical guidelines (e.g. on application and surface preparation)	Where available, at www.hempel.com

In the event of a conflict of information between the PDS and the Additional documents, the order of priority of information shall be in the order as set out above. In such event you should also contact your representative at Hempel for clarification. Furthermore, the buyer/applicator must have full regard to the relevant Safety Data Sheet provided with each Product and which can also be downloaded from www.hempel.com.

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3.7.6 Hempel Hempathane HS 55610

Product Data Sheet

Hempathane HS 55610

Product characteristics

Description
Hempathane HS 55610 is a glossy polyurethane topcoat, cured with aliphatic isocyanate. The product has very good gloss and colour retention and contains zinc phosphate.
Complies with EU Directive 2004/42/EC, The Paints Directive on the limitation of volatile organic compounds: subcategory j.

Recommended use
Hempathane HS 55610 is recommended as VOC compliant, high-build finishing coat for protection of structural steel in severely corrosive environment. The product may be specified as a one coat "direct to metal" system in environments classified as C2 and C3. It may also be applied directly on galvanised steel.

Service temperature:
- Maximum, dry exposure only: 120°C [248°F].

Certificates / Approvals
- EC-type examined as a low flame spread material when used as part of a predefined paint system. Please refer to “Declaration of Conformity” on hempel.com for further details.
- The following shades are formulated with special electrical conductive pigments that makes it possible to design paint systems that meet the requirements in ISO 80079-36:2016 Explosive atmospheres (ATEX): 95000
- Meets requirements to NORSOK M-501 when used as part of a predefined paint system. Edition 6, System 1. Edition 7, System 1A, 1B.

Features
- For severely corrosive atmospheric environment.
- Direct-to-metal in C2 and C3 environments.
- Glossy with very good gloss and colour retention.
- High volume solids and VOC-compliant.
- The minimum temperature for curing is -10°C [14°F].

Product safety

Flash point 31°C [88°F]

VOC content mixed product

Legislation	Value	5% thinning, by volume	Limit value, phase II (2010)[a]
EU	343 g/L [2.86 lb/US gal]	366 g/L [3.05 lb/US gal]	500 g/L [4.17 lb/US gal]
US (coatings)	320 g/L [2.67 lb/US gal]	-	-
US (regulatory)	343 g/L [2.86 lb/US gal]		
China	343 g/L [2.86 lb/US gal]		
Hong Kong	320 g/L [2.67 lb/US gal]		

According to specific legislation, see details in the Explanatory Notes available at Hempel website, hempel.com or at your local Hempel website. VOC values may vary with shade, please consult the Safety Data Sheet, section 9. [a]EU Directive 2004/42/CE. According to EPA Method 24.

Handling
Handle with care. Before and during use, observe safety labels on packaging and paint containers and follow all local and national safety regulations. Always consult Hempel’s Safety Data Sheet for this product along with the Product Data Sheet.

For professional use only.

Product data

Product code
55610

Product components
Base 55619
Curing Agent 97050

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Hempathane HS 55610

Standard shade / code
White 10000 *

Wide range of colours is available via Hempel's tinting system.

Gloss
Glossy

Volume solids
67 ± 2%

Specific gravity
1.4 kg/L [12 lb/US gal]

Reference dry film thickness
80 micron [3.2 mils]

Aluminium shade / code
Aluminium grey 19002

Gloss
Please consult Hempel's Guideline on aluminium pigmented coatings.

Volume solids
58 ± 2%

Specific gravity
1.1 kg/L [10 lb/US gal]

Reference dry film thickness
80 micron [3.2 mils]

Surface preparation

Cleanliness
- Remove oil, grease and other contaminants by suitable detergent cleaning.
- Remove salts, detergents and other contaminants by high pressure fresh water cleaning.

New build:
- Abrasive blasting to min. Sa 2½ (ISO 8501-1) / SP 10 (SSPC).
- Remove dust, blast media and loose materials.

Maintenance and Repair
- Abrasive blasting to min. Sa 2 (ISO 8501-1) / SP 6 (SSPC).
- Minor areas may be hand or power tool cleaned instead of abrasive blasting.
- Water jetting to Wa 2½ (ISO 8501-4).
- Flash rust degree of maximum FR M (ISO 8501-4).
- Remove dust, blast media and loose materials.

Roughness
- Surface profile Medium (S) (ISO 8503-2).

Consult Hempel's separate Surface Preparation Guidelines for more details.

Application

Mixing ratio
Base 55619 : Curing Agent 97050
(7 : 1 by volume)

Stir well before use.

Thinner
Hempel's Thinner 08080

Cleaner
Hempel's Thinner 08080

* Colour stability may be affected by exposure to harsh chemical and/or high temperatures.

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Product Data Sheet

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Hempathane HS 55610

Pot life

Product temperature	10°C [50°F]	20°C [68°F]	30°C [86°F]
Pot life	3½ hours	2 hours	1 hour

Application method

Tool	Thinning max vol.	Application parameters
Airless spray	5%	Nozzle pressure: 175 bar [2500 psi] Nozzle orifice: 0.017-0.021"

If brush or roller application is used, more coats will be necessary to achieve the specified dry film thickness. Never thin more than allowed according to local environmental legislation. Spray data are indicative and subject to adjustment. Pressure is for a material temperature of 20°C [68°F].

Film thickness

Specification range	Low	High	Recommended
Dry film thickness	50 micron [2.0 mils]	125 micron [5.0 mils]	80 micron [3.2 mils]
Wet film thickness	75 micron [3.0 mils]	187 micron [7.5 mils]	120 micron [4.8 mils]
Theoretical spreading rate	13 m²/L [530 sq ft/US gal]	5.3 m²/L [216 sq ft/US gal]	8.3 m²/L [338 sq ft/US gal]

For best performance, avoid excessive film thickness.

Application conditions

- To avoid condensation, apply on a clean and dry surface with a temperature that is at least 3°C [5°F] above the dew point.
- Surface temperature must be above -10°C [14°F] during application and curing.
- Beware of ice on the surface at low temperatures.
- The film formation may be adversely affected by light rain, high humidity and/or condensation during application and the following interval after application: “8 hours, 20°C/68°F”.
- Optimal spraying properties are obtained at paint temperatures of 15-30°C [59-86°F]. Beyond these temperatures additional thinning may be necessary.

Relative Humidity:

- Relative humidity must be below 85% during curing.
- Relative humidity must be below 85% during application.

Drying and overcoating

Product compatibility

- Previous coat: According to Hempel’s Specification. Recommended products are: Hempaprime Multi 500, Hempadur
- Subsequent coat: None.

Drying time

Surface temperature		10°C [50°F]	20°C [68°F]	30°C [86°F]
Touch dry	min	120	90	60
Surface dry	hours	11	3½	2
Hard dry	hours	12	5	3
Fully cured	days	-	7	-

Determined for dry film thickness 80 micron [3.2 mils] at standard conditions, see Hempel’s Explanatory Notes for details.

Overcoating

Hempel’s specification supersedes any guidelines indicated in the overcoating table

Quality name		-10°C [14°F]	10°C [50°F]	20°C [68°F]	30°C [86°F]
Atmospheric medium					
Hempathane HS 55610	Min	30 h	9 h	6 h	3 h
	Max	Ext*	Ext	Ext	Ext

Overcoating times are indicative for products of the same generic chemistry. Consult Hempel’s specification for more information.

Drying conditions

- To obtain the drying time stated, it is important to maintain sufficient ventilation during application, drying and curing.
- Condensation on the freshly applied coating should be avoided.

Overcoating details

- The surface must be dry and clean prior to application.

Other remarks

- Hempel’s Specification supersedes any recommendations given in the Product Data Sheets.

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Product Data Sheet

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Hempathane HS 55610

Storage

Shelf life

Ambient temperature	25°C [77°F]
Base	36 months
Curing Agent	24 months

Shelf life from date of production, when stored in original, unopened containers. Thereafter, the product quality must be re-inspected. Storage at elevated temperatures may reduce shelf life. For advice, please consult Hempel.

Storage conditions

- Product must be stored according to local legislation, at maximum 40°C [104°F], without direct sunlight and protected from rain and snow.
- The curing agent is sensitive to moisture. Store in a dry place and keep the can tightly closed until use.

Carbon Footprint

Dry film thickness	1 µm	1 mil
GWP (Global Warming Potential)	8.7 g CO_2e/m^2	0.045 lb CO_2e/ft^2

The carbon footprint is for 1 square meter / square foot of surface area with a dry film thickness of 1 micron / mil.

The scope includes raw materials, in-bound transport to the Hempel factory, Hempel manufacturing processes, and any Volatile Organic Compounds emitted during and after the application of the product.

It is calculated based on the standard shade defined in this PDS. Values may vary with shade.

Additional documents

Additional information is available at the Hempel website https://www.hempel.com/service-and-support/technical-guidelines or at your local Hempel website:

- Explanatory Notes for Product Data Sheet.
- Application methods.
- Surface Preparation.
- Application Instruction for this product.
- Aluminium pigmented topcoats.

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Sub Section J06

Hydrostatic and/or Pneumatic Testing Procedures

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	12/12/2023	First Issue

Document Title:	**BLPH Project - Hydrostatic, Pneumatic and Leak Testing Procedures**
Document Number:	K559-2254-CWIWP4202202-J06-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-J06-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J06 (incl. J09)
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	J06 – Hydrostatic, Pneumatic and Leak Testing Procedures
Full Title	Description of hydrostatic, pneumatic and leak testing procedures to verify that the hydrogen fuel cell modules operate according to design requirements.
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	December 12th, 2023

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1.0 Introduction and Purpose

This document describes the hydrostatic, pneumatic and leak test procedures carried out on the FCwave™ fuel cell modules and its sub-assemblies. It includes duration of tests, quality of test media, and respective passing criteria.

The tests described in this document are divided into two main sections: FC stack level testing and FCwave™ component and module level testing. The first section is part of the functionality and leak testing activities prior to shipping the FC stacks from Canada to Denmark for further installation in the FCwave™ modules. The second section is part of the module FAT.

Additional container level leak tests are carried out after the installation of the FCwave™ modules and the container solution build has been completed. These additional tests are part of the container FAT and are described in a separate document, namely K559-2254-CWIWP4202202-J08-001 (SDRL Code: J08).

Note: The contents of documents J06 and J09 have been combined into this single document for convenience.

2.0 References

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
FAT001	FAT procedure of FCwave™	Ballard
PRC_001_002_003_004_005	Design criteria for pressure containing components	Ballard
DS/EN 62282-3-100	Stationary fuel cell power systems – Safety	Ballard
K559-2254-CWIWP4202202-J08-001	BLPH Project – Acceptance Test Procedure (FAT)	Ballard

3.0 Definitions and Abbreviations

°C	Degrees Celsius (unit of temperature)
Σ	Sum
atm	Atmospheres (unit of pressure)
bar	Bar (unit of pressure)
bara	Bar absolute (unit of pressure)
barg	Bar gauge (unit of pressure)
DI	De-ionized
EN	European Standard (from the German "*Europäische Norm*")
FAT	Factory Acceptance Test
FC	Fuel Cell
FC#	Fuel Cell Stack Number
H_2	Hydrogen
HRB	Hydrogen Recirculation Blower
L	Leak rate
LT	Low Temperature
ml	Milliliters (unit of volume)
p	Pressure
P_0	Normal atmospheric pressure (1 atm or 1.013 bara)
sccm	Standard cubic centimeter per minute (unit of flow rate)
SDRL	Supplier Document Requirement List
T	Temperature
t	Time
T_0	Normal ambient temperature (0 °C)
V	Volume

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4.0 FC Stack Level Testing

All stacks produced by Ballard in Burnaby, Canada undergo functionality and leak testing prior to being shipped to Hobro, Denmark, where they are then installed in the FCwave™ modules.

The stacks used in the FCwave™ have been designed for operating pressures of up to 1.7 barg. The operating pressure of the FCwave™ is lower (< 1 barg).

4.1 Fuel Cell Stack – External Static Leak Test

The external static leak test of the fuel cell stack is performed under the following conditions:

Table 1. Testing conditions for fuel cell stack external static leak test.

Test / Item	Test Media	Pressure	Criteria
Cathode (Air) Loop	Air	2.0 barg	≤ 0.25 sccm/cell
Anode (Fuel) Loop	Air	2.0 barg	≤ 0.60 sccm/cell
Coolant Loop	Air	2.0 barg	≤ 0.11 sccm/cell

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5.0 FCwave™ Component and Module Level Testing

5.1 Humidifier Leak Test

The shell and tube humidifier is a delicate component, with countless small permeable straws, allowing the transfer of water between the cathode outlet effluent and the incoming air.

After assembly of the three humidifiers on the aftercooler, the assembly is pressure tested with a dedicated humidifier test cart.

Table 2. Testing conditions for humidifier leak test.

Test / Item	Test Media	Pressure	Criteria
External humidifier leak test	Air	1.0 barg	< 5 sccm total
Internal humidifier leak test	Air	0.5 barg	< 5,000 sccm/minute per column

5.2 H_2 Supply Valve Block Test

The H_2 Supply valve is tightness tested by the manufacturer.

5.3 HRB Leak Test

The HRB assembly is leak tested in conjunction with the leak test of the H2Enclosure (see section 5.5).

If in doubt or found necessary, the HRB can be tested individually.

5.4 Cooling Assembly Leak Tests

The liquid cooling lines are pressure tested prior to installation of the H2Enclosure as part of the build test.

The lines can be pressure tested with air to verify that there is no leak.

If in doubt, water is used to verify no droplets form. The lines are filled with water and pressurized for a length of time. When the unit under test is filled and the pressure is established, the pressure can be sealed, and the equipment left unattended for the duration of the test period.

The auxiliary cooling loop runs between the upper and lower cabinet of the FCwave™ module and is therefore tested during the leak test of the entire module (see section 5.6.2).

Table 3. Testing conditions for cooling assembly leak tests (with air as test medium).

Test / Item	Test Media	Pressure	Test Period	Criteria
Main internal cooling loop	Air	2.0 barg	> 1 hour	< 10 sccm
Main external line	Air	2.0 barg	> 1 hour	< 5 sccm
Auxiliary cooling loop	Air	1.0 barg	> 1 hour	< 2 sccm

Table 4. Testing conditions for cooling assembly leak tests (with water as test medium).

Test / Item	Test Media	Pressure	Test Period	Criteria
Main internal cooling loop	DI Water	2.0 barg	> 2 hours	No drops
Main external line	Tap Water	2.0 barg	> 2 hours	No drops
Auxiliary cooling loop	Tap Water	1.0 barg	> 2 hours	No drops

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5.5 FC Stack Assembly in H2Enclosure Leak Test

The stress and leak tests of the FC Stack Assembly in the H2Enclosure, including entry ports and manifolds, ensure proper assembly before sealing the enclosure. These tests are described in the following sub-sections.

5.5.1 FC Stack Assembly Pressure Stress Test

To verify the assembly of hoses and tightness of hose bands, etc. of the FC stack assembly, the H2Enclosure is stress tested with 2.0 bar air pressure. The stress test is to verify that all hose clamps and silicone hose crimps satisfy strength requirements before attaching the H2Enclosure top.

All lines must be pressurized to ensure equal pressure on Air (Cathode), Coolant and Fuel (Anode) side of the stack plates, to minimize stack plate stress.

The test pressure is kept stable at 2.0 bar for a duration of 30 minutes.

Table 5. Testing conditions for FC stack assembly pressure stress test.

Test / Item	Test Media	Pressure	Criteria
Stack assembly stress test	Air	2.0 barg	No damage or malfunction

Additionally, the correct function of the purge line components is also verified.

Table 6. Testing conditions for function test of purge line components.

Test / Item	Test Media	Pressure	Criteria
Pressure sensor	Air	2.0 barg	2.0 bar readout
Purge valve	Air	2.0 barg	Open/Close

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5.5.2 FC Stack Assembly External Leak Test

All lines are pressurized to ensure equal pressure on each side of the stack plates to measure the external leak.

The acceptance criteria result from the sum of the leak rates from the individual stacks and components, with an additional defined amount to allow for minor assembly leak sources. The stacks are tested at 2.0 barg individually as a part of the test procedure during manufacturing (see section 4.1). The leak rate criteria are then correlated to the actual system leak test pressure of 1.1 barg.

This means the leak criteria are dynamic and follow the assembly variances of the stacks.

Table 7. Testing conditions for FC stack assembly external leak test.

Test / Item	Test Media	Pressure	Criteria [sccm]
Total external leak	Air	1.1 barg	Total (Anode + Cathode + Coolant) + 56
Anode (external)	Air	1.1 barg	< (Σ of anode external (FC1..6)@2.0 barg/2)x1.1 + 20
Cathode (external)	Air	1.1 barg	< (Σ of cathode external (FC1..6)@2.0 barg/2)x1.1 + 20
Coolant (external)	Air	1.1 barg	< (Σ of coolant external (FC1..6)@2.0 barg/2)x1.1 + 6

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5.5.3 FC Stack Assembly Internal Leak Test

The internal leak rate is initially determined in ml/minute through a graduated water bath cylinder leak test station and then converted to sccm.

The test initially measures the leak rate from the anode side to the other two sides: cathode and coolant.

The pressure is then applied to the cathode side, and the leak rate to the coolant side is measured.

Table 8. Testing conditions for FC stack assembly external leak test.

Test / Item	Test Media	Pressure	Criteria [sccm]
Anode → Cathode	Air	0.5 barg	< (Σ of anode internal (FC1..6) to cathode) + 15
Anode → Coolant	Air	0.5 barg	< (Σ of anode internal (FC1..6) to coolant) + 6
Cathode → Coolant	Air	0.5 barg	< (Σ of cathode internal (FC1..6) to coolant) + 6

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5.6 Module Stress and Tightness Test

5.6.1 Module Stress Test

To verify the assembly of all hoses and tightness of hose bands, etc. in the FCwave™, the complete module is stress tested with 2.0 barg air pressure.

All lines are pressurized to ensure equal pressure on Air (Cathode), Coolant and Fuel (Anode) side of the stack plates, to minimize stack plate stress.

The test pressure is kept stable at 2.0 barg for a duration of 30 minutes.

Note: The PRV outlet from the valve block is blocked during this test, since the test pressure is above the release pressure.

5.6.2 Module Tightness Test

The module tightness test is carried out after the FCwave™ module has been fully assembled.

During the module leak check, all pressure sensor readings are verified.

The passing criteria are dependant on the results from section 5.5.2.

Table 9. Testing conditions for module tightness test.

Test / Item	Test Media	Pressure	Criteria [sccm]
External leak	Air	1.1 barg	< Total from section 5.5.2 + 110
Anode (external)	Air	1.1 barg	< Anode external from section 5.5.2 + 50
Cathode (external)	Air	1.1 barg	< Cathode external from section 5.5.2 + humidifier total from section 5.1 + 50
Coolant (external)	Air	1.1 barg	< Coolant external from section 5.5.2 + 10

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5.6.3 Pressure Decay Test

As an alternative method for establishing the leak rate of the FC module, a pressure decay over time can be measured, and a leak rate determined for each string.

Instead of reading the individual flows on the flow meters, the test valves are closed when the pressure is stabilized, and the test period started. After a minimum of 10 minutes, the individual pressures of Fuel (Anode), Air (Cathode) and Coolant are noted.

From the measured pressure difference, the actual leak flow can be derived from the free volume in each string and normalized to sccm.

Anode Loop Leak Rate

$$L_{Anode} = V_{Anode} \cdot \frac{T_0}{P_0} \cdot \frac{\left(\frac{p_{1Anode}}{T_1} - \frac{p_{2Anode}}{T_2}\right)}{t}$$

Cathode Loop Leak Rate

$$L_{Cathode} = V_{Cathode} \cdot \frac{T_0}{P_0} \cdot \frac{\left(\frac{p_{1Cathode}}{T_1} - \frac{p_{2Cathode}}{T_2}\right)}{t}$$

Coolant Loop Leak Rate

$$L_{Coolant} = V_{Coolant} \cdot \frac{T_0}{P_0} \cdot \frac{\left(\frac{p_{1Coolant}}{T_1} - \frac{p_{2Coolant}}{T_2}\right)}{t}$$

5.6.4 Auxiliary Cooling Leak Test

The auxiliary cooling loop is tested with air at a pressure of 1.0 barg for > 1 hour or alternatively with tap water at a pressure of 1.0 barg for > 2 hours, as stated in Table 3 and Table 4 of section 5.4, respectively.

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Sub Section J08-001

Acceptance Test Procedure (FAT)

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Revision history		
Rev.	**Date.**	**Description**
001	12/8/2023	First Issue
002	8/6/2024	General update, added H2 pre-heating system
003	9/17/2024	Final update, incl. results and sub-procedures
004	10/28/2025	Revision in header in document updated to match front sheet

Document Title:	**BLPH Project - Acceptance Test Procedure (FAT)**
Document Number:	K559-2254-CWIWP4202202-J08-001
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Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Megablock Factory Acceptance Test
Full Title	Megablock Factory Acceptance Test
Abstract	*Factory acceptance test for verification of full Megablock system*

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Revision Record

Rev #	Description	Revised By	Date (dd-mm-yyyy)
-	Initial Release	RKN	27-02-2024
1	General updates	RKN	17-06-2024
2	Updated with results	TAN	17-09-2024
3	NA		
4	Revision in header updated to match Aconex Revision	JTA	28-10-2025

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1.0 Executive Summary

This document outlines the tests to be included in the factory acceptance test. These tests aim to verify the overall functionality of the fuel cell-based power plant. The verification should show the capability of delivering the expected AC power and that the product is ready to be delivered and installed on site.

1.1 Conclusions

-

1.2 Recommendations

-

1.3 Deficiencies

-

2.0 References

- PWR008 Ballard commissioning document
- EN 60204-1
- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure
- SPC ID 0104 H2 Leak Test Procedure
- SPC ID 0106 Noise Level Measurement Test Procedure
- SPC ID 0105 Thermographic - Electrical Test Procedure

3.0 Definitions and Acronyms

FC	FCwave™
H2	Hydrogen
FAT	Factory Acceptance Test
HT1	High temperature 1050kW cooling system
HT2	High temperature 1050kW cooling system
LT	Low temperature cooling system

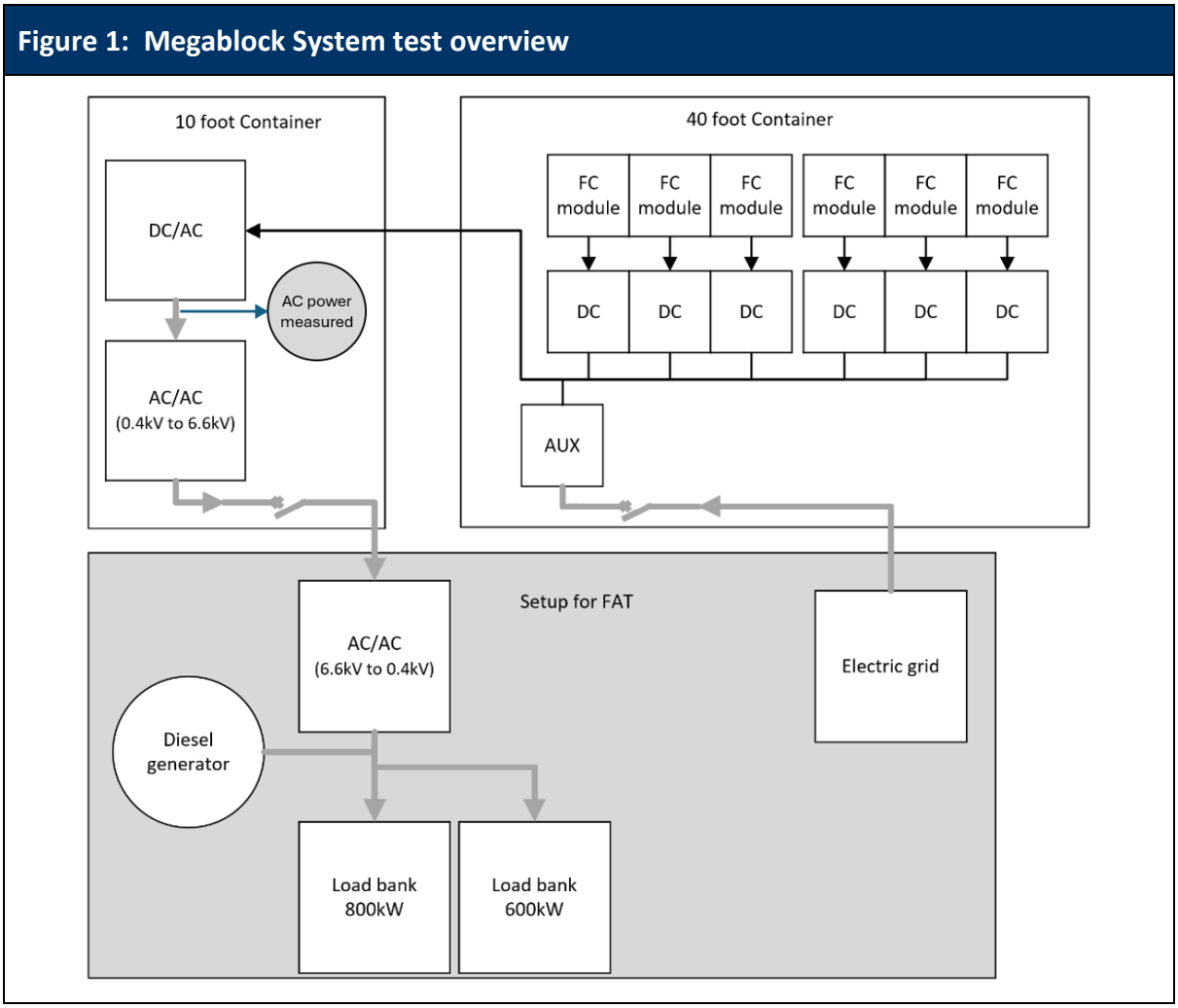
4.0 Objectives and Background

This document describes the factory acceptance tests. The FAT does not include the internal testing that has been done to secure product maturity, mechanical and electrical connections have been done correctly.

The scope of testing is:

- Safety systems are functioning correctly in a complete Megablock with coolers.
- Megablock produces AC current, and the tests shall verify the capability to produce AC current following the demand.
- Tests to verify that the performance of cooling systems is as designed.
- Correct handling of operation, including error handling and service, including the correct signals to communicating systems.

Figure 1: Megablock System test overview



5.0 Functional tests

5.1 F01 Weight

5.1.1 Test

This test will be carried out using the weighbridge at Hobro Varme.

5.1.2 Relevant Standard / document

- General arrangement

5.1.3 Brief Test Plan

- Measure weight during transport using a weighbridge at Hobro Varme.

5.1.4 Pass/Fail criteria.

Table 1: Weights

Item	Expected Weight
40 foot container	25,000 kg
10 foot container	8,000 kg
Cooling platform	9,000 kg

5.1.5 Test Result

Table 2: Weights - Test Result

Date tested	Item	Result	Pass/Fail	Notes
1/7-2024	40 foot container	21,320 kg	Pass	-
1/7-2024	10 foot container	7,310 kg	Pass	-
1/7-2024	Cooling platform	9,060 kg	Pass	-

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5.2 F02 Visual inspection

5.2.1 Test

The test involves an examination of the paint job through visual inspection, assessing the overall build quality, and checking for any dents. The focus is also on evaluating the assembly quality to ensure compliance with weather resistance.

5.2.2 Relevant Standard / document

- No reference

5.2.3 Brief Test Plan

- Visual inspection with customer of full system meaning inside and outside container solution.
- Take comprehensive pictures of the full system and test setup, including close-ups of vital components, with timestamps for reference.

5.2.4 Pass/Fail criteria.

- Visual inspect with customer to review quality of full system.

5.2.5 Test Result

Table 3: Visual inspection – Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Inspection of paint	Accepted	Pass	See item/punch list for further elaboration
13/8-2024	Assessing build quality	Accepted	Pass	See item/punch list for further elaboration
13/8-2024	Check for dents	Accepted	Pass	See item/punch list for further elaboration

5.3 F03 Cooling leakage HT1

5.3.1 Test

Follow designated test procedure for inspection and verification of a leak-free HT1 coolant circuit.

5.3.2 Relevant Standard / document

- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

5.3.3 Brief Test Plan

- Follow test procedure.
- Test procedure 4.4 Pressure decay test with coolant from SPC ID 0103 is performed.

5.3.4 Pass/Fail criteria.

- Allow system to maintain pressure, after 2 hours pressure must not drop more than 0,1 bar.

5.3.5 Test Result

Table 4: Cooling leakage HT1 - Test Result

Date tested	Item	Result	Pass/Fail	Notes
12/8-2024	HT 1	-	Pass	-

5.4 F04 Cooling leakage HT2

Follow designated test procedure for inspection and verification of a leak-free HT2 coolant circuit.

5.4.1 Relevant Standard / document

- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

5.4.2 Brief Test Plan

- Follow test procedure.
- Test procedure 4.4 Pressure decay test with coolant from SPC ID 0103 is performed.

5.4.3 Pass/Fail criteria.

- Allow system to maintain pressure, after 2 hours pressure must not drop more than 0,1 bar.

5.4.4 Test Result

Table 5: Cooling leakage HT2 - Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	HT 2	-	Pass	-

5.5 F05 Cooling leakage LT

Follow designated test procedure for inspection and verification of a leak-free LT coolant circuit.

5.5.1 Relevant Standard / document

- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

5.5.2 Brief Test Plan

- Follow test procedure.
- Test procedure 4.4 Pressure decay test with coolant from SPC ID 0103 is performed.

5.5.3 Pass/Fail criteria.

- Allow system to maintain pressure, after 2 hours pressure must not drop more than 0,1 bar.

5.5.4 Test Result

Table 6: Cooling leakage LT - Test Result

Date tested	Item	Result	Pass/Fail	Notes
14/8-2024	LT	-	Pass	-

5.6 F07 Electrical safety test – 10 foot container

5.6.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

5.6.2 Relevant Standard / document

- EN 60204-1

5.6.3 Brief Test Plan

- According to EN 60204-1

5.6.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

5.6.5 Test Result

Table 7: Electrical safety test - Test results

Date tested	Item	Result	Pass/Fail	Notes
7/8-2024	Grounding Continuity	-	Pass	-
8/8-2024	High Potential	-	Pass	-

Table 8: Electrical safety test - calibration equipment

Unit	Equipment number	Calibration due date	Test used for
Metrel CE-Multitester	086-003	19/1-2025	Grounding Continuity and High Potential

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5.7 F08 Electrical safety test – 40 foot container

5.7.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

5.7.2 Relevant Standard / document

- EN 60204-1

5.7.3 Brief Test Plan

- According to EN 60204-1

5.7.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

5.7.5 Test Result

Table 9: Electrical safety test - Test Result

Date tested	Item	Result	Pass/Fail	Notes
7/8-2024	Grounding Continuity	-	Pass	-
8/8-2024	High Potential	-	Pass	-

Table 10: Electrical safety test - Calibration equipment

Unit	Equipment number	Calibration due date	Test used for
Metrel CE-Multitester	086-003	19/1-2025	Grounding Continuity and High Potential

5.8 F10 Safety

5.8.1 Test

Conduct tests of safety inputs and outputs, including emergency stop buttons, smoke detectors, gas detectors and external connections.

5.8.2 Relevant Standard / document

- Safety input checklist according to EN/ISO 13849-2 procedure

5.8.3 Brief Test Plan

- Trigger each safety input according to checklist.
  - Emergency pushbuttons
  - Smoke detectors test
  - H2 sensor test
  - External safety switches
  - External feedback

5.8.4 Pass/Fail criteria.

- Verified according to checklist.
- Each item triggers the correct emergency stop.

5.8.5 Test Result

Table 11: Safety - Test Result

Date tested	Item	Result	Pass/Fail	Notes
29/7-2024	Emergency pushbuttons	-	Pass	-
29/7-2024	Smoke detectors	-	Pass	3 sensors in 40ft container and 1 sensor in 10 ft container
29/7-2024	H2 sensors	-	Pass	3 sensors in 40ft container
7/8-2024	External safety switches	-	Pass	-
12/8-2024	External feedback	-	Pass	-

Table 12: Safety - Calibration Equipment

Unit	Equipment number	Calibration due date	Test used for
Dräger calibration gas, 2% Hydrogen	Cylinder No: 955-657732	Valid until: 10/1-2029	H2 sensors

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5.9 F16 Nanogrid load test

5.9.1 Test

Energize and verify island mode AUX at load, including power quality measurement.

5.9.2 Relevant Standard / document

-

5.9.3 Brief Test Plan

External supply of DC bus

Verify connection.

Use service interface to start up consumers according cold and warm test consumer list.

Max load cold case test ok.

Max load warm case test ok.

5.9.4 Pass/Fail criteria.

Power quality

5.9.5 Test Result

-

Table 13: Nanogrid load test - Test Result

Date tested	Item	Result	Pass/Fail	Notes
7/8-2024	Max load cold case test	-	Pass	-
7/8-2024	Max load warm case test	-	Pass	-

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5.10 F18 H_2 leakage test

5.10.1 Test procedure

All pipework and H2 instrumentation subassemblies must be inspected, recorded, verified and pass in accordance with the procedure in section 5.4 in *SPC ID 0104 H2 Leak Test Procedure Rev 002* prior to full system FAT.

System H2 leakage test is done system pressure decay test, according to section 5.5 in *SPC ID 0104 H2 Leak Test Procedure Rev 002*.

5.10.2 Pass/Fail criteria.

Pressure decay test with a maximum leakage no greater than specified in test procedure.

Result details are documented in the template *SPC ID 0204 System pressure decay test template*

Parameter	Value	Description
L_A [Nm^3/h]	**2,72 – 3,58 x10^{-3}**	**Maximum allowed pressure decay to pass pressure decay test, where L_A = L_S + L_Mu**
L_S [Nm^3/h]	0	Summarized expected leak rates of all components in the system (per design leak rate).
L_Mu [Nm^3/h]	2,72 – 3,58 x10^{-3}	Calculated accuracy of the measuring system, used to perform the test.
L_C [Nm^3/h]	2,7x10^{-5}	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

5.10.3 Test Result

Table 14: H2 leakage - Test Result

Date tested	Item	Leakage rate L_1 [Nm^3/h]	Pass/Fail	Notes
3/9-2024	H2 line 1	4.03E-05	Pass	-
3/9-2024	H2 line 2	8.06E-05	Pass	-
3/9-2024	H2 line 3	0.00E+00	Pass	-
3/9-2024	H2 line 4	1.60E-04	Pass	-
3/9-2024	H2 line 5	7.27E-05	Pass	-
3/9-2024	H2 line 6	-8.16E-05	Pass	-

5.11 F19 H2 Heater Test

5.11.1 Test

Follow test procedure

5.11.2 Relevant Standard/Document

SPC ID0108 Hydrogen preheating System Test Procedure

5.11.3 Brief Test Plan

Follow test procedure

5.11.4 Pass/Fail criteria

Start Up time test: Pass when the temperature reaches 30°C in less than 12 minutes

Sustain set point temperature at high hydrogen consumption test: pass when the temperature is ±4°C of the set point.

Power Consumption test: The power consumption is between 0-20kW when heater is running full load.

5.11.5 Test Results

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Start Up time	From 19°C to 39°C in 11 minutes	Pass	-
8/8-2024	Sustain set point temperature at high hydrogen consumption	-	Pass	-
13/8-2024	Power Consumption test	18 kW	Pass	-

Unit	Equipment number	Calibration due date	Test used for
Clamp meter	039-040	26/4-2025	Power Consumption test

6.0 Pre-operations tests

6.1 P01 Fuel cell commissioning.

6.1.1 Test

Commissioning according to PWR008.

Service interface to be operated by Service technician level-3.

6.1.2 Relevant Standard / document

- Ballard document PWR008.

6.1.3 Brief Test Plan

Inspection, start-up and conditioning of each individual FC wave.

6.1.4 Pass/Fail criteria.

According to Ballard commissioning document PWR008

6.1.5 Test Result

Table 15: Fuel Cell commissioning - Test Result

Date tested	Item	Result	Pass/Fail	Notes
1/8-2024	FCwave 1	-	-	All tests approved, but down-polarization is yet to be performed
1/8-2024	FCwave 2	-	-	All tests approved, but down-polarization is yet to be performed
1/8-2024	FCwave 3	-	-	All tests approved, but down-polarization is yet to be performed
1/8-2024	FCwave 4	-	-	All tests approved, but down-polarization is yet to be performed
1/8-2024	FCwave 5	-	-	All tests approved, but down-polarization is yet to be performed

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1/8-2024	FCwave 6	-	-	All tests approved, but down-polarization is yet to be performed

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6.2 P02 Emergency stop

6.2.1 Test

Verify emergency stop function during stand-by.

6.2.2 Relevant Standard / document

- No reference

6.2.3 Brief Test Plan

- Use service interface.
- All Fuel Cell System in stand-by.
- Press emergency-stop pushbutton.

6.2.4 Pass/Fail criteria.

- Correct emergency shutdown of systems.
- Correct emergency stop signaling observed.
- Restart prohibited.
- Release emergency stop button.
- Reset possible.
- Restart to stand-by possible.
- No persistent system alarms.

6.2.5 Test Result

Table 16: Emergency stop - Test Result

Date tested	Item	Result	Pass/Fail	Notes
6/8-2024	Emergency stop	-	Pass	-
6/8-2024	HMI emergency stop	-	Pass	-
6/8-2024	Restart prohibited	-	Pass	-
6/8-2024	Reset ok	-	Pass	-
6/8-2024	Restart possible	-	Pass	-
6/8-2024	No persistent alarms	-	Pass	-

6.3 P03 Emergency stop – shut down

6.3.1 Test

Verify emergency stop function on power producing system at minimum fuel cell level.

6.3.2 Relevant Standard / document

- No reference

6.3.3 Brief Test Plan

- Use service interface.
- All FC systems operate at 25% load.
- Press emergency-stop pushbutton.

6.3.4 Pass/Fail criteria.

- Correct emergency shutdown of systems and de-energizing performed.
- Correct emergency stop signaling observed.
- Restart prohibited.
- Release emergency stop button.
- Reset possible.
- Restart to stand-by possible.
- No persistent system alarms.

6.3.5 Test Result

Table 17: Emergency stop - shutdown - Test Result

Date tested	Item	Result	Pass/Fail	Notes
6/8-2024	Emergency stop	-	Pass	-
6/8-2024	HMI emergency stop	-	Pass	-
6/8-2024	Restart prohibited	-	Pass	-
6/8-2024	Reset ok	-	Pass	-
6/8-2024	Restart possible	-	Pass	-
6/8-2024	No persistent alarms.	-	Pass	-

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6.4 P04 Steady state operation – HT1 cooler function

6.4.1 Test

Verify performance of cooling by operating at maximum load and all cooling components forced to 100%.

6.4.2 Relevant Standard / document

- No reference

6.4.3 Brief Test Plan

- Use service interface.
- Operate FC1 to FC3 at 100% load +/-5%.
- Wait for steady coolant temperature (regulated)
- Force cooling system to 100% or HT inlet temperature 10°C
- Wait for steady coolant temperature.

6.4.4 Pass/Fail criteria.

- Measure produced power.
- Measure Cooler fan speed.
- Measure temperatures.
- In controlled mode 10°C< HTin <60°C
- In controlled mode 10°C< HTout - HTin <20°C

6.4.5 Test Result

Table 18: Steady state operation - HT1 cooler function - Test Result

Date tested	Item	Result	Pass/Fail	Notes
8/8-2024	HT1 cooler function	-	Pass	-

6.5 P05 Steady state operation – HT2 cooler function

6.5.1 Test

Verify performance of cooling by operating at maximum load and all cooling components forced to 100%.

6.5.2 Relevant Standard / document

- No reference

6.5.3 Brief Test Plan

- Use service interface.
- Operate FC4 to FC6 at 100% load +/-5%.
- Wait for steady coolant temperature (regulated)
- Force cooling system to 100% or HT inlet temperature 10°C
- Wait for steady coolant temperature.

6.5.4 Pass/Fail criteria.

- Measure produced power.
- Measure Cooler fan speed.
- Measure temperatures.
- In controlled mode 10°C< HTin <60°C
- In controlled mode 10°C< HTout - HTin <20°C

6.5.5 Test Result

Table 19: Steady state operation - HT2 cooler function - Test Result

Date tested	Item	Result	Pass/Fail	Notes
8/8-2024	HT2 cooler function	-	Pass	-

6.6 P06 Steady state operation – LT cooler function

6.6.1 Test

Verify performance of cooling by operating at maximum load and all cooling components forced to 100%.

6.6.2 Relevant Standard / document

- No reference

6.6.3 Brief Test Plan

- Operate all FC at 100% load +/-5%.
- Wait for steady coolant temperature (regulated)
- Force cooling system to 100% or LT inlet temperature 3°C
- Wait for steady coolant temperature.

6.6.4 Pass/Fail criteria.

- Measure produced power.
- Measure Cooler fan speed.
- Measure temperatures.
- In controlled mode 10°C< LTin <45°C
- In controlled mode 3°C< LTout - LTin <15°C

6.6.5 Test Result

Table 20: Steady state operation - LT cooler function - Test Result

Date tested	Item	Result	Pass/Fail	Notes
8/8-2024	LT cooler function	-	Pass	-

6.7 P07 Steady state operation - ventilating function

6.7.1 Test

Verify performance of cooling by operating at maximum load and all cooling components forced to 100%.

6.7.2 Relevant Standard / document

- No reference

6.7.3 Brief Test Plan

- Use service interface.
- Operate system all FC at 100% load +/-5%.
- Wait for steady state on Container internal temperature.
- Forced cooling system to to 100% duty (Ventilation fans, DCDC cooling fans).
- and achieve thermal steady state for 10 minutes.

6.7.4 Pass/Fail criteria.

- Measure produced power.
- Container internal temperature max 5°C>ambient.
- HT forward <25
- HT return <15
- LT forward <14
- LT return <10
- DCDC Cabinet temp <10°

6.7.5 Test Result

Table 21: Steady state operation - ventilating function - Test Result

Date tested	Item	Result	Pass/Fail	Notes
8/8-2024	Ventilating function	-	Pass	-

6.8 P08 Thermographic report – Cooling and ventilation

6.8.1 Test

Thermographic inspection report of solution with focus on cooling and ventilation performance.

6.8.2 Relevant Standard / document

- SPC ID 0102 Thermographic - Cooling and Ventilation Test Procedure

6.8.3 Brief Test Plan

- Thermographic inspection is done while stressing cooling and ventilation circuits. Ventilation circuit can be adjusted and re-tested to ensure even cooling and avoiding hot spots. If accessible surfaces are above 60°C hot surface labels should be installed.

6.8.4 Pass/Fail criteria.

- Surface temperatures on cabinets maximum 60°C if there are no warning label on panel.
- Even temperature distribution on coolers.

6.8.5 Test Result

Table 22: Thermographic report – Cooling and ventilation - Test Result

Date tested	Item	Result	Pass/Fail	Notes
4/9-2024	40 foot container inside	-	Pass	-
4/9-2024	40 foot container outside	-	Pass	-
4/9-2024	10 foot container inside	-	N/A	Not possible for worker to enter during running state and thus not relevant to monitor. See P09's report for thermographic pictures of the inside electrical parts in the 10 foot container.
4/9-2024	10 foot container outside	-	Pass	-
4/9-2024	HT Cooling skid	-	Pass	-
4/9-2024	LT Cooling skid	-	Pass	-

Unit	Equipment number	Calibration due date	Test used for
Thermal camera	045-002	April 2025	40ft container, 10 ft container and Cooling skid

6.9 P09 Thermographic report – Electrical

6.9.1 Test

Follow test procedure to inspect and control all relevant electrical installations.

6.9.2 Relevant Standard / document

- SPC ID 0105 Thermographic - Electrical Test Procedure

6.9.3 Brief Test Plan

- Follow test procedure.

6.9.4 Pass/Fail criteria.

- No cables should exceed the temperature limit specified by the supplier including a correction factor of ambient temperature in container.

6.9.5 Test Result

Table 23: Thermographic report - Electrical - Test Result

Date tested	Item	Result	Pass/Fail	Notes
8/8-2024	40 ft container	-	Pass	-
8/8-2024	10 ft container	-	Pass	-
8/8-2024	Cooling skid	-	Pass	-

Unit	Equipment number	Calibration due date	Test used for
Thermal camera	045-002	April 2025	40ft container, 10 ft container and Cooling skid

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7.0 Operational tests

Operations are done using operator HMI or remote HMI in normal operating mode.

7.1 O01 System Start/Stop - Normal low load operation.

7.1.1 Test

Fuel Cell system can start, deliver minimum power and perform controlled stop without faults. This test is based on DC power.

7.1.2 Relevant Standard / document

- No reference

7.1.3 Brief Test Plan

- All FC in standby
- Request 100kW DC
- Delay 120 seconds
- Request zero power
- Repeat with new preferred FC until all tested.

7.1.4 Pass/Fail criteria.

- Fuel Cell Package starts without faults.
- No persistent system alarms.
- Correct available power signal.
- DC Power output within +/-5% and stable in less than 60 seconds
- Fuel Cell Package stops without faults.
- FC in stand-by in less than 30 seconds.

7.1.5 Test Result

Table 24: System Start/Stop – Normal low load operation - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	FCwave 1	All pass criterias passed except time to standby	Pass with note	Shut down to standby longer than 30 seconds
3/9-2024	FCwave 2	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 58 seconds. Power output dipped to 82 kW during the test.
3/9-2024	FCwave 3	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 55 seconds.
3/9-2024	FCwave 4	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 59 seconds.
3/9-2024	FCwave 5	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 57 seconds.
3/9-2024	FCwave 6	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 1 minute 3 seconds.

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7.2 O02 Error resulting in loss of one FC module.

7.2.1 Test

Verify that FCwave performs stop in case of simulate error and correct transfer to next FC. This test is based on DC power.

7.2.2 Relevant Standard / document

- No reference

7.2.3 Brief Test Plan

- Systems operating at 200kW load, such that 2 fuel cell modules are operating.
- Use module engineering interface to force high coolant temperature error resulting in controlled shut-down.

7.2.4 Pass/Fail criteria.

- Respective FC will perform shutdown.
- Correct alarm signaling.
- Correct signal of reduced available power.
- Restart of FC under test prevented.
- Remaining running FC shall continue operation and increase to cover lost FC production until 200kW production is reestablished.
- No persistent system alarms.

7.2.5 Test Result

Table 25: Error resulting in loss of one FC module - Test Result

Date tested	Item	Result	Pass/Fail	Notes
9/8-2024	Loss of 1 FC test	-	Pass	-

7.3 O06 Noise Level Test

7.3.1 Test

Follow test procedure to check noise level in work environment and noise emitted from Megablock setup.

7.3.2 Relevant Standard / document

- SPC ID 0106 Noise Level Measurement Test Procedure

7.3.3 Brief Test Plan

- Follow test procedure.

7.3.4 Pass/Fail criteria.

- Follow criteria from test procedure.

7.3.5 Test Result

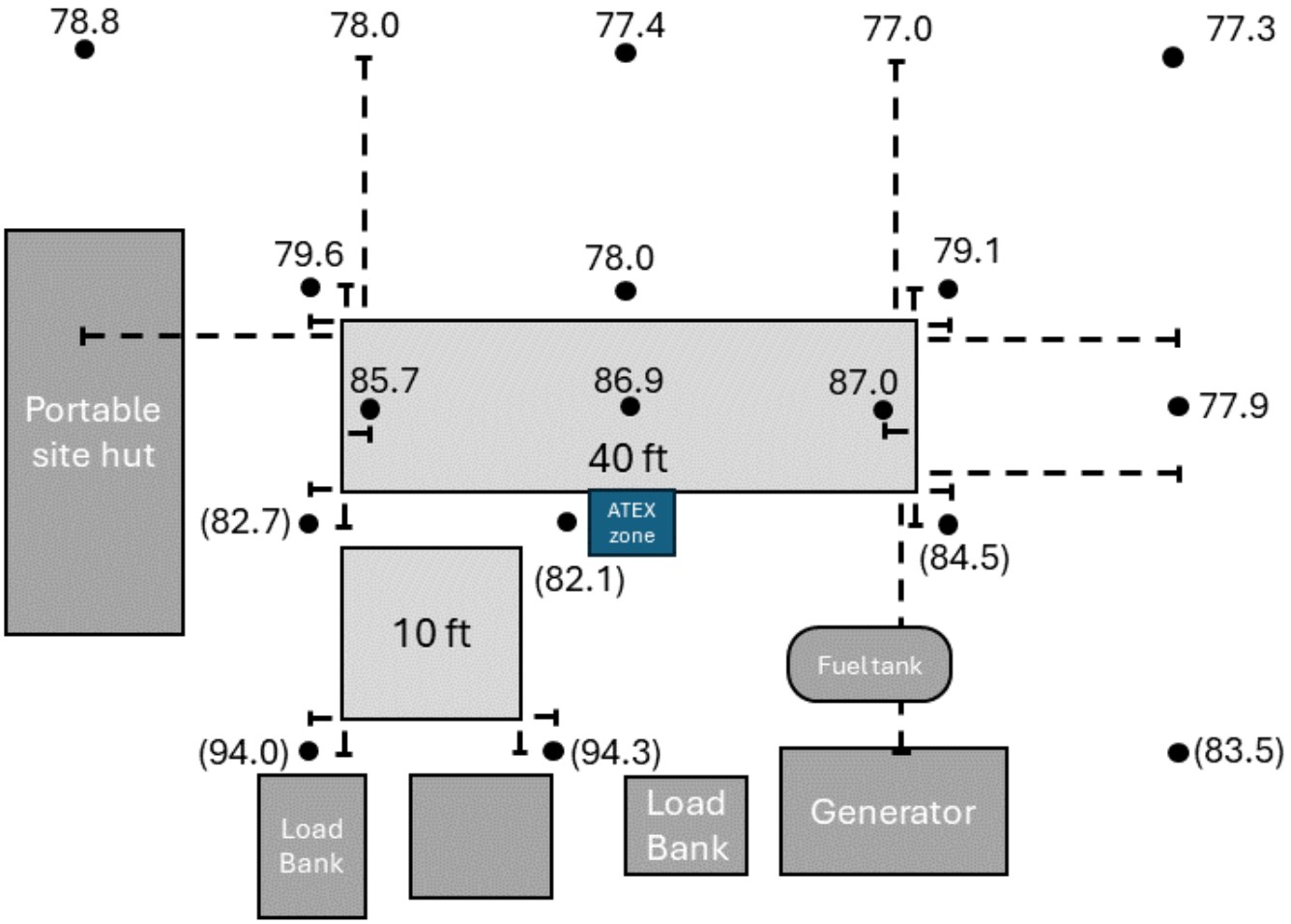
See table and figure below.

Table 26: Noise Level Test - Fully Operational - Test Result

Date tested	Item	Result	Pass/Fail	Notes
4/9-2024	Max noise inside	87 dBA	Pass	Recommendation that service personal wear hearing protection
4/9-2024	Max noise 1 meter	79.6 dBA	Pass	-
4/9-2024	Max noise 7 meter	77.9 dBA	Pass	-

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Title	O06 Noise test, Crosswind
Project	601456B Crosswind BLPH
Test date	04-09-2024
Test description	Megablock at full load producing 1000 kW to grid



Reference measurement with all units turned off = 46 dBA

(xx.x) =Possibly significantly affected by load banks and generator

– =1 meter

– – – – – – =7 meter

7.4 O07 Load Test - Ramp up

7.4.1 Test

Ramp up from 0kW to 1000kW AC power while measuring AC power quality.

7.4.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.4.3 Brief Test Plan

- All FC is stand-by.
- Ramp slope: 0kW to 1000kW AC Power in 180 seconds.

7.4.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

7.4.5 Test Result

Table 27: Load Test - Ramped up - Test Result

Date tested	Item	Result	Pass/Fail	Notes
9/8-2024	Ramp up from 0 kW to 1000kW	-	Pass	-
9/8-2024	AC power quality	-	Pass	-

7.5 O08 Load Test - Ramp Down

7.5.1 Test

Ramp down from 1000kW to 0kW AC power while measuring AC power quality.

7.5.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.5.3 Brief Test Plan

- All FC running.
- Steady state at 1000kW AC.
- Ramp slope: 1000kW to 0kW AC Power in 180 seconds.

7.5.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

7.5.5 Test Result

Table 28: Load Test - Ramp Down - Test Result

Date tested	Item	Result	Pass/Fail	Notes
9/8-2024	Ramp down from 1000kW to 0kW	-	Pass	-
9/8-2024	AC power quality	-	Pass	-

7.6 O09 Load Test – step response 0 to 35%

7.6.1 Test

Test step response by adding 35% load in one step from no load while measuring AC power quality.

7.6.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.6.3 Brief Test Plan

- All FC in stand-by.

- Apply set point by requesting 350kW AC

7.6.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

7.6.5 Test Result

Table 29: Load Test - step response 0 to 35% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 0-35%	45 seconds for start-up 0-350kW AC. Slight overshoot on 30 kW AC	Pass	With reference to document C08 it is estimated that a ramp time to 500 kW is 75 seconds.
3/9-2024	AC power quality	2,9-2,8% VAC THD 2-50 No alarms	Pass	-

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7.7 O10 Load Test – step response 35% to 70%

7.7.1 Test

Test step response by adding 35% load in one step to reach 70% load while measuring AC power quality.

7.7.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.7.3 Brief Test Plan

- 3 FC running delivering 350kW AC steady state.
- 2 FC in stand-by
- Apply set point by requesting 700kW AC power.

7.7.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC
- AC power quality within SPC ID 107
- No persistent system alarms.

7.7.5 Test Result

Table 30: Load Test - step response 35% to 70% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 35%-70%	All 3 started up. 23 seconds startup time	Pass	With reference to document C08 it is estimated that a ramp time from 250 kW to 750 kW is 45 seconds.
3/9-2024	AC power quality	2,8-3,0 % VAC THD 2-50 No alarms	Pass	-

7.8 O11 Load Test – step response 65% to 100%

7.8.1 Test

Test step response by adding 35% load in one step to reach full load while measuring AC power quality.

7.8.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.8.3 Brief Test Plan

- 6 FC running delivering 650kW AC steady state.
- Apply set point by requesting 1000kW AC power.

7.8.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

7.8.5 Test Result

Table 31: Load Test - step response 65% to 100% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 65%-100%	18 seconds startup time	Pass	With reference to document C08 it is estimated that a ramp time from 250 kW to 750 kW is 45 seconds.
3/9-2024	AC power quality	3,0-3,1 % VAC THD 2-50 No alarms	Pass	-

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7.9 O12 Load Test – 100% stability test - 3 hours.

7.9.1 Test

Test steady state at 100% load for 3 hours while measuring power quality.

7.9.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.9.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.

7.9.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

7.9.5 Test Result

Table 32: Load Test – Steady state 100% load - Test Result

Date tested	Item	Result	Pass/Fail	Notes
4/9-2024	Full load test	1000 kW for 3 hours	Pass	See below
4/9-2024	AC power quality	2.3-3.6 % VAC THD 2-50 No alarms	Pass	-

7.10 O13 Load Test – step response 100% to 50%

7.10.1 Test

Test step response by removing 50% load in one step at full load while measuring power quality.

7.10.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.10.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.
- Request 500kW AC.

7.10.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

7.10.5 Test Result

Table 33: Load Test - step response 100% to 50% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 100%-50%	Ramp down in 15 seconds	Pass	With reference to document C08 it is estimated that a ramp down time from 800 kW to 200 kW is 15 seconds.
3/9-2024	AC power quality	3,0-2,6 % VAC THD 2-50 No alarms	Pass	-

7.11 O14 Load Test – step response 50% to 0%

7.11.1 Test

Test step response by removing 50% load in one step to no load while measuring AC power quality.

7.11.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

7.11.3 Brief Test Plan

- 3 FC running delivering 500kW AC.
- Request 0% and apply set point.

7.11.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

7.11.5 Test Result

Table 34: Load Test - step response 50% to 0% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 50%-0%	-	Pass	Test is executed with 6 FC instead of 3 as the plan describes
3/9-2024	AC power quality	NA	NA	Not applicable due to the unit not producing power

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8.0 Appendix

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Short Title	Thermographic - Cooling and Ventilation Test Procedure
Full Title	Thermographic - Cooling and Ventilation Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating cooling and ventilation are performing correct.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-02-2024
2	Updated	TAN	08-08-2024

Checked by: TAN	Date: 6/8-2024
Approved by: TAN	Date: 6/8-2024

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6.0 Appendix 6
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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and background

The objectives of this test procedure is to demonstrate the performance of ventilation and cooling on full system solution. The thermographic inspection will be conducted around solution as well as inside where service staff can enter while system stays operational.

- Ensure ventilation system performing as expected.
- Ensure cooling system is performing as expected.
- Validate accessible surface temperatures.

2.0 References

Document	Titel

3.0 Equipment list

Equipment	Purpose
Thermographic imager	Measure temperatures, capture images and create data folder with evidence.

4.0 Test Procedure

4.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

4.2 Preparation

- Verify equipment is calibrated and withing valid calibration period.
- Identify how and where to measure the ventilation system.
- Identify how and where to measure the cooling system.
- Identify possible heat surfaces to be inspected.

4.3 Measurement locations

- Inside solution:
  - Ventilation of components
  - Container ventilation
  - Surface temperatures
  - Cooling circuit
- Outside solution:
  - Container ventilation
  - Surface temperatures
  - Coolers and cooling circuit

4.4 Conducting measurements

Set the Megablock to full power (1000 kW) and wait until temperatures have stabilised. Monitor the containers and ventilation described in section 4.3 through the thermographic imager and take pictures of all relevant areas with elevated temperatures. File in the pictures in a report.

5.0 Appendix

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Short Title	Cooling Circuit Pressure and Leak Test Procedure
Full Title	Cooling Circuit Pressure and Leak Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating cooling circuits are leak free and can withstand normal operating pressure.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-02-2024

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and background

The objective with this test procedure is to generalise how cooling circuits are leak free and pressure tested.

2.0 References

Document	Titel

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3.0 Equipment list

Equipment	Purpose
Pressure gauge	Monitor pressure

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4.0 Test Procedure

The main purpose of this test procedure is to ensure that the cooling circuit is leak free and can handle maximum system pressure. Furthermore, it is structured in a way to minimize the chance of having big leaks or lose clamps or fittings.

WARNING: The stress test is with elevated pressure, potentially turning plugs or loose fittings into projectiles.

Minimum safety precautions:

- Hose clamps and fittings
- Wear safety goggles
- When dealing with glycol wear gloves
- Check service manual for maximum system pressure.

4.1 Pre-conditioning

- Check and make sure valves in the cooling circuit are in the correct position.
- For pressure testing with coolant in the cooling circuit, make sure the system is fully bleed. Air in the system can act as a spring and can obscure results.
- To achieve stable temperature let system soak for 12 hours. Alternative watch data from temperature sensors in the full system to ensure stable temperature conditions.

4.2 Leak test with air

- Check service manual for maximum system pressure.
- No temperature pre-conditioning needed this is not a sign off test.
- Find compressor and leak test kit.
- Adjust pressure reduction valve to minimum (no pressure after reduction valve)
- Attach leak test kit to cooling circuit (not applying pressure to circuit)
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 20% of maximum system pressure
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 80% of maximum system pressure
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 100% of maximum system pressure
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained – test completed and passed.

4.3 Leak test with air setup

Compressor and adaptor hose to be connected. Close valve to expansion tank so that pressure can build in cooling circuit. Find test setup image in appendix.

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4.4 Pressure decay test with coolant

- Check service manual for maximum system pressure.
- Make sure cooling circuit have been filled and bled before starting this test.
- Make sure pre-conditioning have been done.
- Find coolant pressure test kit.
- Attach test kit to cooling circuit (not applying pressure to circuit)
- Slowly increase pressure 50% of maximum system pressure
- Close valve from test kit.
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from test kit
- Slowly increase pressure to 100% of maximum system pressure
- Close valve from test kit
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Wait 30 minutes if pressure have dropped re-apply pressure to reach 100% system pressure again.
- Wait 2 hours and check pressure again.
    - If pressure have dropped more than 0.1bar
        - Repeat test
    - If pressure have dropped less than 0.1bar after 2 hours – test completed and passed.

4.5 Pressure decay test with coolant setup

Pressure pump and adaptor hose to be connected. Close valve to expansion tank so that pressure can build in cooling circuit. Find test setup image in appendix.

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4.6 Pressure decay test with coolant at increased pressure

- **Do not use this test procedure** for pressure testing cooling circuits with strict pressure limits such as LT circuit on FCwave
- Check service manual for maximum system pressure.
- Make sure cooling circuit have been filled and bled before starting this test.
- Make sure pre-conditioning have been done.
- Find coolant pressure test kit.
- Attach test kit to cooling circuit (not applying pressure to circuit)
- Slowly increase pressure 50% of maximum system pressure
- Close valve from test kit.
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from test kit
- Slowly increase pressure to 150% of maximum system pressure
- Close valve from test kit
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Wait 2 hours and check pressure again.
    - If pressure have dropped more than 0.1bar
        - Repeat test
    - If pressure have dropped less than 0.1bar after 2 hours – test completed and passed.

5.0 Results and discussion

6.0 Appendix

6.1 Cooling leakage HT1 (Suggested section for FAT or SAT document)

6.1.1 Test

Follow designated test procedure for inspection and verification of a leak-free HT1 coolant circuit.

6.1.2 Relevant Standard / document

- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

6.1.3 Brief Test Plan

- Follow test procedure.

6.1.4 Pass/Fail criteria.

- Allow system to maintain pressure, after 2 hours pressure must not drop more than 0,1 bar.

6.1.5 Test Result

Table 1: Cooling leakage HT1 - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	HT 1			

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6.2 Pressure decay test with coolant

Pressure pump and adaptor hose to connect and pressurise.



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6.3 Leak test with air

Compressor and pressure test adaptor hose.



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Short Title	H2 Leak Test Procedure
Full Title	H2 Leak Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating H2 circuits are within allowed limits and can withstand normal operating pressure.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	RKN	13-05-2024
001	Release		
002	Procedure update	TAN	28-08-2024

Checked by: MHA	Date: 30-08-2024
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1.0 Definitions

Abbreviation	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module
SME	Subject Matter Expert
PPE	Personal Protective Equipment
DUT	Device under test

2.0 Objectives and Background

The purpose of this test procedure is to generalise how Ballard Product Solutions secure that the fabricated hydrogen systems are not leaking more than the specified limits and the circuits will withstand maximum operation pressure. Furthermore, this procedure is intended to be used on full systems and/or sub assemblies. This test procedure is based on *IEC 62282-3-1 section 5.4 Leakage tests and 5.4.1 Gas leakage tests* with regards to system tests. For hydrogen pipework testing, the IEC 62282-3-1 references *ISO 15649:2001 "Petroleum and natural gas industries – Piping* which states that piping shall be tested according to *ASME B31.12 Hydrogen piping and pipelines.* Hence, the described procedure for component/pipework inspection and leakage test is based on this standard.

3.0 References

Document	Titel
IEC 62282-3-1:2019	Fuel cell technologies - Part 3-1: Stationary fuel cell power systems - Safety
ASME B31.12-2023	Hydrogen piping and pipelines
SPC ID 0202	Snooper mini H2 sniffing procedure
SPC ID 0203	Pipework inspection and leakage test check sheet template
SPC ID 0204	System pressure decay test template

4.0 Equipment list

Equipment	Type	Purpose
H2 sniffer	Sewerin Snooper Mini H2	Detection instrument to snif/locate source of potential leaks
Pressure sensor	Fluke 700RG07 500PSIG	Measuring device to accurately adjust and monitor gas pressure during leakage test
Test gas	Formier gas 5% hydrogen	Test gas for pressurizing pipework where the 5% hydrogen acts as tracer agent for sniffing.
Sniffer test station	Sewerin SPE-HG	Test instrument the emits a reference gas to check the correct function of the Snooper Mini H2 sniffer
Pressure regulator		Test gas pressure regulator for pressurizing the DUT
Pressure relief valve		Safety valve to ensure safe pipework pressurization during test.

5.0 Test Procedures

Any system is comprised of several subassemblies and/or components. Any of these subsystems must be individually inspected and leakage tested before assembly into the complete system. For systems fabricated or assembled by Ballard Product Solutions, testing per section 5.4 applies. Externally delivered systems/modules as well as Ballard standard products must be tested in accordance with *IEC 62282-3-1:2019* or similar industry relevant standards.

Attention: All test personnel, including external witness should be informed about risks associated with the test and instructed to use proper PPE prior to conducting the test.

WARNING: Pressure testing can potentially turn plugs or loose fittings into projectiles.

Minimum safety precautions:

- The test must be carried out by trained personnel.
- Prior to test start make sure that the work has been HSE risk assessed according to Ballard internal procedures.
- All connection and mechanical assemblies shall be checked before applying pressure.
- All personnel attending the test shall use appropriate PPE.

5.1 Installations and connections

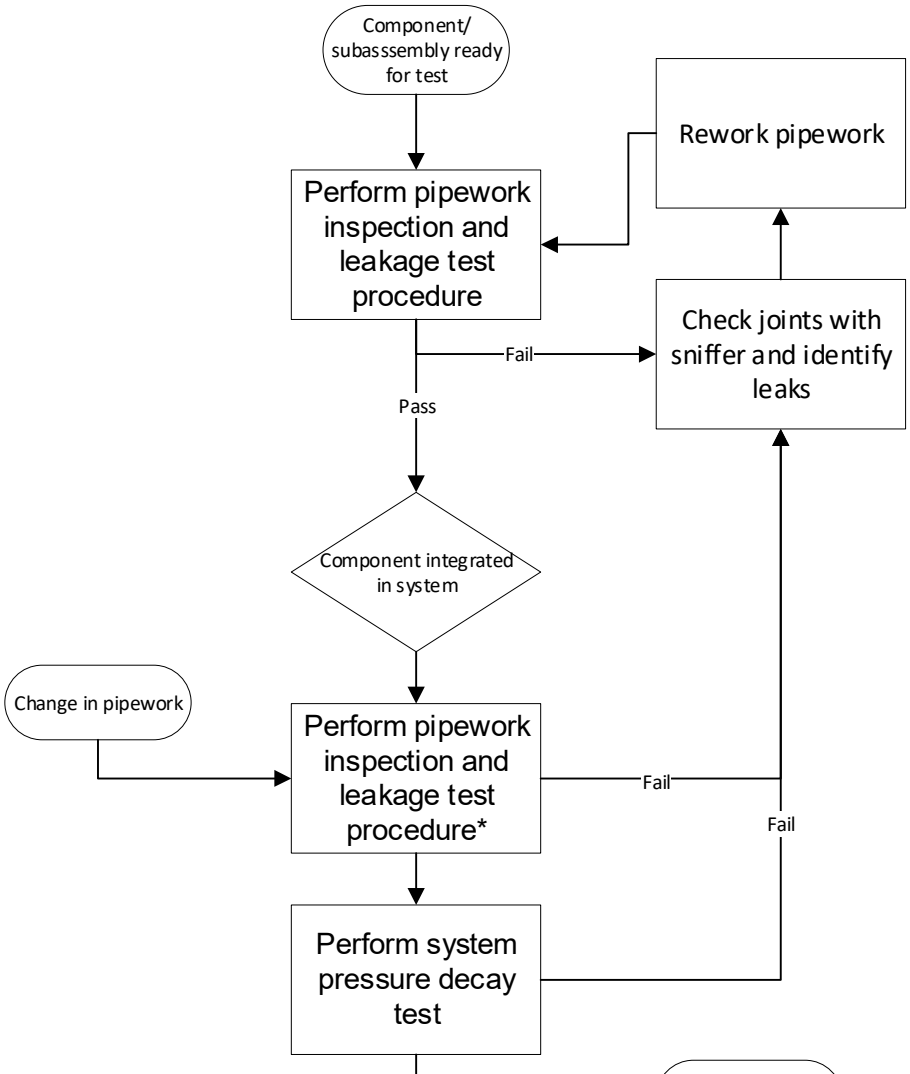
Make sure that all parts of the hydrogen system have been correctly assembled and according to assembly guides and build manuals.

5.2 Review test setup.

Before proceeding to testing, the test setup should be reviewed by a SME. The SME should also determine the pressure of which the system under test will be tested to. Once a setup has been reviewed and approved re-testing can proceed on same approval if the setup remains unchanged. If a diagram of the system under test does not exist create a diagram like the one in appendix. The results from the test should be added on the diagram and saved as part of the test report. During the review a risk assessment should be done and shared with all staff involved with testing and working in proximity to an ongoing test. Make sure that relevant measurement instruments, used during the test all have valid calibration certificates if applicable. Furthermore, ensure that manufacturers procedures are followed for maintaining the equipment accuracy and dependability.

5.3 System test sequence

On any system the following test sequence must be followed during first assembly or reassembly of a system.



* Only for changed/interfacing joints

5.4 Pipework inspection and leakage test

The pipework inspection and leakage test are performed to ensure proper assembly quality is achieved during fabrication and assembly of components/subassemblies. The test is designed to be performed upon work completion in the assembly plant/workshop before release to system assembly.

The test is performed in accordance with or exceeding requirements in *ASME B31.12 Hydrogen piping and pipelines*.

The associated template for documenting the test must be used: *SPC ID 0203 Pipework inspection and leakage test check sheet* template

5.4.1 Test setup

The assembled component or subassembly pipe ends are appropriately sealed off and the pressure regulator with formier gas supply is connected, together with a pressure gauge and appropriate pressure relief valve.

Use of the H2 sniffer instrument must be performed in accordance with *SPC ID 0202 Snooper mini H2 sniffing procedure.*

5.4.2 Test sequence

1. Check for proper functionality of the sniffing tool by using the sniffer test station
2. Inspect the pipework visually for any damage or loose parts
    a. For ferrule fittings, check every fitting with appropriate gap inspection gauge to ensure sufficient tightening is achieved
3. Pressurize pipework to between 1.0-1.2 barg with formier gas and listen for leaks
4. Increase pressure to 50% of test pressure by adjusting the pressure regulator
5. Maintain the pressure for 10 minutes.
6. Listen for leaks and use H2 sniffer to inspect all joints. If leaks are identified record all positions and values in the check sheet, abort test by proceeding to item 10 and file the pipework for rework.
7. If no leaks are detected, proceed to increase pressure to “test pressure” by adjusting the pressure regulator.
8. Maintain the pressure for minimum 10 minutes.
9. Listen for leaks and use the H2 sniffer to inspect all joints. Record all leak positions and values in the check sheet.
10. Blow down system, disconnect test gas supply and secure pipe ends.
11. Check for proper functionality of the sniffing tool by using the sniffer test station.
12. For identified leaks file the pipework for rework.
13. For joints that pass the procedure, a suitable marking must be applied to identify that the joint is verified.
14. If all joints are accepted, sign and file the check sheet.

If leaks are identified during the procedure, the test sequence must be performed again on reworked pipework.

5.4.1 Test evaluation

Each joint of the DUT is subject to the following test pass criteria:

Inspection element	Pass criteria
Visual inspection	No visible damage, incorrect assembly or misplacement of the joint. No dirt, lubricants or foreign materials left on the joint No indication of excessive use of force No indication of incorrect use of tools to assemble the joint.
Auditory inspection	No hearable leaks unless allowed by the particular joint.
Gauge inspection (where applicable)	According to gauge tool instruction.
Sniffing	According to acceptable leakage rate of a particular joint + measurement uncertainty of the sniffer (see SPC ID 0202) To be referenced from the ATEX documentation/design manual and recorded in the check sheet.

5.5 System pressure decay test

The system pressure decay test is performed to validate integrity of pipework and instrumentation of the complete H2 system. The test is performed in accordance with *IEC 62282-3-100:2020 section 6.2: Leakage test.*

5.5.1 Test setup

The system pressure decay test may only be performed if all subassemblies have been validated with the procedure described in section 5.4 or equivalent (for externally delivered subassemblies).

The test is performed using the regular fuel supply of the system at test pressure level.

If appropriate, the test may be isolated and divided into appropriate sections to allow for separate validation of individual pipe sections.

To ensure that the validation of the integrity of the pipework is sound, a measurement system analysis must be performed. The accuracy of the equipment, used to measure the necessary variables of the test must contribute to a measuring error of no more than 2% of the allowable leak rate in the system.

The associated template for documenting the test must be used: *SPC ID 0204 System pressure decay test template*

5.5.2 Test parameters

To properly validate the pipework system, the following variables are used. Variables are either universal constants, calculated values, system design values or measured values:

Variable	Name	Unit	Description
P_ops	Max operating pressure	barg	As defined by manufacturer spec
P_d	Design pressure	barg	Highest pressure that may occur under any and all operating modes, including steady state and transient.
P_t	Test pressure	barg	110% of design pressure
P_PRV	Relief pressure of relief valve	barg.	Test setup PRV
L_A	Max evaluated leak rate for pipework system acceptance	Nm^3/h	Maximum allowed pressure decay to pass pressure decay test
L_S	Expected leak rate for pipework system	Nm^3/h	Summarized expected leak rates of all components in the system (per design leak rate). The leak rates may be obtained from component category values or from actual measured leak rates during acceptance testing of the component.
L_C	Max allowed leak rate zone integrity (Critical leak level)	Nm^3/h	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

Variable	Name	Unit	Description
L_Mu	Measuring system uncertainty	Nm^3/h	Calculated accuracy of the measuring system, used to perform the test. The MSA must consider the complete signal path of sensors and control system.
L1	Actual leak rate	Nm^3/h	Calculated gas leakage rate from the tested system by performing the pressure decay test
V	Internal space volume	m^3	Calculated Internal space volume within the pressurized section (m^3) (gas volume excepting the internal structure volume) Internal pipework space volume must be obtained from the system design team as a value for any of the relevant sections.
T0	Reference temperature	K	Theoretical reference temperature (288.15K)
T1	internal space temperature start	K	Measured internal space temperature at the beginning of measurement
T2	internal space temperature end	K	Measured internal space temperature at the end of measurement
P0	Absolute reference pressure	kPa	Theoretical reference pressure (1 atm) (101.325 kPa)
P1	Internal space pressure start	kPag	Measured internal space pressure at the beginning of measurement
P2	Internal space pressure end	kPag	Measured space pressure at the end of the measurement
Pa1	Absolute pressure start	kPag	Measured atmospheric pressure at the beginning of the measurement
Pa2	Absolute pressure end	kPag	Measured atmospheric pressure at the end of the measurement (kPa)
t	Test duration	min	Measured test duration (t_end – t_start)

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5.5.3 Sequence

If at any point the system pressure is dropping, investigate leak before continuing testing.

1. Introduce hydrogen to the system by increasing gradually the inlet pressure until test pressure level is reached in the system.
2. Close the relevant inlet valve, isolating pressure supply from the system under test.
3. Let the pressure in the system settle for 2 minutes.
4. Start the pressure decay monitoring by recording
   -start time t_start
   -start internal space pressure P1
   -start atmospheric pressure Pa1
   -start temperature T1
5. Wait for 10 minutes
6. Finish the pressure decay monitoring by recording
   -end time t_end
   -end internal space pressure P2
   -end atmospheric pressure Pa2
   -end temperature T2
7. Calculate the leak rate L1
8. Blow down system or continue operation if test is successful.

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5.5.4 Test evaluation

The actual leakage rate from the system is calculated in accordance with *IEC 62282-3-100:2019. Section 6.2* from the pressure difference in the system, measured over time using the following formula, and with variables as described in section 5.5.2:

$$L_1 = V \times T_0/p_0 \times \{(p_1 + p_{a1})/(T_1) - (p_2 + p_{a2})/(T_2)\} \times 60/t$$

The allowable leakage rate of the system is a function of the allowable leak rates of each component in the system and the uncertainty of the measurement system itself.

The expected leakage rate of components/subassemblies may vary from system to system and may be comprised of a mix of maximum allowed leak rates, obtained from the system's *ATEX zone classification and pipework plan* or expected leakage rates obtained from actual measured values in component acceptance tests.

The measurement system must be evaluated (MSA) to estimate the measurement uncertainty (L_Mu). The measuring system can only be considered sound if the calculated uncertainty amounts to less than 2% of the critical leak rate (L_C).

The test pass criteria threshold is calculated as the allowable/expected leak rate of the system + the measurement uncertainty:

$$L_A = L_S + L_Mu$$

System will pass the pressure decay test under the following criteria:

$$L_1 < L_A$$

6.0 Appendix

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Short Title	Thermographic - Electrical Test Procedure
Full Title	Thermographic - Electrical Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating electrical cabinets and installation are performing correct.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-02-2024
2	Updated	TAN	09-08-2024

Checked by: TAN	Date: 9/8-2024
Approved by: TAN	Date: 9/8-2024

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Figure 2 Test pressure set up with principle of attachments. ..... **Error! Bookmark not defined.**

List of Tables

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.1 References

Document	Titel

2.0 Objectives and Background

The objectives of this test procedure are to demonstrate the performance of the electrical parts on full system solution. The thermographic inspection will be conducted around solution as well as inside where service staff can enter while system stays operational.

3.0 Test Procedure

3.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

3.2 Preparation

- Verify equipment is calibrated and withing valid calibration period.
- Identify how and where to measure the ventilation system.
- Identify how and where to measure the cooling system.
- Identify possible heat surfaces to be inspected.

3.3 Measurement locations

- Inside solution:
  - 40ft container
  - 10ft container
- Outside solution:
  - 40ft container
  - 10ft container
  - Cooling skid

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3.4 Conducting measurements

Set the Megablock to full power (1000 kW) and wait until temperatures have stabilised. Monitor the electrical cabinets and electrical installations described in section 3.3 through the thermographic imager and take pictures of all relevant areas with elevated temperatures. File in the pictures in a report.

4.0 Appendix

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Short Title	Noise Level Measurement Test Procedure
Full Title	Noise Level Measurement Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for measuring noise level inside and outside system. To validate work environment but also the noise emitted.

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Revision Record

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and Background

The objective of this test procedure is to determine the noise level generated by a full system solution. The measurements will be conducted around solution as well as inside where service staff can enter while system stays operational.

- Ensure compliance with noise regulations and safety standards.
- Evaluating the impact of the system noise to the surrounding environment.

2.0 References

Document	Titel
ISO 8528	Reciprocating internal combustion engine driven alternating current generating sets – Part 5: Generating sets

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3.0 Equipment list

Equipment	Purpose
Decibel meter	Measure noise level
Anemometer	Measure wind speed
Measuring tape	To measure up to 7 meter

4.0 Test Procedure

4.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

4.2 Preparation

- Verify equipment is calibrated and within valid calibration period.
- Identify the main noise sources inside and outside solution.
- Identify at which the operating points the solution will emit the most noise.
- Identify normal operating point for solution.

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4.3 Measurement locations

- Inside solution
  - Multiple measurements to capture the overall sound level within the work environment.
- Outside solution
  - 1-meter grid around solution
  - 7-meter grid around solution

4.4 Conducting measurements

- If decibel meter does have recording function:
  - Inside container measurement:
    - Measure maximum noise level at identified operating point in 5.2 and at location identified in 5.3. Measure for around 30 seconds to ensure a stable reading.
    - Noise level sweep:
      - Container running normal operating condition.
      - Start record noise level and walk from one end of the container to the other end.
      - Sweep should last around 20 seconds.
  - Outside container 1 meter:
    - Mark up the 1-meter perimeter around the container for example with a cone in each corner. If site does not allow 360 degree walk around at 1 meter while running, multiple recordings can be taken and compared to find maximum noise level.
    - System off (with noisy surroundings take a reference log)
    - Start recording the noise level, and slowly walk around the perimeter marked up.
    - Container running at most noise emitting point.
    - Start recording the noise level, and slowly walk around the perimeter marked up.
    - Analyze and find maximum noise level.

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- Outside container 7 meter:
  - Mark up the 7-meter perimeter around the container for example with a cone in each corner. If site does not allow 360-degree walk around at 7 meter while runnin0g, multiple recordings can be taken and compared to find maximum noise level.
  - System off (with noisy surroundings take a reference log)
  - Start recording the noise level, and slowly walk around the perimeter marked up.
  - Container running at most noise emitting point.
  - Start recording the noise level, and slowly walk around the perimeter marked up.
  - Analyze and find maximum noise level.

- If decibel meter does not have recording function:
  - Inside container measurement:
    - Measure maximum noise level. Measure for around 30 seconds to ensure a stable reading.
    - Noise level at 3 points in the container:

      Container running normal operating condition.

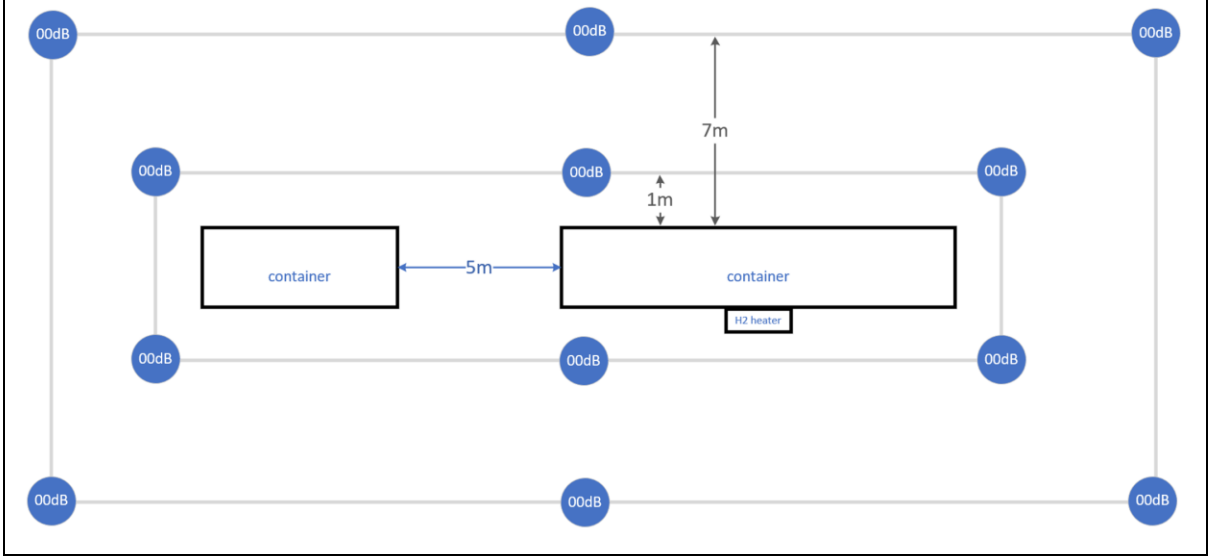
      - Measure noise level 1 meter from the one end of the container.
      - Measure noise in the mid point of the container.
      - Measure noise level 1 meter from the other end of the container.
  - Outside container 1 meter:
    - Mark up the 1-meter perimeter around the container for example with a cone in each corner. (If test setup does not allow full access complete as many points as possible)
    - System off (with noisy surroundings take a reference log)
    - Container running at most noise emitting point.
    - Start measuring the noise level, at each corner and in the mid point. Find reference map in appendix. And note down the noise level.
    - Analyze and find maximum noise level.

- Outside container 7 meter:
  - Mark up the 7-meter perimeter around the container for example with a cone in each corner. (If test setup does not allow access complete as many points as possible)
  - System off (with noisy surroundings take a reference log)
  - Container running at most noise emitting point.
  - Start measuring the noise level, at each corner and in the mid point. Find reference map in appendix. And note down the noise level.
  - Analyze and find maximum noise level.

5.0 Appendix

5.1 Reference map measurement grid

Figure 1: Reference map measurement grid



Short Title	Power Quality Measurement Test Procedure
Full Title	Power Quality Measurement Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating cooling circuits are leak free and can withstand normal operating pressure.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-06-2024
2	Update to match testing requirements	PBL/TAN	01-09-2024

Checked by: PBL	Date: August 2024
Approved by: PBL	Date: September 2024

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Abbreviation	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and Background

This test procedure aims to evaluate the power quality performance of Fuel Cell gensets and compare it to conventional diesel gensets G3.

2.0 References

Document	Titel
ISO 8528-5:2022	Reciprocating internal combustion engine driven alternating current generating sets

3.0 Equipment list

Equipment	Purpose
Fluke 1775	Power Quality Analyzer, measures Voltage, Current and Frequency Data

4.0 Test Procedure

4.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

4.2 Preparation

Fuel Cell Megablock system is to be connected to a variable power consumer such as a load bank or grid connection.

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4.3 Steady state testing

4.3.1 Apply rated power of the fuel cell Megablock system.

4.3.2 Monitor and record the following parameters for at least 10 minutes:

- Voltage
- Frequency
- THDi
- THDu

4.3.3 Analyse data to make sure recorded values are within the limits.

Fill in the following table:

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤±5% At 400V: +/-20V			
	Frequency	≤0.5% At 50Hz: +/-0.25Hz			
	THDu	<5%			
	THDi	<5%			

4.4 Dynamic testing

4.4.1 Apply the following load step changes of rated power of the system. In systems where these load steps are not possible perform alternative dynamic tests:

- 0% to 35%
- 35% to 70%
- 65% to 100%
- 100% to 50%
- 50% to 0%

If it is not possible to perform these load steps, due to either system design or test setup, alternative load steps shall be used, and these should be confirmed with SME and test engineer.

4.4.2 Monitor and record the following parameters for at least 1 minute after each load change:

- Voltage
- Frequency
- THDi
- THDu

Fill in the following tables:

4.4.3 0% to 35%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤-15[c]% At 400V: (<60V_{ac} droop)			
	Frequency	≤-/7+δf_{st})[c] % At 50Hz: >45Hz			
	THDu	<5%			
	THDi	<5%			

4.4.4 35% to 70%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤-15[c]% At 400V: (<60V_{ac} droop)			

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Frequency	≤-/7+δf_{st})^{c} % At 50 Hz: >45Hz			
	THDu	<5%			
	THDi	<5%			

4.4.5 65% to 100%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤-15^{c}% At 400V: (<60V_{ac} droop)			
	Frequency	≤-/7+δf_{st})^{c} % At 50Hz: >45Hz			
	THDu	<5%			
	THDi	<5%			

4.4.6 100% to 50%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤+20% At 400V: (<80V_{ac} overshoot)			
	Frequency	≤+10% At 50Hz <55Hz			

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Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	THDu	<5%			
	THDi	<5%			

4.4.7 50% to 0%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤+20% At 400V: (<80V_{ac} overshoot)			
	Frequency	≤+10% At 50Hz: <55Hz			
	THDu	<5%			
	THDi	<5%			

5.0 Appendix

(intentionally left blank)

Short Title	F19 Hydrogen Preheating System, Testing
Full Title	Crosswind/Baseload Power Hub Fuel Cell Hydrogen Preheating System testing
Abstract	

Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	TAN	06-08-2024
2	Updated specification	TAN	12-08-2024

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1.0 Purpose and Scope

The purpose of this document is to describe the procedures to test the hydrogen preheating system capacities.

2.0 Functional tests

2.1 Start Up Time

2.1.1 Test description

This test is made to find the time from startup of the hydrogen preheating system to it reaches its set temperature of 30°C.

2.1.2 Method

1. Note down ambient temperature and liquid temperature in heater
2. Connect power to hydrogen preheating system and start clock
3. Stop clock when temperature reaches 30°C
4. Note down the time

2.2 Sustain set point temperature at high hydrogen consumption

2.2.1 Test description

Set the system to full power to ensure that the hydrogen preheating system has the capacity to stay at its set point temperature.

Optional: If the ambient temperature at the testing day is assessed too hot compared to the real working scenario, the hydrogen heater temperature can be raised to some extent.

2.2.2 Method

1. Heat up the hydrogen heater to the set temperature
2. Start the container up at full power (1000 kW) and monitor the hydrogen heater temperature

3. Let the system run for 30 minutes and see that the liquid temperature in the heater does not go below the set point temperature more than ±4°C

2.3 Power Consumption

2.3.1 Test description

The test is made to monitor the power consumption from the hydrogen preheating system.

2.3.2 Method

1. Install equipment in the electrical cabinet to measure the power consumption
2. Start up the H2 heater and monitor the power consumption while heating. Note down the average power consumption over 30 seconds.

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Sub Section J08-002

Confirmation of Satisfactory FAT

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	04/09/2024	First Issue

Document Title:	**BLPH Project - Confirmation of Satisfactory FAT**
Document Number:	K559-2254-CWIWP4202202-J08-002
Revision:	Rev001
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-J08-002Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J08
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Ballard Power Systems Europe A/S
Majsmarken 1
DK-9500 Hobro
K559-2254-CWIWP4202202-J08-002

Confirmation of Satisfactory FAT

Part No.	601456B-7002362 Incl. sub-assemblies: 601456B-7002973 601456B-7003716
Product name	FC PowerGen 1000kW
Serial No.	601456B

Ballard Power Systems Europe A/S confirms that the above-listed equipment has satisfactorily with comments undergone and passed the Factory Acceptance Test (FAT) according to

BLPH Project – Acceptance Test Procedure (FAT) [K559-2254-CWIWP4202202-J08-001]

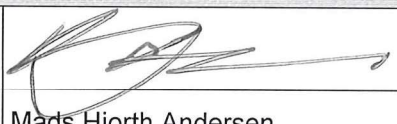
BLPH Project - Test Matrix for FAT and SAT [K559-2254-CWIWP4202202-J99-002]

601456B Crosswind BLPH FAT punch list [K559-2254-CWIWP4202202-J08-003]

prior to the shipment.

CrossWind C.V. acknowledges that the Factory Acceptance Test (FAT) for the above-listed equipment was witnessed and confirms that the test was performed satisfactorily with comments, and all agreed-upon specifications have been met.

Signatures

Ballard Power Systems Europe A/S			
Signature:			
Name:	Mads Hjorth Andersen		
Title:	Project Manager	Date:	04-09-2024
CrossWind C.V.			
Signature:			
Name:	Martin Taylor		
Title:	Crosswind Commissioning Manager	Date:	04-09-2024
Inspector			
Signature:			
Name:	Luigi Pignatelli		
Title:	Inspector for Crosswind	Date:	04-09-2024

Note: This document serves as formal confirmation that the FAT has been successfully completed and witnessed, with both parties in agreement on the satisfactory results. It should be signed by authorized representatives of both parties.

Sub Section J08-003

FAT punch list

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
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Revision history		
Rev.	**Date.**	**Description**
001	15/08/2024	First Issue (FAT 1st run)
002	04/09/2024	Updated (FAT 2nd run)
003	17/09/2024	Updated based on progress (Handover)

Document Title:	**BLPH Project - FAT Punch List**
Document Number:	K559-2254-CWIWP4202202-J08-003
Revision:	Rev003
Sequence Number:	003
File Name:	K559-2254-CWIWP4202202-J08-003Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J08
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

FAT punch list

Document no:	K559-2254-CWIWP4202202-J08-003
FAT performed da	13-15/08 + 03-04/9 2024
List updated:	17-09-2024
Part No.	601456B-7002362
	Incl. sub-assemblies:
	601456B-7002973
	601456B-7003716
Product name	FC PowerGen 1000kW
Serial No.	601456B

Severity:
A - Critical - safety
B - Functional
C - Minor

Item #	Severity	Deadline	Topic	Description	Solution	Status	Responsible	Checked by	Date
1	A	Prior to FAT2	Cooling skid access door	Lock missing	To be added	Closed	ASM	MHA	22-08-2024
2	B	Prior to FAT2	Emergency exit (end of door) poor fitment	Door may blow open	Door must be adjusted	Closed	ASM	MFO	15-08-2024
3	B	Prior to shipment	Spacers for cooling skid	Temperary spacers mounted during FAT	Correct spacers ordered by Ballard. Will be shipped with package. 04-09-2024: Spacers inspected by customer during FAT	Closed	ASM		23-08-2024
4	C	NA	Drain connection	During FAT the drain connection is a hose connection	To be changed to flanged connection. Ordered by Ballard. Will be shipped with package 28-08-2024 Adapter piece missing (to provide correct nozzle position) - to be ordered.	Closed	ASM	MHA	03-09-2024
5	C	NA	Access to cooling skid	No permanent access to the cooling skid pump area	Since no preventive maintenance is needed on the cooling skid, no permanent accessway is made.	Closed	MHA	NA	15-08-2024
6	C	Prior to SAT	Cable tray riser for Cooling skid	On 40ft-10ft cable tray the cable tray riser for the cooling skid is not shown on the GA	GA must be updated. 26-08-2024: GA Updated - to be approved by CW.	Closed	ASM	MHA	26-08-2024
7	C	NA	UC06 door lock broken		Fix it!	Closed	BPH	MHA	15-08-2024
11	A	Prior to FAT2	UC50 Neutral conductor not fastned to cabinet		Fix it!	Closed	JKM	PBL	21-08-2024
12	B	Prior to shipment	10ft earthing	Missing earthing bonding in 10ft container	All cable ladders to be bonded with ground wiring	Closed	JKM	PBL	12-09-2024
13	C	Prior to FAT2	Cable gland with no cable on vent cabinet	Gland should have been a blind	Blind off empty cable gland.	Closed	JKM	PBL	23-08-2024
14	C	Prior to FAT2	10 ft cabling	Cables needs better anchoring to cable ways	To be corrected	Closed	JKM	PBL	20-08-2024
19	C	Prior to shipment	Crane trolly not secured	Must be fixed prior to shipment and during operation	Solutions to be designed 04-09-2024: To be fitted 05-09-2024	Closed	PBH	MHA	06-09-2024
20	C	Prior to shipment	DCDC internal cooling pipes	Concern that piping bend radius is out of spec for pipe used.	Verify with supplier 21-08-2024: Statement from supplier receved, confirming correct tools used for pipework.	Closed	ASM	MHA	21-08-2024
24	B	Prior to shipment	Weight measurement documentation	Documentation missing	Provide necessary documentation 17-09-2024: Added in FAT documentation	Closed	MHA	MHA	17-09-2024
25	A	Prior to FAT2	Check C joint in Fcwave	Since two Fcwave modules had failures, the remaining modules might suffer same error	Check proper sealing on C joint in Fcwave #1, #2, #3 and #4	Closed	MNJ	TAN	21-08-2024
26	A	Prior to shipment	Emergency lighting	Not turned on	Emergency lighting philosophy to be clarified including identification of emergency exits.	Closed	KJM	PBL	30-08-2024

28	A	Prior to FAT2	H2 shutoff valve assembly leaking	Leaks above quality acceptance level (FAT procedure) detected.	Leaks to be corrected to pass FAT criteria	Closed	PBH	TAN	26-08-2024
32	C	Prior to SAT	10ft/40ft LT connection hoses	During FAT the container are placed 15mm closer than specified. Concern that the hoses might be too short.	Bring extra hose to yard 21-08-2024: Extra hoses will be brought to the yard	Closed	PBH	MHA	21-08-2024
33	A	Prior to FAT2	H2 heater junction box	ATEX tag/label missing	Add necessary label 29-08-2024: Junction box moved out of ATEX zone and ID label added (No ATEX label needed).	Closed	JKM	PBL	29-08-2024
34	A	Prior to FAT2	ATEX/leak test procedure	Current FAT test procedure not sufficiently unambiguous.	FAT test leak test procedure must specify to greater extend the measuring principle, method, and standard reference.	Closed	RBS/TAN	MHA	30-08-2024
38	C	Prior to shipment	Cooling skid valve restriction	Due to a cableway, the breather/header tank isolation valve is restricted from fully closing.	To be corrected	Closed	PBH	MHA	03-09-2024
40	C	Prior to shipment	Fcwave Cabinet markings	Missing on cabinets	Add markings	Closed	MKD	PBL	04-09-2024
42	C	Prior to shipment	Cable markings missing	-DCDC cables in 10ft missing tags -UC50 400V cable missing tag -Cables from DC bus to DC/AC missing tags -	Add markings	Closed	MKD	PBL	12-09-2024
43	C	Prior to shipment	Time to shutdown is expected at max 30 sec (FAT procedure O01 item 6.1.4)	Proces takes at least 1:05 minutes	Ballard to investigate if the acceptance criteria is wrong or if the design must be investigated 17-09-2024: Specification in FAT document faulty. Corrected in documentation.	Closed	MFO	MHA	17-09-2024
44	C	Prior to shipment	FAT procedure unclear (O13/O14)	FAT procedure states 3 Fcwaves to be running from 50% to 0% O10 states 3 running 2 standby - to be corrected	Ballard to investigate if the acceptance criteria is wrong or if the design must be investigated 17-09-2024: Specification in FAT document faulty. Corrected in documentation.	Closed	MFO	MHA	17-09-2024
8	C	Prior to SAT	Backup battery control board not shielded		Ballard to investigate if shielding is required	Open	MOS		
9	C	Prior to SAT	External cabinets not shielded from rain during servici	Rain may enter cabinets if opened during bad weather	Ballard to instruct how to safely carry out maintenance in the external cabinets	Open	CJA		
10	A	Prior to SAT	10ft Container Safety Door Sensors	There is an intermittet issue with the 10ft door safety sensors (periodic dropout). The sensors have been disabled in software. The doors are kept padlocked to ensure no danger to people	To be replaced with new sensors 29-08-2024: New sensors fitted and tested, but with temporary plastic brackets. Steel brackets to be fitted prior to energization in the yard.	Open	JKM		
15	C	Prior to SAT	10ft inspection hatch control panel	No door mounted to the cabinet	Internal (cabinet door to be added)	Open	JKM		
16	C	Prior to SAT	Customer/external E-stop	HMI message does not specify that the external e-stop is activated	Must present a relevant alarm 04-09-2024: Will be corrected with next sw release	Open	LNY		
17	C	Prior to SAT	H2 sensor reading in HMI	Current reading in pct vol	To be changed to pct LEL 04-09-2024: Will be corrected with next sw release	Open	LNY		
18	C	Prior to SAT	FCwave #3 - Coolant leak	At FC module #3, there is coolant leakage (drops) at the connections to the heat exchanger, both connections.	To be tightened and/or gaskets replaced. 04-09-2024: Gasket will be changed when LT coolant is drained prior to shipment 17-09-2024: To be corrected during installation	Open	MNJ		

21	C	Prior to SAT	P&ID tags missing	Tags for valves, sensors and actuators missing on cooling circuits	Valves or other removable/serviceable items should be attached with zip ties while internal non service items can be with stickers. External/outside tags are preferred to be stainless/etched. Existing tag system is appropriate for the environment so the zip tie version will be used 04-09-2024: CW to investigate requirement for SS tags externally. Ballard to investigate plastic tag durability for offshore environment.	Open	PBL
22	C	Prior to SAT	Error messages	Error messages not elaborate enough	Review error message readability (must be more explanatory) 04-09-2024: Will be corrected with next sw release	Open	LNY
23	C	Prior to SAT	Main control cabinet (UC20)	Cable duct is too loaded (full).	Correct/reorganize the cables to allow sufficient space. 30-08-2024: Cables rearranged to the extend possible. 12-09-2024: Additional cable ladder will be added prior to SAT	Open	PBL
27	C	Prior to SAT	H2 and smoke detector voting	Currently 1/3	Preferred by Crosswind to be 2/3 to increase fault tolerance to align with platform philosophy. To be risk assessed Ballard	Open	MOS
29	B	Prior to SAT	Coolant leak on cooling skid (HT)	HT2 mixing valve valve seal or flange seal coolant leak	To be investigated and sealed 04-09-2024: Will be corrected when HT coolant is drained.	Open	PBH
30	B	Prior to SAT	HT Cooling hoses too short (leaking)	Between mix manifold and cooler manifold hoses too short.	Short term: Reposition hose clamps. Long term: Replace hoses with correct length.	Open	PBH
31	C	Prior to SAT	Type signs/name plate missing	Temporary name plates placed. To be approved and permanent SS signs will be attached prior to SAT.	To be approved (contents and placements). Will be permanently mounted with rivets and made in laser etched SS. 04-09-2024: To be reviewed and approved by CW. 17-09-2024: Name plates in metal ordered. Will be mounted prior to SAT	Open	MHA
35	B	Prior to SAT	Ventilation output vent louvers	Concern about the ventilation output louvers not sufficiently shielding against offshore storms/rain showers.	To be investigated further by Ballard	Open	
36	B	Prior to SAT	HMI operator screen	Operator screen built for HMI use not ready (Engineering interface not designed for HMI but for laptop use).	Must be developed by Ballard 28-08-2024: Draft HMI ready for review @FAT2	Open	LNY
37	C	Prior to SAT	Paintwork	Damage to paintwork	All chips or missing paint must be touched up	Open	PBH
39	NA	Prior to SAT	Main DCAC	Main DCAC is not fully power factor corrected when running. We are consuming 30-40kVAr during operation.	DC/AC parameters to be tuned during pre-commissioning. Currenly 0,98. Spec is better than 0,95.	Open	MFO

41	B	Prior to SAT	Intermittend timeout of FCwave shutdown test	During shutdown of the FCwave, an intermittant timeout occours (ca 5% of shutdowns) where the test stalls.	Expected to be a software glitch to be corredcted by FCwave dev team.	Open	MFO
45							
46							

Sub Section J09-001

Leak Testing Procedure

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	01/02/2024	First Issue
002	04/11/2025	Updated to match document revision

Document Title:	**Leak** Testing Procedure
Document Number:	K559-2254-CWIWP4202202-J09-001
Revision:	Rev002
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-J09-001-Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J09-001
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Cooling Circuit Pressure and Leak Test Procedure
Full Title	Cooling Circuit Pressure and Leak Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating cooling circuits are leak free and can withstand normal operating pressure.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-02-2024
2	Updated specification	RKN	15-11-2024

Checked by: RKN	Date: 15/11-2024
Approved by: RKN	Date: 15/112024

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and background

The objective with this test procedure is to generalise how cooling circuits are leak free and pressure tested.

2.0 References

Document	Titel

3.0 Equipment list

Equipment	Purpose
Pressure gauge	Monitor pressure

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4.0 Test Procedure

The main purpose of this test procedure is to ensure that the cooling circuit is leak free and can handle maximum system pressure. Furthermore, it is structured in a way to minimize the chance of having big leaks or lose clamps or fittings.

WARNING: The stress test is with elevated pressure, potentially turning plugs or loose fittings into projectiles.

Minimum safety precautions:

- Hose clamps and fittings
- Wear safety goggles
- When dealing with glycol wear gloves
- Check service manual for maximum system pressure.

4.1 Pre-conditioning

- Check and make sure valves in the cooling circuit are in the correct position.
- For pressure testing with coolant in the cooling circuit, make sure the system is fully bleed. Air in the system can act as a spring and can obscure results.
- To achieve stable temperature let system soak for 12 hours. Alternative watch data from temperature sensors in the full system to ensure stable temperature conditions.

4.2 Leak test with air

- Maximum system pressure on Megablock is 1.5barg.
- No temperature pre-conditioning needed; this is not a sign off test.
- Find compressor and leak test kit.
- Adjust pressure reduction valve to minimum (no pressure after reduction valve)
- Attach leak test kit to cooling circuit (not applying pressure to circuit)
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 20% of maximum system pressure (0.3barg)
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 80% of maximum system pressure (1.2barg)
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 100% of maximum system pressure (1.5barg)
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained – test completed and passed.

4.3 Leak test with air setup

Compressor and adaptor hose to be connected. Close valve to expansion tank so that pressure can build in cooling circuit. Find test setup image in appendix.

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4.4 Pressure decay test with coolant

- Maximum system pressure on Megablock is 1.5 barg.
- Make sure cooling circuit have been filled and bled before starting this test.
- Make sure pre-conditioning have been done.
- Find coolant pressure test kit.
- Attach test kit to cooling circuit (not applying pressure to circuit)
- Slowly increase pressure 50% of maximum system pressure (0.75barg)
- Close valve from test kit.
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from test kit
- Slowly increase pressure to 100% of maximum system pressure (1.5barg)
- Close valve from test kit
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Wait 30 minutes if pressure have dropped re-apply pressure to reach 100% system pressure again.
- Wait 2 hours and check pressure again.
    - If pressure have dropped more than 0.1bar
        - Repeat test
    - If pressure have dropped less than 0.1bar after 2 hours – test completed and passed.

4.5 Pressure decay test with coolant setup

Pressure pump and adaptor hose to be connected. Close valve to expansion tank so that pressure can build in cooling circuit. Find test setup image in appendix.

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5.0 Results and discussion

6.0 Appendix

6.1 Cooling leakage HT1 (Suggested section for FAT or SAT document)

6.1.1 Test

Follow designated test procedure for inspection and verification of a leak-free HT1 coolant circuit.

6.1.2 Relevant Standard / document

- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

6.1.3 Brief Test Plan

- Follow test procedure.

6.1.4 Pass/Fail criteria.

- Allow system to maintain pressure, after 2 hours pressure must not drop more than 0,1 bar.

6.1.5 Test Result

Table 1: Cooling leakage HT1 - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	HT 1			

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6.2 Pressure decay test with coolant

Pressure pump and adaptor hose to connect and pressurise.



6.3 Leak test with air

Compressor and pressure test adaptor hose.



Sub Section J99-001

Site Acceptance Test (SAT) Procedure

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	28/06/2024	First Issue with General Updates from Initial Draft
002	18/10/2024	Updated following FAT completion
003	19/11/2024	Updates based on the review with Crosswind
004	21/03/2025	Updates based on the review with Crosswind
005	08/08/2025	Updates based on the review with Crosswind

Document Title:	**BLPH Project - Site Acceptance Test (SAT) Procedure**
Document Number:	K559-2254-CWIWP4202202-J99-001
Revision:	Rev005
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-J99-001Rev005
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Megablock Site Acceptance Test
Full Title	Megablock Site Acceptance Test
Abstract	*Site acceptance test for verification of full Megablock system*

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Revision Record

Rev #	Description	Revised By	Date (dd-mm-yyyy)
-	Initial Release	RKN	28-05-2024
1	General updates	RKN	28-06-2024
1.1	General updates	TAN	18-09-2024
2	Update prior to release to CW	PBL	16-10-2024
3	Updates based on review with CW	RKN	19-11-2024
4	Updates based on review with CW	RKN	09-01-2025
5	Updates based on review with CW	RKN	08-08-2025

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1.0 Executive Summary

This document outlines the recommended commissioning activities and site acceptance tests. These tests aim to verify correct installation, and that the system performance onsite matches the performance level shown during FAT. There should be no CAT A items outstanding prior to power up.

2.0 References

- Confirmation of Satisfactory SAT - Signature Page
- PWR008 Ballard commissioning document
- EN 60204 Electrical safety test 10ft
- EN 60204 Electrical safety test 40ft
- EN 60204 Electrical safety test Cng Pltfrm
- F07 & F08, Electrical safety SAT
- F10 Safety checklist
- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure
- SPC ID 0104 H2 Leak Test Procedure
- SPC ID 0106 Noise Level Measurement Test Procedure
- SPC ID 0204 System pressure decay test template
- SPC ID 0102 Thermographic - Cooling and Ventilation Test Procedure
- SPC ID 0105 Thermographic - Electrical Test Procedure
- SPC ID 0107 Power Quality Measurement Test Procedure

3.0 Definitions and Acronyms

FC	FCwave™
H2	Hydrogen
FAT	Factory Acceptance Test
SAT	Site Acceptance Test
HT1	High temperature 1050kW cooling system 1
HT2	High temperature 1050kW cooling system 2
LT	Low temperature cooling system

4.0 Objectives and Background

The tests in the document are based on the test matrix in document J99-02 (Aconex K559-2254-CWIWP4202202-J99-002-Rev002)

This document describes the witnessed Site Acceptance Tests. The tests do not include the internal testing that has been done to secure product maturity, mechanical and electrical connections have been done correctly.

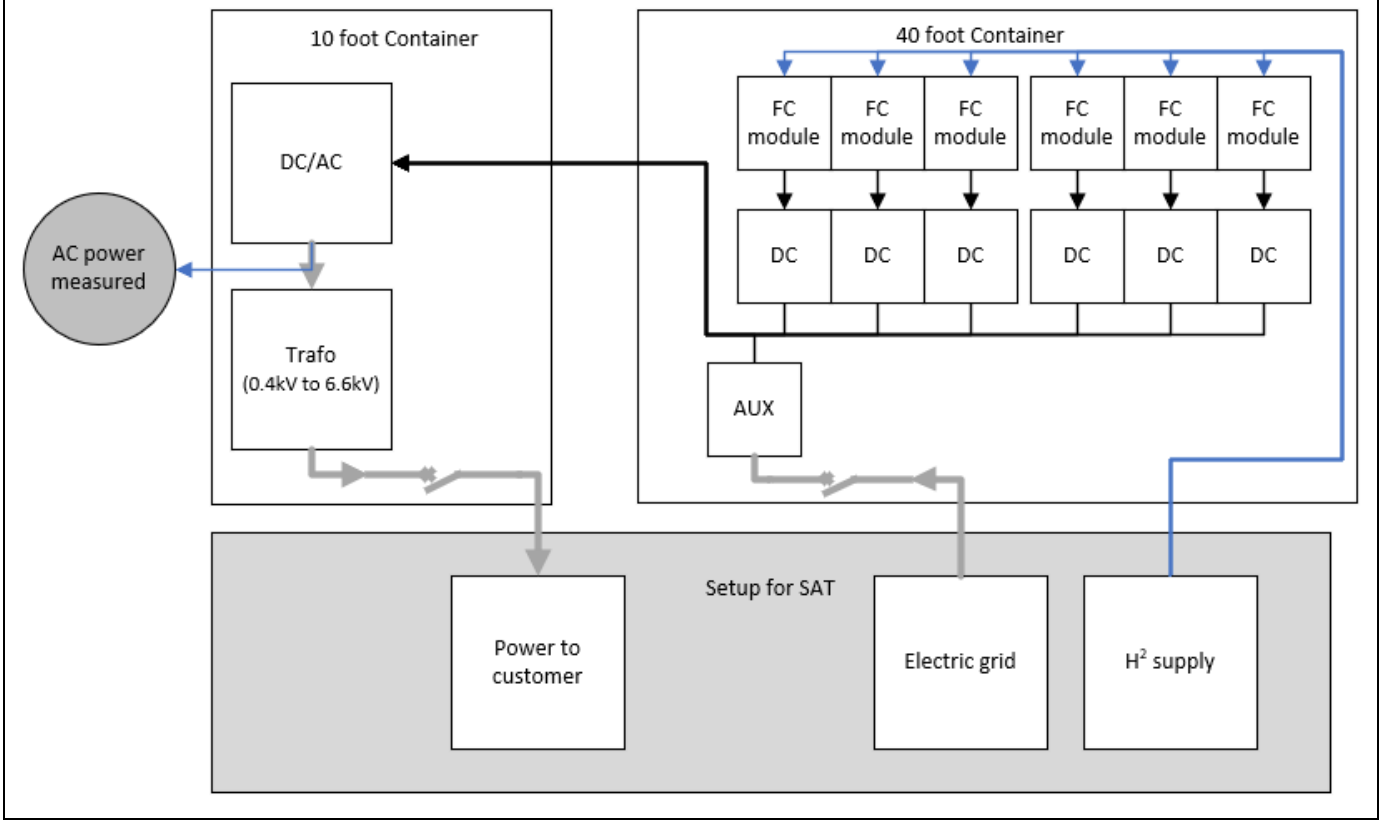
The SAT is not intended to replace an integration test. If third-party features are not yet ready for testing, those specific test cases will be temporarily excluded from the SAT and should be performed during integration testing. This will not affect the overall SAT signoff.

There should be no CAT A items outstanding prior to power up.

The scope of testing is:

- Visual Inspection of the delivered product (Tri-party walkaround)
- Verification of safety systems for the Megablock.
- Production of electrical power to the customer grid to verify performance.

Figure 1: Megablock System test overview



5.0 Note on Power Quality Measurements

The power quality measurements are indicative during SAT, as the measured power quality depends also on the customer load dissipating the produced power. Ballard is also not capable of measuring power quality on the 6.6kV bus, and any measurements are done on the 400V side of the output transformer. This results in lower measurements than on the medium voltage side of the output transformer, as the transformer inductance is an integral part of the harmonic dampening of the FC package.

Power quality measurements have been removed from pass/fail criteria.

6.0 Note on Electrical Load

The electrical load that is to dissipate the power generated by the FC package is not in Ballard scope. During step response tests and full load tests, it is required that it is present and able to absorb the power from the FC package.

7.0 Functional tests

7.1 F02 Visual inspection

7.1.1 Test

The test involves an examination of the paint job through visual inspection, assessing the overall build quality, and checking for any dents. The focus is also on evaluating the assembly quality to ensure compliance with weather resistance.

This test is superseded by the tri party walkaround.

7.1.2 Relevant Standard / document

- No reference

7.1.3 Brief Test Plan

- Visual inspection with customer of full system, meaning inside and outside container solution.
- Take comprehensive pictures of the full system and test setup, including close-ups of vital components, with timestamps for reference.

7.1.4 Pass/Fail criteria.

- Visual inspect with customer to review quality of full system.

7.1.5 Test Result

Table 1: Visual inspection – Test Result

Date tested	Item	Result	Pass/Fail	Notes

7.2 F07 Electrical safety test – 10-foot container

7.2.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

7.2.2 Relevant Standard / document

- EN 60204 Electrical safety test 10ft
- F07 & F08, Electrical safety SAT

7.2.3 Brief Test Plan

- According to EN 60204-1

7.2.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

7.2.5 Test Result

Table 2: Electrical safety test - Test results

Date tested	Item	Result	Pass/Fail	Notes

Table 3: Electrical safety test - calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for

7.3 F08 Electrical safety test – 40-foot container

7.3.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

7.3.2 Relevant Standard / document

- EN 60204 Electrical safety test 40ft
- EN 60204 Electrical safety test Cng Pltfrm
- F07 & F08, Electrical safety SAT

7.3.3 Brief Test Plan

- According to EN 60204-1

7.3.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

7.3.5 Test Result

Table 4: Electrical safety test - Test Result

Date tested	Item	Result	Pass/Fail	Notes

Table 5: Electrical safety test - Calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for

7.4 F10 Safety

7.4.1 Test

Conduct tests of safety inputs and outputs, including emergency stop buttons, smoke detectors, gas detectors and external connections.

7.4.2 Relevant Standard / document

- F10 Safety checklist

7.4.3 Brief Test Plan

- Trigger each safety input according to checklist.
  - Emergency pushbuttons
  - Smoke detectors test
  - H2 sensor test
  - External safety switches
  - External feedback

7.4.4 Pass/Fail criteria.

- Verified according to checklist.
- Each item triggers the correct alarm

7.4.5 Test Result

Table 6: Safety - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	Emergency pushbuttons			
	Smoke detectors			
	H2 sensors			
	External safety switches			
	External feedback			

Table 7: Safety – Calibration/Equipment

Unit	Equipment number	Calibration due date	Equipment used for

7.5 F18 H_2 Leakage test

7.5.1 Test procedure

All pipework and H2 instrumentation subassemblies must be inspected, recorded, verified and pass in accordance with the procedure in section 5.4 in *SPC ID 0104 H2 Leak Test Procedure Rev 002* prior to full system SAT.

System H2 leakage test is done system pressure decay test, according to section 5.5 in *SPC ID 0104 H2 Leak Test Procedure Rev 002*.

7.5.2 Pass/Fail criteria.

Pressure decay test with a maximum leakage no greater than specified in test procedure.

Result details are documented in the template *SPC ID 0204 System pressure decay test template*

Parameter	Value	Description
L_A [Nm^3/h]	**2,72 – 3,58 x10^{-3}**	**Maximum allowed pressure decay to pass pressure decay test, where L_A = L_S + L_Mu**
L_S [Nm^3/h]	0	Summarized expected leak rates of all components in the system (per design leak rate).
L_Mu [Nm^3/h]	2,72 – 3,58 x10^{-3}	Calculated accuracy of the measuring system, used to perform the test.
L_C [Nm^3/h]	2,7x10^{-5}	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

7.5.3 Test Result

Table 8: H2 leakage - Test Result

Date tested	Item	Leakage rate L_1 [Nm^3/h]	Pass/Fail	Notes
	H2 line 1			
	H2 line 2			
	H2 line 3			
	H2 line 4			
	H2 line 5			
	H2 line 6			

8.0 Operational tests

Operations are done using operator HMI or remote HMI in normal operating mode.

8.1 O01 System Start/Stop - Normal low load operation.

8.1.1 Test

Fuel Cell system can start, deliver minimum power and perform controlled stop without faults. This test is based on DC power.

8.1.2 Relevant Standard / document

- No reference

8.1.3 Brief Test Plan

- All FC in standby
- Request 100kW DC
- Delay 120 seconds
- Request zero power
- Repeat with new preferred FC until all tested.

8.1.4 Pass/Fail criteria.

- Fuel Cell Package starts without faults.
- No persistent system alarms.
- Correct available power signal.
- DC Power output within +/-5% and stable in less than 60 seconds
- Fuel Cell Package stops without faults.
- Fuel Cell in stand-by in less than 120 seconds.

8.1.5 Test Result

Table 9: System Start/Stop – Normal low load operation - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	FCwave 1			
	FCwave 2			
	FCwave 3			
	FCwave 4			
	FCwave 5			
	FCwave 6			

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8.2 O09 Load Test – step response 0 to 35%

8.2.1 Test

Test step response by adding 35% load in one step from no load while measuring AC power quality.

8.2.2 Relevant Standard / document

- N/A

8.2.3 Brief Test Plan

- All FC in stand-by.
- Apply set point by requesting 350kW AC

8.2.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.2.5 Test Result

Table 10: Load Test - step response 0 to 35% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	Step response 0-35%			
	AC power quality		Indicative	

8.3 O10 Load Test – step response 35% to 70%

8.3.1 Test

Test step response by adding 35% load in one step to reach 70% load while measuring AC power quality.

8.3.2 Relevant Standard / document

- N/A

8.3.3 Brief Test Plan

- 3 FC running delivering 350kW AC steady state.
- 3 FC in stand-by
- Apply set point by requesting 700kW AC power.

8.3.4 Pass/Fail criteria.

- No persistent system alarms.

8.3.5 Test Result

Table 11: Load Test - step response 35% to 70% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	Step response 35%-70%			
	AC power quality		Indicative	

8.4 O11 Load Test – step response 65% to 100%

8.4.1 Test

Test step response by adding 35% load in one step to reach full load while measuring AC power quality.

8.4.2 Relevant Standard / document

- N/A

8.4.3 Brief Test Plan

- 6 FC running delivering 650kW AC steady state.
- Apply set point by requesting 1000kW AC power.

8.4.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.4.5 Test Result

Table 12: Load Test - step response 65% to 100% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	Step response 65%-100%			
	AC power quality		Indicative	

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8.5 O12 Load Test – 100% stability test - 3 hours.

8.5.1 Test

Test steady state at 100% load for 3 hours while measuring power quality.

This test is also dependent on the hydrogen supply for the system.

8.5.2 Relevant Standard / document

- N/A

8.5.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.

8.5.4 Pass/Fail criteria

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.5.5 Test Result

Table 13: Load Test – Steady state 100% load - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	Full load test			
	AC power quality		Indicative	

8.6 O13 Load Test – step response 100% to 50%

8.6.1 Test

Test step response by removing 50% load in one step at full load while measuring power quality.

8.6.2 Relevant Standard / document

- N/A

8.6.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.
- Request 500kW AC.

8.6.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.6.5 Test Result

Table 14: Load Test - step response 100% to 50% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	Step response 100%-50%			
	AC power quality		Indicative	

8.7 O14 Load Test – step response 50% to 0%

8.7.1 Test

Test step response by removing 50% load in one step to no load while measuring AC power quality.

8.7.2 Relevant Standard / document

- N/A

8.7.3 Brief Test Plan

- 3-6 FC running delivering 500kW AC.
- Request 0% and apply set point.

8.7.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.7.5 Test Result

Table 15: Load Test - step response 50% to 0% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	Step response 50%-0%			
	AC power quality	n/a	n/a	Unit not producing power

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Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Grounding continuity
EN 60204-1:2018 - Section 18.2.2 - Test 1
Test performed with a test current of 10A

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	Busbar to busbar	0,024	Ohm	
	Module 1	0,018	Ohm	
	DC/DC cabinet 1	0,023	Ohm	
	Module 2	0,024	Ohm	
	DC/DC cabinet 2	0,019	Ohm	
	Module 3	0,026	Ohm	
	DC/DC cabinet 3	0,016	Ohm	
	Module 4	0,026	Ohm	
	DC/DC cabinet 4	0,016	Ohm	
	Module 5	0,024	Ohm	
	DC/DC cabinet 5	0,017	Ohm	
	Module 6	0,029	Ohm	
	DC/DC cabinet 6	0,015	Ohm	
	Control cabinet	0,021	Ohm	
	Control cabinet right door	0,032	Ohm	
	Lifting crane track, dolly	0,028	Ohm	
	LT piping	0,031	Ohm	
	Isolation transformer cover	0,039	Ohm	
	Cable tray	0,019	Ohm	

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	Busbar to busbar	0,019	Ohm	
	Main DC/Acpoint 1	0,032	Ohm	
	Main DC/Acpoint 2	0,024	Ohm	
	Main DC/Acpoint 3	0,027	Ohm	
	DC/AC conduncter point 1	0,037	Ohm	
	DC/AC conduncter point 2	0,022	Ohm	
	DC/AC conduncter point 3	0,023	Ohm	
	LT coolant pipe	0,024	Ohm	
	Cable tray	0,02	Ohm	
	Main transforer grounding bolt	0,023	Ohm	
	Main transformer chassis	0,02	Ohm	
	Cable tray	0,022	Ohm	

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Isolation resistance
EN 60204-1:2018 - Section 18.3
Test performed with a test voltage of 1000V

Main location	Location	Measurement FAT	Unit	Measurement SAT
40 ft container	L1-PE	> 999.9	MOhm	
	Cooling skid L1	10,01	Mohm	
	Colling skid L2	6,252	Mohm	
	Cooling skid L3	12,81	Mohm	
	AUX supply L1	251	Mohm	
	AUX supply L2	337	MOhm	
	AUX supply L3	237	Mohm	

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	L1+L2+L3-PE on AC circuit	592	Mohm	

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Isolation resistance

EN 60204-1:2018 - Section 18.4

Test performed with a test voltage of 2500VAC

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	PE and L1	0	mA	
	PE and L2	0	mA	
	PE and L3	0	mA	

Main location	Location	Measurement FAT	Unit	Measurement SAT
10 FT container	PE and L1	7,1	mA	
	PE and L2	7,1	mA	
	PE and L3	7	mA	

Title	F10 Safety checklist
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Checklist for safety inputs

Main location	Location	Checked
40ft container	Emergency pushbuttons	
	40ft side door	
	UC50	
	UC30	
	Smoke detector	
	Left	
	Middle	
	Right	
	H2 sensor	
	Left	
	Middle	
	Right	
	External safety swithces	
	External feedback	

Megablock		40ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

1. Introduction

The Megablock system contains many components utilizing potentially dangerous voltages and currents. It is a safety requirement that the electrical safety is tested before a product is shipped.

The testing is done according to the standard EN60204-1 Chapter 18, from which the tests in this document are described with room to note test results.

2. Revision Record

Rev #	Author	Description	Revised By	Date
1.0	PBL	Initial Release		09/11-2023
2.0	PBL	Adapted from 40ft Coolant Skid document		04/07-2024
3.0	CJA	Adapted from 10ft power converter container document		15/10-2024
4.0	RKN	General review		09/01-2025

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Figure 5 – EN60204-1:2018, Chapter 18.3 9
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Table 6 – Summary Table 13

5. Purpose and structure of this document

As Megablock is a large system, containing several parts assembled individually and brought together to fulfill the customer requirements, the components are tested individually.

With each component tested before final assembly, the interconnect must be tested, both before initial operation and after any disassembly, e.g. after shipping.

The purpose of this document is to compare the requirements outlined in EN60204-1 Chapter 18 against following testing performed Megablock components.

This is required for the CE approval of the Megablock Fuel Cell Power Plant.

This document is structured as follows:

1. The requirements from EN60204-1 are outlined:
    a. Section 7
2. Test Specifications to comply with the requirement outlined above.
    a. Sections 10 to 16
3. Summary table
    a. Section 17

6. References

Document	Title	Author
DS/EN 60204-1:2018	Safety of machinery – Electrical equipment of machines – Part 1: General Requirements	CENELEC

Table 1 – References

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7. Requirements from EN60204-1 Ch 18

Figure 1 is reproduced from the EN60204-1 Ch18.1:

18.1 General

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g):

a) verification that the electrical equipment complies with its technical documentation;
b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to 18.2;
d) insulation resistance test (see 18.3);
e) voltage test (see 18.4);
f) protection against residual voltage (see 18.5);
g) verification that the relevant requirements of 8.2.6 are met;
h) functional tests (see 18.6).

Figure 1 – Excerpt from EN60204-1:2018, Chapter 18.1

The mapping between the headlines from the standard and the requirement ID used in this document is listed in Table 2.

Requirement headline	EN60204-1 Chapter 18.1	EN60204-1 Chapter	Requirement ID
Verification that the electrical equipment complies with its technical documentation	A	n/a	A1
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	B	18.2.2 – Test #1	A2
Verification of conditions for protection by automatic disconnection of supply	C	18.2	A3
Insulation resistance tests	D	18.3	A4
Voltage tests	E	18.4	A5
Protection against residual voltages	F	18.5	A6
Verification that the relevant requirements of 8.2.6 are met	G	8.2.6	A7

Table 2 – Requirement headlines, chapter, and ID mapping

Functional testing of the equipment is outside the scope of this document.

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Megablock		40ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

8. Test Equipment.

The test equipment is a CE MultiTester, manufactured by Metrel.

Test Equipment	Ballard Equipment ID	Calibration valid until:

9. Device Under Test

The device to be tested is the 40ft Fuel Cell Container for the Megablock project.

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Megablock		40ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

10. A1 – Verification that the electrical equipment complies with its technical documentation

EN60204-1 requirements:

a) verification that the electrical equipment complies with its technical documentation;

Figure 2 – EN60204-1:2018, Chapter 18.1

Megablock Component requirements:

Inspection of the electrical equipment and cabinets to ensure congruence between documentation and equipment/cabinet.

Megablock Component validation:

Component	40ft Container
Result (pass/fail)	
Date and Initials	

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11. A2 – Verification of continuity of the protective bonding circuit

EN60204-1 requirements:

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

Figure 3 – EN60204-1:2018, Chapter 18.2.2

Megablock Component requirements:

The EN60204-1 Chapter 18.2.2, Test #1 specifies a current of 10A.

Megablock Component bonding resistance test is performed with a current of 10A and a test period of 10 seconds.

Megablock Component validation:

The primary earthing point for the 40ft Fuel Cell Container is the main ground bar located in +UC50.

Each component is verified and compared to expected values for the following locations.

ID	Test Point	Expected Value	Recorded Value
1	Busbar to busbar	<100mΩ	
2	Module 1		
3	DC/DC cabinet 1		
4	Module 2		
5	DC/DC cabinet 2		
6	Module 3		
7	DC/DC cabinet 3		
8	Module 4		
9	DC/DC cabinet 4		
10	Module 5		
11	DC/DC cabinet 5		

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12	Module 6		
13	DC/DC cabinet 6		
14	Control cabinet		
15	Control cabinet right door		
16	Lifting crane track, dolly		
17	LT piping		
18	Isolation transformer cover		
19	Cable tray		

Table 3 – Bonding Resistance Test point and expected resistance values.

When performing the test, ensure the connection between the test leads and the equipment is not contributing to inaccurate measurements.

12. A3 - Verification of conditions for protection by automatic disconnection of supply

EN60204-1 requirements:

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Figure 4 – EN60204-1:2018, Chapter 18.2

Megablock Component requirements:

As specified in chapter 18.2.1, Test #1 is performed (see section 11).

Chapter 18.2.1 further specifies testing of Residual Current Devices (RCD) according to manufacturer specifications.

Megablock RCD Testing:

All RCD (Residual Current Device) in the Megablock system is equipped with self-test functionality from the manufacturer. This takes the shape of a push button, which must cause the RCD device to trip when actuated.

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Test Specification	RKN	09-01-2025	4.0.0

For the test, first enable all RCD circuits, and then actuate the self-test button on the devices. The devices must trip within 1 second. After the trip, use a multimeter to verify that the output of the device has no voltage (<10VAC)

Component	RCD Devices in UC20 (40ft Control Cabinet)
Result – 3ph RCD	
Result – 1ph RCD/MCCB	
Date and Initials	

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13. A4 - Insulation resistance tests

EN60204-1 requirements:

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Figure 5 – EN60204-1:2018, Chapter 18.3

Megablock Component requirements:

Before performing this test, isolate all fuel cell DCDC converters from the DC bus (Cabinets UC01 to UC05)

Use a set of test leads and alligator clips to create a single AC node (3 phases shorted together)

The Megablock Component insulation requirements are higher than as specified chapter 18.3. The test is specified in Table 4):

Test point	Pass criteria	Test Voltage [VDC]
Internal side of the output breaker	>1MΩ	500

Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements

Megablock Component validation:

Each component is verified and compared to pass criteria in Table 4.

Component	Fuel Cell Container
Result – AC Node (value and pass/fail)	
Date and Initials	

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Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

14. A5 – Voltage tests

EN60204-1 requirements:

18.4 Voltage tests

When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected during testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

Figure 6 – EN60204-1:2018, Chapter 18.4

Megablock Component requirements:

The requirements from EN 60204-1:2018, Chapter 18.4 is compared in Table 5.
AC Voltage for Megablock Components is at most 480V, so twice the supply voltage is 960Vac.

Parameter	EN 60204-1:2018, Chapter 18.4	Megablock Component Testing
Voltage [VAC]	960	2500
Frequency [Hz]	50 or 60	50
Duration [sec]	1	10
Maximum Current [mA]	No arcing	5

Table 5 – Voltage Test Requirements

Megablock Component validation:

Connection point is internal side of main output breaker.

Component	Fuel Cell Container
Voltage Test – L1 (value and pass/fail)	
Voltage Test – L2 (value and pass/fail)	
Voltage Test – L3 (value and pass/fail)	
Date and Initials	

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Megablock		40ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

15. A6 – Protection against residual voltages

EN60204-1 requirements:

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

Figure 7 – EN60204-1:2018, Chapter 18.5

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V when the supply is disconnected shall be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 μC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure that contains the live parts.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can include children, warnings are not sufficient and therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

Figure 8 – EN60204-1:2018, Chapter 6.2.4

Megablock Component requirements:

Identical to EN60204-1 requirements.

Megablock Component validation:

No live parts of the Megablock Component system are accessible without disassembling barriers or accessing electrical cabinets. All connectors are IP2X or higher in unmated state in applications higher than 60V (power system)

Frequency converters and motor drives are marked with applicable durations before internal capacitors are discharged.

Maintenance procedures for the Megablock Component module include a manual verification before any work on exposed components is permitted.

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16. A7 – Verification that the relevant requirements of 8.2.6 are met

EN60204-1 requirements:

8.2.6 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA

Where electrical equipment has an earth leakage current that is greater than 10 mA AC or DC in any protective conductor, one or more of the following conditions for the integrity of each section of the associated protective bonding circuit that carries the earth leakage current shall be satisfied:

a) the protective conductor is completely enclosed within electrical equipment enclosures or otherwise protected throughout its length against mechanical damage;

b) the protective conductor has a cross-sectional area of at least 10 mm^2 Cu or 16 mm^2 Al;

c) where the protective conductor has a cross-sectional area of less than 10 mm^2 Cu or 16 mm^2 Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.

d) the supply is automatically disconnected in case of loss of continuity of the protective conductor;

e) where a plug-socket combination is used, an industrial connector in accordance with IEC 60309 series, with adequate strain relief and a minimum protective earthing conductor cross-section of 2,5 mm^2 as part of a multi-conductor power cable is provided.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.6.

Figure 9 – EN60204-1:2018, Chapter 8.2.6

Megablock Component requirements:

The Megablock Component does not have a leakage current higher than 10mA.

Megablock Component validation:

The protection against excessive leakage current is twofold:

- Ground fault detection is installed with a proven component (Bender Isometer). Detection of ground fault causes system shutdown and service technician is dispatched.
- Conductivity measurement of internal coolant is a part of the regular maintenance procedures (see N01-003 Service and Maintenance Manual)

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17. Summary Table

The requirements from sections 10 to 16, together with results are summarized below in Table 6:

Requirement headline	EN60204-1 Chapter	Req ID	Pass/Fail?
Verification that the electrical equipment complies with its technical documentation	n/a	A1	
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	18.2.2 – Test #1	A2	
Verification of conditions for protection by automatic disconnection of supply	18.2	A3	
Insulation resistance tests	18.3	A4	
Voltage tests	18.4	A5	
Protection against residual voltages	18.5	A6	
Verification that the relevant requirements of 8.2.6 are met	8.2.6	A7	

Table 6 – Summary Table

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Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

1. Introduction

The Megablock system contains many components utilizing potentially dangerous voltages and currents. It is a safety requirement that the electrical safety is tested before a product is shipped.

The testing is done according to the standard EN60204-1 Chapter 18, from which the tests in this document are described with room to note test results.

2. Revision Record

Rev #	Author	Description	Revised By	Date
1.0	PBL	Initial Release		09/11-2023
2.0	PBL	Adapted from 40ft Coolant Skid document		04/07-2024
3.0	RKN	General review		09/01-2025

3. List of Figures

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5. Purpose and structure of this document

As Megablock is a large system, containing several parts assembled individually and brought together to fulfill the customer requirements, the components are tested individually.

With each component tested before final assembly, the interconnect must be tested, both before initial operation and after any disassembly, e.g. after shipping.

The purpose of this document is to compare the requirements outlined in EN60204-1 Chapter 18 against following testing performed Megablock components.

This is required for the CE approval of the Megablock Fuel Cell Power Plant.

This document is structured as follows:

1. The requirements from EN60204-1 are outlined:
    a. Section 7
2. Test Specifications to comply with the requirement outlined above.
    a. Sections 10 to 16
3. Summary table
    a. Section 17

6. References

Document	Title	Author
DS/EN 60204-1:2018	Safety of machinery – Electrical equipment of machines – Part 1: General Requirements	CENELEC

Table 1 – References

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7. Requirements from EN60204-1 Ch 18

Figure 1 is reproduced from the EN60204-1 Ch18.1:

18.1 General

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g):

a) verification that the electrical equipment complies with its technical documentation;
b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to 18.2;
d) insulation resistance test (see 18.3);
e) voltage test (see 18.4);
f) protection against residual voltage (see 18.5);
g) verification that the relevant requirements of 8.2.6 are met;
h) functional tests (see 18.6).

Figure 1 – Excerpt from EN60204-1:2018, Chapter 18.1

The mapping between the headlines from the standard and the requirement ID used in this document is listed in Table 2.

Requirement headline	EN60204-1 Chapter 18.1	EN60204-1 Chapter	Requirement ID
Verification that the electrical equipment complies with its technical documentation	A	n/a	A1
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	B	18.2.2 – Test #1	A2
Verification of conditions for protection by automatic disconnection of supply	C	18.2	A3
Insulation resistance tests	D	18.3	A4
Voltage tests	E	18.4	A5
Protection against residual voltages	F	18.5	A6
Verification that the relevant requirements of 8.2.6 are met	G	8.2.6	A7

Table 2 – Requirement headlines, chapter, and ID mapping

Functional testing of the equipment is outside the scope of this document.

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Test Specification	RKN	09-01-2025	3.0.0

8. Test Equipment.

The test equipment is a CE MultiTester, manufactured by Metrel.

Test Equipment	Ballard Equipment ID	Calibration valid until:

9. Device Under Test

The device to be tested is the 10ft container for the Megablock project.

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10. A1 – Verification that the electrical equipment complies with its technical documentation

EN60204-1 requirements:

a) verification that the electrical equipment complies with its technical documentation;

Figure 2 – EN60204-1:2018, Chapter 18.1

Megablock Component requirements:

Inspection of the electrical equipment and cabinets to ensure congruence between documentation and equipment/cabinet.

Megablock Component validation:

Component	10ft Container
Result (pass/fail)	
Date and Initials	

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Test Specification	RKN	09-01-2025	3.0.0

11. A2 – Verification of continuity of the protective bonding circuit

EN60204-1 requirements:

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

Figure 3 – EN60204-1:2018, Chapter 18.2.2

Megablock Component requirements:

The EN60204-1 Chapter 18.2.2, Test #1 specifies a current of 10A.

Megablock Component bonding resistance test is performed with a current of 10A and a test period of 10 seconds.

Megablock Component validation:

The primary earthing point for the Power Converter Container is the main ground bar located at the rear of the main output breaker (=BA30-FC30).

Each component is verified and compared to expected values for the following locations.

ID	Test Point	Expected Value	Recorded Value
1	Busbar to busbar	<100mΩ	
2	Main DC/Acpoint 1		
3	Main DC/Acpoint 2		
4	Main DC/Acpoint 3		
5	DC/AC conduncter point 1		
6	DC/AC conduncter point 2		
7	DC/AC conduncter point 3		
8	LT coolant pipe		
9	Cable tray		

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10	Main transforer grounding bolt		
11	Main transformer chassis		
12	Cable tray		

Table 3 – Bonding Resistance Test point and expected resistance values.

When performing the test, ensure the connection between the test leads and the equipment is not contributing to inaccurate measurements.

12. A3 - Verification of conditions for protection by automatic disconnection of supply

EN60204-1 requirements:

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Figure 4 – EN60204-1:2018, Chapter 18.2

Megablock Component requirements:

As specified in chapter 18.2.1, Test #1 is performed (see section 11). Chapter 18.2.1 further specifies testing of Residual Current Devices (RCD) according to manufacturer specifications.

Megablock Component module does not contain any RCD devices.

13. A4 - Insulation resistance tests

EN60204-1 requirements:

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Figure 5 – EN60204-1:2018, Chapter 18.3

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Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

Megablock Component requirements:

Before performing this test, isolate all fuel cell DCDC converters from the DC bus (Cabinets UC01 to UC06)

Use a set of test leads and alligator clips to create a single AC node (3 phases shorted together)

The Megablock Component insulation requirements are higher than as specified chapter 18.3. The test is specified in Table 4):

Test point	Pass criteria	Test Voltage [VDC]
=LA01+UC31-QB01	>1MΩ	500

Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements

Megablock Component validation:

Each component is verified and compared to pass criteria in Table 4.

Component	Power Converter Container
Result – AC Node (value and pass/fail)	
Date and Initials	

14. A5 – Voltage tests

EN60204-1 requirements:

18.4 Voltage tests

When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected during testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

Figure 6 – EN60204-1:2018, Chapter 18.4

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Megablock Component requirements:

The requirements from EN 60204-1:2018, Chapter 18.4 is compared in Table 5.
AC Voltage for Megablock Components is at most 480V, so twice the supply voltage is 960Vac.

Parameter	EN 60204-1:2018, Chapter 18.4	Megablock Component Testing
Voltage [VAC]	960	2500
Frequency [Hz]	50 or 60	50
Duration [sec]	1	10
Maximum Current [mA]	No arcing	5

Table 5 – Voltage Test Requirements

Megablock Component validation:

Connection point is internal side of main output breaker.

Component	Power Converter Container
Voltage Test – L1 (value and pass/fail)	
Voltage Test – L2 (value and pass/fail)	
Voltage Test – L3 (value and pass/fail)	
Date and Initials	

15. A6 – Protection against residual voltages

EN60204-1 requirements:

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

Figure 7 – EN60204-1:2018, Chapter 18.5

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Megablock		10ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V when the supply is disconnected shall be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 µC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure that contains the live parts.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can include children, warnings are not sufficient and therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

Figure 8 – EN60204-1:2018, Chapter 6.2.4

Megablock Component requirements:

Identical to EN60204-1 requirements.

Megablock Component validation:

No live parts of the Megablock Component system are accessible without disassembling barriers or accessing electrical cabinets. All connectors are IP2X or higher in unmated state in applications higher than 60V (power system)

Frequency converters and motor drives are marked with applicable durations before internal capacitors are discharged.

Maintenance procedures for the Megablock Component module include a manual verification before any work on exposed components is permitted.

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16. A7 – Verification that the relevant requirements of 8.2.6 are met

EN60204-1 requirements:

8.2.6 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA

Where electrical equipment has an earth leakage current that is greater than 10 mA AC or DC in any protective conductor, one or more of the following conditions for the integrity of each section of the associated protective bonding circuit that carries the earth leakage current shall be satisfied:

a) the protective conductor is completely enclosed within electrical equipment enclosures or otherwise protected throughout its length against mechanical damage;

b) the protective conductor has a cross-sectional area of at least 10 mm^2 Cu or 16 mm^2 Al;

c) where the protective conductor has a cross-sectional area of less than 10 mm^2 Cu or 16 mm^2 Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.

d) the supply is automatically disconnected in case of loss of continuity of the protective conductor;

e) where a plug-socket combination is used, an industrial connector in accordance with IEC 60309 series, with adequate strain relief and a minimum protective earthing conductor cross-section of 2,5 mm^2 as part of a multi-conductor power cable is provided.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.6.

Figure 9 – EN60204-1:2018, Chapter 8.2.6

Megablock Component requirements:

The Megablock Component does not have a leakage current higher than 10mA.

Megablock Component validation:

The protection against excessive leakage current is twofold:

- Ground fault detection is installed with a proven component (Bender Isometer). Detection of ground fault causes system shutdown and service technician is dispatched.
- Conductivity measurement of internal coolant is a part of the regular maintenance procedures (see N01-003 Service and Maintenance Manual)

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17. Summary Table

The requirements from sections 10 to 16, together with results are summarized below in Table 6:

Requirement headline	EN60204-1 Chapter	Req ID	Pass/Fail?
Verification that the electrical equipment complies with its technical documentation	n/a	A1	
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	18.2.2 – Test #1	A2	
Verification of conditions for protection by automatic disconnection of supply	18.2	A3	
Insulation resistance tests	18.3	A4	
Voltage tests	18.4	A5	
Protection against residual voltages	18.5	A6	
Verification that the relevant requirements of 8.2.6 are met	8.2.6	A7	

Table 6 – Summary Table

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

1. Introduction

The Megablock system contains many components utilizing potentially dangerous voltages and currents. It is a safety requirement that the electrical safety is tested before a product is shipped.

The testing is done according to the standard EN60204-1 Chapter 18, from which the tests in this document are described with room to note test results.

2. Revision Record

Rev #	Author	Description	Revised By	Date
1.0	PBL	Initial Release		9/11-2023
2.0	PBL	General updates		21/10-2024
3.0	RKN	General review		09/01-2025

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

Table 6 – Summary Table 14

5. Purpose and structure of this document

As Megablock is a large system, containing several parts assembled individually and brought together to fulfill the customer requirements, the components are tested individually.

With each component tested before final assembly, the interconnect must be tested, both before initial operation and after any disassembly, e.g. after shipping.

The purpose of this document is to compare the requirements outlined in EN60204-1 Chapter 18 against following testing performed Megablock components.

This is required for the CE approval of the Megablock Fuel Cell Power Plant.

This document is structured as follows:

1. The requirements from EN60204-1 are outlined:
    a. Section 7
2. Test Specifications to comply with the requirement outlined above.
    a. Sections 10 to 16
3. Summary table
    a. Section 17

6. References

Document	Title	Author
DS/EN 60204-1:2018	Safety of machinery – Electrical equipment of machines – Part 1: General Requirements	CENELEC

Table 1 – References

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7. Requirements from EN60204-1 Ch 18

Figure 1 is reproduced from the EN60204-1 Ch18.1:

18.1 General

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g):

a) verification that the electrical equipment complies with its technical documentation;
b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to 18.2;
d) insulation resistance test (see 18.3);
e) voltage test (see 18.4);
f) protection against residual voltage (see 18.5);
g) verification that the relevant requirements of 8.2.6 are met;
h) functional tests (see 18.6).

Figure 1 – Excerpt from EN60204-1:2018, Chapter 18.1

The mapping between the headlines from the standard and the requirement ID used in this document is listed in Table 2.

Requirement headline	EN60204-1 Chapter 18.1	EN60204-1 Chapter	Requirement ID
Verification that the electrical equipment complies with its technical documentation	A	n/a	A1
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	B	18.2.2 – Test #1	A2
Verification of conditions for protection by automatic disconnection of supply	C	18.2	A3
Insulation resistance tests	D	18.3	A4
Voltage tests	E	18.4	A5
Protection against residual voltages	F	18.5	A6
Verification that the relevant requirements of 8.2.6 are met	G	8.2.6	A7

Table 2 – Requirement headlines, chapter, and ID mapping

Functional testing of the equipment is outside the scope of this document.

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

8. Test Equipment.

Test Equipment	Ballard Equipment ID	Calibration valid until:

9. Device Under Test

The device to be tested is the coolant skid for the Megablock project. A rendering is shown below with selected items highlighted.

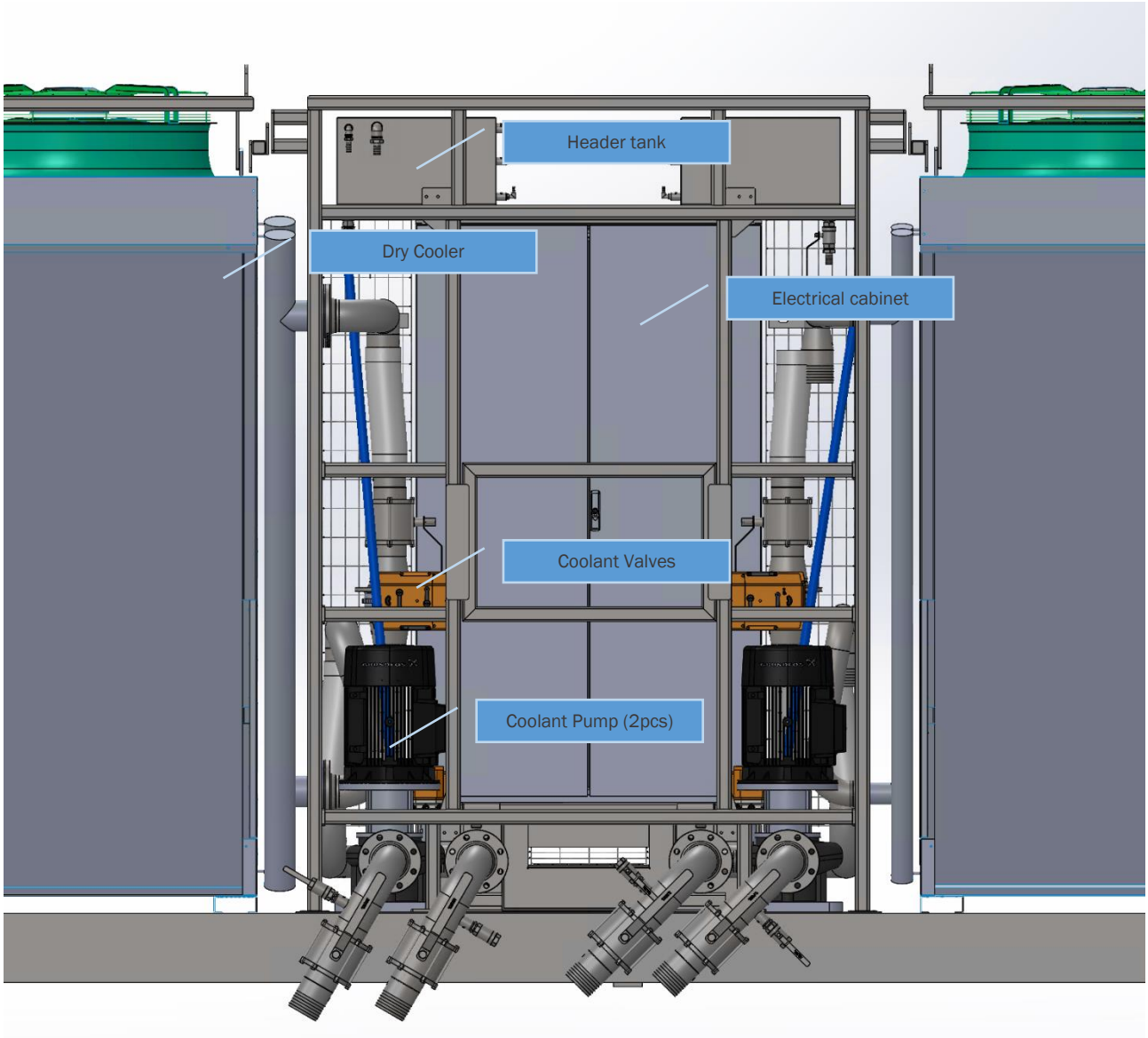


Figure 2 – Front view of coolant skid centre section with callouts.

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

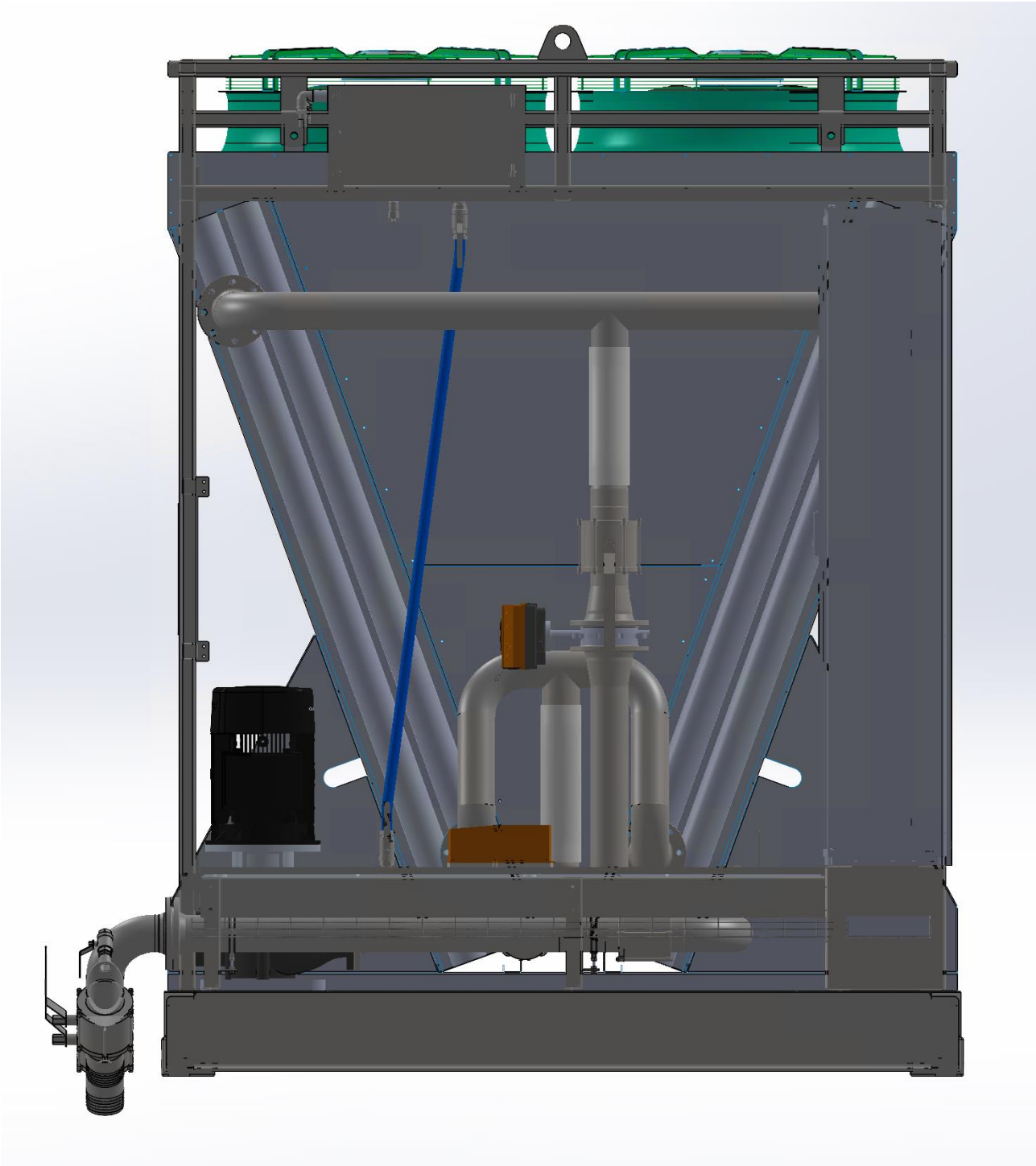


Figure 3 – Section view of the coolant skid, looking from centre towards left.

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

10. A1 – Verification that the electrical equipment complies with its technical documentation

EN60204-1 requirements:

a) verification that the electrical equipment complies with its technical documentation;

Figure 4 – EN60204-1:2018, Chapter 18.1

Megablock Component requirements:

Inspection of the electrical equipment and cabinets to ensure congruence between documentation and equipment/cabinet.

Megablock Component validation:

Component	Coolant Skid
Result (pass/fail)	
Date and Initials	

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11. A2 – Verification of continuity of the protective bonding circuit

EN60204-1 requirements:

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

Figure 5 – EN60204-1:2018, Chapter 18.2.2

Megablock Component requirements:

The EN60204-1 Chapter 18.2.2, Test #1 specifies a current of 10A.

Megablock Component bonding resistance test is performed with a current of 10A and a test period of 10 seconds.

Megablock Component validation:

The primary earthing point for the coolant skid is the main ground terminal in the control enclosure.

Each component is verified and compared to expected values for the following locations.

ID	Test Point	Expected Value	Recorded Value
1	Control Cabinet Backplate	<100mΩ	
2	Grounding Bar, Below PLC		
3	HT1 Cooling Pipe, From HT1 Cooler		
4	HT1 Manual Valve, HT1 Cooler Outlet		
5	HT1 Coolant Pump, Grounding Connection		
6	HT1 Header Tank, Bolts		
7	HT1 Cooler Frame (Metal)		
8	HT2 Cooling Pipe, From HT1 Cooler		
9	HT2 Manual Valve, HT1 Cooler Outlet		
10	HT2 Coolant Pump, Grounding Connection		

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11	HT2 Header Tank, Bolts		
12	HT2 Cooler Frame (Metal)		

Table 3 – Bonding Resistance Test point and expected resistance values.

When performing the test, ensure the connection between the test leads and the equipment is not contributing to inaccurate measurements.

Notes to test points:

- Point 1-2 is inside the electrical cabinet.
- Point 3-6 is indicated on Figure 6 – Test points for Grounding Test
- Point 7-12 are identical to points 3-6, except mirrored to HT2.

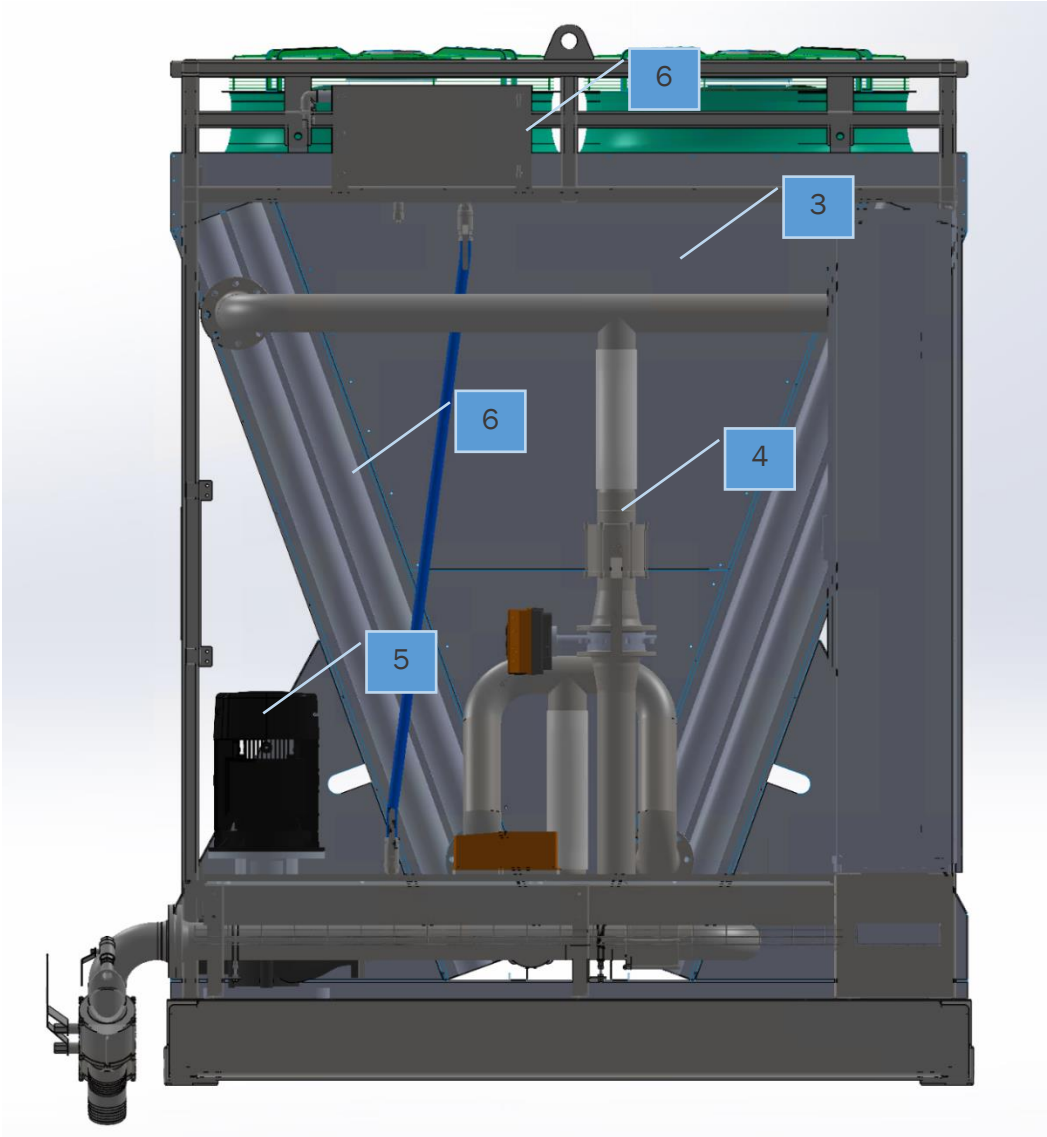


Figure 6 – Test points for Grounding Test

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12. A3 - Verification of conditions for protection by automatic disconnection of supply

EN60204-1 requirements:

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Figure 7 – EN60204-1:2018, Chapter 18.2

Megablock Component requirements:

As specified in chapter 18.2.1, Test #1 is performed (see section 11). Chapter 18.2.1 further specifies testing of Residual Current Devices (RCD) according to manufacturer specifications. Megablock Component module does not contain any RCD devices.

Megablock Component is not a TN-system, and Test #2 is not relevant.

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13. A4 - Insulation resistance tests

EN60204-1 requirements:

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Figure 8 – EN60204-1:2018, Chapter 18.3

Megablock Component requirements:

The Megablock Component insulation requirements are higher than as specified chapter 18.3. The test is specified in Table 4):

Test point	Pass criteria	Test Voltage [VDC]
UC40-FC04	>1MΩ	500

Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements

Megablock Component validation:

Each component is verified and compared to pass criteria in Table 4.

Component	Coolant Skid
Result – AC Node (value and pass/fail)	
Date and Initials	

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14. A5 – Voltage tests

EN60204-1 requirements:

18.4 Voltage tests

When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected during testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

Figure 9 – EN60204-1:2018, Chapter 18.4

Megablock Component requirements:

The requirements from EN 60204-1:2018, Chapter 18.4 is compared in Table 5.
AC Voltage for Megablock Components is at most 480V, so twice the supply voltage is 960Vac.

Parameter	EN 60204-1:2018, Chapter 18.4	Megablock Component Testing
Voltage [VAC]	960	2500
Frequency [Hz]	50 or 60	50
Duration [sec]	1	10
Maximum Current [mA]	No arcing	5

Table 5 – Voltage Test Requirements

Megablock Component validation:

Component	Coolant Skid
Voltage Test – L1 (value and pass/fail)	
Voltage Test – L2 (value and pass/fail)	
Voltage Test – L3 (value and pass/fail)	
Date and Initials	

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15. A6 – Protection against residual voltages

EN60204-1 requirements:

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

Figure 10 – EN60204-1:2018, Chapter 18.5

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V when the supply is disconnected shall be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 μC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure that contains the live parts.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can include children, warnings are not sufficient and therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

Figure 11 – EN60204-1:2018, Chapter 6.2.4

Megablock Component requirements:

Identical to EN60204-1 requirements.

Megablock Component validation:

No live parts of the Megablock Component system are accessible without disassembling barriers. All connectors are IP2X or higher in unmated state in applications higher than 60V (power system)

Frequency converters and motor drives are marked with applicable durations before internal capacitors are discharged.

Maintenance procedures for the Megablock Component module include a voltage drawdown process and manual verification before any work on exposed components is permitted.

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16. A7 – Verification that the relevant requirements of 8.2.6 are met

EN60204-1 requirements:

8.2.6 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA

Where electrical equipment has an earth leakage current that is greater than 10 mA AC or DC in any protective conductor, one or more of the following conditions for the integrity of each section of the associated protective bonding circuit that carries the earth leakage current shall be satisfied:

a) the protective conductor is completely enclosed within electrical equipment enclosures or otherwise protected throughout its length against mechanical damage;

b) the protective conductor has a cross-sectional area of at least 10 mm^2 Cu or 16 mm^2 Al;

c) where the protective conductor has a cross-sectional area of less than 10 mm^2 Cu or 16 mm^2 Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.

d) the supply is automatically disconnected in case of loss of continuity of the protective conductor;

e) where a plug-socket combination is used, an industrial connector in accordance with IEC 60309 series, with adequate strain relief and a minimum protective earthing conductor cross-section of 2,5 mm^2 as part of a multi-conductor power cable is provided.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.6.

Figure 12 – EN60204-1:2018, Chapter 8.2.6

Megablock Component requirements:

The Megablock Component does not have a leakage current higher than 10mA.

Megablock Component validation:

The protection against excessive leakage current is twofold:

- Ground fault detection is in the scope of the 10ft Container (DCAC system)
- Conductivity measurement of internal coolant is a part of the regular maintenance procedures (see N01-003 Service and Maintenance Manual)

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17. Summary Table

The requirements from sections 10 to 16, together with results are summarized below in Table 6:

Requirement headline	EN60204-1 Chapter	Req ID	Pass/Fail?
Verification that the electrical equipment complies with its technical documentation	n/a	A1	
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	18.2.2 – Test #1	A2	
Verification of conditions for protection by automatic disconnection of supply	18.2	A3	
Insulation resistance tests	18.3	A4	
Voltage tests	18.4	A5	
Protection against residual voltages	18.5	A6	
Verification that the relevant requirements of 8.2.6 are met	8.2.6	A7	

Table 6 – Summary Table

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Short Title	Thermographic - Cooling and Ventilation Test Procedure
Full Title	Thermographic - Cooling and Ventilation Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating cooling and ventilation are performing correct.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-02-2024
2	Updated	TAN	08-08-2024
3	Updated procedure	RKN	15-11-2024

Checked by: RKN	Date: 15/11-2024
Approved by: RKN	Date: 15/11-2024

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and background

The objectives of this test procedure is to demonstrate the performance of ventilation and cooling on full system solution. The thermographic inspection will be conducted around solution as well as inside where service staff can enter while system stays operational.

- Ensure ventilation system performing as expected.
- Ensure cooling system is performing as expected.
- Validate accessible surface temperatures.

2.0 References

Document	Titel

3.0 Equipment list

Equipment	Purpose
Thermographic imager	Measure temperatures, capture images and create data folder with evidence.

4.0 Test Procedure

4.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

4.2 Preparation

- Verify equipment is calibrated and withing valid calibration period.
- Identify how and where to measure the ventilation system.
    - Access to areas that are normally accessible during operation to sweep for hot surfaces.
- Identify how and where to measure the cooling system.
    - It should be possible to view majority of cooling skid to check temperature distribution.
        - If this is not possible, review need for additional equipment during measurements
- Identify possible hot surfaces to be inspected.

4.3 Measurement locations

- Inside solution:
  - Ventilation of components
  - Container ventilation
  - Surface temperatures
  - Cooling circuit
- Outside solution:
  - Container ventilation
  - Surface temperatures
  - Coolers and cooling circuit

4.4 Conducting measurements

Set the Megablock to full power (1000 kW) and wait until temperatures have stabilised. Monitor the containers and ventilation described in section 4.3 through the thermographic imager and take pictures of all relevant areas with elevated temperatures. File in the pictures in a report.

5.0 Appendix

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Short Title	Cooling Circuit Pressure and Leak Test Procedure
Full Title	Cooling Circuit Pressure and Leak Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating cooling circuits are leak free and can withstand normal operating pressure.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-02-2024
2	Updated specification	RKN	15-11-2024

Checked by: RKN	Date: 15/11-2024
Approved by: RKN	Date: 15/112024

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and background

The objective with this test procedure is to generalise how cooling circuits are leak free and pressure tested.

2.0 References

Document	Titel

3.0 Equipment list

Equipment	Purpose
Pressure gauge	Monitor pressure

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4.0 Test Procedure

The main purpose of this test procedure is to ensure that the cooling circuit is leak free and can handle maximum system pressure. Furthermore, it is structured in a way to minimize the chance of having big leaks or lose clamps or fittings.

WARNING: The stress test is with elevated pressure, potentially turning plugs or loose fittings into projectiles.

Minimum safety precautions:

- Hose clamps and fittings
- Wear safety goggles
- When dealing with glycol wear gloves
- Check service manual for maximum system pressure.

4.1 Pre-conditioning

- Check and make sure valves in the cooling circuit are in the correct position.
- For pressure testing with coolant in the cooling circuit, make sure the system is fully bleed. Air in the system can act as a spring and can obscure results.
- To achieve stable temperature let system soak for 12 hours. Alternative watch data from temperature sensors in the full system to ensure stable temperature conditions.

4.2 Leak test with air

- Maximum system pressure on Megablock is 1.5barg.
- No temperature pre-conditioning needed; this is not a sign off test.
- Find compressor and leak test kit.
- Adjust pressure reduction valve to minimum (no pressure after reduction valve)
- Attach leak test kit to cooling circuit (not applying pressure to circuit)
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 20% of maximum system pressure (0.3barg)
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 80% of maximum system pressure (1.2barg)
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from compressed air
- Slowly increase pressure from reduction valve to 100% of maximum system pressure (1.5barg)
- Close valve from compressed air
    - If pressure is not maintained
        - Open valve from compressed air again and look for leaks (where surface material is suitable soapy water spray can be used for leak detection)
        - Fix leak and repeat step.
    - If pressure is maintained – test completed and passed.

4.3 Leak test with air setup

Compressor and adaptor hose to be connected. Close valve to expansion tank so that pressure can build in cooling circuit. Find test setup image in appendix.

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4.4 Pressure decay test with coolant

- Maximum system pressure on Megablock is 1.5 barg.
- Make sure cooling circuit have been filled and bled before starting this test.
- Make sure pre-conditioning have been done.
- Find coolant pressure test kit.
- Attach test kit to cooling circuit (not applying pressure to circuit)
- Slowly increase pressure 50% of maximum system pressure (0.75barg)
- Close valve from test kit.
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Open valve from test kit
- Slowly increase pressure to 100% of maximum system pressure (1.5barg)
- Close valve from test kit
    - Quick inspection of cooling circuit for any coolant leaks.
    - If pressure is not maintained
        - Further inspection of test setup and cooling circuit
            - If there is still air in the system if can cause spring effect and drop in pressure
        - Found and fixed issue, repeat step.
    - If pressure is maintained
        - Continue to next step.
- Wait 30 minutes if pressure have dropped re-apply pressure to reach 100% system pressure again.
- Wait 2 hours and check pressure again.
    - If pressure have dropped more than 0.1bar
        - Repeat test
    - If pressure have dropped less than 0.1bar after 2 hours – test completed and passed.

4.5 Pressure decay test with coolant setup

Pressure pump and adaptor hose to be connected. Close valve to expansion tank so that pressure can build in cooling circuit. Find test setup image in appendix.

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5.0 Results and discussion

6.0 Appendix

6.1 Cooling leakage HT1 (Suggested section for FAT or SAT document)

6.1.1 Test

Follow designated test procedure for inspection and verification of a leak-free HT1 coolant circuit.

6.1.2 Relevant Standard / document

- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

6.1.3 Brief Test Plan

- Follow test procedure.

6.1.4 Pass/Fail criteria.

- Allow system to maintain pressure, after 2 hours pressure must not drop more than 0,1 bar.

6.1.5 Test Result

Table 1: Cooling leakage HT1 - Test Result

Date tested	Item	Result	Pass/Fail	Notes
	HT 1			

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6.2 Pressure decay test with coolant

Pressure pump and adaptor hose to connect and pressurise.



6.3 Leak test with air

Compressor and pressure test adaptor hose.



Short Title	H2 Leak Test Procedure
Full Title	H2 Leak Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating H2 circuits are within allowed limits and can withstand normal operating pressure.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	RKN	13-05-2024
001	Release		
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1.0 Definitions

Abbreviation	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module
SME	Subject Matter Expert
PPE	Personal Protective Equipment
DUT	Device under test

2.0 Objectives and Background

The purpose of this test procedure is to generalise how Ballard Product Solutions secure that the fabricated hydrogen systems are not leaking more than the specified limits and the circuits will withstand maximum operation pressure. Furthermore, this procedure is intended to be used on full systems and/or sub assemblies. This test procedure is based on *IEC 62282-3-1 section 5.4 Leakage tests and 5.4.1 Gas leakage tests* with regards to system tests. For hydrogen pipework testing, the IEC 62282-3-1 references *ISO 15649:2001 "Petroleum and natural gas industries – Piping* which states that piping shall be tested according to *ASME B31.12 Hydrogen piping and pipelines.* Hence, the described procedure for component/pipework inspection and leakage test is based on this standard.

3.0 References

Document	Titel
IEC 62282-3-1:2019	Fuel cell technologies - Part 3-1: Stationary fuel cell power systems - Safety
ASME B31.12-2023	Hydrogen piping and pipelines
SPC ID 0202	Snooper mini H2 sniffing procedure
SPC ID 0203	Pipework inspection and leakage test check sheet template
SPC ID 0204	System pressure decay test template

4.0 Equipment list

Equipment	Type	Purpose
H2 sniffer	Sewerin Snooper Mini H2	Detection instrument to snif/locate source of potential leaks
Pressure sensor	Fluke 700RG07 500PSIG	Measuring device to accurately adjust and monitor gas pressure during leakage test
Test gas	Formier gas 5% hydrogen	Test gas for pressurizing pipework where the 5% hydrogen acts as tracer agent for sniffing.
Sniffer test station	Sewerin SPE-HG	Test instrument the emits a reference gas to check the correct function of the Snooper Mini H2 sniffer
Pressure regulator		Test gas pressure regulator for pressurizing the DUT
Pressure relief valve		Safety valve to ensure safe pipework pressurization during test.

5.0 Test Procedures

Any system is comprised of several subassemblies and/or components. Any of these subsystems must be individually inspected and leakage tested before assembly into the complete system. For systems fabricated or assembled by Ballard Product Solutions, testing per section 5.4 applies. Externally delivered systems/modules as well as Ballard standard products must be tested in accordance with *IEC 62282-3-1:2019* or similar industry relevant standards.

Attention: All test personnel, including external witness should be informed about risks associated with the test and instructed to use proper PPE prior to conducting the test.

WARNING: Pressure testing can potentially turn plugs or loose fittings into projectiles.

Minimum safety precautions:

- The test must be carried out by trained personnel.
- Prior to test start make sure that the work has been HSE risk assessed according to Ballard internal procedures.
- All connection and mechanical assemblies shall be checked before applying pressure.
- All personnel attending the test shall use appropriate PPE.

5.1 Installations and connections

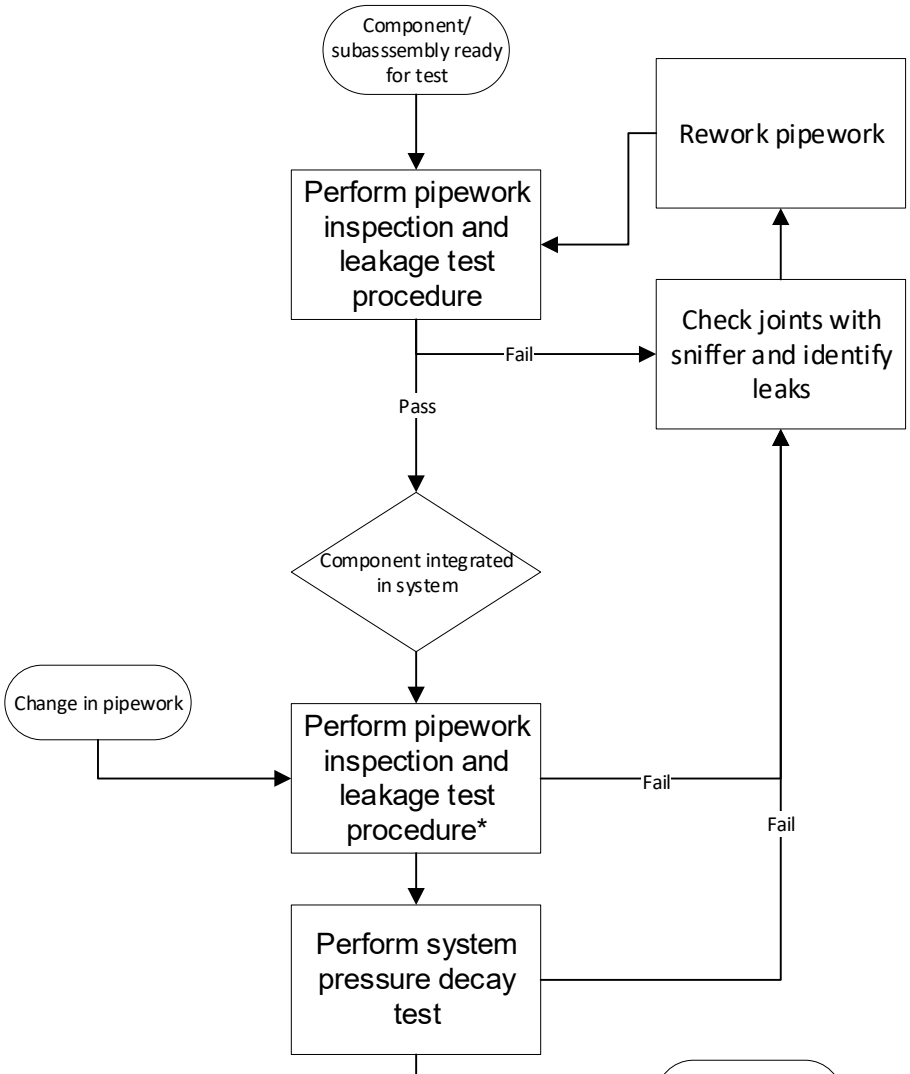
Make sure that all parts of the hydrogen system have been correctly assembled and according to assembly guides and build manuals.

5.2 Review test setup.

Before proceeding to testing, the test setup should be reviewed by a SME. The SME should also determine the pressure of which the system under test will be tested to. Once a setup has been reviewed and approved re-testing can proceed on same approval if the setup remains unchanged. If a diagram of the system under test does not exist create a diagram like the one in appendix. The results from the test should be added on the diagram and saved as part of the test report. During the review a risk assessment should be done and shared with all staff involved with testing and working in proximity to an ongoing test. Make sure that relevant measurement instruments, used during the test all have valid calibration certificates if applicable. Furthermore, ensure that manufacturers procedures are followed for maintaining the equipment accuracy and dependability.

5.3 System test sequence

On any system the following test sequence must be followed during first assembly or reassembly of a system.



* Only for changed/interfacing joints

5.4 Pipework inspection and leakage test

The pipework inspection and leakage test are performed to ensure proper assembly quality is achieved during fabrication and assembly of components/subassemblies. The test is designed to be performed upon work completion in the assembly plant/workshop before release to system assembly.

The test is performed in accordance with or exceeding requirements in *ASME B31.12 Hydrogen piping and pipelines*.

The associated template for documenting the test must be used: *SPC ID 0203 Pipework inspection and leakage test check sheet* template

5.4.1 Test setup

The assembled component or subassembly pipe ends are appropriately sealed off and the pressure regulator with formier gas supply is connected, together with a pressure gauge and appropriate pressure relief valve.

Use of the H2 sniffer instrument must be performed in accordance with *SPC ID 0202 Snooper mini H2 sniffing procedure.*

5.4.2 Test sequence

1. Check for proper functionality of the sniffing tool by using the sniffer test station
2. Inspect the pipework visually for any damage or loose parts
    a. For ferrule fittings, check every fitting with appropriate gap inspection gauge to ensure sufficient tightening is achieved
3. Pressurize pipework to between 1.0-1.2 barg with formier gas and listen for leaks
4. Increase pressure to 50% of test pressure by adjusting the pressure regulator
5. Maintain the pressure for 10 minutes.
6. Listen for leaks and use H2 sniffer to inspect all joints. If leaks are identified record all positions and values in the check sheet, abort test by proceeding to item 10 and file the pipework for rework.
7. If no leaks are detected, proceed to increase pressure to “test pressure” by adjusting the pressure regulator.
8. Maintain the pressure for minimum 10 minutes.
9. Listen for leaks and use the H2 sniffer to inspect all joints. Record all leak positions and values in the check sheet.
10. Blow down system, disconnect test gas supply and secure pipe ends.
11. Check for proper functionality of the sniffing tool by using the sniffer test station.
12. For identified leaks file the pipework for rework.
13. For joints that pass the procedure, a suitable marking must be applied to identify that the joint is verified.
14. If all joints are accepted, sign and file the check sheet.

If leaks are identified during the procedure, the test sequence must be performed again on reworked pipework.

5.4.1 Test evaluation

Each joint of the DUT is subject to the following test pass criteria:

Inspection element	Pass criteria
Visual inspection	No visible damage, incorrect assembly or misplacement of the joint. No dirt, lubricants or foreign materials left on the joint No indication of excessive use of force No indication of incorrect use of tools to assemble the joint.
Auditory inspection	No hearable leaks unless allowed by the particular joint.
Gauge inspection (where applicable)	According to gauge tool instruction.
Sniffing	According to acceptable leakage rate of a particular joint + measurement uncertainty of the sniffer (see SPC ID 0202) To be referenced from the ATEX documentation/design manual and recorded in the check sheet.

5.5 System pressure decay test

The system pressure decay test is performed to validate integrity of pipework and instrumentation of the complete H2 system. The test is performed in accordance with *IEC 62282-3-100:2020 section 6.2: Leakage test.*

5.5.1 Test setup

The system pressure decay test may only be performed if all subassemblies have been validated with the procedure described in section 5.4 or equivalent (for externally delivered subassemblies).

The test is performed using the regular fuel supply of the system at test pressure level.

If appropriate, the test may be isolated and divided into appropriate sections to allow for separate validation of individual pipe sections.

To ensure that the validation of the integrity of the pipework is sound, a measurement system analysis must be performed. The accuracy of the equipment, used to measure the necessary variables of the test must contribute to a measuring error of no more than 2% of the allowable leak rate in the system.

The associated template for documenting the test must be used: *SPC ID 0204 System pressure decay test template*

5.5.2 Test parameters

To properly validate the pipework system, the following variables are used. Variables are either universal constants, calculated values, system design values or measured values:

Variable	Name	Unit	Description
P_ops	Max operating pressure	barg	As defined by manufacturer spec
P_d	Design pressure	barg	Highest pressure that may occur under any and all operating modes, including steady state and transient.
P_t	Test pressure	barg	110% of design pressure
P_PRV	Relief pressure of relief valve	barg.	Test setup PRV
L_A	Max evaluated leak rate for pipework system acceptance	Nm^3/h	Maximum allowed pressure decay to pass pressure decay test
L_S	Expected leak rate for pipework system	Nm^3/h	Summarized expected leak rates of all components in the system (per design leak rate). The leak rates may be obtained from component category values or from actual measured leak rates during acceptance testing of the component.
L_C	Max allowed leak rate zone integrity (Critical leak level)	Nm^3/h	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

Variable	Name	Unit	Description
L_Mu	Measuring system uncertainty	Nm^3/h	Calculated accuracy of the measuring system, used to perform the test. The MSA must consider the complete signal path of sensors and control system.
L1	Actual leak rate	Nm^3/h	Calculated gas leakage rate from the tested system by performing the pressure decay test
V	Internal space volume	m^3	Calculated Internal space volume within the pressurized section (m^3) (gas volume excepting the internal structure volume) Internal pipework space volume must be obtained from the system design team as a value for any of the relevant sections.
T0	Reference temperature	K	Theoretical reference temperature (288.15K)
T1	internal space temperature start	K	Measured internal space temperature at the beginning of measurement
T2	internal space temperature end	K	Measured internal space temperature at the end of measurement
P0	Absolute reference pressure	kPa	Theoretical reference pressure (1 atm) (101.325 kPa)
P1	Internal space pressure start	kPag	Measured internal space pressure at the beginning of measurement
P2	Internal space pressure end	kPag	Measured space pressure at the end of the measurement
Pa1	Absolute pressure start	kPag	Measured atmospheric pressure at the beginning of the measurement
Pa2	Absolute pressure end	kPag	Measured atmospheric pressure at the end of the measurement (kPa)
t	Test duration	min	Measured test duration (t_end – t_start)

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5.5.3 Sequence

If at any point the system pressure is dropping, investigate leak before continuing testing.

1. Introduce hydrogen to the system by increasing gradually the inlet pressure until test pressure level is reached in the system.
2. Close the relevant inlet valve, isolating pressure supply from the system under test.
3. Let the pressure in the system settle for 2 minutes.
4. Start the pressure decay monitoring by recording
   -start time t_start
   -start internal space pressure P1
   -start atmospheric pressure Pa1
   -start temperature T1
5. Wait for 10 minutes
6. Finish the pressure decay monitoring by recording
   -end time t_end
   -end internal space pressure P2
   -end atmospheric pressure Pa2
   -end temperature T2
7. Calculate the leak rate L1
8. Blow down system or continue operation if test is successful.

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5.5.4 Test evaluation

The actual leakage rate from the system is calculated in accordance with *IEC 62282-3-100:2019. Section 6.2* from the pressure difference in the system, measured over time using the following formula, and with variables as described in section 5.5.2:

$$L_1 = V \times T_0/p_0 \times \{(p_1 + p_{a1})/(T_1) - (p_2 + p_{a2})/(T_2)\} \times 60/t$$

The allowable leakage rate of the system is a function of the allowable leak rates of each component in the system and the uncertainty of the measurement system itself.

The expected leakage rate of components/subassemblies may vary from system to system and may be comprised of a mix of maximum allowed leak rates, obtained from the system's *ATEX zone classification and pipework plan* or expected leakage rates obtained from actual measured values in component acceptance tests.

The measurement system must be evaluated (MSA) to estimate the measurement uncertainty (L_Mu). The measuring system can only be considered sound if the calculated uncertainty amounts to less than 2% of the critical leak rate (L_C).

The test pass criteria threshold is calculated as the allowable/expected leak rate of the system + the measurement uncertainty:

$$L_A = L_S + L_Mu$$

System will pass the pressure decay test under the following criteria:

$$L_1 < L_A$$

6.0 Appendix

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Short Title	Thermographic - Electrical Test Procedure
Full Title	Thermographic - Electrical Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating electrical cabinets and installation are performing correct.

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
1	Initial Draft	RKN	01-02-2024
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Checked by: TAN	Date: 9/8-2024
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Figure 2 Test pressure set up with principle of attachments. ..... **Error! Bookmark not defined.**

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.1 References

Document	Titel

2.0 Objectives and Background

The objectives of this test procedure are to demonstrate the performance of the electrical parts on full system solution. The thermographic inspection will be conducted around solution as well as inside where service staff can enter while system stays operational.

3.0 Test Procedure

3.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

3.2 Preparation

- Verify equipment is calibrated and withing valid calibration period.
- Identify how and where to measure the ventilation system.
- Identify how and where to measure the cooling system.
- Identify possible heat surfaces to be inspected.

3.3 Measurement locations

- Inside solution:
  - 40ft container
  - 10ft container
- Outside solution:
  - 40ft container
  - 10ft container
  - Cooling skid

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3.4 Conducting measurements

Set the Megablock to full power (1000 kW) and wait until temperatures have stabilised. Monitor the electrical cabinets and electrical installations described in section 3.3 through the thermographic imager and take pictures of all relevant areas with elevated temperatures. File in the pictures in a report.

4.0 Appendix

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Short Title	Noise Level Measurement Test Procedure
Full Title	Noise Level Measurement Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for measuring noise level inside and outside system. To validate work environment but also the noise emitted.

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Revision Record

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Abrevassion	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and Background

The objective of this test procedure is to determine the noise level generated by a full system solution. The measurements will be conducted around solution as well as inside where service staff can enter while system stays operational.

- Ensure compliance with noise regulations and safety standards.
- Evaluating the impact of the system noise to the surrounding environment.

2.0 References

Document	Titel
ISO 8528	Reciprocating internal combustion engine driven alternating current generating sets – Part 5: Generating sets

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3.0 Equipment list

Equipment	Purpose
Decibel meter	Measure noise level
Anemometer	Measure wind speed
Measuring tape	To measure up to 7 meter

4.0 Test Procedure

4.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

4.2 Preparation

- Verify equipment is calibrated and within valid calibration period.
- Identify the main noise sources inside and outside solution.
- Identify at which the operating points the solution will emit the most noise.
- Identify normal operating point for solution.

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4.3 Measurement locations

- Inside solution
  - Multiple measurements to capture the overall sound level within the work environment.
- Outside solution
  - 1-meter grid around solution
  - 7-meter grid around solution

4.4 Conducting measurements

- If decibel meter does have recording function:
  - Inside container measurement:
    - Measure maximum noise level at identified operating point in 5.2 and at location identified in 5.3. Measure for around 30 seconds to ensure a stable reading.
    - Noise level sweep:
      - Container running normal operating condition.
      - Start record noise level and walk from one end of the container to the other end.
      - Sweep should last around 20 seconds.
  - Outside container 1 meter:
    - Mark up the 1-meter perimeter around the container for example with a cone in each corner. If site does not allow 360 degree walk around at 1 meter while running, multiple recordings can be taken and compared to find maximum noise level.
    - System off (with noisy surroundings take a reference log)
    - Start recording the noise level, and slowly walk around the perimeter marked up.
    - Container running at most noise emitting point.
    - Start recording the noise level, and slowly walk around the perimeter marked up.
    - Analyze and find maximum noise level.

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- Outside container 7 meter:
  - Mark up the 7-meter perimeter around the container for example with a cone in each corner. If site does not allow 360-degree walk around at 7 meter while runnin0g, multiple recordings can be taken and compared to find maximum noise level.
  - System off (with noisy surroundings take a reference log)
  - Start recording the noise level, and slowly walk around the perimeter marked up.
  - Container running at most noise emitting point.
  - Start recording the noise level, and slowly walk around the perimeter marked up.
  - Analyze and find maximum noise level.

- If decibel meter does not have recording function:
  - Inside container measurement:
    - Measure maximum noise level. Measure for around 30 seconds to ensure a stable reading.
    - Noise level at 3 points in the container:

      Container running normal operating condition.

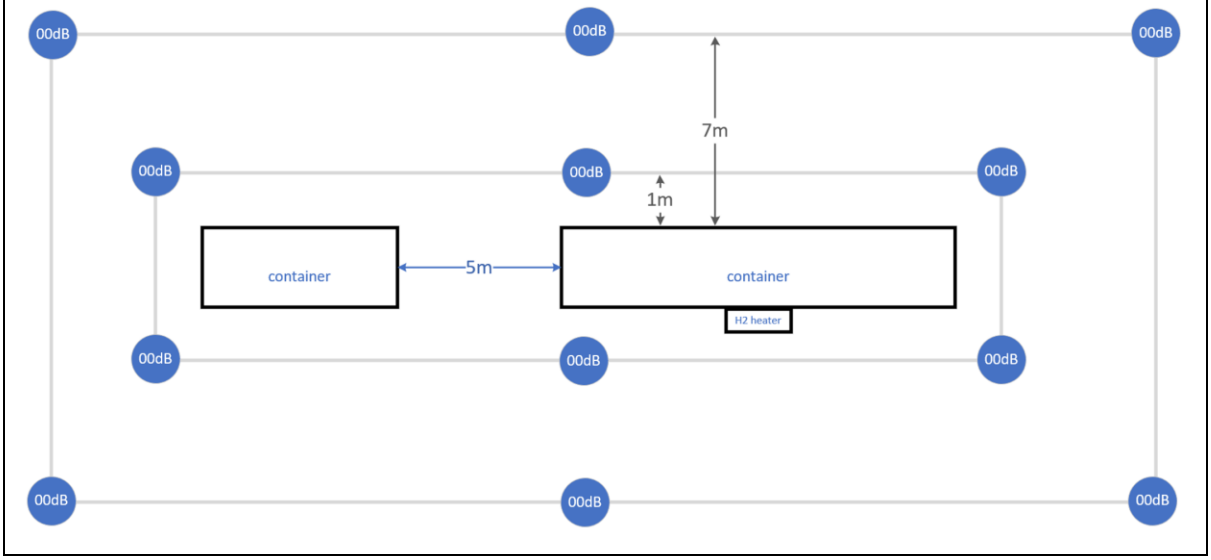
      - Measure noise level 1 meter from the one end of the container.
      - Measure noise in the mid point of the container.
      - Measure noise level 1 meter from the other end of the container.
  - Outside container 1 meter:
    - Mark up the 1-meter perimeter around the container for example with a cone in each corner. (If test setup does not allow full access complete as many points as possible)
    - System off (with noisy surroundings take a reference log)
    - Container running at most noise emitting point.
    - Start measuring the noise level, at each corner and in the mid point. Find reference map in appendix. And note down the noise level.
    - Analyze and find maximum noise level.

- Outside container 7 meter:
  - Mark up the 7-meter perimeter around the container for example with a cone in each corner. (If test setup does not allow access complete as many points as possible)
  - System off (with noisy surroundings take a reference log)
  - Container running at most noise emitting point.
  - Start measuring the noise level, at each corner and in the mid point. Find reference map in appendix. And note down the noise level.
  - Analyze and find maximum noise level.

5.0 Appendix

5.1 Reference map measurement grid

Figure 1: Reference map measurement grid



Short Title	Power Quality Measurement Test Procedure
Full Title	Power Quality Measurement Test Procedure
Abstract	This document describes the background, criteria and specifies the test procedure for validating cooling circuits are leak free and can withstand normal operating pressure.

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Abbreviation	Meaning
FCwave	FCwave 200kW Marine Fuel Cell Module

1.0 Objectives and Background

This test procedure aims to evaluate the power quality performance of Fuel Cell gensets and compare it to conventional diesel gensets G3.

2.0 References

Document	Titel
ISO 8528-5:2022	Reciprocating internal combustion engine driven alternating current generating sets

3.0 Equipment list

Equipment	Purpose
Fluke 1775	Power Quality Analyzer, measures Voltage, Current and Frequency Data

4.0 Test Procedure

4.1 Personal protective equipment

Before commencing the test procedure always analyze the work environment and make sure you take the right precautions.

Suggested PPE depending on solution and work environment:

- Safety shoes
- Goggles
- Hearing protection

4.2 Preparation

Fuel Cell Megablock system is to be connected to a variable power consumer such as a load bank or grid connection.

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4.3 Steady state testing

4.3.1 Apply rated power of the fuel cell Megablock system.

4.3.2 Monitor and record the following parameters for at least 10 minutes:

- Voltage
- Frequency
- THDi
- THDu

4.3.3 Analyse data to make sure recorded values are within the limits.

Fill in the following table:

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤±5% At 400V: +/-20V			
	Frequency	≤0.5% At 50Hz: +/-0.25Hz			
	THDu	<5%			
	THDi	<5%			

4.4 Dynamic testing

4.4.1 Apply the following load step changes of rated power of the system. In systems where these load steps are not possible perform alternative dynamic tests:

- 0% to 35%
- 35% to 70%
- 65% to 100%
- 100% to 50%
- 50% to 0%

If it is not possible to perform these load steps, due to either system design or test setup, alternative load steps shall be used, and these should be confirmed with SME and test engineer.

4.4.2 Monitor and record the following parameters for at least 1 minute after each load change:

- Voltage
- Frequency
- THDi
- THDu

Fill in the following tables:

4.4.3 0% to 35%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤-15[c]% At 400V: (<60V_{ac} droop)			
	Frequency	≤-/7+δf_{st})[c] % At 50Hz: >45Hz			
	THDu	<5%			
	THDi	<5%			

4.4.4 35% to 70%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤-15[c]% At 400V: (<60V_{ac} droop)			

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Frequency	≤-/7+δf_{st})^{c} % At 50 Hz: >45Hz			
	THDu	<5%			
	THDi	<5%			

4.4.5 65% to 100%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤-15^{c}% At 400V: (<60V_{ac} droop)			
	Frequency	≤-/7+δf_{st})^{c} % At 50Hz: >45Hz			
	THDu	<5%			
	THDi	<5%			

4.4.6 100% to 50%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤+20% At 400V: (<80V_{ac} overshoot)			
	Frequency	≤+10% At 50Hz <55Hz			

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Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	THDu	<5%			
	THDi	<5%			

4.4.7 50% to 0%

Date tested	Parameter	Criteria (ISO8528-5:2022, Table 4)	Result	Pass/Fail	Notes
	Voltage	≤+20% At 400V: (<80V_{ac} overshoot)			
	Frequency	≤+10% At 50Hz: <55Hz			
	THDu	<5%			
	THDi	<5%			

5.0 Appendix

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SPC ID 0204 System Pressure Decay Test Template

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-	Initial Draft	TAN	21/08/2024
1	Released	TAN	30/08/2024
2	Updated	TAN	09/09/2024

Purpose	Pressure decay test template for recording tightness and evaluating system pipework integrity
Reference procedure	SPC ID 0104 rev 002 H2 Leak Test Procedure

Checked by	MHA	Date: 09/09-2024
Approved by	MHA	Date: 09/09-2024

Title	
Project	
Test date	
Identification of piping system (photo or P&ID) [✓ or -]	

Test volume	
Test fluid/gas	
Test location	
Test performed by	
Results approved by	
Filing date	

L_S - Expected leak rate for pipework system							
Ferrule fittings tightness tolerance	<		bar				
Bonded seal tightness tolerance	<		bar				
L_S total*	= 0		bar				
L_S total	=	0	NM3/h				
L_Mu - Measuring system uncertainty							
pressure gauge uncertainty							
transmitter FS (full scale)	=		barg				
Linearity	<		% of FS	=	<	0	mbar
Non-repeatability	<		% of FS	=	<	0	mbar
Analogue input	±		microA	=			mbar/10 minutes
Accuracy ±0.25% actual reading	±		microA		=		mbar
Temperature uncertainty (3 Kelvin)				=	±	82	mbar/10 minutes
L_Mu total					=	82,0	mbar
*=All joints and valves are considered to be classified "enhanced tightness". Hence zero allowable leak rate							

Calculation of L_Mu, measuring system uncertainty

	V	T0	T1	T2	P0	P1	P2	Pa1	Pa2	t	L_Mu
	M3	°C	°C	°C	kPa	barg	barg	kPa	kPa	minutes	NM3/h
String 1	3,46E-03	15	15	15	101,325	7,150	7,068	101,325	101,325	10	1,68E-03
String 2	3,05E-03	15	15	15	101,325	7,150	7,068	101,325	101,325	10	1,48E-03

String 3	2,67E-03	15	15	15	101,325	7,150	7,068	101,325	101,325	10	1,29E-03
String 4	2,74E-03	15	15	15	101,325	7,150	7,068	101,325	101,325	10	1,33E-03
String 5	3,12E-03	15	15	15	101,325	7,150	7,068	101,325	101,325	10	1,52E-03
String 6	3,50E-03	15	15	15	101,325	7,150	7,068	101,325	101,325	10	1,70E-03

Calculation of L_A, max evaluated leak rate for pipework system acceptance

	L_S	L_Mu		L_A
	NM3/h	NM3/h		NM3/h
String 1	0	1,68E-03	=	1,68E-03
String 2	0	1,48E-03	=	1,48E-03
String 3	0	1,29E-03	=	1,29E-03
String 4	0	1,33E-03	=	1,33E-03
String 5	0	1,52E-03	=	1,52E-03
String 6	0	1,70E-03	=	1,70E-03

Procedure

Fill in design pressure = barg
The Test Pressure is 1.1 times design pressure or above = 0 barg
If the system previosly has been leakage tested with formier gas, this test can also use the used gas for operation
To perform the test follow "Sequence" paragraph 5.5.3 in SPC 0104 H2 Leak Test Procedure

Calculation of L1, actual leak rate

	V	T0	T1	T2	P0	P1	P2	Pa1	Pa2	t	L1 (gas leakage rate)
	M3	°C	°C	°C	kPa	barg	barg	kPa	kPa	minutes	NM3/h
String 1		15			101,325						#DIV/0!
String 2		15			101,325						#DIV/0!
String 3		15			101,325						#DIV/0!
String 4		15			101,325						#DIV/0!
String 5		15			101,325						#DIV/0!
String 6		15			101,325						#DIV/0!

Sensor	Sensor placement
Temperature sensor T1 & T2	BT01 Sensor in H2 heater
Pressure sensor P1 & P2	FCwave pressure inlet sensor
Atmospheric pressure Pa1 & Pa2	Data from https://www.dmi.dk/maalinger/show/DK/2620167/Hobro/

Result of test

	L1	<	L_A	Pass (Below acceptance criteria L_A)
	NM3/h		NM3/h	Pass/Fail
String 1	#DIV/0!	<	1,68E-03	
String 2	#DIV/0!	<	1,48E-03	
String 3	#DIV/0!	<	1,29E-03	
String 4	#DIV/0!	<	1,33E-03	
String 5	#DIV/0!	<	1,52E-03	
String 6	#DIV/0!	<	1,70E-03	

Title:
P&ID of Hydrogen Supply system

SPC ID:
Revision:

Printed on:

Sub Section J99-002

Test Matrix for FAT & SAT

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	25/06/2024	First Issue
002	06/08/2024	Added Testing for H2 Pre-heating System (F19)
003	31/07/2025	Updates to reflect tests completed during SAT/IOT

Document Title:	**BLPH Project - Test Matrix for FAT & SAT**
Document Number:	K559-2254-CWIWP4202202-J99-002
Revision:	Rev003
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-J99-002-Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99-002
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

				FAT round 1 and 2 [-F]						SAT and IOT [-S]			
Test phase	**Test ID**	**Test name**	**Test description**	**External test**	**Ballard Internal**	**Ballard Report**	**Witnessed FAT**	**Estimated Duration [hrs]**	**Installation**	**Ballard SAT internal**	**Ballard SAT report**	**SAT witnessed**	**Estimated Duration [hrs]**
Functional tests	**F01**	Weight	Weighing of: -40 foot container -10 foot container -Cooling platform	x		x							
	F02	Visual inspection	-Examine paint job -Assess overall build quality -Check for dents			x	x	3			x	x	3
	F03	Cooling leakage HT1	Pressure decay test of HT1			x				x			
	F04	Cooling leakage HT2	Pressure decay test of HT2			x				x			
	F05	Cooling leakage LT	Pressure decay test of LT			x				x			
	F06	Interconnection test - Electrical	Inspection of interconnection between 40foot container and cooling platform		x				M				
	F07	Electrical safety test- 10 foot container	-Electrical safety -Grounding continuity -High Potential and other relevant testing			x	x	0,5			x		
	F08	Electrical safety test- 40 foot container	Electrical safety Grounding continuity High Potential and other relevant testing			x	x	0,5			x		
	F09	Power up	Power up electrical system controls using external AUX and verify everything is working as expected: -Light and accessories -Master container controller and HMI -Cooler interface board		x				M	x			
	F10	Safety	Test of Safety Input and Outputs, including emergency stop buttons, smoke detectors, gas detectors and external connections			x	x	0,5			x		
	F11	Busbar torque checks	Ensure that the electrical busbar connections are properly secured with the expected torque setting on the connections. Torqued during installation and marked		x				M				
	F12	AUX power	Power up electrical system using external AUX and verify 400VAC BOP components are working as expected: -LT pump -HT1 pump -HT2 pump -40 foot container ventilation -DC/DC cabinet ventilation -Container heating -LT cooler fans -HT1 cooler fans -HT2 cooler fans		x				M	x			
	F13	Nanogrid / AUX integration	Safe transfer switch AUX to Nanogrid		x				M				
	F14	24VDC in 40 foot container	Voltage checks on 24V supply		x				M				
	F15	24VDC in 40 foot container from Battery UPS	Voltage checs of 24V when supplied from UPS		x				M				
	F16	Nanogrid load test	Measure power consumption: -Max load cold case (Full heating, minimal fans and pump speeds) -Max load warm case (No heating, maximum fans and pump speeds)			x				x			
	F17	H2 valve - installation	Use service interface to verify correct FC / H2valve set-up		x				M				
	F18	H2 leakage	Pressure decay and sniffer test			x	x	0,5			x	x	0,5
	F19	H2 Heater Test	Start up time, thermal stability and power sonsumption			x				x			
Pre-operation tests	**P01**	Fuel cell commissioning	Commissioning according to PWR008 by service technician			x				(only re-conditioning)			
	P02	Emergency stop	Verify emergency stop function during stand-by			x				x			
	P03	Emergency stop - shut down	Verify emergency stop function on power producing system			x				x			
	P04	Steady state operation - HT1 cooler function	Verify performance of cooling by operating at maximum load and all cooling components forced to 100%			x							
	P05	Steady state operation - HT2 cooler function	Verify performance of cooling by operating at maximum load and all cooling components forced to 100%			x							
	P06	Steady state operation - LT cooler function	Verify performance of cooling by operating at maximum load and all cooling components forced to 100%			x							
	P07	Steady state operation - ventilation function	Verify performance of cooling by operating at maximum load and all cooling components forced to 100%			x							
	P08	Thermographic report - cooling and ventilation	Thermographic inspection report of solution with focus on cooling and ventilation performance			x							
	P09	Thermographic report - electrical	Thermographic inspection report of relevant electrical installations			x							
Operation tests	**O01**	System Start/Stop - normal low load operation	Fuel Cell system can start, deliver minimum power and perform controlled stop without faults			x	x	2			x	x	2
	O02	Error resulting in loss of one FC module	Verify that FCwave stops in case of simulate error and correct transfer to next Fcwave			x							
	O03	1 FC module out for service	Verify that Fcwave out for service does correct transfer to next Fcwave		x								
	O04	Steady state operation 1-3	Operate system at 100% load and achieve thermal steady state		x					x			
	O05	Steady state operation 4-6	Operate system at 100% load and achieve thermal steady state		x					x			
	O06	Noise level test	Measure noise level while running system at 100% load			x							
	O07	Load Test - Ramp up	Ramp up from 0kW to 1000kW in 180 seconds, while measuring AC power quality			x					x	x	0,5
	O08	Load Test - Ramp down	Ramp down from 1000kW to 0kW in 180 seconds, while measuring AC power quality			x					x	x	0,5
	O09	Load Test - step response 0% to 35%	Test step response by adding 35% load in one step from no load			x	x	1					
	O10	Load Test - step response 35% to 70%	Test step response by adding 35% load in one step to reach 70% load			x	x	1					
	O11	Load Test - step response 65% to 100%	Test step response by adding 35% load in one step to reach full load			x	x	1					
	O12	Load Test - 100% stability test	Run 100% load to show the full system is performing as intended			x	x	3			x	x	1
	O13	Load Test - step response 100% to 50%	Test step response by removing 50% load in one step at full load			x	x	1					
	O14	Load Test - step response 50% to 0%	Test step response by removing 50% load in one step to no load			x	x	1					
						Hours of witness testing		15				Hours of witness testing	7,5

Sub Section J99-003

Confirmation of Satisfactory SAT-Signature page

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	16/01/2025	First Issue
002	01/08/2025	Signature from Ballard

Document Title:	**BLPH Project - Confirmation of Satisfactory SAT - Signature Page.pdf**
Document Number:	K559-2254-CWIWP4202202-J99-3-003
Revision:	Rev002
Sequence Number:	003
File Name:	K559-2254-CWIWP4202202-J99-3-003Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99-3
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Ballard Power Systems Europe A/S
Majsmarken 1
DK-9500 Hobro
K559-2254-CWIWP4202202-J99-003

Confirmation of Satisfactory SAT

Part No.	601456B-7002362 Incl. sub-assemblies: 601456B-7002973 601456B-7003716
Product name	FC PowerGen 1000kW
Serial No.	601456B

Ballard Power Systems Europe A/S confirms that the above-listed equipment has satisfactorily with comments undergone and passed the Site Acceptance Test (SAT) according to

BLPH Project – Site Acceptance Test (SAT) Procedure [K559-2254-CWIWP4202202-J99-001]

BLPH Project - Test Matrix for FAT and SAT [K559-2254-CWIWP4202202-J99-002]

prior to the site integration test.

CrossWind C.V. acknowledges that the Site Acceptance Test (SAT) for the above-listed equipment was witnessed and confirms that the test was performed satisfactorily with comments, and all agreed-upon specifications have been met.

Signatures

Ballard Power Systems Europe A/S			
Signature:			
Name:	Rasmus Knudsen		
Title:	Test Engineer	Date:	01/08/2025
CrossWind C.V.			
Signature:			
Name:	John Mackillop		
Title:	Crosswind Operations Engineer	Date:	05/08/25
Inspector			
Signature:			
Name:			
Title:	Inspector for Crosswind	Date:	

Note: This document serves as formal confirmation that the SAT has been successfully completed and witnessed, with both parties in agreement on the satisfactory results. It should be signed by authorized representatives of both parties.

Sub Section J99-004

F10 Safety Checklist

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
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Revision history		
Rev.	**Date.**	**Description**
001	16/01/2025	First Issue

Document Title:	**BLPH Project - F10, Safety checklist**
Document Number:	K559-2254-CWIWP4202202-J99-4-004
Revision:	Rev001
Sequence Number:	004
File Name:	K559-2254-CWIWP4202202-J99-4-004Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99-4
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Title	F10 Safety checklist
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Checklist for safety inputs

Main location	Location	Checked
40ft container	Emergency pushbuttons	
	40ft side door	
	UC50	
	UC30	
	Smoke detector	
	Left	
	Middle	
	Right	
	H2 sensor	
	Left	
	Middle	
	Right	
	External safety swithces	
	External feedback	

Sub Section J99-005

F07 u0026 F08, Electrical safety SAT

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
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Revision history		
Rev.	**Date.**	**Description**
001	16/01/2025	First Issue

Document Title:	**BLPH Project -F07 \u0026 F08, Electrical safety SAT**
Document Number:	K559-2254-CWIWP4202202-J99-5-005
Revision:	Rev001
Sequence Number:	005
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99-5
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Grounding continuity
EN 60204-1:2018 - Section 18.2.2 - Test 1
Test performed with a test current of 10A

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	Busbar to busbar	0,024	Ohm	
	Module 1	0,018	Ohm	
	DC/DC cabinet 1	0,023	Ohm	
	Module 2	0,024	Ohm	
	DC/DC cabinet 2	0,019	Ohm	
	Module 3	0,026	Ohm	
	DC/DC cabinet 3	0,016	Ohm	
	Module 4	0,026	Ohm	
	DC/DC cabinet 4	0,016	Ohm	
	Module 5	0,024	Ohm	
	DC/DC cabinet 5	0,017	Ohm	
	Module 6	0,029	Ohm	
	DC/DC cabinet 6	0,015	Ohm	
	Control cabinet	0,021	Ohm	
	Control cabinet right door	0,032	Ohm	
	Lifting crane track, dolly	0,028	Ohm	
	LT piping	0,031	Ohm	
	Isolation transformer cover	0,039	Ohm	
	Cable tray	0,019	Ohm	

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	Busbar to busbar	0,019	Ohm	
	Main DC/Acpoint 1	0,032	Ohm	
	Main DC/Acpoint 2	0,024	Ohm	
	Main DC/Acpoint 3	0,027	Ohm	
	DC/AC conduncter point 1	0,037	Ohm	
	DC/AC conduncter point 2	0,022	Ohm	
	DC/AC conduncter point 3	0,023	Ohm	
	LT coolant pipe	0,024	Ohm	
	Cable tray	0,02	Ohm	
	Main transforer grounding bolt	0,023	Ohm	
	Main transformer chassis	0,02	Ohm	
	Cable tray	0,022	Ohm	

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Isolation resistance
EN 60204-1:2018 - Section 18.3
Test performed with a test voltage of 1000V

Main location	Location	Measurement FAT	Unit	Measurement SAT
40 ft container	L1-PE	> 999.9	MOhm	
	Cooling skid L1	10,01	Mohm	
	Colling skid L2	6,252	Mohm	
	Cooling skid L3	12,81	Mohm	
	AUX supply L1	251	Mohm	
	AUX supply L2	337	MOhm	
	AUX supply L3	237	Mohm	

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	L1+L2+L3-PE on AC circuit	592	Mohm	

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	
Test location	
Test performed by	

Isolation resistance

EN 60204-1:2018 - Section 18.4

Test performed with a test voltage of 2500VAC

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	PE and L1	0	mA	
	PE and L2	0	mA	
	PE and L3	0	mA	

Main location	Location	Measurement FAT	Unit	Measurement SAT
10 FT container	PE and L1	7,1	mA	
	PE and L2	7,1	mA	
	PE and L3	7	mA	

Sub Section J99-006

EN 60204 Electrical safety test 10ft

Ballard Power Systems Europe A/S
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9500 Hobro
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Revision history		
Rev.	**Date.**	**Description**
001	16/01/2025	First Issue

Document Title:	**BLPH Project -EN 60204 Electrical safety test 10ft**
Document Number:	K559-2254-CWIWP4202202-J99-6-006
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Sequence Number:	006
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99-6
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Megablock		10ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

1. Introduction

The Megablock system contains many components utilizing potentially dangerous voltages and currents. It is a safety requirement that the electrical safety is tested before a product is shipped.

The testing is done according to the standard EN60204-1 Chapter 18, from which the tests in this document are described with room to note test results.

2. Revision Record

Rev #	Author	Description	Revised By	Date
1.0	PBL	Initial Release		09/11-2023
2.0	PBL	Adapted from 40ft Coolant Skid document		04/07-2024
3.0	RKN	General review		09/01-2025

3. List of Figures

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4. List of Tables

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5. Purpose and structure of this document

As Megablock is a large system, containing several parts assembled individually and brought together to fulfill the customer requirements, the components are tested individually.

With each component tested before final assembly, the interconnect must be tested, both before initial operation and after any disassembly, e.g. after shipping.

The purpose of this document is to compare the requirements outlined in EN60204-1 Chapter 18 against following testing performed Megablock components.

This is required for the CE approval of the Megablock Fuel Cell Power Plant.

This document is structured as follows:

1. The requirements from EN60204-1 are outlined:
    a. Section 7
2. Test Specifications to comply with the requirement outlined above.
    a. Sections 10 to 16
3. Summary table
    a. Section 17

6. References

Document	Title	Author
DS/EN 60204-1:2018	Safety of machinery – Electrical equipment of machines – Part 1: General Requirements	CENELEC

Table 1 – References

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7. Requirements from EN60204-1 Ch 18

Figure 1 is reproduced from the EN60204-1 Ch18.1:

18.1 General

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g):

a) verification that the electrical equipment complies with its technical documentation;
b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to 18.2;
d) insulation resistance test (see 18.3);
e) voltage test (see 18.4);
f) protection against residual voltage (see 18.5);
g) verification that the relevant requirements of 8.2.6 are met;
h) functional tests (see 18.6).

Figure 1 – Excerpt from EN60204-1:2018, Chapter 18.1

The mapping between the headlines from the standard and the requirement ID used in this document is listed in Table 2.

Requirement headline	EN60204-1 Chapter 18.1	EN60204-1 Chapter	Requirement ID
Verification that the electrical equipment complies with its technical documentation	A	n/a	A1
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	B	18.2.2 – Test #1	A2
Verification of conditions for protection by automatic disconnection of supply	C	18.2	A3
Insulation resistance tests	D	18.3	A4
Voltage tests	E	18.4	A5
Protection against residual voltages	F	18.5	A6
Verification that the relevant requirements of 8.2.6 are met	G	8.2.6	A7

Table 2 – Requirement headlines, chapter, and ID mapping

Functional testing of the equipment is outside the scope of this document.

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Megablock		10ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

8. Test Equipment.

The test equipment is a CE MultiTester, manufactured by Metrel.

Test Equipment	Ballard Equipment ID	Calibration valid until:

9. Device Under Test

The device to be tested is the 10ft container for the Megablock project.

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10. A1 – Verification that the electrical equipment complies with its technical documentation

EN60204-1 requirements:

a) verification that the electrical equipment complies with its technical documentation;

Figure 2 – EN60204-1:2018, Chapter 18.1

Megablock Component requirements:

Inspection of the electrical equipment and cabinets to ensure congruence between documentation and equipment/cabinet.

Megablock Component validation:

Component	10ft Container
Result (pass/fail)	
Date and Initials	

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Megablock		10ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

11. A2 – Verification of continuity of the protective bonding circuit

EN60204-1 requirements:

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

Figure 3 – EN60204-1:2018, Chapter 18.2.2

Megablock Component requirements:

The EN60204-1 Chapter 18.2.2, Test #1 specifies a current of 10A.

Megablock Component bonding resistance test is performed with a current of 10A and a test period of 10 seconds.

Megablock Component validation:

The primary earthing point for the Power Converter Container is the main ground bar located at the rear of the main output breaker (=BA30-FC30).

Each component is verified and compared to expected values for the following locations.

ID	Test Point	Expected Value	Recorded Value
1	Busbar to busbar	<100mΩ	
2	Main DC/Acpoint 1		
3	Main DC/Acpoint 2		
4	Main DC/Acpoint 3		
5	DC/AC conduncter point 1		
6	DC/AC conduncter point 2		
7	DC/AC conduncter point 3		
8	LT coolant pipe		
9	Cable tray		

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Megablock		10ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

10	Main transforer grounding bolt		
11	Main transformer chassis		
12	Cable tray		

Table 3 – Bonding Resistance Test point and expected resistance values.

When performing the test, ensure the connection between the test leads and the equipment is not contributing to inaccurate measurements.

12. A3 - Verification of conditions for protection by automatic disconnection of supply

EN60204-1 requirements:

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Figure 4 – EN60204-1:2018, Chapter 18.2

Megablock Component requirements:

As specified in chapter 18.2.1, Test #1 is performed (see section 11). Chapter 18.2.1 further specifies testing of Residual Current Devices (RCD) according to manufacturer specifications.

Megablock Component module does not contain any RCD devices.

13. A4 - Insulation resistance tests

EN60204-1 requirements:

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Figure 5 – EN60204-1:2018, Chapter 18.3

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Megablock		10ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

Megablock Component requirements:

Before performing this test, isolate all fuel cell DCDC converters from the DC bus (Cabinets UC01 to UC06)

Use a set of test leads and alligator clips to create a single AC node (3 phases shorted together)

The Megablock Component insulation requirements are higher than as specified chapter 18.3. The test is specified in Table 4):

Test point	Pass criteria	Test Voltage [VDC]
=LA01+UC31-QB01	>1MΩ	500

Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements

Megablock Component validation:

Each component is verified and compared to pass criteria in Table 4.

Component	Power Converter Container
Result – AC Node (value and pass/fail)	
Date and Initials	

14. A5 – Voltage tests

EN60204-1 requirements:

18.4 Voltage tests

When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected during testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

Figure 6 – EN60204-1:2018, Chapter 18.4

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Megablock Component requirements:

The requirements from EN 60204-1:2018, Chapter 18.4 is compared in Table 5.
AC Voltage for Megablock Components is at most 480V, so twice the supply voltage is 960Vac.

Parameter	EN 60204-1:2018, Chapter 18.4	Megablock Component Testing
Voltage [VAC]	960	2500
Frequency [Hz]	50 or 60	50
Duration [sec]	1	10
Maximum Current [mA]	No arcing	5

Table 5 – Voltage Test Requirements

Megablock Component validation:

Connection point is internal side of main output breaker.

Component	Power Converter Container
Voltage Test – L1 (value and pass/fail)	
Voltage Test – L2 (value and pass/fail)	
Voltage Test – L3 (value and pass/fail)	
Date and Initials	

15. A6 – Protection against residual voltages

EN60204-1 requirements:

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

Figure 7 – EN60204-1:2018, Chapter 18.5

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Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V when the supply is disconnected shall be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 µC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure that contains the live parts.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can include children, warnings are not sufficient and therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

Figure 8 – EN60204-1:2018, Chapter 6.2.4

Megablock Component requirements:

Identical to EN60204-1 requirements.

Megablock Component validation:

No live parts of the Megablock Component system are accessible without disassembling barriers or accessing electrical cabinets. All connectors are IP2X or higher in unmated state in applications higher than 60V (power system)

Frequency converters and motor drives are marked with applicable durations before internal capacitors are discharged.

Maintenance procedures for the Megablock Component module include a manual verification before any work on exposed components is permitted.

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16. A7 – Verification that the relevant requirements of 8.2.6 are met

EN60204-1 requirements:

8.2.6 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA

Where electrical equipment has an earth leakage current that is greater than 10 mA AC or DC in any protective conductor, one or more of the following conditions for the integrity of each section of the associated protective bonding circuit that carries the earth leakage current shall be satisfied:

a) the protective conductor is completely enclosed within electrical equipment enclosures or otherwise protected throughout its length against mechanical damage;

b) the protective conductor has a cross-sectional area of at least 10 mm^2 Cu or 16 mm^2 Al;

c) where the protective conductor has a cross-sectional area of less than 10 mm^2 Cu or 16 mm^2 Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.

d) the supply is automatically disconnected in case of loss of continuity of the protective conductor;

e) where a plug-socket combination is used, an industrial connector in accordance with IEC 60309 series, with adequate strain relief and a minimum protective earthing conductor cross-section of 2,5 mm^2 as part of a multi-conductor power cable is provided.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.6.

Figure 9 – EN60204-1:2018, Chapter 8.2.6

Megablock Component requirements:

The Megablock Component does not have a leakage current higher than 10mA.

Megablock Component validation:

The protection against excessive leakage current is twofold:

- Ground fault detection is installed with a proven component (Bender Isometer). Detection of ground fault causes system shutdown and service technician is dispatched.
- Conductivity measurement of internal coolant is a part of the regular maintenance procedures (see N01-003 Service and Maintenance Manual)

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17. Summary Table

The requirements from sections 10 to 16, together with results are summarized below in Table 6:

Requirement headline	EN60204-1 Chapter	Req ID	Pass/Fail?
Verification that the electrical equipment complies with its technical documentation	n/a	A1	
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	18.2.2 – Test #1	A2	
Verification of conditions for protection by automatic disconnection of supply	18.2	A3	
Insulation resistance tests	18.3	A4	
Voltage tests	18.4	A5	
Protection against residual voltages	18.5	A6	
Verification that the relevant requirements of 8.2.6 are met	8.2.6	A7	

Table 6 – Summary Table

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Sub Section J99-007

EN 60204 Electrical safety test 40ft

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Revision history		
Rev.	**Date.**	**Description**
001	16/01/2025	First Issue

Document Title:	**BLPH Project -EN 60204 Electrical safety test 40ft**
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Megablock		40ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

1. Introduction

The Megablock system contains many components utilizing potentially dangerous voltages and currents. It is a safety requirement that the electrical safety is tested before a product is shipped.

The testing is done according to the standard EN60204-1 Chapter 18, from which the tests in this document are described with room to note test results.

2. Revision Record

Rev #	Author	Description	Revised By	Date
1.0	PBL	Initial Release		09/11-2023
2.0	PBL	Adapted from 40ft Coolant Skid document		04/07-2024
3.0	CJA	Adapted from 10ft power converter container document		15/10-2024
4.0	RKN	General review		09/01-2025

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Figure 6 – EN60204-1:2018, Chapter 18.4 10
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Figure 8 – EN60204-1:2018, Chapter 6.2.4 11
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Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements 9

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Table 5 – Voltage Test Requirements 10
Table 6 – Summary Table 13

5. Purpose and structure of this document

As Megablock is a large system, containing several parts assembled individually and brought together to fulfill the customer requirements, the components are tested individually.

With each component tested before final assembly, the interconnect must be tested, both before initial operation and after any disassembly, e.g. after shipping.

The purpose of this document is to compare the requirements outlined in EN60204-1 Chapter 18 against following testing performed Megablock components.

This is required for the CE approval of the Megablock Fuel Cell Power Plant.

This document is structured as follows:

1. The requirements from EN60204-1 are outlined:
    a. Section 7
2. Test Specifications to comply with the requirement outlined above.
    a. Sections 10 to 16
3. Summary table
    a. Section 17

6. References

Document	Title	Author
DS/EN 60204-1:2018	Safety of machinery – Electrical equipment of machines – Part 1: General Requirements	CENELEC

Table 1 – References

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7. Requirements from EN60204-1 Ch 18

Figure 1 is reproduced from the EN60204-1 Ch18.1:

18.1 General

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g):

a) verification that the electrical equipment complies with its technical documentation;
b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to 18.2;
d) insulation resistance test (see 18.3);
e) voltage test (see 18.4);
f) protection against residual voltage (see 18.5);
g) verification that the relevant requirements of 8.2.6 are met;
h) functional tests (see 18.6).

Figure 1 – Excerpt from EN60204-1:2018, Chapter 18.1

The mapping between the headlines from the standard and the requirement ID used in this document is listed in Table 2.

Requirement headline	EN60204-1 Chapter 18.1	EN60204-1 Chapter	Requirement ID
Verification that the electrical equipment complies with its technical documentation	A	n/a	A1
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	B	18.2.2 – Test #1	A2
Verification of conditions for protection by automatic disconnection of supply	C	18.2	A3
Insulation resistance tests	D	18.3	A4
Voltage tests	E	18.4	A5
Protection against residual voltages	F	18.5	A6
Verification that the relevant requirements of 8.2.6 are met	G	8.2.6	A7

Table 2 – Requirement headlines, chapter, and ID mapping

Functional testing of the equipment is outside the scope of this document.

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Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

8. Test Equipment.

The test equipment is a CE MultiTester, manufactured by Metrel.

Test Equipment	Ballard Equipment ID	Calibration valid until:

9. Device Under Test

The device to be tested is the 40ft Fuel Cell Container for the Megablock project.

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Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

10. A1 – Verification that the electrical equipment complies with its technical documentation

EN60204-1 requirements:

a) verification that the electrical equipment complies with its technical documentation;

Figure 2 – EN60204-1:2018, Chapter 18.1

Megablock Component requirements:

Inspection of the electrical equipment and cabinets to ensure congruence between documentation and equipment/cabinet.

Megablock Component validation:

Component	40ft Container
Result (pass/fail)	
Date and Initials	

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11. A2 – Verification of continuity of the protective bonding circuit

EN60204-1 requirements:

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

Figure 3 – EN60204-1:2018, Chapter 18.2.2

Megablock Component requirements:

The EN60204-1 Chapter 18.2.2, Test #1 specifies a current of 10A.

Megablock Component bonding resistance test is performed with a current of 10A and a test period of 10 seconds.

Megablock Component validation:

The primary earthing point for the 40ft Fuel Cell Container is the main ground bar located in +UC50.

Each component is verified and compared to expected values for the following locations.

ID	Test Point	Expected Value	Recorded Value
1	Busbar to busbar	<100mΩ	
2	Module 1		
3	DC/DC cabinet 1		
4	Module 2		
5	DC/DC cabinet 2		
6	Module 3		
7	DC/DC cabinet 3		
8	Module 4		
9	DC/DC cabinet 4		
10	Module 5		
11	DC/DC cabinet 5		

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12	Module 6		
13	DC/DC cabinet 6		
14	Control cabinet		
15	Control cabinet right door		
16	Lifting crane track, dolly		
17	LT piping		
18	Isolation transformer cover		
19	Cable tray		

Table 3 – Bonding Resistance Test point and expected resistance values.

When performing the test, ensure the connection between the test leads and the equipment is not contributing to inaccurate measurements.

12. A3 - Verification of conditions for protection by automatic disconnection of supply

EN60204-1 requirements:

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Figure 4 – EN60204-1:2018, Chapter 18.2

Megablock Component requirements:

As specified in chapter 18.2.1, Test #1 is performed (see section 11).

Chapter 18.2.1 further specifies testing of Residual Current Devices (RCD) according to manufacturer specifications.

Megablock RCD Testing:

All RCD (Residual Current Device) in the Megablock system is equipped with self-test functionality from the manufacturer. This takes the shape of a push button, which must cause the RCD device to trip when actuated.

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Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

For the test, first enable all RCD circuits, and then actuate the self-test button on the devices. The devices must trip within 1 second. After the trip, use a multimeter to verify that the output of the device has no voltage (<10VAC)

Component	RCD Devices in UC20 (40ft Control Cabinet)
Result – 3ph RCD	
Result – 1ph RCD/MCCB	
Date and Initials	

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13. A4 - Insulation resistance tests

EN60204-1 requirements:

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Figure 5 – EN60204-1:2018, Chapter 18.3

Megablock Component requirements:

Before performing this test, isolate all fuel cell DCDC converters from the DC bus (Cabinets UC01 to UC05)

Use a set of test leads and alligator clips to create a single AC node (3 phases shorted together)

The Megablock Component insulation requirements are higher than as specified chapter 18.3. The test is specified in Table 4):

Test point	Pass criteria	Test Voltage [VDC]
Internal side of the output breaker	>1MΩ	500

Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements

Megablock Component validation:

Each component is verified and compared to pass criteria in Table 4.

Component	Fuel Cell Container
Result – AC Node (value and pass/fail)	
Date and Initials	

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Megablock		40ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

14. A5 – Voltage tests

EN60204-1 requirements:

18.4 Voltage tests

When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected during testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

Figure 6 – EN60204-1:2018, Chapter 18.4

Megablock Component requirements:

The requirements from EN 60204-1:2018, Chapter 18.4 is compared in Table 5.
AC Voltage for Megablock Components is at most 480V, so twice the supply voltage is 960Vac.

Parameter	EN 60204-1:2018, Chapter 18.4	Megablock Component Testing
Voltage [VAC]	960	2500
Frequency [Hz]	50 or 60	50
Duration [sec]	1	10
Maximum Current [mA]	No arcing	5

Table 5 – Voltage Test Requirements

Megablock Component validation:

Connection point is internal side of main output breaker.

Component	Fuel Cell Container
Voltage Test – L1 (value and pass/fail)	
Voltage Test – L2 (value and pass/fail)	
Voltage Test – L3 (value and pass/fail)	
Date and Initials	

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Megablock		40ft Container Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	4.0.0

15. A6 – Protection against residual voltages

EN60204-1 requirements:

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

Figure 7 – EN60204-1:2018, Chapter 18.5

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V when the supply is disconnected shall be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 μC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure that contains the live parts.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can include children, warnings are not sufficient and therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

Figure 8 – EN60204-1:2018, Chapter 6.2.4

Megablock Component requirements:

Identical to EN60204-1 requirements.

Megablock Component validation:

No live parts of the Megablock Component system are accessible without disassembling barriers or accessing electrical cabinets. All connectors are IP2X or higher in unmated state in applications higher than 60V (power system)

Frequency converters and motor drives are marked with applicable durations before internal capacitors are discharged.

Maintenance procedures for the Megablock Component module include a manual verification before any work on exposed components is permitted.

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16. A7 – Verification that the relevant requirements of 8.2.6 are met

EN60204-1 requirements:

8.2.6 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA

Where electrical equipment has an earth leakage current that is greater than 10 mA AC or DC in any protective conductor, one or more of the following conditions for the integrity of each section of the associated protective bonding circuit that carries the earth leakage current shall be satisfied:

a) the protective conductor is completely enclosed within electrical equipment enclosures or otherwise protected throughout its length against mechanical damage;

b) the protective conductor has a cross-sectional area of at least 10 mm^2 Cu or 16 mm^2 Al;

c) where the protective conductor has a cross-sectional area of less than 10 mm^2 Cu or 16 mm^2 Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.

d) the supply is automatically disconnected in case of loss of continuity of the protective conductor;

e) where a plug-socket combination is used, an industrial connector in accordance with IEC 60309 series, with adequate strain relief and a minimum protective earthing conductor cross-section of 2,5 mm^2 as part of a multi-conductor power cable is provided.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.6.

Figure 9 – EN60204-1:2018, Chapter 8.2.6

Megablock Component requirements:

The Megablock Component does not have a leakage current higher than 10mA.

Megablock Component validation:

The protection against excessive leakage current is twofold:

- Ground fault detection is installed with a proven component (Bender Isometer). Detection of ground fault causes system shutdown and service technician is dispatched.
- Conductivity measurement of internal coolant is a part of the regular maintenance procedures (see N01-003 Service and Maintenance Manual)

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17. Summary Table

The requirements from sections 10 to 16, together with results are summarized below in Table 6:

Requirement headline	EN60204-1 Chapter	Req ID	Pass/Fail?
Verification that the electrical equipment complies with its technical documentation	n/a	A1	
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	18.2.2 – Test #1	A2	
Verification of conditions for protection by automatic disconnection of supply	18.2	A3	
Insulation resistance tests	18.3	A4	
Voltage tests	18.4	A5	
Protection against residual voltages	18.5	A6	
Verification that the relevant requirements of 8.2.6 are met	8.2.6	A7	

Table 6 – Summary Table

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Sub Section J99-008

EN 60204 Electrical safety test Cng Pltfrm

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Revision history		
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001	16/01/2025	First Issue

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Code:	J99-8
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

1. Introduction

The Megablock system contains many components utilizing potentially dangerous voltages and currents. It is a safety requirement that the electrical safety is tested before a product is shipped.

The testing is done according to the standard EN60204-1 Chapter 18, from which the tests in this document are described with room to note test results.

2. Revision Record

Rev #	Author	Description	Revised By	Date
1.0	PBL	Initial Release		9/11-2023
2.0	PBL	General updates		21/10-2024
3.0	RKN	General review		09/01-2025

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

Table 6 – Summary Table 14

5. Purpose and structure of this document

As Megablock is a large system, containing several parts assembled individually and brought together to fulfill the customer requirements, the components are tested individually.

With each component tested before final assembly, the interconnect must be tested, both before initial operation and after any disassembly, e.g. after shipping.

The purpose of this document is to compare the requirements outlined in EN60204-1 Chapter 18 against following testing performed Megablock components.

This is required for the CE approval of the Megablock Fuel Cell Power Plant.

This document is structured as follows:

1. The requirements from EN60204-1 are outlined:
    a. Section 7
2. Test Specifications to comply with the requirement outlined above.
    a. Sections 10 to 16
3. Summary table
    a. Section 17

6. References

Document	Title	Author
DS/EN 60204-1:2018	Safety of machinery – Electrical equipment of machines – Part 1: General Requirements	CENELEC

Table 1 – References

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7. Requirements from EN60204-1 Ch 18

Figure 1 is reproduced from the EN60204-1 Ch18.1:

18.1 General

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g):

a) verification that the electrical equipment complies with its technical documentation;
b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to 18.2;
d) insulation resistance test (see 18.3);
e) voltage test (see 18.4);
f) protection against residual voltage (see 18.5);
g) verification that the relevant requirements of 8.2.6 are met;
h) functional tests (see 18.6).

Figure 1 – Excerpt from EN60204-1:2018, Chapter 18.1

The mapping between the headlines from the standard and the requirement ID used in this document is listed in Table 2.

Requirement headline	EN60204-1 Chapter 18.1	EN60204-1 Chapter	Requirement ID
Verification that the electrical equipment complies with its technical documentation	A	n/a	A1
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	B	18.2.2 – Test #1	A2
Verification of conditions for protection by automatic disconnection of supply	C	18.2	A3
Insulation resistance tests	D	18.3	A4
Voltage tests	E	18.4	A5
Protection against residual voltages	F	18.5	A6
Verification that the relevant requirements of 8.2.6 are met	G	8.2.6	A7

Table 2 – Requirement headlines, chapter, and ID mapping

Functional testing of the equipment is outside the scope of this document.

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

8. Test Equipment.

Test Equipment	Ballard Equipment ID	Calibration valid until:

9. Device Under Test

The device to be tested is the coolant skid for the Megablock project. A rendering is shown below with selected items highlighted.

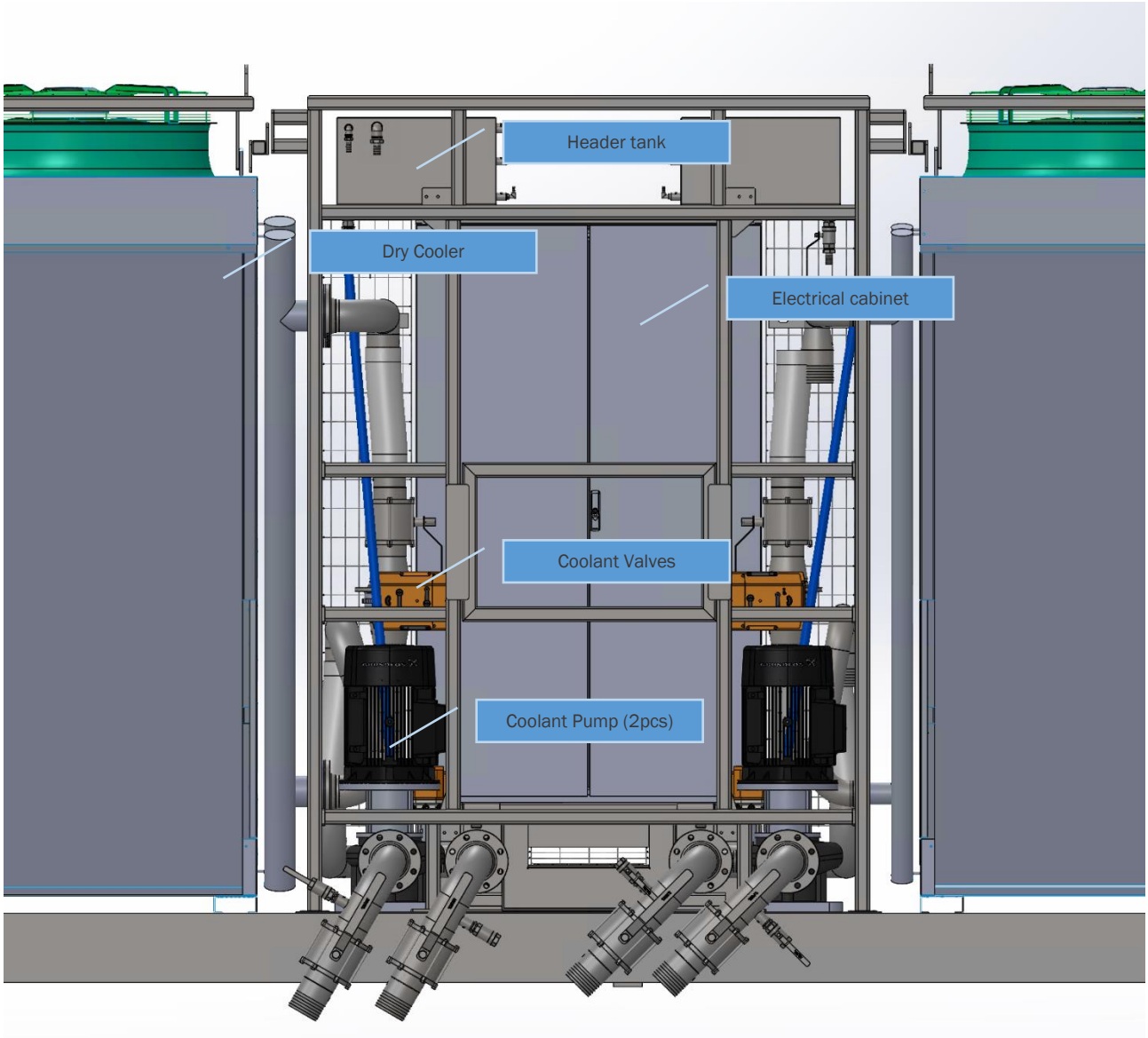


Figure 2 – Front view of coolant skid centre section with callouts.

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

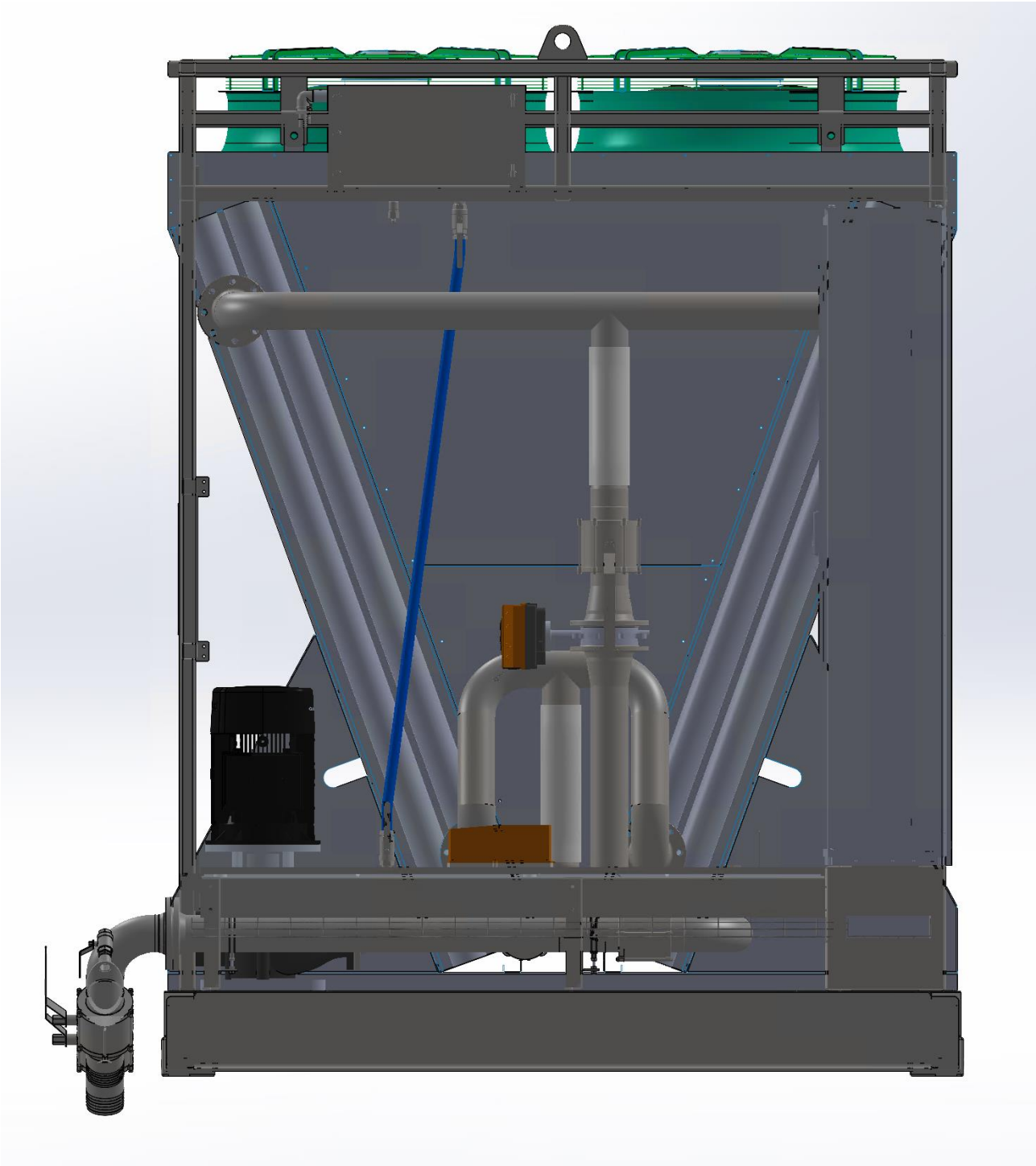


Figure 3 – Section view of the coolant skid, looking from centre towards left.

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Megablock		Electrical Safety Checklist	
Document type	*Author*	*Revision date*	*Revision*
Test Specification	RKN	09-01-2025	3.0.0

10. A1 – Verification that the electrical equipment complies with its technical documentation

EN60204-1 requirements:

a) verification that the electrical equipment complies with its technical documentation;

Figure 4 – EN60204-1:2018, Chapter 18.1

Megablock Component requirements:

Inspection of the electrical equipment and cabinets to ensure congruence between documentation and equipment/cabinet.

Megablock Component validation:

Component	Coolant Skid
Result (pass/fail)	
Date and Initials	

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11. A2 – Verification of continuity of the protective bonding circuit

EN60204-1 requirements:

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

Figure 5 – EN60204-1:2018, Chapter 18.2.2

Megablock Component requirements:

The EN60204-1 Chapter 18.2.2, Test #1 specifies a current of 10A.

Megablock Component bonding resistance test is performed with a current of 10A and a test period of 10 seconds.

Megablock Component validation:

The primary earthing point for the coolant skid is the main ground terminal in the control enclosure.

Each component is verified and compared to expected values for the following locations.

ID	Test Point	Expected Value	Recorded Value
1	Control Cabinet Backplate	<100mΩ	
2	Grounding Bar, Below PLC		
3	HT1 Cooling Pipe, From HT1 Cooler		
4	HT1 Manual Valve, HT1 Cooler Outlet		
5	HT1 Coolant Pump, Grounding Connection		
6	HT1 Header Tank, Bolts		
7	HT1 Cooler Frame (Metal)		
8	HT2 Cooling Pipe, From HT1 Cooler		
9	HT2 Manual Valve, HT1 Cooler Outlet		
10	HT2 Coolant Pump, Grounding Connection		

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11	HT2 Header Tank, Bolts		
12	HT2 Cooler Frame (Metal)		

Table 3 – Bonding Resistance Test point and expected resistance values.

When performing the test, ensure the connection between the test leads and the equipment is not contributing to inaccurate measurements.

Notes to test points:

- Point 1-2 is inside the electrical cabinet.
- Point 3-6 is indicated on Figure 6 – Test points for Grounding Test
- Point 7-12 are identical to points 3-6, except mirrored to HT2.

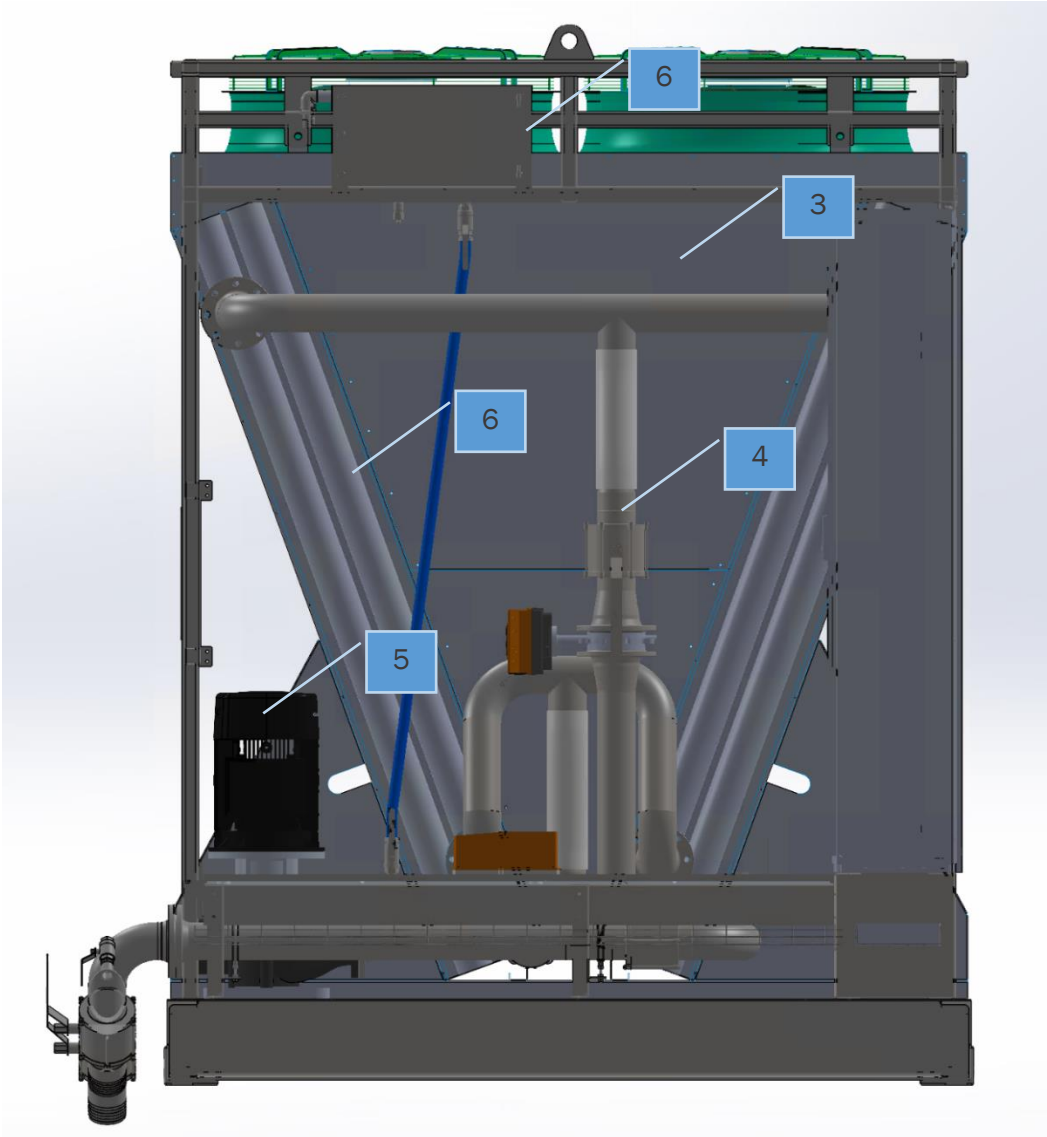


Figure 6 – Test points for Grounding Test

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12. A3 - Verification of conditions for protection by automatic disconnection of supply

EN60204-1 requirements:

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Figure 7 – EN60204-1:2018, Chapter 18.2

Megablock Component requirements:

As specified in chapter 18.2.1, Test #1 is performed (see section 11). Chapter 18.2.1 further specifies testing of Residual Current Devices (RCD) according to manufacturer specifications. Megablock Component module does not contain any RCD devices.

Megablock Component is not a TN-system, and Test #2 is not relevant.

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13. A4 - Insulation resistance tests

EN60204-1 requirements:

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Figure 8 – EN60204-1:2018, Chapter 18.3

Megablock Component requirements:

The Megablock Component insulation requirements are higher than as specified chapter 18.3. The test is specified in Table 4):

Test point	Pass criteria	Test Voltage [VDC]
UC40-FC04	>1MΩ	500

Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements

Megablock Component validation:

Each component is verified and compared to pass criteria in Table 4.

Component	Coolant Skid
Result – AC Node (value and pass/fail)	
Date and Initials	

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14. A5 – Voltage tests

EN60204-1 requirements:

18.4 Voltage tests

When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected during testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

Figure 9 – EN60204-1:2018, Chapter 18.4

Megablock Component requirements:

The requirements from EN 60204-1:2018, Chapter 18.4 is compared in Table 5.
AC Voltage for Megablock Components is at most 480V, so twice the supply voltage is 960Vac.

Parameter	EN 60204-1:2018, Chapter 18.4	Megablock Component Testing
Voltage [VAC]	960	2500
Frequency [Hz]	50 or 60	50
Duration [sec]	1	10
Maximum Current [mA]	No arcing	5

Table 5 – Voltage Test Requirements

Megablock Component validation:

Component	Coolant Skid
Voltage Test – L1 (value and pass/fail)	
Voltage Test – L2 (value and pass/fail)	
Voltage Test – L3 (value and pass/fail)	
Date and Initials	

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15. A6 – Protection against residual voltages

EN60204-1 requirements:

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

Figure 10 – EN60204-1:2018, Chapter 18.5

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V when the supply is disconnected shall be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 μC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure that contains the live parts.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can include children, warnings are not sufficient and therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

Figure 11 – EN60204-1:2018, Chapter 6.2.4

Megablock Component requirements:

Identical to EN60204-1 requirements.

Megablock Component validation:

No live parts of the Megablock Component system are accessible without disassembling barriers. All connectors are IP2X or higher in unmated state in applications higher than 60V (power system)

Frequency converters and motor drives are marked with applicable durations before internal capacitors are discharged.

Maintenance procedures for the Megablock Component module include a voltage drawdown process and manual verification before any work on exposed components is permitted.

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16. A7 – Verification that the relevant requirements of 8.2.6 are met

EN60204-1 requirements:

8.2.6 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA

Where electrical equipment has an earth leakage current that is greater than 10 mA AC or DC in any protective conductor, one or more of the following conditions for the integrity of each section of the associated protective bonding circuit that carries the earth leakage current shall be satisfied:

a) the protective conductor is completely enclosed within electrical equipment enclosures or otherwise protected throughout its length against mechanical damage;

b) the protective conductor has a cross-sectional area of at least 10 mm^2 Cu or 16 mm^2 Al;

c) where the protective conductor has a cross-sectional area of less than 10 mm^2 Cu or 16 mm^2 Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.

d) the supply is automatically disconnected in case of loss of continuity of the protective conductor;

e) where a plug-socket combination is used, an industrial connector in accordance with IEC 60309 series, with adequate strain relief and a minimum protective earthing conductor cross-section of 2,5 mm^2 as part of a multi-conductor power cable is provided.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.6.

Figure 12 – EN60204-1:2018, Chapter 8.2.6

Megablock Component requirements:

The Megablock Component does not have a leakage current higher than 10mA.

Megablock Component validation:

The protection against excessive leakage current is twofold:

- Ground fault detection is in the scope of the 10ft Container (DCAC system)
- Conductivity measurement of internal coolant is a part of the regular maintenance procedures (see N01-003 Service and Maintenance Manual)

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17. Summary Table

The requirements from sections 10 to 16, together with results are summarized below in Table 6:

Requirement headline	EN60204-1 Chapter	Req ID	Pass/Fail?
Verification that the electrical equipment complies with its technical documentation	n/a	A1	
Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2)	18.2.2 – Test #1	A2	
Verification of conditions for protection by automatic disconnection of supply	18.2	A3	
Insulation resistance tests	18.3	A4	
Voltage tests	18.4	A5	
Protection against residual voltages	18.5	A6	
Verification that the relevant requirements of 8.2.6 are met	8.2.6	A7	

Table 6 – Summary Table

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Sub Section J99-009

Ballard Method Statement

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	23/01/2025	First Issue
002	11/04/2025	Campaign 4 Hot Commissioning added
003	15/05/2025	Updated with all activities for hot commissioning

Document Title:	**BLPH Project-Ballard (Fuel Cell) Method Statement**
Document Number:	K559-2254-CWIWP4202202-J99-9-009
Revision:	Rev003
Sequence Number:	009
File Name:	K559-2254-CWIWP4202202-J99-9-009Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99-9
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Base Load Power Hub (BLPH)

TITLE: Ballard (Fuel Cell) Method Statement

Document Number: K559-2254-CWIWP4202202-J99-009

Rev.	Date	Description	Prepared	Reviewed	Approved
06	15/05/2025	Issue for Review (IFR)	JTA	PBL	KH
05	01/05/2025	Issue for Review (IFR)	RKN	JTA	KH
04	11/04/2025	Issue for Review (IFR)	RKN	JTA	KH
03	16/01/2025	Issue for Review (IFR)	PBL	RKN	KH
02	09/01/2025	Issue for Review (IFR)	PBL	RKN	KH
01	14/12/2024	Issue for Review (IFR)	PBL/RKN	MHA	MHA
00	06/11/2024	Issue for Review (IFR)	PBL/RKN	MHA	MHA

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Revision / Change Log

Rev.	Description
00	Issue for Review (internal only)
01	Updated for Mechanical Completion Dossier (internal only)
02	Added Software Update method statement (Activity 18) & aligned to new schedule (internal only)
03	Updated text on Cooler VFD test (Campaign 3, Activity 3)
04	Updated campaign 4 activities (hot commissioning)
05	Updates campaign 4 (hot commissioning)
06	Updates to include additional hot commissioning activities.

HOLDS LIST

No.	Description
1	
2	
3	
4	

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None

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

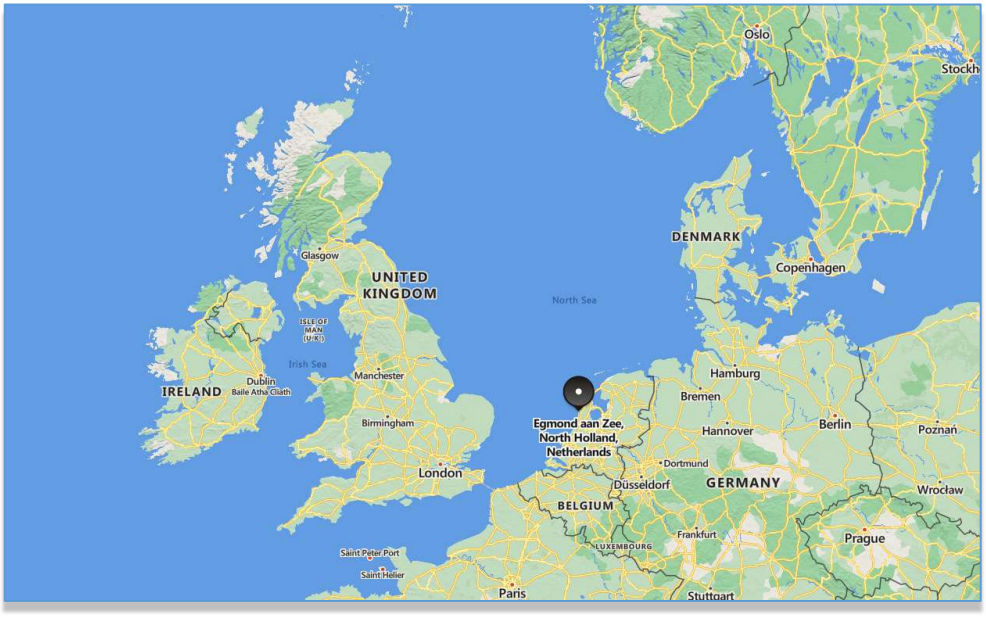


Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map

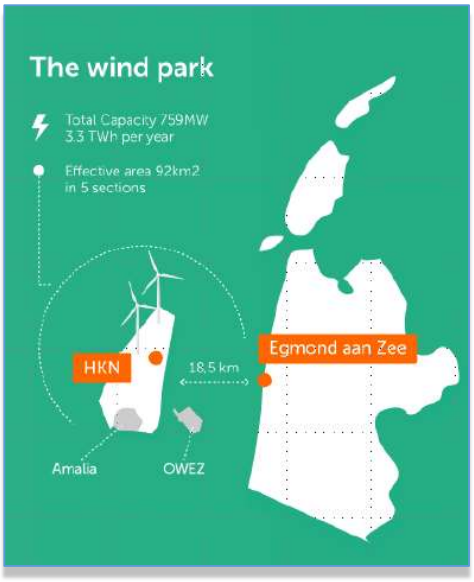


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile is located on coordinates E 590719.1, N 5841602.3 and is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

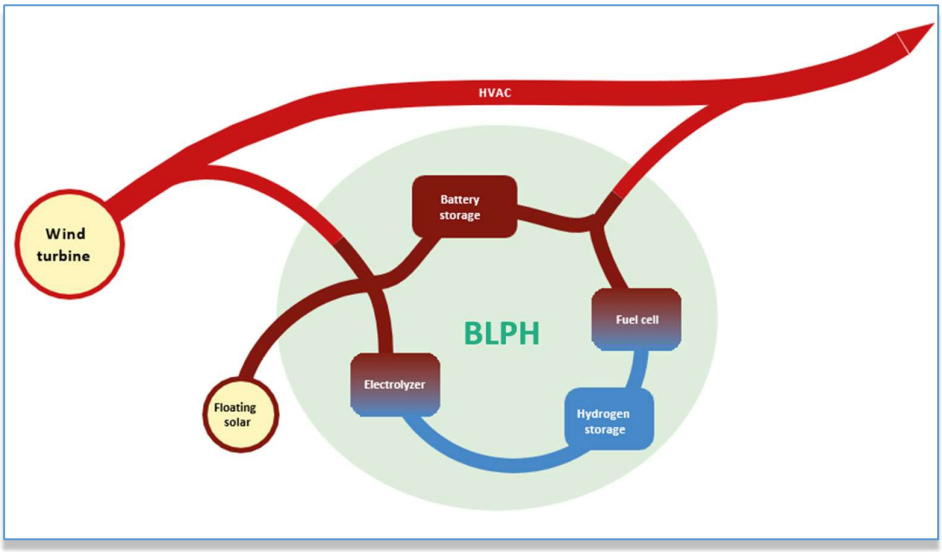


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH is to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

The purpose of this Procedure/Plan is to establish a detailed methodology for carrying out:

All activities at the integration yard.

2.1 REFERENCES

Doc. No.	Description
BLPH-Ballard-Fuel-Cell_Schedule-Update_Oct-2024_Rev007	Latest Ballard Schedule
K559-2254-CWIWP4202202-J99-001-Rev004	Site Acceptance Test (SAT) Procedure

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY)	CrossWind C.V.
CONTRACTOR (CTR)	ROSETTI MARINO S.p.A.
PROJECT	HOLLANDSE KUST NOORD WIND PARK Project
VENDOR	Ballard

Table 2 - Definitions and Abbreviations

2.3 LIST OF DRAWINGS

Drawing No.	Description
K559-2254-CWIWP4202202-B01-001Rev009	General Arrangement

2.4 APPLICABLE SPECIFICATIONS, CODES AND STANDARDS

Description	Company Doc. Number

2.5 CRITICALITY, KEY RISK AND CONTROLS

The work described in the procedure has been classified as Critical.

All the work must be carried in the vicinity of the Fuel Cell already installed on the platform. The key risk is electrical shock once energisation occurs, and risks associated with the introduction of hydrogen.

Adequate lighting shall be provided.

2.6 ROLES & RESPONSIBILITIES

2.6.1 Company Representative

Responsibilities:

- Management of all resources, equipment / materials and subcontractors mobilized for the execution of the onshore activities;
- Promotes safety & quality to all personnel within his organization;
- Assess project risks and ensure proper mitigation;

2.6.2 Vendor Representative

Responsibilities:

- Implements and issues a comprehensive and supported Progress Reporting System to the Project Manager all the necessary info to be used as a basis for decisions (i.e. Target, Actual & Forecast), to maintain analyses in a proactive manner the possible impacts to contractual key dates on a continuous basis.
- Preparation of project specific templates for Periodical Project Progress Report to Client (Daily)
- Safely execute the work in compliance with all HSE & Quality requirements.

2.6.3 Vendor workers

- Peter Blok Hansen (lead)
- Peter Van Black (lead – CE&I)
- Rasmus Knudsen (lead – Mechanical)
- John Holebæk
- Mikkel Kannegaard

2.7 LIST OF MACHINERIES, TOOLS AND EQUIPMENT

S.No.	DESCRIPTION	QTY
1	General PPE	3
2	Various tools for electrical wiring	1
3	Various tools for mechanical installation	1

4	H2 Sniffer - Sewerin Snooper Mini H2	1
5	Pressure sensor - Fluke 700RG07 500PSIG	1
6	Test gas - Formier gas 5% hydrogen	1
7	Sniffer test station - Sewerin SPE-HG	1
8	Pressure regulator	1
9	Pressure relief valve	1
10	Snoke generator for fire detector test	1
11	H2 test gas for detector test	1
12	Coolant pumping/filling equipment	1
13	CE multitester	1
14	Multimeter	1

- H2 Sniffer - Sewerin Snooper Mini H2, Detection instrument to sniff/locate source of potential leaks.
- Pressure sensor - Fluke 700RG07 500PSIG, measuring device to accurately adjust and monitor gas pressure during leakage test.
- Test gas - Formier gas 5% hydrogen. Test gas for pressurizing pipework where the 5% hydrogen acts as tracer agent for sniffing
- Sniffer test station - Sewerin SPE-HG. Test instrument the emits a reference gas to check the correct function of the Snooper Mini H2 sniffer.
- Pressure regulator, Test gas pressure regulator for pressurizing the DUT.
- Pressure relief valve, Safety valve to ensure safe pipework pressurization during test.

2.8 SEQUENCE OF ACTIVITIES

This method statement has been developed to provide the necessary information and guidelines toensure satisfactory and safe execution at Site.

2.8.1 General Requirements and Site Preparation

- All CONTRACTOR approved AFC drawings, schedule and construction documents (Method Statement andJSA) shall be available and understood by site construction team.
- During the operation in the ups room only qualified personnel shall be allowed.
- Adequate ventilation and lighting shall be provided.
- Identify the working area and barricade with proper signage by company. (Such as Warning,Work in Progress).
- Ensure that all the necessary equipment and tools are approved by CONTRACTOR focal safety/maintenance personnel and are in good condition and safe to use with

current colorcodes and CONTRACTOR stickers.

- All competent direct and indirect manpower shall be available at site.
- Personnel shall be qualified and approved by Company for such job.
- All the doors at nearest roof elevation shall be kept open during the work and shall be properly barricaded for personal entry.
- Keep the work permit in the PTW Bag and display at work booth.
- Entry and Exit register shall be kept ready and ensure to maintain properly.
- Tool box talks with LMRA will be done prior work start.

2.8.2 Mandatory Requirements

ATEX corrections

- No interfaces live (no AUX power, no HV power, no H2 pressurized).

Pre-commissioning

- No interfaces live (no AUX power, no HV power, no H2 pressurized).

Commissioning (Powered)

- Mechanically Complete.
    - ITRs complete.
    - Rosetti drain connection complete.
- Aux Power available.

Commissioning Campaign 2

- Air compressor on platform – coolant system testing.
- Coolant IBCs on platform – coolant system testing.
- Spill pads available. – coolant system testing.
- Formier gas procured – H2 installation leak test.

Commissioning Campaign 3

- Platform communication ready.
- Rosetti test genset setup ready for energisation – 6.6kV.

Commissioning Campaign 4

- Commissioning test setup ready for hydrogen – H2 supply, LB & 6.6kV.
- Rosetti H2 interface connection complete.
- Confirmation from Crosswind ready for SAT.

2.8.3 Sequence of Activities

2.8.3.1 ATEX CORRECTIONS

ACTIVITY 1 – PREPARE CONTAINER FOR ATEX CORRECTIONS

- Remove existing internal drain hoses (40' container).
- Remove collector tank.
- Remove bulkhead plate with drain flange.
- Modify 6x H2 fuel pipe bulkhead entries (enlarge holes for new pipe glands).

ACTIVITY 2 – NEW DRAIN INSTALLATION

Note once this activity is complete CONTRACTOR are to complete the drainpipe interface connection.

- Install new collector box assembly.
- Install and route 6x SS pipes from FC wave to collector box.
- Install external exhaust.
- CONTRACTOR to connect drain interface.

ACTIVITY 3 – ATEX INSPECTION

Note this is not currently detailed in the schedule.

- Perform ATEX ITR inspection

ACTIVITY 4 – MECHANICAL COMPLETION PRE-CHECK INSPECTIONS

Note this is not currently detailed in the schedule.

- CONTRACTOR to complete mechanical and electrical prechecks utilizing the provided ITRs by COMPANY.
- ITRs to be reviewed by COMPANY & VENDOR prior to triparty walkdown.

2.8.3.2 TRIPARTY WALKDOWN

To be completed with the COMPANY, CONTRACTOR & VENDOR in attendance upon completion of all the above activities.

Walkdown procedure is to be provided by CONTRACTOR

2.8.3.3 COMMISSIONING (POWERED)

ACTIVITY 1 – AUX FIRST POWER ON

- Check 400V AUX connection integrity
- Power up the container controller

Enable essential systems in container (lighting, heating, ventilation, detection systems)

ACTIVITY 2 – SUBSYTEMS POWER ON CHECK

- Power up remaining BOP functions

2.8.3.4 COMMISSIONING CAMPAIGN 2

ACTIVITY 1 – PREPARE COOLANT FILL (SETUP PUMPS, HOSES, TANKS)

- CONTRACTOR to lifr air compressor on to platform.
- CONTRACTOR to lift 2x IBC coolant tanks to platform
- CONTRACTOR to ensure scaffolding to access cooling skid service area
- CONTRACTOR to provide spill kit and overflow routing for coolant
- Connect pump station to IBC tanks and cooling skid, including header tank return flow pipework

ACTIVITY 2 – COOLANT SYSTEM LEAK TEST (DRY)

Vendor to complete cooling system dry leakage test as per Vendor Document: SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

- HT coolant system dry leakage test (with compressed air)
- LT coolant system dry leakage test (with compressed air)
- Connect pump station to IBC tanks and cooling skid, including header tank return flow pipework

ACTIVITY 3 – COOLANT FILL

- Perform HT coolant filling procedure
- Perform LT coolant filling procedure

ACTIVITY 4 – COOLANT SYSTEM DEGAS

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- Perform HT system degas procedure (pump agitation and coolant top up)
- Perform LT system degas procedure (pump agitation and coolant top up)

ACTIVITY 5 – COOLING SYSTEM LEAK CHECK (WET)

Vendor to complete Cooling Circuit Pressure and Leak Test procedure per Vendor Document: SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure

- Perform leak test procedure on HT system
- Perform leak test procedure on LT system

ACTIVITY 6 – H2 INSTALLATION ASSEMBLY LEAK TESTING

Vendor to complete *Pipework inspection and leakage test* per Vendor Document: SPC ID 0104 H2 Leak Test Procedure

- Install test pressurization equipment to H2 manifold
- Perform sniffing test to ensure pipework tightness
    - Pressurize pipework with formier gas and perform sniffing procedure

2.8.3.5 COMMISSIONING CAMPAIGN 3

ACTIVITY 1 – IO TEST (PACKAGE INTERNAL)

- Test all sensors and actuators on BOP systems

ACTIVITY 2 ELECTRICAL SAFETY CHECK (PART OF SAT PROCEDURE)

- According to SAT procedure.
    - F07 Electrical Safety Test – 10 foot container
    - F08 Electrical Safety Test – 40 foot container
    - F10 Safety

ACTIVITY 3 FUNCTION CHECK OF VFD COOLER/HVAC

- Manually operate HT Cooling system pumps and fans, checking functionality of fans, pumps and valves.

ACTIVITY 4 - SOFTWARE UPDATE ON CONTROL SYSTEMS

- Connect Ballard laptop to control system of container and fuel cells
- From Ballard servers, upload updated versions of programming on the container and fuel control systems.
- This activity will cause disruptions on communication between BLPH and Fuel Cell package, as the control system is stopped as a part of the upgrade process.
- This activity allows activity #3 in campaign 4 to be completed, which includes testing of the software functions which have been impacted by the changes.

ACTIVITY 5 - PLATFORM COMMUINCATION CHECK

Note the platform is to be "communication ready" by CONTRACTOR before this activity can start and be completed.

- CONTRACTOR to bring communication interface live
- Check network communication between package controller and platform
- Check E-stop (hardwired) between package controller and platform

ACTIVITY 6 – HV LINK CHECK (6.6 kV TRAFO ENERGIZATION)

Note the platform is genset is to be confirmed ready by CONTRACTOR before this activity can start and be completed.

- Perform LOTO procedure with CONTRACTOR (Lock 10ft container with breaker room key)
- CONTRACTOR to energize 6,6kV supply to package

ACTIVITY 7 – TEST BACKFLOW 6.6KV TRAFO

Note the platform is genset is to be confirmed ready by CONTRACTOR before this activity can start and be completed.

- Energize DC link through 6,6kV supply (backflow)
- Bring BOP functions to operation to test load capability

ACTIVITY 8 – BRING FUEL CELLS TO STANDBY (NO H2)

Note the platform is genset is to be confirmed ready by CONTRACTOR before this activity can start and be completed.

- Energize DC link (backflow)
- Bring Fuel Cell 1 – 6 to standby state (power from DC link) – no H2 introduced.
- Operate BOP components within each Fuel Cell

2.8.3.6 COMMISSIONING CAMPAIGN 4 (HOT COMMISSIONING)

ACTIVITY 1 – COMPLETION OF OPEN PUNCH LIST ITEMS

VENDOR to complete open punch list items including the necessary software updates.

ACTIVITY 2 – RETEST – PLATFORM COMMUNICATION CHECK

Retest of network communication between package and platform due to new alarm list in bit array.

ACTIVITY 3 – H2 AVAILABILITY AND QUALITY CHECK (BEFORE INTRODUCING H2 to FC MODULES)

Note CONTRACTOR to confirm following ACTIVITY 3 tasks completed before VENDOR can continue HOT _COMMISSIONING. If H2 quality check is not completed, COMPANY takes full responsibility for potential damages or repairs caused by poor fuel quality.

- CONTRACTOR providing documentation on H2 fuel quality from sampling point
- CONTRACTOR providing Load Bank

ACTIVITY 4 – FILL H2 HEATER WITH COOLANT

- CONTRACTOR to lift 1x IBC coolant tanks to platform
- CONTRACTOR to provide spill kit and overflow routing for coolant
- VENDOR connecting pump to H2 heater and fill to level

ACTIVITY 5 – COMMISSIONING SINGLE FC WITH REDUCED PRESSURE (UNTIL SINGLE FC COMMISSIONED) (WITH H2, 0 to 200 KW, 6.6KV LIVE)

Main purpose: Start 1 FC verifying H2 fuel quality and regulator capable of start-up and commissioning

Note if FC module shutdown due to low H2 quality, VENDOR will stop activities and wait for CONTRACTOR to perform new H2 quality checks. If FC modules shutdown due to H2 pressure issues CONTRACTOR must perform pressure regulator adjustments. If H2 quality check is not completed, COMPANY takes full responsibility for potential damages or repairs caused by poor fuel quality.

- First start of one FC module (first start from long time out of service)
    - If FC module does not start after completing VENDOR start up procedure VENDOR will stop further start up attempts. If VENDOR deems the cause to be poor fuel quality, COMPANY/CONTRACTOR will have the responsibility to improve fuel quality before continuing.
- Continue conditioning by running one FC module at varies load point between 50kW and 200kW

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ACTIVITY 6 (ROSETTI) – REGULATOR/CONTROL VALVE TUNING WITH FC (UNTIL BASELINE FUNCTIONALITY IS PROVEN WITH FC (REDUCED LOAD, INLET RANGE) (WITH H2, 0 to 200 KW, 6.6KV LIVE)

Main purpose: Give CONTRACTOR the opportunity to adjust and setup regulator control for a single (one) FC Module

Note if FC modules shutdown due to low H2 quality, VENDOR will stop activities and wait for CONTRACTOR to perform new H2 quality checks. If FC modules shutdown due to H2 pressure issues CONTRACTOR must perform pressure regulator adjustments before VENDOR continue testing.

- CONTRACTOR to adjust H2 regulators
- Start FC Module No.1 from idle to max load (50 to 200kW)
- Run module – ramping up and down
- Start stop test of module with storage tank high and low pressure

ACTIVITY 7 – COMMISSIONING REST OF FCs (5PCS) (WITH H2, 0 to 200 KW, 6.6KV LIVE)

Main purpose: Start the last 5 FC modules and commission

Note if FC module shutdown due to low H2 quality, VENDOR will stop activities and wait for CONTRACTOR to perform new H2 quality checks. If FC modules shutdown due to H2 pressure issues CONTRACTOR must perform pressure regulator adjustments. If H2 quality check is not completed, COMPANY takes full responsibility for potential damages or repairs caused by poor fuel quality.

- Conditioning of each individual FC modules (first start from long time out of service)
- Continue conditioning by running each individual FC modules at varies load points between 50kW and 200kW

ACTIVITY 8 (ROSETTI) – FULL REGULATOR/CONTROL VALVE VERIFICATION WITH 6 FC (WITH H2, 0 to 1000 KW, 6.6KV LIVE)

Main purpose: Give CONTRACTOR the opportunity to adjust and setup regulator control for the full power range

Note if FC modules shutdown due to low H2 quality, VENDOR will stop activities and wait for CONTRACTOR to perform new H2 quality checks. If FC modules shutdown due to H2 pressure issues CONTRACTOR must perform pressure regulator adjustments before VENDOR continue testing.

- CONTRACTOR to adjust H2 regulators
- Start FC Module No.1 to 6 tests from idle to max load (0 to 1000kW)
- Run modules – ramping up and down. At high and low storage tank pressure
- Start stop test of all modules with storage tank high and low pressure.

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2.8.3.7 RFSU CERTIFICATE

Ready for Start Up Certificate to be signed by COMPANY, CONTRACTOR & VENDOR upon completion of all the above activities.

2.8.3.8 SITE ACCEPTANCE TEST

Note all activities above must be successfully completed before commencement of the SAT.

Note if FC modules shutdown due to low H2 quality, VENDOR will stop activities and wait for CONTRACTOR to perform new H2 quality checks. If FC modules shutdown due to H2 pressure issues CONTRACTOR must perform pressure regulator adjustments before VENDOR continue testing.

SAT to follow document: K559-2254-CWIWP4202202-J99-001-Rev004, Site Acceptance Test (SAT) Procedure

- Follow SAT procedure

2.9 CLASS OF WORK

2.9.1 Proposed Work Window to CONTRACTOR Yard

Refer to schedule as listed in the references.

2.9.2 Disciplines

Discipline Included in Work Scope							
Piping	Structural	Electrical	Instrument	Rigging	Scaffolding	Vendor	Insulation
X		X	X		X	X	

2.9.3 Equipment/System Affected/Impacts to Operation

N/A

2.9.4 Special Requirements

The table below shows the activities which require the attention of CONTRACTOR

Activity	Requirements
• Scaffolding for accessing cooling skid service area.	

• Scaffolding for installing drain exhaust.	
• Spill kits and containment pallets.	
• 230V utility connection (for power tools and pumps) available on platform/next to FC package.	
• Drainpipe interface connection.	
• Crane available for lifting activities – Air compressor, coolant IBCs etc..	
• Platform communication ready	
• Test Genset ready for energization	
• Commissioning test set up ready (H2 Supply, LB & 6.6kV)	

2.10 HOUSE KEEPING & DEMOBILIZATION

As per CONTRACTOR procedures.

2.11 TIME SCHEDULE

The tasks are executed in day shift, 8 working hours per day.

2.12 GENERAL SAFETY, PTW SYSTEMS & SAFETY CHECK LISTS

2.12.1 General Safety

- All construction activities shall comply with the CONTRACTOR Safety Management System.
- Safety will be the main target during the whole of the execution of works. Workers will be fullyadhered to safety requirements.
- There will be a full time safety representative from COMPANY to ensure the safety throughout the scheduled activity.
- Tool box talk shall be conducted by performing party prior to start of the job every day attended byall the concerned work party. The performing party shall make a record of the toolbox meeting in presence of HSE person.
- Make sure that all the relevant signatures are obtained in PTW and all the work group signatures inthe appropriate area after the job briefing
- All Hazardous activities shall be identified and adequate safety precautions shall be taken as per JSA/RA.
- All the personnel working at site shall wear PPE as per CONTRACTOR PPE policy.
- All Insulators shall wear special PPE such as disposable coverall, hand gloves, mask as

recommendedin SDS.

- Work permit pack should include the relevant documents (MS, JSA/RA, SDS etc.)
- COMPANY's supervisor will ensure that all workers, directly or indirectly employed by it, have attended the necessary safety training required by law, safety regulations and have necessary workexperience. Documented evidence of such training shall be given upon request.
- Hygiene will be of utmost priority and the work areas will be maintained clean all rubbish and debris will be removed regularly.
- After completion of the job all waste shall be segregated and disposed separately as per RM policy & procedure for Waste Management. (PRO-HSE-28)
- Demobilize all tools and equipment from site after completion of work including housekeeping andcleaning the work location.

2.12.2 Permit To Work System

CONTRACTOR Permit to Work system (PRO-HSE-23) is a formal written Agreement andmean of Communication between CONTRACTOR and VENDOR while performing the task.

"Permit to Work system" provides a mechanism to control certain hazardous activities, non-routine activities and ensure a safe working environment so that the work carried out is conducted in a safe, coordinated & consistent manner without harm to people, Asset and Environment.

Dedicated training on PTW System will be provided by CONTRACTOR upon request.

2.12.3 PTW Office:

Original of the PTW and Original Certificates/ Documents shall be kept in the PTW Office (Project HSE office) and a copy at site in order to avoid spoil or misplaced. Also, this shall be easily accessible to both PTW holder and CONTRACTOR when it requires.

2.12.4 Lost Permit/Documents:

If any permits or associated documents are lost then the work must be stopped and new permit and associated document must be obtained before work started.

2.12.5 Operations Hold point:

Task list may have HOLD POINTS against some activities. The purpose of a hold point is to allow the intervention of CONTRACTOR before executing the activity. This can be added by CONTRACTOR Area Operator at the time of issuing the permit (on the hard copy) if required. In such cases, the PTW holder shall consult CONTRACTOR Area Operator and visit the site and obtain the signature in the task list before startingthe work. CONTRACTOR shall be informed of any special requirements after the site verification study.

2.12.6 PTW Suspension:

All permits are considered suspended at the end of the shift. If during the shift, a permit needs to be suspended due to some reasons, then CONTRACTOR shall collect the permit pack from site. PTW suspension due to Emergency situation during shift following an emergency Alarm, all PTWs shall be considered suspended and Permit receiver must leave the permits in PTW office at the work site. CONTRACTOR Shift Supervisor shall revalidate all PTWs after "All Clear "announcement. In case of false alarm, no need of PTW revalidation if the interruption is less than one hour.

For planned emergency exercise/drill, need not required to suspend the PTWs.

2.12.7 Safety Checklist

The following activities will be carried out:

- Discuss work scope permits with the production / discipline supervisors.
- Toolbox talk with foreman / charge-hand.
- Walk job with production / discipline supervisors.
- PIC to check worksite immediately prior to work starting.
- PPE Check List.

2.13 JOB SAFETY ANALYSIS

Shall be prepared separately as an attachment to PTW. Can be replaced by a Risk Assessment of the activities required for any step to complete the scope of work.

2.14 ATTACHMENTS

2.14.1 BLPH-Ballard-Fuel-Cell_Schedule-Update_Dec-2024_Rev001 Latest Ballard Schedule

2.14.2 K559-2254-CWIWP4202202-J99-001-Rev003, Acceptance Test (SAT) Procedure

2.14.3 K559-2254-CWIWP4202202-B01-001Rev008, General Arrangement Drawing

Sub Section J99-010

Ballard Risk assessment for container solution

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	16/01/2025	First Issue

Document Title:	**BLPH Project-Ballard Risk Assessment for container solution**
Document Number:	K559-2254-CWIWP4202202-J99-10-10
Revision:	Rev001
Sequence Number:	10
File Name:	K559-2254-CWIWP4202202-J99-10-10Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J99-10
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Project data

Project name	601456B Crosswind BLPH

Stationary Fuel cell module. converting Hydrogen to electricity.

For stationary purposes, Also intended for the CE marking approval.

Functional description

Fuel Cell Container

The container contains 4-6 FCwave units. Each FC wave is a separate unit with full hydrogen safety and a double wall barrier to ventilate any possible hydrogen leakages directly to the outside. Ventilation is led to a level above the cooling radiators, to ensure that any hydrogen is kept away from igniting sources. This solution ensures that the interior of the container is not an Ex-zone. The fuel cell container is equipped with a ventilation system, which will ensure that the filtered process air for the FC wave is available. The ventilation system will also create a flow through the container, for cooling and ventilating the room. The container inside is kept at a small overpressure to prevent ingress of dust or fumes from the outside. The DC/DC panels for fuel cell output in the container connect each FC wave to a common DC link busbar. Each DC/DC panel for fuel cell output can be isolated electrically, to allow for maintenance on the specific cabinet or related FC wave. The system controller is a centralized unit that monitors and operates the entire FC Power Gen system and include a separate safety controller to prevent any critical failure or emergency situations to escalate. The power for auxiliary units such as water pumps, container ventilation and basic power is fed from a 400V AUX power panel during shut down.

Customer interface container

The customer interface container provides the main output AC power to the customer output. The DC power from the fuel cell container converts into 50Hz AC through the DC/AC output converter located in the customer interface container. This converter is further connected to the isolation transformer and main breakers for the customer connections. The container doors are prevented from opening during operationt. Access is restricted to instructed and trained personnel, and only after a safety procedure is followed, which will de-energize the container to a safe mode.

Cooling Unit

The purpose of the high-temperature (HT) cooling system is to dissipate the heat generated by the fuel cells. It is an open unpressurized system with an open header tank for volume changes due to temperature. The purpose of the Low-Temperature (LT) cooling system is to provide cooling for power electronics. Like HT, it is also an open unpressurized system with an open header tank for volume changes due to temperature.

Function

Functional Modes

Shut down

The hydrogen supply is manually isolated from the container. The container will be internally heated to keep temperature above freezing. Light and service plugs are available in the container, and the controller can be accessed by the customer.

Stand.by

The hydrogen supply is available to the fuel cell container when needed. Availability of hydrogen at an allowable pressure is provided by the customer hydrogen supply system. Loss of the hydrogen signal or hydrogen pressure error will place the FC Power Gen system in failure state. The FC Power Gen hydrogen manifold is closed. The main breaker of the customer grid is disconnected by the control system. The container will be internally heated to keep temperature above freezing. Light and service plugs are available in the container, and the controller can be accessed by the communication interface.If the FC Power Gen system receives an operating signal and no failures are observed, the FC Power Gen will go to operating state and perform a start-up.

Operating

The hydrogen supply is available to the fuel cell container. Availability of hydrogen at allowable pressure is provided by the customer hydrogen supply system. Loss of hydrogen signal or hydrogen pressure error will place the FC PowerGen system in failure state.The main breaker of the customer grid is controlled by the control system. The normal operating condition is the FC PowerGen operating and producing, where the main breaker is closed and the FC PowerGen system supporting the microgrid. .If the producing signal is removed, the FC Power Gen will open the main customer grid breaker and then perform a controlled shutdown going back to stand-by mode. The current available power is continuously signaled to the customers power management system together with various operating data. It is the responsibility of the customers power management system to avoid overloading the customer grid, e.g., by managing allowable consumers on the customer grid.The FC Power Gen system will allow for a FC wave fuel cell unit to be out due to service or failure, and continue supporting the customer grid with remaining fuel cells, at a lower available power level. If a critical error is seen by the FC Power Gen control system, the system will shut down to failure mode.

Failure

When an error that require the FC Power Gen to shut down is identified, the system will enter into one of the following states:

	• Emergency shutdown will immediately stop hydrogen supply and disconnect the FC power Gen from the customer grid. The FC Power Gen will remain in failure mode until the necessary action has been taken to rectify the error condition and the state has manually been cleared. The network connection will provide error data and engineering access for analyzing and correcting the		
Project number	PRJ-2024-07-04-0002		
Type	601456B Crosswind BLPH		
Serial number	601456B	**Created by**	Chaudhary Hijab
Machine number	-	**Created on**	04-07-2024
Order	601456B	**Last change**	20-08-2024 11:19
Model	FC PowerGen 1000kW ®/ TM		
Product	N/A		
Commercial name	FC PowerGen 1000kW ®/ TM		
Additional information	N/A		
Batch number	N/A		
Scheduled date of placing on the market			
	The overall project is divided into 3 subproject in order to perform risk assessment precisely. 1) Fuel cell container: This part consists of risks involved in fuel cells, fuel cell DC/DC converter system, system controller, auxiliary supply input, low temperature pump system, container ventilation and integrated safety. Following are the hazard zone in the fuel cell container: ☐Electrical cabinets (MCU, AUX,breakers) ☐Fuel' container built (inside and outside) ☐DC/DC panels for fuel cell output ☐Raised floor ☐Container ventilation system ☐Fuel cell, H2 enclosure ventilation extension and exhaust (internal) ☐External exhaust ☐Crane ☐Hydrogen supply 2) Cooling System: This part consists of risks involved in 2 HT radiators dimensioned for the specific site, 2 HT pump systems, 1 LT pump system, piping/valves/vessels and a cooling control panel/cabinets. Following are the hazard zones in the cooling system:		

Project note	☐Cooling platforms (HT & LT) ☐Pipings/valves/vessels ☐HT cooling radiators ☐HT pumps ☐Electrical cabinets ☐Inverter cabinets ☐Modem box (removable) ☐LT cooling radiators 3) Main Power output container: This part consists of risks involved in microgrid DC/AC, microgrid transformer, microgrid main breaker. Following are the hazard zones in the main power output container: ☐Electrical cabinets ☐Ventilation for power output container ☐Transformer ☐AC power connection (customer interface) ☐Main panel and control panel for power output container ☐Main power output container Besides, we have 2 interfaces are also added in the risk assessment: 1) Fuel cell container<...> Main power output container: This part consists of risks involved in the connections between two containers. Following are the hazard involved in this interface: ☐Interconnecting bridge between containers ☐Interconnection of power cables 2) Fuel cell container<...> Cooling: This part consists of risks involved in the connections between fuel cell containers and cooling. Following are the hazard involved in this interface: ☐Connecting parts (40' and cooling skid)

Limits of the machine

Intended use

The FC PowerGen system acts as a grid following power generator, providing up to 1MW at 6.6kVAC 50Hz. This system is designed and is intended to be used for offshore stationery application (fixed installed system). Hydrogen supply to the system is in the customer scope and the details about the hydrogen standards, quality etc are mentioned in the integration and other manuals that will be provided to the customers. The customer local Power Management System (PMS) requests the amount of power to be generated within the given dynamic and capacity limits of the system, which are communicated in real-time on the Modbus TCP/IP. The Modbus data is transported between the system and the PMS. The system have multiple operating data available on the same Modbus, including alarms.The FC Power Gen is placed in operation by request from PMS via Modbus, and similarly can be stopped, if necessary, which will stop power supplying the to the grid. The system can be stopped remotely on request. During normal operation, a power request of 0 is accepted by the system.

Dynamic Properties:

In order to match the response (ramping) time of the fuel cells in the FC PowerGen load should be managed as following:

Load increase ramp: Load is requested by the customer and the module/modules start up to deliver the power as demanded. One fuel cell modules takes approx 30 secs to ready to deliver the power.

Block loading can be accommodated in steps below 200 kW, with a minimum of 90 seconds between each step.
Calculated Maximum Power (CMP):
Range is 0 to 1000 kW. CMP will dynamically provide the maximum available power from the Megablock under current running conditions. The value will typically be 1000 kW.

In the following situations the CMP may be reduced:

☐ One or more fuel cells are out of service due to error or maintenance. This will reduce the CMP in steps of around 180kW.
☐ High temperature or other conditions which reduce the total capacity due to derating.
☐ Complete stop due to system failure, loss of hydrogen or remote stop from Customer control system. This will reduce CMP to 0kW

Reasonably foreseeable misuse

☐ Untrained personnel working on the system.
☐ Personnel working on the system not following proper instructions declared in the Ballard manuals
☐ Hydrogen handling: quality/temperature/pressure not aligned with the standards declared in the Ballard manuals.
☐Water/glycol mixture handling: the concentration and quality not aligned with the specification declared in the manuals.
☐System in operation without following Ballard service schedule and service bulletins.
☐Cleaning of containers from outside using high pressure water spray guns could possibly damage paint and other components.
☐Process air and/or ventilation air blocked.
☐Operation out of environmental ranges in the Ballard manuals.
☐Load ramping up/down abruptly or not according to the instruction provided.
☐Transportation of the system without proper preservation initiatives including transport safety measures.

Space limits

Space limits are defined as per the general arrangement layout drawing attached.(601456B-7 Rev007)

Time limits

Expected lifetime of the system: 10 years if maintained according to the Ballard service manual instructions.

Other limits

☐The system is designed to operate in seismic zone lower than 0.1 m/s2 according to European norm EN1998-1

Links (e.g. requirement specifications, functional specifications,...)

Type	File	Short note
Linked file	601456B-7 Rev007.pdf	

Signatory of the EC/EU-declaration

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Risk assessment

601456B Crosswind BLPH

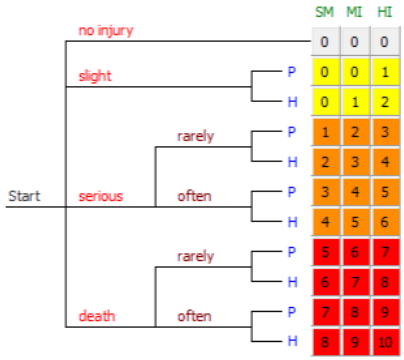
Project data			
Project name	601456B Crosswind BLPH	**Created by**	Chaudhary Hijab
Project number	PRJ-2024-07-04-0002	**Created on**	04-07-2024
Product	N/A	**Last change**	26-08-2024 13:46
Function	Stationary Fuel cell module. converting Hydrogen to electricity. For stationary purposes, Also intended for the CE marking approval. Functional description Fuel Cell Container The container contains 4-6 FCwave units. Each FC wave is a separate unit with full hydrogen safety and a double wall barrier to ventilate any possible hydrogen leakages directly to the outside. Ventilation is led to a level above the cooling radiators, to ensure that any hydrogen is kept away from igniting sources. This solution ensures that the interior of the container is not an Ex-zone. The fuel cell container is equipped with a ventilation system, which will ensure that the filtered process air for the FC wave is available. The ventilation system will also create a flow through the container, for cooling and ventilating the room. The container inside is kept at a small overpressure to prevent ingress of dust or fumes from the outside. The DC/DC panels for fuel cell output in the container connect each FC wave to a common DC link busbar. Each DC/DC panel for fuel cell output can be isolated electrically, to allow for maintenance on the specific cabinet or related FC wave. The system controller is a centralized unit that monitors and operates the entire FC Power Gen system and include a separate safety controller to prevent any critical failure or emergency situations to escalate. The power for auxiliary units such as water pumps, container ventilation and basic power is fed from a 400V AUX power panel during shut down. Customer interface container The customer interface container provides the main output AC power to the customer output. The DC power from the fuel cell container converts into 50Hz AC through the DC/AC output converter located in the customer interface container. This converter is further connected to the isolation transformer and main breakers for the customer connections. The container doors are prevented from opening during operationt. Access is restricted to instructed and trained personnel, and only after a safety procedure is followed, which will de-energize the container to a safe mode. Cooling Unit The purpose of the high-temperature (HT) cooling system is to dissipate the heat generated by the fuel cells. It is an open unpressurized system with an open header tank for volume changes due to temperature. The purpose of the Low-Temperature (LT) cooling system is to provide cooling for power electronics. Like HT, it is also an open unpressurized system with an open header tank for volume changes due to temperature.		

	Functional Modes Shut down The hydrogen supply is manually isolated from the container. The container will be internally heated to keep temperature above freezing. Light and service plugs are available in the container, and the controller can be accessed by the customer. Stand.by The hydrogen supply is available to the fuel cell container when needed. Availability of hydrogen at an allowable pressure is provided by the customer hydrogen supply system. Loss of the hydrogen signal or hydrogen pressure error will place the FC Power Gen system in failure state. The FC Power Gen hydrogen manifold is closed. The main breaker of the customer grid is disconnected by the control system. The container will be internally heated to keep temperature above freezing. Light and service plugs are available in the container, and the controller can be accessed by the communication interface.If the FC Power Gen system receives an operating signal and no failures are observed, the FC Power Gen will go to operating state and perform a start-up. Operating The hydrogen supply is available to the fuel cell container. Availability of hydrogen at allowable pressure is provided by the customer hydrogen supply system. Loss of hydrogen signal or hydrogen pressure error will place the FC PowerGen system in failure state.The main breaker of the customer grid is controlled by the control system. The normal operating condition is the FC PowerGen operating and producing, where the main breaker is closed and the FC PowerGen system supporting the microgrid. .If the producing signal is removed, the FC Power Gen will open the main customer grid breaker and then perform a controlled shutdown going back to stand-by mode. The current available power is continuously signaled to the customers power management system together with various operating data. It is the responsibility of the customers power management system to avoid overloading the customer grid, e.g., by managing allowable consumers on the customer grid.The FC Power Gen system will allow for a FC wave fuel cell unit to be out due to service or failure, and continue supporting the customer grid with remaining fuel cells, at a lower available power level. If a critical error is seen by the FC Power Gen control system, the system will shut down to failure mode. Failure When an error that require the FC Power Gen to shut down is identified, the system will enter into one of the following states: • Emergency shutdown will immediately stop hydrogen supply and disconnect the FC power Gen from the customer grid. The FC Power Gen will remain in failure mode until the necessary action has been taken to rectify the error condition and the state has manually been cleared. The network connection will provide error data and engineering access for analyzing and correcting the error condition.
Type	601456B Crosswind BLPH
Order	601456B
Commercial name	FC PowerGen 1000kW ®/ TM
Model	FC PowerGen 1000kW ®/ TM
Machine number	-
Serial number	601456B

Print options

View	Hazard zones	Display	All hazards

Legend



Safexpert risk graph

V = Value (0 - 10):
0 = Lowest Risk
10 = Highest Risk
SH = Severity of the harm:
N = no injury
SL = slight injury
SE = serious injury
D = death
DS = Duration of stay in hazard zone:
R = rarely to more often
O = often to continuously
RA = Possibility of recognition and avoidance:
P = Possible under certain circumstances
H = Hardly possible
PO = Probability of occurence:
SM = Small (improbable)
MI = Middle (probably occur a number of times during the life)
HI = High (happen often)

Measure number

Type of measure

Measure description

2	PIC	Place the spindle height indicator near the height dial	PLr / SILr	PL / SIL	Applied documents

Control engineering	Cat. = Category PLr = Performance level required (before) PL = Performance level (after) SILr = Safety integrity level required (before) SIL = Safety integrity level (after)
Types of measure	ISD = Inherently safe design measure SCP = Safeguarding / complementary protective measure PPE = Personal protection equipment PIC = Note on the machinery (Pictogram, ...) OI = Note in the Operating instruction

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601456B Crosswind BLPH

Limit of the product: Use-, space-, time- and other limits

Complete solution

1 - Mechanical hazards

in all phases of the "life"

Hazard description

The mechanical hazards of the complete solution are described in detail in the subprojects and interface risk assessments.

Risk assessment and risk reduction

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
1	ISD	Measures are presented in the subprojects along with the risks.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

in all phases of the "life"

Hazard description

The electrical hazards of the complete solution are described in detail in the subprojects and interface risk assessments.

Risk assessment and risk reduction

	0	Risk IN: SH: No injury, PO: Small			
1	ISD	Measures are also presented along with risks in the subprojects risk assessments.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

3 - Thermal hazards

in all phases of the "life"

Hazard description

The thermal hazards of complete solution are described in detail in the subprojects and interface risk assesments.

Risk assessment and risk reduction

	0	Risk IN: SH: No injury, PO: Small			
1	ISD	Measures are presented along with risk assesment in the subprojects and interfaces.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

4 - Noise hazards

in all phases of the "life"

Hazard description

The noise hazards of complete solution are described in detail in the subprojects and interface risk assesments.

Risk assessment and risk reduction

	0	Risk IN: SH: No injury, PO: Small			
1	ISD	Measures are presented along with risks in the subprojects and interfaces risk assesments.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Fuel Cell Container,40'

Limit of the product: Use-, space-, time- and other limits

Container ventilation system

1 - Mechanical hazards

1.3 - crushing

in all phases of the "life"

Hazard description

Risk of crushing individual fingers from all louver dampers inside the container.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PIC	Caution label indicating risk of crush on all louvre dampers inside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

1 - Mechanical hazards

1.4 - cutting or severing

Malfunctioning

Hazard description

Ventilator failure leading to overpressure in the container (700 pa) that could possibly result in the opening of doors unintended and that rapid opening could lead to the personnel damage.

Risk assessment and risk reduction

	4	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Hardly possible, PO: Small			
1	SCP	DP Sensor will detect the overpressure and make an error in the SW.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Crane

1 - Mechanical hazards

1.3 - crushing

Maintenance

Hazard description

Moving FC wave and power electronics equipment IN/OUT during maintenance with crane operation. Errors in those crane operation could possibly result in personnel damage.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Proper marking and fences during crane operations to be arrange(	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	Only relevant and trained people to be allowed in the area during installation.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	OI	Lifting to be done only in a clear weather condition.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
4	OI	Proper lifting procedure to be designed to avoid any risk. Service manuals to be added in details.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 26-08-2024

1 - Mechanical hazards

1.8 - impact

in all phases of the "life"

Hazard description

Risk of hitting individuals head due to the presence of crane inside the container.

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	PIC	Caution marking indicating an overhead obstacle to be pasted in the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

External exhaust

1 - Mechanical hazards

1.11 - slipping, tripping and falling

in all phases of the "life"

Hazard description

Risk of slipping/falling down due to the ice formation in cold weather as process water is sprayed out through the external exhaust during operation.

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	PPE	Proper shoes and PPE to be considered below process exhaust.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	SCP	Restriction of access in the area during cold weather conditions.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

3 - Thermal hazards

3.6 - scald

Normal operation

Hazard description

The steam coming out of the process exhaust is more than 60°C. Direct personal exposure could possibly result in scalding/burning.

Risk assessment and risk reduction

	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Middle			
1	OI	Working physically on the exhaust to be declared 'not allowed' during operation.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Safety caution markings to be added on the process exhaust pipings outside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	OI	Operator manual to be provided the information about the hot surface and high temperature.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

7 - Material/ substance hazards

7.1 - breathing difficulties, suffocation

Malfunctioning

Hazard description

Leakage on pipe clamps - risk of low oxygen level 10% worst case.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	ISD	set the lowest oxygen level possible >10%.	PLr / SILr	PL / SIL	Applied documents
	3	Risk OUT: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
2	SCP	Container ventilation system when in operation.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

7 - Material/ substance hazards

7.5 - explosion

Malfunctioning

Hazard description

Pipe connection leakage to container room could possibly spread hydrogen in the container that could lead to a potential explosion.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Container is equipped with H2 sensor to detect potential leakage.	PLr / SILr	PL / SIL	Applied documents
	3	Risk OUT: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
2	SCP	Straub connector is constructed to 10bar to avoid leakage.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Electrical cabinets (MCU, AUX, Breaker)

2 - Electrical hazards

2.4 - electrocution

Testing

Hazard description

Risk of electrocution due to touching live parts during testing.

Risk assessment and risk reduction

	7	Risk IN: SH: Death, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Lockout and tagout procedures to be followed precisely.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	OI	Residual voltage check to be done before any other work.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.4 - electrocution

Assembly, installation

Hazard description

Turning on the customer auxiliary power supply during installation/commissioning due to human negligence could possibly result in electrocution if not handled carefully.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Locking out or tagging out the circuit breaker to avoid dangerous situations.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	PPE	Safety shoes, appropirate clothing, safety gloves, safety goggles etc to be considered.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	OI	Integration/Service manuals to be provided with details and followed precisely.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

2 - Electrical hazards

2.4 - electrocution

Commissioning, adjustments

Hazard description

Turning on the customer auxiliary power supply during installation/commissioning due to human negligence could possibly result in electric shock if not handled carefully.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Locking out and tagging out the circuit breakers to avoid dangerous situations.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	SCP	Installation/Service manuals to be followed precisely.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	SCP	PPE to be considered for safety.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

2 - Electrical hazards

2.4 - electrocution

Troubleshooting

Hazard description

No plugs for capacitor voltage measurement outside the auxiliary panel. Panel doors need to be opened for troubleshooting or maintenance and capacitors could be charged. This could result in potential electrocution if not handled safely.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Plugs to be considered outside the panel (like DC/DC panels) or an option of grounding/shorting switch to be considered for safety purposes.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	OI	Instructions to be provided and followed regarding that.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.8 - shock

in all phases of the "life"

Hazard description

Troubleshooting in control panel for fuel cell genset during Live operation and touching live parts has risk of potential shock.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	IP20 to be the minimum criteria declared for the components inside the panel.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	SCP	Polycarbonate covers to be added in order to avoid the shock/ touching.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	PPE	PPE to be considered during the installation/commissioning/troubleshooting process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
4	PIC	Live parts to be marked inside PLC panel.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

3 - Thermal hazards

3.1 - burn

Testing

Hazard description

Risk of burning individual fingers due to touching hot surfaces and components.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Gloves to be considered during the testing process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Hydrogen supply

3 - Thermal hazards

3.1 - burn

in all phases of the "life"

Hazard description

Risk of burning hands due to touching hot surface on the hydrogen pre-heater.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Wearing gloves to be considered near the hydrogen heater.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Caution marking to be placed on the hydrogen heater.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

7 - Material/ substance hazards

7.5 - explosion

Testing

Hazard description

Risk of explosion due to leakage of hydrogen during testing.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Proper bench testing procedures of components to be performed prior to assembly.	PLr / SILr	PL / SIL	Applied documents
	2	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
2	SCP	Proper leak test of assembly to be performed prior to hydrogen supply.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

7 - Material/ substance hazards

7.5 - explosion

Malfunctioning

Hazard description

External leakage on exhaust pipe can possibly result in the sucking of hydrogen into the container leading to a potential explosion.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Container is equipped with H2 sensors to detect potential leakage.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	SCP	intake H2 sensor to detect contaminated air entering the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

7 - Material/ substance hazards

7.5 - explosion

Reasonably foreseeable misuse

Hazard description

Hydrogen inlet pressure exceeds 10 barg could result in hydrogen release and explosion.

Risk assessment and risk reduction

	6	Risk IN: SH: Death, DS: Rarely to more often, RA: Hardly possible, PO: Small			
1	ISD	Hydrogen pipings and valves rated for more than 15 times safely release valve pressure (>150 bar).	PLr / SILr	PL / SIL	Applied documents
	3	Risk OUT: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
2	SCP	Upstream safety pressure release valve - sized to full flow from upstream regulator requirement to integrator in BPSE Fuel cell integration manual.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	SCP	Under normal operation - un manned Fuel cell container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

7 - Material/ substance hazards

7.5 - explosion

in all phases of the "life"

Hazard description

Malfunctioning of one of the hydrogen valves could possibly keep supplying the hydrogen into the container even after making emergency shutdown. This could result in accumulation of hydrogen in the container and could possibly result in a potential explosion.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Two valves in series to be placed in order to safeguarding the failure from one valve.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	SCP	Safety output signal to be sent to the supplier of the hydrogen so the main valve could be shut off and stops supplying the hydrogen.	PLr / SILr SIL 2	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Fuel cell container built (Inside/Roof)

1 - Mechanical hazards

1.3 - crushing

Maintenance

Hazard description

Fans filter replacement requires their unassembly. During the unassembly, there is a risk of crushing due to the heavy weight of the fans. Also, during reassembly, if the screws are not tightened properly the fans won't be adjusted at their place properly and could possibly fall down. Personnel standing/working down the container could potentially get severely injured.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Only trained personnel to be working on maintenance.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Caution marking about the following the instructions to be pasted on the top of the fan.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	OI	Service manual to be provided mentioning the detailed descriptions and to be followed during the maintenance.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.3 - crushing

in all phases of the "life"

Hazard description

DC cable ducts installed on the roof inside the container have sharp corners. Could possibly result in the personnel head injury.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Rubber covers to be added to cover the sharp corners.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	PPE	PPE to be declared compulsory near the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

1 - Mechanical hazards

1.5 - drawing-in or trapping

Maintenance

Hazard description

Risk of trapping an injured individual inside the container if the access of unlocking emergency door is not available from inside.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	OI	Instruction about unlocking the emergency exit while working in the container to be added in the relevant manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.5 - drawing-in or trapping

in all phases of the "life"

Hazard description

Container gets locked outside while individual is working inside. Could cause personal disturbance.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Emergency push bars to be installed that can be unlocked from inside.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	OI	Communication device to be kept along while working inside to keep the contact and instructions about it to be provided in the relevant manual.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	PIC	Only authorized people to be given access inside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

1 - Mechanical hazards

1.5 - drawing-in or trapping

Malfunctioning

Hazard description

Risk of individual trapping inside during the FCwave module moving out due to the malfunctioning.

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Emergency door to be installed at the end of the container with the access to open from inside.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	OI	Mention the location of emergency door in the operator manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

	0	Risk IN: SH: No injury, PO: Small			
3	PIC	Marking indicating the emergency door to be pasted outside the emergency door.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

1 - Mechanical hazards

1.11 - slipping, tripping and falling

Troubleshooting

Hazard description

Personnel working on the top of the container during trouble shooting without suitable lifting equipment. Imbalance could potentially result in falling from almost 3m height and severe injuries.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Customer to provide suitable lift or scaffolding for all the lifting procedures on site.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	SCP	Rainy, extreme winds or snowy days to be avoided for installation.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	PPE	Helmets and proper shoes (PPE) to be declared mandatory during installation/assembly.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Hardly possible, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
4	OI	More than one person to be present on-site during work.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.11 - slipping, tripping and falling

Maintenance

Hazard description

Personnel working on the top of the container during maintenance without safe lifting equipment. Imbalance could potentially result in falling from almost 3m height and severe injuries.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Rainy, extreme winds or snowy days to be avoided for installation.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	PPE	Helmets and proper shoes (PPE) to be declared mandatory during installation/assembly.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Hardly possible, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Hardly possible, PO: Small			
3	OI	Customer to provide suitable scaffolding or lift for all the lifting processes at site.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
4	OI	More than one person to be present on-site during work.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.11 - slipping, tripping and falling

in all phases of the "life"

Hazard description

Wet shoes coming from outside could result in slippery container floor. Tripping/Falling or personal damage

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Anti-slipping floor plates to be installed inside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Safety shoes to be declared mandatory inside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

1 - Mechanical hazards

1.11 - slipping, tripping and falling

Assembly, installation

Hazard description

Personnel working on the top of the container during assembly without a harness. Imbalance could potentially result in falling from almost 3m height and severe injuries.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	OI	Customer to provide suitable scaffoldings, lifts during the procedure on site.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	SCP	Rainy, extreme winds or snowy days to be avoided for installation.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	PPE	Helmets and proper shoes (PPE) to be declared mandatory during installation/assembly.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Hardly possible, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
4	OI	More than one person to be present on-site during work.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.14 - other mechanical hazards

in all phases of the "life"

Hazard description

Risk of individuals falling, tripping or difficulties in access due to the unsafe entry and exit passage of the container.

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	OI	Level free access inside the container to be provided by the customers.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.14 - other mechanical hazards

Normal operation

Hazard description

Snow accumulated on the top of the container during winter season turns into ice. Ice falling from the top could potentially cause personal injury to the people standing/working down.

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	PPE	PPE should be considered at personnel presence near the container.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	PPE	Wearing helmets to be declared compulsory near the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Hardly possible, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Hardly possible, PO: Small			
3	OI	Instructions about the severe weather precautions to be included regarding that in the operational/safety manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

2 - Electrical hazards

2.8 - shock

in all phases of the "life"

Hazard description

Risk of shock due to improper grounding of the container.

Risk assessment and risk reduction

	7	Risk IN: SH: Death, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Container should be grounded as presented in the general arrangement drawings.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	SCP	Grounding continuity test to be performed before starting the system.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	PIC	Caution markings as per '60204-1:2016 Clause 8 paragraph 8.2.4: Each protective conductor connecting point shall be marked or labelled as such, using the symbol IEC 60417-5019:2006-08, or with the letters PE, the graphical symbol being preferred, or by use of the bicolor combination GREEN-AND-YELLOW, or by any combination of these' to be pasted on the container	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.8 - shock

Testing

Hazard description

Risk of shock due to the leak hoses/pipes/fittings inside the panels spraying on the live electrical parts.

Risk assessment and risk reduction

	7	Risk IN: SH: Death, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Prior to first power on the system, pressure testing should be completed and approved.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.8 - shock

Programming

Hazard description

System not responding to low insulation resistance due to the programming errors could potentially result in electric shock.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Signals from insulation resistance to be transferred directly to the safety controller to avoid any risk.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	Testing of the system during commissioning.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	OI	Test interval to be added in the service manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

2 - Electrical hazards

2.9 - other electrical hazards

in all phases of the "life"

Hazard description

Risk of injured individual getting trapped inside the container for long time due to the non-availability of space to enter the rescue equipment (stretchers etc).

Risk assessment and risk reduction

	4	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Hardly possible, PO: Small			
1	SCP	Emergency door with a wide opening to be installed in the container for the accessibility of bringing rescue equipment inside.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Emergency door area should be free and accessible from outside in case of emergency situations.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

3 - Thermal hazards

3.1 - burn

in all phases of the "life"

Hazard description

Risk of fire and burns due to the human negligence inside the container.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Smoke detectors to be installed in order to shut down the system in case of fire.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	Caution marking 'no smoking' 'no open flames' to be added on the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

3 - Thermal hazards

3.1 - burn

Malfunctioning

Hazard description

Risk of touching hot surface on the air heater cabinet if the container fans are not in operation while heating is ON.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Electrical interlock to be added to ensure that heating elements can only be operational if fans are running.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

3 - Thermal hazards

3.6 - scald

in all phases of the "life"

Hazard description

The steam coming out of the process exhaust is more than 60°C. Direct personal exposure could possibly result in scalding/burning.

Risk assessment and risk reduction

	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Middle			
1	OI	Working physically on the exhaust to be declared 'not allowed' during operation.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Safety caution markings to be added on the process exhaust pipings outside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	OI	Operator manual to be provided the information about the hot surface and high temperature.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

4 - Noise hazards

4.1 - discomfort

Normal operation

Hazard description

High level noise during normal operation (all FCwave modules operational) inside the container that could possibly results in severe hearing issues

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Noise testing to be performed inside the container during operation to check the severity.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Hardly possible, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Hardly possible, PO: Small			
2	PPE	PPE to be considered during inside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Hardly possible, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Hardly possible, PO: Small			
3	PIC	Caution marking about using hearing protections and information about automatic starting up of the system to be added.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

19 - Hazardous events: Control system

19.6 - Unintended/unexpected start-up

in all phases of the "life"

Hazard description

Customer control system remotely starts while the personnel are working inside the container could possibly result in severe personnel damage.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Locking out and tagging out the circuit breakers during assembly/installation/maintenance to avoid dangerous situations.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PPE	PPE to be considered during installation/service/maintenance/troubleshooting process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	OI	Integration/Service manuals with lock out and tag out procedures to be provided.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

DC/DC panels for fuel cell output

2 - Electrical hazards

2.4 - electrocution

Maintenance

Hazard description

DC/DC cabinets consists of capacitors that could remain charged for sometime after turning off the system. Maintenance of the DC/DC panels for fuel cell output while those capacitors are charged could result in potential electrocution or electric arc.

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	There are plugs available for the service personnel to measure the charge without getting in contact with the live electrical part.	PLr / SILr	PL / SIL	Applied documents
	2	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
2	OI	Detailed lock out and tag out procedures for DC/DC cabinets to be provided in service manual.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Hardly possible, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Hardly possible, PO: Small			
3	PIC	Caution marking regarding the electrical hazards to be pasted on the DC/DC panels.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.8 - shock

Malfunctioning

Hazard description

Cooling water sprayed on the live wires inside the DC/DC panels for fuel cell from the cooling hoses due to the leakage of coolant water. Possibility of short circuit and shock if the doors are open.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Hoses to be replaced into solid metal pipes.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Raised floor

1 - Mechanical hazards

1.4 - cutting or severing

Testing

Hazard description

Raised floor panel needs to be removed for maintenance/troubleshooting. The cable trays and horizontal support brackets installed down have sharp edges. Could possibly result in the personnel injury/cuts to legs/hands/arms.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Possibly minimum plates to be removed for work at a time.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	PPE	PPE should be considered during installation/commissioning/maintenance process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

1 - Mechanical hazards

1.4 - cutting or severing

Troubleshooting

Hazard description

Raised floor panel needs to be removed for maintenance/troubleshooting. The cable trays and horizontal support brackets installed down have sharp edges. Could possibly result in the personnel injury/cuts to legs/hands/arms.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Possibly minimum plates to be removed for work at a time.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	PPE	PPE should be considered during installation/commissioning/maintenance process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

1 - Mechanical hazards

1.4 - cutting or severing

Maintenance

Hazard description

Raised floor panel needs to be removed for maintenance/troubleshooting. The horizontal support brackets installed down have sharp edges. Could possibly result in the personnel injury/cuts to legs/hands/arms.

Risk assessment and risk reduction

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
1	SCP	Possibly minimum floor plates to be removed for work at a time.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	PPE	PPE to be considered to avoid injuries.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

2 - Electrical hazards

2.8 - shock

Hazard description

Risk assessment and risk reduction

No measures defined!

3 - Thermal hazards

3.6 - scald

Malfunctioning

Hazard description

There are piping connections on the raised floor. Those pipes leakage could result in the spillage of hot liquid (more than 65°C) inside the container.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Thorough inspection to be done of connection points to avoid leakage.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	A complete leakage testing to be performed.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	SCP	A detailed pressure testing to be performed.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
4	PPE	PPE to be considered while working inside the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

21 - Hazardous events: Workstation and/or work process design

21.4 - Painful and tiring postures

Maintenance

Hazard description

The maintenance work below the raised floor for long time can be in a tiring posture that could result in tiredness.

Risk assessment and risk reduction

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
1	SCP	Frequent breaks during work to be considered.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Hardly possible, PO: Small			
2	PPE	Knee pads to be used during the maintenance work.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Fuel cell, H2 enclosure ventilation system and exhaust (internal)

7 - Material/ substance hazards

7.5 - explosion

Assembly, installation

Hazard description

Leakage in the fittings between H2 supply pipe and FC modules can possibly result in the hydrogen release and therefore explosion. Also, the connection point between H2 supply and Hydrogen pipe can leak and can cause explosion.

Risk assessment and risk reduction

	6	Risk IN: SH: Death, DS: Rarely to more often, RA: Hardly possible, PO: Small			
1	ISD	Fitting included in FCwave double wall and detection system.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	ISD	Fitting intended for Hydrogen (Double Compression Ring Fitting).	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

601456B Crosswind BLPH

Interface: Fuel Cell Container,40' <--> Power Converter container, 10'

Interconnecting bridge between containers

1 - Mechanical hazards

1.3 - crushing

Assembly, installation

Hazard description

Risk of getting injured by falling objects (pipes/wires/cable tray) during installation.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Safety helmets, shoes (PPE) to be declared mandatory during the installation process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Proper lifting plan to be provided by the customer and to be followed during installation at site.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	OI	Only authorised people to be allowed to perform crane operations.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.5 - drawing-in or trapping

Assembly, installation

Hazard description

Risk of individuals falling down from the height during installation of the pipes/cables.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Safety helmets/shoes to be used during the installation process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Proper lift to be used during the installation process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Interface: Fuel Cell Container,40' <--> Cooling Unit

Interconnection of power cables

2 - Electrical hazards

2.8 - shock

Assembly, installation

Hazard description

Risk of getting a shock during installation if there is power on the cables feeding the cooling skid electric panel.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Locking out and tagging out procedure to be followed precisely.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	Only trained Ballard personnel to be available for installation of the system.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Connecting parts (40' and cooling skid)

1 - Mechanical hazards

1.3 - crushing

Assembly, installation

Hazard description

Risk of crushing into personnel during the lifting of cooling skid up to the container.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	OI	Detailed installation guide and lifting procedure to be provided by the customer.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Local rules for the lifting of equipment to be followed precisely and to be mentioned in the manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

3 - Thermal hazards

3.1 - burn

Normal operation

Hazard description

Risk of getting a burn from touching hot pipes (above 65 degrees) during normal operation.

Risk assessment and risk reduction

	3	Risk IN: SH: Serious injury, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	PIC	Caution marking indication hot surface to be added on the cooling pipes.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 20-08-2024

Cooling Unit

Limit of the product: Use-, space-, time- and other limits

Cooling skid platform

1 - Mechanical hazards

1.5 - drawing-in or trapping

Assembly, installation

Hazard description

Risk of getting slipped and fall into the cooling skid frame from the platform that could possibly result in injuries to leg and trapping inside.

Risk assessment and risk reduction

	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Middle			
1	SCP	Working on platform to be avoided in snowy and rainy weather conditions.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PPE	Safety shoes to be considered while working on the service platform.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

1 - Mechanical hazards

1.11 - slipping, tripping and falling

in all phases of the "life"

Hazard description

Risk of slipping/tripping while entering or exiting the cooling skid platform.

Risk assessment and risk reduction

	7	Risk IN: SH: Death, DS: Rarely to more often, RA: Hardly possible, PO: Middle			
1	SCP	Proper means to access (scaffolding) to be arranged for different phases of life operations.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Access to the cooling platform must be according to the local rules and regulations.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

3 - Thermal hazards

3.6 - scald

Troubleshooting

Hazard description

The system needs to be in operation during trouble shooting process and the water in HT cooling pipes pipes could get hot (upto 60ºC). There is a risk of being scalded with the hot water due to the leakage in the cooling pipes.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	PPE should be considered during the troubleshooting operations.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

3 - Thermal hazards

3.6 - scald

Commissioning, adjustments

Hazard description

There are cooling hoses installed next to the cooling skid platform and are connected to the header tank. During the commissioning process the system is operational and the hoses contain hot water (up to 65°C). There is a risk of scalding person working on the platform due to the leakage in those hoses.

Risk assessment and risk reduction

	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Middle			
1	ISD	Metal connections have special grooves to prevent hoses from slipping off.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	Metal straps around the hoses installed.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	PPE	Safety goggle and safety clothing to be used while working on the cooling skid.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
4	PIC	Caution marking regarding hot surface to be pasted on the hoses.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

4 - Noise hazards

4.1 - discomfort

Commissioning, adjustments

Hazard description

High noise during the system in operation could possibly result in discomfort during commissioning process on the skid platform.

Risk assessment and risk reduction

	2	Risk IN: SH: Slight injury, RA: Hardly possible, PO: High			
1	PPE	Hearing protections to be used while working on the platform.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
2	OI	Personnel working on cooling skid is not allowed during the full load operation (all FCwave running). This instruction to be mentioned in the relevant manuals.	PLr / SILr	PL / SIL	Applied documents
		Risk OUT:			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

22 - Other hazardous events

in all phases of the "life"

Hazard description

Risk of falling down from the platform due to extreme weather events.

Risk assessment and risk reduction

	7	Risk IN: SH: Death, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Access to be prohibited during extreme weather conditions.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Piping/Valves/Vessels

7 - Material/ substance hazards

7.5 - explosion

Malfunctioning

Hazard description

Due to the manual valve at the inlet/outlet of the fuel cell module inadvertently closed, Loss of cooling in cooling fluid for the fuel cell module leading to loss of cooling for the fuel cell stacks. Due to continuous heat production at the membrane of the fuel cell, potential to exceed design pressure leading to failure of the packing in the membrane. Leakage of H2 in an enclosed area potential for ignition and internal explosion of H2. Potential for multiple fatalities.

Risk assessment and risk reduction

	6	Risk IN: SH: Death, DS: Rarely to more often, RA: Hardly possible, PO: Small			
1	ISD	High temperature coolant transmitter to be used for shutting down individual Fuel Cells. Unload DC/DC converter and disconnect electrically from the power converters.	PLr / SILr	PL / SIL	Applied documents
	2	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
2	SCP	Firewire Linear Heat Detector around the Fuel Cell Modules to be added that shutdown the individual Fuel Cell via fire safety system by disconnecting electrically from the power converter and closing the Fuel Cell supplier.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

HT cooling radiators

1 - Mechanical hazards

1.3 - crushing

Malfunctioning

Hazard description

Risk of crushing personnel damage while removing HT coolers because of malfunction.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	PPE should be considered during the maintenance process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Service manuals should be provided with all the details and to be followed precisely.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

3 - Thermal hazards

3.1 - burn

Commissioning, adjustments

Hazard description

Risk of burns due to touching of the hot HT cooler pipe beside the platform when the system is in operation.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Caution markings to be added on the pipes to avoid physical touch.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PPE	PPE to be considered and face covered helmets to be used.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

7 - Material/ substance hazards

7.5 - explosion

Malfunctioning

Hazard description

Loss of cooling in HT cooling system 1 and subsequently loss of cooling for 3 of the fuel cell modules. Due to continuous heat production at the membrane of the fuel cell, potential to exceed design pressure leading to failure of the packing in the membrane. Leakage of H2 in an enclosed area potential for ignition and internal explosion of H2. Potential for multiple fatalities.

Risk assessment and risk reduction

	6	Risk IN: SH: Death, DS: Rarely to more often, RA: Hardly possible, PO: Small			
1	SCP	High temperature coolant transmitter to be designed for shutting down individual Fuel Cells. Unload DC/DC converter and disconnect electrically from the power converters.	PLr / SILr	PL / SIL	Applied documents
	2	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Hardly possible, PO: Small			
2	SCP	Firewire Linear Heat Detector around the Fuel Cell Modules to be used to shutdown the individual Fuel Cell via fire safety system by disconnecting electrically from the power converter and closing the Fuel Cell supplier.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

7 - Material/ substance hazards

7.10 - sensitization

in all phases of the "life"

Hazard description

Risk of allergic reaction due to skin/eyes exposure to the cooling fluid.

Risk assessment and risk reduction

	2	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Middle			
1	PPE	Safety goggles/face shield/chemical resistant gloves to be considered while working.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

HT Pump

1 - Mechanical hazards

1.3 - crushing

Maintenance

Hazard description

HT pump maintenance requires disassembly and lifting operation. Risk of crushing and personnel damage if not handled safely.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Safety shoes required during the lifting operations.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Disassembly procedure with the lifting equipment to be provided in the relevant manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Electrical cabinet

1 - Mechanical hazards

1.10 - shearing

Assembly, installation

Hazard description

Risk of getting sheared on hands/arms during the installation of cables in the lower part of the cabinet.

Risk assessment and risk reduction

	1	Risk IN: SH: Slight injury, RA: Hardly possible, PO: Middle			
1	PPE	PPE to be considered during installation process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

2 - Electrical hazards

2.8 - shock

Testing

Hazard description

Risk of touching the live wires in the cooling skid panel and getting a shock during troubleshooting process.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	IP20 rated covers to be considered to avoid the touching of live wires.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PPE	PPE should be considered necessary during the trouble shooting process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	PIC	Caution marking regarding the risk of electrical shock to be pasted on the cabinet.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.8 - shock

Troubleshooting

Hazard description

Risk of touching the live wires in the cooling skid panel and getting a shock during troubleshooting process.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	IP20 rated covers to be considered to avoid the touching of live wires.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PPE	PPE should be considered necessary during the trouble shooting process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
3	PIC	Caution marking regarding the risk of electrical shock to be pasted on the cabinet.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Power Converter container, 10'

Limit of the product: Use-, space-, time- and other limits

Container 10'

2 - Electrical hazards

2.8 - shock

in all phases of the "life"

Hazard description

Risk of shock due to improper grounding of the system.

Risk assessment and risk reduction

	7	Risk IN: SH: Death, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Grounding should be done as presented in the general arrangement diagrams.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	Ground continuity testing to be performed before starting the system.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3		Caution marking as per '60204-1:2016 Clause 8 paragraph 8.2.4: Each protective conductor connecting point shall be marked or labelled as such, using the symbol IEC 60417-5019:2006-08, or with the letters PE, the graphical symbol being preferred, or by use of the bicolor combination GREEN-AND-YELLOW, or by any combination of these' to be pasted in the container'.	PLr / SILr	PL / SIL	Applied documents
		Risk OUT:			

Risk adequately reduced ☑ No ☐ Yes

Electrical Cabinets

2 - Electrical hazards

2.8 - shock

Commissioning, adjustments

Hazard description

Risk of electric shock from control panel if the front door is opened during rainy or snowy conditions.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Trouble shooting or commissioning operations in rainy and snowy weather conditions to be avoided.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	SCP	Rain roof to be added to avoid the snow and water accumulation in the panel.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.8 - shock

Testing

Hazard description

Risk of shock during the trouble shooting in the control panel as there are measurements wires coming in the control panel for output container (3X400V AC, 750V DC) from the main output panel and DC link.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Tools according to EN 60 900 with 'double triangle', Gloves, safety goggles, suitable clothing and shoes to be used during trouble shooting process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Caution labels indicating electric shock risk.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.8 - shock

Troubleshooting

Hazard description

Risk of shock during the trouble shooting in the control panel as there are measurements wires coming in the control panel for output container (3X400V AC, 750V DC) from the main output panel and DC link.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Tools according to EN 60 900 with 'double triangle', Gloves, safety goggles, suitable clothing and shoes to be used during trouble shooting process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Caution labels indicating electric shock risk.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Ventilation for output container

1 - Mechanical hazards

1.3 - crushing

Malfunctioning

Hazard description

Risk of crushing during disassembly of fan for the repair.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	OI	Ballard should be contacted if the fan malfunctions before disassembling it. This info to be mentioned in the relevant manual.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

Transformer

1 - Mechanical hazards

1.3 - crushing

Transport

Hazard description

Displacement of the transformer in the container during transport could possibly result in crushing personnel while opening the main door on site.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Transformer to be fixated with brackets before transport.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	OI	Visual inspection to be done from the side door before opening the main doors onsite. Follow the proper sequence mentioned in the transport manual when the container arrives.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

	0	Risk IN: SH: No injury, PO: Small			
3	OI	Manual should be provided with info about securing the transformer for transport with a steel spacer block. Prior to transformer energising, the block should be replace by the insulator.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 26-08-2024

1 - Mechanical hazards

1.11 - slipping, tripping and falling

in all phases of the "life"

Hazard description

Risk of tripping on the cable trays and hit the head against the transformer terminals or other components.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	PPE	Safety helmets to be considered during trouble shooting process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Yellow and black tapes to be pasted on the floor as a caution.	PLr / SILr	PL / SIL	Applied documents
		Risk OUT:			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.3 - effects on medical implants

Normal operation

Hazard description

Individuals with a ICD- implantable cardioverter defibrillator could possibly get disturbed due the electromagnetic field inside and outside the container.

Risk assessment and risk reduction

	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	OI	Individuals using ICD- implantable cardioverter defibrillator to be restricted near the container and to be mentioned in the safety manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PIC	Caution lables about electromagnetic fields to be pasted on the container	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

2 - Electrical hazards

2.4 - electrocution

Testing

Hazard description

Risk of electrocution while performing testing with temporary transformer connections.

Risk assessment and risk reduction

	7	Risk IN: SH: Death, DS: Often to continuously, RA: Possible under certain circumstances, PO: Small			
1	SCP	Lockout/tagout procedures to followed precisely.	PLr / SILr	PL / SIL	Applied documents
	1	Risk OUT: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	OI	Verification of no residual voltage at the terminals before proceeding the work.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

AC power connection (customer interface)

1 - Mechanical hazards

1.4 - cutting or severing

Assembly, installation

Hazard description

Risk of cutting hands/arms during the installation of the cables on the busbars.

Risk assessment and risk reduction

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
1	PPE	Proper gloves and arm coverings to be considered during installation.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☐ No ☑ Yes Chaudhary Hijab 12-08-2024

2 - Electrical hazards

2.4 - electrocution

in all phases of the "life"

Hazard description

Risk of electrocution if the system is not deenergized completely while the individuals are working on the installation.

Risk assessment and risk reduction

	0	Risk IN: SH: No injury, PO: Small			
1	PIC	Warning labels should be pasted on each container door to avoid access.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	5	Risk IN: SH: Death, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
2	OI	Locking out and tagging out the circuit breaker at the customer end to be declared mandatory and to be mentioned in the integration manual.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Main power output container

2 - Electrical hazards

2.8 - shock

Troubleshooting

Hazard description

Risk of shock if a person enters the container during the operation.

Risk assessment and risk reduction

	6	Risk IN: SH: Death, DS: Rarely to more often, RA: Hardly possible, PO: Small			
1	SCP	Two types of safety locks to be installed in the container. One for restricting access and other for disconnection of power inside the container. The latter one will not prevent the access but turns off the power in the container as a safety measure. Both main doors to be locked using padlocks.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	OI	Instructions for not allowing personnel entry in the container to be added in the manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			
	0	Risk IN: SH: No injury, PO: Small			
3	OI	Proper instructions about deenergizing equipment in the container to be added in the manuals.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: No injury, PO: Small			

	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
4	PIC	Caution stickers on the container doors marking no entry/high voltage electric shock risk as per '60204-11 clause 7 paragraph 17.2'.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

4 - Noise hazards

4.1 - discomfort

Normal operation

Hazard description

Discomfort due to the high level of noise from converters and other equipment outside and close to the container.

Risk assessment and risk reduction

	1	Risk IN: SH: Serious injury, DS: Rarely to more often, RA: Possible under certain circumstances, PO: Small			
1	SCP	Noise level to be measured during the testing process.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
	0	Risk IN: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			
2	PPE	Hearing protections to be considered near the container.	PLr / SILr	PL / SIL	Applied documents
	0	Risk OUT: SH: Slight injury, RA: Possible under certain circumstances, PO: Small			

Risk adequately reduced ☑ No ☐ Yes

Sub Section J99-011

Completed SAT Procedure

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	12/08/2025	First Issue

Document Title:	**BLPH Project - Confirmation of Satisfactory SAT - Signature Page.pdf**
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Purchaser Job:	K559-2254
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Base Load Power Hub (BLPH)

OTP – Hydrogen Fuel Cell Package

Document Number: 123A90-PML-COM-PRO-03062

Document Class: 2

{ DOCUMENT PREPARED IN COLLABORATION WITH CROSSWIND PMT }

01	30/01/2025	Accepted for Construction (AFC)	G.DELMISSIER	A.IVESON	M.BRUNELLI
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Rev.	Date	Description	Prepared	Reviewed	Approved

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Accepted for Construction (AFC)

HOLDS LIST

No.	Description
1	Awaiting details of commissioning spare parts from Ballard
2	
3	

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1 INTRODUCTION

1.1 Project Overview

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.2 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.



Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map



Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile is located on coordinates E 590719.1, N 5841602.3 and is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.3 Project Concept

All components included in the BLPH will be integrated onshore on a topside and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

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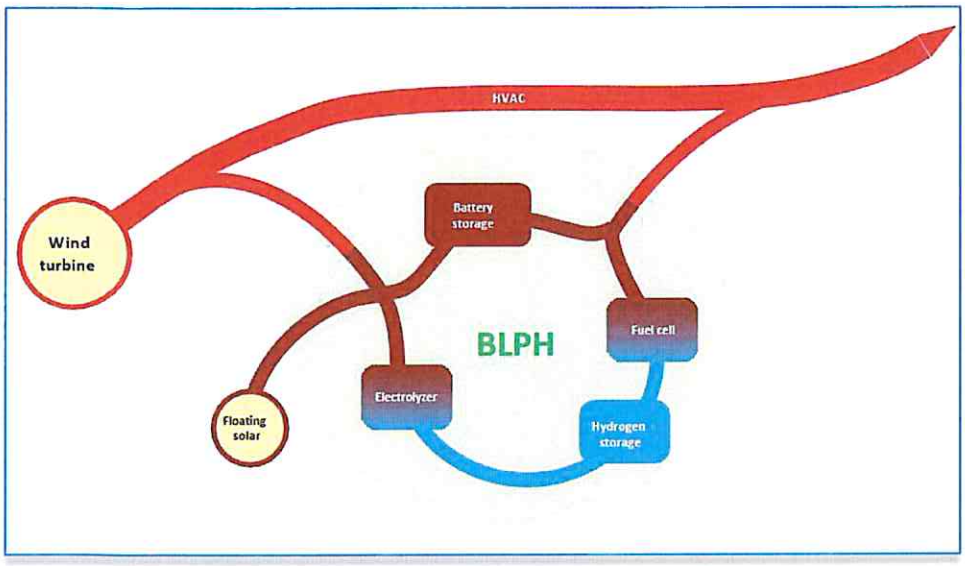


Figure 3 - BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.
The purpose of the BLPH is to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

2 DOCUMENT SCOPE

The purpose of this document is to describe the dedicated Commissioning procedure together with the detailed test steps to be implemented for the preparation and execution of the operation testing of the Hydrogen Fuel Cell Package

The document will cover all related test steps to be performed at both the onshore Worksite construction yard and the offshore SITE.

3 OTP SUMMARY

3.1 Test Objective

The operating test of the Hydrogen Fuell Cell system is executed to ensure that the system is started up in a safe and controlled manner and to verify the correct operation according to the project requirements.

Aim of this document is to provide the sequence and appropriate actions to verify the safety systems of the system along with ability for the system to produce electrical power.

Please note that Pre-commissioning activities are described in detail in the method statement document K559-2254-CWIWP4202202-J99-009 as well as in the Vendor SAT procedure K559-2254-CWIWP4202202-J99-001. For the sake of completeness, these activities will be mentioned here as part of necessary steps but will not be part of the OTP.

Activities shall be developed as follows:

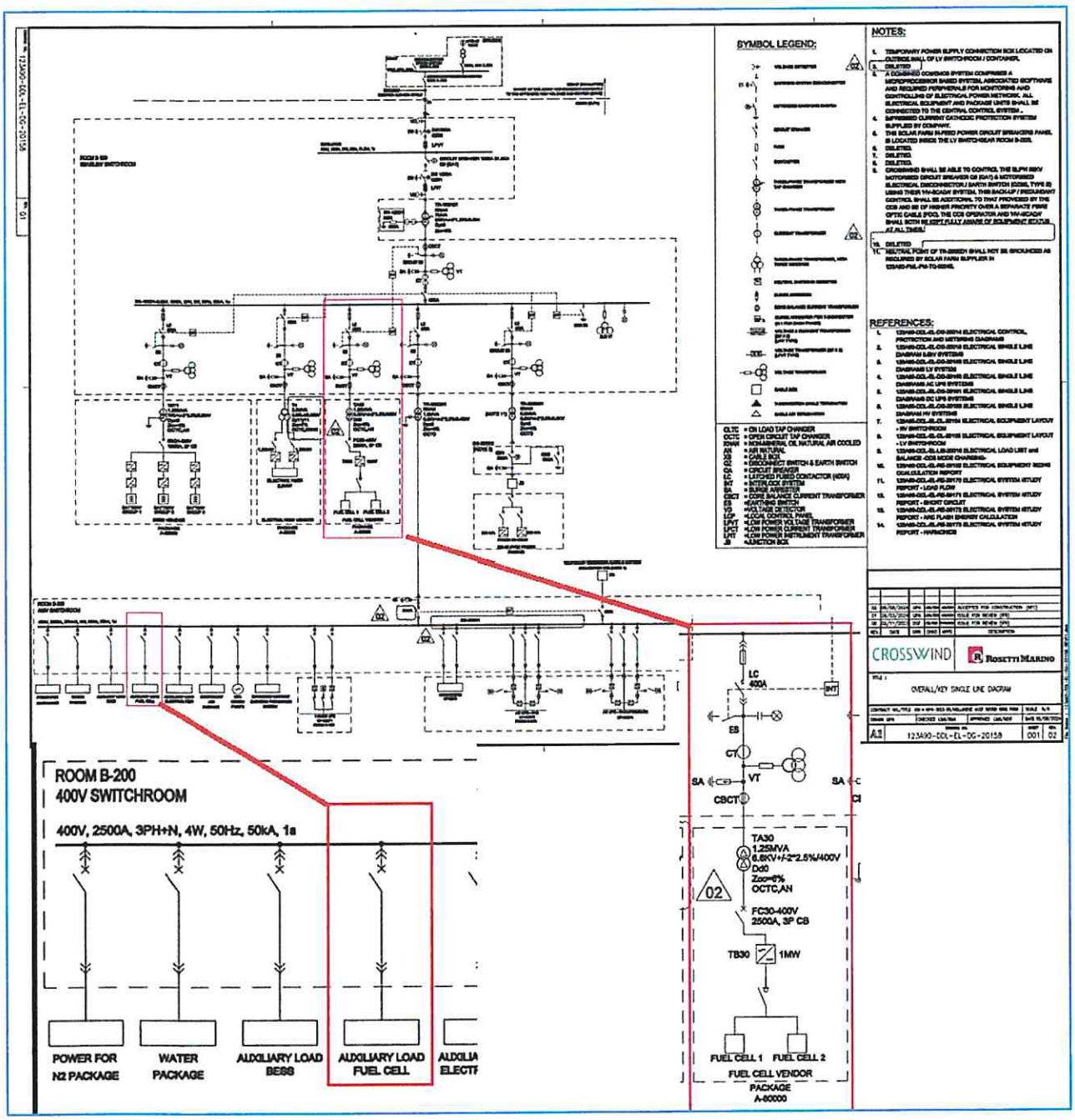
- Onshore pre-commissioning and commissioning activities at Contractor site (WORKSITE)
  - PHASE 1: Pre-commissioning (powered) activities including the following (NOT PART OF THIS OTP):
    - Leak Testing of modified H2 heater manifold assembly and coolant system leak test.
    - Aux first power on
    - Collant System fill and degas
  - PHASE 2: Pre-commissioning (powered) activities including the following (NOT PART OF THIS OTP):
    - IO test (package internal)
    - Platform communication check
    - Testing of 6.6 kV Trafo
    - Software upgrades testing
    - H2 supply check
    - External interface checks
    - Software upgrade testing
  - PHASE 3: Vendor SAT & Integrated function test of Hydrogen Fuel Cell package.

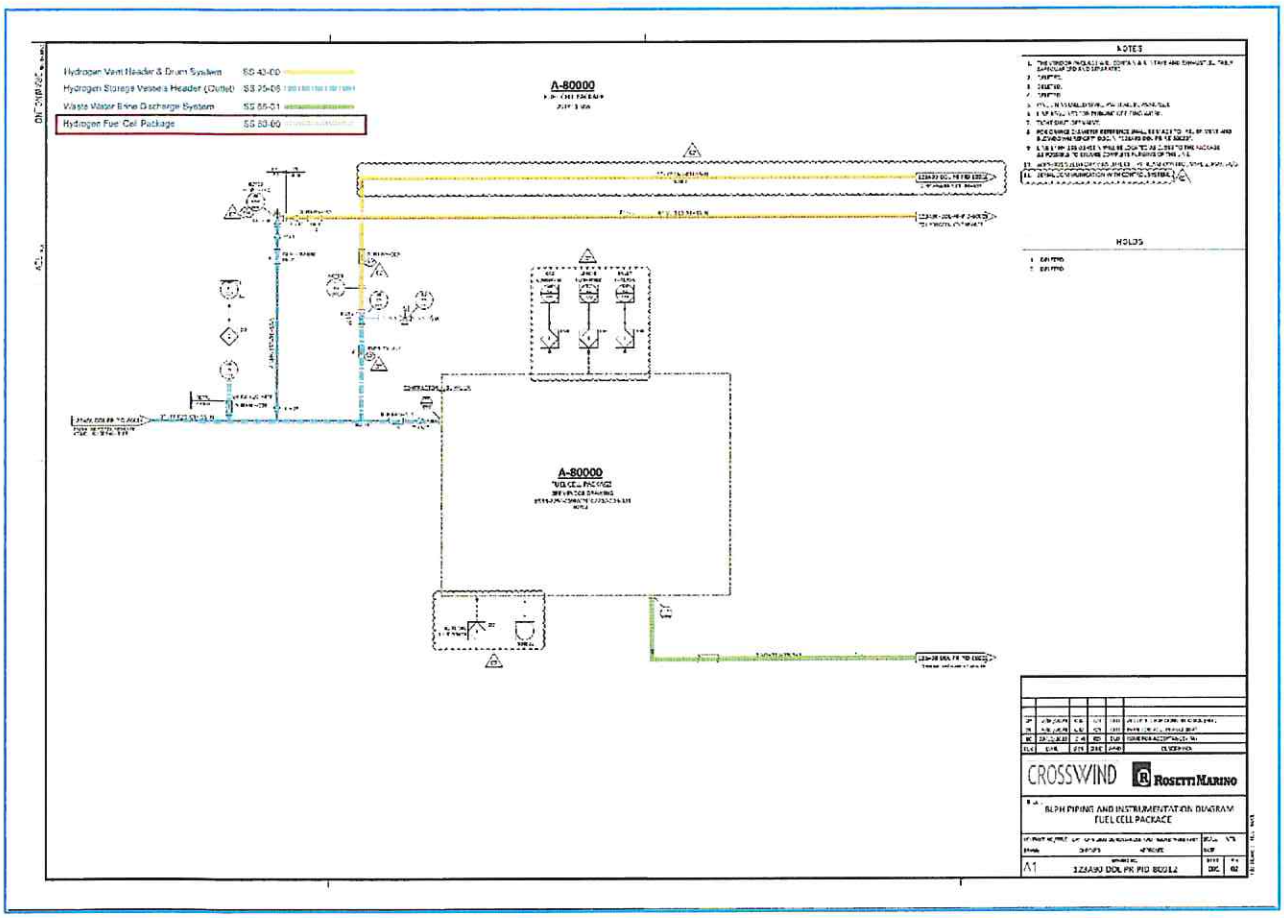
- Offshore commissioning (SITE)
  - PHASE 4: Integrated function test of Hydrogen Fuel Cell package (OFFSHORE).

PHASES 1 – 2 are covered by and contained within the vendor Method Statement. PHASES 3 - 4 are included within this OTP document, and the Vendor SAT procedure.

3.2 System Boundary Limits

See below the interested systems and subsystems on the Overall Single Line Diagram





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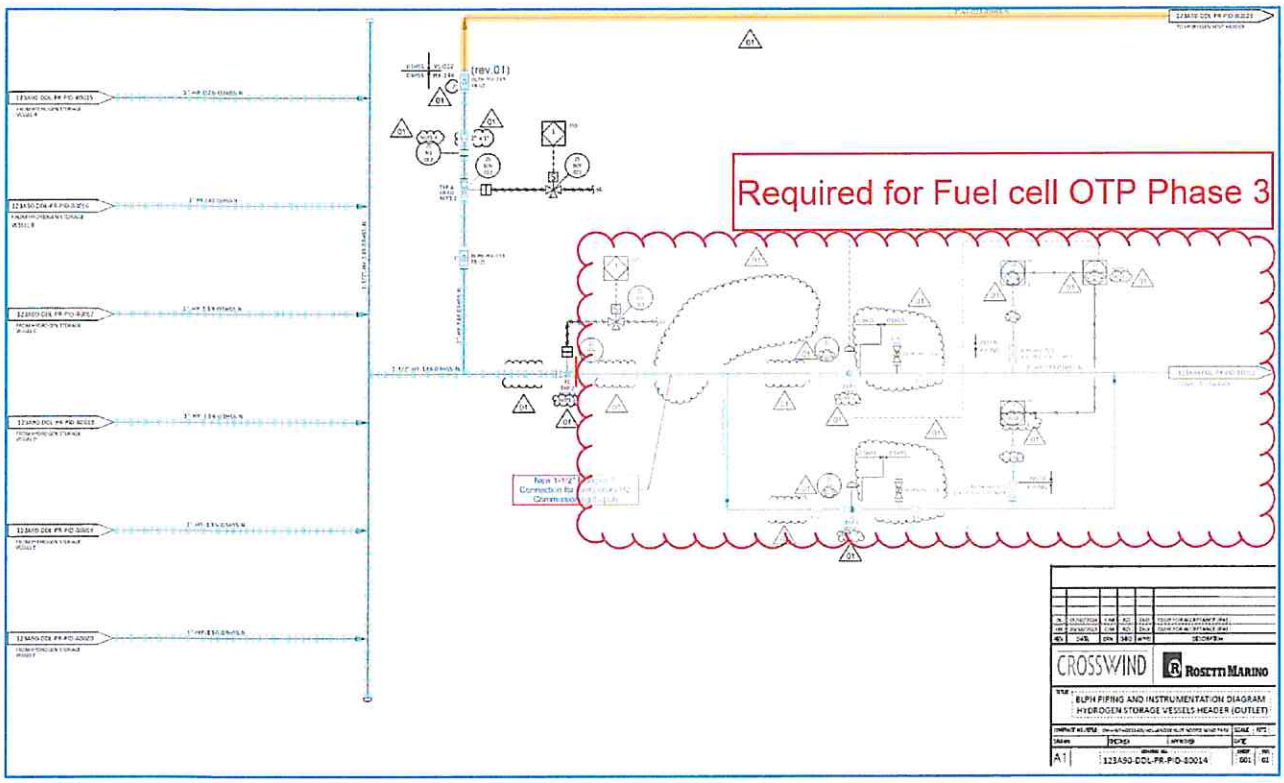


Figure 4 – OTP System Boundary Limits

3.3 Test and System Description

Proceeding with this OTP is confirmation that the following system:

- 80-00 Hydrogen Fuel Cell

That all equipment is installed in accordance with the following vendor documents:

- K559-2254-CG-PHI-001 Commissioning Philosophy
- ELO-INN-PBH-DWG-0005 General Arrangement Drawing
- ELO-ELE-BPH-DWG- 0005 Electrical Single Line Diagram Power Distribution
- ELO-INN-BPH-CKT-0006 Alarm warning list
- ELO-INN-BPH-DWG-0008 Process Flow Diagrams
- K559-2254-EL-ELL-002 BLPH - Electrical Load List (CCS MODE 2(A) 'HOT STANDBY')
- K559-2254-EL-ELL-003 BLPH - Electrical Load List (CCS MODE 3(C) 'DISCHARGING')
- K559-2254-EL-ELL-004 BLPH - Electrical Load List (CCS MODE 4(A) 'COLD STANDBY')
- K559-2254-EL-ELL-005 BLPH - Electrical Load List (CCS MODE 4A(D) 'EMERGENCY MODE (Island))
- K559-2254-EL-ELL-006 BLPH - Electrical Load List (CCS MODE 5(D) 'POWER OUT (Blackout))
- K559-2254-PR-PHI-001 - Main process control philosophy

3.4 Safety Devices

- Appropriate Personnel Protective Equipment (PPE) and safety equipment e.g., safety shoes, hand gloves, helmet, earplugs etc. are available and must be used in line with the site requirements.
- For entry into the 40' container standard PPE as stated above must be worn. Phones are not permitted within the 40' container.
- Access to the 10' transformer container is not permitted during operation and the container is to be double locked, the second lock being controlled by the CONTRACTOR.
  This is in addition to all normal PPE in line with site requirements.
- Warning safety signs are to be posted with restricted access to essential personnel only.
- Adequate firefighting equipment must be present at site.

3.4.1 HSE Management

- All necessary safety precautions must be taken to avoid any risk of personnel injury.
- All personnel involved in this operational test shall be competent for the tasks they will be required to undertake
- Place safety / warning signs and segregate the entire area with barrier tapes (safety barriers) of a colour distinguished (blue and white) from those used for construction activities
- Restrict access into area only to authorized personnel
- Conduct "Toolbox Talk" with all personnel prior to starting test work
- Appropriate Personnel Protective Equipment (PPE) and safety equipment e.g. safety shoes, hand gloves, helmet, earplugs etc. are available and must be used in line with the site requirements. Flame retardant coveralls should be worn.
- ATEX Field radios or Walkie-Talkies will be required for communication during testing.
- Portable gas detectors to be used by all personnel after H2 introduction.
- All activities carried out on the project shall be performed in accordance with the "Permit to Work" system Doc. PRO-HSE-23
- Electrical and mechanical isolations are to be assured as per Doc. PRO-HSE-08 and "Commissioning and start-up operation" procedure.
- Observe and enforce all international codes and regulations to safeguard personnel, plant and environment.
- Ensure that the working area is clean, tidy, well illuminated and that access and escape routes are free from obstructions.

Before starting work on any of the activities in this OTP it is the responsibility of the persons performing the work to:

- Familiarize themselves with the plant/equipment to be worked on
- Ensure they are aware of all other work activities that are taking place, or due to take place
- If necessary, re-plan any situation/activity
- Ensure proper communications between parties involved in the execution of the OTP
- Read the relevant Vendor documentation for the equipment covered by this OTP and observe any special requirements and limitations recommended or imposed by Vendor
- Verify that all personnel involved in the implementation of this procedure are familiar with its content as well as the associated safety requirements (Toolbox Talk)

3.5 Acceptance Criteria

- Before Power ON:

Visual inspection and verification are a crucial step to identify any obvious issues with the installation, such as loose connections, missing components, or damage to the equipment.

Crosschecking the installation with engineering documentation ensures that the installation is done correctly and according to the manufacturer's guidelines. These steps can help identify any missing or incorrect components, and wrong connections - – Refer to Vendor SAT chapters 7.1, through 7.4

All package ITRs to be completed & RFC issued for sub-system 80-00.

Apply padlocks on all necessary Breakers per LoTo Procedure.

Applicable locations:
- AC Power Distribution (BA20+UC50)
- Control System, Container #1 (LA01+UC20)
- Coolant Skid Cabinet, Container #1 (HE01+UC30
- DCDC Cabinets #1-6 (+UC01 to +UC06)
- Control System, Container #2 (LA01+UC31)
- Power Conversion Output, Container #2 (BA30+DA03)

See Ballard produced document "BLPH Project – Electrical Single Line Diagrams" – BPSE-ELE-BPH-DWG-00005

Powering ON the unit is an essential step to verify that the equipment is functioning correctly. Observing if everything is OK and any alarm will help detect possible errors or malfunctions.

Phase 1 (Not in the OTP) will prove correct (NOT PART OF THIS OTP):
- All piping (H2 and cooling) installed correctly.
- All cooling systems are filled correctly.
- Energization of the AUX circuits is successful; all the subsystems are working according to specification.
- All necessary Software updates are performed, and the package internal communication is proven successful.
- The safety critical functions integrated in the Hydrogen Fuel Cell package are working according to specification.

Phase 2 (Not in the OTP) will prove correct (NOT PART OF THIS OTP):
- All necessary Software updates are performed, and the package internal communication is proven successful.
- Functionality checks of the Package VFDs.
- The communication with the EMCS/PCS.
- The installation and functionality of the 6.6kv Trafo.

Phase 3 will prove correct:
- Completion of the Vendor SAT procedure.
- Functionality of the Hydrogen Fuell Cell package in coordination with Required Associated Subsystems packages on BLPH. (ONSHORE)

Phase 4 will prove correct:
- Functionality of the Hydrogen Fuel Cell package in coordination with the other packages on BLPH (OFFSHORE).

Performing the steps in this OTP as per engineering documents is crucial to ensure that the equipment is operating correctly and that it meets the desired design specifications. Observing the results will help identify any issues that may arise during the operation.

Overall, following these steps shall provide a comprehensive and effective way to verify the equipment installation and functionality.

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4 DOCUMENTS REFERENCES AND ABBREVIATIONS

4.1 Reference Documents

4.1.1 Company Documents and Standards

Document ID	Document Title
[1] K559-2254-CG-PHI-001	Commissioning Philosophy
[2] K559-2254-EL-ELL-002	BLPH Electrical Load List (CCS MODE 2(A) 'HOT STANDBY')
[3] K559-2254-EL-ELL-003	BLPH Electrical Load List (CCS MODE 3(C) 'DISCHARGING')
[4] K559-2254-EL-ELL-004	BLPH Electrical Load List (CCS MODE 4(A) 'COLD STANDBY')
[5] K559-2254-EL-ELL-005	BLPH Electrical Load List (CCS MODE 4A(D) 'EMERGENCY MODE (Island))
[6] K559-2254-EL-ELL-006	BLPH Electrical Load List (CCS MODE 5(D) 'POWER OUT (Blackout))
[7] K559-2254-PR-PHI-001	Main process control philosophy

Table 1: Company Documents and Standards

Note – These documents were produced in FEED and made available to RM for info. They have subsequently been superseded by Detailed Design, similar or same deliverables.

4.1.2 Project Documents

Document ID	Document Title
[1] 123A90-PML-PM-LIS-01001	Master Document Register
[2] 123A90-PML-PM-PL-00001	Project Execution Plan
[3] 123A90-PML-QHSE-PL-00001	Project HSE Plan
[4] 123A90-PRO-HSE-23	RM Yard Permit To Work Procedure
[5] 123A90-PML-COM-PL-03002	Mechanical Completion & Commissioning Exec. Plan
[6] 123A90-PML-COM-PRO-03007	Commissioning Strategy
[7] 123A90-PML-COM-LIS-03011	System/Sub-Systems List
[8] 123A90-PML-COM-LIS-03012	System/Sub-System Boundary Limit Diagrams
[9] 123A90-PML-COM-PRO-03038	Leak Test Procedure
[10]123A90-PML-COM-SP-03032	Pre-Commissioning Functional Test Sheet Template Collection (ITR-B)
[11]123A90-PML-COM-SP-03014	Commissioning TDS - Temporary Equipment & Facilities
[12]123A90-PML-COM-PRO-03019	OTP – Onshore Performance & Integrated Test Procedure
[13]123A90-PML-COM-LIS-03034	Inhibit-Override Register

Document ID	Document Title
[14]123A90-PML-COM-LIS-03035	PSV Calibration Register
[15]123A90-PML-COM-PRO-03036	OTP - Black Start Procedure
[16]123A90-PML-COM-LIS-03024	Commissioning Spare Parts and Consumables List
[17]123A90-PML-COM-PRO-03022	Initial offshore START-UP procedures
[18]123A90-PML-COM-SP-03057	Worksite WEF (Work Execution Flow Scheme)
[19]123A90-PML-COM-SP-03058	Site WEF (Work Execution Flow Scheme)
[20]123A90-PML-COM-RE-03001	Commissioning Final Dossier (ITR-B)
[21]123A90-PML-QHSE-PRO-00116	Flushing and Cleaning Procedures
[22]123A90-PML-QHSE-SP-00118	Mechanical Completion Check Sheet Template Collection (ITR-A)
[23]123A90-PML-QHSE-RE-00115	Mechanical Completion Final Dossier (ITR-A)
[24]123A90-PML-QHSE-PRO-00117	Punch list Management Procedure
[25]123A90-PML-COM-PRO-03041	OTP - Hydrogen Storage & Venting Systems
[26]123A90-PML-COM-PRO-03042	OTP - Sea Water Intake & Fresh Water Treatment Systems
[27]123A90-PML-COM-PRO-03043	OTP - Instrument Air System
[28]123A90-PML-COM-PRO-03055	OTP - Nitrogen Generation System
[29]123A90-PML-COM-PRO-03044	OTP - HVAC Systems
[30]123A90-PML-COM-PRO-03045	OTP - HV Switchgear & 66 kV Transformer Systems
[31]123A90-PML-COM-PRO-03046	OTP - 6.6 kV Switchgear & Transformer Systems
[32]123A90-PML-COM-PRO-03047	OTP - LV Switch Board & LV Distribution Board Systems
[33]123A90-PML-COM-PRO-03048	OTP - Lighting & Small Power Systems
[34]123A90-PML-COM-PRO-03049	OTP - Electrical Heat Tracing Systems
[35]123A90-PML-COM-PRO-03050	OTP - UPS Systems
[36]123A90-PML-COM-PRO-03051	OTP - Data Network Systems
[37]123A90-PML-COM-PRO-03052	OTP - Telecom & Surveillance Systems
[38]123A90-PML-COM-PRO-03053	OTP - Navaid System
[39]123A90-PML-COM-PRO-03054	OTP - F&G and ESD C&E Logics
[40]123A90-PML-QHSE-PRO-00120	Proverlis Management Procedure
[41]123A90-PML-COM-PRO-03056	OTP – Document Template
[42]123A90-DDL-IN-RE-40095	Process Control Logics Description

Table 2: Reference Project Deliverables

4.1.3 Vendor Documents

Document ID	Document Title
[1] K559-2254-CWIWP4202202-C06-001Rev007	Electrical Single Line Diagram
[2] K559-2254-CWIWP4202202-B01-001Rev009	General Arrangement
[3] K559-2254-CWIWP4202202-N01-001Rev001	Integration Manual
[4] K559-2254-CWIWP4202202-N01-002Rev002	Operators Manual
[5] K559-2254-CWIWP4202202-E03-007Rev001	Electrical Interface Document
[6] K559-2254-CWIWP4202202-K03-001Rev001	Performance Test Results (FAT)
[7] K559-2254-CWIWP4202202-J99-001-Rev003	SAT Procedure
[8] K559-2254-CWIWP4202202-C08-001Rev004	Control Philosophy & Block Logic Diagrams
[9] K559-2254-CWIWP4202202-J99-009	Method Statement

Table 3: Company Key Reference Documentation

4.2 Acronyms and Abbreviations

Acronyms / Abbreviations	Description
BLPH	BaseLoad Power Hub
CO	Carbon monoxide
EMCS	Electrical Monitoring & Control System
ESD	Emergency Stop Devices
FAT	Factory Acceptance Test
FTE	Full Time Employees
F&G	Fire and Gas
PPE	Personal Protective Equipment
ITR	Inspection & Test Record
LOTO	Lock Out Tag Out
OTP	Operational Test Procedure
PCS	Power Conversion System
SAT	Site Acceptance Test
SOC	State Of Charge

Table 1: Acronyms and Abbreviations

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5 OTP AT ONSHORE WORKSITE

This chapter refer to the activities on the Contractor worksite (construction yard).

5.1 Planning and Manpower

5.1.1 Planned tasks with estimated manpower

Estimated manpower for the different phases of the OTP are:

- 2 Vendor FTE.
- 1 Commissioning Supervisor from Company
- 1 Commissioning Supervisor from Contractor
- 1 Operator from EMCS vendor
- 1 Operations Engineer from Company.

5.1.2 Pre-Commissioning duration estimate:

- **PHASE 1:** 12 days approx. (Not in the OTP)
- **PHASE 2:** 12 days approx. (Not in the OTP)

5.1.3 Test duration estimate

The test duration should be as follows:

- **PHASE 3:** 3 days approx.
- **PHASE 4:** 2 days approx.

If necessary, the estimated time can be extended in order to complete all required pre-commissioning and commissioning activities.

5.1.4 Vendor Assistance

Vendor Ballard will lead and/or supervise the onshore commissioning activities. For offshore commissioning Ballard will provide remote support.

5.1.5 Summary of interface signals to be tested:

Please refer to the following documents;

- **BPSE-INN-BPH-REG-00006** – Modbus Table
- **BPSE-INN-BPH-OTH-00012** - BLPH - FC Package Modbus Table

5.2 OTP Test Requirements – Onshore WORKSITE

5.2.1 Pre-Commissioning Achievement

Prior to commencement of commissioning activities, the relevant pre-commissioning documentation be fully signed.

5.2.2 Commissioning Achievement

The commissioning achievement will be the full successful operation, functionality and integration of the Hydrogen Fuel Cell package installed on BLPH.

5.2.3 Status of Required Associated Subsystems

- PHASE 3

Subsystems required RFC for Commissioning of the Hydrogen Fuel Cell Package

- 83-00 400V Switchboard SG200N1
- 83-00 Auxiliary power supply
- 83-20 Distribution board
- 88-00: Earthing System
- 83-99: Temporary Yard 400/230V Main and auxiliary power supplies
- 87-00: EMCS
- 87-10: PCS
- 82-00: MV 6.6 kV Switchboard (SG-100D1)
- 82-10: Power Transformer 1.25 MVA
- 82-99: MV 6.6 kV Temporary Yard Supply Integrated Test
- 70-00: F&G Control System
- 79-00: Emergency Shutdown Systems (SIS)
- 25-01 to 25-08 (Partial): Hydrogen Storage Vessels & Header
- 43-00: Hydrogen Vent Header and Drum System
- 55-01: Waste Water Brine Discharge System

- PHASE 4

- Subsystems required RFC for OFFSHORE Commissioning of the Hydrogen Fuel Cell Package
- 83-00 400V Switchboard SG200N1
- 83-00 Auxiliary power supply
- 83-20 Distribution board
- 88-00: Earthing System
- 87-00: EMCS
- 87-10: PCS
- 82-00: MV 6.6 kV Switchboard (SG-100D1)
- 82-10: Power Transformer 1.25 MVA
- 70-00: F&G Control System
- 79-00: Emergency Shutdown Systems (SIS)
- 25-01 to 25-08: Hydrogen Storage Vessels & Header
- 43-00: Hydrogen Vent Header and Drum System
- 55-01: Waste Water Brine Discharge System
- 81-20: Power Transformer 7 MVA (TR-100AD1)
- 81-10: GIS 66 kV (HNA6-AFA70)
- 81-00: 66 kV Subsea Cable

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5.2.4 Special Tools & Test Equipment

The following special tool and Test Equipment are required:

S.No.	DESCRIPTION	QTY
1	General PPE	3
2	Various tools for electrical wiring	1
3	Various tools for mechanical installation	1
4	H2 Sniffer - Sewerin Snooper Mini H2	1
5	Pressure sensor - Fluke 700RG07 500PSIG	1
6	Test gas - Formier gas 5% hydrogen	1
7	Sniffer test station - Sewerin SPE-HG	1
8	Pressure regulator	1
9	Pressure relief valve	1
10	Smoke generator for fire detector test	1
11	H2 test gas for detector test	1
12	Coolant pumping/filling equipment	1
13	CE multitester	1
14	Multimeter	1

- H2 Sniffer - Sewerin Snooper Mini H2, Detection instrument to sniff/locate source of potential leaks.
- Pressure sensor - Fluke 700RG07 500PSIG, measuring device to accurately adjust and monitor gas pressure during leakage test.
- Test gas - Formier gas 5% hydrogen. Test gas for pressurizing pipework where the 5% hydrogen acts as tracer agent for sniffing
- Sniffer test station - Sewerin SPE-HG. Test instrument that emits a reference gas to check the correct function of the Snooper Mini H2 sniffer.
- Pressure regulator, Test gas pressure regulator for pressurizing the DUT.
- Pressure relief valve, Safety valve to ensure safe pipework pressurization during test.

TESTING & MEASUREMENT INSTRUMENT USED			
Type	Serial N.	Calibration certificate	Validity

5.2.5 Commissioning Spare Parts

HOLD 2

5.2.6 Temporary Facilities

Phase 3: Temporary emergency stop and/or fire and gas detection may be required if deemed necessary after suitable risk assessment. This will depend on the availability of interacting sub-systems.

If a temporary H2 connection is provided by Rosetti to ensure testing can progress this will be subject to a separate risk assessment & permit for installation/operation.

5.3 OTP Description – Onshore WORKSITE

5.3.1 OTP Test Preparation

Step	Description	Result	Verified by	Date
1	System Ready for Commissioning Certificate (RFC) is issued and approved.	✓		04.07.25
2	No Mechanical Completion or Pre-commissioning punch list 'A' items are outstanding against the system to be commissioned.	✓		"
3	Factory Acceptance Test Procedure has been carried out successfully (refer to Doc. K559-2254-CWIWP4202202-K03-001Rev001)	✓		"
4	All personnel involved in the implementation of this procedure are familiar with its content as well as with associated safety requirements (Toolbox Talk to be conducted before initiation of activities).	✓		"
5	A final walkdown of the system has been completed, to ensure that the system and the area are ready for commissioning.	✓		"
6	Check that areas are free for work and escape routes are clear of any obstructions.	✓		"
7	All safety barriers and warning signs have been installed.	✓		"
8	Ensure that proper communications have been established between parties involved in the implementation of the procedure.	✓		"
9	Verify availability of test equipment and spares as per section 5.2.	✓		"
10	With reference to Commissioning Temporary equipment & Facilities (refer on Doc. 123A90-PML-COM-SP-03014), check that power is available to any temporary equipment or test equipment (if any).	✓		"
11	System(s) isolations as per LOTO procedure defined within HSSE Permits to Work and Commissioning procedures duly prepared and approved	✓		"
12	All yard personnel have been duly notified by dedicated LUN (Livening Up Notification) that the system(s) is ready for commissioning.	✓		"

Step	Description	Result	Verified by	Date

5.3.2 Electrical Preparation

Step	Description	Result	Verified by	Date
1	Check related punch list 'B' items and confirm acceptability for start of commissioning activities.	✓		4-7-25
2	Verify that all relevant associated systems / subsystems are completed.	✓		"
3	Check that grounding and bonding are in accordance with applicable documents.	✓		"
4	Verify and confirm the correct circuit breaker protection settings according to latest protection study revision.	✓		"
5	Verify and confirm the completion of the final connections between the LV 400V Switchboard and the FC, the MV 6.6kV and FC, and the EMCS.	✓		"
6	Assess the need for additional temporary F&G or E-Stop protection during ONSHORE phases and implement necessary changes.	✓		"

5.3.3 Mechanical Preparation

Step	Description	Result	Verified by	Date
1	Check the correct flow direction of the valves.	✓		4-07-25
2	Confirm leak testing is complete and documented.	✓		"
3	Ensure package PSV setpoints are correct for the designed operating pressure.	✓		"
4	Ensure all unnecessary isolations are removed and package is ready to receive hydrogen.	✓		"

5.3.4 Instrument Preparation

Step	Description	Result	Verified by	Date
1	Check related punch list 'B' items and confirm acceptability for start of commissioning	✓		4-7-25

Step	Description	Result	Verified by	Date
	activities.			
2	Verify that all relevant associated systems / subsystems are ready.	✓		4-7-25
3	Check Inhibit and Override register has been prepared and validated.	✓		"
4	Verify that relevant equipment/ components are available and in operation for start of commissioning activities.	✓		"
5	Verify availability of test equipment as per section 5.2.4.	✓		"

5.3.5 Piping Preparation

Step	Description	Result	Verified by	Date
1	Ensure Process Water drain connection is correctly connected to the Rosetti system	✓		4-7-25
2	Ensure H2 supply connection is correctly connected from the Rosetti system	✓		4-7-25
3	Review Rosetti flange management and confirm all interface connections have been torqued and leak tested with details recorded and signed for.	✓		4-7-25
4	Ensure Blind flange/ positive isolation is in place at test boundary.	✓		4-7-25

5.3.6 Additional Discipline Preparation

Not applicable.

5.4 Test Steps – Onshore WORKSITE - PHASES 1-2 (NOT PART OF THIS OTP)

The previous chapters must be successfully performed prior to commissioning of the Hydrogen Fuel Cell Package.

Please refer to the following documents for Phase 1-2 pre-commissioning Onshore activities:

- Method Statement, Doc No: K559-2254-CWIWP4202202-J99-009.
- SAT Procedure, Doc No: K559-2254-CWIWP4202202-J99-001

5.4.1 OTP Steps WORKSITE - PHASE 3

It is foreseen that previous sections are successfully performed.

Please refer to SAT document K559-2254-CWIWP4202202-J99-001 ***section 7 and 8*** for Phase 3 commissioning Onshore activities.

5.4.2 OTP Steps WORKSITE - PHASE 4

It is foreseen that previous sections are successfully performed.

In the following steps the functionality of the Hydrogen Fuel Cell package shall be tested for operation in all BLPH operating modes.

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Hydrogen Fuel Cell Integrated Testing ONSHORE

Step	Description	Result	Verified by	Date
Fuel Cell operating modes to be controlled from PCS via ECMS.				
1	Confirm on PCS that CCS operating mode is in "IDLE". Confirm Fuel Cell Package is in sleep mode.	✓	S. M	5-7-25
2	On PCS, change CCS operating mode to "IMPORT". Confirm no change at Fuel Cell package.	✓	"	"
3	On PCS, change CCS operating mode to "HOT STANDBY". Confirm Fuel Cell is now in Standby mode.	✓	"	"
4	Confirm H2 storage is available. This requires a reading of ≥ 20 barg on at least one of the following pressure transmitters: • 25-PT-035 • 25-PT-037 • 25-PT-040 • 25-PT-043 • 25-PT-046 • 25-PT-049	✓	"	"
NOTE: Pressure control via valves 25-PV-055A & 25-PV-055B should already be successfully tested via Hydrogen Venting & Storage OTP 123A90-PML-COM-PRO-03042				
5	On PCS, change CCS operating mode to "EXPORT". Confirm Fuel Cell status changes to running.	✓	"	5-7-25
6	Confirm that power output can be controlled via the EMCS over modbus. Test power output at increments of 0.25MW up to and including 1MW.	✓	"	"
7	On PCS, change CCS operating mode to "COLD STANDBY". Confirm Fuel Cell shuts down and returns to Sleep mode.	✓	"	"
8	On PCS, change CCS operating mode to "EMERGENCY (Island Mode)". Confirm Fuel Cell recommences discharge of power.	✓	"	14-7-25
9	On PCS, change CCS operating mode to "MAINTENANCE". Confirm Fuel Cell can only be operated locally.	✓	"	14-7-25

Step	Description	Result	Verified by	Date
10	On PCS, return CCS operating mode to "EXPORT". Initiate Fuel Cell F&G event via 1 of the 3 hydrogen detectors located inside the container and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters • Safe Torque Off of all Motor Drives	✓		05.7.25
11	On PCS, return CCS operating mode to "EXPORT". Operate the Fuel Cell Package Emergency Stop and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters • Safe Torque Off of all Motor Drives	✓		05.7.25

Full details of the EMCS HMI control graphics can be found in Document Number: **123A90-DDL-EL-SP-20039 Functional and Technical Design Specification, IDS and DDS for Electrical Monitoring and Control System (EMCS)**

Hydrogen Fuel Cell Integrated Testing ONSHORE Notes and Remarks

TESTING CARRIED OUT ALONGSIDE OIT OTP. FUEL CELL WAS RAMPED UP FROM 300KW TO 1MW AND THEN BACK DOWN TO 300KW. BEFORE DISCONNECTING. THE FUEL CELL WAS NOT USED BELOW 300KW DUE TO INSTABILITY OF THE BLPH CONTROL VALVES. DURING RAMP UP AND DOWN THE FUEL CELL WAS CONTROLLED IN 100KW INCREMENTS. PLEASE REFER TO THE OIT OTP FOR MORE INFORMATION.

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5.4.2.1 Hydrogen Fuel Cell Integrated Testing ONSHORE - Certifying Authority Table of Attendances

Name and Surname	Certifying Authority	Position	Signature
S. Mackhof			

5.4.2.2 Hydrogen Fuel Cell Integrated Testing ONSHORE - Final Signatures and Company Acceptance

Name and Surname	Company Representative	Position	Signature
S. Mackhof	CW	OPS ENGINEER	
Gedas Paulauskas	Ballard	Service Tech.	

5.5 Post-test Conditions

Throughout Phase 1 to 4, AUX power shall be maintained active to ensure monitoring of the package and functionality of its safety features.
All other sub-systems shall be de-energized and, if deemed necessary, LOTO.
No AUX power will be provided during sea transport.

5.6 Reinstatement and Preservation Tasks

Generally, the system/ sub-system shall be reinstated at its initial condition; and the following activities must be carried out as minimum:

- all inhibition performed for the test shall be removed (as per Inhibit / Override List)
- all equipment/devices shall be returned in healthy functional conditions.

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6 OTP AT SITE

6.1 Planning and Manpower

6.1.1 Offshore Site overview

It is expected that all pre-commissioning tests, systems energization and commissioning steps will have been successfully performed during the Onshore Phases.
Consequently, during the offshore SITE phase, the respective systems will be inspected prior to re-energization. No additional test steps will be required on these items of equipment, correct operation and functioning will be verified.

6.1.2 Planned tasks with estimated manpower

Estimated manpower for the entire duration of the Test:

- 1 Operations Engineer from Client
- 1 Commissioning representative from Client
- 1 operator from EMCS vendor
- 1 Supervisor from Contractor

6.1.3 Test duration estimate

The test duration should be as follows:

- 2 days approx.

If necessary, the estimated time can be extended to complete all required pre-commissioning and commissioning activities.

6.1.4 Vendor Assistance

- For offshore commissioning Ballard will provide remote support.

6.1.5 Items Postponed to C&E OTP

- Not Applicable

6.1.6 HOLDS

- Not Applicable

6.2 OTP Test Requirements – Offshore SITE

6.2.1 Pre-Commissioning Achievement

- Not applicable

6.2.2 Commissioning Achievement

The commissioning achievement will be the full successful operation, functionality and integration of the Hydrogen Fuel Cell package installed on BLPH.

The successful commissioning result, achieved during the WORKSITE commissioning phase for the functionality and safeguard of the Hydrogen Fuel Cell Package, will allow for a smoother commissioning phase of the offshore SITE.

- The systems and subsystems involved:
- 83-00 400V Switchboard SG200N1
- 83-00 Auxiliary power supply
- 83-20 Distribution board
- 88-00: Earthing System
- 87-00: EMCS
- 87-10: PCS
- 82-00: MV 6.6 kV Switchboard (SG-100D1)
- 82-10: Power Transformer 1.25 MVA
- 70-00: F&G Control System
- 79-00: Emergency Shutdown Systems (SIS)
- 25-01 to 25-08: Hydrogen Storage Vessels & Header
- 55-01: Waste Water Brine Discharge System
- 81-20: Power Transformer 7 MVA (TR-100AD1)
- 81-10: GIS 66 kV (HNA6-AFA70)
- 81-00: 66 kV Subsea Cable

6.2.3 Status of Required Associated Subsystems

The systems involved has been already energized and commissioned in WORKSITE Phase

6.2.4 Special Tools & Test Equipment

The following special tool and Test Equipment are required:

S.No.	DESCRIPTION	QTY
1	General PPE	3
2	Various tools for electrical wiring	1
3	Various tools for mechanical installation	1
4	H2 Sniffer - Sewerin Snooper Mini H2	1
5	Pressure sensor - Fluke 700RG07 500PSIG	1
6	Test gas - Formier gas 5% hydrogen	1
7	Sniffer test station - Sewerin SPE-HG	1
8	Pressure regulator	1
9	Pressure relief valve	1
10	Smoke generator for fire detector test	1
11	H2 test gas for detector test	1
12	Coolant pumping/filling equipment	1
13	CE multitester	1
14	Multimeter	1

- H2 Sniffer - Sewerin Snooper Mini H2, Detection instrument to sniff/locate source of potential leaks.
- Pressure sensor - Fluke 700RG07 500PSIG, measuring device to accurately adjust and monitor gas pressure during leakage test.
- Test gas - Formier gas 5% hydrogen. Test gas for pressurizing pipework where the 5% hydrogen acts as tracer agent for sniffing
- Sniffer test station - Sewerin SPE-HG. Test instrument the emits a reference gas to check the correct function of the Snooper Mini H2 sniffer.
- Pressure regulator, Test gas pressure regulator for pressurizing the DUT.

- Pressure relief valve, Safety valve to ensure safe pipework pressurization during test.

TESTING & MEASUREMENT INSTRUMENT USED			
Type	Serial N.	Calibration certificate	Validity

6.2.5 Consumable List

- Not applicable

6.2.6 Commissioning Spare Parts

HOLD 2

6.2.7 Temporary Facilities

- Not applicable

6.3 OTP Description – SITE

The SITE test will consist of a repeat of the onshore integration testing with the BLPH now installed situ to it's permanent connections. In the following steps the functionality of the Hydrogen Fuel Cell package shall be tested for operation in all BLPH operating modes.

6.3.1 OTP Test Preparation

Step	Description	Result	Verified by	Date
1	System Ready for Operation (RFO) Certificate is issued and approved.	✓		4-7-25
2	No blocking punch list items are outstanding against the system to be commissioned.	✓		"
3	System(s), (de)isolations as per LOTO procedure enclosed within commissioning Work Permits procedures prepared and approved	✓		"
4	Verify and confirm that all steps performed at WORKSITE of this procedure are completed without any pending issues that would prevent from proceeding with the offshore SITE PROCEDURE	✓		"

Step	Description	Result	Verified by	Date
5	All personnel involved in the implementation of this procedure are familiar with this procedure as well as with associated safety requirements (Toolbox Talk to be conducted before initiation of activities).	✓		4.7.25
6	A final walkdown after hook-up of the system has been completed, any preservation items have been removed and to ensure that the system and the area are ready for energization.	✓		"
7	Check that areas are free for work and escape routes are clear of any obstructions.	✓		"
8	Ensure that proper communications have been established between parties involved in the implementation of the procedure.	✓		"
9	Verify availability of test equipment and consumables as per chapters 6.2.4.	✓		"
10	All personnel have been duly notified during dedicated daily SIMOPS meetings that the system(s) is ready for operation.	✓		"

6.3.2 Electrical Preparation

Step	Description	Result	Verified by	Date
1	No blocking punch list items are outstanding against the system to be commissioned.	✓		4.7.25
2	Review and confirm no changes are required to be performed on existing protection settings.	✓		"

6.3.3 Mechanical Preparation

Step	Description	Result	Verified by	Date
1	No blocking punch list items are outstanding against the system to be commissioned.	✓		4.7.25
2	Ensure Fuel Cell package correctly connected to upstream H2 supply.	✓		"
3	Ensure Fuel Cell package correctly connected to downstream process waste water line.	✓		"

6.3.4 Instrument Preparation

Not applicable.

6.3.5 Piping Preparation

Not applicable

6.3.6 Additional Discipline Preparation

Not applicable.

6.4 OTP Test Steps – Offshore PHASE 4

The previous chapters must be successfully performed prior to final operational test of the Hydrogen Fuel Cell

6.4.1.1 Hydrogen Fuel Cell Integrated Testing OFFSHORE

Step	Description	Result	Verified by	Date
	Hydrogen Fuel Cell operating modes to be controlled from PCS via ECMS.			
1	Confirm on PCS that CCS operating mode is in "IDLE". Confirm Fuel Cell Package is in sleep mode.			
2	On PCS, change CCS operating mode to "IMPORT". Confirm no change at Fuel Cell package.			
3	On PCS, change CCS operating mode to "HOT STANDBY". Confirm Fuel Cell is now in Standby mode.			
4	Confirm H2 storage is available. This requires a reading of ≥ 20 barg on at least one of the following pressure transmitters: • 25-PT-035 • 25-PT-037 • 25-PT-040 • 25-PT-043 • 25-PT-046 • 25-PT-049			
	NOTE: Pressure control via valves 25-PV-055A & 25-PV-055B should already be successfully tested via Hydrogen Venting & Storage OTP 123A90-PML-COM-PRO-03042			
5	On PCS, change CCS operating mode to "EXPORT". Confirm Fuel Cell status changes to running.			
6	Confirm that power output can be controlled via the EMCS over modbus. Test power output at increments of 0.25MW up to and including 1MW.			
7	On PCS, change CCS operating mode to "COLD STANDBY". Confirm Fuel Cell shuts down and returns to Sleep mode.			
8	On PCS, change CCS operating mode to "EMERGENCY (Island Mode)". Confirm Fuel Cell recommences discharge of power.			

Step	Description	Result	Verified by	Date
9	On PCS, change CCS operating mode to "MAINTENANCE". Confirm Fuel Cell can only be operated locally.			
10	On PCS, return CCS operating mode to "EXPORT". Initiate Fuel Cell F&G event via 1 of the 3 hydrogen detectors located inside the container and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters Safe Torque Off of all Motor Drives			
11	On PCS, return CCS operating mode to "EXPORT". Operate the Fuel Cell Package Emergency Stop and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters Safe Torque Off of all Motor Drives			

6.4.1.2 Hydrogen Fuel Cell Integrated Testing OFFSHORE Notes and Remarks

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6.4.1.3 Hydrogen Fuel Cell Integrated Testing OFFSHORE - Certifying Authority Table of Attendances

Name and Surename	Certifying Authority	Position	Signature

6.4.1.4 Hydrogen Fuel Cell Integrated Testing OFFSHORE - Final Signatures and Company Acceptance

Name and Surname	Company Representative	Position	Signature
Name and Surename	**Certifying Authority**	**Position**	**Signature**

6.5 Post-test Conditions

After functional tests have been completed, system / sub-systems are left in healthy and safety condition and operational.

6.6 Reinstatement tasks

Generally, the system/ sub-system shall be reinstated at its initial condition; and the following activities must be carried out as minimum:

- all inhibition done for the test shall be removed (as per Inhibit / Override List)
- all equipment/devices shall be returned in healthy functional conditions.

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7 APPENDICES

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7.1 Vendor SAT Procedure

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7.2 Proverlis Summary System Reports

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7.3 Equipment Related Technical Queries

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7.4 As Built Documentation

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7.5 Management of Change – Summary Table of Tasks and Details of Affected Related Documentation

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File: 123A90-PML-COM-PRO-03062

Short Title	Megablock Site Acceptance Test
Full Title	Megablock Site Acceptance Test
Abstract	*Site acceptance test for verification of full Megablock system*

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Revision Record

Rev #	Description	Revised By	Date (dd-mm-yyyy)
-	Initial Release	RKN	28-05-2024
1	General updates	RKN	28-06-2024
1.1	General updates	TAN	18-09-2024
2	Update prior to release to CW	PBL	16-10-2024
3	Updates based on review with CW	RKN	19-11-2024
4	Updates based on review with CW	RKN	09-01-2025

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1.0 Executive Summary

This document outlines the recommended commissioning activities and site acceptance tests. These tests aim to verify correct installation, and that the system performance onsite matches the performance level shown during FAT. There should be no CAT A items outstanding prior to power up.

2.0 References

- Confirmation of Satisfactory SAT - Signature Page
- PWR008 Ballard commissioning document
- EN 60204 Electrical safety test 10ft
- EN 60204 Electrical safety test 40ft
- EN 60204 Electrical safety test Cng Pltfrm
- F07 & F08, Electrical safety SAT
- F10 Safety checklist
- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure
- SPC ID 0104 H2 Leak Test Procedure
- SPC ID 0106 Noise Level Measurement Test Procedure
- SPC ID 0204 System pressure decay test template

3.0 Definitions and Acronyms

FC	FCwave™
H2	Hydrogen
FAT	Factory Acceptance Test
SAT	Site Acceptance Test
HT1	High temperature 1050kW cooling system 1
HT2	High temperature 1050kW cooling system 2
LT	Low temperature cooling system

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4.0 Objectives and Background

The tests in the document are based on the test matrix in document J99-02 (Aconex K559-2254-CWIWP4202202-J99-002-Rev002)

This document describes the witnessed Site Acceptance Tests. The tests do not include the internal testing that has been done to secure product maturity, mechanical and electrical connections have been done correctly.

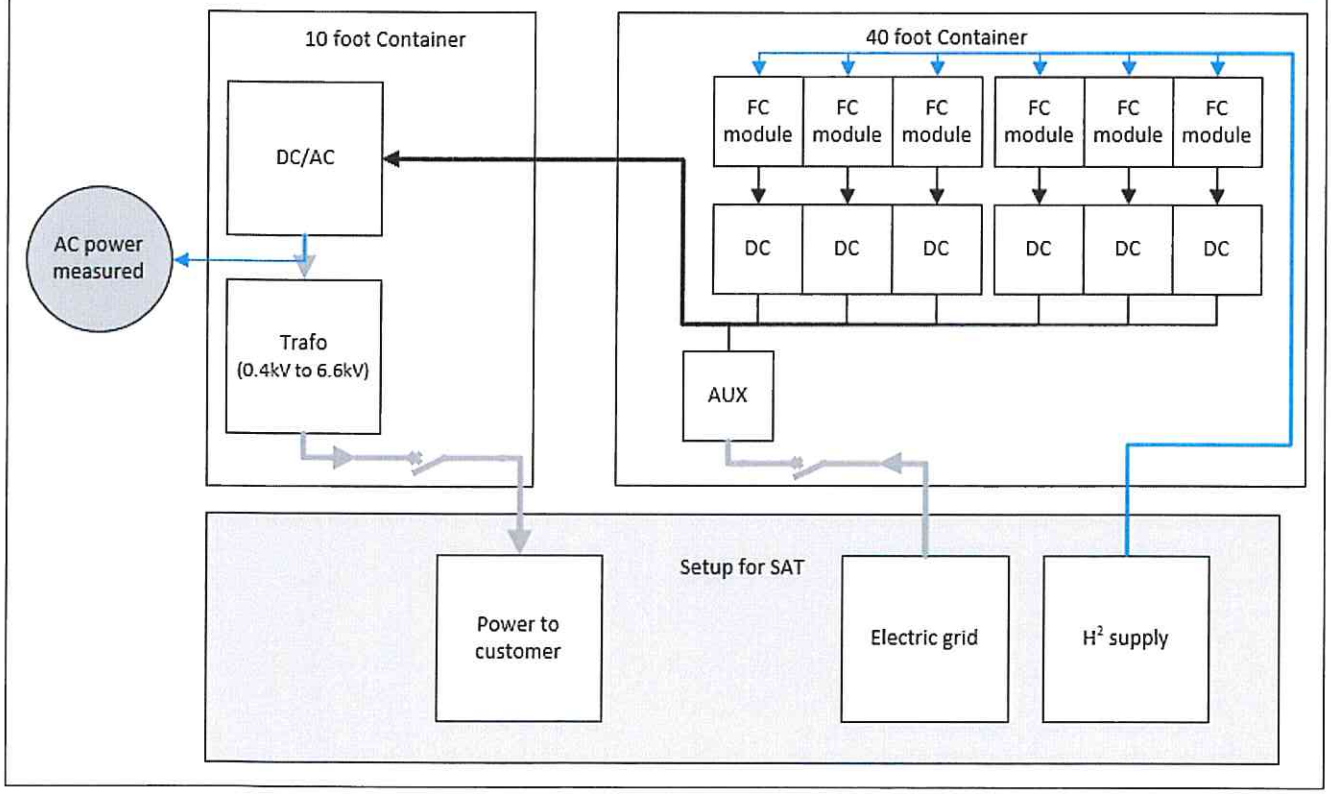
The SAT is not intended to replace an integration test. If third-party features are not yet ready for testing, those specific test cases will be temporarily excluded from the SAT and should be performed during integration testing. This will not affect the overall SAT signoff.

There should be no CAT A items outstanding prior to power up.

The scope of testing is:

- Visual Inspection of the delivered product (Tri-party walkaround)
- Verification of safety systems for the Megablock.
- Production of electrical power to the customer grid to verify performance.

Figure 1: Megablock System test overview



5.0 Note on Power Quality Measurements

The power quality measurements are indicative during SAT, as the measured power quality depends also on the customer load dissipating the produced power. Ballard is also not capable of measuring power quality on the 6.6kV bus, and any measurements are done on the 400V side of the output transformer. This results in lower measurements than on the medium voltage side of the output transformer, as the transformer inductance is an integral part of the harmonic dampening of the FC package.

Power quality measurements have been removed from pass/fail criteria.

6.0 Note on Electrical Load

The electrical load that is to dissipate the power generated by the FC package is not in Ballard scope. During step response tests and full load tests, it is required that it is present and able to absorb the power from the FC package.

7.0 Functional tests

7.1 F02 Visual inspection

7.1.1 Test

The test involves an examination of the paint job through visual inspection, assessing the overall build quality, and checking for any dents. The focus is also on evaluating the assembly quality to ensure compliance with weather resistance.

This test is superseded by the tri party walkaround.

7.1.2 Relevant Standard / document

- No reference

7.1.3 Brief Test Plan

- Visual inspection with customer of full system, meaning inside and outside container solution.
- Take comprehensive pictures of the full system and test setup, including close-ups of vital components, with timestamps for reference.

7.1.4 Pass/Fail criteria.

- Visual inspect with customer to review quality of full system.

7.1.5 Test Result

Table 1: Visual inspection – Test Result

Date tested	Item	Result	Pass/Fail	Notes
04/06/25	40' Container	ok	Pass	Peter Bleeker
04/06/25	10' Container	ok	Pass	Peter Bleeker
04/06/25	Cooling Skid	ok	Pass	Peter Bleeker

Peter Bleeker 09/06 '25

7.2 F07 Electrical safety test – 10-foot container

7.2.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

7.2.2 Relevant Standard / document

- EN 60204 Electrical safety test 10ft
- F07 & F08, Electrical safety SAT

7.2.3 Brief Test Plan

- According to EN 60204-1

7.2.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

7.2.5 Test Result

Table 2: Electrical safety test - Test results

Date tested	Item	Result	Pass/Fail	Notes
06/02/25	Grounding Continuity	OK	Pass	See test sheet
06/02/25	Isolation resistance	OK	Pass	See test sheet.

Pilo Blah 04/06 '25

Table 3: Electrical safety test - calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
	086 - 023	2025-06-04	Tests F07 & F08

7.3 F08 Electrical safety test – 40-foot container

7.3.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

7.3.2 Relevant Standard / document

- EN 60204 Electrical safety test 40ft
- EN 60204 Electrical safety test Cng Pltfrm
- F07 & F08, Electrical safety SAT

7.3.3 Brief Test Plan

- According to EN 60204-1

7.3.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

7.3.5 Test Result

Table 4: Electrical safety test - Test Result

Date tested	Item	Result	Pass/Fail	Notes
06/02/25	Grounding Continuity	OU	Pass	See test sheet
06/02/25	Isolation Resistance	OU	Pass	See test sheet

Table 5: Electrical safety test - Calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
	086-003	2025-06-04	F08 & F07

Peter Blum
04/06/25

7.4 F10 Safety

7.4.1 Test

Conduct tests of safety inputs and outputs, including emergency stop buttons, smoke detectors, gas detectors and external connections.

7.4.2 Relevant Standard / document

- F10 Safety checklist

7.4.3 Brief Test Plan

- Trigger each safety input according to checklist.
  - Emergency pushbuttons
  - Smoke detectors test
  - H2 sensor test
  - External safety switches
  - External feedback

7.4.4 Pass/Fail criteria.

- Verified according to checklist.
- Each item triggers the correct alarm

7.4.5 Test Result

Table 6: Safety - Test Result

Date tested	Item	Result	Pass/Fail	Notes
19/02/2025	Emergency pushbuttons	✓	PASS	✓
19/02/2025	Smoke detectors	✓	PASS	✓
19/02/2025	H2 sensors	✓	PASS	✓
19/02/2025	External safety switches	✓	PASS	ADDED 120 OHM RESISTOR
19/02/2025	External feedback	✓	PASS	✓

Peter Black
P. Black

F. SCRIGNI
ROSETTA MARINO
04/00/25

Table 7: Safety – Calibration/Equipment

Unit	Equipment number	Calibration due date	Equipment used for
—	—	—	—

7.5 F18 H_2 Leakage test

7.5.1 Test procedure

All pipework and H2 instrumentation subassemblies must be inspected, recorded, verified and pass in accordance with the procedure in section 5.4 in *SPC ID 0104 H2 Leak Test Procedure Rev 002* prior to full system SAT.

System H2 leakage test is done system pressure decay test, according to section 5.5 in *SPC ID 0104 H2 Leak Test Procedure Rev 002*.

7.5.2 Pass/Fail criteria.

Pressure decay test with a maximum leakage no greater than specified in test procedure.

Result details are documented in the template *SPC ID 0204 System pressure decay test template*

Parameter	Value	Description
L_A [Nm^3/h]	**2,72 – 3,58 x10^{-3}**	**Maximum allowed pressure decay to pass pressure decay test, where L_A = L_S + L_Mu**
L_S [Nm^3/h]	0	Summarized expected leak rates of all components in the system (per design leak rate).
L_Mu [Nm^3/h]	2,72 – 3,58 x10^{-3}	Calculated accuracy of the measuring system, used to perform the test.
L_C [Nm^3/h]	2,7x10^{-5}	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

7.5.3 Test Result

Table 8: H2 leakage - Test Result

Date tested	Item	Leakage rate L_1 [Nm^3/h]	Pass/Fail	Notes
19/2/25	H2 line 1	0	Pass	See test Sheet
19/2/25	H2 line 2	0	Pass	See test sheet
19/2/25	H2 line 3	0	Pass	See test Sheet
19/2/25	H2 line 4	0	Pass	See test sheet
19/2/25	H2 line 5	0	Pass	See test sheet
19/2/25	H2 line 6	0	Pass	See test Sheet

Dylan Bhell 04/06

8.0 Operational tests

Operations are done using operator HMI or remote HMI in normal operating mode.

8.1 O01 System Start/Stop - Normal low load operation.

8.1.1 Test

Fuel Cell system can start, deliver minimum power and perform controlled stop without faults. This test is based on DC power.

8.1.2 Relevant Standard / document

- No reference

8.1.3 Brief Test Plan

- All FC in standby
- Request 100kW DC
- Delay 120 seconds
- Request zero power
- Repeat with new preferred FC until all tested.

8.1.4 Pass/Fail criteria.

- Fuel Cell Package starts without faults.
- No persistent system alarms.
- Correct available power signal.
- DC Power output within +/-5% and stable in less than 60 seconds
- Fuel Cell Package stops without faults.
- Fuel Cell in stand-by in less than 120 seconds.

8.1.5 Test Result

Table 9: System Start/Stop – Normal low load operation - Test Result

Date tested	Item	Result	Pass/Fail	Notes
14/6/25	FCwave 1	All pass criteria passed	pass	See below
14/6/25	FCwave 2	"	pass	"
14/6/25	FCwave 3	"	pass	"
14/6/25	FCwave 4	"	pass	"
16/6/25	FCwave 5	"	pass	"
16/6/25	FCwave 6	"	pass	"

Normal low load operation was tested during the conditioning of the modules on Sat June 14th + Monday June 16th.

Each FC module was ramped up from 0 - 200kw Output. All 6 modules exceeded 200 kw.

8.2 O09 Load Test – step response 0 to ~~35%~~ 40%

8.2.1 Test

Test step response by adding 35% load in one step from no load while measuring AC power quality.

8.2.2 Relevant Standard / document

- N/A

8.2.3 Brief Test Plan

- All FC in stand-by.
- Apply set point by requesting 350kW AC

8.2.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.2.5 Test Result

Table 10: Load Test - step response 0 to 35% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
04/07/2025	Step response 0-35%	—	Pass	—
	AC power quality		Indicative	

Gedas Paulauskas
Ballard

8.3 O10 Load Test – step response ~~35%~~ 40% to 70%

8.3.1 Test

Test step response by adding 35% load in one step to reach 70% load while measuring AC power quality.

8.3.2 Relevant Standard / document

- N/A

8.3.3 Brief Test Plan

- 3 FC running delivering 350kW AC steady state.
- 3 FC in stand-by
- Apply set point by requesting 700kW AC power.

8.3.4 Pass/Fail criteria.

- No persistent system alarms.

8.3.5 Test Result

Table 11: Load Test - step response 35% to 70% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/07/2025	Step response 35%-70%	—	Pass	—
	AC power quality		Indicative	

Gedas Pocelauskas
Ballard

8.4 O11 Load Test – step response 65% to 100%

8.4.1 Test

Test step response by adding 35% load in one step to reach full load while measuring AC power quality.

8.4.2 Relevant Standard / document

- N/A

8.4.3 Brief Test Plan

- 6 FC running delivering 650kW AC steady state.
- Apply set point by requesting 1000kW AC power.

8.4.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.4.5 Test Result

Table 12: Load Test - step response 65% to 100% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/07/2025	Step response 65%-100%	—	Pass	—
	AC power quality		Indicative	

Gedas Paulauskas
Ballard

8.5 O12 Load Test – 100% stability test - 1 hours.

8.5.1 Test

Test steady state at 100% load for 1 hours while measuring power quality.

This test is also dependent on the hydrogen supply for the system.

8.5.2 Relevant Standard / document

- N/A

8.5.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.

8.5.4 Pass/Fail criteria

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.5.5 Test Result

Table 13: Load Test – Steady state 100% load - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3.7.25	Full load test	1000kw	Pass	—
	AC power quality		Indicative	

Gedas Pavlauskas
Ballard

8.6 O13 Load Test – step response 100% to 50%

8.6.1 Test

Test step response by removing 50% load in one step at full load while measuring power quality.

8.6.2 Relevant Standard / document

- N/A

8.6.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.
- Request 500kW AC.

8.6.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.6.5 Test Result

Table 14: Load Test - step response 100% to 50% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/07/2025	Step response 100%-50%	—	Pass	—
	AC power quality		Indicative	

Gedas Paulauskas
Ballard

8.7 O14 Load Test – step response 50% to 0%

8.7.1 Test

Test step response by removing 50% load in one step to no load while measuring AC power quality.

8.7.2 Relevant Standard / document

- N/A

8.7.3 Brief Test Plan

- 3-6 FC running delivering 500kW AC.
- Request 0% and apply set point.

8.7.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.7.5 Test Result

Table 15: Load Test - step response 50% to 0% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/04/2025	Step response 50%-0%	—	Pass	—
	AC power quality	n/a	n/a	Unit not producing power

Gedas Paukauskas
Ballard

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	06/02/2025
Test location	40ft Container, RM Yard, Ravenna
Test performed by	PBL, MKD

Grounding continuity
EN 60204-1:2018 - Section 18.2.2 - Test 1
Test performed with a test current of 10A

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	Busbar to busbar	0,024	Ohm	0,01
	Module 1	0,018	Ohm	0,015
	DC/DC cabinet 1	0,023	Ohm	0,006
	Module 2	0,024	Ohm	0,011
	DC/DC cabinet 2	0,019	Ohm	0,006
	Module 3	0,026	Ohm	0,017
	DC/DC cabinet 3	0,016	Ohm	0,006
	Module 4	0,026	Ohm	0,02
	DC/DC cabinet 4	0,016	Ohm	0,008
	Module 5	0,024	Ohm	0,013
	DC/DC cabinet 5	0,017	Ohm	0,006
	Module 6	0,029	Ohm	0,017
	DC/DC cabinet 6	0,015	Ohm	0,005
	Control cabinet	0,021	Ohm	0,014
	Control cabinet right door	0,032	Ohm	0,048
	Lifting crane track, dolly	0,028	Ohm	0,008
	LT piping	0,031	Ohm	0,022
	Isolation transformer cover	0,039	Ohm	0,015
	Cable tray	0,019	Ohm	0,012

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	Busbar to busbar	0,019	Ohm	0,007
	Main DC/Acpoint 1	0,032	Ohm	0,031
	Main DC/Acpoint 2	0,024	Ohm	0,014
	Main DC/Acpoint 3	0,027	Ohm	0,011
	DC/AC conduncter point 1	0,037	Ohm	0,007
	DC/AC conduncter point 2	0,022	Ohm	0,009
	DC/AC conduncter point 3	0,023	Ohm	0,006
	LT coolant pipe	0,024	Ohm	0,014
	Cable tray	0,02	Ohm	0,007
	Main transforer grounding bolt	0,023	Ohm	0,009
	Main transformer chassis	0,02	Ohm	0,007
	Cable tray MV cables	0,022	Ohm	0,011

Name and date: Rhea Bhatt June 4th

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	06/02/2025
Test location	40ft Vontainer, RM Yard, Ravenna
Test performed by	PBL, MKD

Isolation resistance
EN 60204-1:2018 - Section 18.3
Test performed with a test voltage of 1000V

Main location	Location	Measurement FAT	Unit	Measurement SAT
40 ft container	L1-PE	> 999.9	MOhm	> 999.9
	Cooling skid L1	10,01	Mohm	12,11
	Colling skid L2	6,252	Mohm	5,21
	Cooling skid L3	12,81	Mohm	10,12
	AUX supply L1	251	Mohm	316
	AUX supply L2	337	MOhm	364
	AUX supply L3	237	Mohm	248

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	L1+L2+L3-PE on AC circuit	592	Mohm	Transformer connected, RM scope

Name and date: 

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	06/02/2025
Test location	40ft container, RM Yard, Ravenna
Test performed by	PBL, MKD

Isolation resistance
EN 60204-1:2018 - Section 18.4
Test performed with a test voltage of 2500VAC

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	PE and L1	0	mA	0,6
	PE and L2	0	mA	0,6
	PE and L3	0	mA	0,6

Main location	Location	Measurement FAT	Unit	Measurement SAT
10 FT container	PE and L1	7,1	mA	Transformer connected, RM scope
	PE and L2	7,1	mA	Transformer connected, RM scope
	PE and L3	7	mA	Transformer connected, RM scope

Name and date: Peter Bell, Sun, 4th

BALLARD

Ballard Power Systems Europe A/S
Majsmarken 1
DK-9500 Hobro

Confirmation of Satisfactory H2 leakage test

Part No.	601456B-7002362 Incl sub-assemblies 601456B-7002973 601456B-7003716
Product name	FC PowerGen 1000kW
Serial No.	601456B

Ballard Power Systems Europe A/S confirms that the above-listed equipment has satisfactorily with comments undergone and passed the H2 leakage test according to

BLPH Project – SPC ID 0104 H2 Leak Test Procedure rev 02 Max 11,240 BARG < 1 hr dur

CrossWind C.V. acknowledges that the H2 leakage test for the above-listed equipment was witnessed and confirms that the test was performed satisfactorily with comments, and all agreed-upon specifications have been met

Signatures

Ballard Power Systems Europe A/S			
Signature:	Preben H 2		
Name:	PREBEN JENSEN		
Title:	SENIOR APPLICATION ENGINEER	Date:	19/2/25
CrossWind C.V.			
Signature:			
Name:			
Title:	Crosswind Commissioning Manager	Date:	
Inspector			
Signature:			
Name:	DAVE HUSGROVE		
Title:	Inspector for Crosswind	Date:	19/2/2025

Note: This document serves as formal confirmation that the H2 leakage test has been successfully completed and witnessed, with both parties in agreement on the satisfactory results. It should be signed by authorized representatives of both parties.

Section K

Certification Data

Sub Section K01-001

Declaration of Conformity (FCwave™)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	Date.	Description
001	19/09/2024	First Issue
002	07/02/2025	Latest revision of Declaration replace rev 001
004	28/02/2025	Comments to CrossWind - No corrections

Document Title:	BLPH Project - Declaration of Conformity (FCwave)
Document Number:	K559-2254-CWIWP4202202-K01-001
Revision:	Rev004
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K01-001Rev004
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Declaration of Conformity

As manufacturer, Ballard Power Systems Europe A/S, Majsmarken 1, 9500 Hobro, Denmark, hereby declares that the product(s) mentioned below:

Product no. and name:

Product no.: **7001000** Product name: **FCwave**
Product Designation: **Fuel Cell Power System**

Complies with the requirements of the following Union harmonized legislation, standards and specifications:

Legislation:

- Machinery Directive (2006/42/EC)
- Electromagnetic Compatibility Directive (2014/30/EU)
- RoHS (2011/65/EU)

References:

Directive	Standard	Description
MD	EN 62282-3-100:2020	Fuel cell technologies - Part 3-100: Stationary fuel cell power systems - Safety
EMC	EN 61000-6-2:2019	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments
EMC	EN 61000-6-4:2019	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
RoHS	EN IEC 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Additional:

This declaration is only valid as long as the service and maintenance instructions for the product is followed, and the product is not modified.

The pressurized equipment in the product is out of scope for the PED directive 2014/68/EU, as it is covered by article 4, section 3. Hence the PED directive is not listed.

Hobro, 05.09.2024
Place and date

CEO & President, Jesper Themsen
Ballard Power Systems Europe A/S

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Specifications and descriptions in this document were in effect at the time of publication. Ballard Power Systems, Inc. reserves the right to change specifications, product appearance or to discontinue products at any time.

Sub Section K01-002

Declaration of Conformity (FC PowerGen 1000kW®)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001		First Issue
002	14/02/2025	New release of DoC for CrossWind container

Document Title:	**BLPH Project - Declaration of Conformity (Container Solution)**
Document Number:	K559-2254-CWIWP4202202-K01-002
Revision:	Rev002
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-K01-002Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Declaration of Conformity

Ballard Power Systems Europe A/S, Majsmarken 1, 9500 Hobro, Denmark hereby declares that the product(s) mentioned below:

Product no. and name:

Product no.: **601456B-7002362** Product name: **FC PowerGen 1000kW**
Product designation: **Stationary Fuel Cell Power System**

Complies with the requirements of the following directives and standards:

Accessories/sub-assemblies:
The following accessories/sub-assemblies are also cowered by this DoC (If any):

Product no.:	**601456B-7002362**	Product name:	**40ft Fuel Cell Container**
Product no.:	**601456B-7002973**	Product name:	**Cooling unit**
Product no.:	**601456B-7003716**	Product name:	**10ft Converter container**

Directives:

- Machinery Directive (2006/42/EC)
- Pressure equipment (2014/68EU)
- ATEX Directive (2014/34/EU)
- Low voltage Directive (2014/35/EU)
- Electromagnetic Compatibility (EMC) (2014/30/EU)

Additional:

This declaration is only valid as long as the service and maintenance instructions for the product is followed, and the product is not modified.
Hydrogen Manifold compliance to PED is covered by K599-2254-CWIWP4202202-K01-003.

Hobro, 13022025

Henrik Rise Christensen
Digitally signed by Henrik Rise Christensen
DN: cn=Henrik Rise Christensen, c=DK, ou=Ballard Power Systems Europe, email=hri@ballardeurope.com
Date: 2025.02.13 20:11:12 +01'00'

Director, Operations & Business
Henrik Rise Christensen
Ballard Power Systems Europe A/S

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Sub Section K01-003

PED Compliance H2 Manifold Addendum (ATEX)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001		First Issue
002		Drawing added
003		Revision corrected
004	12/2/2025	Updated according to agreement with Brenmer and Kyle

Document Title:	**BLPH Project - PED Compliance H2 Manifold Addendum**
Document Number:	K559-2254-CWIWP4202202-K01-3
Revision:	Rev004
Sequence Number:	3
File Name:	K559-2254-CWIWP4202202-K01-3Rev004
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

PED compliance H2 manifold

Full Title: *Addendum – PED compliance H2 manifold for DoC*

Abstract: The following document will contain an internal walk through of the compliance of the Pressure equipment directive and the technical dossier for Declaration of conformity

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1.0 Executive Summary

The document will contain a walkthrough of the analysis of Pressure equipment directive compliance according to 2008/68/EU. The analysis concluded that the maximum pipe diameter is a DN32 and a pressure of 6,5 Barg. Due to this the conformity category is "category 1" which leads to "Module A" conformity assessment procedure. Documentation according to this is described, and/or combined in a PED dossier to verify compliance with PED module A.

2.0 Reference documents

Table 2-1: Reference documents

Document no.:	Document name:
2014/68/EU	Pressure equipment directive
K559-2254-CWIWP4202202-K01-002	Declaration of Conformity (Container Solution)
K559-2254-CWIWP4202202-J09-001	Leak Test Procedure
K559-2254-CWIWP4202202-L01-001	Material Test Certificates
K559-2254-CWIWP4202202-J02-001	WPS and PQR Records (incl. J03 - NDE Procedures)

3.0 Definitions and Acronyms

Table 3-1: Definitions and Acronyms

Document no.:	Document name:
PED	Pressure Equipment directive
DoC	Declaration of Conformity

4.0 Purpose

The following document will contain the PED analysis of the H2 manifold as an add on part to the FC PowerGen 1000kW®. The document is created based on the process described in the PED 2014/68/EU

The following part which is not a part of the document 550002 and will be covered by this PED statement: **DN32 H2 collector manifold**

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5.0 Analysis of technical demands in relation to 2010/68/EU

5.1 Background for analysis

Table 5-1: Background for *conformity assessment*

Item	**Document name:**
Dimensioning pipe size	DN32
Maximum operating pressure	6,5 Barg
Fluida groupe[1]	Hydrogen Groupe 1

[1] According to article 13 a)

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5.2 Analysis of conformity category.

According to article 4 section C, the category for Fluida groupe 1 is defined in following table 6 in the PED shown in Figure 1.

Figure 1: Conformity category PED 2008/68/EU Tabel 6

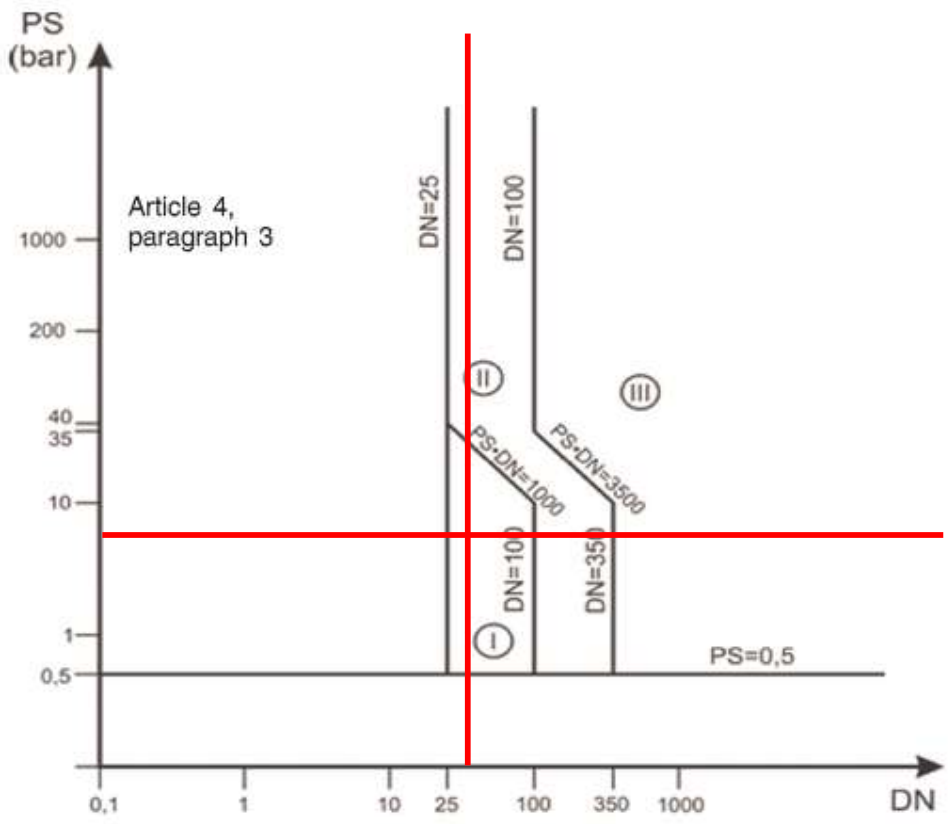


Table 6

Piping referred to in Article 4(1)(c)(i), first indent

The Red lines is an approximate line of the Size and pressure of the part. The intersection will define the point defining the category.

As visualized in the Figure 1, the category applicable for the part will be **Category 1.** As shown in the diagram from PED Annex II section 1. The "Conformity group I" will refer to a "module A" Conformity assessment procedure according to PED Annex III. The following procedure will be described in the following sections of this document.

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6.0 Technical documentation

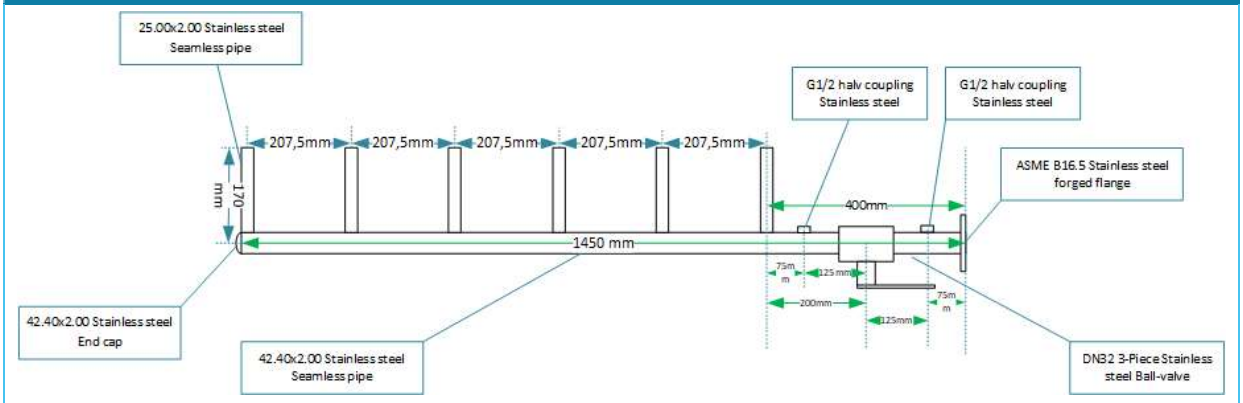
6.1 General description of the product

The product is a hydrogen manifold capable of distributing hydrogen from a single input into 6 independent outputs. The product contains an ASME B16.5 flange for connecting the input. A DN32 pipe with 25mm branches all in stainless steel. There is installed a 3-part welded ball valve type DVC 131150032 suitable for hydrogen 6,5 Barg. The valve is for manually blocking the hydrogen supply during e.g. service.

The product may not be installed in applications where a non-sufficient pressure relief valve set to 10 Barg is not installed.

6.2 Drawings of the Construction

Figure 2: Technical drawing of H2 Manifold



6.3 Results of construction calculations and examination

As the part is not relying on any structural strength since the pipe is not holding any weight, the only relevant construction is the pipe pressure rating. The following pipes are used:

- DN32 42.40x2.00mm EN-10216-5 1.4401/1.4404 TC2 pressure tested to 1500 PSI
- 25.00x2.00mm EN-10216-5 TC2 A269 213 pressure tested to 199 Barg

All assessment is done according to "module A" requirements in PED

#	Component	Material Certificate
1	42.4x2.0 Stainless Steel Cold Finish Seamless Pipes	K559-2254-CWIWP4202202-L01-001
2	25.0x2.0 Stainless Steel Seamless Pipes	K559-2254-CWIWP4202202-L01-001

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3	42.4 ASME B16.5 Stainless Steel Forged Flanges	K559-2254-CWIWP4202202-L01-001
4	G½ Coupling Stainless	K559-2254-CWIWP4202202-L01-001
5	42.4x2.0 Stainless Steel End Caps	K559-2254-CWIWP4202202-L01-001

6.4 Inspection and test

6.4.1 Hydrogen pressure test

The hydrogen manifold has gone through several tests to verify the tightness of the system, even though the material used for manufacturing the hydrogen manifold is certified at a higher pressure than the intended maximum pressure of the Hydrogen manifold.

To sum up the test:

- Individual test of component. Procedure according to 62282-3-100:2020 section 6.2 Leakage test)
- Complete assembly test Formier gas 5% H2. Procedure according to 62282-3-100:2020 section 6.2 Leakage test and "Leak Test Procedure" K559-2254-CWIWP4202202-J09-001
- Complete test pure H2. Procedure according to 62282-3-100:2020 section 6.2 Leakage test and "Leak Test Procedure" K559-2254-CWIWP4202202-J09-001

6.4.2 Welding testing

The following welds on the hydrogen manifold has been tested according to the certificates included in the Certificate dossier.

Welding procedure and welding test results are described in document "WPS and PQR Records (incl. J03 - NDE Procedures)" K559-2254-CWIWP4202202-J02-001

7.0 Appendix documents

Appendix	Document name	Document number
Appendix A	WPS and PQR Records (incl. J03 - NDE Procedures)	K559-2254-CWIWP4202202-J02-001
Appendix B	Material Test Certificates	K559-2254-CWIWP4202202-L01-001

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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	9/2/2025	Welder certificate added

Document Title:	**BLPH Project - WPS and PQR Records**
Document Number:	K559-2254-CWIWP4202202-J02-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-J02-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Svejseprocedureprøvedokumentation

Welding Procedure Qualification Record

Complete documentation

DS/EN ISO 15613:2005

WPQR nr.:	141 T/T BBW 8.1 01
Dimension:	Rør: Ø20x3,0 - Ø50x2 mm
Materiale:	1.4301 - 1.4301

Udarbejdet af

weldadvice

Europæisk Svejse Rådgivning

For

TJ TECHNOLOGY

Ågade 65
7850 Stoholm

Indholdsfortegnelse / Table of contents

Svejseprocedureprøveattest / Welding procedure qualification record

141 T/T BBW 8.1 01

Visuel Kontrol 2015554-VT 01

Ikke Destruktiv Kontrol / Non Destructive Testing
Radiographic testing 78961-116-20219
Penetrant testing 78961-116-20219

Destruktiv Kontrol / Destructive Testing
Mechanical test report M026517:1

Materialecertifikater / Material Certificates
Chandan Steel Limited EN 10204, 3.1: Heat No: CH-2861
Siderinox S.p.a. EN 10204, 3.1: Heat No: 0440628

Tilsatsmateriale / Consumables
Hyundai SMT-316LSi, Ø1,6 mm EN 10204, 3.1: Lot No: V9988

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SVEJSEPROCEDUREPRØVEATTEST
WELDING PROCEDURE QUALIFICATION RECORD

Kvalifikation i henhold til: Qualification i according to: DS/EN ISO 15613:2005
Standard/Norm: Standard/Code:
Kundens specifikation: Client's specification:

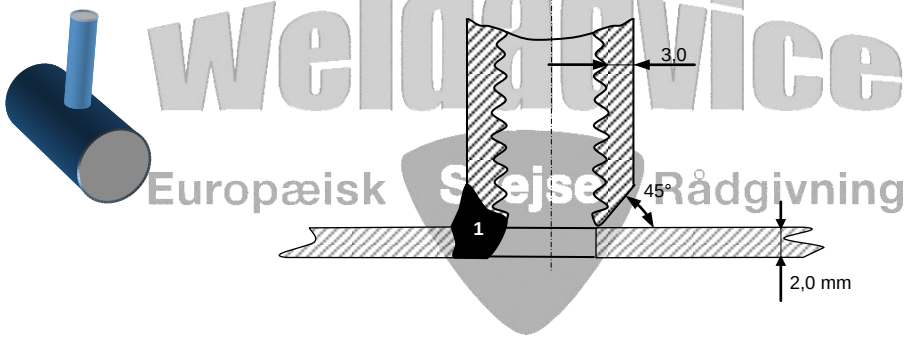
WPQR NO. 141 T/T BBW 8.1 01
Date: 15/01-2016
Blad/Sheet 1/ 1
Side/Page 1 / 2

Kunde/Client | Projekt/Project

Svejsning udført af /Welding carried out by: Brian Ravn | Mærke nr./Stamp no.

Standard/Code: EN 10217-7			Grundmaterialer/Base Materials	Standard/Code: EN 10088-3		
Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -		Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -
Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8	til/to	Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 3,0	Dia. mm: 20,0

Fugedetaljer og sømopbygning (Skitse)
Joint details and welding sequence (Sketch)



weldadvice
Europæisk Svejse Rådgivning

Svejsestilling/ Welding position: PC

Hæftning/Tacking:	Som Streng 1 / As run no. 1
Min. Forvarmetemp.: Min. preheat temp.:	16 °C
Længde: Length:	2 stk. af 4 mm
Antal strenge: No of runs:	1
Andre data: Other data:	
2. side: Fugning/Gouging:	☐ Ja Yes ☒ Nej No
Forvarmetemp.: Preheat temp.:	°C
Elektrode dia.: Electrode dia.:	mm
Lufttryk: Air pressure:	bar
2. side: Slibning/Grinding:	☐ Ja Yes ☒ Nej No

Streng No. / Run No.	Svejse-proces / Weld. proces	G Gas, T Tråd/Wire, P Pulver/Flux, E Electrode; ∇ Fabrikat og betegnelse / Manufacture and trade mark	Dimension: Diameter -Længde/ Diameter -Length mm	Standard: Klassifikation/ Classification (G EN ISO 14175:2008, T EN ISO 14343-A, E EN ISO 6848)	H_2 Skala/ Scale EN 1011	Beskyttelsesgas Shielding Gas: l/min	Dyse/ Nozzle mm Ø	Baggas Back shielding gas: Type/ l/min	Bem. Note No.
1	141	G *Strandmøllen, Pro Line H_2*	-	*R1*	-	*9*	*7*	*Formier* / *10*	-
1	141	T *Hyundai SMT-316LSi*	*1,6*	*G 19 12 3 L Si*	*D*	-	-	- / -	-
1	141	E *Wolframelektrode LaO_2*	*1,6*	*WL20*	-	-	-	- / -	-
								/	
								/	
								/	

Streng No. / Run No.	Program nr. / Program No.	AC DC / Pol.	Strøm/Current Amp	Tråd-hast. / Wire speed m/min	mm	Svejsehast mm/min. eller strækkelængde mm / Travel speed mm/min. or run-out length mm: Volt		S: XX: ∇ U.pendling/stringer pendling/weaving Strengbredde/ run width Max. mm	Heat input KJ/mm	Forvarme/ Preheat °C / Interpass-temp.	Bem. Note No.
1	-	*DC-*	*75*	-	-	*9,0*	*40*	*5,6*	*0,61*	*16* / -	-
										/	
										/	
										/	
										/	
										/	
										/	

Efterfølgende varmebeh./PWHT: ☒ Nej No ☐ Ja, se bilag nr.: Yes, see enclosure No.:

Bemærkninger-andre oplysninger/Notes-other informations

Vi bekræfter, at de givne oplysninger er korrekte og at prøven er tildannet, svejst og varmebehandlet i.h.t. ovennævnte standard/norm og/eller kundens specifikation./We confirm that the statements in this record are correct and that the test was prepared, welded and heat treated according to the above specified standard/code and/or client's specification.

Sted/Place | Dato/Date

Producentens underskrift
Contractor's signature

Prøvesvejsningen var mærket: The test coupon was marked: 2015544-01A, PC H.H. 15/01-2016

Charge/Heat: CH-2861
Charge/Heat: 0440628
Filler metal Lot: V9988

weldadvice
Europæisk Svejse Rådgivning
Messingvej 32 B DK 8940 Randers SV
Tlf.: +45 8640 6805 - Fax: +45 8640 6807

Gennemgået/bevidnet
Reviewed/witnessed by

Repræsenterende
Representing

Prøvningsresultat og godkendelse; Se bagside / Test results and approvals; See revers side

NON-DESTRUCTIVE EXAMINATION	WPQR No.: 141 T/T BBW 8.1 01	Blad/Sheet 1/1	Side/Page 2/2

Metode/ Method - resultat / result	Standard	Rapport nr./ Report no.
1. Visual examination Result: ***Accepteret/ Accepted***	Procedure standard: ***DS/EN ISO 17637:2011*** according to: ***DS/EN ISO 5817, Level B (C)***	***2015544-VT-01***
2. Radiographic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17636-1:2013 Class B*** according to: ***EN ISO 10675-1:2013, Level 1***	***78961-116-20219***
3. Ultrasonic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17640:2011 class B*** according to: ***EN 11666:2011- level 2***	
4. Magnetic particle testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17638:2009*** according to: ***DS/EN ISO 23278:2009 Level 2x***	
5. Dye penetrant testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 3452-1:2013*** according to: ***DS/EN 23277:2009- Level 2x***	***78961-116-20219***
6. Other examination Procedure: Result:	Type: according to:	

Place Randers	Date 19/01-2016	Witnessed/reviewed by (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature		Representing (Examiner or Notified Body)

Heino Harstad

MECHANICAL TESTING

According to DS/EN ISO 15614-1:2004/A1:2008/A2:2012; PED 97/23/EC

1. Tensile tests

EN ISO 6892-1:2009; EN ISO 4136:2012

Specified Y.S. min. *N/mm²* Specified U.T.S. min. *N/mm²*

Test no.	Dim.	Area	Gauge length	Yield Load	$R_{P0,2}$ N/mm²	$R_{P1,0}$ Load	R_{eH} N/mm²	R_m N/mm²	Elong A %	Remarks

2. Bend tests

DS/EN ISO 5173:2010 / EN ISO 7438:2005

Specified degr. 180° Former dia. mm

Type and dimensions	Bend angel	Results	Type and dimensions	Bend angel	Results

3. Impact tests

EN ISO 148-1:2013/ ISO 9016

Dim.: mm Specified type of test : V-notch Specified: J Testing temp. °C

Test no. VWT	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J
Average WM		Average FL		Average FL+2		Average FL+5		Average FL		Average FL+2		Average FL+5	

4. Macro Examination

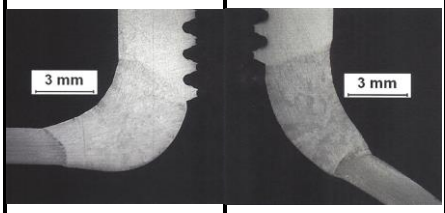
Separate sheet with picture ☐ Yes ☒ No Results:

5. Hardness tests

ISO 9015-1, EN ISO 6507-1:2006

Specified type of test: HV10 Req. max.

Sketch showing indentations



	Base metal (2mm)			HAZ (0,5 mm)				Weld metal			HAZ (0,5mm)				Base metal (2mm)		
A																	
B																	
C																	
D																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

6. Other/Supplementary Tests.

☒ No ☐ Yes See enclosures:

7. Further enclosures:

M026517:1

Place Randers	22/01-2016	Witnessed/reviewed (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature		Representing (Examiner or Test Body)

Heino Harstad

Vi godkender herved denne svejseprocedure til svejsning på omtalte projekt under de begrænsninger, der er givet i standarden/normen og/eller kundens specifikation.

We hereby approve this welding procedure for welding on the referring projekt within the limitations given in the standard/code and/or client´s specifikation.

Place Date

Underskrift af kunde/kunderepræsentant
Client´s or representative´s signature

Markrapport
Visuel kontrol af svejsesømme

Rekvirent TJ Technology, Ågade 65, 7850 Stoholm	**Sag nr.** 2015544	**Rapport nr.** VT-01
Entreprenør	**Dato.** 15/01-2016	**side af** 1 / 1
Emne Branch Connection Ø20x3 mm – Ø50,8x2 mm	**Tegning ref.:** 222446-D1324559	
Mrk. 2015544-01A	**Materiale:** X5 CrNi18-10	

Fugetype ☒ Stumpsøm	☐ Kantsøm	☐ Andet	☐ Slebet	**PWHT** ☐ Ja	☒ Nej	**Timer efter svejsning**
Undersøgelsesprocedure / klasse ☒ EN ISO 17637	☐ NS 10250	☐ ASME Sect. V	☐ Andet:			
Kvalitetskrav ☒ EN ISO 5817 Level B (C)	☐ ASME Sect.	☐ Andet:				
Udstyr ☒ Hulspejl	☒ Lygte	☐ Skydelære	☐ Kantsømlære	☐ Andet:		
Undersøgelsesomfang ☒ Kontrol før svejsning	☒ Kontrol under udførelse	☒ Kontrol efter svejsning	☐			
Omfang ☐ Visuel besigtigelse %	☒ Visuel kontrol 100 %	☐ Tilfældigt udvalgt	☐ Udpeget			

Undersøgelsens resultat

Accepteret / Accepted

Rep. opmærkning. ☐ På emne ☐ På skitse	**Kontrol af** ☐ Opslibning ☐ Reparation	**Bilag vedlagt** ☐ Ingen ☐ Stk.	**Inspektø**	**Certifikat type. / nr.** IWT-NO/0147

Attestationer	**Tekniker**	**Certifikat type / nr.**
	Tekniker	**Certifikat type / nr.**

9-11-01-L

Weldadvice I/S · Messingvej 32B · DK-8940 Randers SV · Tlf.: +45 8640 6805 · Fax: +45 8640 6807
CVR nr.: 2768 9620 · E-Mail: mail@weldadvice.dk ·Internet: www.weldadvice.dk/ www.weldadvice.com

Prøvningsrapport - Ikke-destruktiv Prøvning

KUNDE Weldadvice, Europæisk Svejse Rådgivning I/S, Messingvej 32 B, 8940 Randers SV, Denmark

KONTAKT Heino Harstad, Weldadvice, Europæisk Svejse Rådgivning I/S, Messingvej 32 B, 8940 Randers SV, Denmark

ENTREPRENØR

BYGHERRE

ARBEJDSSTED Force - Lab.

REKVISITIONS ID. 2015544-01

Rekvisitions Beskrivelse	Specifik Job Information
	6. Stk. svejseprøver/ kantsømme

78961-KHC A

Sammenfatning

Svejsninger, ingen sporbarhed, EN ISO 15614-1:2006/A2:2012

NDT Metode	Prøvningsspecifikation	Acceptkriterie	Andre krav
Penetrant (PT)	EN/ISO 3452-1:2013	EN/ISO 23277:2009 - 2X	
Radiografi (RT)	EN/ISO 17636-1:2013 - B	EN/ISO 10675-1:2013 - 1	

PRØVNINGSRESULTAT

	Svejsning Status	
	Acceptkriterie opfyldt	6 svejsninger

Detaljer om prøvningsresultat kan findes i "PRØVNINGSRESULTAT DETALJER" sektionen.

Tekniske data, NDT informationer, identifikation af udstyr, kalibreringsdata for udstyr, og andre relevante data, er registreret for hver NDT-metode i sektionen for Prøvningsmetode Detaljer. Uddrag fra Prøvningsrapporten må kun gengives efter skriftlig tilladelse fra FORCE Technology. Den elektroniske version af Prøvningsrapporten, som er gemt i "FORCE NDT Online", er defineret som originalen. Prøvningsresultaterne gælder kun for de emner som er testet. FORCE Technology - Almindelige betingelser er en integreret del af aftalen, medmindre andet er skriftligt aftalt.

PRØVNINGSRESULTAT - DETALJER

	Svejsninger hvor acceptkriterie er opfyldt		
Reference	**Svejsning Id. (Rep./Udv.)**	**Svejser(e)**	**Prøvningsmetode(r)**
2015544-01	01A-1	-	PT, RT
	01A-2	-	PT, RT
	02B-1	-	PT, RT
	02B-2	-	PT, RT
	03C	-	PT, RT
	04D	-	PT, RT

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PRØVNINGSOMFANG

RT. og PT. af 6. stk. svejseprøver, i muligt omfang.

SVEJSNING DETALJER

Reference	Svejsning Id. (Rep./Udv.)	Materialer	Overfladebeskaffenhed	Varmebehandling
		Dimensioner	Tidspunkt for prøvning	Temperatur (ca.)
		Nominel tykkelse	Timer efter sidste fremstillingstrin	Svejsningstype-fugeform-metode(r)
2015544-01	01A-1, 01A-2	Rustfrit stål	Som svejst	Ingen information
		20 mm	Ingen information	-
		3 mm	-	Ingen information-Ingen information-Ingen information
	02B-1, 02B-2	Rustfrit stål	Som svejst	Ingen information
		50 mm	Ingen information	-
		2 mm	-	Ingen information-Ingen information-Ingen information
	03C	Rustfrit stål	Som svejst	-
		50 mm	Ingen information	-
		2-2 mm	-	Ingen information-Ingen information-Ingen information
	04D	Rustfrit stål	Som svejst	-
		50 mm	Ingen information	-
		1,6-15 mm	-	Ingen information-Ingen information-Ingen information

Ovenstående oplysninger er til information og angives kun i den udstrækning, de er tilgængelige og relevante. Deres angivelse i denne prøvningsrapport kan ikke betragtes som en verifikation af deres rigtighed og de er ikke omfattet af nogen akkreditering.

PRØVNINGSMETODE - DETALJER

Penetrant Prøvning (PT) **Prøvningstidspunkt 19-01-2016 - 19-01-2016**

Personale

Navn (Tekniker Nr.)	Certifikattype	Certifikat nr.	Reference [Svejsning Ids]
Keld Hald Christensen (1)	EN ISO 9712 PT (EN 473) Level 2	0063-N2-P	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]

Produkter

Type	Parti Nr.	Produkt	Prøvningstekniske oplysninger Nr.
Halogenfri Opløsningsmiddel Fremkalder		Spotcheck SKD-S2	1
Vandafvaskelig/Opløsningsmiddel Rød Penetrant		Spotcheck SKL-WP	1
Halogenfri Rensevæske/Afrensning af Overskudspenetrant		Spotcheck SKC-S	1

Prøvningstekniske oplysninger

Nr.	Reference [Svejsning Ids]	For-rengøring	Penetreringstid	Fremkaldertid	Lysforhold
		Betegnelse	Emulgeringstid	-	Lys intensitet
1	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]	Penetrant Rensemiddel	15 min.	15 min.	Hvidt lys - kunstig
		IICd2	-	-	> 1000 LUX

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Radiografi Prøvning (RT) **Prøvningstidspunkt 19-01-2016 - 19-01-2016**

Personale

Navn (Tekniker Nr.)	Certifikattype	Certifikat nr.	Reference [Svejsning Ids]
Keld Hald Christensen (1)	EN ISO 9712 RT (EN 473) Level 2 (incl. aluminium)	0063-N2-R	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]

Udstyr

Type	Id.	Andre data	Prøvningstekniske oplysninger Nr.
RT X-RAY TUBE, SMART 225	XRL-10	FOCAL SPOT 3 MM, EN 12543, (DIRECT BEAM), 70-225 kV, 4,0 mA	1-4
RT FILM VIEWING UNIT, WILNOSOL	VGA-110	H UNIVERSAL, DENSITY D UP TO 3,7	1-4
RT DENSITOMETER, WILNOS LCD 51	PDE-21	MAXIMUM DENSITY D = 5,0	1-4

Prøvningstekniske oplysninger

Nr.	Optageteknik	Fremkaldelse	IQI (Certifikat nr.)	Spænding
	Antal film per svejsning/objekt	Folietype (tykkelse)	IQI placering	Strøm / Aktivitet
	Filmtype	Kilde/Brændplet størrelse	Gennemstrålet tykkelse	Eksponeringstid
	Kilde / detektor eller film afstand (SFD / SDD)	Kilde / objekt afstand (f/D)	Objekt / film afstand (b/d)	Opløsning
1	Dobbeltvæg/Enkeltbillede - Rør, Kontakt (DV/EB)	Maskine	10 FE EN ()	140 kV
	1	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	750.0 mm	50.0 mm	-
2	Dobbeltvæg/Dobbeltbillede - Rør, Ellipse (DV/DB)	Maskine	10 FE EN ()	140 kV
	2	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	750.0 mm	50.0 mm	-
3	Enkeltvæg/Enkeltbillede - Plade (EV/EB)	Maskine	10 FE EN ()	140 kV
	4	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	790.0 mm	10.0 mm	-
4	Enkeltvæg/Enkeltbillede - Plade (EV/EB)	Maskine	13 FE EN ()	200 kV
	4	Pb (0.02 / 0.02 mm)	Filmside	4.0 mA
	Foma / Indux R5	3.0 mm	15.0 mm	90 sek
	800.0 mm	785.0 mm	15.0 mm	-

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Film

Film id.	Prøvningstekniske oplysninger Nr.	Sværtning	IQI Nr.	Følsomhed	Ug
01, 02, 05	1	2,5	16	5.00 %	0.20 mm
03, 04	2	2,5	16	5.00 %	0.20 mm
06-09	3	2,5	16	5.00 %	0.04 mm
10-13	4	2,5	13	1.33 %	0.06 mm

Svejsning på film

Reference	Svejsning Id [Film Id'er]
2015544-01	01A-1 [01], 01A-2 [02], 02B-1 [03,04], 02B-2 [05], 03C [06-09], 04D [10-13]

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PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

SWEDAC ACKREDITERING 5622 ISO/IEC 17025

SAFE CONTROL MATERIALTEKNIK

Beställare / Ordered by Weldadvice Messingvej 32B DK-8940 Randers SV	**Orderdatum / Date of order** 2016-01-20	**Reg. nummer / Reg. number** M026517:1
Er referens / Your reference Heino Harstad	**Inlämningsdatum / Object (-s) received** 2016-01-20	**Sidnummer / Page** 1(2)
Ordernummer / Order number 2015544-02	**Rapportdatum / Date of report** 2016-01-25	**Vår referens / Our reference** Johan Ageryd

Assignment:	Procedure qualification test according to EN ISO 15 614-1:2004.	
Test object(s):	Branch connection. Half V- groove.	
Material:	1.4301/ 1.4307	1.4301/ 1.4307
Group:	8.1	8.1
Dimension:	Ø 20 x 3.0 mm	Ø 50 x 2.0 mm
Heat number:	CH-2861	0440628
pWPS:	WPS TJ Tech 02	
Procedure number:	2015544-01A	
Identification mark:	2015544-01A	
Weld method:	141	
Position:	PC	
Filler metal:	Hyundai SMT-316LSi, Ø 1.6 mm	
Note:	-	
Result:	Accepted according to referenced standard.	
Signature:	SAFE CONTROL Johan Ageryd	

"Laboratorier ackrediteras av Styrelsen för ackreditering och teknisk kontroll (SWEDAC) enligt svensk lag. Den ackrediterade verksamheten vid laboratoriet uppfyller kraven i SS-EN ISO/IEC 17 025 (2005). Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänner annat". Provningsresultaten i denna rapport avser endast provade objekt.

"Laboratories are accredited by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC) under the terms of Swedish legislation. The accredited laboratory activities meet the requirements in SS-EN ISO/IEC 17 025 (2005). This report may not be reproduced other than in its full, except with the prior written approval of the issuing laboratory". The test results in this report refer only to tested objects.

Safe Control Materialteknik AB • Tillgängligheten 1 • S-417 01 Göteborg
Tel. +46 (0)31 65 64 70 • Fax +46 (0)31 65 64 80
E-mail: info@safecontrol.se • www.safecontrol.se

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

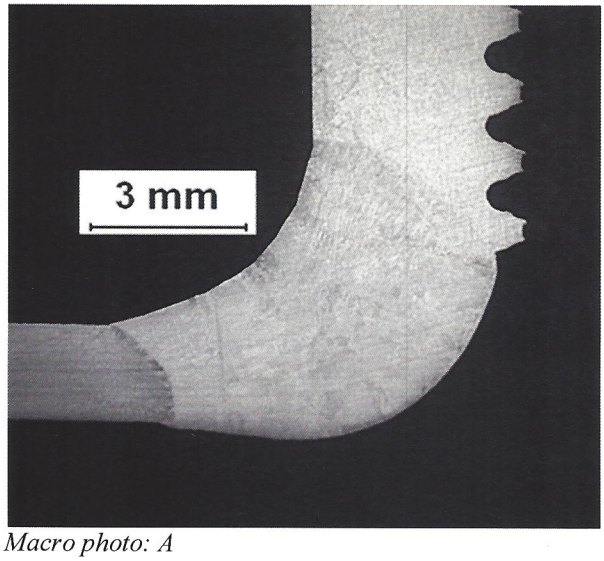
Teknisk instruktion / Technical instruction	Märkning / Marking	Reg. nummer / Reg. number
Macroscopic and microscopic examination of welds	2015544-01A	M026517:1
TI Dokumentnr./ TI Document no.	**Provningsutrustning / Testing equipment**	**Sidnummer / Page**
SCMM1	SCM 9	2(2)
Provning enligt / Testing according to	**Provningsdatum / Testing date**	**Utfört av / Performed by**
SS-EN 1321	2016-01-22	Johan Ageryd

Macroscopic examination:

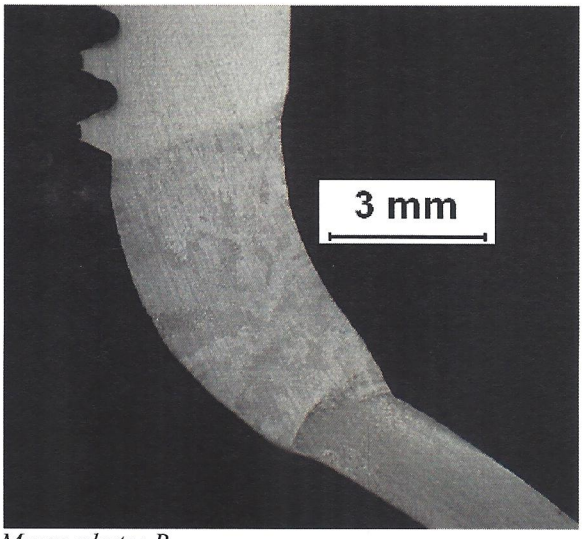
Two macro samples were cut out for macroscopic examination of weld metal, HAZ and base metal. The macro samples were ground (to 2000- paper) and examined in not etched and etched condition at magnification of 1× - 20×.

Macro sample			Base metal		Filler metal	Etchant *(acc. to SIS-CEN/CR 12361:1996)*
ID / No	Position	Orientation	Horizontal	Vertical		
2015544-01A	PC	Perpendicular to the weld direction	1.4301/ 1.4307	1.4301/ 1.4307	Hyundai SMT-316LSi	B.5 (Kalling´s)
Examined macro samples are assessed to fulfil the requirements in EN ISO 5817:2014. See macro photos below.						

Macro photos:



Macro photo: A



Macro photo: B

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurement: ± 1.5 %

Not.: Avsteg från punkt 10 i SS-EN 1321 har gjorts. Beteckning har ej redovisats i enlighet med exemplifierade versioner.
Note: Deviation from clause 10 in SS-EN 1321 has been done. Description has not been presented in accordance with exemplified versions.

Signatur/ Signature:

SAFE CONTROL
Johan Ageryd

CHANDAN STEEL LIMITED

(GOVT. OF INDIA RECOGNISED EXPORT HOUSE)

ISO 9001 : 2008 CERTIFICATE No. 04 100 011022-E3

ADM. OFFICE: 504, SUKH SAGAR, N. S. PATKAR MARG, MUMBAI 400 007, INDIA

Tel.: 91-22- 66290600. Fax.: 91-22-66290633/34

Website : www.chandansteel.net

Email : csl@chandansteel.net

WORKS: Plot No. 35, G. I. D. C., Umbergaon

Dist Valsad, Gujarat - 396 171.

Tel.: 91-260- 308 9999 Fax.: 91-260 308 9872

E-mail : exports@chandansteel.net

CE 0045 14 0045-CPR-1394

L/c. No.:

L/c. Date:

F824 QC 09A / 02 / 10.12.2012

MILL TEST /INSPECTION CERTIFICATE 3.1

ACCORDING TO EN 10204 : 2005

Consignee		Test Certificate No.	: EXP/00645 - 09/2015-2016
DACAPO STAINLESS A/S		Date of Issue	: 22.09.2015
NEPTUNVEJ 1		P. O. No.	: 45060220
8600 SILKEBORG		SC_No. & Date	: 15-16/00345, Dt.01.08.2015
DENMARK		Invoice No. & Date	: EXP/00645/2015-16 Dt.22.09.2015
PRODUCT DESCRIPTION		LENGTH	Net Wt.
STAINLESS STEEL ROUND BARS		Ordered	Actual
[CONDITION - 1D & 2D]		6.0 - 6.1 Mtrs.	6.0 - 6.1 Mtrs.
			2731 Kgs.

Article No.	Item No.	Heat No.	Material/Grade	Size mm	Tolerance	Process Route
-	5000200006	CH-2861	1.4301/1.4307	20.00 mm	h9	Electric Melting, A.O.D. Refining, Continuous Casting

CHEMICAL COMPOSITION (Weight %)

	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Ti	Co	N
Min.	-	-	-	-	-	18.00	-	8.00	-	-	-	-
Max.	0.030	1.00	2.00	0.045	0.030	19.50	-	10.50	-	-	-	0.1000
Results	0.029	0.43	1.65	0.045	0.028	18.30	-	8.03	-	-	-	0.0650

MECHANICAL PROPERTIES

Specified Values	Test Method :- EN ISO 6892-1					Hardness EN ISO 6506-1	Test Method :- DIN EN ISO 148 - 1 Charpy (V) Impact Test (2mm) at 20 °C (Joules) Sample Size - 10 x 10 x 55 mm			
	Proof Strength N/mm² /MPa		Tensile Strength N/mm²/MPa (Rm)	Elongation after Fracture A %	Reduction of Area %					
	0.2%(Rp0.2)	1%(Rp1.0)				(BHN)	I	II	III	Avg.
Results	448	485	715	44	65	222-225	230	240	245	238

Remarks:

1. Condition : 1D & 2D (Bright drawn & Polished).
2. Solution annealed at 1050 °C.
3. PMI test done 100% & found Satisfactory.
4. Both ends Chamfered.
5. The material is fully killed and calcium treated.
6. Material has improved machinability.
7. Material is free from radio-active contamination.
8. Intergranular Corrosion test carried out as per EN/ISO 3651-2-1998 (Test method A) found satisfactory.
9. Surface Defects found satisfactory as per EN 10277-1 Class 3.
10. The material conforms to DIN EN 10088-3:2005, EN 10088-5:2009, EN 10272-2008, AD2000 W2/W10, ASTM A276-13/A182-13/A479-13a, ASME SA276-10/ SA182-10/SA 479- 2010 SECTION II, PART A Specification.
11. Location of sample - off centre, Direction - Longitudinal, Test Temp - Room Temp., Shape of Test Piece - Round.
12. Marking details - Company Logo, Size, Grade & Heat No.
13. The material is manufactured /melt in Chandan Steel Mill and is of Indian Origin.

BUNDLE NO.: 64, 65, 67 to 69 COLOUR : BLUE

Intended use : Building construction or civil engineering.

Regulated substance : No performance determined.

It is hereby certified that the above results are true and correct in every details and are meeting the requirements of specification & purchase order.

D.O.P. No.: 1.4301/ROUND BAR

D.O.P. can be seen here: www.chandansteel.net

BSR

B. S. RAUTELA

MANAGER - Q.A./WORKS INSPECTOR

SIDERINOX

Siderinox S.p.a. Frazione Caselle 20081 Morimondo (MI) Italia
Ufficio Commerciale: Tel. 02 9498151 - Fax 02 949815250/251
Ufficio Amministrativo: Tel. 02 9498161 - Fax 02 949816350
Ufficio Spedizioni: Tel. 02 949816222 - Fax 02 949815350
Ufficio Acquisti : Tel. 02 949816345 - Fax 02 949816350
Casella e-mail: sx@siderinox.it Sito web: www.siderinox.it

Capitale Sociale Euro 3.300.000 i.v.
Cod. Fiscale e Reg. Imp. MI N. 01825510157
R.E.A. Milano N. 878116
Centro Meccanografico n. MI074282
Partita IVA 01825510157

AZIENDA CON SISTEMA
DI GESTIONE QUALITÀ
CERTIFICATO DA DNV GL
=ISO 9001=

INSPECTION CERTIFICATE EN 10204 3.1 N° 424885 of 02.02.2015

Purchaser **INOX STAAL A/S**

DDT	SIDERINOX order number	Customer's order
N 8 of 02.02.2015	N 5 of 22.01.2015	N 15836-1 of 22.01.2015

Product description

Stainless steel round pipe Ø 50,8 x 2 mm AISI 304/304L brushed EN 10217-7 Longitudinally welded

Dimension	Steel type	Quantity (m)	Weight (kg)
50,8 x 2 mm	EN 1.4301/1.4307 / AISI 304/304L	366	815

Production Norm	Rolling	Tolerances	Welding factor
EN 10217-7	Hot rolled	D3 \ T3	V=1

Marking MANUFACTURER'S MARK - DIMENSION - STEELGRADE - HEAT N. - PRODUCTION NORM - EXECUTION - E.C. INSPECTOR - WORK INSPEKTOR

Manufacturing process — Surface finishing W0

CHEMICAL COMPOSITION

Heat	% C	%Mn	%P	% S	%Si	%Cr	% Ni	% Mo	% Ti
	0,000 - 0,030	0,000 - 2,000	0,000 - 0,040	0,000 - 0,010	0,000 - 1,000	17,500 - 19,500	8,000 - 10,000	0,000 - 0,000	0,000 - 0,000
0440628	0,022	1,680	0,027	0,001	0,380	18,240	8,090		

The chemical values refer to the certificate issued by the steel mill according to EN 10088 / 10028-7 / ASTM A 240 and stored at our office.

TEST RESULTS

* (D) Direction: (L) Longitudinal, (T) Transverse - ** (P) Position: (W) Welding, (M) Material

Test unit	Test Class	(D) *	(P) **	TENSILE TEST in Nmm2=MPa				HARDNESS
				Yield Strength		Tensile Strength	Elongation	
				Rp 0,2%	Rp 1%	Rm	A %	HRB
				195 -	230 -	500 - 740	40 -	
T14100996	TC1	L	M	246	330	658	48	
T14100998	TC1	L	M	235	314	627	49	

Visual inspection	OK	Drift expanding test		Sealing test	
		UNI EN ISO 8493	OK	UNI EN ISO 10893-1	OK
Check on dimensions	OK	Flattenning test		Non destructive Eddy Current test	
		UNI EN ISO 8492	OK	UNI EN ISO 10893-2	OK
Antimixing test	OK	Weld bend test		Intergranular corrosion test	
		EN 910	OK	N. P.	N. P.

WE CERTIFY THAT THE MATERIAL SUPPLIED COMPLIES WITH THE REQUIREMENTS AGREED ON THIS ORDER

Remarks:

Cerfications:
UNI EN ISO 9001
Dir. PED 97/23/EC Encl. 1, Point 4.3, Comma 3
AQUAP from Nr. 7293-06-TU to Nr 7298-06-TU

Qualifications:
WPS/WPAR: UNI EN ISO 15609-1/UNI EN ISO 15614-11
WLD: UNI EN ISO 14732 operator
NDT: UNI EN ISO 9712 operator

Document issued by the mill's Inspector
D. Ricco

Document confirmed by the authorized company responsible
W. Amodeo

CERTIFIED MATERIAL REPORT

CMR No. : 1502253500015 Date of Issue : 2015-02-25

Customer	HYUNDAI WELDING EUROPE OFFICE		
Trade Name	SMT-316LSi Inox	Size	1.6mm*1000mm*5kg
Lot No.	V9988	Purchaser's Order No.	
Applicable Specification	AWS A5.9 ER316LSi	* According to EN 10204-2004 : 3.1	

Welding Current		Shielding Gas		Post Weld Heat Treatment (℃ × hr.)	

Mechanical Properties	Tensile Test			Impact Test (CVN - Joule)				
	YS(MPa)	TS(MPa)	EL(%)	Temp.(℃)	X1	X2	X3	Avg.
	-	-	-		-	-	-	-
Spec.								

Chemical Composition (%)

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo		
(WIRE)	0.021	0.97	1.71	0.027	0.011	0.20	11.33	18.30	2.57		
Spec.	≤0.03	0.65 ~1.00	1.0 ~2.5	≤0.03	≤0.03	≤0.75	11.0 ~14.0	18.0 ~20.0	2.0 ~3.0		

We hereby certifies that the material covered by this report has been inspected in accordance with and been found to meet the applicable requirements of specification and customer's requirements.

Approved by

K.W. Park

QA Manager Park K. W.

HYUNDAI HYUNDAI WELDING CO., LTD.
Head Office #507,Teheran-ro,Gangnam-gu,Seoul,Republic of Korea
Pohang Plant #100,Daesong-ro,Nam-gu,Pohang,Republic of Korea

Svejseprocedureprøvedokumentation

Welding Procedure Qualification Record

Complete documentation

DS/EN ISO 15614-1:2006/A1:2008/A:2:2012

WPQR nr.:	141 T BW 8.1 02
Dimension:	Rør: Ø50,8x2,0 mm
Materiale:	1.4301 - 1.4301

Udarbejdet af

weldadvice

Europæisk Svejse Rådgivning

For

TJ TECHNOLOGY

Ågade 65
7850 Stoholm

Indholdsfortegnelse / Table of contents

Svejseprocedureprøveattest / Welding procedure qualification record

141 T BW 8.1 02

Visuel Kontrol 2015554-VT 02

Ikke Destruktiv Kontrol / Non Destructive Testing
Radiographic testing 78961-116-20219
Penetrant testing 78961-116-20219

Destruktiv Kontrol / Destructive Testing
Mechanical test report M026517:2

Materialecertifikater / Material Certificates
Siderinox S.p.a. EN 10204, 3.1: Heat No: 0440628

Tilsatsmateriale / Consumables
Hyundai SMT-316LSi, Ø1,6 mm EN 10204, 3.1: Lot No: V9988

weldadvice Europæisk Svejse Rådgivning

TJ TECHNOLOGY
Ågade 65
7850 Stoholm

SVEJSEPROCEDUREPRØVEATTEST
WELDING PROCEDURE QUALIFICATION RECORD

Kvalifikation i henhold til: Qualification i according to: DS/EN ISO 15614-1:2006/A1:2008/A:2:2012
Standard/Norm: Standard/Code:
Kundens specifikation: Client's specification:

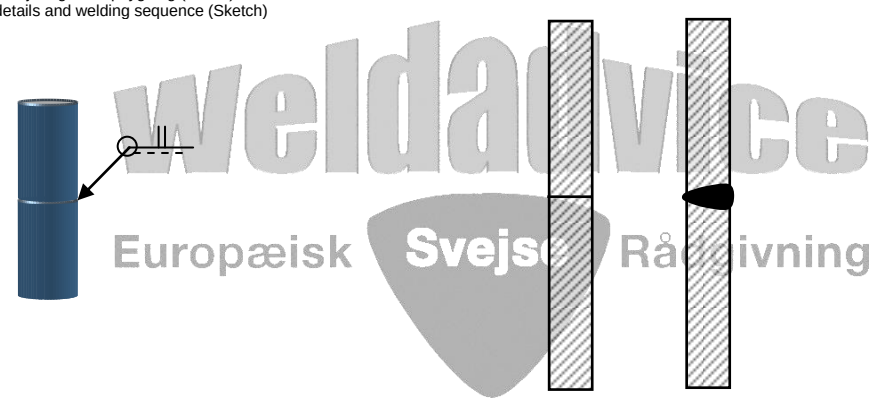
WPQR NO. 141 T BW 8.1 02
Date: 15/01-2016
Blad/Sheet 1/ 1
Side/Page 1 / 2

Kunde/Client | Projekt/Project

Svejsning udført af /Welding carried out by: Brian Ravn | Mærke nr./Stamp no.

Standard/Code: EN 10217-7			Grundmaterialer/Base Materials	Standard/Code: EN 10217-7		
Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -		Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -
Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8	til/to	Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8

Fugedetaljer og sømopbygning (Skitse)
Joint details and welding sequence (Sketch)



weldadvice Europæisk Svejse Rådgivning

Svejsestilling/Welding position: PC

Hæftning/Tacking:	Som Streng 1 / As run no. 1
Min. Forvarmetemp.: Min. preheat temp.:	16 °C
Længde: Length:	4 stk. 2-4 mm
Antal strenge: No of runs:	1
Andre data: Other data:	
2. side: Fugning/Gouging:	☐ Ja Yes ☒ Nej No
Forvarmetemp.: Preheat temp.:	°C
Elektrode dia.: Electrode dia.:	mm
Lufttryk: Air pressure:	bar
2. side: Slibning/Grinding:	☐ Ja Yes ☒ Nej No

Streng No. / Run No.	Svejse-proces / Weld. proces	G T P E ∇	Gas, Tråd/Wire, Pulver/Flux, Electrode; Fabrikat og betegnelse / Manufacture and trade mark	Dimension: Diameter -Længde/ Diameter -Length mm	Standard: Klassifikation/ Classification G T E	H_2 Skala/ Scale EN 1011	Beskyttelsesgas Shielding Gas: l/min	Dyse/ Nozzle mm Ø	Baggas Back shielding gas: Type/ l/min	Bem. Note No.
1	141	G	Strandmøllen, Pro Line H_2	-	EN ISO 14175:2008 / EN ISO 6848: R1	-	9,0	7	Formier / 10	-
1	141	E	Wolframelektrode LaO_2	1,6	WL20	-	-	-	- / -	-
									/ -	-
									/	
									/	
									/	

Streng No. / Run No.	Program nr. / Program No.	AC DC Pol.	Strøm/Current Amp	Tråd-hast. Wire speed m/min	mm	Svejsehast mm/min. eller strækkelængde mm. Travel speed mm/min. or run-out length mm	Volt	S: XX: ∇ U.pendling/stringer pendling/weaving Strengbredde/ run width Max. mm	Heat input KJ/mm	Forvarme/ Preheat /Interpass-temp. °C	Bem. Note No.
1	Pulsed		82	-	-	9,0	99		0,27	16 / -	1*)
										/	
										/	
										/	
										/	
										/	
										/	

Efterfølgende varmebeh./PWHT: ☒ Nej No ☐ Ja, se bilag nr.: Yes, see enclosure No.:

Bemærkninger-andre oplysninger/Notes-other informations
1*) Welding without filler metal

Vi bekræfter, at de givne oplysninger er korrekte og at prøven er tildannet, svejst og varmebehandlet i.h.t. ovennævnte standard/norm og/eller kundens specifikation./We confirm that the statements in this record are correct and that the test was prepared, welded and heat treated according to the above specified standard/code and/or client's specification.

Sted/Place | Dato/Date

Producentens underskrift
Contractor's signature

Prøvesvejsningen var mærket: The test coupon was marked: 2015544-02B, PC H.H. 15/01-2016

Charge/Heat:
Charge/Heat: 0440628
Filler metal Lot: Welded without filler metal

weldadvice Europæisk Svejse Rådgivning
Messingvej 32 B DK 8940 Randers SV
Tlf.: +45 8640 6805 - Fax: +45 8640 6807

Gennemgået/bevidnet
Reviewed/witnessed by

Repræsenterende
Representing

Prøvningsresultat og godkendelse; Se bagside / Test results and approvals; See revers side

NON-DESTRUCTIVE EXAMINATION	WPQR No.: 141 T BW 8.1 02	Blad/Sheet 1/1	Side/Page 2/2

Metode/ Method - resultat / result	Standard	Rapport nr./ Report no.
1. Visual examination Result: ***Accepteret/ Accepted***	Procedure standard: ***DS/EN ISO 17637:2011*** according to: ***DS/EN ISO 5817, Level B (C)***	***2015544-VT-02***
2. Radiographic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17636-1:2013 Class B*** according to: ***EN ISO 10675-1:2013, Level 1***	***78961-116-20219***
3. Ultrasonic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17640:2011 class B*** according to: ***EN 11666:2011- level 2***	
4. Magnetic particle testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17638:2009*** according to: ***DS/EN ISO 23278:2009 Level 2x***	
5. Dye penetrant testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 3452-1:2013*** according to: ***DS/EN 23277:2009- Level 2x***	***78961-116-20219***
6. Other examination Procedure: Result:	Type: according to:	

Place Randers	Date 19/01-2016	Witnessed/reviewed by (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature Heino Harstad		Representing (Examiner or Notified Body)

MECHANICAL TESTING

According to DS/EN ISO 15614-1:2004/A1:2008/A2:2012; PED 97/23/EC

1. Tensile tests

EN ISO 6892-1:2009; EN ISO 4136:2012

Specified Y.S. min. *≥195; ≥230 N/mm²* Specified U.T.S. min. *500 - 700 N/mm² - 470 670 N/mm²*

Test no.	Dim.	Area mm²	Gauge length	Yield Load	$R_{P0,2}$ N/mm²	$R_{P1,0}$ Load	R_{eH} N/mm²	R_m N/mm²	Elong A %	Remarks
TT/1	12.01x1.58	19.16						638		HAZ
TT/2	12.02x1.77	21.49						632		HAZ

2. Bend tests

DS/EN ISO 5173:2010 / EN ISO 7438:2005

Specified degr. 180° Former dia. 4x2 mm

Type and dimensions	Bend angel	Results	Type and dimensions	Bend angel	Results
TFBB/1 (2x18 mm)	180	Accepteret / Accepted	TRBB/1 (2x19 mm)	180	Accepteret / Accepted
TFBB/2 (2x21 mm)	180	Accepteret / Accepted	TRBB/2 (2x19 mm)	180	Accepteret / Accepted

3. Impact tests

EN ISO 148-1:2013/ ISO 9016

Dim.: mm Specified type of test : V-notch Specified: J Testing temp. °C

Test no. VWT	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J
Average WM		Average FL		Average FL+2		Average FL+5		Average FL		Average FL+2		Average FL+5	

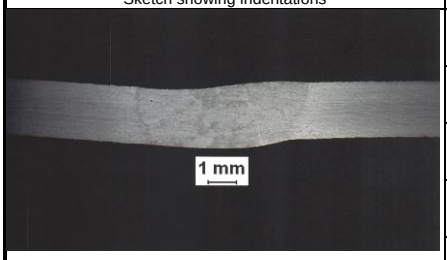
4. Macro Examination

Separate sheet with picture ☒ Yes ☐ No Results: Accepteret / Accepted

5. Hardness tests

ISO 9015-1, EN ISO 6507-1:2006

Specified type of test: HV10 Req. max.

Sketch showing indentations		Base metal (2mm)			HAZ (0,5 mm)				Weld metal			HAZ (0,5mm)				Base metal (2mm)		
	A																	
	B																	
	C																	
	D																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

6. Other/Supplementary Tests.

☒ No ☐ Yes See enclosures:

7. Further enclosures:

M026517:2

Place Randers	25/01-2016	Witnessed/reviewed (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature Heino Harstad		Representing (Examiner or Test Body)

Vi godkender herved denne svejseprocedure til svejsning på omtalte projekt under de begrænsninger, der er givet i standarden/normen og/eller kundens specifikation.

We hereby approve this welding procedure for welding on the referring projekt within the limitations given in the standard/code and/or client´s specifikation.

Place Date

Underskrift af kunde/kunderepræsentant
Client´s or representative´s signature

Markrapport
Visuel kontrol af svejsesømme

Rekvirent TJ Technology, Ågade 65, 7850 Stoholm	**Sag nr.** 2015544	**Rapport nr.** VT-02
Entreprenør	**Dato.** 15/01-2016	**side af** 1 / 1
Emne Rør: Ø50,8x2 mm	**Tegning ref.:** 222446-D1324560	
Mrk. 2015544-02B	**Materiale:** X5 CrNi18-10	

Fugetype
☒ Stumpsøm ☐ Kantsøm ☐ Andet ☐ Slebet

PWHT
☐ Ja ☒ Nej

Timer efter svejsning

Undersøgelsesprocedure / klasse
☒ EN ISO 17637 ☐ NS 10250 ☐ ASME Sect. V ☐ Andet:

Kvalitetskrav
☒ EN ISO 5817 Level B (C) ☐ ASME Sect. ☐ Andet:

Udstyr
☒ Hulspejl ☒ Lygte ☐ Skydelære ☐ Kantsømlære ☐ Andet:

Undersøgelsesomfang
☒ Kontrol før svejsning ☒ Kontrol under udførelse ☒ Kontrol efter svejsning ☐

Omfang
☐ Visuel besigtigelse % ☒ Visuel kontrol 100 % ☐ Tilfældigt udvalgt ☐ Udpeget

Undersøgelsens resultat

Accepteret / Accepted

Rep. opmærkning.	**Kontrol af**	**Bilag vedlagt**	**Inspektør**	**Certifikat type. / nr.**
☐ På emne ☐ På skitse	☐ Opslibning ☐ Reparation	☐ Ingen ☐ Stk.		IWT-NO/0147

Attestationer	**Tekniker**	**Certifikat type / nr.**
	Tekniker	**Certifikat type / nr.**

9-11-01-L

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

SWEDAC ACKREDITERING 5022 ISO/IEC 17025

SAFE CONTROL MATERIALTEKNIK

Beställare / Ordered by
Weldadvice
Messingvej 32B
DK-8940 Randers SV

Orderdatum / Date of order
2016-01-20

Reg. nummer / Reg. number
M026517:2

Er referens / Your reference
Heino Harstad

Inlämningsdatum / Object (-s) received
2016-01-20

Sidnummer / Page
1(4)

Ordernummer / Order number
2016544-02

Rapportdatum / Date of report
2016-01-25

Vår referens / Our reference
Johan Ageryd

Assignment:	Procedure qualification test according to EN ISO 15 614-1:2004.
Test object(s):	Butt weld. Two welded pipes.
Material:	1.4301/1.4307
Group:	8.1
Dimension:	Ø 50.8 x 2 mm
Heat number:	0440628 – C1309304
pWPS:	WPS TJ Tech 01
Procedure number:	2015544-02B
Identification mark:	2015544-02B
Weld method:	141
Position:	PC
Filler metal:	Hyundai SMT-316LSi, Ø1,6 mm.
Note:	-
Result:	Accepted according to referenced standard.
Signature:	SAFE CONTROL Johan Ageryd

"Laboratorier ackrediteras av Styrelsen för ackreditering och teknisk kontroll (SWEDAC) enligt svensk lag. Den ackrediterade verksamheten vid laboratoriet uppfyller kraven i SS-EN ISO/IEC 17 025 (2005). Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänner annat". Provningsresultaten i denna rapport avser endast provade objekt.

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Safe Control Materialteknik AB • Tillgängligheten 1 • S-417 01 Göteborg
Tel. +46 (0)31 65 64 70 • Fax +46 (0)31 65 64 80
E-mail: info@safecontrol.se • www.safecontrol.se

SWEDAC ACKREDITERING 5622 ISO/IEC 17025

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

Teknisk instruktion / Technical instruction
Tensile testing

Märkning / Marking
2015544-02B

Reg. nummer / Reg. number
M026517:2

TI Dokumentnr./ TI Document no.
SCDR1

Provningsutrustning / Testing equipment
SCM 1, 39, UTM V.2.10.02
SCM 107 extensometer L_e 50 mm

Sidnummer / Page
2(4)

Provning enligt / Testing according to
SS-EN ISO 6892-1:2009B10

Provningsdatum / Testing date
2016-01-21

Utfört av / Performed by
Harald Fredriksson

Tensile testing:

Pipe strip acc. to ISO 4136 / No	Dimensions		Square-area	Yield strength				Tensile strength	Elongation	Location of fracture
	Diameter/ width	Thickness		$R_{p0.2}$	$R_{p1.0}$	R_{eL}	R_{eH}	R_m	A_5	
	mm		mm^2	MPa					%	
TT/1	12.01	1.58	19.16	-	-	-	-	638	-	HAZ
TT/2	12.02	1.77	21.49	-	-	-	-	632	-	HAZ
SS-EN 10217-7:2005 1.4307:				≥180	≥215	-	-	470-670	≥35 T ≥40 L	-
SS-EN 10217-7:2005 1.4301:				≥195	≥230	-	-	500-700	≥35 T ≥40 L	-

Result: Satisfactory according to the requirement for the base material.

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

R_m: 2.0 % *$R_{p0.2}$ / $R_{p1.0}$:3.0 %* *R_{eH} / R_{eL}: 2.0 %*

Signatur/ Signature:

SAFE CONTROL Harald Fredriksson

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

Teknisk instruktion / Technical instruction	Märkning / Marking	Reg. nummer / Reg. number
Bend testing	2015544-02B	M026517:2
TI Dokumentnr./ TI Document no.	**Provningsutrustning / Testing equipment**	**Sidnummer / Page**
SCSP1	SCM 1 and mandrel Ø 8mm	3(4)
Provning enligt / Testing according to	**Provningsdatum / Testing date**	**Utfört av / Performed by**
SS-EN ISO 7438:2005	2016-01-21	Harald Fredriksson

Bend testing:

Sample type acc. to SS-EN ISO 5173 / No	Dimensions		Bending-angle	Diameter of mandrel	Observations and result
	Thickness (a)	Width (b)			
	mm	mm	°		
TFBB/1	2	18	180	4 x Test thickness (a)	Satisfactory, without remarks.
TFBB/2	2	21	180	4 x Test thickness (a)	Satisfactory, without remarks.
TRBB/1	2	19	180	4 x Test thickness (a)	Satisfactory, without remarks.
TRBB/2	2	19	180	4 x Test thickness (a)	Satisfactory, without remarks.

Result: Satisfactory according to the requirement in EN ISO 15614-1.

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurment: ± 0.2mm

Signatur/ Signature: SAFE CONTROL Harald Fredriksson

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

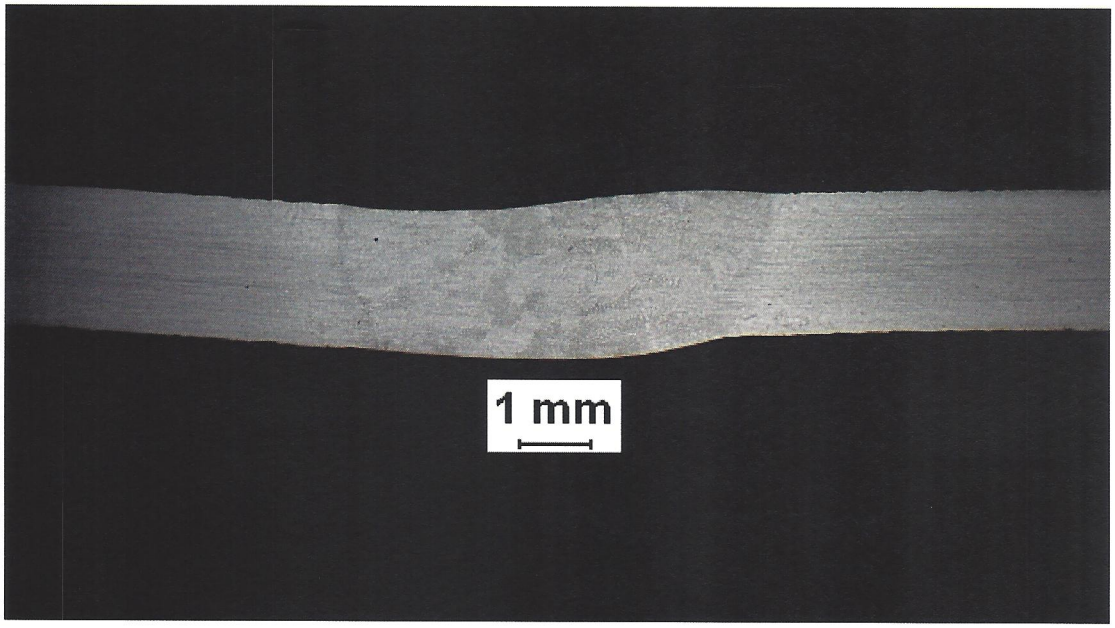
Teknisk instruktion / Technical instruction Macroscopic and microscopic examination of welds	**Märkning / Marking** 2015544-02B	**Reg. nummer / Reg. number** M026517:2
TI Dokumentnr./ TI Document no. SCMM1	**Provningsutrustning / Testing equipment** SCM 9	**Sidnummer / Page** 4(4)
Provning enligt / Testing according to SS-EN 1321	**Provningsdatum / Testing date** 2016-01-21	**Utfört av / Performed by** Johan Ageryd

Macroscopic examination:

One macro sample was cut out for macroscopic examination of weld metal, HAZ and base metal. The macro sample was ground (to 2000- paper) and examined in not etched and etched condition at magnification of 1× - 20×.

Macro sample			Base metal		Filler metal	Etchant *(acc. to SIS-CEN/CR 12361:1996)*
ID / No	Position	Orientation	Left	Right		
2015544-02B	PC	Perpendicular to the weld direction	1.4301/1.4307	1.4301/1.4307	Hyundai SMT-316LSi	B.5 (Kalling´s)
Examined macro sample is assessed to fulfil the requirements in EN ISO 5817:2014. See macro photo below.						

Macro photo:



Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurement: ± 1.5 %

Not.: Avsteg från punkt 10 i SS-EN 1321 har gjorts. Beteckning har ej redovisats i enlighet med exemplifierade versioner.
Note: Deviation from clause 10 in SS-EN 1321 has been done. Description has not been presented in accordance with exemplified versions.

Signatur/ Signature:

SAFE CONTROL
Johan Ageryd

SIDERINOX

Siderinox S.p.a. Frazione Caselle 20081 Morimondo (MI) Italia
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Ufficio Amministrativo: Tel. 02 9498161 - Fax 02 949816350
Ufficio Spedizioni: Tel. 02 949816222 - Fax 02 949815350
Ufficio Acquisti : Tel. 02 949816345 - Fax 02 949816350
Casella e-mail: sx@siderinox.it Sito web: www.siderinox.it

Capitale Sociale Euro 3.300.000 i.v.
Cod. Fiscale e Reg. Imp. MI N. 01825510157
R.E.A. Milano N. 878116
Centro Meccanografico n. MI074282
Partita IVA 01825510157

AZIENDA CON SISTEMA
DI GESTIONE QUALITÀ
CERTIFICATO DA DNV GL
=ISO 9001=

INSPECTION CERTIFICATE EN 10204 3.1 N° 424885 of 02.02.2015

Purchaser **INOX STAAL A/S**

DDT	SIDERINOX order number	Customer's order
N 8 of 02.02.2015	N 5 of 22.01.2015	N 15836-1 of 22.01.2015

Product description

Stainless steel round pipe Ø 50,8 x 2 mm AISI 304/304L brushed EN 10217-7 Longitudinally welded

Dimension	Steel type	Quantity (m)	Weight (kg)
50,8 x 2 mm	EN 1.4301/1.4307 / AISI 304/304L	366	815

Production Norm	Rolling	Tolerances	Welding factor
EN 10217-7	Hot rolled	D3 \ T3	V=1

Marking MANUFACTURER'S MARK - DIMENSION - STEELGRADE - HEAT N. - PRODUCTION NORM - EXECUTION - E.C. INSPECTOR - WORK INSPEKTOR

Manufacturing process — Surface finishing W0

CHEMICAL COMPOSITION

Heat	% C	%Mn	%P	% S	%Si	%Cr	% Ni	% Mo	% Ti
	0,000 - 0,030	0,000 - 2,000	0,000 - 0,040	0,000 - 0,010	0,000 - 1,000	17,500 - 19,500	8,000 - 10,000	0,000 - 0,000	0,000 - 0,000
0440628	0,022	1,680	0,027	0,001	0,380	18,240	8,090		

The chemical values refer to the certificate issued by the steel mill according to EN 10088 / 10028-7 / ASTM A 240 and stored at our office.

TEST RESULTS

* (D) Direction: (L) Longitudinal, (T) Transverse - ** (P) Position: (W) Welding, (M) Material

Test unit	Test Class	(D) *	(P) **	TENSILE TEST in Nmm2=MPa				HARDNESS
				Yield Strength		Tensile Strength	Elongation	
				Rp 0,2%	Rp 1%	Rm	A %	HRB
				195 -	230 -	500 - 740	40 -	
T14100996	TC1	L	M	246	330	658	48	
T14100998	TC1	L	M	235	314	627	49	

Visual inspection	OK	Drift expanding test		Sealing test	
		UNI EN ISO 8493	OK	UNI EN ISO 10893-1	OK
Check on dimensions	OK	Flattenning test		Non destructive Eddy Current test	
		UNI EN ISO 8492	OK	UNI EN ISO 10893-2	OK
Antimixing test	OK	Weld bend test		Intergranular corrosion test	
		EN 910	OK	N. P.	N. P.

WE CERTIFY THAT THE MATERIAL SUPPLIED COMPLIES WITH THE REQUIREMENTS AGREED ON THIS ORDER

Remarks:

Cerfications:
UNI EN ISO 9001
Dir. PED 97/23/EC Encl. 1, Point 4.3, Comma 3
AQUAP from Nr. 7293-06-TU to Nr 7298-06-TU

Qualifications:
WPS/WPAR: UNI EN ISO 15609-1/UNI EN ISO 15614-11
WLD: UNI EN ISO 14732 operator
NDT: UNI EN ISO 9712 operator

Document issued by the mill's Inspector
D. Ricco

Document confirmed by the authorized company responsible
W. Amodeo

CERTIFIED MATERIAL REPORT

CMR No. : 1502253500015 Date of Issue : 2015-02-25

Customer	HYUNDAI WELDING EUROPE OFFICE		
Trade Name	SMT-316LSi Inox	Size	1.6mm*1000mm*5kg
Lot No.	V9988	Purchaser's Order No.	
Applicable Specification	AWS A5.9 ER316LSi	* According to EN 10204-2004 : 3.1	

Welding Current		Shielding Gas		Post Weld Heat Treatment (℃ × hr.)	

Mechanical Properties	Tensile Test			Impact Test (CVN - Joule)				
	YS(MPa)	TS(MPa)	EL(%)	Temp.(℃)	X1	X2	X3	Avg.
	-	-	-		-	-	-	-
Spec.								

Chemical Composition (%)

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo		
(WIRE)	0.021	0.97	1.71	0.027	0.011	0.20	11.33	18.30	2.57		
Spec.	≤0.03	0.65 ~1.00	1.0 ~2.5	≤0.03	≤0.03	≤0.75	11.0 ~14.0	18.0 ~20.0	2.0 ~3.0		

We hereby certifies that the material covered by this report has been inspected in accordance with and been found to meet the applicable requirements of specification and customer's requirements.

Approved by

K.W. Park

QA Manager Park K. W.

HYUNDAI HYUNDAI WELDING CO., LTD.
Head Office #507,Teheran-ro,Gangnam-gu,Seoul,Republic of Korea
Pohang Plant #100,Daesong-ro,Nam-gu,Pohang,Republic of Korea

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 P/T FW 5.1 FM3 S t2 D21.3 PH sl

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242580 Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør	
Sømtype Type of joint	FW		FW:Kantsøm	
Materialegruppe(r) Material group(s)	5.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM3		FM1, FM2, FM3	
Type og betegnelse Type and designation Tabel/table 4 Tabel/table 5	 S	DS EN ISO 21952-A W CrMo1 Si	S, M	
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)				
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW				
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4	
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6	
Svejseposition Welding position BW tabel/table 9 FW tabel/table 10	 PH		all FW positions, except vertical dowr	
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)	

Svejseproceduresspecifikations-nr.:
Welding procedure specification No.: SP141-075

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):
13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242580

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s2 D21.3 H-L045 ss gb

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242582

Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	T		T:Rør	
Sømtype Type of joint	BW		BW:Stumpsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar	
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	2		2-4	
Materialetykkelse i mm for FW Material thickness in mm for FW				
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6	
Svejseposition Welding position BW tabel/table 9	H-L045		all BW positions, except vertical down	
FW tabel/table 10				
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)	

Svejseprocedurespecifikations-nr.: SP141-199
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):
13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242582

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 P/T FW 8.1 FM5 S t2 D50 PH sl

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec
H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 25350
Welding passport No.:

Svejserens navn: Morten Pedersen
Welder's name:

Fødselsdato: 21-4-1988
Birth date:

Adresse: Bækkevej 6
Address: 9500 Hobro

Prøvningsinstans: Nordisk Svejse Kontrol A/S
Examining body: Stejlundvænget 4 6870 Ølgod

Reference-nr./Reference No. 241393

Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør	
Sømtype Type of joint	FW		FW:Kantsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)				
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW				
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4	
Rørdiameter i mm Pipe diameter in mm	50		>=25	
Svejseposition Welding position BW tabel/table 9			all FW positions, except vertical dowr	
FW tabel/table 10	PH			
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)	

Svejseprocedurespecifikations-nr.:
Welding procedure specification No.: SP141-123

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 17-03-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift): 18-03-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 17-03-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 241393

Prøveemne undersøgt (dato):
Test piece examined (date): 18-03-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 18-03-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 17-03-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 17-03-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 21-03-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
14/9-22	CEO	
16/3-23	CEO	
11/9-23	CEO	

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 238073

Prøveemne undersøgt (dato):
Test piece examined (date): 29-10-2021

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 29-10-2021 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 28-10-2021

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 28-10-2024

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 01-11-2021 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	~~Underskrift~~/Signature
27/4 - 22	CEO	
24/10 - 22	CEO	
28/4 - 23	CEO	
23/10 - 23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s1.5 D76 H-L045 ss gb

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 25350
Welding passport No.:

Svejserens navn: Morten Pedersen
Welder's name:

Fødselsdato: 21-4-1988
Birth date:

Adresse: Bækkevej 6, 9500 Hobro
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 238073

Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	T		P:Plade T:Rør	
Sømtype Type of joint	BW		BW:Stumpsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar	
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	1.5		1.5-3,0	
Materialetykkelse i mm for FW Material thickness in mm for FW				
Rørdiameter i mm Pipe diameter in mm	76		>=38	
Svejseposition Welding position BW tabel/table 9	H-L045		all BW positions, except vertical down	
FW tabel/table 10				
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)	

Svejseprocedurespecifikations-nr.: SP141-189
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED

Svejsning af prøveemne udført/Welding of test piece terminated: 28-10-2021

NSK NB 2735

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):

29-10-2021 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 28-10-2021 Brian Gravgaard

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	7/19/2024	First Issue
002	12/1/2025	Updated, naming of components and cerrificates

Document Title:	**BLPH Project - Material Test Certificates**
Document Number:	K559-2254-CWIWP4202202-L01-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-L01-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	L01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Material Test Certificates
Full Title	Material Test Certificates

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	July 19, 2024
2.0	Update, naming of components	JTA	Dec 01, 2025

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1.0 General

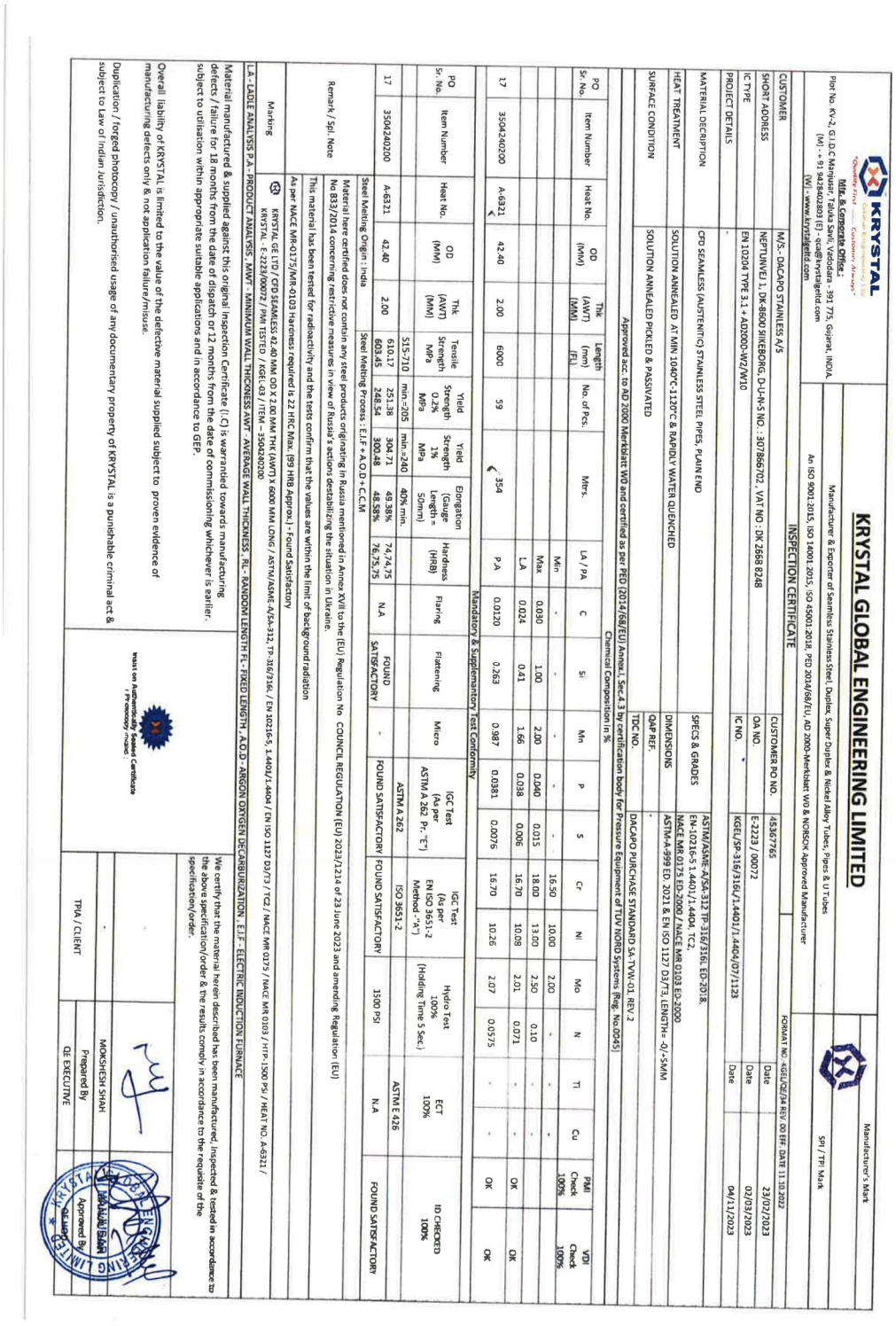
This document contains Material Test Certificates of products supplied to Ballard for the manufacturing of the H2 manifold for 1 MW Fuel Cell Power Container intended for CrossWind.

The Material Test Certificates state the national material specifications that the materials conform to, incl. chemical analysis, specification range analysis mechanical test results, and heat-treated conditions, and are valid for the following products:

- 42.4x2.0 Stainless Steel Cold Finish Seamless Pipes
- 25.0x2.0 Stainless Steel Seamless Pipes
- 42.4 ASME B16.5 Stainless Steel Forged Flanges
- G½ Coupling Stainless
- 42.4x2.0 Stainless Steel End Caps

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1.1 42.4x2.0 Stainless Steel Cold Finish Seamless Pipes



150861

KRYSTAL

Manufacturer & Exporter of Seamless Stainless Steel, Duplex, Super Duplex & Nickel Alloy Tubes, Pipes & U/T-Tubes

An ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, PED 2014/68/EU, AD 2000-Merkblatt W0 & NORSOK Approved Manufacturer

KRYSTAL GLOBAL ENGINEERING LIMITED

Manufacturer's Mark

SPI / TPI Mark

Mfg. & Corporate Office :
Plot No. KV-2, G.I.D.C Manjusar, Taluka Savli, Vadodara - 391 775, Gujarat, INDIA
(M) : - 91 9428402803 (E) - qca@krystalgetd.com
(W) : www.krystalgetd.com

FORMAT NO: KGEL/QE/04 REV. 00 EFF. DATE 11.10.2022

INSPECTION CERTIFICATE

CUSTOMER: M/S.- DACAPO STAINLESS A/S — CUSTOMER PO NO.: 4536765 — Date: 23/02/2023
SHORT ADDRESS: NEPTUNVEJ 1, DK-8600 SILKEBORG, D-U-N-S NO. : 307866702 , VAT NO : DK 2668 8248 — QA NO.: E-2223 / 00072 — Date: 02/03/2023
I.C TYPE: EN 10204 TYPE 3.1 + AD2000-W2/W10 — I.C NO.: KGEL/SP-316/316L/1-4401/1-4404/07/1123 — Date: 04/11/2023
PROJECT DETAILS: -
MATERIAL DESCRIPTION: CFD SEAMLESS (AUSTENITIC) STAINLESS STEEL PIPES, PLAIN END — SPECS & GRADES: ASTM/ASME-A/SA-312 TP-316/316L ED-2018. EN-10216-5 1.4401/1.4404. TC1, NACE MR 0175 ED-2009 / NACE MR 0103 ED-2000
HEAT TREATMENT: SOLUTION ANNEALED AT MIN 1040°C-1120°C & RAPIDLY WATER QUENCHED — DIMENSIONS: ASTM-A-999 ED: 2021 & EN ISO 1127 D3/T3, LENGTH+ -0/+5MM
SURFACE CONDITION: SOLUTION ANNEALED PICKLED & PASSIVATED — Q&P REF.: -
TDC NO.: DACAPO PURCHASE STANDARD SA-TUV-01 REV 2

Approved acc. to AD 2000 Merkblatt W0 and certified as per PED (2014/68/EU) Annex I, Sec.4.3 by certification body for Pressure Equipment of TUV NORD Systems (Reg. No.0045)

Chemical Composition in %

PO Sr. No.	Item Number	Heat No.	OD (MM)	Thk (AWT) (MM)	Length (mm) (FL)	No. of Pcs.	Mtrs.	LA / PA	C	Si	Mn	P	S	Cr	Ni	Mo	N	Ti	Cu	PMI Check 100%	VDI Check 100%
								Min.	-	-	-	-	-	16.50	10.00	2.00	-	-	-		
								Max	0.030	1.00	2.00	0.040	0.015	18.00	13.00	2.50	0.10	-	-		
								LA	0.024	0.41	1.66	0.038	0.006	16.70	10.08	2.01	0.071	-	-	OK	OK
17	3504240200	A-6321	42.40	2.00	6000	59	354	PA	0.0120	0.263	0.987	0.0381	0.0076	16.70	10.26	2.07	0.0575	-	-	OK	OK

Mandatory & Supplementary Test Conformity

PO Sr. No.	Item Number	Heat No.	OD (MM)	Thk (AWT) (MM)	Tensile Strength MPa	Yield Strength 0.2% MPa	Yield Strength 1% MPa	Elongation (Gauge Length – 50mm)	Hardness (HRB)	Flaring	Flattening	Micro	IGC Test (As per ASTM A 262 Pr. "E")	IGC Test (As per EN ISO 3651-2 Method "A")	Hydro Test 100% (Holding Time 5 Sec.)	ECT 100%
					515-710	min-205	min-240	40% min.					ASTM A 262	ISO 3651-2		ASTM E 426
17	3504240200	A-6321	42.40	2.00	610.17 / 603.45	251.38 / 248.54	304.71 / 300.48	49.38% / 48.58%	74,74,75 / 76,75,75	N.A	FOUND SATISFACTORY	-	FOUND SATISFACTORY	FOUND SATISFACTORY	1500 Psi	N.A

Steel Melting Origin : India — Steel Melting Process : E.I.F + A.O.D + C.C.M

Material here certified does not contain any steel products originating in Russia mentioned in Annex XVII to the (EU) Regulation No COUNCIL REGULATION (EU) 2022/1214 of 23 June 2023 and amending Regulation (EU) No 833/2014 concerning restrictive measures in view of Russia's actions destabilizing the situation in Ukraine.

Remark / Spl. Note: This material has been tested for radioactivity and the tests confirm that the values are within the limit of background radiation

As per NACE MR-01/75/MR-0103 Hardness required is 22 HRC Max. (99 HRB Approx.) - Found Satisfactory

Marking: KRYSTAL GE LTD / CFD SEAMLESS 42.40 MM OD X 2.00 MM THK (AWT) X 6000 MM LONG / ASTM/ASME-A/SA-312, TP-316/316L / EN 10216-5, 1.4401/1.4404 / EN ISO 1127 D3/T3 / TC2 / NACE MR 0175 / NACE MR 0103 / HTP-1500 PSI / HEAT NO. A-6321 / KRYSTAL - E-2223/00072 / PMI TESTED / KGEL-03 / ITEM - 3504240200

LA - LADLE ANALYSIS, P.A - PRODUCT ANALYSIS, AWT - MINIMUM WALL THICKNESS, AWT - AVERAGE WALL THICKNESS, RL - RANDOM LENGTH, FL - FIXED LENGTH, A.O.D - ARGON OXYGEN DECARBURIZATION, E.I.F. - ELECTRIC INDUCTION FURNACE

Material manufactured & supplied against this original Inspection Certificate (I.C) is warranted towards manufacturing defects / failure for 18 months from the date of dispatch or 12 months from the date of commissioning whichever is earlier, subject to utilisation within appropriate suitable applications and in accordance to GEP.

Overall liability of KRYSTAL is limited to the value of the defective material supplied subject to proven evidence of manufacturing defects only & not application failure/misuse.

Duplication / forged photocopy / unauthorised usage of any documentary property of KRYSTAL is a punishable criminal act & subject to Law of Indian Jurisdiction.

We certify that the material herein described has been manufactured, inspected & tested in accordance to the above specification/order & the results comply in accordance to the requisite of the specification/order.

TPIA / CLIENT — Prepared By QE EXECUTIVE: MOKSHESH SHAH — Approved By QUALITY CONTROL: MR. ANJU BAAR

KRYSTAL ENGINEERING LIMITED

Inspection Certificate

TA CHEN STAINLESS PIPE CO., LTD.
NO. 125 HSIN-TIEN 2ND ST.,
JENG-TEH, TAINAN, TAIWAN
TEL:(06)2793254 FAX:(06)2701382
COUNTRY ORIGIN:TAIWAN

EN 10204-3.1

Commodity : STAINLESS STEEL WELDED PIPE
Customer : DACAPO STAINLESS B.V.
Specification : ASTM A312/A312M-2022a /ASTM A999-2018
ASME SA312-2021/ASME BPVC.II.A-2021
Destination : ROTTERDAM
Grade : TP316
Customer O/N :31134407 **Certificate No** : XF0200034
Delivery Condition: ANNEALED AND PICKLED
Factory O/N : _____ **Date** : 2023/6/19 **INVOICE No** : HO27XF0200

Item No.	Case No. (Crate No.)	Heat No.	Size		Quantity	Weight	Chemical Composition in %								
					(Pcs)	(Kgs)	C	Si	Mn	P	S	Ni	Cr	Mo	N
01	006	1014299	2-1/2"	SCH40S			0.080	1.000	2.000	0.045	0.030	14.00	18.00	3.000	-
							0.020	0.480	0.917	0.031	0.0012	10.23	16.800	2.063	0.030
02	004	1017422	1"	SCH40S			0.022	0.440	0.940	0.036	0.0057	10.17	16.770	2.100	0.029
03	006	1025545	2"	SCH40S			0.020	0.460	0.990	0.025	0.0009	10.11	16.750	2.040	0.019
04	004	1027133	3/4"	SCH40S			0.009	0.360	0.940	0.032	0.0033	10.06	16.710	2.060	0.021
05	004	1027133	3/4"	SCH40S			0.009	0.360	0.940	0.032	0.0033	10.06	16.710	2.060	0.021
Total															

Item No.	Tensile Test (Gage Lth=50mm)				Hardness	Bend	Flattening	HT TEMP °F	Dimension And	Hydrostatic
	0.2% Yield Strength PSI	1.0% Yield Strength PSI	Tensile Strength PSI	Elongation %	Test HRB	Test	Test	Quenching In Water	Surface Condition	Test PSI
	30000		75000	T25/L35				1900		2500
	-	-	-					-		-
01	43100	-	89000	50	84.00	OK	OK	1904	OK	2100
02	40200	-	88000	51.5	80.00	OK	OK	1904	OK	2500
03	38400	-	84100	55	79.00	OK	OK	1904	OK	1900
04	42800	-	87600	50	80.00	OK	OK	1904	OK	2500
05	42800	-	87600	50	80.00	OK	OK	1904	OK	2500

Remarks
1. EDDY CURRENT TEST : O.K.
2. HARDNESS : MADE WITH ASTM A262
3. P.M.I. TESTED : O.K.
4. LOT MATERIAL ACC. ASTM A262
5. RAW MATERIAL FOR PIPE FITTINGS
6. PED 2014/68/EU

TA CHEN STAINLESS PIPE CO.,LTD. Q/C Dept. NO.125 HSIN-TIEN 2ND STREET, TAINAN, TAIWAN, R.O.C.

We hereby certify the above statement to be true and correct every detail
TA CHEN has established a QMS according to ISO 9001, which is certified by LRQA (ISO 9001-0067066)

George Yang
Manager of Inspection Section/George Yang

Inspection Certificate

TA CHEN STAINLESS PIPE CO., LTD.
NO. 125 HSIN-TIEN 2ND ST.,
JENG-TEH, TAINAN, TAIWAN
TEL:(06)2793254 FAX:(06)2701382
COUNTRY ORIGIN:TAIWAN

EN 10204-3.1

Commodity : STAINLESS STEEL WELDED PIPE
Customer : DACAPO STAINLESS B.V.
Specification : ASTM A312/A312M-2022a /ASTM A999-2018
ASME SA312-2021/ASME BPVC.II.A-2021
Destination : ROTTERDAM
Grade : TP316
Customer O/N :31134407
Certificate No : XF0200035
Delivery Condition: ANNEALED AND PICKLED
Factory O/N :
Date : 2023/6/19
INVOICE No : HO27XF0200

Item No.	Case No. (Crate No.)	Heat No.	Size	Quantity (Pcs)	Weight (Kgs)	Chemical Composition in % C	Si	Mn	P	S	Ni	Cr	Mo	N
06	004	1027136	1" SCH40S		0.080	-	-	-	-	-	10.00	16.00	2.000	-
					0.009	0.420	1.000	2.000	0.045	0.030	14.00	18.00	3.000	-
07	001	1028471	1-1/4" SCH40S		0.016	0.440	0.890	1.110	0.032	0.0033	10.07	16.650	2.070	0.018
08	001	28037601	1/2" SCH40S		0.014	0.350	1.320	0.029	0.029	0.0018	10.08	16.880	2.050	0.021
											10.05	16.110	2.050	-
Total														

Item No.	Tensile Test (Gage Lth=50mm) 0.2% Yield Strength PSI	1.0% Yield Strength PSI	Tensile Strength PSI	Elongation %	Hardness Test HRB	Bend Test	Flattening Test	HT TEMP °F And Quenching In Water	Dimension And Surface Condition	Hydrostatic Test PSI
	30000		75000	T25/L35				1900		2500
	-		-					-		-
06	40300	-	82700	57	82.00	OK	OK	1904	OK	2500
07	41500	-	87100	48.5	78.00	OK	OK	1904	OK	2500
08	34084	-	78610	70	72.00	OK	OK	1904	OK	2500

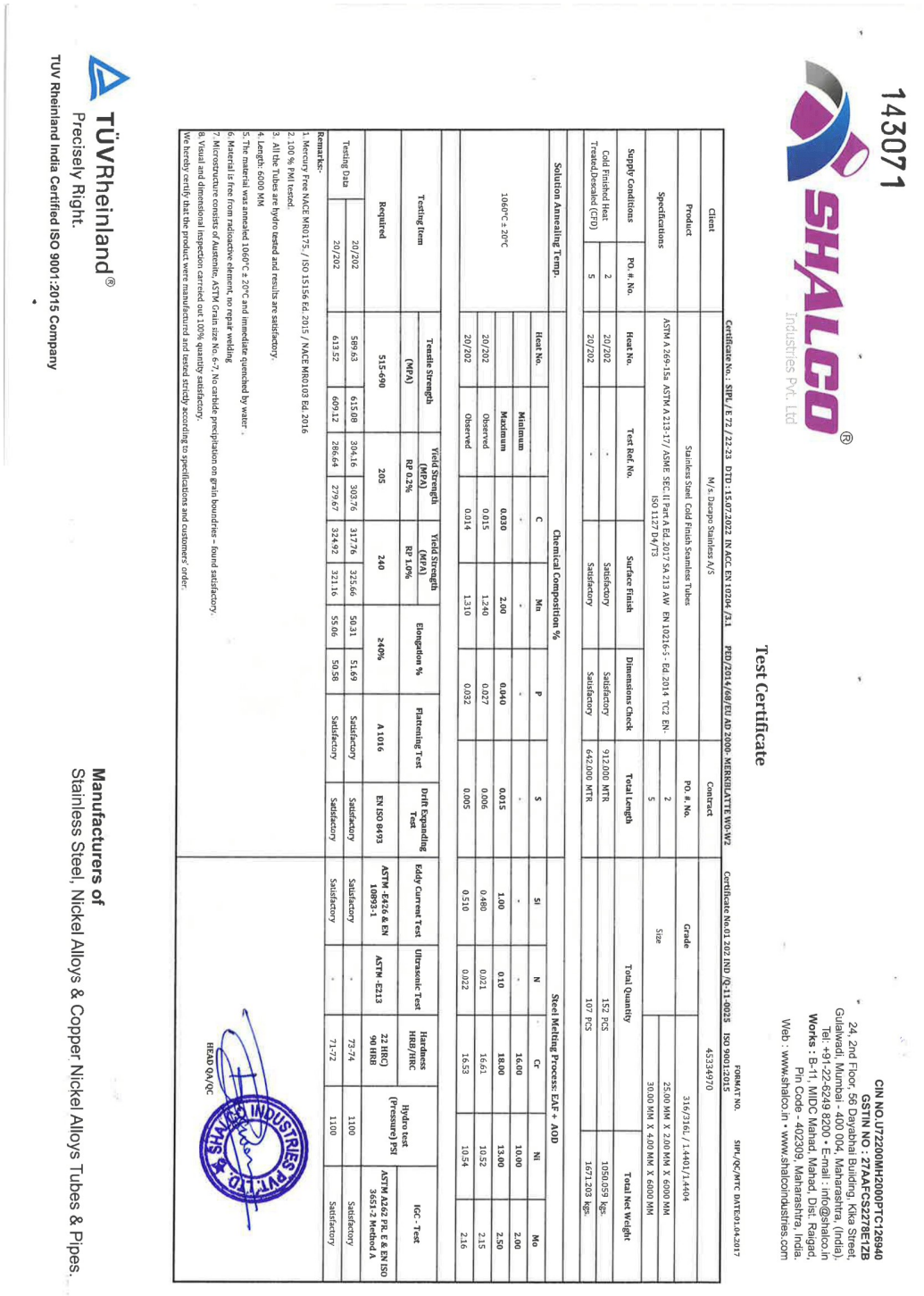
Remarks
1. EDDY CURRENT TEST : O.K.
2. HARDNESS : HRA≤ MRO175-15
3. P. M. I. TESTED : O.K.
4. FLARE TEST ACC. TO ASTM A262
5. RAW MATERIAL FOR PIPE FITTINGS
6. PED 2014/68/EU

TA CHEN STAINLESS PIPE CO. LTD. Q/C Dept. 125 HSIN-TIEN 2ND STREET, TAINAN, TAIWAN, R.O.C.

We hereby certify the above statement to be true and correct every detail
TA CHEN has established a QMS according to ISO 9001, which is certified by LRQA (ISO 9001-0067066)

George Yang
Manager of Inspection Section/George Yang

1.2 25.0x2.0 Stainless Steel Seamless Pipes



143071

SHALCO® Industries Pvt. Ltd

CIN NO.U72200MH2000PTC126940
GSTIN NO : 27AAFCS2278E1ZB
24, 2nd Floor, 56 Dayabhai Building, Kika Street, Gulalwadi, Mumbai - 400 004, Maharashtra, (India).
Tel: +91-22-6249 8200 • E-mail : info@shalco.in
Works : B-11, MIDC Mahad, Mahad, Dist. Raigad, Pin Code - 402309, Maharashtra, India.
Web : www.shalco.in • www.shalcoindustries.com

FORMAT NO. SHPL/QC/MTC DATE:01.04.2017

Test Certificate

Certificate No.: SHPL/E 72 /22-23 DTD :15.07.2022 IN ACC.EN 10204 /3.1 PED/2014/68/EU AD 2000- MERKBLATTE W0-W2 Certificate No.01 202 IND /Q-11-0025 ISO 9001:2015 45334970

Client	M/s. Daraqo Stainless A/S	Contract			
Product	Stainless Steel Cold Finish Seamless Tubes	PO. #. No.	Grade	316/316L / 1.4401/1.4404	
Specifications	ASTM A 269-15a ASTM A 213-17/ ASME SEC. II Part A Ed. 2017 SA 213 AW EN 10216-5 : Ed. 2014 TC2 EN-ISO 1127 D4/T3	2 5	Size	25.00 MM X 2.00 MM X 6000 MM 30.00 MM X 4.00 MM X 6000 MM	

Supply Conditions	PO. #. No.	Heat No.	Test Rel. No.	Surface Finish	Dimensions Check	Total Length	Total Quantity	Total Net Weight
Cold Finished Heat Treated,Descaled (CFD)	2	20/202	-	Satisfactory	Satisfactory	912.000 MTR	152 PCS	1050.059 kgs.
	5	20/202	-	Satisfactory	Satisfactory	642.000 MTR	107 PCS	1671.203 kgs.

Solution Annealing Temp.: 1060°C ± 20°C

Chemical Composition %

Steel Melting Process: EAF + AOD

Heat No.		C	Mn	P	S	Si	N	Cr	Ni	Mo
20/202	Minimum	-	-	-	-	-	-	16.00	10.00	2.00
	Maximum	0.030	2.00	0.040	0.015	1.00	0.10	18.00	13.00	2.50
	Observed	0.015	1.240	0.027	0.006	0.480	0.021	16.61	10.52	2.15
20/202	Observed	0.014	1.310	0.032	0.005	0.510	0.022	16.53	10.54	2.16

Testing Item		Tensile Strength (MPA)	Yield Strength (MPA) RP 0.2%	Yield Strength (MPA) RP 1.0%	Elongation %	Flattening Test	Drift Expanding Test	Eddy Current Test	Ultrasonic Test	Hardness HRB/HRC	Hydro test (Pressure) PSI	IGC - Test
Required		515-690	205	240	≥40%	A 1016	EN ISO 8493	ASTM -E426 & EN 10893-1	ASTM -E213	22 HRC/ 90 HRB		ASTM A262 PR. E & EN ISO 3651-2 Method A
Testing Data	20/202	589.63	615.08	304.16	303.76	317.76	325.66	50.31	51.69	Satisfactory	Satisfactory	-	73.74	1100	Satisfactory
	20/202	613.52	609.12	286.64	279.67	324.92	321.16	55.06	50.58	Satisfactory	Satisfactory	Satisfactory	-	71.72	1100	Satisfactory

Remarks:-
1. Mercury Free NACE MR0175 / ISO 15156 Ed. 2015 / NACE MR0103 Ed. 2016
2. 100 % PMI tested.
3. All the Tubes are hydro tested and results are satisfactory.
4. Length: 6000 MM
5. The material was annealed 1060°C ± 20°C and immediate quenched by water .
6. Material is free from radioactive element, no repair welding
7. Microstructure consists of Austenite, ASTM Grain size No. 6-7, No carbide precipitation on grain boundries - found satisfactory.
8. Visual and dimensional inspection carreied out 100% quantity satisfactory.

We hereby certify that the product were manufactured and tested strictly according to specifications and customers' order.

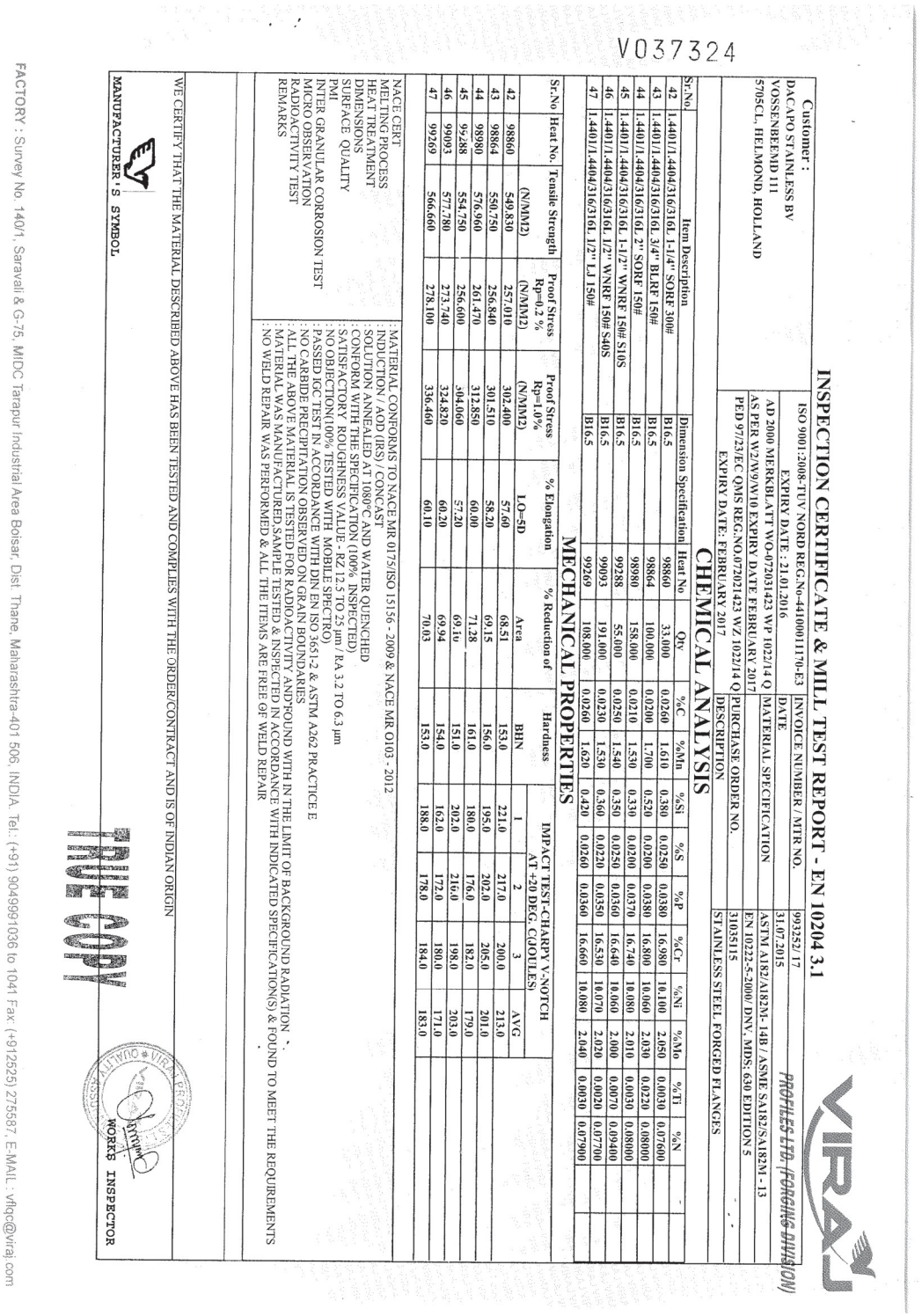
HEAD QA/QC

SHALCO INDUSTRIES PVT. LTD.

TÜVRheinland®
Precisely Right.
TUV Rheinland India Certified ISO 9001:2015 Company

Manufacturers of
Stainless Steel, Nickel Alloys & Copper Nickel Alloys Tubes & Pipes.

1.3 42.4 ASME B16.5 Stainless Steel Forged Flanges



VIRAJ

PROFILES LTD. (FORGING DIVISION)

INSPECTION CERTIFICATE & MILL TEST REPORT - EN 10204 3.1

Customer :
DACAPO STAINLESS BV
VOSSENBEEMD 111
5705CL, HELMOND, HOLLAND

ISO 9001:2008-TUV NORD REG.No-44100011170-E3
EXPIRY DATE : 21.01.2016
AD 2000 MERKBLATT WO-0720314423 WP 1022/14 Q
AS PER W2/W9/W10 EXPIRY DATE FEBRUARY 2017
FED 97/23/EC QMS REG.NO.07202142 WZ 1022/14 Q
EXPIRY DATE: FEBRUARY 2017

INVOICE NUMBER / MTR NO. 993252/ 17
DATE 31.07.2015
MATERIAL SPECIFICATION ASTM A182/A182M- 14B / ASME SA182/SA182M - 13
EN 10222-5-2000/ DNV, MDS: 630 EDITION 5
PURCHASE ORDER NO. 31035115
DESCRIPTION STAINLESS STEEL FORGED FLANGES

V037324

CHEMICAL ANALYSIS

Sr.No	Item Description	Dimension Specification	Heat No.	Qty	%C	%Mn	%Si	%S	%P	%Cr	%Ni	%Mo	%Ti	%N
42	1.4401/1.4404/316/316L 1-1/4" SORF 300#	B16.5	98860	33.000	0.0260	1.610	0.380	0.0250	0.0380	16.980	10.100	2.050	0.0030	0.07600
43	1.4401/1.4404/316/316L 3/4" BLRF 150#	B16.5	98864	100.000	0.0200	1.700	0.520	0.0200	0.0380	16.800	10.060	2.030	0.0220	0.08000
44	1.4401/1.4404/316/316L 2" SORF 150#	B16.5	98980	158.000	0.0210	1.530	0.330	0.0200	0.0370	16.740	10.080	2.010	0.0030	0.08000
45	1.4401/1.4404/316/316L 1-1/2" WNRF 150# S10S	B16.5	99288	55.000	0.0250	1.540	0.350	0.0250	0.0360	16.640	10.060	2.000	0.0070	0.09400
46	1.4401/1.4404/316/316L 1/2" WNRF 150# S40S	B16.5	99093	191.000	0.0230	1.530	0.360	0.0220	0.0350	16.530	10.070	2.020	0.0020	0.07700
47	1.4401/1.4404/316/316L 1/2" LJ 150#	B16.5	99269	108.000	0.0260	1.620	0.420	0.0260	0.0360	16.660	10.080	2.040	0.0030	0.07900

MECHANICAL PROPERTIES

Sr.No	Heat No.	Tensile Strength	Proof Stress Rp=0.2 %	Proof Stress Rp=1.0%	% Elongation	% Reduction of	Hardness	IMPACT TEST-CHARPY V-NOTCH AT +20 DEG. C(JOULES)			
		(N/MM2)	(N/MM2)	(N/MM2)	LO=5D	Area	BHN	1	2	3	AVG
42	98860	549.830	257.010	302.400	57.60	68.51	153.0	221.0	217.0	200.0	213.0
43	98864	550.750	256.840	301.510	58.20	69.15	156.0	195.0	202.0	205.0	201.0
44	98980	576.960	261.470	312.850	60.00	71.28	161.0	180.0	176.0	182.0	179.0
45	99288	554.750	256.600	304.060	57.20	69.16	151.0	202.0	216.0	198.0	203.0
46	99093	577.780	273.740	324.820	60.20	69.94	154.0	162.0	172.0	180.0	171.0
47	99269	566.660	278.100	336.460	60.10	70.03	153.0	188.0	178.0	184.0	183.0

NACE CERT : MATERIAL CONFORMS TO NACE MR 0175/ISO 15156 - 2009 & NACE MR 0103 - 2012
MELTING PROCESS : INDUCTION / AOD (IRS) / CONCAST
HEAT TREATMENT : SOLUTION ANNEALED AT 1080°C AND WATER QUENCHED
DIMENSIONS : CONFORM WITH THE SPECIFICATION (100% INSPECTED)
SURFACE QUALITY : SATISFACTORY ROUGHNESS VALUE - RZ 12.5 TO 25 µm / RA 3.2 TO 6.3 µm
PMI : NO OBJECTION(100% TESTED WITH MOBILE SPECTRO)
INTER GRANULAR CORROSION TEST : PASSED IGC TEST IN ACCORDANCE WITH DIN EN ISO 3651-2 & ASTM A262 PRACTICE E
MICRO OBSERVATION : NO CARBIDE PRECIPITATION OBSERVED ON GRAIN BOUNDARIES
RADIOACTIVITY TEST : ALL THE ABOVE MATERIAL IS TESTED FOR RADIOACTIVITY AND FOUND WITH IN THE LIMIT OF BACKGROUND RADIATION
REMARKS : MATERIAL WAS MANUFACTURED,SAMPLE TESTED & INSPECTED IN ACCORDANCE WITH INDICATED SPECIFICATION(S) & FOUND TO MEET THE REQUIREMENTS
: NO WELD REPAIR WAS PERFORMED & ALL THE ITEMS ARE FREE OF WELD REPAIR

WE CERTIFY THAT THE MATERIAL DESCRIBED ABOVE HAS BEEN TESTED AND COMPLIES WITH THE ORDER/CONTRACT AND IS OF INDIAN ORIGIN

MANUFACTURER'S SYMBOL

TRUE COPY

WORKS INSPECTOR

FACTORY : Survey No. 140/1, Saravali & G-75, MIDC Tarapur Industrial Area Boisar, Dist. Thane, Maharashtra-401 506. INDIA. Tel.: (+91) 9049991036 to 1041 Fax :(+912525) 275587, E-MAIL : vftqc@viraj.com

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ANY COPIES MADE ARE CONSIDERED UNCONTROLLED UNLESS STAMPED OTHERWISE IN RED.

1.4 G½ Coupling Stainless Steel

V153121

TA CHEN STAINLESS PIPE CO., LTD.

INSPECTION CERTIFICATE

ISO 9001-2015

Certificate No. 0067066

Commodity : STAINLESS STEEL PIPE NIPPLE

Customer : DACAPO STAINLESS B.V.

EN 10204/3.1

NO.125 HSIN-TIEN 2ND STREET,
HSIN-TIEN JENG-TEH ,TAINAN
TAIWAN, R.O.C.
TEL:+886 6 2701756
FAX:+886 6 2701382 , 2798057

Specification: ASTM A312/A312M 2022a
Grade ____: TP316L

Destination : ROTTERDAM
Customer's O/N : 31134407
Factory O/N : HO27X3741
Invoice No : HO27XF0200

Certificate No : MTR112060059002
Date : 2023/06/19

No.	Size	Article	End Type	Part No.	Qty (pcs)	Heat No.	CHEMICAL ANALYSIS(%) C	Si	Mn	P	S	Ni	Cr	Mo	TENSION TEST Yield Strength MPA	Tensile Strength MPA	Elongation %
							max 0.035	max 1.000	max 2.000	max 0.045	max 0.030	10.00 14.00	16.00 18.00	2.00 3.00	min 170	min 485	min 35
10	1/4"	FULL COUPLING	ISO228-1G	TB03211855	2000	28037601	0.014	0.350	1.320	0.029	0.002	10.05	16.11	2.05	235	542	70
11	1/2"	FULL COUPLING	ISO228-1G	TB03212580	2000	1027133	0.009	0.360	0.940	0.032	0.003	10.06	16.71	2.06	278	594	54
12	1"	FULL COUPLING	ISO228-1G	TB03213590	2100	1028471	0.016	0.440	1.110	0.029	0.004	10.08	16.88	2.05	284	601	50
13	1-1/2"	FULL COUPLING	ISO228-1G	TB03214505	276	1025545	0.020	0.460	0.990	0.025	0.001	10.11	16.75	2.04	265	580	55
14	2"	FULL COUPLING	ISO228-1G	TB03215135	112	1014299	0.020	0.480	0.917	0.031	0.001	10.23	16.80	2.06	286	611	50
15	1/2"	HALF COUPLING	ISO228-1G	TB04212580	2400	1027133	0.009	0.360	0.940	0.032	0.003	10.06	16.71	2.06	278	594	54
16	3/4"	HALF COUPLING	ISO228-1G	TB04213045	64	1017422	0.022	0.440	0.940	0.036	0.006	10.17	16.77	2.10	259	596	54
17	3/4"	HALF COUPLING	ISO228-1G	TB04213045	486	1027136	0.009	0.420	0.890	0.032	0.003	10.07	16.65	2.07	271	598	50.5

REMARK:FULL COUPLINGS(SOCKETS) AND HALF COUPLINGS ARE MADE FROM PIPE.
REMARK:ASTM A262 PRACTICE E:O.K.

TA CHEN STAINLESS PIPE CO., LTD. Q/C Dept. NO.125, HSIN-TIEN 2ND STREET, HSIN-TIEN JENG-TEH, TAINAN, TAIWAN, R.O.C.

Supervisor:

page:2 / 2

1.5 42.4x2.0 Stainless Steel End Caps

V159283

BERCELLESI BERINOX STAINLESS STEEL FITTINGS

Quality Management System certified by LRQA

The QMS supports the requirements of Annex I Sec. 4.3 of PED 2014/68/EU

CERTIFICATO DI COLLAUDO EN 10204 3.1
Inspection certificate
Certificat d'inspection

Num: 22514 / 23 **Data:** 12/12/2023

Cliente Customer Client: DACAPO STAINLESS BV
VOSSENBEEMD 111

5705CL HELMOND -

Specifica prodotto/Product specification/Spécification du produit: EN 10253/4 type A

Pos Item Poste	Qta Qty Qté	Articolo Item Article	Descrizione e dimensione Description and size Désignation et dimension	Grado acciaio Grade Nuance	Colata Heat Coulée
10	250,00		END CAPS 316L 42.4x2	1.4404/316L	0468184
20	100,00		END CAPS 304L 60.3x3	1.4301/304/1.4307/304L	Y210918D41-6
30	100,00		END CAPS 304L 76.1x3	1.4301/304/1.4307/304L	53586
40	50,00		END CAPS 304L 101.6x3	1.4301/304/1.4307/304L	150057
50	30,00		END CAPS 316L 101.6x3	1.4404/316L	22000841
60	500,00		END CAPS 316L 60.3x2	1.4404/316L	0547275

Pos Item Poste	Costruttore materia prima Manufacturer raw material Fabricant matériel de base	Certificato Certificate Certificat	Specifica materia prima Requirement material Spécification matériel de base
10	MARCEGAGLI SPECIALTIES	723284184	EN10028-7 EN10088-2 EN10088-4 ASTM A240 A480
20	PT. INDONESIA GUANG CHING	2021110604	EN10088-2 EN10028-7 EN10088-4 ASTM A240 A480
30	MARCEGAGLI SPECIALTIES	723394949	EN10028-7 EN10088-2 EN10088-4 ASTM A240 A480
40	APERAM GENK BELGIUM	22K0005913	EN10088-2 EN10028-7 ASTM A240 SA240 ADW2 W10
50	LIEN KUO METAL IND. CO.	1091029013	EN10088-2 EN10028-7 ASTM A240 A480
60	MARCEGAGLI SPECIALTIES	723387929	EN10028-7 10088-2 10088-4 ASTM A240 A480 ADW0 W2

Analisi chimica/Chemical composition/Analyse chimique — **Caratteristiche meccaniche/Mechanical properties/Caractéristiques mécaniques**

Colata Heat Coulée	C %	Mn %	Si %	P %	S %	Cr %	Ni %	Mo %	Ti %	Cu%	N%	Snerv. Rp 0,2/1,0 Yield Strength Limite élastique	Rottura Rm Tensile strength Rupture	Allung. A50mm Elongation Allongement	Durezza Hardness Dureté
0468184	0,016	1,100	0,350	0,032	0,00100	16,820	10,080	2,030			0,048	286 / 323 N/mm²	605 N/mm²	53,10	81 HRB
Y210918D41-6	0,022	1,410	0,380	0,029	0,00200	18,130	8,010				0,068	284 /	648 MPa	59,10	86 HRB
53586	0,024	1,300	0,390	0,031	0,00200	18,200	8,000				0,068	320 / 373 N/mm²	640 N/mm²	46,30	84 HRB
150057	0,024	1,510	0,470	0,034	0,00400	18,080	8,010				0,073	298 / 339 MPa	634 MPa	52,00	86 HRB
22000841	0,024	1,210	0,240	0,040	0,00500	16,230	10,050	2,030			0,042	323 /	591 N/mm²	52,00	79 HRB
0547275	0,024	1,090	0,380	0,029	0,00100	16,690	10,030	2,060			0,049	265 / 304 N/mm²	585 N/mm²	56,70	79 HRB

L'analisi chimica e le caratteristiche meccaniche sono conformi al certificato originale rilasciato dal fabbricante di materia prima.
The chemical analysis and mechanical properties fully comply with the certificate issued by the manufacturer of the base material.
L'analyse chimique et les caractéristiques mécaniques sont conformes au certificat émis par le producteur de la matière première.

Doc. di trasporto n. Delivery note n. Bon de livraison n. 62 / d40 **Data** Date Date 07/12/2023 **Ordine n.** Order n. Commande n. 380000477

Si attesta che i prodotti spediti sono conformi ai requisiti dell'ordine.
We certify that delivered products comply with the customer's requirement.
Nous certifions que les produits livrés sont conformes aux spécifications de la commande.

Note / Remarks / Remarques

Test superati con esito positivo:
Test passed successfully / Test passé avec succès

Dimensional	X
Visual	X
Antimixing Test	X
Intergranular Corrosion Test EN ISO 3651-2	X

Test aggiuntivi richiesti nell'ordine:
Additional tests required in order
Tests supplémentaires requis dans la commande

I certificati sono conservati nel nostro archivio.
The certificates are kept in our archives.
Les certificats sont conservés dans nos archives.

Il materiale è conforme alle specifiche di prodotto dichiarate.
The material correspond to the product's specification declared.
Le matériel est conforme aux spécifications du produit declaré.

Per dimensioni diverse alle specifiche è garantita la conformità al ns catalogo.
Size different from the specifications are guaranteed to be in compliance with our catalogue.
Les dimensions différentes de la spécification sont conformes à notre catalogue.

MARCHIO DI FABBRICA:
Trade mark
Marque du producteur

APPROVATO
Approved
Approuvé
P. BERCELLESI

PB

Questo certificato costruito da un processo di trattamento dei dati informatici è applicabile senza firme in originale. La sua emissione attesta che il processo di costruzione e controllo degli articoli in oggetto è stato eseguito conformemente alle prescrizioni del sistema./ This certificate was built from a data processing system and can be applied without an original signature. Its release certifies that the process of construction and inspection of the items mentioned was executed in accordance with the requirements of the system./ Ce certificat a été conçu à partir d'un procédé de traitement des données et peu être diffusé sans signature originale. Son émission certifie que le procédé de construction et d'inspection des articles en question e été mené en conformément aux exigences du système.

BERCELLESI BERINOX SRL - Via per Carpiano, 24 - 20077 Melegnano (Mi) - Tel.(02) 98.23.10.72 ra Fax (02) 98.39.103

Sub Section K02-001

Equipment Hazardous Area Certificates & Schedule

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	23/05/2023	First Issue
002	18/09/2023	Updated according to comments
003	30/08/2024	Updated according to comments
004	15/11/2024	Updated following ATEX Register (K02-002)
005	19/03/2025	Updatad in accordance with Code 2 corrections

Document Title:	**BLPH Project - Equipment Hazardous Area Certificates & Schedule**
Document Number:	BPSE-INN-BPH-CER-00006
Legacy Number:	K559-2254-CWIWP4202202-K02-001
Revision:	Rev005
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K02-001Rev005
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	K02-001 - Equipment Hazardous Area Certificates and Schedule
Full Title	Certificates and documentation of equipment for hazardous area of 1MW hydrogen fuel cell container for Crosswind
Abstract	

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Revision Record

Rev #	Description	Revised By	Date [dd/mm/yyyy]
1.0	Initial Release	RBS	23/05/2023
2.0	Updated to address review comments	EZE	18/09/2023
3.0	Expanded to include components from H2 Pre-heating System	EZE	30/08/2024
4.0	Updated following ATEX Register (K02-002)	RBS	15/11/2024
5.0	Updated following ATEX Register	KHE	18/03/2025

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1.0 Purpose

The purpose of this document is to provide the ATEX certificates of the equipment for hazardous area of the 1MW fuel cell container (MEGABLOCK) provided by Ballard Power Systems Europe to CrossWind.

2.0 References

Table 1 – List of references.

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-K02-002	ATEX Register	Ballard

3.0 List of ATEX Equipment

The ATEX Register lists the following ATEX equipment as shown in the table below. For more details, please refer to the ATEX Register.

Table 2 – List of ATEX equipment (extract from document K559-2254-CWIWP4202202-K02-002).

Location	Manufacturer	Model Type Catalogue Number	Serial Number	ATEX Certification Marking	Reference Document	ATEX Certificate Number	Installation Zone	Notes / Comments	P.O	Vendor	Skid /Package	Barrier Calculation ref.	Non-electrical Equipment	Special Conditions for Safe Use	
=HA01+DA02 - H2 Supply System	IFM Electronic AS	LM701A LMACE-E12E-Q9KG-1/US/3D/3G	10000160523	II 3G Ex nA IIC T4 Gc	K559-2254-CWIWP4202202-C03-001	8003330	Zone 2		8517643	IFM Electronic AS	A-80000	No	No	No	
=HA01+DA02 - H2 Supply System	IFM Electronic AS	EVC14A ADOGH040VAT0025H04/3G/2D	N/A	II 3G Ex ec IIC Gc	K559-2254-CWIWP4202202-E03-003	BVS 08ATEX E 109U	Zone 2		8520141	IFM Electronic AS	A-80000	No	No		
=HA01+DA02 - H2 Supply System	HUBA Controls AG	Pressure Transducer 520 Series	N/A	Ex II 1/2G Ex ia IIC T4 Ga/Gb	K559-2254-CWIWP4202202-C03-001	SEV 10 ATEX 0145	Zone 2		8516809	HUBA Controls AG	A-80000	K559-2254-CWIWP420220	No	No	
=LA01+UC42 - EX Barrier Box	IFM Electronic AS	EN C03A ADOGH040MSN0010H04/1G/1D	N/A	II 2(1) Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=LA01+UC42 - EX Barrier Box	PR Electronics AS	9106-B1B	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA	K559-2254-CWIWP4202202-E03-008	DEKRA 11ATEX0244 X	No Zone		146113-1	PR Electronics AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=HA01+DA02 - H2 Supply System	IFM Electronic AS	TT1050 TT-100KBBD10……/US/	100000113592	N/A	K559-2254-CWIWP4202202-C03-001	N/A	Zone 2	Simple apparatus acc	8516509	IFM Electronic AS	A-80000	K559-2254-CWIWP420220	No	No	
=LA01+UC42 - EX Barrier Box	IFM Electronic AS	EN C03A ADOGH040MSN0010H04/1G/1D	N/A	Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U9	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA	K559-2254-CWIWP4202202-E03-008	IECEx 07ATEX0148 X	No Zone		8520371	PR Electronics AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-1	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements AS	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Lapp Group	OLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No	
=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-2	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements AS	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Lapp Group	OLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No	
=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - Non EX Box	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Non EX Box	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80001	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	IECEx CML 19.0045X	Zone 2		CD3034021	Semcomaritime	A-80002	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80003	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034021	Semcomaritime	A-80004	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80005	No	No	Yes	

4.0 ATEX Certificates

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4.1 BL01 – Electronic Level Sensor, LMT01A

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ifm electronic

EU – Konformitätserklärung

EU declaration of conformity

Déclaration de conformité UE

ifm electronic gmbh
Friedrichstraße 1
45128 Essen
Germany

Telefon: +49 (0)201 / 24 22 - 0
Telefax: +49 (0)201 / 24 22 - 1200
Internet: www.ifm.com

Die EU-Konformitätserklärung gilt für folgende Geräte:	The EU declaration of conformity applies to the following units:	La déclaration de conformité UE s'applique aux appareils suivants:

Elektronische Füllstandssensoren der Produktfamilie
Electronic level sensors of the product family
Capteurs des niveau électroniques de la famille de produits

LMTxxA

Die alleinige Verantwortung für die Ausstellung dieser Konformitäts-erklärung trägt der Hersteller.	This declaration of conformity is issued under the sole responsibility of the manufacturer.	La présente déclaration de conformité est établie sous la seule responsabilité du fabricant.
Wir bestätigen die Übereinstimmung mit den wesentlichen Anforderungen der europäischen Richtlinie(n):	We confirm the conformity to the essential requirements of the European directive(s):	Nous confirmons la conformité aux exigences essentielles de la (des) directive(s) européenne(s):
2011/65/EU **2014/30/EU** **2014/34/EU**	**2011/65/EU** **2014/30/EU** **2014/34/EU**	**2011/65/UE** **2014/30/UE** **2014/34/UE**
Folgende Norm(en) wurde(n) angewandt:	The following standard(s) was (were) applied:	La (Les) norme(s) suivante(s) a (ont) été appliquée(s):

EN IEC 63000: 2018
EN 61000-6-3: 2007 +A: 2011 + AC: 2012
EN 61000-6-4: 2007 +A1: 2011
EN IEC 61000-6-2: 2019
EN 60079-15: 2010
EN 60079-31: 2014
EN IEC 60079-0: 2018

Kennzeichnung	Marking	Marquage
	Ex II 3D Ex tc IIIC T90°C Dc **Ex II 3G Ex nA IIC T4 Gc**	

Artikel - Nr.: 80304277

Tettnang, 20.07.2021
(Ort und Datum der Ausstellung)
(Place and date of issue)
(Lieu et date de l'établissement)

(Unterschrift) i.V. Alfred Wagner /
(Signature) Head of development
(Signature)

Dokument-Nr.: 8003330

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ifm electronic

Declaración UE de conformidad

Dichiarazione di conformità UE

EU – försäkran om överensstämmelse

ifm electronic gmbh
Friedrichstraße 1
45128 Essen
Germany

Telefon: +49 (0)201 / 24 22 - 0
Telefax: +49 (0)201 / 24 22 - 1200
Internet: www.ifm.com

La declaración UE de conformidad se aplica a los siguientes productos:	La dichiarazione di conformità UE si applica ai seguenti dispositivi:	EU-försäkran om överensstämmelse gäller för följande enheter:

Sensores electrónicos de nivel de la gama de productos
Sensori elettronici di livello della serie
Elektroniska nivågivare i produktfamiljen

LMTxxA

La presente declaración de conformidad se expide bajo la exclusiva responsabilidad del fabricante.	La presente dichiarazione di conformità è rilasciata sotto la responsabilità esclusiva del fabbricante.	Tillverkaren har ensam ansvar för utfärdandet av denna försäkran om överensstämmelse.
Certificamos la conformidad con los requisitos esenciales de la(s) directiva(s) europea(s):	Confermiamo la conformità con i requisiti essenziali della(e) direttiva(e) europea(e):	Vi intygar att alla väsentliga krav i den (de) europeiska direktivet (direktiven) är uppfyllda:
2011/65/UE **2014/30/UE** **2014/34/UE**	**2011/65/UE** **2014/30/UE** **2014/34/UE**	**2011/65/EU** **2014/30/EU** **2014/34/EU**
Se ha(n) aplicado la(s) siguiente(s) norma(s):	La(e) seguente(i) norma(e) è(sono) stata(e) applicata(e):	Följande standard(er) tillämpas:

EN IEC 63000: 2018
EN 61000-6-3: 2007 +A: 2011 + AC: 2012
EN 61000-6-4: 2007 +A1: 2011
EN IEC 61000-6-2: 2019
EN 60079-15: 2010
EN 60079-31: 2014
EN IEC 60079-0: 2018

Marcado	Contrassegno	Märkning
	Ⓔx II 3D Ex tc IIIC T90°C Dc Ⓔx II 3G Ex nA IIC T4 Gc	

N° de artículo: 80304277

Tettnang, 20.07.2021
(Lugar y fecha de expedición)
(Luogo e data del rilascio)
(Ort och datum för utfärdande)

(Firma) i.V. Alfred Wagner /
(Firma) Head of development
(Underskrift)

Nº de documento: 8003330

4.2 BL01-WG01 – Connecting Cable with Socket for Level Sensor, EVC14A

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DEKRA

1 # EU-Baumusterprüfbescheinigung

2 **Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014**

3 Nr. der EU-Baumusterprüfbescheinigung: **BVS 08 ATEX E 109 U** Ausgabe: **01**

4 Komponente: **Kabeldosen und -stecker Typ EVC** A**

5 Hersteller: **ifm electronic gmbh**

6 Anschrift: **Friedrichstraße 1, 45128 Essen, Deutschland**

7 Die Bauart dieses Produktes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

8 Die Zertifizierungsstelle der DEKRA Testing and Certification GmbH, benannte Stelle Nr. 0158 gemäß Artikel 17 der Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014, bescheinigt, dass das Produkt die wesentlichen Gesundheits- und Sicherheitsanforderungen für die Konzeption und den Bau von Produkten zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie erfüllt.
Die Ergebnisse der Prüfung sind in dem vertraulichen Prüfprotokoll BVS PP 08.2137 EU niedergelegt.
Diese Ausgabe der EU-Baumusterprüfbescheinigung ersetzt die bisherige Ausgabe der EG-Baumusterprüfbescheinigung BVS 08 ATEX E 109 U inklusive der Nachträge 1 bis 2.

9 Die Einhaltung der Grundlegenden Sicherheits- und Gesundheitsanforderungen wurde überprüft durch Berücksichtigung von:

EN IEC 60079-0:2018	**Allgemeine Anforderungen**
EN IEC 60079-7:2015 + A1:2018	**Erhöhte Sicherheit „e“**
EN 60079-31:2014	**Schutz durch Gehäuse „t“**

10 Das Zeichen „U“ hinter der Zertifikatsnummer weist darauf hin, dass dieses Zertifikat nicht mit Zertifikaten für Geräte oder Schutzsysteme verwechselt werden darf. Diese Teilzertifizierung kann als Grundlage für die Zertifizierung eines Geräts oder Schutzsystems verwendet werden. Die „Einschränkungen für die Verwendung“ ist unter Punkt 17 dieser Bescheinigung aufgeführt.

11 Diese EU-Baumusterprüfbescheinigung bezieht sich nur auf den technischen Entwurf des angegebenen Produkts gemäß der Richtlinie 2014/34/EU.
Weitere Anforderungen der Richtlinie gelten für den Herstellungsprozess und die Bereitstellung dieses Produkts. Diese sind nicht Gegenstand der Zertifizierung.

12 Die Kennzeichnung des Produktes muss die folgenden Angaben enthalten:

Ex **II 2D Ex tb IIIC Db**
II 3G Ex ec IIC Gc

DEKRA Testing and Certification GmbH
Bochum, 17.02.2023

Geschäftsführer

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
Zertifizierungsstelle: Dinnendahlstraße 9, 44809 Bochum
Telefon +49.234.3696-400, Fax +49.234.3696-401, DTC-Certification-body@dekra.com

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13 **Anlage zur**

14 **EU-Baumusterprüfbescheinigung**

BVS 08 ATEX E 109 U Ausgabe 01

15 **Beschreibung des Produktes**

15.1 **Gegenstand und Typ**

Kabeldosen und -stecker Typ EVC**A

** - Kabellänge (0,1 ...100 m)

15.2 **Beschreibung**

Die 90° abgewinkelten M12 Kabeldosen Typ EVC0*A haben 4 Kontakte und ein angespritztes 4-adriges Kabel. Sie sind mit einer Edelstahl-Überwurfmutter versehen, die zur mechanischen Befestigung des Kabels an den Betriebsmitteln verwendet wird. Die Fixierung wird über eine spezielle Befestigungstechnik sichergestellt, die über eine Rasterung ein ungewolltes Lösen der Mutter verhindert. Die Kabeldosen und -stecker Typ EVC**A sind in der Zündschutzart Erhöhte Sicherheit „ec" und Schutz durch Gehäuse „tb" ausgeführt.

Grund für diese Ausgabe

- Umstellung auf die Richtlinie 2014/34/EU
- Aktualisierung der Normen EN IEC 60079-0:2018 und EN 60079-31:2014, sowie Umstellung von EN 60079-15:2010 auf EN IEC 60079-7:2015+A1:2018.

15.3 **Kenngrößen**

Bemessungsspannung		AC/DC 60 V
Stromtragfähigkeit		2 A
Umgebungstemperaturbereich	-	20 °C ≤ T_a ≤ 60 °C
Anzugsdrehmoment der Überwurfmutter		1,2… 1,5 Nm

16 **Prüfprotokoll**

BVS PP 08.2137 EU, Stand 17.02.2023

17 **Einschränkungen für die Verwendung**

Die Kabeldosen und -stecker müssen an ein metallisches Gegenstück angeschlossen werden, das die IP-Anforderungen gemäß EN IEC 60079-7 und EN 60079-31 erfüllt und eine M12-Größe hat.

Die Kabeldosen und -stecker müssen gegen eine Schlagenergie > 4 J geschützt sein.

Die Kabeldosen und -stecker müssen gegen UV-Licht geschützt sein.

Die Kontermutter muss mit einem Anzugsmoment von 1,2...1,5 Nm angezogen werden.

Die Kabel sind fest zu verlegen und gegen mechanische Beschädigungen zu schützen.

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
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18 **Wesentliche Gesundheits- und Sicherheitsanforderungen**

Erfüllt durch Einhaltung der unter Punkt 9 genannten Anforderungen.

19 **Zeichnungen und Unterlagen**

Die Zeichnungen und Unterlagen sind in dem vertraulichen Prüfprotokoll gelistet.

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
Zertifizierungsstelle: Dinnendahlstraße 9, 44809 Bochum
Telefon +49.234.3696-400, Fax +49.234.3696-401, DTC-Certification-body@dekra.com

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Translation

1 # EU-Type Examination Certificate

2 **Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014**

3 EU-Type Examination Certificate Number: **BVS 08 ATEX E 109 U** Issue: **01**

4 Component: **Sockets and plugs type EVC**A**

5 Manufacturer: **ifm electronic gmbh**

6 Address: **Friedrichstraße 1, 45128 Essen, Germany**

7 This product and any acceptable variations thereto are specified in the appendix to this certificate and the documents referred to therein.

8 DEKRA Testing and Certification GmbH, Notified Body number 0158, in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.
The examination and test results are recorded in the confidential Report No. BVS PP 08.2137 EU.
This issue of the EU-Type Examination Certificate replaces the previous issue of the EC-Type Examination Certificate BVS 08 ATEX E 109 U including supplements 1 to 2.

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0:2018	**General requirements**
EN IEC 60079-7:2015 + A1:2018	**Increased Safety "e"**
EN 60079-31:2014	**Protection by Enclosure "t"**

10 The sign "U" placed behind the certificate number indicates that this certificate should not be confounded with certificates issued for equipment or protective systems. This partial certification may be used as a basis for certification of an equipment or protective systems. "Schedule of limitations" is listed under item 17 of this certificate.

11 This EU-Type Examination Certificate relates only to the technical design of the specified product in accordance to the Directive 2014/34/EU. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

12 The marking of the product shall include the following:

II 2D Ex tb IIIC Db
II 3G Ex ec IIIC Gc

DEKRA Testing and Certification GmbH
Bochum, 2023-02-17

Signed: Dr. Rolf Krökel

Managing Director

This certificate may only be reproduced in its entirety and without any change.

DEKRA Testing and Certification GmbH, Handwerkstr. 15, 70565 Stuttgart, Germany
Certification body: Dinnendahlstr. 9, 44809 Bochum, Germany
Phone +49.234.3696-400, Fax +49.234.3696-401, e-mail DTC-Certification-body@dekra.com

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13 **Appendix**

14 **EU-Type Examination Certificate**

BVS 08 ATEX E 109 U issue 01

15 **Product description**

15.1 **Subject and type**

Sockets and plugs type EVC**A

**-length of cable (0.1 ...100 m)

15.2 **Description**

The 90° angled M12 sockets type EVC0*A have 4 pins and a potted 4-wire cable. They are equipped with a stainless steel lock nut to fasten the socket at the equipment. A special fastening technique protects against unintended loosening. The plugs and sockets type EVC**A are built in type of protection Increased Safety “ec” and Protection by Enclosure “tb”.

Reason for this issue

- Change to Directive 2014/34/EU
- The reason of the supplement is the updating to the standards EN IEC 60079-0:2018 and EN 60079-31:2014, as well as change from EN 60079-15:2010 to EN IEC 60079-7:2015+A1:2018.

15.3 **Parameters**

Rated voltage AC/DC	60 V
Current carrying capacity	2 A
Ambient temperature range	-20 °C ≤ T_a ≤ 60 °C
Tightening torque of lock nut	1.2… 1.5 Nm

16 **Report Number**

BVS PP 08.2137 EU, as of 2023-02-17

17 **Schedule of limitations**

The sockets have to be connected to a metallic counterpart which meets the IP requirements according to EN IEC 60079-7 and EN 60079-31 which has a M12 size.

The sockets have to be protected against an impact energy > 4 J.

The sockets have to be protected against UV emitting light.

The lock nut has to be fastened with a tightening torque of 1.2…1.5 Nm.

The cables have to be installed in a fixed manner and have to be protected against mechanical damage.

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18 **Essential Health and Safety Requirements**

Met by compliance with the requirements mentioned in item 9.

19 **Remarks and additional information**

Drawings and documents are listed in the confidential report.

We confirm the correctness of the translation from the German original.
In the case of arbitration only the German wording shall be valid and binding.

DEKRA Testing and Certification GmbH
Bochum, 2023-02-17
BVS-Pz/Mu A 20220792 / 342813900

Managing Director

DEKRA Testing and Certification GmbH, Handwerkstr. 15, 70565 Stuttgart, Germany
Certification body: Dinnendahlstr. 9, 44809 Bochum, Germany
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4.3 BP01 – Pressure Sensor, 520 Series

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EU-Type Examination Certificate

(1)

(2) Equipment or protective system intended for use in potentially explosive atmospheres **- Directive 2014/34/EU**

(3) Certificate number: **SEV 10 ATEX 0145**

(4) Product: Pressure transmitter, Types: 520.*, 522.*, 527.*, 528.*

(5) Manufacturer: Huba Control AG

(6) Address: Industriestrasse 17, 5436 Würenlos, Switzerland

(7) The equipment and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) Eurofins, notified body No. 1258, in accordance with article 17 of Directive 2014/34/EU of the European parliament and of the council, dated 26 February 2014, certifies that this product has been found to comply with the essential health and safety requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.
The examination and test results are recorded in confidential report no 21CH-00562.X04

(9) Compliance with the essential health and safety requirements has been assured by compliance with:

EN IEC 60079-0:2018
EN 60079-11:2012
EN 60079-26:2015

Except in respect of those requirements listed at item 18 of the schedule.

(10) If the sign «X» is placed after the certificate number, it indicates that the product is subjected to special conditions for safe use specified in the schedule to this certificate. The sign "U" is placed after the certificate number. It indicates that this certificate must not be mistaken for a certificate intended for an equipment or protective system. This partial certification may be used as a basis for certification of an equipment or protective system.

(11) This EU type examination certificate relates only to design and construction of the specified product. Further requirements of this directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

(12) The marking of the product shall include the following:

II 1/2G Ex ia IIC T4 Ga/Gb
II 1/2D Ex ia IIIC T125 °C Da/Db

Eurofins Electric & Electronic Product Testing AG
Notified Body ATEX

Martin Plüss
Product Certification

www.eurofins.ch Fehraltorf, 2021-12-16 Issue: 4 Page 1 of 2

T8a_V01

eurofins | E&E

(13) # Appendix

(14) **EU-Type Examination Certificate no. SEV 10 ATEX 0145**

(15) **Description of product**

The pressure transmitter is used to measure relative and absolute pressure of gases, liquids and refrigerants (incl. ammonia). The pressure transmitter differ in the pressure measuring cell and the pressure range. For the measuring of the pressure the signal of a pressure measuring cell made of stainless steel (type 520.* / 522.*) or made of ceramic (type 527.* / 528.*) with a membrane is converted into a 4…20 mA output signal by the electronic.
The pressure transmitter can be installed in the partition which separates the area, which requires apparatus of category 1 from the area, which requires apparatus of category 2. The pressure measuring cell may be used only for flammable substances for which the membranes of cells are sufficiently chemically and corrosion resistant.
Effective internal inductance and capacitance for versions with plugs complying with EN 175301-80 A (IP65) or M12x1 (IP67)

Classification of installation and use:	stationary
Ingress protection:	IP65 with connector EN 175301-803A IP67 with connector M12x1
Rated ambient temperature range (°C):	-25 °C ≤ Tamb ≤ +85 °C
Rated medium temperature range (°C):	-30 °C … +120 °C
Rated ambient temperature range (°C) for Ex Components:	N/A

Ratings:
Connection to certified intrinsically safe resistive circuits with maximum values:

Ui ≤ 30 V
Ii ≤ 100 mA
Pi ≤ 750 mW
Ci = 0 nF
Li = 0 µH

Output:
4 … 20 mA

(16) **Report number** 21CH-00562.X04

(17) **"Special conditions for safe use" / "Schedule of limitations"**
None

(18) **Essential health and safety requirements**
In addition to the essential health and safety requirements (EHSRs) covered by the standards listed at item 9, the following are considered relevant to this product, and conformity is demonstrated in the report:

Clause **Subject**
None

(19) **Drawings and Documents**
See test report "Manufacturer's Documents"

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres
for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	**IECEx SEV 16.0007**	Page 1 of 5	Certificate history:
Status:	**Current**	Issue No: 2	Issue 1 (2018-03-12) Issue 0 (2016-05-19)
Date of Issue:	2021-12-16		
Applicant:	**Huba Control AG** Industriestrasse 17 5436 Würenlos **Switzerland**		
Equipment:	**Pressure transmitter Type 520.*, 522.*, 527.*, 528.***		
Optional accessory:			
Type of Protection:	**ia**		
Marking:	Ex ia IIC T4 Ga/Gb Ex ia IIIC T125 °C Da/Db		

SWISS ACCREDITATION sas.admin.ch SCESp 0127

Approved for issue on behalf of the IECEx Certification Body: **Martin Plüss**

Position: **Manager Product Certification**

Signature: (for printed version)

Date: 2021-12-16

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting www.iecex.com or use of this QR Code.

Certificate issued by:

Eurofins Electric & Electronic Product Testing AG
Luppmenstrasse 3
8320 FEHRALTORF .
Switzerland

eurofins | E&E

IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 2 of 5

Date of issue: 2021-12-16 Issue No: 2

Manufacturer: **Huba Control AG**
Industriestrasse 17
5436 Würenlos
Switzerland

Additional manufacturing locations:

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements.This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-11:2011 Edition:6.0	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"
IEC 60079-26:2014-10 Edition:3.0	Explosive atmospheres – Part 26: Equipment with Equipment Protection Level (EPL) Ga

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Report:

CH/SEV/ExTR16.0008/02

Quality Assessment Report:

CH/SEV/QAR12.0006/06

IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 3 of 5

Date of issue: 2021-12-16 Issue No: 2

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

Pressure transmitter Type 520.*, 522.*, 527.*, 528.*

The pressure transmitter is used to measure relative and absolute pressure of gases, liquids and refrigerants (incl. ammonia). The pressure transmitter differ in the pressure measuring cell and the pressure range. For the measuring of the pressure the signal of a pressure measuring cell made of stainless steel (type 520.* / 522.*) or made of ceramic (type 527.* / 528.*) with a membrane is converted into a 4...20 mA output signal by the electronic.

The pressure transmitter can be installed in the partition which separates the area, which requires apparatus of category 1 from the area, which requires apparatus of category 2. The pressure measuring cell may be used only for flammable substances for which the membranes of cells are sufficiently chemically and corrosion resistant.

Effective internal inductance and capacitance for versions with plugs complying with EN 175301-80 A (IP65) or M12x1 (IP67)

SPECIFIC CONDITIONS OF USE: NO

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IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 4 of 5

Date of issue: 2021-12-16 Issue No: 2

Equipment (continued):

Classification of installation and use ..... : stationary
Ingress protection ..... : IP65 with connector EN 175301-803A
IP67 with connector M12x1
Rated ambient temperature range (°C)..... : -25 °C ≤ Tamb ≤ +85 °C
Rated medium temperature range (°C) ..... : -30 °C ... +120 °C
Rated ambient temperature range (°C) for Ex Components ....: N/A

Rating:
Power Supply:

Connection to certified intrinsically safe resistive circuits with maximum values:

U_i ≤ 30 VDC
I_i ≤ 100 mA
P_i ≤ 0.75 W
L_i = 0 µH
C_i = 0 nF

Output:
4 ... 20 mA

SWISS ACCREDITATION sas.admin.ch SCESp 0008

IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 5 of 5

Date of issue: 2021-12-16 Issue No: 2

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above)
All previous addendums have been combined in a new file with current test reports and drawings.

SWISS ACCREDITATION
sas.admin.ch
SCESp 0236

4.4 BP01-WG01 – Connecting Cable with Socket for Pressure Sensor, ENC03A

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DEKRA

EU-Baumusterprüfbescheinigung

Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014

3 Nr. der EU-Baumusterprüfbescheinigung: **BVS 11 ATEX E 009 X** Ausgabe: **01**

4 Gerät: **Steckverbinder Typ ENC**A**

5 Hersteller: **ifm electronic gmbh**

6 Anschrift: **Friedrichstraße 1, 45128 Essen, Deutschland**

7 Die Bauart dieses Produktes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

8 Die Zertifizierungsstelle der DEKRA Testing and Certification GmbH, benannte Stelle Nr. 0158 gemäß Artikel 17 der Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014, bescheinigt, dass das Produkt die wesentlichen Gesundheits- und Sicherheitsanforderungen für die Konzeption und den Bau von Produkten zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie erfüllt.
Die Ergebnisse der Prüfung sind in dem vertraulichen Prüfprotokoll BVS PP 11.2018 EU niedergelegt.
Diese Ausgabe der EU-Baumusterprüfbescheinigung ersetzt die bisherige Ausgabe der EG-Baumusterprüfbescheinigung BVS 11 ATEX E 009 X inklusive des Nachtrags 1.

9 Die Einhaltung der Grundlegenden Sicherheits- und Gesundheitsanforderungen wurde überprüft durch Berücksichtigung von:

EN IEC 60079-0:2018	**Allgemeine Anforderungen**
EN 60079-11:2012	**Eigensicherheit „i"**

10 Falls das Zeichen „X" hinter der Bescheinigungsnummer steht, bedeutet dies, dass das Produkt den unter Punkt 17 dieser Bescheinigung aufgeführten „Besondere Bedingungen für die Installation und den Betrieb" unterliegt.

11 Diese EU-Baumusterprüfbescheinigung bezieht sich nur auf den technischen Entwurf des angegebenen Produkts gemäß der Richtlinie 2014/34/EU.
Weitere Anforderungen der Richtlinie gelten für den Herstellungsprozess und die Bereitstellung dieses Produkts. Diese sind nicht Gegenstand der Zertifizierung.

12 Die Kennzeichnung des Produktes muss die folgenden Angaben:

II 1G Ex ia IIB T6 Ga	**II 1G Ex ia IIB T5 Ga**	**II 1D Ex ia IIIC T_{200}70°C Da**
II 2G Ex ia IIC T6 Gb	**II 2G Ex ia IIC T5 Gb**	**for -20 °C ≤ T_a ≤ +60 °C**
II 1D Ex ia IIIB T_{200}85°C Da	**II 1D Ex ia IIIB T_{200}95°C Da**	
for -25 °C ≤ T_a ≤ +75 °C	**for -25 °C ≤ T_a ≤ +85 °C**	

DEKRA Testing and Certification GmbH
Bochum, 06.09.2023

Geschäftsführer

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
Zertifizierungsstelle: Dinnendahlstraße 9, 44809 Bochum
Telefon +49.234.3696-400, Fax +49.234.3696-401, DTC-Certification-body@dekra.com

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13 **Anlage zur**

14 **EU-Baumusterprüfbescheinigung**

BVS 11 ATEX E 009 X Ausgabe 01

15 **Beschreibung des Produktes**

15.1 **Gegenstand und Typ**

Steckverbinder Typ ENC**A

In der vollständigen Bezeichnung werden anstelle der ** Ziffern eingefügt, die Änderungen kennzeichnen wie: Art des Kabels, Länge des Kabels, Konstruktion gerade oder gebogen.

15.2 **Beschreibung**

Der Steckverbinder wird bei eigensicheren Geräten für den Anschluss der eigensicheren Stromkreise verwendet.
Die Steckdose ist ein einfaches elektrisches Betriebsmittel.
Der Steckverbinder hat ein fest angeschlossenes Kabel und ist konstruktionsbedingt in der Lage, zwei verschiedene eigensichere Stromkreise bis zu einer Summe von Spannungen von 30 V zu führen; in diesem Fall muss das Kabel wirksam gegen Beschädigung geschützt werden.

Grund für diese Ausgabe:

- Umstellung auf die Richtlinie 2014/34/EU
- Aktualisierung der Norm EN IEC 60079-0:2018
- Modifikation des Umgebungstemperaturbereichs
- Erweiterung der "Besondere Bedingungen für die Verwendung"

15.3 **Kenngrößen**

Spannung	U_i	DC	30	V
Strom	I_i		1	A
Leistung	P_i			
Für den Einsatz in Gruppe II			1	W
Für den Einsatz in Gruppe III			1	W
Umgebungstemperaturbereich (mit Ausnahme von IIIC)	T_a	-25 °C bis +75 °C / +85 °C		
Für Gruppe IIIC	T_a	-20 °C bis +60 °C		

Für Umgebungstemperaturen bis 75 °C sind die Sensoren als T6 bzw. T_{200} 85 °C klassifiziert (ausgenommen Gruppe IIIC).
Für Umgebungstemperaturen bis 85 °C sind die Sensoren als T5 bzw. T200 95 °C klassifiziert (ausgenommen Gruppe IIIC).

Der Steckverbinder darf zwei verschiedene eigensichere Stromkreise bis zu einer Summe der Spannungen von 30 V führen.

Die Werte der internen Kapazität und Induktivität hängen von der Länge des fest angeschlossenen Kabels ab und werden wie folgt berechnet:

Interne Kapazität	C_i	0,1 nF/m
Interne Induktivität	L_i	2 µH/m

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16 **Prüfprotokoll**

BVS PP 11.2018 EU, Stand 06.09.2023

17 **Besondere Bedingungen für die Installation und den Betrieb**

17.1 Die Steckverbinder und das angeschlossene Kabel müssen so installiert werden, dass intensive elektrostatische Aufladung ausgeschlossen ist.

17.2 Aus Platzgründen kann die Kennzeichnung nicht vollständig auf dem Gerät angebracht werden. Die vollständige Kennzeichnung ist der Betriebsanleitung zu entnehmen.

17.3 Das Kabel und der Steckverbinder müssen fest verlegt und wirksam gegen mechanische Beschädigungen geschützt werden.

17.4 Für Gruppe IIIC:

- Der Betrieb des Steckverbinders ohne ein geeignetes M12-Gegenstück ist nicht zulässig. Das M12-Gegenstück muss die IP-Anforderungen nach IEC 60079-11 erfüllen.
- Beim Öffnen des Steckverbinders muss das Eindringen von Staub vermieden werden.
- Der Steckverbinder muss vor UV-Strahlung geschützt werden.
- Die Überwurfmutter muss mit einem Anzugsdrehmoment von 1,2...1,5 Nm angezogen werden.

18 **Wesentliche Gesundheits- und Sicherheitsanforderungen**

Erfüllt durch Einhaltung der unter Punkt 9 genannten Anforderungen.

19 **Zeichnungen und Unterlagen**

Die Zeichnungen und Unterlagen sind in dem vertraulichen Prüfprotokoll gelistet.

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Translation

1 # EU-Type Examination Certificate

2 **Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014**

3 EU-Type Examination Certificate Number: **BVS 11 ATEX E 009 X** Issue: **01**

4 Equipment: **Socket type ENC**A**

5 Manufacturer: **ifm electronic gmbh**

6 Address: **Friedrichstraße 1, 45128 Essen, Germany**

7 This product and any acceptable variations thereto are specified in the appendix to this certificate and the documents referred to therein.

8 DEKRA Testing and Certification GmbH, Notified Body number 0158, in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.
The examination and test results are recorded in the confidential Report No. BVS PP 11.2018 EU.
This issue of the EU-Type Examination Certificate replaces the previous issue of the EC-Type Examination Certificate BVS 11 ATEX E 009 X including supplement 1.

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0:2018	**General requirements**
EN 60079-11:2012	**Intrinsic Safety "i"**

10 If the sign "X" is placed after the certificate number, it indicates that the product is subject to the "Specific Conditions of Use" listed under item 17 of this certificate.

11 This EU-Type Examination Certificate relates only to the technical design of the specified product in accordance with the Directive 2014/34/EU. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

12 The marking of the product shall include the following:

II 1G Ex ia IIB T6 Ga **II 2G Ex ia IIC T6 Gb** **II 1D Ex ia IIIB T_{200}85°C Da** **for -25 °C ≤ T_a ≤ +75 °C**	**II 1G Ex ia IIB T5 Ga** **II 2G Ex ia IIC T5 Gb** **II 1D Ex ia IIIB T_{200}95°C Da** **for -25 °C ≤ T_a ≤ +85 °C**	**II 1D Ex ia IIIC T_{200}70°C Da** **for -20 °C ≤ T_a ≤ +60 °C**

DEKRA Testing and Certification GmbH
Bochum, 2023-09-06

Signed: Oliver Brumm

Managing Director

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13 **Appendix**

14 **EU-Type Examination Certificate**

BVS 11 ATEX E 009 X issue 01

15 **Product description**

15.1 **Subject and type**

Steckverbinder type ENC**A

In the complete denomination instead of the ** numerals will be inserted which characterize modifications as: kind of cable, length of cable, construction straight or bent.

15.2 **Description**

The socket is used as intrinsically safe apparatus for the connection of the intrinsically safe circuits.
The socket is a simple apparatus.
The socket has a permanently connected cable and is due to construction able to carry two different intrinsically safe circuits up to a sum of voltages of 30 V; in this case the cable must be effectively protected against damage.

Reason for this issue:

- Change to Directive 2014/34/EU
- Standards update EN IEC 60079-0:2018
- Modification of the ambient temperature range
- Extension of the "Special conditions for use"

15.3 **Parameters**

Voltage	U_i	DC	30	V
Current	I_i		1	A
Power	P_i			
For use in Group II			1	W
For use in Group III			1	W
Ambient temperature range (except IIIC)	T_a	-25 °C up to +75 °C / +85 °C		
For Group IIIC	T_a	-20 °C up to 60 °C		

For ambient temperatures up to 75 °C, the sensors are classified as T6 resp. T_{200} 85 °C (except Group IIIC).
For ambient temperatures up to 85 °C, the sensors are classified as T5 resp. T_{200} 95 °C (except Group IIIC).

The socket may carry two different intrinsically safe circuits up to a sum of voltages of 30 V.

The values of internal capacitance and inductance depend on the length of the permanently connected cable and be calculated as:

Internal capacitance	C_i	0.1	nF/m
Internal inductance	L_i	2	µH/m

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16 **Report Number**

BVS PP 11.2018 EU, as of 2023-09-06

17 **Specific Conditions of Use**

17.1 The connectors and the connected cable must be installed in a way that an intensive electrostatic charge is excluded.

17.2 Due to space restriction the markings may not be applied completely to the unit. See operating instructions for the compete marking.

17.3 The cable and socket must be installed fixed and effectively protected against mechanical damage.

17.4 For Group IIIC:

- The operation of the sockets without a suitable M12 counterpart is not permissible.
  The M12 counterpart has to meet the IP requirements according to IEC 60079-11.
- When the socket is opened, the ingress of dust must be avoided.
- The sockets have to be protected against UV emitting light.
- The lock nut has to be fastened with a tightening torque of 1.2…1.5 Nm.

18 **Essential Health and Safety Requirements**

Met by compliance with the requirements mentioned in item 9.

19 **Remarks and additional information**

Drawings and documents are listed in the confidential report.

We confirm the correctness of the translation from the German original.
In the case of arbitration only the German wording shall be valid and binding.

DEKRA Testing and Certification GmbH
Bochum, 2023-09-06
BVS-Fro/Mu A 20220779 / 342812500

Managing Director

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4.5 TF01 – Pressure Sensor Ex Barrier, 9106B

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CERTIFICATE

EU-Type Examination

(1)

(2) **Equipment or protective systems intended for use in potentially explosive atmospheres - Directive 2014/34/EU**

(3) EU-Type Examination Certificate Number: **DEKRA 11ATEX0244 X** Issue Number: **4**

(4) Product: **HART-Transparent Repeater, Types 9106B1A, 9106B1B, 9106B2A , 9106B2B and Types 9106A1A, 9106A1B, 9106A2A , 9106A2B**

(5) Manufacturer: **PR electronics A/S**

(6) Address: **Lerbakken 10, 8410 Rønde, Denmark**

(7) This product and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) DEKRA Certification B.V., Notified Body number 0344 in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.

The examination and test results are recorded in confidential test report number NL/DEK/ExTR11.0097/04.

(9) Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0 : 2018 **EN 60079-11 : 2012**

EN 60079-15 : 2019 **EN 60079-7 : 2015 + A1 : 2018**

except in respect of those requirements listed at item 18 of the Schedule.

(10) If the sign "X" is placed after the certificate number, it indicates that the product is subject to the Specific Conditions of Use specified in the schedule to this certificate.

(11) This EU-Type Examination Certificate relates only to the design and construction of the specified product. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

(12) The marking of the product shall include the following:

II (1) G [Ex ia Ga] IIC/IIB/IIA
II (1) D [Ex ia Da] IIIC
I (M1) [Ex ia Ma] I

Date of certification: 23 June 2020

DEKRA Certification B.V.

R. Schuller
Certification Manager

Page 1/4

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DEKRA

(13) **SCHEDULE**

(14) **to EU-Type Examination Certificate DEKRA 11ATEX0244 X** Issue No. **4**

(15) **Description**

HART-Transparent Repeater, Types 9106B1A, 9106B1B, 9106B2A, 9106B2B and Types 9106A1A, 9106A1B, 9106A2A, 9106A2B for rail mounting, are 24 V powered isolating barriers that serve as a repeater.
The repeater transfers the intrinsically safe 4 - 20 mA current signal (with HART communication) of either a loop powered transmitter or an active current source to a non-intrinsically safe 4 - 20 mA output signal (with HART communication).
The Repeater is supplied via terminals at the front of the module, or via Power Rail Type 9400.
Removable display module 4501 can be used for programming of the Repeater.

The HART-Transparent Repeater, Types 9106B*A, 9106A*A are one channel version and Types 9106B*B, 9106A*B are two channel version.

Ambient temperature range -20 °C to +60 °C.

Marking

The equipment marking may additionally include the code II 3 G Ex ec nC IIC T4 Gc.

Electrical data

All Repeater Types

Supply (terminals 31, 32 and rear contacts): U = 19,2 ... 31,2 Vdc.

Status-Relay output (terminals 33, 34):
U ≤ 32 Vac or 32 Vdc, I ≤ 0,5 Aac or I ≤ 1 Adc respectively.
If the Repeater is installed outside the hazardous area, the following data for the relay contacts apply: U ≤ 110 Vdc or 125 Vac, I ≤ 0,3 Adc or I ≤ 0,5 Aac respectively.

Outputs (terminals 11, 12 resp. 13, 14): I = 4 ... 20 mA.

For all circuits above: U_m = 253 Vac (max. frequency 400 Hz).

Repeater Types 9106B1A, 9106B1B, 9106B2A, 9106B2B

Loop current input (terminals 43, 44 resp. terminals 53, 54):
in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, with following maximum values:
for Type 9106B1A and Type 9106B1B:
U_o = 27,5 V; I_o = 92,6 mA; P_o = 0,64 W;
C_o = 0,084 µF (IIC) or 0,67 µF (IIB) or 2,23 µF (IIA) or 3,94 µF (I) ;
L_o = 4,15 mH (IIC) or 16,59 mH (IIB) or 33,17 mH (IIA) or 54,42 mH (I);
L_o/R_o = 223 µH/Ω (IIB) or 447 µH/Ω (IIA) or 733 µH/Ω (I)

for Type 9106B2A and Type 9106B2B:
U_o = 25,3 V; I_o = 96 mA; P_o = 0,61 W;
C_o = 0,104 µF (IIC) or 0,818 µF (IIB) or 2,85 µF (IIA) or 4,74 µF (I);
L_o = 3,86 mH (IIC) or 15,43 mH (IIB) or 30,86 mH (IIA) or 50,64 mH (I).
L_o/R_o = 234 µH/Ω (IIB) or 468 µH/Ω (IIA) or 769 µH/Ω (I)
For group IIIC, the parameters of group IIB apply.

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(13) **SCHEDULE**

(14) **to EU-Type Examination Certificate DEKRA 11ATEX0244 X** Issue No. **4**

Current input (terminals 41, 42 resp. terminals 51, 52):
in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, for connection to a certified intrinsically safe circuit, with following maximum values:
U_i = 30 V; I_i = 120 mA; P_i = 0,85 W; $_{Ci}$ = 2 nF; L_i = 0 µH;
U_o = 0 V; I_o = 0 mA; P_o = 0 mW.

Current input and Loop current input of one channel are not applied simultaneously.

Both channels (terminals 41...44 and terminals 51...54) are infallibly galvanically isolated from each other and from the non-intrinsically safe supply and output circuits

Combination of Loop current input of channel 1 (terminals 43, 44) and Current input of channel 2 (terminals 51, 52) in series, where terminal 43 is connected to terminal 51:
Loop current circuit (terminals 44 and 52) is in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, with following maximum values:
for Type 9106B1A and Type 9106B1B:
U_o = 27,5 V; I_o = 92,6 mA; P_o = 0,64 W;
C_o = 0,084 µF (IIC) or 0,67 µF (IIB) or 2,23 µF (IIA) or 3,94 µF (I) ;
L_o = 4,15 mH (IIC) or 16,59 mH (IIB) or 33,17 mH (IIA) or 54,42 mH (I);
L_o/R_o = 223 µH/Ω (IIB) or 447 µH/Ω (IIA) or 733 µH/Ω (I)

for Type 9106B2A and Type 9106B2B:
U_o = 25,3 V; I_o = 96 mA; P_o = 0,61 W;
C_o = 0,104 µF (IIC) or 0,818 µF (IIB) or 2,85 µF (IIA) or 4,74 µF (I);
L_o = 3,86 mH (IIC) or 15,43 mH (IIB) or 30,86 mH (IIA) or 50,64 mH (I).
L_o/R_o = 234 µH/Ω (IIB) or 468 µH/Ω (IIA) or 769 µH/Ω (I)
For group IIIC, the parameters of group IIB apply.

Combination of both Current inputs (terminals 41, 42 resp. 51, 52) in series, where terminal 41 is connected to terminal 52:
Current input (terminals 42 and 51) is in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, for connection to a certified intrinsically safe circuit, with following maximum values:
U_i = 30 V; Ii = 120 mA; Pi = 0,85 W; C_i = 4 nF; L_i = 0 µH;
U_o = 0 V; I_o = 0 mA; P_o = 0 mW.

Installation instructions

The instructions provided with the product shall be followed in detail to assure safe operation.

(16) **Report Number**

No. NL/DEK/ExTR11.0097/04.

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DEKRA

(13) **SCHEDULE**

(14) **to EU-Type Examination Certificate DEKRA 11ATEX0244 X** Issue No. **4**

(17) **Specific conditions of use**

The HART Transparent Repeater shall be installed in a controlled environment with suitably reduced pollution, limited to pollution degree 2 or better.

The non intrinsically safe circuits shall be limited to overvoltage category I/II as defined in EN 60664-1.

If the HART-Transparent Repeater is installed in an explosive atmosphere where the use of apparatus of equipment category 3 G is required, the following specific conditions of use apply:

The HART Transparent Repeater shall be installed in an enclosure in type of protection Ex n or Ex e, providing a degree of protection of at least IP54. Cable entry devices and blanking elements shall fulfil the same requirements.

Removable Display Module 4501, when connected to the Repeater, may not be damaged and shall be free of dust and moisture.

(18) **Essential Health and Safety Requirements**

Covered by the standards listed at item (9)

(19) **Test documentation**

As listed in Report No. NL/DEK/ExTR11.0097/04.

(20) **Certificate history**

Issue 1 -	214940700	initial certificate
Issue 2 -	215635200	changes to the construction and standards update
Issue 3 -	219950900	changes to the electrical data
Issue 4 -	224396500	assesed per latest edition of the standards addition of 9106Axx models

Page 4/4

Form 227A
Version 1 (2016-04)

4.6 BT01 – Temperature Sensor, TT1050

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ifm electronic

EU – Konformitätserklärung

EU declaration of conformity

Déclaration de conformité UE

ifm electronic gmbh
Friedrichstraße 1
45128 Essen
Germany

Telefon: +49 (0)201 / 24 22 - 0
Telefax: +49 (0)201 / 24 22 - 1200
Internet: www.ifm.com

Die EU-Konformitätserklärung gilt für folgende Geräte:	The EU declaration of conformity applies to the following units:	La déclaration de conformité UE s'applique aux appareils suivants:

Temperatursensoren der Produktfamilie
Temperature sensors of the product family
Capteurs de température de la famille de produits

TTxxxx/ TMxxxx/ TSxxxx/ TXxx81/ TX4511/ TX9920/ TY9159

Wir bestätigen die Übereinstimmung mit den grundlegenden Anforderungen der europäischen Richtlinie(n):	We confirm the conformity to the essential requirements of the European directive(s):	Nous confirmons la conformité aux exigences essentielles de la (des) directive(s) européenne(s):
2011/65/EU	**2011/65/EU**	**2011/65/UE**

Folgende Norm(en) wurde(n) angewandt:	The following standard(s) was (were) applied:	La (Les) norme(s) suivante(s) a (ont) été appliquée(s):

EN IEC 63000: 2018

Malvern, July 22nd , 2021
(Ort und Datum der Ausstellung)
(Place and date of issue)
(Lieu et date de l'établissement)

(Unterschrift) i.V. Peter Breh
(Signature) Director of Technology
(Signature)

Dokument-Nr.: 8003349

4.7 BT02-WG01 – Connecting Cable with Socket for Temperature Sensor, ENC03A

[Please refer to certificate from Section 4.4.]

4.8 TF01 – Temperature Sensor Ex Barrier, 9113B-U9

[Please refer to certificate from Section 4.5.]

4.9 EA01..02 – Immersion Heater, D-8640

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ISSeP
Institut scientifique de service public
Métrologie environnementale
Recherche - Analyses
Essais - Expertises

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e-mail :
direction@issep.be
site web :
http://www.issep.be

(1) EC TYPE EXAMINATION CERTIFICATE

(2) **Equipment or protective system intended for use in potentially explosive atmospheres**
Directive 94/9/EC

(3) EC type examination certificate number: **ISSeP08ATEX008X**

(4) Equipment or protective system: housing for electrical heating apparatus
Type: D-8640

(5) Applicant – Manufacturer :
Sinus Jevi Electric Heating B.V.

(6) Address: Nijverheidsweg 2
1671 GC Medemblik

(7) This equipment or protective system and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) ISSeP, notified body n^{r} 492 in accordance with article 9 of the Council Directive 94/9/EC of 23 March 1994, certifies that this equipment or protective system has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective systems intended for use in potentially explosive atmospheres given in annex II to the Directive.

The examination and test results are recorded in confidential report no 06090

(9) Compliance with the Essential Health and Safety Requirements has been assured by compliance with:
EN 60079-0: 2006 (IEC 60079-0: 2004) EN 60079-1: 2007 (IEC 60079-1: 2007)
EN 60079-7: 2007 (IEC 60079-7:2006)
EN 61241-0: 2006 (IEC 61241-0: 2004) EN 61241-1: 2004 (IEC 61241-1: 2004)

(10) If the symbol "X" is placed after the certificate number, it indicates that the equipment or protective system is subject to special conditions for safe use specified in the schedule to this certificate

(11) This EC TYPE EXAMINATION CERTIFICATE relates only to the design, examination and tests of the specified equipment or protective system in accordance to the Directive 94/9/EC. Further requirements of this Directive may apply to the manufacturing process and supply of this equipment or protective system. These are not covered by this certificate.

(12) The marking of the equipment or protective system shall include the following indications:
Ex II 2 G D Ex de IIC T6 to T1 Ex tD A21 IP66 T110°C

Colfontaine, the 07.03.2008

INSTITUT SCIENTIFIQUE DE SERVICE PUBLIC
Zoning A. Schweitzer - B7340 Colfontaine (Wasmes)
Tél: ++ 32 65 610811 – Fax: ++ 32 65 610808

Marcel Lambert,
Manager.

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1/3

RÉGION WALLONNE

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(13) SCHEDULE

(14) **EC TYPE EXAMINATION CERTIFICATE No ISSeP08ATEX008X**

(15) Description of the equipment :
Electrical heating apparatus allotted to the heating of inert liquids and gases. This apparatus bears the type designation D-8640 and consists of:

- a certified flameproof connection box
- certified electrical heating elements
- a manually rearmed protective device

The length "H" (to see drawing 953.D8640-01) required to not exceed the temperature limit of 80°C inside the connection box in accordance with the different temperature classes is listed in the here-below table

Temperature class	Length "H" (mm)
T6	50
T5	75
T4	100
T3	150
T2	200
T1	250

Remark :
When the heating elements are fitted on the bottom plate of the housing, the temperature is limited by a safety thermostat and an additional marking is foreseen for the cables (to see drawing 953.D8521-04)

Temperature classes

TEMPERATURE CLASS	TEMPERATURE SETTING OF THE THERMOSTAT (°C)					
	Inert liquids	Gases				
	Power dissipated by the heating element (W/cm^2)	Power dissipated by the heating element (W/cm^2)				
	7,5	2	1,5	1	0,5	0,2
T6	90	-----	-----	-----	-----	-----
T5	110	-----	-----	-----	-----	65
T4	145	-----	-----	-----	70	85
T3	210	-----	-----	90	110	130
T2	310	130	135	150	190	250
T1	-------	230	250	300	-----	-----

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SCHEDULE

EC TYPE EXAMINATION CERTIFICATE No ISSeP08ATEX008X

Electrical parameters
Voltage supply: 110 up to 690 V
Eventual prescriptions
The ambient temperature range: -30 °C to + 50°C
Routine tests
The manufacturer shall make the routine verifications and tests to ensure that the electrical apparatus produced complies with the specification submitted to the testing station together with the prototype.
Each empty enclosure shall be submitted to a routine test under the pressure of 10.5 bar maintained during at least 10 seconds (maximum 60 seconds)

(16) Report n° 06090 of 5.03.2008 composed of 29 pages
The descriptive and technical note from the manufacturer dated of 25.05.2007 related to heating apparatus – size 6" (6 and 3 pages)
The additional descriptive note dated 1.08.2007 (2 pages)
The notices of instruction (8 pages)
A data sheet related to the sealing gasket dated 1.09.2006
The drawings
953.D6150-10 of 19.11.2002 Rev.1 of 28.01.2008
953.D8521-04 of 14.08.2006
953.D8615-20 of 18.02.2008
953.D8640-01 of 29.08.2002
953.D8640-03 of 9.12.2002
953.D8640-05 of 10.01.2005
953.D8640-11 of 11.05.2000
953.D8640-12 of 24.10.2000 – Rev.1 of 21.01.2008
953.D8640-13 of 20.05.2005
953.D8640-20 of 8.12.2003
953.D8640-22 of 7.05.2007 – Rev.1 of 18.02.2008
953.D8640-23 of 7.05.2007 – Rev.1 of 18.02.2008

(17) Special conditions for safe use: symbol X
- The layer of dust accumulated on the housing shall not exceed 5 mm.
- The ignition temperature of the dust shall be higher than 185°C
- The setting of the protective device to the limit temperature ensuring the temperature class shall be realised for each apparatus under the responsibility of the manufacturer. Furthermore this device shall be sealed and its setting shall not be modified later.
- The temperature sensor of the protective device shall be placed as nearest as possible to the tube containing the heating elements.
- When the apparatus is energised the tube containing the heating elements shall be completely immersed in the liquid – the depth of immersion above the tube is at least 50 mm.
- The values of the power dissipated by the heating elements mentioned in the table (page 2) cannot be exceeded

(18) Essential Health and Safety Requirements: covered by the standards listed at 9 and by the descriptive documents of the manufacturer

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VARIATION

EC TYPE EXAMINATION CERTIFICATE N° ISSeP08ATEX008X/1

(14) Equipment: housing for electrical heating apparatus type D-8640

(15) Subject to the variation:
To allow the manufacturing of this equipment under the name of the mother company JEVI A/S located at Godthaabsvej 7 – 7100 Vejle – Denmark

Marking : Unchanged except the addition of the name and address of the mother company

Eventual Prescriptions :
Ambient temperature range: -30°C ≤ Tamb ≤ +50°C

(16) Report n°09103 of 5.10.2009 (5 pages) completed by the descriptive documents below:
The drawings
953.D8615-11 of 10.09.2009
953.D8640-22 of 7.05.2007 – Rev.2 of 2.10.2009
953.D8640-23 of 7.05.2007 – Rev.2 of 2.10.2009

(17) Special conditions for safe use: unchanged

(18) Essential Health and Safety Requirements: covered by the standards listed at point 9 of the initial certificate and by the descriptive documents of the manufacturer.

Colfontaine, 07.10.2009

Marcel Lambert,
Manager.

INSTITUT SCIENTIFIQUE DE SERVICE PUBLIC
Zoning A. Schweitzer - B 7340 Colfontaine (Wasmes)
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VARIATION

EC TYPE EXAMINATION CERTIFICATE N° ISSeP08ATEX008X/2

(14) Apparatus: Housing for electrical heating apparatus type D-8640.

(15) Subject of the variation

- To permit the extension of the ambient temperature range. This one becomes: -50 °C ≤ Ta ≤ +50 °C.
- To permit the updating of the certificate according to the latest edition of the standards in force. (IEC 60079-0: 2011 – EN 60079-1: 2007 – EN 60079-7: 2007 – EN 60079-31: 2009)

Marking: Unchanged, except the code « Ex de IIC T6 to T1 / Ex tD A21 IP66 T110°C » which is now « Ex d IIC T6…T1 Gb / Ex tb IIIC T110°C Db ».

Eventual prescriptions: Unchanged.

(16) Report N° 12032 completed by 10 documents.

(17) Special conditions for safe use: Unchanged.

(18) Essential Health and Safety Requirements

- Covered by the standards listed at point 9 of the initial certificate.

Colfontaine, 27.08.2012.

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colfontaine@issep.be

Marcel LAMBERT,
Director.

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4.10 EA01-WD01 and EA02-WD01 – Control Cable for Immersion Heater, CLASSIC 135 CH

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LAPP

LEISTUNGSERKLÄRUNG
Gemäß Anhang III der Verordnung (EU) Nr. 305/2011

Declaration of Performance
According to Annex III of Regulation (EU) no. 305/2011

Dokument-Nr.
Document-no.

UILCPRDoP17_1123460-1_C

1. Eindeutiger Kenncode des Produkttyps
Unique identification code of the product type

OELFLEX_CLASSIC_135_CH_BK-1

2. Verwendungszweck
Usage
Kabel und Leitungen für allgemeine Anwendungen in Bauwerken in Bezug auf die Anforderungen an das Brandverhalten
Cables for general applications in construction works subject to reaction to fire requirements

3. Hersteller
Manufacturer

U.I. Lapp GmbH
Schulze-Delitzsch-Straße 25
D-70565 Stuttgart

4. System zur Bewertung und Überprüfung der Leistungsbeständigkeit
System of assessment and verification of constancy of performance

System 3

5. Harmonisierte Norm
Harmonised standard

EN 50575:2014 + A1:2016

6. Produktzertifizierungsstelle
Product certification body

No. 0366

7. Erklärte Leistung
Declared Performance

Wesentliche Merkmale *Essential characteristics*	Leistung *Performance*	Harmonisierte technische Spezifikation *Harmonized technical standard*
Brandverhalten *Reaction to fire*	**Dca-s3-d2-a3**	**EN 50575:2014 + A1:2016**
Gefährliche Stoffe *Hazardous substances*	**NPD**	

8. Die Leistung des in Nummer 1 genannten Produkts ist in Übereinstimmung mit der erklärten Leistung in Punkt 7.
The performance of the referred product in paragraphs 1 is in conformity with the declared performance in Section 7.

Diese Leistungserklärung ist ausgestellt unter der allgemeinen Verantwortung des unter Punkt 3 genannten Herstellers.
This declaration of performance is issued under the general responsibilities listed in section 3. Manufacturer.

Unterzeichnet für und im Namen des Herstellers von:
Signed for and in name of the manufacturer by:

Stuttgart, 12.05.2021
U.I.Lapp GmbH
Leiter Kabelentwicklung
Head of Cable Development

i.V. Alexander Terpe

U.I. Lapp GmbH
Schulze-Delitzsch-Straße 25
70565 Stuttgart
Tel.: +49 (0)7 11/78 38-01
Fax: +49 (0)7 11/78 38-26 40
E-Mail: info@lappkabel.de
www.lappkabel.de

Registergericht
Stuttgart HRB 12720

Geschäftsführer
Matthias Lapp, Dr. Matthias Kirchherr,
Boris Katic, Lutz Grotebrune

Vorsitzende des Aufsichtsrats
Andreas Lapp

Niederlassung
Hannover

Ein Unternehmen der Lapp Gruppe

Lapp Insulator ist kein
Unternehmen der Lapp Gruppe

FM PD 0802/02_04.21

Seite 1 von 1

4.11 EA01..02 – Cable Gland for Immersion Heater, ICG 653 UNIV Os M20

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	**IECEx CML 18.0131X**	Page 1 of 4	Certificate history:
Status:	**Current**	Issue No: 4	Issue 3 (2021-09-29) Issue 2 (2020-04-20) Issue 1 (2020-02-11) Issue 0 (2019-05-10)
Date of Issue:	2024-03-26		

Applicant: **Hawke International (A Division of Hubbell Limited) (A Member of the Hubbell group of companies)**
Oxford Street West
Ashton under Lyne
OL7 0NA
United Kingdom

Equipment: **Ranges of Barrier and Diaphragm Seal Hybrid Cable Glands**

Optional accessory:

Type of Protection: **Flameproof "db", Increased Safety "eb", Restricted Breathing "nR", Dust Ignition "tb"**

Marking: Ex db IIC Gb
Ex eb IIC Gb
Ex tb IIIC Db

-60°C to +80°C

Approved for issue on behalf of the IECEx Certification Body: **H M Amos**

Position: **Technical Specialist**

Signature: (for printed version)

Date: (for printed version) March, 26, 2024

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting www.iecex.com or use of this QR Code.

Certificate issued by:

Eurofins E&E CML Limited
Unit 1, Newport Business Park
New Port Road
Ellesmere Port, CH65 4LZ
United Kingdom

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 18.0131X** Page 2 of 4

Date of issue: 2024-03-26 Issue No: 4

Manufacturer: **Hawke International (A Division of Hubbell Limited) (A Member of the Hubbell group of companies)**
Oxford Street West
Ashton under Lyne
OL7 0NA
United Kingdom

Manufacturing locations:

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements.This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-1:2014 Edition:7.0	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
IEC 60079-31:2013 Edition:2	Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t"
IEC 60079-7:2017 Edition:5.1	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Reports:

GB/CML/ExTR18.0186/00
GB/CML/ExTR19.0255/00
GB/CML/ExTR20.0050/00
GB/CML/ExTR21.0018/00
GB/CML/ExTR23.0028/00

Quality Assessment Report:

GB/BAS/QAR06.0061/10

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 18.0131X** Page 3 of 4

Date of issue: 2024-03-26 Issue No: 4

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

Refer to Annex for full description and conditions of manufacture.

SPECIFIC CONDITIONS OF USE: YES as shown below:
Refer to Annex for specific conditions of use.

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 18.0131X** Page 4 of 4

Date of issue: 2024-03-26 Issue No: 4

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above)
Refer to certificate annex for details of changes.

Annex:

Certificate Annex IECEx CML 18.0131X Issue 4.pdf

eurofins cml

Annexe to:	IECEx CML 18.0131X Issue 4
Applicant:	Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of companies)
Apparatus:	Ranges of Barrier and Diaphragm Seal Hybrid Cable Glands

Description

The ranges of cable glands are designed in two versions: barrier and diaphragm seal. Hybrid configurations of these glands are also described.

All cable glands within the ranges are manufactured in brass, nickel plated brass, stainless steel, or aluminium.

Both barrier and diaphragm seal type glands internal parts marked with an asterisk (*) in the description below are interchangeable with respect to the type of application. When parts are interchanged, these assemblies may be dual marked with both product types on the stamp band. The "Deluge Boot" colour indicates the internal component that is used, the ICG/653/UNIV being indicated by a red deluge boot. This does not apply to the ICG 653 UNIV J-Size.

Cable glands may be fitted with an optional external clamp or a Hawke Gland Mounted Clamp (GMC) accessory. When fitted, no additional clamping is required on the barrier or diaphragm sealed glands.

Items in *italic* are optional and may be omitted from the cable gland dependent on the application.

Hybrid cable glands are available for the gland types ICG/653/UNIV and 501/453/UNIV. These types are fitted with the middle nut and back nut components of any smaller trade size compared to the entry. Glands may combine entries and seals with small armour clamping rings and back nut seals. Hybrid gland marking to include second size reference with no spaces e.g. for example C2 to C hybrid size reference would be C2C.

The use of Hawke IP sealing washers may be considered a suitable sealing method to maintain IP rating to the enclosure (see conditions of use) and will maintain the service temperature.

Where marked IIC or IIIC, the equipment can also be marked for gas groups IIA or IIB and for dust groups IIIA or IIIB.

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Company Reg No. 8554022 VAT No. GB163023642

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Type 501/453/UNIV Cable Gland

501/453/UNIV cable gland is a diaphragm seal cable gland the glands are fitted with a diaphragm silicone rubber seal and are designed for effectively filled type cable when used for flameproof applications. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes Os (M16) up to and including F(M75). The entry thread form can either be metric or NPT equivalent. They are used with cables that are circular and armoured, un-armoured or braided cables. The cable gland comprises the following components:

a) Entry
b) Deluge boot *
c) Diaphragm seal *
d) Spigot *
e) Armour clamping ring
f) Middle nut
g) Back nut
h) Back nut clamp
i) Back nut seal

Type ICG/653/UNIV Cable Gland

The ICG/653/UNIV Cable Gland is a barrier seal type gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or corrugated cables. This cable gland is available in sizes Os (M16) up to and including J (M100). The entry thread form is either metric or NPT equivalent. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. Trade size J is IP66 only.
The cable gland comprises the following components:

a) Entry
b) Deluge boot*
c) Compound chamber*
*d) Resin dam **
e) Spigot*
*f) VBL Clip **
g) Armour/braid clamping ring
h) Middle nut
i) Back nut
j) Back nut clamp
k) Back nut seal

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Type 710 Cable Gland

The 710 Cable gland is a barrier cable gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or corrugated cables. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes Os (M16) up to and including F (M75). The entry thread form is either metric or NPT equivalent. The cable gland comprises the following components:

a) Entry
b) Deluge boot
c) Compound chamber
d) Resin dam
e) Spigot
f) Middle nut
g) Back nut
h) Back nut clamp
i) Back nut seal

Type 711 Cable Gland

711 Cable gland is a barrier cable gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or corrugated cables. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes A (M20) up to and including F (M75). The entry thread form is either metric or NPT equivalent. The cable gland comprises the following components:

a) Entry
b) Deluge boot
c) Compound chamber
d) Resin dam
e) Front diablo support
f) Diablo cage
g) Rear diablo support
h) Middle nut
i) Back nut
j) Back nut clamp
k) Back nut seal

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TEMPLATE FRM5100236 0H

Ballard Confidential

Printed on: Wednesday, March 19, 2025

Type 753 Cable Gland

753 cable gland Cable gland is a barrier cable gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or braided cables. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes Os (M16) up to and including F(M75). The entry thread form is either metric or NPT equivalent. The cable gland comprises the following components:

a) Entry
b) Deluge boot
c) Compound chamber
d) Resin dam
e) Spigot
f) Middle nut
g) Back nut
h) Back nut clamp
i) Back nut seal

Cable glands types ICG/653/UNIV, 710, 711 and 753, in trade sizes Os to F, have been subjected to overpressure test up to 62bar/900 Psi.

Variation 1

1. To update the certification drawing with minor dimensional corrections.
2. To include the type of protection “Ex nR” Restricted Breathing.
3. To include an additional specific condition of use for braided cables.

Variation 2

1. Introduction of undersize compound pot for gland size Os, O, D, E and F.
2. Introduction of thread size M16 for size Os and O, except from gland type 711.
3. Adding NPT thread size: 1½”, 2”, 2½” for gland size D, E and F respectively.

Variation 3

1. To amend the specific conditions of safe use.
2. Update GA drawings.
3. Add accessory optional item GMC 'Gland Mounted Clamp'.
4. Clarify the Ingress Protections IP ratings.
5. To review and update the cable glands against the latest standard.
6. Hybrid Gland Combinations to permit flexibility.
7. Update the marking.
8. To revise the equipment title.
9. To revise the product description.

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Variation 4

1. To introduce and update the certification product description to include type ICG 653 oversize cable gland J-Size.
2. Removal of Ex nR from IECEx CML 18.0131X.
3. To review and assess the ICG 653 Oversize cable glands J-Size against the latest technical knowledge IEC 60079-0:2017 Ed.7.
4. To review the ICG 653 Oversize cable gland J-Size against the latest Increase Safety requirements "Ex eb".
5. To amend the specific condition of safe use.
6. To remove the condition of manufacture.
7. Introduction of new set of certification drawings.

Conditions of Manufacture

None

Specific Conditions of Use

The following conditions relate to safe installation and/or use of the equipment.

i. 501/453/UNIV when used with unarmoured or braided cables are only suitable for fixed installations, the cable for which shall be effectively clamped to prevent pulling and twisting (does not apply when fitted with rear clamping device or Hawke Gland Mounted Clamp (GMC)).

ii. Barrier glands of sizes C2, D, E and F and containing (Express) XO99-41-2 resin when used with unarmoured or braided cables are only suitable for fixed installations, the cable for which must be effectively clamped to prevent pulling and twisting. No clamping is required on barrier cable glands sizes Os-C2, or if containing 2122 Hawkeseal or 2132 QSP compound.

iii. The entry thread shall be suitably sealed (in accordance with IEC 60079-14) to maintain the ingress protection rating of the associated enclosure. This condition does not apply if the Hawke International nylon sealing washer is installed as part of the gland assembly.

Components covered by Ex Certificates issued to older editions of Standards

None

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TEMPLATE FRM5100236 0H

Ballard Confidential

Printed on: Wednesday, March 19, 2025

4.12 QM1.1..1.6 and QM2.1..2.6 – Solenoid Valve, NF X E210D488E 24/DC

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ATTESTATION D'EXAMEN UE DE TYPE
EU TYPE EXAMINATION CERTIFICATE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

	Directive 2014/34/UE	**Directive 2014/34/EU**
2	Appareil ou Système de Protection destiné à être utilisé en Atmosphères Explosibles	Equipment or Protective System Intended for use in Potentially Explosive Atmospheres
3	Produit : Tête magnétique	Product : Magnetic head
	Type: *NF-*	
4	Fabricant :	Manufacturer :
	ASCO SAS	
5	Adresse :	Address :
	53 rue de Beauce 28110 Lucé FRANCE	
6	Ce produit et ses variantes éventuelles acceptées sont décrits dans l'annexe de la présente attestation et dans les documents descriptifs cités en référence.	This product and any acceptable variations thereto are specified in the schedule to this certificate and the documents therein referred to.
7	Le LCIE, Organisme Notifié sous la référence 0081 conformément à l'article 17 de la directive 2014/34/UE du Parlement européen et du Conseil du 26 février 2014, certifie que ce produit est conforme aux Exigences Essentielles de Sécurité et de Santé pour la conception et la construction de produits destinés à être utilisés en atmosphères explosibles, données dans l'annexe II de la Directive.	LCIE, Notified Body number 0081 in accordance with article 17 of the Directive 2014/34/EU of the European Parliament and the Council of 26 February 2014 certifies that product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres, given in Annex II to the Directive.
	Les résultats des vérifications et essais figurent dans le(s) rapport(s) confidentiel(s) N° :	The examination and test results are recorded in confidential report(s) N°:
	19 547 010 ; 36439010 ; 43226010 ; 60014591-507770 ; 60054967-555404/01 ; 84176-574816 ; 90110-581349 ; 96896-592747 ; 99828-598318 ; 106456-611161 ; 117816-635598-01 ; 120216-640042 ; 140308-682225 ; 143136-689151 – CR22/05/17 ; 158525-730110	
8	Le respect des Exigences Essentielles de Sécurité et de Santé est assuré par la conformité à :	Compliance with the Essential Health and Safety Requirements has been assured by compliance with :
	EN 60079-0:2012 + A11:2013 ; EN 60079-1:2014 ; EN 60079-31:2014	
9	Le signe « X » lorsqu'il est placé à la suite du numéro de l'attestation, indique que cet appareil est soumis aux conditions particulières d'utilisation, mentionnées dans l'annexe de cette attestation.	If the sign "X" is placed after the certificate number, it indicates that the product is subject to the Specific Conditions of Use specified in the schedule to this certificate.
10	Cette Attestation d'Examen UE de Type concerne uniquement la conception et la construction du produit spécifié. Des exigences supplémentaires de la directive sont applicables pour la fabrication et la fourniture du produit. Ces dernières ne sont pas couvertes par la présente attestation.	This EU Type Examination Certificate relates only to the design and construction of the specified product. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.
11	Le marquage du produit est mentionné dans l'annexe de cette attestation.	The marking of the product is specified in the schedule to this certificate.

Fontenay-aux-Roses, le 31 janvier 2019

Responsable de Certification
Certification Officer
Julien Gauthier

LABORATOIRE CENTRAL DES INDUSTRIES ELECTRIQUES
S.A.S au capital de 15.745.984 €
RCS Nanterre B 408 363 174
33 avenue du Général Leclerc
F - 92266 FONTENAY AUX ROSES

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Une société de Bureau Veritas

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92260 Fontenay-aux-Roses
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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

12 **DESCRIPTION DU PRODUIT**

Le produit est constitué d'une enveloppe en aluminium ou en acier inoxydable contenant une bobine et deux bornes de connexions.

Il fonctionne sur différentes puissances (AC-DC). Il est conçu pour être utilisé avec des vannes avec 2, 3, 4 ou 5 voies.

Les types de protection sont « d » (enveloppe antidéflagrante) et « t » (protection contre l'inflammation des poussières).

Il y a également 2 versions spéciales où les caractéristiques électriques sont différentes, à la demande de clients.

DESCRIPTION OF PRODUCT

The product is made of an aluminium or stainless steel enclosure including a coil and two connections terminals.

It operates on different wattage (AC-DC). It is designed to be used in conjunction with valves with 2, 3, 4 or 5 channels.

The types of protection are "d" (flameproof enclosure) and "t" (dust ignition protection).

There is also 2 specific version where the electrical ratings are different, at customer's request.

DETAIL DE LA GAMME

* | NF | - | *

Modèle de la bobine
MXX
M12-I
M12-II

Matière de l'enveloppe
WS = Acier inoxydable
Vide = Aluminium

Note : les bobines se distinguent par leurs dimensions.

Pour la version spéciale NF 14462403.24/DC :

* | NF | - | M12-II

Modèle de la bobine
M12-II

Matière de l'enveloppe
WS = Acier inoxydable
Vide = Aluminium

Pour la version spéciale X263429069235F1:

* | NF | - | MXX

Modèle de la bobine
MXX

Matière de l'enveloppe
WS = Acier inoxydable
Vide = Aluminium

RANGE DETAILS

* | NF | - | *

Model of coil
MXX
M12-I
M12-II

Material enclosure
WS = Stainless steel
Blank = Aluminium

Note: the coils are distinguished by their dimension.

For the specific version NF 14462403.24/DC :

* | NF | - | M12-II

Model of coil
M12-II

Material enclosure
WS = Stainless steel
Blank = Aluminium

For the specific version X263429069235F1:

* | NF | - | MXX

Model of coil
MXX

Material enclosure
WS = Stainless steel
Blank = Aluminium

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
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1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

CARACTERISTIQUES

Tension d'alimentation :
6 à 250 V DC / rectifié ou 6 à 380 V AC.

Pour la version spéciale NF 14462403.24/DC :

Tension d'alimentation : 24 V DC
Puissance maximale : 36.2 W
Fonctionnement électrique intermittent :
- Temps de fonctionnement = 2 minutes
- Temps à l'arrêt = 5 minutes
Température maximale du fluide : 55°C.

Pour la version spéciale X263429069235F1 :

Tension d'alimentation : 24 V DC
Puissance maximale : 11.2 W
Fonctionnement électrique intermittent :
- Temps de fonctionnement = 2 minutes
- Temps à l'arrêt = 15 minutes
Température maximale du fluide : 70°C.

RATINGS

Supply voltage :
6 to 250 V DC / rectified or 6 to 380 V AC.

For the specific version NF 14462403.24/DC :

Supply voltage : 24 V DC
Maximum power : 36.2W
Electric operation intermittent :
- Time on = 2 minutes
- Time off = 5 minutes.
Maximum fluid temperature: 55°C.

For the specific version X263429069235F1 :

Supply voltage : 24 V DC
Maximum power : 11.2W
Electric operation intermittent :
- Time on = 2 minutes
- Time off = 15 minutes.
Maximum fluid temperature: 70°C.

MARQUAGE

Le marquage du produit doit comprendre :

ASCO SAS ou ASCO™
Adresse : …
Type : *NF-* (1)
N° de fabrication : …
Année de fabrication : …
Ⓔx II 2 G D
Ex db IIC T6…220°C (T2) Gb (2)
Ex tb IIIC T85°C…T220°C Db (2)
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +…°C (2)
AVERTISSEMENTS –
NE PAS OUVRIR SOUS TENSION.
APRES MISE HORS TENSION, ATTENDRE 35 MINUTES AVANT L'OUVERTURE.
Sur la plaque de marquage :
T câble : …°C (2)
U = ….V ; I = …. A ; P = …. W (3)

(1) : complété par la désignation du type.
(2) : voir les tableaux des températures.
(3) : complété par les paramètres électriques.

MARKING

The marking of the product shall include the following :

ASCO SAS or ASCO™
Address: …
Type : *NF-* (1)
Serial number: …
Year of construction: …
Ⓔx II 2 G D
Ex db IIC T6…220°C (T2) Gb (2)
Ex tb IIIC T85°C…T220°C Db (2)
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +…°C (2)
WARNINGS –
DO NOT OPEN WHEN ENERGIZED.
AFTER DE-ENERGIZING, DELAY 35 MINUTES BEFORE OPENING.
On the marking plate :
T cable : …°C (2)
U = ….V; I = …. A; P = …. W (3)

(1): completed with type designation.
(2): see temperatures tables.
(3): completed by electrical parameters.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

MARQUAGE (suite)

Tables des températures :

- Pour une température de fluide plus basse que la température ambiante :

Classe de température *Temperature class* (Gaz / *Gas*)	Température de surface *Surface temperature* (Poussière / *Dust*)	Température ambiante max. *Max. Amb. Temp.* (°C)	Puissance maximale / *Maximum power* (W)	
			Courant alternatif *Alternating current (AC) supply*	Courant continu ou rectifié *Direct current (DC) supply or rectified*
T6	T85°C	25	17	31,5
		40	11,5	20
		60	5,5	8,5
		75	1	2,5
T5	T100°C	25	21	40,5
		40	15	32,5
		60	10,5	18
		75	6	10
T4	T135°C	25	28,5	40,5
		40	22,5	37,5
		60	19,5	32,5
		75	16,5	31
		80	15,4	25
		100	10,5	20

- Pour une température de fluide plus haute que la température ambiante :

Température ambiante max. *Max. Amb. Temp.* (°C)	Puissance maximale / *Maximum power* (W)		Température maximale du fluide *Maximum fluid temperature* (°C)			
	Courant alternatif *Alternating current (AC) supply*	Courant continu ou rectifié *Direct current (DC) supply or rectified*				
25	17	31,5	40	75	140	-
40	11,5	20	55	90	155	-
60	5,5	8,5	75	110	175	-
75	1	2,5	90	125	180	-
25	21	40,5	-	60	125	-
40	15	32,5	-	75	140	-
60	10,5	18	-	95	160	-
75	6	10	-	110	175	-
25	28,5	40,5	-	-	90	-
40	22,5	37,5	-	-	105	-
60	19,5	32,5	-	-	125	-
75	16,5	31	-	-	140	-
80	15,4	25	-	-	145	160
100	10,5	20	-	-	165	-
Classe de température / *Temperature class* (G)			T5	T4	T3	220°C
Température de surface / *Surface temperature* (D)			T100°C	T125°C	T200°C	T220°C

MARKING (continued)

Temperatures tables :

- For a fluid temperature lower than ambient temperature :

- For a fluid temperature higher than ambient temperature :

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

MARQUAGE (suite)

- Table de température pour le choix des câbles :

Température ambiante max. *Max. Amb. Temp.* (°C)	Température du câble *Cable temperature* (°C)	Puissance maximale / *Maximum power* (W)	
		Courant alternatif *Alternating current (AC)* supply	Courant continu ou rectifié *Direct current (DC) supply or rectified*
25	70	26	40,5
	80	30	-
40	70	16	23
	80	22,5	37,5
60	70	4	6
	80	10	14
	90	17	27
	100	25	40,5
75	80	1,5	4
	90	7,5	13
	100	14	24
	105	18	32
80	120	15,4	25
100	105	3	5
	110	6,5	10
	120	13,5	23,5

Pour la version spéciale NF 14462403.24/DC :

ASCO SAS ou ASCO™
Adresse : …
Type : *NF-M12-II (1)
N° de fabrication : …
Année de fabrication : …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X

-60°C ≤ Tamb ≤ +55°C

AVERTISSEMENTS –
NE PAS OUVRIR SOUS TENSION.
APRES MISE HORS TENSION, ATTENDRE 35 MINUTES AVANT L'OUVERTURE.

U = ….V ; I = …. A ; P = …. W (2)

(1) : complété par la désignation du type.
(2) : complété par les paramètres électriques.

MARKING (continued)

- Temperature table for choosing cable :

For the specific version NF 14462403.24/DC :

ASCO SAS or ASCO™
Address: …
Type : *NF-M12-II (1)
Serial number: …
Year of construction: …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X

-60°C ≤ Tamb ≤ +55°C

WARNINGS –
DO NOT OPEN WHEN ENERGIZED.
AFTER DE-ENERGIZING, DELAY 35 MINUTES BEFORE OPENING.

U = ….V; I = …. A; P = …. W (2)

(1): completed with type designation.
(2): completed by electrical parameters.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

MARQUAGE (suite)

Pour la version spéciale X263429069235F1 :

ASCO SAS ou ASCO™
Adresse : …
Type : *NF-MXX (1)
N° de fabrication : …
Année de fabrication : …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +70°C

AVERTISSEMENTS –
NE PAS OUVRIR SOUS TENSION.
APRES MISE HORS TENSION, ATTENDRE 35 MINUTES AVANT L'OUVERTURE.
U = ….V ; I = …. A ; P = …. W (2)

(1) : complété par la désignation du type.
(2) : complété par les paramètres électriques.

L'appareil doit également comporter le marquage normalement prévu par les normes de construction qui le concernent sous la responsabilité du fabricant.

MARKING (continued)

For the specific version X263429069235F1 :

ASCO SAS or ASCO™
Address: …
Type : *NF-MXX (1)
Serial number: …
Year of construction: …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +70°C

WARNINGS –
DO NOT OPEN WHEN ENERGIZED.
AFTER DE-ENERGIZING, DELAY 35 MINUTES BEFORE OPENING.
U = ….V; I = …. A; P = …. W (2)

(1): completed with type designation.
(2): completed by electrical parameters.

The equipment shall also bear the usual marking required by the product standards applying to such equipment under the manufacturer responsibility.

13 **CONDITIONS PARTICULIERES D'UTILISATION**

a. Les joints antidéflagrants ne sont pas destinés à être réparés.

b. Les fermetures spéciales du couvercle sont des vis hexagonales à six pans creux conformes à l'ISO 4762. La classe de propriété minimale des vis doit être A4-70. Le cas échéant, les vis du couvercle doivent être remplacées par des vis identiques.

c. Le classement en température dépend de la température ambiante. Voir tableaux des températures.

SPECIFIC CONDITIONS OF USE

The flameproof joints are not intended to be repaired.

The special fasteners of the cover are hexagon socket head cap screws conforming to ISO 4762. The minimum grade of screws must be A4-70. If any, the screws shall only be replaced with identical ones.

The temperature class depend on ambient temperature. See temperature tables.

14 **EXIGENCES ESSENTIELLES DE SANTE ET DE SECURITE**

Couvertes par les normes listées au point 8.

ESSENTIAL HEALTH AND SAFETY REQUIREMENTS

Covered by standards listed at 8.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

15 **DOCUMENTS DESCRIPTIFS** / **DESCRIPTIVE DOCUMENTS**

N°	Description	Reference	Rev.	Date	Page(s)
1.	Dossier technique, tête magnétique type (WS)NF. *Technical file, magnetic solenoid (WS)NF type.*	293584	M	2018/11/22	37
2.	Notice d'instruction ((WS)NF – MXX) *Installation and maintenance instruction, Flameproof solenoid operator ((WS)NF – MXX)*	AJN 123620-794	--	--	--
3.	Notice d'instruction ((WS)NF – M12 – II) *Installation and maintenance instruction, Flameproof solenoid operator ((WS)NF – M12 – II)*	AJN 123620-793	--	--	--
4.	Notice d'instruction ((WS)NF – M12 – I) *Installation and maintenance instruction, Flameproof solenoid operator ((WS)NF – M12 – I)*	AJN 123620-795	--	--	--
5.	Notice d'instruction NF/WSNF – MXX (Version X263429069235F1) *Installation and maintenance instruction, Flameproof solenoid operator NF/WSNF – MXX (Version X263429069235F1)*	536657-001	--	--	--

16 **INFORMATIONS COMPLEMENTAIRES** / **ADDITIONAL INFORMATIONS**

Essais individuels

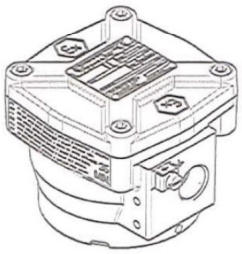
N/A

Routine tests

N/A

Vue générale

Apparatus overview



Sites de fabrication additionnels

ASCO SAS
53 rue de Beauce
28110 LUCE, FRANCE

ASCO JOUCOMATIC Ltd
2 Pit Hey Place
West Pimbo
SKELMERSDALE Lancashire WN8 9PG,
ROYAUME-UNI

ASCO CONTROLS B.V.
Neonstraat 3
6718 WX Ede, PAYS-BAS

Additional manufacturing locations

ASCO SAS
53 rue de Beauce
28110 LUCE, France

ASCO JOUCOMATIC Ltd
2 Pit Hey Place
West Pimbo
SKELMERSDALE Lancashire WN8 9PG,
UNITED KINGDOM

ASCO CONTROLS B.V.
Neonstraat 3
6718 WX Ede, The NETHERLANDS

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CERT-ATEX-FORM 04 Rev. 05

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

INFORMATIONS COMPLEMENTAIRES (suite)

Sites de fabrication additionnels (suite)

ASCO NUMATICS SP .Z.O.O
Kurczaki 132
93331 Lodz, POLOGNE

ASCO L.P.
160 Park Avenue, Florham Park
New Jersey 07932, USA

ASCO L.P.
1561 Colombia Highway
Aiken, South Carolina 29801, USA

ASCOTECH, SA de C.V
Circuito del progresso, #27
Parque Industrial Progresso, Mexicali
Baja California 21190 MEXIQUE

ASCO NUMATICS (India) Pvt.Ltd,
57, Kundrathur Main Road,
Gerugambakkam,Porur
Chennai. 600128, Tamilnadu, INDE

ASCO VALVE (Shanghai) Co. Limited
No. 480, Xin Miao N°.3 Road, Xia Qiao Town,
Song Jiang District
Shanghai 201612, P.R. CHINE

ASCO Japan Co, Ltd
1-20 Takahata-cho, Nishinomiya, Hyogo
663-8202, JAPON

ASCO ASIA
Block 4008, Ang Mo Kio Avenue 10
#04- 08/10/17/22, Techplace 1
569625, SINGAPOUR

Conditions de certification

Les détenteurs d'attestations d'examen UE de type doivent également satisfaire les exigences de contrôle de production telles que définies à l'article 13 de la Directive 2014/34/UE.

En accord avec l'Article 41 de la Directive 2014/34/UE, les attestations d'examen CE de type mentionnant la Directive 94/9/CE émises avant la date d'application de la Directive 2014/34/UE (20 avril 2016) peuvent être considérées comme émises en accord avec la Directive 2014/34/UE. Les nouvelles versions de ces attestations peuvent conserver le numéro de l'attestation d'origine émise avant le 20 avril 2016.

ADDITIONAL INFORMATIONS (continued)

Additional manufacturing locations (continued)

ASCO NUMATICS SP .Z.O.O
Kurczaki 132
93331 Lodz, POLAND

ASCO L.P.
160 Park Avenue, Florham Park
New Jersey 07932, USA

ASCO L.P.
1561 Colombia Highway
Aiken, South Carolina 29801, USA

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Baja California 21190 MEXICO

ASCO NUMATICS (India) Pvt.Ltd,
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Gerugambakkam,Porur
Chennai. 600128, Tamilnadu, INDIA

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Shanghai 201612, P.R. CHINA

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1-20 Takahata-cho, Nishinomiya, Hyogo
663-8202, JAPAN

ASCO ASIA
Block 4008, Ang Mo Kio Avenue 10
#04- 08/10/17/22, Techplace 1
569625, SINGAPORE

Conditions of certification

Holders of EU type examination certificates are also required to comply with the production control requirements defined in article 13 of Directive 2014/34/EU.

In accordance with Article 41 of Directive 2014/34/EU, EC-Type Examination Certificates referring to Directive 94/9/EC that were in existence prior to the date of application of Directive 2014/34/EU (20 April 2016) may be referenced as if they were issued in accordance with Directive 2014/34/EU. New issues of such certificates may continue to bear the original certificate number issued prior to 20 April 2016.

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Une société de Bureau Veritas

33 Avenue du Général Leclerc
92260 Fontenay-aux-Roses
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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

17 **DETAILS DES MODIFICATIONS DE L'ATTESTATION**

Version 00 : 02/03/2001	Version initiale selon les normes suivantes : - EN 50014:1997, - EN 50018:1994.
Version 01 : 18/01/2002	Possibilité d'utiliser l'équipement en atmosphère poussières.
Version 02 : 10/09/2002	Modification du dossier technique.
Version 03 : 28/11/2003	Diminution de la température ambiante minimale à -60°C.
Version 04 : 10/09/2007	Mise à jour normative suivant les normes suivantes : - EN 60079-0:2006, - EN 60079-1:2004, - EN 61241-0:2006, - EN 61241-1:2004. Mise à jour des classements en température.
Version 05 : 23/10/2008	Ajout de sites de production.
Version 06 : 05/03/2009	Ajout d'un site de production.
Version 07 : 25/02/2010	Ajout d'un site de production. Modification du dossier technique.
Version 08 : 12/10/2010	Mise à jour normative suivant les normes suivantes : - EN 60079-0:2009, - EN 60079-1:2007, - EN 61241-1:2004. Mise à jour des classements en température.
Version 09 : 27/12/2011	Mise à jour normative suivant la norme EN 60079-31:2009.
Version 10 : 08/03/2013	Mise à jour de la liste des sites de production.
Version 11 : 25/04/2013	Ajout d'un nouveau site de production.
Version 12 : 25/02/2016	Changement du nom de la société. Mise à jour normative suivant les normes suivantes : - EN 60079-0:2012 + A11:2013, - EN 60079-31:2014. Ajout d'un nouveau site de production.
Version 13 : 25/10/2016	Ajout d'une version spéciale codifiée NF 14462403.24/DC, pour le type *NF-M12-II. Mise à jour suivant la norme EN 60079-1:2014.

DETAILS OF CERTIFICATE CHANGES

Issue 00 : 2003/03/02	Initial issue according to following standards: - EN 50014:1997, - EN 50018:1994.
Issue 01 : 2002/01/18	Possibility to use the equipment in dust atmosphere.
Issue 02 : 2002/09/10	Technical file modification.
Issue 03 : 2003/11/28	Decrease of minimal ambient operating temperature to -60°C.
Issue 04 : 2007/09/10	Normative update according to following standards : - EN 60079-0:2006, - EN 60079-1:2004, - EN 61241-0:2006, - EN 61241-1:2004. Update of temperature classes.
Issue 05 : 2008/10/23	Addition of manufacturing locations.
Issue 06 : 2009/03/05	Addition of a manufacturing location.
Issue 07 : 2010/02/25	Addition of a new manufacturing location. Technical file modification.
Issue 08 : 2010/10/12	Normative update according to following standards : - EN 60079-0:2009, - EN 60079-1:2007, - EN 61241-1:2004. Update of temperature tables.
Issue 09 : 2011/12/27	Normative update according to standard EN 60079-31:2009.
Issue 10 : 2013/03/08	Update of manufacturing locations list.
Issue 10 : 2013/04/25	Addition of a new manufacturing location.
Issue 12 : 2016/02/25	Change of company name. Normative update according to following standards : - EN 60079-0:2012 + A11:2013, - EN 60079-31:2014. Addition of a new manufacturing location.
Issue 13 : 2016/10/25	Addition of a specific version, codified NF 14462403.24/DC for type *NF-M12-II. Normative update according to standard EN 60079-1:2014.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

DETAILS DES MODIFICATIONS DE L'ATTESTATION (suite)

Version 14 : 26/07/2017	Correction de la version 13 (mise à jour du marquage et de la description du produit). Nouvelle détermination de la pression d'explosion. Mise à jour des conditions particulières d'utilisation. Mise à jour de la liste des sites de production.
Version 15 :	Ajout d'une version spéciale codifiée X263429069235F1, pour le type *NF-MXX. Mise à jour de la liste des sites de production. Clarification sur la définition du type.

DETAILS OF CERTIFICATE CHANGES (continued)

Issue 14 : 2017/07/26	Correction of the issue 13 (update marking and description of product). New determination of explosion pressure. Update of specific conditions of use. Update of manufacturing locations list.
Issue 15 :	Addition of a specific version, codified X263429069235F1, for type *NF-MXX. Update list of manufacturing locations. Clarification of type definition.

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4.13 QM1.1..1.6 and QM2.1..2.6 – 1/2" NPT to M20 Adaptor, ADU102904

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EU TYPE-EXAMINATION CERTIFICATE

1. **EU type-examination Certificate (Module B)**
2. **Equipment or Protective System intended for use in potentially explosive atmospheres (Directive 2014/34/EU)**
3. **EU type examination certificate Nr** **ITS16ATEX101339X R.1**
4. **Product:** AD-U, AM-D/AM-U, AF-U, AD-E4 Thread Adapters, RD-U, RD-E4 Reducers and AE-E Earthlead Adapters, Reducers, UN-D / UN-U, UF-D / UF-U, FB and FL Unions
5. **Manufacturer:** EATON ELECTRICAL SYSTEMS Ltd Trading as Eaton, Raxton, Redapt or Capri
   Applicant: EATON ELECTRICAL SYSTEMS Ltd Trading as Eaton, Raxton, Redapt or Capri
6. **Address:** Kingsway South Westgate, Aldridge West Midlands WS9 8FS
   Address: Kingsway South Westgate, Aldridge West Midlands WS9 8FS
7. This product and any acceptable variation thereto are specified in the schedule to this certificate and therein referred to.
8. INTERTEK ITALIA S.p.A., Notified Body n° 2575 in accordance with article 17 of the Directive 2014/34/EU of the European Parliament and Council of the 26 February 2014, certifies that the equipment or protective system has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective system intended for use in potentially explosive atmosphere, given in Annex II of the Directive.

   The examination and tests results are recorded in confidential technical evaluation Intertek Report Nr. 105332195LHD-001 dated 31st August 2023.
9. Compliance with the Essential Health and Safety Requirements has been assured by compliance with EN IEC 60079-0:2018, EN 60079-1:2014, EN IEC 60079-7:2015+A1:2018 and EN 60079-31:2014 except in respect of those requirements referred to at item 16 of the Schedule.
10. If the sign X is placed after the certificate number, it indicates that the product is subject to Specific Conditions of Use specified in the schedule to this certificate.
11. This EU-Type Examination Certificate relates only to the design and construction of the specified product. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.
12. The marking of the product shall include the following:

Types AD-U, AM-D/AM-U, AF-U Thread Adapters, RD-U Reducers and UN-D / UN-U, UF-D / UF-U, FB and FL Unions (Mining not applicable to Aluminium version)

I M2 Ex db I Mb
II 2 G Ex db IIC Gb
I M2 Ex eb I Mb
II 2 G Ex eb IIC Gb
II 2D Ex tb IIIC Db

Type AE-E earth lead Adapters, Reducers (Mining not applicable to Aluminium version)

I M2 Ex eb I Mb,
II 2G Ex eb IIC Gb,
II 2D Ex tb IIIC Db

Type AD-E 4 Thread Adapters or RD-E4 Reducers

II 2G Ex eb IIC Gb,
II 2D Ex tb IIIC Db

Certificate issue date

1st September 2023

Mark Newman
Certification Officer
Intertek Italia S.p.A. (NB 2575)

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

PDR N° 277B

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC

Signatory of EA, IAF and ILAC Mutual Recognition Agreements

This Certificate is for the exclusive use of Intertek's client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this Certificate. Only the Client is authorized to permit copying or distribution of this Certificate and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek.

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SCHEDULE

EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

13. **DESCRIPTION OF THE EQUIPMENT OR PROTECTIVE SYSTEM**

Adaptors and Reducers
The ranges of thread adaptors and reducers each comprise a hollow body with an external male thread and an internal female thread. The devices are used to convert an existing cable entry aperture thread to a different thread form and / or size. The adaptors and reducers may optionally be machined with a groove to fit an 'o' ring seal. An increase of up to two step thread sizes is permitted on the AD-U series.

AD-U and RD-U Series – Metallic hexagonal or round bodied adaptors (AD-U) or reducers (RD-U)
Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/ Gb Ex tb IIIC Db
M12 TO M120 (or equivalent thread forms)

The **AM-D / AM-U** range of Male to Male thread adaptors each comprises a hexagon body with a male thread form at each end. The devices are used to convert an existing cable entry aperture thread to a different thread form and/or size. Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/ Gb Ex tb IIIC Db
M16 TO M90 (or equivalent thread forms)

The **AF-U** range of Female to Female thread adaptors each comprises a hexagon body with a female thread form at each end. The devices are used to convert an existing cable entry aperture thread to a different thread form and/or size. Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/ Gb Ex tb IIIC Db
M16 TO M120 (or equivalent thread forms)

Types **AD-E4** Adaptors and Types **RD-E4** Reducers are glass fibre nylon versions, 30% Glass filled Nylon is the standard material type and 40% Glass filed Nylon is a specific type. They are designed to convert an existing cable entry aperture in the associated apparatus to a different thread form and/or size. Each device comprises a hollow body with a male thread at one end and a female thread at the other. The AD-E4 is a hexagon type adaptor. The RD-E4 is a hexagon type reducer.
Coded: Ex eb IIC Gb, Ex tb IIIC Db

The **AE-E** Series range of earth lead adaptors and reducers each comprise a hexagon body with a male thread at one end and a female thread machined into the other. The devices are designed to provide a connection from a cable gland or termination to earth via a 300mm long earth lead cable riveted and soldered to the body and additionally may be used to convert an existing cable entry aperture thread to a different thread form and/or size. Coded Ex eb I/IIC Mb/Gb Ex tb IIIC Db IP6X
M16 TO M75 (or equivalent thread forms)

Type **UN-D / UN-U and FB** Male to Female Unions and **UF-D / UF-U and FL** Female to Female Unions each comprise a hexagon body, an internally threaded cone and an external nut. The devices are designed for connection when a conventional adaptor is impractical. Additionally, they may be used to convert an existing cable entry to a different thread form and/or size.
Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/Gb Ex tb IIIC Db IP6X
M16 TO M75 for FB-FL (or equivalent thread forms)
UN-D / UN-U and **UF-D / UF-U** are between M20 and M75 (or equivalent thread forms)

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SCHEDULE

EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

Thread forms Options:

ISO Metric (to BS3463), PG to DIN40430, NPT (ANSI/ASME B1.20.1), NPS (ANSI/ASME B1.20.1), ISO Pipe Thread (BS21) BSPP/BSPT, Imperial conduit ET BS31 BSP to BS21 or thread forms complying with standard EN 60079-1.

As an option for AD-E4 & ADU adaptors (Ex eb or tb application only), male threads can be drilled with holes to drain the water (when assembled with a breather drain for instance).

Material options:

Brass to BS 2874:1985
Brass to BS 2872:1989
Lead-free brass: CW724R Stainless
steel to BS 970: part4 Mild steel to
BS 970: Part 1: 1983 Aluminium
(Not for Group I) 30 % Glass filled
Nylon
40% Glass filled Nylon

CE Marking shall be accompanied by the identification number of the Notified Body responsible for surveillance of production.

14. **DRAWINGS AND DOCUMENTS**

TITLE	DOCUMENT Nr	LEVEL	DATE
*Ex d I&IIC AND Exe I&II ADAPTORS	AD-U	2	24-05-2021
*Ex accessories Safety Instructions	CAP184267	2022-03b	-
*Technical Specification	SPEC-ADAPT-RD-Rev-I-0.docx	0	2023/03/09
*Ex Accessories – Adaptors & Reducers – ATEX & IECEx (2 Pages)	MARK-ADAPT-RD-Rev-I-0.docx	0	2023/03/09
Ex e II CERTIFIED G.F.N ADAPTORS & REDUCERS	AD / RD-E4	2	09-07-2019
Ex e II CERTIFIED EARTH LEAD ADAPTORS	AE-E Adaptor	1	09-03-2016
Ex e II CERTIFIED EARTH LEAD REDUCER	AE-E Reducer	1	09-03-2016
Ex d I&IIC & Ex e I&II F x F ADAPTOR/ REDUCER	AF-U	1	08-03-2016
MALE x MALE ADAPTOR / REDUCER	AM-U	1	08-03-2016
Ex d I&IIC & Exe I &II REDUCERS	RD-U	1	08-03-2016
Exd/ Exe IIC UNIONS	UN-U/ UF-U	1	08-03-2016
FB-FL SERIES UNIONS	FB-FL	1	05-04-2016
Marking Drawing	IECExITS16.0013X ITS16ATEX101339X	1	15-11-2016

Documents marked with a '*' have been modified or added as part of the revision. Copies of the above listed documents are kept at Intertek Italia S.p.A. archive.

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EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

15. **SPECIFIC CONDITIONS OF USE**

1. When used in flameproof applications. only one adaptor or reducer is to be used with any single cable entry on the associated equipment.
2. The interfaces between these devices and the associated enclosure cannot be defined; therefore, it is the user's responsibility to ensure that the appropriate ingress protection level is maintained at these interfaces.
3. Aluminum variants are not permitted for Group I applications
4. At their point of mounting, these devices are suitable for use at the following temperatures dependent on the type of 'o'-ring:

O-ring Service temp

Material	Service Temperature
None fitted	-60°C to 200°C*
EPDM	-50°C to +100°C
Nitrile	-30°C to +80°C
Neoprene	-40°C to +80°C
Viton	-20°C to +180°C*
Silicone	-60°C to +180°C *
Fluorosilicone	-60°C to +130°C
30% Glass Filled Nylon	-30°C to +90°C
40% Glass Filled Nylon	-20°C to +45°C

Note:. The limiting temperatures specified above are de-rated by 20K according to Clause 7.2.2 'Material Selection' of EN 60079-0

Note: The maximum temperature is limited to 150°C in Group I application (Coal dust, Mining) O-ring materials affect marked with '*' above.

Note: Unless fitted with an interface sealing O-ring with lower properties, temperatures shall then be limited as per the manufacturer's instructions.

Conditions specific to type:

AD-U Adaptors and RD-U Reducers

1. When installed in Group I applications, the ADU M12 (M) to M20 (F) adaptor manufactured in brass shall be installed where the risk of impact is low

AE-E Earth Lead Adaptors and Reducer

2. At their point of mounting, these devices are suitable for use at -20°C to +40°C.

AD-E4, RD-E4

3. The adaptors/reducers, made from non-metallic material, are only suitable for installation in areas considered to be a low risk from mechanical impact.
4. The adaptors/reducers, made from non-metallic material 40% Glass Filled Nylon, shall be adequately protected from direct exposure to sunlight.

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SCHEDULE

EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

16. **ESSENTIAL HEALTH AND SAFETY REQUIREMENTS**

The relevant essential Health and Safety Requirements have been identified and assessed in Intertek Report Nr. 105332195LHD-001 dated 31st August 2023.

17. **ROUTINE (FACTORY) TESTS**

None.

18. **DETAIL OF CERTIFICATE CHANGES**

R.1 (?? August 2023):

- Add holes into threads for the Adaptors & Reducers AD-U / AD-E4 in order to drain moisture when associated with a breather.
- Update of some drawings.
- Update to EN IEC 60079-0:2018.

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4.14 QM1.1..QM1.6 and QM2.1..QM2.6 – Cable Gland for Solenoid Valve, 501/421 O M20 Brass

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eurofins

cml B.V. certification management

EU Type Examination Certificate CML 19ATEX1167X Issue 3

1 Equipment intended for use in Potentially Explosive Atmospheres Directive 2014/34/EU

2 Equipment **A Range of Cable Glands with Compression Seals**

501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474

3 Manufacturer **Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)**

4 Address **Oxford Street West, Ashton-under-Lyne, Lancashire, OL7 0NA United Kingdom**

5 The equipment is specified in the description of this certificate and the documents to which it refers.

6 CML B.V., Chamber of Commerce No 67386717, Koopvaardijweg 32, 4906CV Oosterhout, The Netherlands, Notified Body Number 2776, in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this equipment has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment intended for use in potentially explosive atmospheres given in Annex II to the Directive.

The examination and test results are recorded in the confidential reports listed in Section 12.

7 If an 'X' suffix appears after the certificate number, it indicates that the equipment is subject to conditions of safe use (affecting correct installation or safe use). These are specified in Section 14.

8 This EU Type Examination certificate relates only to the design and construction of the specified equipment or component. Further requirements of Directive 2014/34/EU Article 13 apply to the manufacture of the equipment or component and are separately certified.

9 Compliance with the Essential Health and Safety Requirements, with the exception of those listed in the confidential report, has been demonstrated through compliance with the following documents:

EN IEC 60079-0:2018 EN 60079-1:2014 EN 60079-31:2014

EN IEC 60079-7:2015+A1:2018

10 The equipment shall be marked with the following:

Ex II 2 G D

Ex db IIC Gb

Ex eb IIC Gb

Ex tb IIIC Db
IP 66/67/X8 – 10m/24h
See conditions of use for service temperature range

RvA C 640 PRODUCTS

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L A Brisk
Assistant Certification Manager

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CML 19ATEX1167X
Issue 3

11 Description

Each of the following gland types may be manufactured in brass, nickel plated brass, stainless steel or aluminium and may be supplied with agreed alternative entry thread forms.

The Type 501/421 Cable Gland is intended for use with an effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component in the size range Os to J
b) A compressible sealing ring
c) A compression spigot
d) A back nut
e) An optional earth continuity device for use with metallic sheathed cables

The Type 501/421 'Size 2K' Gland comprises the following components only: -

a) A dedicated entry component
b) A compressible sealing ring
c) A nylon skid washer
d) A threaded compression spigot

The Type 501/423 Cable Gland is intended for use with effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component, in the size range Os to J
b) Two compressible sealing rings
c) Two compression spigots
d) A middle nut
e) A back nut
f) An optional earth continuity device for use with metallic sheathed cables

The Type 501/453 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cable and comprises the following components:

a. An entry component, in the size range Os to J
b. A compressible sealing ring.
c. A combined compression spigot and armour clamping cone.
d. A reversible armour clamping ring.
e. A middle nut
f. An outer seal assembly (sleeve seal and support cage)
g. A back nut
h. An optional earth continuity device for use with metallic inner sheathed cables

The Type PSG 553 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cables of unspecified construction and comprises the following components: -

a) An entry component in the size range Os to C
b) A compressible seal designed to accept a number of individual conductors
c) A combined compression spigot and armour clamping cone
d) A reversible armour clamping ring.
e) A middle nut
f) An outer seal assembly (sleeve seal and support cage)
g) A back nut

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CML 19ATEX1167X
Issue 3

The Type 501/414 Conduit Stopping Gland is intended for use with an effectively filled and circular unarmoured cable enclosed within a conduit and comprises the following components: -

a) An entry component in the size range Os to F
b) A compressible sealing ring
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut

The Type SB474 Conduit Stopping Gland is intended for use with a number of circular conductors enclosed within a conduit and comprises the following components: -

a) An entry component in the size range O to C
b) A compressible seal designed to accept a number of individual conductors
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut.

Design option

1. The use of a 3M cold Shrink tubing to be fitted to the outer sheath of specific non-circular cables as specified in the drawing 320000, and fitted into 'Os', 'O' and 'A' sizes of the 501/453 cable glands. To ensure that the IP sealing arrangement utilizing the cable shrink tube assembly does not affect the assigned IP rating of the glands. The selection of the relevant cable gland to meet the protection concept for the cable and the enclosure it is fitted on to as detailed in EN 60079-14 remain un-affected.
2. The gland assemblies as described above are rated for ingress protection IP66 and 67.
3. Cable glands may be fitted with an optional external clamp or a second accessory option type Hawke Gland Mounted Clamp (GMC).
4. Where marked IIC or IIIC, the equipment can also be marked for gas groups IIA or IIB and for dust groups IIIA or IIIB.

Variation 1

This variation introduces the following modifications:

i. Update GA drawings.
ii. Add accessory optional item GMC 'Gland Mounted Clamp'.
iii. Clarify the ingress protection, IP ratings.
iv. To review and update the cable glands against the latest standard.
v. To include the 501/453 RAC type cable Gland.
vi. To permit the update to gland sizes.
vii. Update the marking.
viii. To revise the equipment title.
ix. To revise the product description.
x. To revise the specific conditions of use.

Variation 2

This variation introduces the following modifications, and it is is applicable to Type PSG 553 RAC Cable Gland and Type SB474 Conduit Stopping Gland.

i. To introduce a new seal design for PSG/553/RAC, sizes Os to C and SB 474, sizes O to C; as a result the product description was amended.

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CML 19ATEX1167X
Issue 3

ii. To introduce a new compressible seal which has an increased service temperature of -60°C to +100°C; to reflect this modification the product description and Specific Conditions of Use were updated.
iii. To permit minor editorial updates to the Product Description.
iv. To permit changes to the Specific Conditions of Use.
v. To remove cable gland types 501/452 RAC and PSG 421; as a result, the product description was amended.

Variation 3
This variation introduces the following modifications:

i. To modify the core diameter range on sizes O/A/B/C and B-ALT of the PSG 553 RAC and SB474 gland types and modify certification documentation.

12 Certificate history and evaluation reports

Issue	Date	Associated report	Notes
0	04 June 2019	R11908A/00	The issue of the prime certification.
1	28 Sept 2021	R13593A/00	The introduction of variation 1. (UKEX)
2	31 Mar 2022	R14930A/00	The introduction of variation 2
3	23 Aug 2023	R16380A/00	The introduction of variation 3

Note: Drawings that describe the equipment or component are listed in the Annex.

13 Conditions of Manufacture

None

14 Specific Conditions of Use (Special Conditions)

The following conditions relate to safe installation and/or use of the equipment.

i. The PSG/553/RAC and SB 474 cables glands are limited to an operating temperature range of -60°C to +80°C, unless marked “P PSG/553/RAC” and “P SB 474” respectively. In these cases, they are suitable for use with an operating temperature range of -60°C to +100°C. All other cable gland types are suitable for use with an operating temperature range of -60°C to +100°C.

ii. When the glands are used for increased safety or dust protection the entry thread shall be suitably sealed (in accordance with IEC 60079-14) to maintain the ingress protection rating of the associated enclosure. Not applicable when Hawke IP 66/67 seal is used.

iii. Glands for use with conduit, unarmoured or braided cables are only suitable for fixed installations, the cable for which must be effectively clamped to prevent pulling and twisting (does not apply when fitted with rear clamping device or Hawke Gland Mounted Clamp (GMC)).

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Certificate Annex

Certificate Number	**CML 19ATEX1167X**
Equipment	**A Range of Cable Glands with Compression Seals** **501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474**
Manufacturer	**Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)**

The following documents describe the equipment or component defined in this certificate:

Issue 0

Drawing No	Sheets	Rev	Approved date	Title
501 421	1 to 2	L	04 June 2019	General Arrangement for Unarmoured 501 421 Gland
501 421 Oversized	1 of 1	H	04 June 2019	General Arrangement for Unarmoured 501 421 Oversized Gland
501 423	1 of 1	L	04 June 2019	General Arrangement for 501/423 Gland
501 423 Oversized	1 of 1	H	04 June 2019	General Arrangement for 501/423 Oversized Gland
501 414	1 of 1	L	04 June 2019	General Arrangement for 501/414 Conduit Stopper Box (using Compression Seal)
501 452 RAC X	1 of 1	A	04 June 2019	General Arrangement of Gland Type 501/452/RAC-X
501 453 RAC X	1 of 1	A	04 June 2019	General Arrangement of Gland Type 501/453/RAC-X
PSG 553 RAC X	1 of 1	A	04 June 2019	General Arrangement for PSG 553 Gland
PSG 421	1 of 1	B	04 June 2019	General Arrangement for Unarmoured PSG 421 Glan
SB 474	1 of 1	L	04 June 2019	General Arrangement for SB 474 Gland

Issue 1

Drawing No.	Sheets	Rev	Approved date	Title
320016*	1 of 1	A	28 Sept 2021	501/453/RAC
320021*	1 of 1	A	28 Sept 2021	501/421 schedule drawing
320026*	1 of 1	A	28 Sept 2021	501/423 schedule drawing
320028*	1 of 1	A	28 Sept 2021	501/452/RAC schedule drawing
320035*	1 of 1	A	28 Sept 2021	PSG/421 schedule drawing
320037*	1 of 1	A	28 Sept 2021	PSG/553/RAC schedule drawing
320038*	1 of 1	A	28 Sept 2021	501/414 schedule drawing
320040*	1 of 1	A	28 Sept 2021	SB 474 schedule drawing

The following component drawings are common to each of the cable gland as indicated.

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Certificate Annex

Certificate Number CML 19ATEX1167X

Equipment A Range of Cable Glands with Compression Seals

501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474

Manufacturer Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)

	Drawing No.	Sheets	Rev	Approved /issued date	Title	501/421	501/423	501/452/RAC	PSG/421	PSG/553/RAC	501/414	SB 474	CSB 656N	501/453/RAC
a	320002	1 of 1	A	28-09-2021	Armour clamping ring			x		x				x
b	320009	1 of 1	A	28-09-2021	Middle nut			x		x				x
c	320003	1 of 1	A	28-09-2021	Back nut seal					x				x
d	320010	1 of 1	A	28-09-2021	Back nut					x				x
e	320011	1 of 1	A	28-09-2021	Thread forms		x	x	x	x	x	x	x	x
f	320012	1 of 1	A	28-09-2021	External clamp	x				x				x
g	320082	1 of 1	A	28-09-2021	GMC	x	x			x				x
h	320031	1 of 1	A	28-09-2021	ALT Compound Chamber Entry								x	
i	320032	1 of 1	A	28-09-2021	ALT Compound Chamber								x	
j	320017	1 of 1	A	28-09-2021	Compression seal entry	x	x	x	x	x	x	x		x
k	320018	1 of 1	A	28-09-2021	Compression seal	x	x	x			x			x
l	320022	1 of 1	A	28-09-2021	Compression spigot	x	x		x					
m	320023	1 of 1	A	28-09-2021	Tail nut	x	x		x		x	x	x	
n	3027 2k	1 of 1	A	28-09-2021	Nylon skid washer	x								
o	3077 Os-2K	1 of 1	A	28-09-2021	Spigot 411/321/421 2K Gland	x								
p	320027	1 of 1	A	28-09-2021	Body nut		x							
q	320036	1 of 1	A	28-09-2021	PSG Seal				x	x		x		
r	320039	1 of 1	A	28-09-2021	Conduit gland body						x	x	x	

Issue 2

	Drawing No.	Sheets	Rev	Approved date	Title
01	320036	1 of 1	B	31 Mar 2022	PSG Seal Schedule Drawing
02	320037	1 of 1	B	31 Mar 2022	PSG/553/RAC Schedule Drawing
03	320040	1 of 1	B	31 Mar 2022	SBS474 Schedule Drawing
04	320091	1 of 1	A	31 Mar 2022	PPSG Seal Schedule Drawing

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Certificate Annex

Certificate Number	**CML 19ATEX1167X**
Equipment	**A Range of Cable Glands with Compression Seals** **501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474**
Manufacturer	**Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)**

Issue 3

Drawing No	Sheets	Rev	Approved date	Title
320091	1 of 1	B	23 Aug 2023	PPSG Seal Schedule Drawing

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres

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Certificate No.:	**IECEx CML 19.0045X**	Page 1 of 4	Certificate history:
Status:	**Current**	Issue No: 3	Issue 2 (2022-03-31) Issue 1 (2021-09-28) Issue 0 (2019-06-04)
Date of Issue:	2023-08-23		

Applicant: **Hawke International**
A Division of Hubbell Limited
A Member of the Hubbell Group of Companies
Oxford Street West
Ashton-under-Lyne
Lancashire OL7 0NA
United Kingdom

Equipment: **A Range of Cable Glands with Compression Seals 501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474**

Optional accessory:

Type of Protection: **Flameproof Ex "db", Increased Safety Ex "eb" and Dust Protection by Enclosure Ex "tb"**

Marking: Ex db IIC Gb

Ex eb IIC Gb

Ex tb IIIC Db

IP 66/67/X8-10m/24h

See conditions of use for service temperature range

Approved for issue on behalf of the IECEx Certification Body: **L A Brisk**

Position: **Assistant Certification Manager**

Signature: (for printed version)

Date: (for printed version) 23 Aug 2023

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Certificate issued by:

Eurofins E&E CML Limited
Unit 1, Newport Business Park
New Port Road
Ellesmere Port, CH65 4LZ
United Kingdom

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 19.0045X** Page 2 of 4

Date of issue: 2023-08-23 Issue No: 3

Manufacturer: **Hawke International**
A Division of Hubbell Limited
A Member of the Hubbell Group of Companies
Oxford Street West
Ashton-under-Lyne, Lancashire, OL7 0NA
United Kingdom

Manufacturing locations: **Hawke International**
A Division of Hubbell Limited
A Member of the Hubbell Group of Companies
Oxford Street West
Ashton-under-Lyne, Lancashire, OL7 0NA
United Kingdom

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements.This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-1:2014 Edition:7.0	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
IEC 60079-31:2022 Edition:3.0	Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure "t"
IEC 60079-7:2017 Edition:5.1	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Reports:

GB/CML/ExTR19.0096/00 GB/CML/ExTR21.0018/00 GB/CML/ExTR21.0314/00
GB/CML/ExTR23.0191/00

Quality Assessment Report:

GB/BAS/QAR06.0061/10

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 19.0045X** Page 3 of 4

Date of issue: 2023-08-23 Issue No: 3

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

Each of the gland types may be manufactured in brass, stainless steel or aluminium and may be supplied with agreed alternative entry thread forms.

Refer to Certificate Annex for full product description.

SPECIFIC CONDITIONS OF USE: YES as shown below:
Refer to Certificate Annex for list of specific conditions of use.

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 19.0045X** Page 4 of 4

Date of issue: 2023-08-23 Issue No: 3

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above)
Issue 1
This issue introduces the following changes:

1. Update GA drawings.
2. Add accessory optional item GMC 'Gland Mounted Clamp'.
3. Clarify the ingress protection, IP
4. To review and update the cable glands against the latest standard.
5. To include the 501/453 RAC type cable Gland.
6. To permit the update to gland sizes.
7. Update the marking.
8. To revise the equipment title.
9. To revise the product description.
10. To revise the specific conditions of use.

Issue 2
This issue introduces the following changes and it is applicable to Type PSG 553 RAC Cable Gland and Type SB474 Conduit Stopping Gland.

1. To introduce a new seal design for PSG/553/RAC, sizes Os to C and SB 474, sizes O to C; as a result the product description was amended.
2. To introduce a new compressible seal which has an increased service temperature of -60°C to +100°C; to reflect this modification the product description and Specific Conditions of Use were updated.
3. To permit minor editorial updates to the Product Description.
4. To permit changes to the Specific Conditions of Use.
5. To remove cable gland types 501/452 RAC and PSG 421; as a result, the product description was amended.

Issue 3
This issue introduces the following changes:

1. To modify the core diameter range on sizes O/A/B/C and B-ALT of the PSG 553 RAC and SB474 gland types and modify certification documentation.
2. To review and update the equipment against the latest requirement of IEC 60079-31:2022 Ed.3.

Annex:

Certificate Annex IECEx CML 19.0045X Iss 3.pdf

Annexe to:	IECEx CML 19.0045X, Issue 3
Apparatus:	A Range of Cable Glands with Compression Seals 501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474
Applicant:	Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)

Description

Each of the following gland types may be manufactured in brass, nickel plated brass, stainless steel or aluminium and may be supplied with agreed alternative entry thread forms.

The Type 501/421 Cable Gland is intended for use with an effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component in the size range Os to J
b) A compressible sealing ring
c) A compression spigot
d) A back nut
e) An optional earth continuity device for use with metallic sheathed cables

The Type 501/421 'Size 2K' Gland comprises the following components only: -

a) A dedicated entry component
b) A compressible sealing ring
c) A nylon skid washer
d) A threaded compression spigot

The Type 501/423 Cable Gland is intended for use with effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component, in the size range Os to J
b) Two compressible sealing rings
c) Two compression spigots
d) A middle nut
e) A back nut
f) An optional earth continuity device for use with metallic sheathed cables

The Type 501/453 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cable and comprises the following components:

a. An entry component, in the size range Os to J
b. A compressible sealing ring.
c. A combined compression spigot and armour clamping cone.
d. A reversible armour clamping ring.
e. A middle nut
f. An outer seal assembly (sleeve seal and support cage)
g. A back nut
h. An optional earth continuity device for use with metallic inner sheathed cables

Eurofins E&E CML Limited
Newport Business Park, New Port Road
Ellesmere Port, CH65 4LZ, UK

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Printed on: Wednesday, March 19, 2025

The Type PSG 553 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cables of unspecified construction and comprises the following components: -

a) An entry component in the size range Os to C
b) A compressible seal designed to accept a number of individual conductors
c) A combined compression spigot and armour clamping cone
d) A reversible armour clamping ring.
e) A middle nut
f) An outer seal assembly (sleeve seal and support cage)
g) A back nut

The Type 501/414 Conduit Stopping Gland is intended for use with an effectively filled and circular unarmoured cable enclosed within a conduit and comprises the following components: -

a) An entry component in the size range Os to F
b) A compressible sealing ring
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut

The Type SB474 Conduit Stopping Gland is intended for use with a number of circular conductors enclosed within a conduit and comprises the following components: -

a) An entry component in the size range O to C
b) A compressible seal designed to accept a number of individual conductors
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut.

Design option

1. The use of a 3M cold Shrink tubing to be fitted to the outer sheath of specific non-circular cables as specified in the drawing 320000, and fitted into 'Os', 'O' and 'A' sizes of the 501/453 cable glands. To ensure that the IP sealing arrangement utilizing the cable shrink tube assembly does not affect the assigned IP rating of the glands. The selection of the relevant cable gland to meet the protection concept for the cable and the enclosure it is fitted on to as detailed in EN 60079-14 remain un-affected.
2. The gland assemblies as described above are rated for ingress protection IP66 and 67.
3. Cable glands may be fitted with an optional external clamp or a second accessory option type Hawke Gland Mounted Clamp (GMC).
4. Where marked IIC or IIIC, the equipment can also be marked for gas groups IIA or IIB and for dust groups IIIA or IIIB

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Conditions of Manufacture

None

Specific Conditions of Use

The following conditions relate to safe installation and/or use of the equipment.

i. The PSG/553/RAC and SB 474 cables glands are limited to an operating temperature range of -60°C to +80°C, unless marked "P PSG/553/RAC" and "P SB 474" respectively. In these cases, they are suitable for use with an operating temperature range of -60°C to +100°C. All other cable gland types are suitable for use with an operating temperature range of -60°C to +100°C.

ii. When the glands are used for increased safety or dust protection the entry thread shall be suitably sealed (in accordance with IEC 60079-14) to maintain the ingress protection rating of the associated enclosure. Not applicable when Hawke IP 66/67 seal is used.

iii. Glands for use with conduit, unarmoured or braided cables are only suitable for fixed installations, the cable for which must be effectively clamped to prevent pulling and twisting (does not apply when fitted with rear clamping device or Hawke Gland Mounted Clamp (GMC)).

Components used which are covered by Ex Certificates issued to older editions of Standards

None

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Ellesmere Port, CH65 4LZ, UK

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4.15 XT01..06 – Compression Seal for Wall Penetration, Roxtec RS 50 B Ex-kit

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Attestation of Conformity for Components

We, Roxtec International AB, declare under sole responsibility that the products to which this declaration relates is in accordance with the provisions of the Directive 2014/34/EU
The products complies following harmonized stancards:

EN IEC 60079-0:2018, EN IEC 60079-7:2015/A1:2018 and EN 60079-31:2014

The standards listed in the EC-Type Examination Certificate are no longer harmonized, the revised (now harmonized) standards have been compared to the standards used for certification purposes and no changes in the "state of the art" apply to the equipment.

Cable Transit Device:
G...W Ex, S Ex, S...S0...Ex, SRC Ex, SK Ex, S BTB Ex, S...WM Ex,
SF...W Ex, R...W Ex, RO...W Ex, RS...W Ex and B...C Ex

Certificate:
No.12ATEX1279U issued by Nemko (id.no. 0470), based on EC-type Examination performed by them.
No. SP03ATEX7102 issued by RISE - Research Institutes of Sweden
(id.no 0402), based on assessment of the quality system performed by them.

Characteristics and how the components shall be incorporated into equipment:
Stated in EC-type Examination certificate and the instructions which accompany the components.

Marking:
CE 0402 Ex II 2G Ex e IIC Gb
CE 0402 Ex II 2D Ex tb IIIC Db

Karlskrona 2021-02-11

Roxtec International AB
Box 540
S-371 23 Karlskrona
SWEDEN

Jörgen Åkesson
Explosion Protection Manager

EU Declaration of Conformity

We, Roxtec International AB, declare under sole responsibility that the products to which this declaration relates is in accordance with the provisions of the Directive 2014/34/EU.
The products complies with following harmonized standards:

EN IEC 60079-0:2018, EN IEC 60079-7:2015/A1:2018 and EN 60079-31:2014
The standards listed in the EC-Type Examination Certificate are no longer harmonized, the revised (now harmonized) standards have been compared to the standards used for certification purposes and no changes in the "state of the art" apply to the equipment.

Cable Transit Device:
CF 16 Ex, CF 8/32 Ex, G Ex, G BG Ex, SF Ex, SF BG Ex, SFX...B Ex, R...B Ex, RO...B Ex, RS...B Ex, B...B Ex and C RS T- Ex

Certificate:
No.12ATEX1278X issued by Nemko (id.no. 0470), based on EC-Type Examination performed by them.
No. SP03ATEX7102 issued by RISE - Research Institutes of Sweden
(id.no 0402), based on assessment of the quality system performed by them.

Marking:
CE 0402 Ex II 2G Ex e IIC Gb
CE 0402 Ex II 2D Ex tb IIIC Db

Karlskrona 2021-02-11
Roxtec International AB
Box 540
SE-371 23 Karlskrona
SWEDEN

Jörgen Åkesson
Explosion Protection Manager

EU Declaration of Conformity

Document number: DOC-000575 revision F

We, Roxtec International AB, declare under sole responsibility that the products to which this declaration relates is in accordance with the provisions of the Directive 2014/34/EU.
The products complies with following harmonized standards:

EN IEC 60079-0:2018, EN IEC 60079-7:2015/A1:2018 and EN 60079-31:2014

The standard EN 60079-7:2015 listed in the EC-Type Examination Certificate are no longer harmonized. The revised (now harmonized) EN IEC 60079-7:2015/A1:2018 have been compared to the standard used for certification purposes and no changes in the "state of the art" apply to the equipment.

Cable Transit Device:
HD 16 Ex, HD 24 Ex, HD 32 Ex, HDLC Ex

Certificate:
No.15 ATEX6419X issued by Presafe (id. No 2460), based on EC-Type Examination performed by them.
No. SP03ATEX7102 issued by RISE - Research Institutes of Sweden (id.no 0402), based on assessment of the quality system performed by them.

Marking:
CE 0402 Ex II 2G Ex eb IIC Gb
CE 0402 Ex II 2D Ex tb IIIC Db

Karlskrona 2021-02-11
Roxtec International AB
Box 540
SE-371 23 Karlskrona
SWEDEN

Jörgen Åkesson
Explosion Protection Manager

Roxtec

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification Scheme for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	IECEx NEM 12.0014X	Issue No: 4	Certificate history:
Status:	**Current**	Page 1 of 5	Issue No. 4 (2015-11-04) Issue No. 3 (2015-07-08) Issue No. 2 (2015-05-07) Issue No. 1 (2015-01-27) Issue No. 0 (2013-03-15)
Date of Issue:	**2015-11-04**		

Applicant: **Roxtec International AB**
Rombvägen 2
Box 540
SE-371 23 Karlskrona
Sweden

Equipment: **Cable Transit Device**
Optional accessory:

Type of Protection: **Ex e IIC Ex tb IIIC**

Marking:

Ex e IIC Gb, Ta -40°C To +80°C for CF 8 and CF 32.
Ex e IIC Gb, Ta -60°C To +80°C for all other variants.
Ex tb IIIC Db, Ta -40°C To +80°C for CF 8 and CF 32.
Ex tb IIIC Db, Ta -60°C To +80°C for all other variants.

Approved for issue on behalf of the IECEx Certification Body: Bjørn Spongsveen

Position: Certification Manager, Ex-products

Signature:
(for printed version)

Date:

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Certificate issued by:

NEMKO
Gaustadelleen 30
Oslo N-0314
Norway

IECEx Certificate of Conformity

Certificate No:	IECEx NEM 12.0014X	Issue No: 4
Date of Issue:	**2015-11-04**	Page 2 of 5
Manufacturer:	**Roxtec International AB** Rombvägen 2 Box 540 SE-371 23 Karlskrona **Sweden**	
Additional Manufacturing location(s):		

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS:

The electrical apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

IEC 60079-0 : 2011 Edition:6.0	Explosive atmospheres - Part 0: General requirements
IEC 60079-31 : 2008 Edition:1	Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure 't'
IEC 60079-7 : 2006-07 Edition:4	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

*This Certificate **does not** indicate compliance with electrical safety and performance requirements other than those expressly included in the Standards listed above.*

TEST & ASSESSMENT REPORTS:

A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in

Test Report:

NO/NEM/ExTR12.0016/00 NO/NEM/ExTR12.0016/01 NO/NEM/ExTR12.0016/02
NO/NEM/ExTR12.0016/03 NO/NEM/ExTR12.0016/04

Quality Assessment Report:

SE/SP/QAR09.0001/04 SE/SP/QAR09.0001/03

IECEx Certificate of Conformity

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Schedule

EQUIPMENT:

Equipment and systems covered by this certificate are as follows:

The Cable Transit Devices 'CTDs'(see Type Designation below), for use with circular cables both armoured and non-armoured or corrugated cables (see Corrugated cables below) of non-interrupted and non-metallic outer jacket type or conduits. The CTDs consists of multi diameter sealing modules (type RM Ex and CM Ex as standard or with EMC properties) that depending on each individual size, accepts a limited number of cable diameters in applicable types of frames or sleeves and shall be marked with the Ex symbol.

The modules are made of mirrored rubber profiles and each part has a number of thin rubber layers that are ending up with a solid rubber core. The layers are made with two different colours to make the adaption to a cable exactly same on both halves and are allowed to differ one layer at most. To achieve appropriate sealing and mechanical properties to prevent the cables from slippage there shall always be a visible separation between the sealing module halves.

The modules made of EPDM are available with layers and core, but some greater sizes are also available without the core. In addition there are also single diameter- and solid modules.

The correct sizes and procedure of assembling the cables to the modules are described in detail in the enclosed installation instructions. Ex Compression devices are used to achieve appropriate compression of the modules and solids some CTDs uses compression units that expands inside the CTDs and some others have incorporated solid rubber profiles that achieve the expansion.

There are also two types of CTDs that incorporates both the compression device and multi diameter modules as a single unit, but still with two halves. The method to assemble the compression devices etc. and to achieve sealing of the CTDs is described in detail in the enclosed installation instructions.

Most CTDs that has a rectangular opening with or without rounded corners with modules of type RM Ex are all available for different combinations with several openings in width and/or in high. CTDs for use with rectangular openings with CM Ex modules (one type with dual opening) and round sleeves are only available with single openings.

The CTDs installation instructions listed in this report will define each variant in detail and all applicable parts that are approved for use within that variant.

CONDITIONS OF CERTIFICATION: YES as shown below:

Conditions for safe use

1. For maintaining the explosion protection, the installation instructions that accompany the products shall be considered.
2. Only cable for fixed installation is permitted for the cable transit device.
3. For optimum reliability wait 24 hours or longer after installation before exposing the cables/pipes to strain or pressure.

IECEx Certificate of Conformity

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EQUIPMENT (continued):

Type Designations:
CF 8 Ex, CF 32 Ex, CF 16 Ex, C RS T… Ex, RS…B Ex, G… Ex, SF… Ex, SFX...B Ex, B…B Ex, R…B Ex and RO…B Ex
Temperature Range:
CF 8 Ex and CF 32 Ex , -40°C to +80°C
CF 16, C RS T…, RS…B, G…, SF…, SFX...B, B…B, R…B and RO…B, -60°C to +80°C
Corrugated cables for use with: CF 8, CF 32, SF… and G…
ACIC (Armoured Control and Instrumentation Cable) according to C22.1-06 CEC,
ACWU (Armoured Cable for Wet locations) according to UL4,
TECK90 according to C22.2 No. 131-07
MC (Metal Clad) according to UL1569

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DETAILS OF CERTIFICATE CHANGES (for issues 1 and above):

New revisions added and corrections to mistyping in previous descriptive document list, issue No. 4.0.

4.16 XT07..09 – Cable Gland for Wall Penetration, 501/421 O M20 Brass

[Please refer to certificate from Section 4.14.]

4.17 XT07..09 – M32 to M20 Reducer, RDU100604

[Please refer to certificate from Section 4.13.]

4.18 XT10..11 – Cable Gland for Wall Penetration, 501/421 A M20 Brass

[Please refer to certificate from Section 4.14.]

4.19 XT10..11 – M40 to M20 Reducer, RDU100704

[Please refer to certificate from Section 4.13.]

Sub Section K02-002

ATEX Register

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
007	21/07/2025	Updated

KBR
ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

ACCEPTED	(Code 1)
ACCEPTED WITH COMMENTS	(Code 2)
NOT ACCEPTED	(Code 3)
NOT REVIEWED	(Code 4)

ACCEPTANCE DOES NOT RELIEVE SUPPLIER FROM FURNISHING MATERIAL IN CONFORMANCE WITH ORDER. REFER TO SDR-1 FOR FULL DEFINITION OF ACCEPTANCE CONDITIONS.

DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - ATEX Register**
Document Number:	K559-2254-CWIWP4202202-K02-002
Revision:	007
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-K02-002007
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

No.	Revision	Tag Number	Description	Location	Manufacturer	Model Type Catalogue Number	Serial Number	ATEX Certification Marking	Reference Document	ATEX Certificate Number	Installation Zone	Notes / Comments	P.O	Vendor	Skid /Package	Barrier Calculation ref.	Non-electrical Equipment	Special Conditions for Safe Use
1	04	BL01	Electronic level sensor; Operating voltage 18...30 DC V; ATEX; M12 Connector; Gold-plated contacts	=HA01+DA02 - H2 Supply System	IFM Electronic AS	LMT01A LMACE-A12E-QSKG-1/US/3D/3G	100000160523	II 3G Ex nA IIC T4 Gc	K559-2254-CWIWP4202202-C03-001	8003330	Zone 2		8517643	IFM Electronic AS	A-80000	No	No	No
2	04	BL01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Black	=HA01+DA02 - H2 Supply System	IFM Electronic AS	EVC14A ADOGH040VAT0025H04/3G/2D	N/A	II 3G EX ec IIC Gc	K559-2254-CWIWP4202202-E03-003	BVS 08ATEX E 109U	Zone 2		8520141	IFM Electronic AS	A-80000	No	No	No
3	04	BP01	Pressure Transduer, 0-10 barg, 4-20mA, ATEX, -25 to 85°C Ta, M12 Connector, 10..30 VDC, 2-wire, G1/2 Process Connection, FPM Seal	=HA01+DA02 - H2 Supply System	HUBA Controls AG	Pressure Transducer 520 Series	N/A	Ex II 1/2G Ex ia IIC T4 Ga/Gb	K559-2254-CWIWP4202202-C03-001	SEV 10 ATEX 0145	Zone 2		8516809	HUBA Controls AG	A-80000	K559-2254-CWIWP42022(	No	No
4	04	BP01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	II 2G Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP42022(	No	Yes
5	04	TF01	BP01 - Pressure Sensor – Ex Barrier (9106-B1B)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9106-B1B	N/A	II (1) G [Ex ia Ga] IIC//IB/IIA	K559-2254-CWIWP4202202-E03-008	DEKRA 11ATEX0244 X	No Zone		146131-1	PR Electronics AS	A-80000	K559-2254-CWIWP42022(	No	Yes
6	04	BT01	Temperature sensor: liquids and gases Connection: stainless steel (1.4404 / 316L) Ambient temperature: -25...80 °C	=HA01+DA02 - H2 Supply System	IFM Electronic AS	TT1050 TT-100KBBD10-...../US/	100000113592	N/A	K559-2254-CWIWP4202202-C03-001	N/A	Zone 2	Simple apparatus acco	8516509	IFM Electronic AS	A-80000	K559-2254-CWIWP42022(	No	No
7	04	BT02-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP42022(	No	Yes
8	04	TF01	BT01 - Temperature Sensor – Ex Barrier (9113B-U9)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U9	N/A	II (1) G [Ex ia Ga] IIC//IB/IIA	K559-2254-CWIWP4202202-E03-008	KEMA 07ATEX0148 X	No Zone		8520371	PR Electronics AS	A-80000	K559-2254-CWIWP42022(	No	Yes
9	04	EA01	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2" , ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-1	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements A	A-80000	No	No	Yes
10	04	EA01-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No
11	04	EA01	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes
12	04	EA02	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-2	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements A	A-80000	No	No	Yes
13	04	EA02-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No
14	04	EA02	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes
15	04	QM1.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes
16	04	QM1.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
17	04	QM1.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
18	04	QM2.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
19	04	QM2.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
20	04	QM2.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
21	04	QM1.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes
22	04	QM1.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
23	04	QM1.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
24	04	QM2.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
25	04	QM2.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
26	04	QM2.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
27	04	QM1.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes
28	04	QM1.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
29	04	QM1.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
30	04	QM2.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
31	04	QM2.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
32	04	QM2.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
33	04	QM1.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
34	04	QM1.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
35	04	QM1.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
36	04	QM2.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
37	04	QM2.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
38	04	QM2.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
39	04	QM1.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
40	04	QM1.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
41	04	QM1.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
42	04	QM2.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
43	04	QM2.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
44	04	QM2.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
45	04	QM1.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
46	04	QM1.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
47	04	QM1.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
48	04	QM2.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
49	04	QM2.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
50	04	QM2.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
51	04	XT01	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
52	04	XT02	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
53	04	XT03	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
54	04	XT04	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
55	04	XT05	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
56	04	XT06	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
57	04	XT07	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Non EX Box	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
58	04	XT07	M32 to M20 Ex Reducer	=HA01+DA02 - Non EX Box	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
59	04	XT08	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
60	04	XT08	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
61	04	XT09	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
62	04	XT09	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80001	No	No	Yes
63	04	XT10	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	IECEx CML 19.0045X	Zone 2		CD3034021	Semco maritime	A-80002	No	No	Yes
64	04	XT10	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80003	No	No	Yes
65	04	XT11	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034021	Semco maritime	A-80004	No	No	Yes
66	04	XT11	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80005	No	No	Yes

Sub Section K02-003

ATEX Design journal

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003	28/01/2025	updated additional parts added
004	12/02/2025	2.1.2 - 1st paragraph corrected from eb or e to db or d
005	19/03/2025	Updated according to code 2 comments

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ATEX design journal

Full Title: *FC PowerGen 1000kW® - ATEX design journal*

Abstract: The following document will contain an internal walk through of the ATEX related components and philosophies for the installation on the *FC PowerGen 1000kW®*

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1.0 Objectives and Background

The following document contains the design journal and considerations for the EX related system. This document is an internal document stating the decisions and background for a safe system.

This is an addendum to the ATEX dossier containing the following documents.

- ATEX general arrangement
- ATEX register
- ATEX inspection checklist
- ATEX personal competences
- Intrinsically safe calculations
- Datasheet dossier
- Certification dossier

2.0 *FC PowerGen 1000kW®*

2.1 H2 solenoid valve

2.1.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***Emerson ASCO*** valve ***NF X E210D488E 24/DC*** with the following EX approvals: ***II 2 G D Ex db IIC T2..T6 Gb*** hereby confirming that the points above is covered by the certificate.

2.1.2 Cable glands

The cable glands for the installation shall maintain the certificate and appropriate Type of protection as the valve accordingly to section 10.2 in IEC 60079-14, hence the cable gland shall be a type of protection: db or d.

The following component is ***HAWKE* 501/421/O M20 421OM20** *with an adaptor to fit the thread of the valve from* ***Eaton Corporation*** *type* ***ADU102904*** with the following EX approvals: **Ex db IIC Gb Ex eb IIC Gb** for the cable gland, and **II 2G Ex db IIC Gb II 2G Ex eb IIC Gb** hereby confirming that the points above is covered by the certificate.

2.1.3 Cable and installation

The valve is installed with a LAPP 3G1 and resistant to UV light making them suitable for outside use.

The grounding is installed inside the valve to eliminate any risk of corrosion. The cable is in all its length (from valve to terminal box) un-cut

The cable is installed together with the other valves, with at smooth bend before cable glands. The cable will be mechanical fixed to a cable tray making sure no mechanical ware will happen.

The diameter of the cable is according to manufacture 8,4mm which is within the specifications (6,5-11,9mm) provided by the manufacture of the cable glands.

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2.2 H2 pressure transmitter

2.2.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***HUBA controls AG*** type ***520930S04M801*** with the following EX approvals: ***Ex II 1/2G EX ia IIC T4 Ga/Gb*** hereby confirming that the points above are covered by the certificate.

2.2.2 Ex barrier

The component will be installed with an Ex barrier eliminating the potential current going out the component and zone. The following Ex barrier is chosen: ***PR electronic 9106-B1B*** with the following EX approvals: ***II (1) G [Ex ia Ga] IIC/IIB/IIA*** hereby confirming that the points above are covered by the certificate. Installation of the barrier will be covered in section 2.8

2.2.3 Cables

For the connection of the temperature transmitter to the Ex barrier the following cable is used: ***IFM ENC03A*** with the following EX approvals: ***Ex ia IIC T6 Gb*** hereby confirming that the points above are covered by the certificate.

2.3 H2 heater heating element

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***JEVI Heating Elements A/S*** heating element ***D-8640*** with the following EX approvals: ***Ex d IIC T4 Gb*** hereby confirming that the points above is covered by the certificate.

The heating element has a build in over temperature cut off. The heating element is factory tested to make sure to not be able to overheat as part of the EX installation.

The flameproof type of protection is a threaded joint type and is installed according to IEC 60079-1. This means that there are no distances required to obstructions.

2.3.1 Cable glands

The cable glands for the installation shall maintain the certificate and appropriate Type of protection as the valve accordingly to point 16.3 in IEC 60079-0, hence the cable gland shall be a type of protection: d.

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For this component the cable gland was delivered as part of the delivery from the manufacture of the heating element. Following cable glands for the valve is delivered: ***HAWKE*** type ***ICG 653 UNIV Os M20*** with the EX approvals: ***EX db IIC Gb and EX eb IIC GB***

2.3.2 Cable and installation

The Heater unit is installed with a LAPP 4G2.5 and resistant to UV light making them suitable for outside use.

The grounding is installed inside the heating unit to eliminate any risk of corrosion. The cable is in all its length (from heating unit to terminal box) un-cut

The cable is installed together with the other non intrinsically safe components, with at smooth bend before cable glands. The cable will be mechanical fixed to a cable tray making sure no mechanical ware will happen.

The diameter of the cable is according to manufacture 9 mm which is within the specifications (5,5-12mm) provided by the manufacture of the cable glands.

2.4 H2 heater Level sensor

2.4.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***IFM LMT01A*** with the following EX approvals: ***II 3G Ex nA IIC T4 Gc X*** hereby confirming that the points above is covered by the certificate.

2.4.2 Ex barrier

The level sensor does not require a barrier due to the type of protection not being intrinsically safe.

2.4.3 Cables

For the connection of the temperature transmitter to the controller the following cable is used: ***IFM EVC14A*** with the following EX approvals: ***II 3G EX ec IIC Gc*** hereby confirming that the points above is covered by the certificate.

Installation of the cabling will be separated from intrinsically safe sensors, as the cable on this devise is not protected by an ex barrier.

2.5 H2 heater Temperature transmitter

2.5.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

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Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The temperature transmitter is defined as a simple apparatus accordingly to IEC 60079-14 section 16.4 as the type of transmitter is resister type PT1000 hence no possibility for generating any voltage by its own. Hereby eliminating the option of calculating the surface temperature. Since there are no requirement for an Ex certificate for an simple apparatus, there are no code for concluding the match.

2.5.2 Ex barrier

The component will be installed with an Ex barrier eliminating the potential current going out the component and zone. The following Ex barrier is chosen: ***PR electronic 9113B-U9*** with the following EX approvals: ***II (1) G [Ex ia Ga] IIC/IIB/IIA*** hereby confirming that the points above is covered by the certificate. Installation of the barrier will be covered in section 2.8

2.5.3 Cables

For the connection of the temperature transmitter to the Ex barriere the following cable is used: ***IFM ENC03A*** with the following EX approvals: ***Ex ia IIC T6 Gb*** hereby confirming that the points above is covered by the certificate.

2.6 H2 feed pipe container penetration

2.6.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is chosen to safe penetrate the container: **Roxtec** cable and pipe penetration type: **RS 50 B Ex-kit AISI316/AISI316** with the following EX approvals**: II 2G EX e IIC Gb** hereby confirming that the points above is covered by the certificate.

2.7 Electrical container penetration within EX zone

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***HAWKE*** cable gland type **501/421/O M20 and 501/421/A M20** with the following adaptor to compensate for the hole size: **Eaton Corporation** type **RDU100604 and RDU100704** with the following EX approvals: **Ex db IIC Gb Ex eb IIC Gb** for the cable glands and **II 2G Ex db IIC Gb II 2G Ex eb IIC Gb** for the reducers hereby confirming that the points above is covered by the certificate.

2.7.1 Cable and installation

The following type of cables are used in the above-mentioned cable glands:

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- ÖLFLEX CLASSIC 110 CH 4X1 from Mastercontorller in 40' container to cooling skid cabinet. Diameter 8,9mm with an allowable diameter for the cable gland of 6,5mm to 11,9mm
- ETHERLINE® TORSION Cat.6A from mastercontorller in 40' container to cooling skid cabinet. Diameter 8,9mm with an allowable diameter for the cable gland of 6,5mm to 11,9mm
- ETHERLINE® TORSION Cat.6A from mastercontorller in 40' container to cooling skid cabinet. Diameter 8,9mm with an allowable diameter for the cable gland of 6,5mm to 11,9mm
- ÖLFLEX CLASSIC 135 CH 18G0,75 from mastercontroller cabinet in 40' to hydrogen valve box. Diameter 13mm with an allowable diameter for the cable gland of 10,0mm to 14,3mm
- ÖLFLEX CLASSIC 135 CH 18G0,75 from mastercontorller in 40' container to cooling skid cabinet. Diameter 13mm with an allowable diameter for the cable gland of 10,0mm to 14,3mm

2.8 General electrical installation

There are no junction boxes within the zone except the one which is a part of the components. All junction boxes are moved outside the zone.

Cables are all installed below the temperature of the zone and goes uncut through the zone as 60079-14pt. 9.6.1

The intrinsically safe barriers are positioned in a separate junction box outside the Ex Zone. The junction box will contain the components which are described in section 2.2.2 and 2.5.2. The intrinsically safe circuits are separated from the non-safe circuit. Where the one side of the box will contain the non-safe part and the opposite side containing the intrinsically safe circuit hereby following the guidelines/philosophy from the manufacture of the Ex barriers. The circuits are to be installed **50mm** apart from each other according to section 16.5.3 in IEC 60079-14

The junction box will be the following: ***Schneider Electric Thalassa PLS, fiber glass armed polyester cabinet, IP65, 180 x 270 x 180mm, gray*** With the IP rating of IP65. The box will be marked with: *"Warning - Non Intrinsically safe circuits protected by internal IP20 cover"*

The cables will be separated from the non-safe circuits in the cable tray.

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Sub Section K02-004

Personal Competences Ex Works

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001	08/11/2024	First Issue
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Personnel competences Ex work

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1.0 Purpose

The purpose of this document is to highline the competences of the personnel working on Ex related equipment and systems. The following definitions are defined according to IEC 60079-14 Annex A

2.0 Definitions

Definitions of terms or acronyms unique to the Policy.

BPSE: Ballard Power Systems Europe.

3.0 Responsible Persons

As described in IEC 60079-14 Annex A section A.2.1 the following knowledge and skills is required to be approved for being the **Responsible Person** on a EX installation

"Responsible persons who are responsible for the processes involved in the design, selection and erection of explosion protected equipment shall possess, at least, the following:

a) general understanding of relevant electrical engineering;

b) understanding and ability to read and assess engineering drawings;

c) practical understanding of explosion protection principles and techniques;

d) working knowledge and understanding of relevant standards in explosion protection;

e) basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration.

Such persons shall confine their involvement to the management of competent operatives conducting selection and erection duties and not engage themselves directly in the work without ensuring their practical skills at least meet the requirements given in A.2.2."

Besides the knowledge and skills, the following competences are also required in some way to approve for the **Responsible Person** as described in IEC 60079-14 Annex A section A.3.2.

"Responsible persons shall be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified in A.2.1 relevant to the types of protection and/or types of equipment involved."

4.0 Operatives/technicians

As described in IEC 60079-14 Annex A section A.2.2 the following knowledge and skills is required to be approved for being **Operatives** or **technicians** on a EX installation.

"*Operatives/technicians shall possess, to the extent necessary to perform their tasks, the following:*

a) understanding of the general principles of explosion protection;

b) understanding of the general principles of types of protection and marking;

c) understanding of those aspects of equipment design which affect the protection concept;

d) understanding of content of certificates and relevant parts of this standard;

e) general understanding of inspection and maintenance requirements of IEC 60079-17;

f) familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard;

g) understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection."

Besides the knowledge and skills, the following competences are also required in some way to approve for being **Operatives** or **technicians** as described in IEC 60079-14 Annex A section A.3.3.

"*Operatives/technicians shall be able to demonstrate their competency and provide evidence*

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of attaining the knowledge and skill requirements specified in A.2.2 relevant to the types of protection and/or types of equipment involved.

They shall also be able to demonstrate their competency with documentary evidence in the:

a) use of documentation in 4.2;

b) production of reports, e.g. inspection reports, to the user as identified in 4.2;

c) practical skills necessary for the preparation and installation of relevant concepts of protection;

d) use and production of installation records as identified in 4.2."

5.0 Designer

As described in IEC 60079-14 Annex A section A.2.3 the following knowledge and skills is required to be approved for being **Designer** on a EX installation.

"*Designers shall possess, to the extent necessary to perform their tasks, the following:*

a) detailed knowledge of the general principles of explosion protection;

b) detailed knowledge of the general principles of types of protection and marking;

c) detailed knowledge of those aspects of equipment design which affect the protection concept;

d) detailed knowledge of content of certificates and relevant parts of this standard;

e) understanding of practical skills for the preparation and installation of relevant concepts of protection;

f) detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection;

g) detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard;

h) general understanding of inspection and maintenance requirements of IEC 60079-17."

*Besides the knowledge and skills, the following competences are also required in some way to approve for being **Designers** as described in IEC 60079-14 Annex A section A.3.4.*

"Designers shall be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified in A.2.3 relevant to the types of protection and/or types of equipment involved.

They shall also be able to demonstrate their competency with documentary evidence in the:

a) production of documentation specified in 4.2;

b) production of designers certificates to the user as identified in 4.2;

c) practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved;

d) updated and production of installation records as identified in 4.2."

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6.0 Appendices

Table 6-1: List of people and competences for Crosswind project

Name:	Initials:	Background/competences:	Allowable role:
Rasmus Simonsen	RBS	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering) Graduated in 2020 Experience 2023-present Ballard power system lead ATEX engineer on stationary products. Responsible for EX design and approval on various containerized solutions for land based and marine applications. EX consultant for various customers and internal projects. 2020-2023 Fuel cell development project manager. Lead engineer and owner of documentation for storage and testing facilities involving liquid and gas installations. Courses -ATEX course at Teknologisk Institut -Zone classification 60079-10 course at TML safety engineering -Internal Ballard H2 fuel cell course	Responsible person, Operatives/technician and designer

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Table 6-1: List of people and competences for Crosswind project			
Karin Hesselholt	KHE	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering) Graduated in 1987 Experience: 1987 to 2006 (Maersk Line). Worked as Marine Engineer -Chief Engineer onboard LPG/C vessels Performing maintenance work on cargo equipment as well as performing Approval Scheme on behalf of Lloyds Register. 2013 to 2017 (Svanehøj Pumps) Senior Project Manager on delivery of Cargo Pumps for Statoil Floating Storage Vessels. Preforming ATEX certification of the Cargo Pumps (capacity 500m^3 crude Oil/hour) for installation in Zone 1. Notified Body DTI (Teknologisk Institut) 2020 – present (Ballard Power Systems) Senior Application Engineer/Marine Specialist. Working with development of the Fcwave module and the Type Approval of the modules with Class Societies DNV, LR and ABS. Participating in HAZID approvals for marine installation of FCwave modules in Vessels. Courses -ATEX course at Teknologisk Institut -Internal Ballard H2 fuel cell course	Project Manager/Technician and designer

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Table 6-1: List of people and competences for Crosswind project			
Peter Blach	PBL	Qualification -Automation Engineer Graduated in 2012 Experience 2017 – present (Ballard Power Systems) Working with development of the FCwave module and the Type Approval of the modules with Class Societies DNV Courses -Internal Ballard H2 fuel cell course	Operatives/technician and designer
Peter Blok	PBH	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering)	Operatives/technician
Andreas Simony	ASM	Qualification -BSc - Motorsport Technology Graduated in 2016 -MSc - Racing Engine Design Graduated in 2017 Experience NA Courses -Internal Ballard H2 fuel cell course	Operatives/technician

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Table 6-1: List of people and competences for Crosswind project			
Rasmus Knudsen	RKL	Qualification -BSc - Motorsport Technology Graduated in 2016 -MSc - Racing Engine Design Graduated in 2017 Experience NA Courses -Internal Ballard H2 fuel cell course	Operatives/technician
Morten Fog	MFO	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering) Graduated in 2008	Operatives/technician and designer

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Table 6-2: *Qualifications Rasmus Simonsen*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	x		
understanding and ability to read and assess engineering drawings	x		
practical understanding of explosion protection principles and techniques	x		
working knowledge and understanding of relevant standards in explosion protection	x		
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration	x		
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	x		
understanding of the general principles of types of protection and marking	x		
understanding of those aspects of equipment design which affect the protection concept	x		
understanding of content of certificates and relevant parts of this standard	x		
general understanding of inspection and maintenance requirements of IEC 60079-17	x		
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard	x		
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	x		
use of documentation in 4.2	x		
production of reports, e.g. inspection reports, to the user as identified in 4.2	x		
practical skills necessary for the preparation and installation of relevant concepts of protection	x		
use and production of installation records as identified in 4.2.	x		
Designer qualification			

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Table 6-2: *Qualifications Rasmus Simonsen*			
detailed knowledge of the general principles of explosion protection	x		
detailed knowledge of the general principles of types of protection and marking	x		
detailed knowledge of those aspects of equipment design which affect the protection concept	x		
detailed knowledge of content of certificates and relevant parts of this standard	x		
understanding of practical skills for the preparation and installation of relevant concepts of protection	x		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	x		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard	x		
general understanding of inspection and maintenance requirements of IEC 60079-17	x		
production of documentation specified in 4.2	x		
production of designers certificates to the user as identified in 4.2	x		
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved	x		
updated and production of installation records as identified in 4.2	x		

Table 6-3: *Qualifications Peter Blach*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques	X		

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Table 6-3: *Qualifications Peter Blach*			
working knowledge and understanding of relevant standards in explosion protection	X		
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		x	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking	X		
understanding of those aspects of equipment design which affect the protection concept	X		
understanding of content of certificates and relevant parts of this standard	X		Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		To an electrical point of view
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		To an electrical point of view
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		
practical skills necessary for the preparation and installation of relevant concepts of protection	X		Primarily to an electrical point of view
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection	X		
detailed knowledge of the general principles of types of protection and marking	X		

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Table 6-3: *Qualifications Peter Blach*			
detailed knowledge of those aspects of equipment design which affect the protection concept	X		To an electrical point of view
detailed knowledge of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
production of documentation specified in 4.2	X		
production of designers certificates to the user as identified in 4.2	X		
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved	X		
updated and production of installation records as identified in 4.2	X		

Table 6-4: *Qualifications Peter Blok*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques	X		

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Table 6-4: *Qualifications Peter Blok*			
working knowledge and understanding of relevant standards in explosion protection		X	
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking	X		
understanding of those aspects of equipment design which affect the protection concept	X		
understanding of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	Familiar with what is specified by designer
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		
practical skills necessary for the preparation and installation of relevant concepts of protection	X		
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection		X	
detailed knowledge of the general principles of types of protection and marking		X	

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Table 6-4: *Qualifications Peter Blok*			
detailed knowledge of those aspects of equipment design which affect the protection concept		X	
detailed knowledge of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection		X	
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
production of documentation specified in 4.2		X	
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved		X	
updated and production of installation records as identified in 4.2		x	

Table 6-5: *Qualifications Andreas Simony*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering		X	
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques		X	

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Table 6-5: *Qualifications Andreas Simony*			
working knowledge and understanding of relevant standards in explosion protection		X	
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking		X	Informed on the relevant information I reference to our system
understanding of those aspects of equipment design which affect the protection concept		X	Informed on the relevant information I reference to our system
understanding of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	On instruction by qualified personnel
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2		X	Instructed in the relevant reports for Ballard use
practical skills necessary for the preparation and installation of relevant concepts of protection	X		
use and production of installation records as identified in 4.2.		X	Instructed in the relevant reports for Ballard use
Designer qualification			

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Table 6-5: *Qualifications Andreas Simony*			
detailed knowledge of the general principles of explosion protection		X	
detailed knowledge of the general principles of types of protection and marking		X	
detailed knowledge of those aspects of equipment design which affect the protection concept		X	
detailed knowledge of content of certificates and relevant parts of this standard		X	
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Will be informed in refence to the Ballard procedure of documenting inspection and maintenance
production of documentation specified in 4.2		X	Capable of creating mechanical documentation according to standard
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved		X	
updated and production of installation records as identified in 4.2		X	

Table 6-6: *Qualifications Rasmus Knudsen*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			

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Table 6-6: *Qualifications Rasmus Knudsen*			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques		X	
working knowledge and understanding of relevant standards in explosion protection		X	
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking		X	Informed on the relevant information I reference to our system
understanding of those aspects of equipment design which affect the protection concept		X	Informed on the relevant information I reference to our system
understanding of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	On instruction by qualified personnel
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		

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Table 6-6: *Qualifications Rasmus Knudsen*			
practical skills necessary for the preparation and installation of relevant concepts of protection	X		
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection		X	
detailed knowledge of the general principles of types of protection and marking		X	
detailed knowledge of those aspects of equipment design which affect the protection concept		X	
detailed knowledge of content of certificates and relevant parts of this standard		X	
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	
general understanding of inspection and maintenance requirements of IEC 60079-17	x		Will be informed in refence to the Ballard procedure of documenting inspection and maintenance
production of documentation specified in 4.2		X	
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved		X	
updated and production of installation records as identified in 4.2		x	

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Table 6-7: *Qualifications Morten Fog*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques	X		
working knowledge and understanding of relevant standards in explosion protection	X		
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking	X		
understanding of those aspects of equipment design which affect the protection concept	X		
understanding of content of certificates and relevant parts of this standard	X		
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Will be informed in refence to the Ballard procedure of documenting inspection and maintenance
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		To the use for Ballard applications
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		
practical skills necessary for the preparation and installation of relevant concepts of protection	X		

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Table 6-7: *Qualifications Morten Fog*			
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection	X		
detailed knowledge of the general principles of types of protection and marking	X		
detailed knowledge of those aspects of equipment design which affect the protection concept	X		
detailed knowledge of content of certificates and relevant parts of this standard	X		
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		
general understanding of inspection and maintenance requirements of IEC 60079-17	X		
production of documentation specified in 4.2	X		
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved	X		
updated and production of installation records as identified in 4.2	X		

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Sub Section K03

Performance Test Results (FAT)

Ballard Power Systems Europe A/S
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001	17/09/2024	First Issue

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Ballard Power Systems Europe A/S
Majsmarken 1
DK-9500 Hobro
K559-2254-CWIWP4202202-J08-002

Confirmation of Satisfactory FAT

Part No.	601456B-7002362 Incl. sub-assemblies: 601456B-7002973 601456B-7003716
Product name	FC PowerGen 1000kW
Serial No.	601456B

Ballard Power Systems Europe A/S confirms that the above-listed equipment has satisfactorily with comments undergone and passed the Factory Acceptance Test (FAT) according to

BLPH Project – Acceptance Test Procedure (FAT) [K559-2254-CWIWP4202202-J08-001]

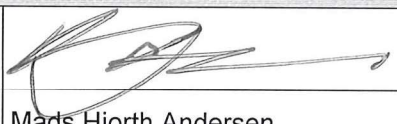
BLPH Project - Test Matrix for FAT and SAT [K559-2254-CWIWP4202202-J99-002]

601456B Crosswind BLPH FAT punch list [K559-2254-CWIWP4202202-J08-003]

prior to the shipment.

CrossWind C.V. acknowledges that the Factory Acceptance Test (FAT) for the above-listed equipment was witnessed and confirms that the test was performed satisfactorily with comments, and all agreed-upon specifications have been met.

Signatures

Ballard Power Systems Europe A/S			
Signature:			
Name:	Mads Hjorth Andersen		
Title:	Project Manager	Date:	04-09-2024
CrossWind C.V.			
Signature:			
Name:	Martin Taylor		
Title:	Crosswind Commissioning Manager	Date:	04-09-2024
Inspector			
Signature:			
Name:	Luigi Pignatelli		
Title:	Inspector for Crosswind	Date:	04-09-2024

Note: This document serves as formal confirmation that the FAT has been successfully completed and witnessed, with both parties in agreement on the satisfactory results. It should be signed by authorized representatives of both parties.

Short Title	Megablock Witnessed Factory Acceptance Test - CrossWind
Full Title	Megablock Witnessed Factory Acceptance Test - CrossWind
Abstract	*A selection of the Factory Acceptance Tests of the CrossWind Megablock system with witnesses from the CrossWind, Shell, Rosetti Marino and a surveyor from Fulkrum (CrossWind).*

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Revision Record

Rev #	Description	Revised By	Date (dd-mm-yyyy)
-	Initial Release	RKN	27-02-2024
1	General updates	RKN	17-06-2024
1a	Updated with results	TAN	20/8-2024
2	Updated leak test procedure	TAN	30-08-2024
2a	Updated with results	TAN	30-08-2024
2b	Updated with leakage rates	MHA	02-09-2024

Luigi Signarelli
ON BEHALF OF CrossWind
DATE 4/9/2024 WR

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1.0 Executive Summary

This document outlines the tests to be included in the witnessed Factory Acceptance Test. These tests aim to show the overall functionality of the fuel cell-based power plant. The verification should show the capability of delivering the expected AC power and that the product is ready to be delivered and installed on site.

When the delegations from CrossWind, Shell, Rosetti Marino and the surveyor from Fulkrum (CrossWind) were at Ballard Europe, Hobro to witness the selection of Factory Acceptance Tests 4/12 tests were performed and passed. The remaining eight tests are to be performed later are the following:

- F18 H2 leakage test
- O01 System Start/stop
- O09 Load Test – Step response 0 to 35%
- O10 Load Test – step response 35% to 70%
- O11 Load Test – Step response 65 to 100%
- O12 Load Test – 100% stability test – 3 hours
- O13 Load Test – Step response 100% to 50%
- O14 Load Test – step response 50% to 0%

2.0 References

- PWR008 Ballard commissioning document
- EN 60204-1
- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure
- SPC ID 0104 H2 Leak Test Procedure

3.0 Definitions and Acronyms

FC	FCwave™
H2	Hydrogen
FAT	Factory Acceptance Test
HT1	High temperature 1050kW cooling system
HT2	High temperature 1050kW cooling system
LT	Low temperature cooling system

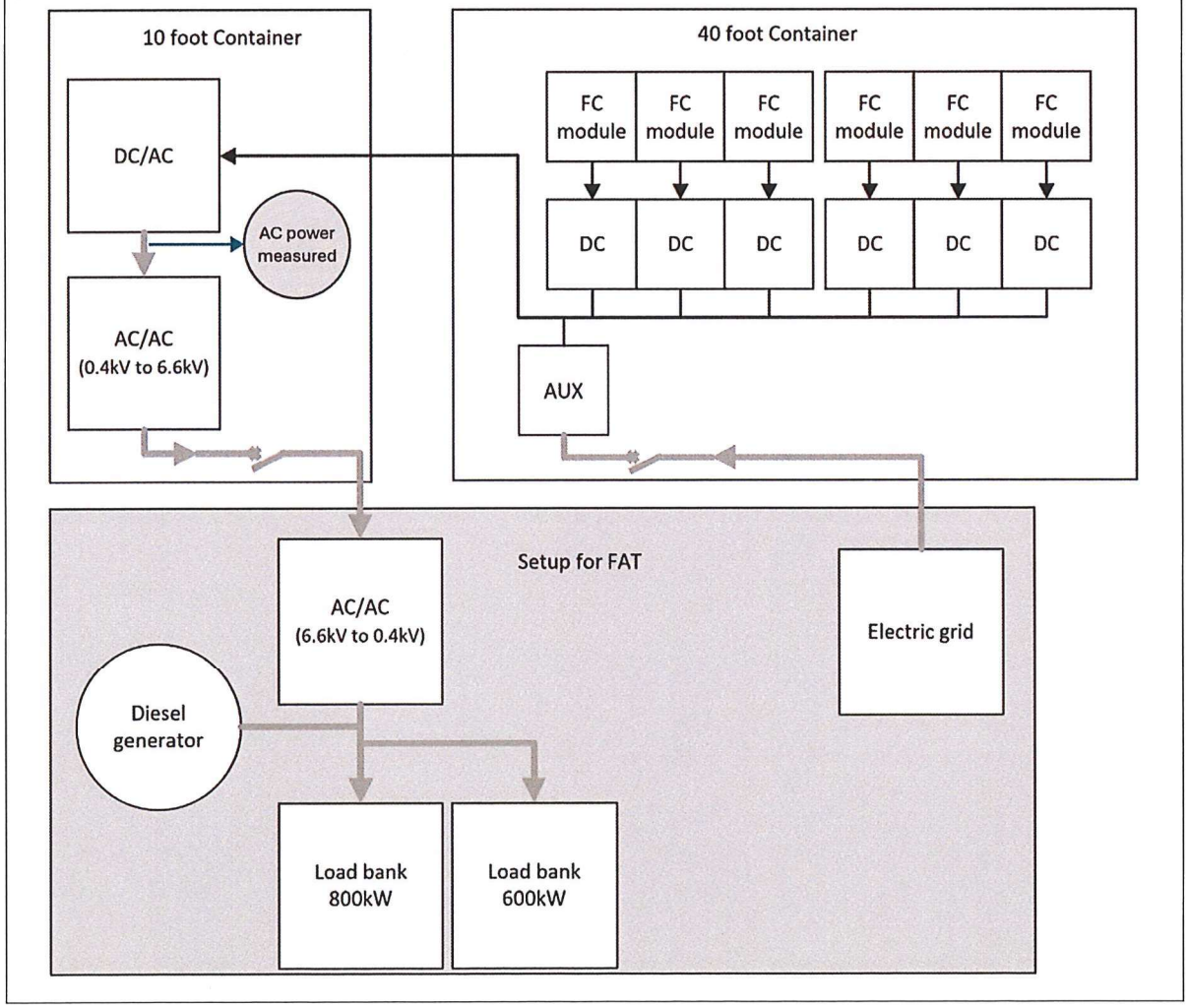
4.0 Objectives and Background

This document describes the witnessed Factory Acceptance Tests. The tests do not include the internal testing that has been done to secure product maturity, mechanical and electrical connections have been done correctly.

The scope of testing is:

- Go through the Megablock with the customer to find defects that needs to be corrected
- Safety systems are functioning correctly in a complete Megablock with coolers.
- Megablock produces AC current, and the tests shall verify the capability to produce AC current following the demand.

Figure 1: Megablock System test overview



5.0 Functional tests

5.1 F02 Visual inspection

5.1.1 Test

The test involves an examination of the paint job through visual inspection, assessing the overall build quality, and checking for any dents. The focus is also on evaluating the assembly quality to ensure compliance with weather resistance.

5.1.2 Relevant Standard / document

- No reference

5.1.3 Brief Test Plan

- Visual inspection with customer of full system meaning inside and outside container solution.
- Take comprehensive pictures of the full system and test setup, including close-ups of vital components, with timestamps for reference.

5.1.4 Pass/Fail criteria.

- Visual inspect with customer to review quality of full system.

5.1.5 Test Result

Table 1: Visual inspection – Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Inspection of paint	Accepted	Pass	See item list for further elaboration
13/8-2024	Assessing build quality	Accepted	Pass	See item list for further elaboration
13/8-2024	Check for dents	Accepted	Pass	See item list for further elaboration

5.2 F07 Electrical safety test – 10-foot container

5.2.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

5.2.2 Relevant Standard / document

- EN 60204-1

5.2.3 Brief Test Plan

- According to EN 60204-1

5.2.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

5.2.5 Test Result

Table 2: Electrical safety test - Test results

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Grounding Continuity	Accepted	Pass	-
13/8-2024	High Potential	Accepted	Pass	-

Table 3: Electrical safety test - calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
Metrel CE-Multitester	086-003	19/1-2025	Grounding Continuity and High Potential

5.3 F08 Electrical safety test – 40-foot container

5.3.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

5.3.2 Relevant Standard / document

- EN 60204-1

5.3.3 Brief Test Plan

- According to EN 60204-1

5.3.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

5.3.5 Test Result

Table 4: Electrical safety test - Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Grounding Continuity	Accepted	Pass	-
13/8-2024	High Potential	Accepted	Pass	-

Table 5: Electrical safety test - Calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
Metrel CE-Multitester	086-003	19/1-2025	Grounding Continuity and High Potential

5.4 F10 Safety

5.4.1 Test

Conduct tests of safety inputs and outputs, including emergency stop buttons, smoke detectors, gas detectors and external connections.

5.4.2 Relevant Standard / document

- Safety input checklist according to EN/ISO 13849-2 procedure

5.4.3 Brief Test Plan

- Trigger each safety input according to checklist.
  - Emergency pushbuttons
  - Smoke detectors test
  - H2 sensor test
  - External safety switches
  - External feedback

5.4.4 Pass/Fail criteria.

- Verified according to checklist.
- Each item triggers the correct alarm

5.4.5 Test Result

Table 6: Safety - Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Emergency pushbuttons	OK	Pass	-
13/8-2024	Smoke detectors	OK	Pass	3 sensors in 40ft container and 1 sensor in 10 ft container
13/8-2024	H2 sensors	OK	Pass	3 sensors in 40ft container
13/8-2024	External safety switches	OK	Pass	-
13/8-2024	External feedback	OK	Pass	-

Table 7: Safety - Calibration Equipment

Unit	Equipment number	Calibration due date	Equipment used for
Dräger calibration gas, 2% Hydrogen	Cylinder No: 955-657732	Valid until 10/1-2029	H2 sensors

5.5 F18 H_2 Leakage test

5.5.1 Test procedure

All pipework and H2 instrumentation subassemblies must be inspected, recorded, verified and pass in accordance with the procedure in section 5.4 in *SPC ID 0104 H2 Leak Test Procedure Rev 002* prior to full system FAT.

System H2 leakage test is done system pressure decay test, according to section 5.5 in *SPC ID 0104 H2 Leak Test Procedure Rev 002.*

5.5.2 Pass/Fail criteria.

Pressure decay test with a maximum leakage no greater than specified in test procedure.

Result details are documented in the template *SPC ID 0204 System pressure decay test template*

Parameter	Value	Description
L_A [Nm^3/h]	**2,72 – 3,58 x10^{-3}**	**Maximum allowed pressure decay to pass pressure decay test, where L_A = L_S + L_Mu**
L_S [Nm^3/h]	0	Summarized expected leak rates of all components in the system (per design leak rate).
L_Mu [Nm^3/h]	2,72 – 3,58 x10^{-3}	Calculated accuracy of the measuring system, used to perform the test.
L_C [Nm^3/h]	2,7x10^{-5}	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

5.5.3 Test Result

Table 8: H2 leakage - Test Result

Date tested	Item	Leakage rate L_1 [Nm^3/h]	Pass/Fail	Notes
3/9-2024	H2 line 1	4.03E-05	Pass	-
3/9-2024	H2 line 2	8.06E-05	Pass	-
3/9-2024	H2 line 3	0.00E+00	Pass	-
3/9-2024	H2 line 4	1.60E-04	Pass	-
3/9-2024	H2 line 5	7.27E-05	Pass	-
3/9-2024	H2 line 6	-8.16E-05	Pass	-

6.0 Operational tests

Operations are done using operator HMI or remote HMI in normal operating mode.

6.1 O01 System Start/Stop - Normal low load operation.

6.1.1 Test

Fuel Cell system can start, deliver minimum power and perform controlled stop without faults. This test is based on DC power.

6.1.2 Relevant Standard / document

- No reference

6.1.3 Brief Test Plan

- All FC in standby
- Request 100kW DC
- Delay 120 seconds
- Request zero power
- Repeat with new preferred FC until all tested.

6.1.4 Pass/Fail criteria.

- Fuel Cell Package starts without faults.
- No persistent system alarms.
- Correct available power signal.
- DC Power output within +/-5% and stable in less than 60 seconds
- Fuel Cell Package stops without faults.
- FC in stand-by in less than 30 seconds.

6.1.5 Test Result

Table 9: System Start/Stop – Normal low load operation - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	FCwave 1	All pass criterias passed except time to standby	Pass with note	Shut down to standby longer than 30 seconds
3/9-2024	FCwave 2	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 58 seconds. Power output dipped to 82 kW during the test.
3/9-2024	FCwave 3	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 55 seconds.
3/9-2024	FCwave 4	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 59 seconds.
3/9-2024	FCwave 5	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 57 seconds.
3/9-2024	FCwave 6	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 1 minute 3 seconds.

6.2 O09 Load Test – step response 0 to 35%

6.2.1 Test

Test step response by adding 35% load in one step from no load while measuring AC power quality.

6.2.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.2.3 Brief Test Plan

- All FC in stand-by.
- Apply set point by requesting 350kW AC

6.2.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.2.5 Test Result

Table 10: Load Test - step response 0 to 35% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 0-35%	45 seconds for start-up 0-350kW AC. Slight overshoot on 30 kW AC	Pass	With reference to document C08 it is estimated that a ramp time to 500 kW is 75 seconds.
3/9-2024	AC power quality	2,8-2,9% VAC THD 2-50 No alarms	Pass	

6.3 O10 Load Test – step response 35% to 70%

6.3.1 Test

Test step response by adding 35% load in one step to reach 70% load while measuring AC power quality.

6.3.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.3.3 Brief Test Plan

- 3 FC running delivering 350kW AC steady state.
- 2 FC in stand-by
- Apply set point by requesting 700kW AC power.

6.3.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC
- AC power quality within SPC ID 107
- No persistent system alarms.

6.3.5 Test Result

Table 11: Load Test - step response 35% to 70% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 35%-70%	All 3 started up. 23 seconds startup time	Pass	With reference to document C08 it is estimated that a ramp time from 250 kW to 750 kW is 45 seconds.
3/9-2024	AC power quality	2,8-3,0 % VAC THD 2-50 No alarms	Pass	

6.4 O11 Load Test – step response 65% to 100%

6.4.1 Test

Test step response by adding 35% load in one step to reach full load while measuring AC power quality.

6.4.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.4.3 Brief Test Plan

- 6 FC running delivering 650kW AC steady state.
- Apply set point by requesting 1000kW AC power.

6.4.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.4.5 Test Result

Table 12: Load Test - step response 65% to 100% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 65%-100%	18 seconds startup time	Pass	With reference to document C08 it is estimated that a ramp time from 250 kW to 750 kW is 45 seconds.
3/9-2024	AC power quality	3,0-3,1 % VAC THD 2-50 No alarms	Pass	

6.5 O12 Load Test – 100% stability test - 3 hours.

6.5.1 Test

Test steady state at 100% load for 3 hours while measuring power quality.

6.5.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.5.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.

6.5.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.5.5 Test Result

Table 13: Load Test – Steady state 100% load - Test Result

Date tested	Item	Result	Pass/Fail	Notes
04-09-24	Full load test	1000 kW for 3 hours	Pass	See below
04-09-24	AC power quality	2.3-3.6 % VAC THD 2-50 No alarms	Pass	

- Following added to document 05/09/2024
- In agreement with customer, after half elapsed time of the test, BOP load was increased to maximum by the following:
  - All HT fans forced to 100%
  - HT Coolant pumps forced to 70%
  - Ventilation (40ft+10ft) increased to 100%
- No impact on power delivery was observed.

6.6 O13 Load Test – step response 100% to 50%

6.6.1 Test

Test step response by removing 50% load in one step at full load while measuring power quality.

6.6.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.6.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.
- Request 500kW AC.

6.6.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.6.5 Test Result

Table 14: Load Test - step response 100% to 50% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 100%-50%	Ramp down in 15 seconds	Pass	Wit reference to document C08 it is estimated that a ramp down time from 800 kW to 200 kW is 15 seconds.
3/9-2024	AC power quality	3,0-2,6 % VAC THD 2-50 No alarms	Pass	

6.7 O14 Load Test – step response 50% to 0%

6.7.1 Test

Test step response by removing 50% load in one step to no load while measuring AC power quality.

6.7.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.7.3 Brief Test Plan

- 3 FC running delivering 500kW AC.
- Request 0% and apply set point.

6.7.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.7.5 Test Result

Table 15: Load Test - step response 50% to 0% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
03-09-2024	Step response 50%-0%		Pass	Test is executed with 6 FC instead of 3 as the plan describes
—	AC power quality	NA	NA	Not applicable due to the unit not producing power

ON BEHALF OF Ballard
DATE 6/9/2024 WR

SPC ID 0203 Pipework inspection and leakage test check sheet

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on allowable leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 heater, String 1	1-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 1	1-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 3	3-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 5	5-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater string 1,2,3 Inlet

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





H2 Heater string 4,5,6 Inlet



H2 Heater string 1,2,3,4,5,6 Shut-off Valve & Pipes

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





SPC ID 0203 Pipework inspection and leakage test check sheet

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on expected leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 Heater+Container, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 1	1-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 3	3-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container string 1,2,3,4,5,6



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

H2 Container pipe to FCwave



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

SPC ID 0204 System Pressure Decay Test Template

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-08-2024
2	Updated	TAN	09-09-2024

Purpose	Pressure decay test template for recording tightness and evaluating system pipework integrity
Reference procedure	SPC ID 0104 rev 002 H2 Leak Test Procedure

Checked by	MHA	Date: 09/09-2024
Approved by	MHA	Date: 09/09-2024

Title	System Pressure Decay, Complete Assembly, Crosswind
Project	601456B Crosswind BLPH
Test date	03-09-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓ see Sheet "P&ID"

Test volume	String 1 HA01+DA02-QM01 to YV_H30 solenoid valve in FCwave 1. Similar valves for string 2-6.
Test fluid/gas	Hydrogen
Test location	Crosswind Container, Majsmarken 1, 9500 Hobro Denmark
Test performed by	TAN
Results approved by	MHA
Filing date	09-09-2024

L_S - Expected leak rate for pipework system							
Ferrule fittings tightness tolerance	< 0		bar				
Bonded seal tightness tolerance	< 0		bar				
L_S total*	= 0		bar				
L_S total	=	0	NM3/h				
L_Mu - Measuring system uncertainty							
pressure gauge uncertainty							
transmitter FS (full scale)	=	16	barg				
Linearity	<	0.2	% of FS	=	<	32	mbar
Non-repeatability	<	0.1	% of FS	=	<	16	mbar
Analogue input	±	10	microA	=		10	mbar/10 minutes
Accuracy ±0.25% actual reading	±	32.5	microA		=	32.5	mbar
Temperature uncertainty (3 Kelvin)				=	±	82	mbar/10 minutes
L_Mu total					=	172.5	mbar

*=All joints and valves are considered to be classified "enhanced tightness". Hence zero allowable leak rate

Calculation of L_Mu, measuring system uncertainty

	V	T0	T1	T2	P0	P1	P2	Pa1	Pa2	t	L_Mu
	M3	°C	°C	°C	kPa	barg	barg	kPa	kPa	minutes	NM3/h
String 1	3.46E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.53E-03
String 2	3.05E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.12E-03

String 3	2.67E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	2.72E-03
String 4	2.74E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	2.80E-03
String 5	3.12E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.19E-03
String 6	3.50E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.58E-03

Calculation of L_A, max evaluated leak rate for pipework system acceptance

	L_S	L_Mu		L_A
	NM3/h	NM3/h		NM3/h
String 1	0	3.53E-03	=	3.53E-03
String 2	0	3.12E-03	=	3.12E-03
String 3	0	2.72E-03	=	2.72E-03
String 4	0	2.80E-03	=	2.80E-03
String 5	0	3.19E-03	=	3.19E-03
String 6	0	3.58E-03	=	3.58E-03

Procedure

Fill in design pressure =	6.5	barg
The Test Pressure is 1.1 times design pressure or above =	7.15	barg
If the system previosly has been leakage tested with formier gas, this test can also use the used gas for operation		
To perform the test follow "Sequence" paragraph 5.5.3 in SPC 0104 H2 Leak Test Procedure		

Calculation of L1, actual leak rate

	V	T0	T1	T2	P0	P1	P2	Pa1	Pa2	t	L1 (gas leakage rate)
	M3	°C	°C	°C	kPa	barg	barg	kPa	kPa	minutes	NM3/h
String 1	0.003458573	15	19.7	19.7	101.325	7.494	7.492	1015	1015	10	4.03E-05
String 2	0.003458573	15	19.7	19.7	101.325	7.578	7.574	1015	1015	10	8.06E-05
String 3	0.002666793	15	19.7	19.7	101.325	7.95	7.95	1015	1015	10	0.00E+00
String 4	0.002741607	15	19.7	19.7	101.325	7.552	7.542	1015	1015	10	1.60E-04
String 5	0.003120525	15	19.7	19.7	101.325	7.452	7.448	1015	1015	10	7.27E-05
String 6	0.003500483	15	19.7	19.7	101.325	7.28	7.284	1015	1015	10	-8.16E-05

Sensor	Sensor placement
Temperature sensor T1 & T2	BT01 Sensor in H2 heater
Pressure sensor P1 & P2	FCwave pressure inlet sensor
Atmospheric pressure Pa1 & Pa2	Data from https://www.dmi.dk/maalinger/show/DK/2620167/Hobro/

Result of test

	L1	<	L_A	Pass (Below acceptance criteria L_A)
	NM3/h		NM3/h	Pass/Fail
String 1	4.03E-05	<	3.53E-03	Pass
String 2	8.06E-05	<	3.12E-03	Pass
String 3	0.00E+00	<	2.72E-03	Pass
String 4	1.60E-04	<	2.80E-03	Pass
String 5	7.27E-05	<	3.19E-03	Pass
String 6	-8.16E-05	<	3.58E-03	Pass

Title: System Pressure Decay, Complete Assembly, CrossWind
P&ID of Hydrogen Supply system

SPC ID: 0204
Revision: 2

Printed on: 09-09-2024

Hydrogen Supply System - Fuel Cells 1-6

=RE01
Fuel Cell System 1

+GB01
FCwave 1

-XM01
20mm
H2 Supply Inlet

-WP_H2927
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB02
FCwave 2

-XM01
20mm
H2 Supply Inlet

-WP_H2926
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB03
FCwave 3

-XM01
20mm
H2 Supply Inlet

-WP_H2925
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

=RE02
Fuel Cell System 2

+GB04
FCwave 4

-XM01
20mm
H2 Supply Inlet

-WP_H2924
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB05
FCwave 5

-XM01
20mm
H2 Supply Inlet

-WP_H2923
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB06
FCwave 6

-XM01
20mm
H2 Supply Inlet

-WP_H2922
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

=HA01+DA02
Hydrogen Supply System, Container #1 Outside

-XT01
Wall pass-through

-WP_H2917
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT02
Wall pass-through

-WP_H2916
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT03
Wall pass-through

-WP_H2915
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT04
Wall pass-through

-WP_H2914
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT05
Wall pass-through

-WP_H2913
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT06
Wall pass-through

-WP_H2912
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

Y V
QM21

=HA01+DA02-QM21
DN20
Shut-off valve

Y V
QM22

=HA01+DA02-QM22
DN20
Shut-off valve

Y V
QM23

=HA01+DA02-QM23
DN20
Shut-off valve

Y V
QM24

=HA01+DA02-QM24
DN20
Shut-off valve

Y V
QM25

=HA01+DA02-QM25
DN20
Shut-off valve

Y V
QM26

=HA01+DA02-QM26
DN20
Shut-off valve

-WP_H2907
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2906
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2905
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2904
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2903
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2902
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

Y V
QM11

=HA01+DA02-QM11
DN20
Shut-off Valve

Y V
QM12

=HA01+DA02-QM12
DN20
Shut-off Valve

Y V
QM13

=HA01+DA02-QM13
DN20
Shut-off Valve

Y V
QM14

=HA01+DA02-QM14
DN20
Shut-off Valve

Y V
QM15

=HA01+DA02-QM15
DN20
Shut-off Valve

Y V
QM16

=HA01+DA02-QM16
DN20
Shut-off Valve

-BL01
SI = 11 mm
Ex Point Liquid Detection

BT01
PT1000 -40...150 °C
Liquid Temperature Sensor

-CM01
SS316, Volume 146L
Hydrogen Heater Vessel

-WP01
DN25, 3000m
Tube Coil

-WP02
DN25, 3000m
Tube Coil

-WP03
DN25, 3000m
Tube Coil

-WP04
DN25, 3000m
Tube Coil

-WP05
DN25, 3000m
Tube Coil

-WP06
DN25, 3000m
Tube Coil

-EA01
3x400V, 9kW, Ex
Heating Element 1

-EA02
3x400V, 9kW, Ex
Heating Element 2

-WP_H2947
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2946
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2945
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2944
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2943
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2942
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

H

=HA01+DA02-QM01
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM02
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM03
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM04
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM05
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM06
DN25
Isolation Valve, Lockable

=HKN70
Baseload Power Hub, Hydrogen Supply

0.5 - 25.4 g/s
-5.4 - 80°C
3.5 - 4.5 barg
Hydrogen

=HA01+DA02-XM01
DN32 ASME B16.5
H2 Supply Connection

P T
BT01

=HA01+DA02-BP01
0...10 barg
Hydrogen Inlet
Pressure Transmitter

-WP_H2900
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
0.5 - 25.4 g/s

H

=HA01+DA02-QM00
DN32
Manual shutoff valve
Lockable

-WP_H2901
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
0.5 - 25.4 g/s

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	-.P13
EPLAN Project Pages	319
=	+ + + & 802

REVISION INFORMATION	
DESCRIPTION	
DATE	08-Mar-24

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DRAWING	6014568 C03 Process and Instrumentation Diagram
REVISION	-.P13
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Hydrogen Supply System
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1
LANGUAGE EN	SHEET/TOTAL 4 / 14

FRMS110653/08

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	13-08-2024
Test location	Crosswind Containers, Majsmarken 1, 9500 Hobro, Denmark
Test performed by	PBL & TAN

Grounding continuity

EN 60204-1:2018 - Section 18.2.2 - Test 1

Test performed with a test current of 10A

Main location	Location	Measurement	Unit
40ft container	Busbar to busbar	0.024	Ohm
	Module 1	0.018	Ohm
	DC/DC cabinet 1	0.023	Ohm
	Module 2	0.024	Ohm
	DC/DC cabinet 2	0.019	Ohm
	Module 3	0.026	Ohm
	DC/DC cabinet 3	0.016	Ohm
	Module 4	0.026	Ohm
	DC/DC cabinet 4	0.016	Ohm
	Module 5	0.024	Ohm
	DC/DC cabinet 5	0.017	Ohm
	Module 6	0.029	Ohm
	DC/DC cabinet 6	0.015	Ohm
	Control cabinet	0.021	Ohm
	Control cabinet right door	0.032	Ohm
	Lifting crane track, dolly	0.028	Ohm
	LT piping	0.031	Ohm
	Isolation transformer cover	0.039	Ohm
	Cable tray	0.019	Ohm

Main location	Location	Measurement	Unit
10ft container	Busbar to busbar	0.019	Ohm
	Main DC/Acpoint 1	0.032	Ohm
	Main DC/Acpoint 2	0.024	Ohm
	Main DC/Acpoint 3	0.027	Ohm
	DC/AC conduncter point 1	0.037	Ohm
	DC/AC conduncter point 2	0.022	Ohm
	DC/AC conduncter point 3	0.023	Ohm
	LT coolant pipe	0.024	Ohm
	Cable tray	0.02	Ohm
	Main transforer grounding bolt	0.023	Ohm
	Main transformer chassis	0.02	Ohm
	Cable tray	0.022	Ohm

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	13-08-2024
Test location	Crosswind Containers, Majsmarken 1, 9500
Test performed by	PBL & TAN

Isolation resistance
EN 60204-1:2018 - Section 18.3
Test performed with a test voltage of 1000V

Main location	Location	Measurement	Unit
40 ft container	L1-PE	> 999.9	MOhm
	Cooling skid L1	10.01	Mohm
	Colling skid L2	6.252	Mohm
	Cooling skid L3	12.81	Mohm
	AUX supply L1	251	Mohm
	AUX supply L2	337	MOhm
	AUX supply L3	237	Mohm

Main location	Location	Measurement	Unit
10ft container	L1+L2+L3-PE on AC circuit	592	Mohm

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	13-08-2024
Test location	Crosswind Containers, Majsmarken 1, 9500
Test performed by	PBL & TAN

Isolation resistance

EN 60204-1:2018 - Section 18.4

Test performed with a test voltage of 2500VAC

Main location	Location	Measurement	Unit	Notes
40ft container	PE and L1	0	mA	The surge arrestor has been bypassed to allow the test to be conducted
	PE and L2	0	mA	
	PE and L3	0	mA	

Main location	Location	Measurement	Unit	Notes
10 FT container	PE and L1	7.1	mA	
	PE and L2	7.1	mA	
	PE and L3	7	mA	

Date: 2024-09-11

Author: PBL, TAN

Ballard Power Systems Europe

Summary:

Thermographic report from Crosswind FAT2, 2024-09-04.

System is operating at 100% (1MW) and have been at full power for >1 hour with the cooling and ventilation system operating at 100%.

Test start at 8:55

The first few images are the system from a distance.

First half of the report shows thermal images from inside the 40ft container, with focus on DC power cables, pumps and fans and process exhaust pipes.

Second half of the report shows the system test equipment and outside the system.

There are no items of concern.

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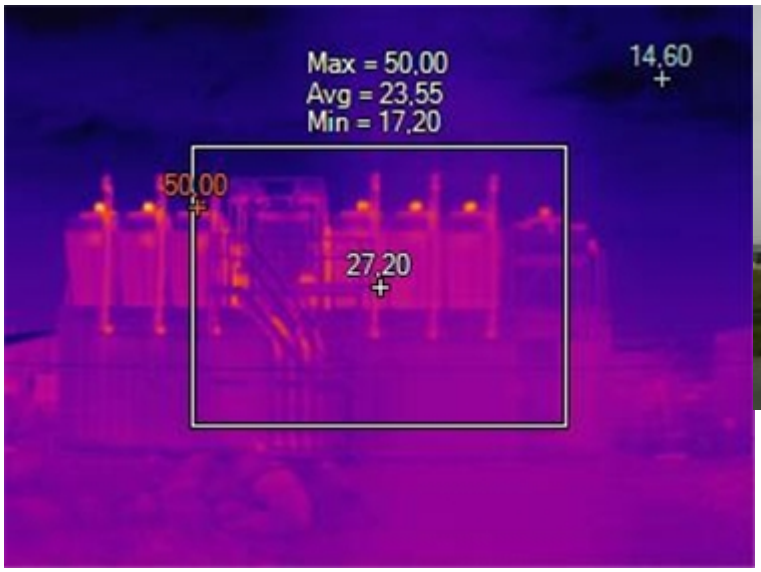




Image Info

Name	IR_00252.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	14,60 °C to 50,00 °C
Image Time	04/09/2024 11:45:17 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27,2 °C	27,2 °C	27,2 °C	0,95	22,0 °C	0,00	
Centerbox	50,0 °C	17,2 °C	23,6 °C	0,95	22,0 °C	2,67	
Hot	50,0 °C	50,0 °C	50,0 °C	0,95	22,0 °C	0,00	
Cold	14,6 °C	14,6 °C	14,6 °C	0,95	22,0 °C	0,00	

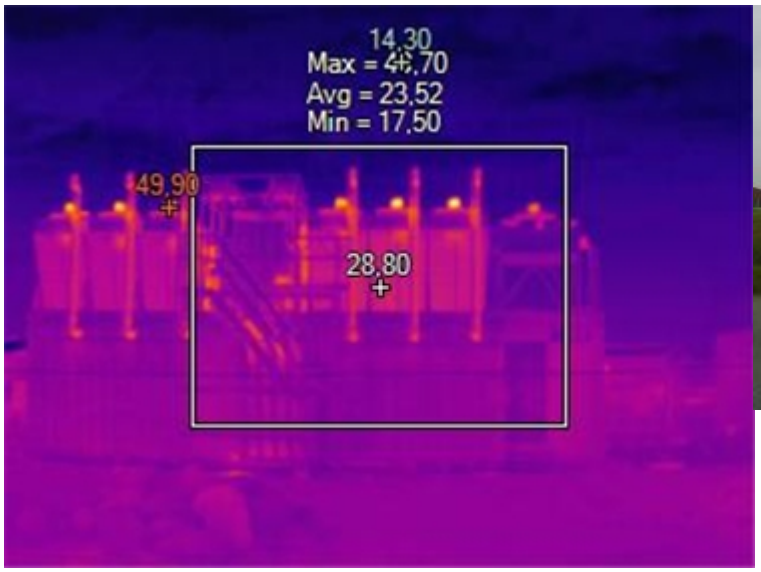


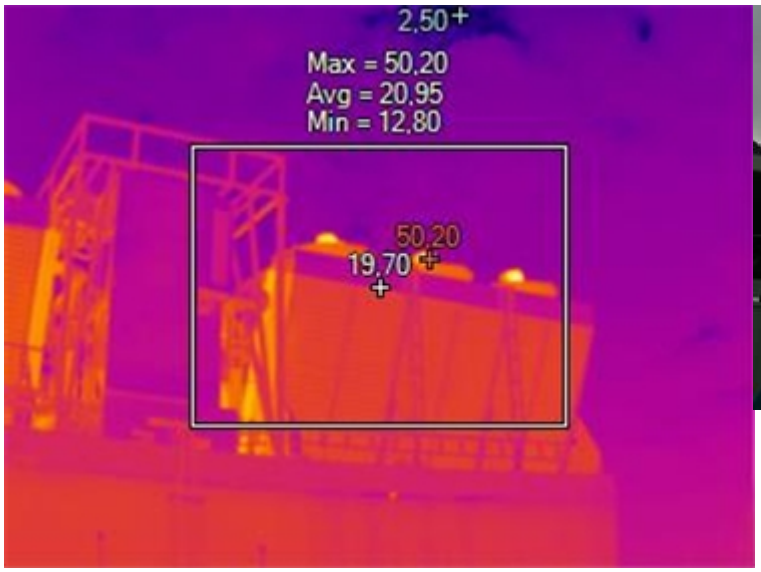


Image Info

Name	IR_00251.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	14,30 °C to 49,90 °C
Image Time	04/09/2024 11:45:00 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,8 °C	28,8 °C	28,8 °C	0,95	22,0 °C	0,00	
Centerbox	49,7 °C	17,5 °C	23,5 °C	0,95	22,0 °C	3,28	
Hot	49,9 °C	49,9 °C	49,9 °C	0,95	22,0 °C	0,00	
Cold	14,3 °C	14,3 °C	14,3 °C	0,95	22,0 °C	0,00	



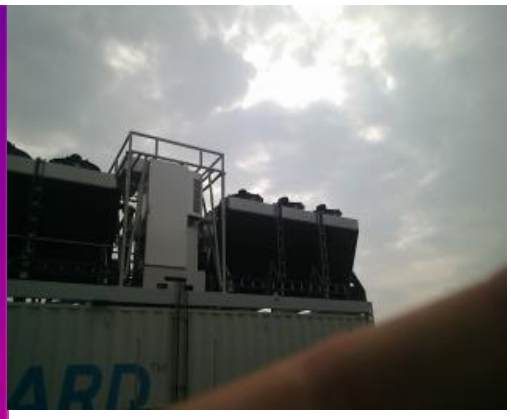


Image Info

Name	IR_00250.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	2,50 °C to 50,20 °C
Image Time	04/09/2024 11:43:56 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	19,7 °C	19,7 °C	19,7 °C	0,95	22,0 °C	0,00	
Centerbox	50,2 °C	12,8 °C	20,9 °C	0,95	22,0 °C	5,34	
Hot	50,2 °C	50,2 °C	50,2 °C	0,95	22,0 °C	0,00	
Cold	2,5 °C	2,5 °C	2,5 °C	0,95	22,0 °C	0,00	

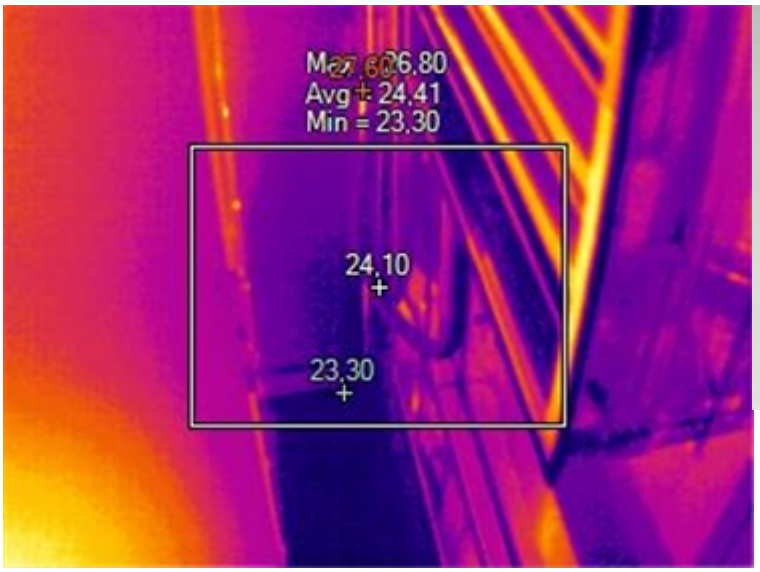




Image Info

Name	IR_00248.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,30 °C to 27,60 °C
Image Time	04/09/2024 11:31:07 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24,1 °C	24,1 °C	24,1 °C	0,95	22,0 °C	0,00	
Centerbox	26,8 °C	23,3 °C	24,4 °C	0,95	22,0 °C	0,56	
Hot	27,6 °C	27,6 °C	27,6 °C	0,95	22,0 °C	0,00	
Cold	23,3 °C	23,3 °C	23,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00247.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	23.10 °C to 28.60 °C
Image Time	04/09/2024 11:31:00 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	28.6 °C	23.2 °C	23.9 °C	0.95	22.0 °C	0.55	
Hot	28.6 °C	28.6 °C	28.6 °C	0.95	22.0 °C	0.00	
Cold	23.1 °C	23.1 °C	23.1 °C	0.95	22.0 °C	0.00	

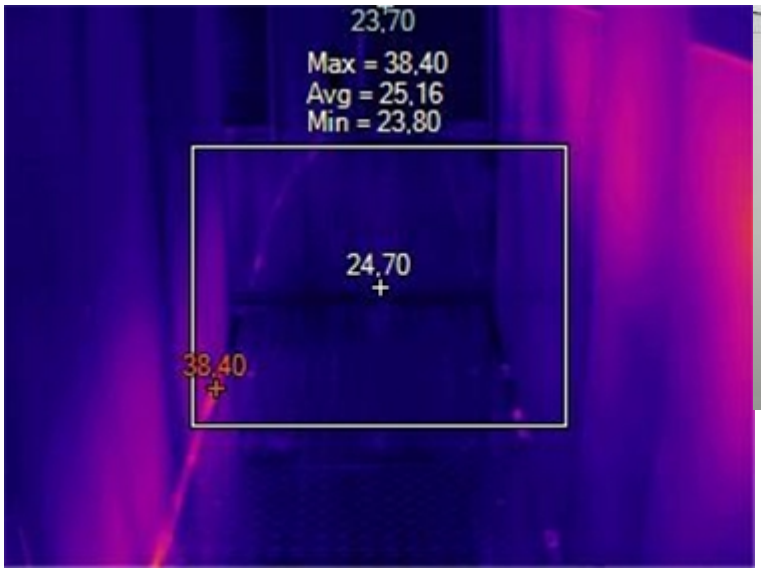




Image Info

Name	IR_00246.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,70 °C to 38,40 °C
Image Time	04/09/2024 11:30:47 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24,7 °C	24,7 °C	24,7 °C	0,95	22,0 °C	0,00	
Centerbox	38,4 °C	23,8 °C	25,2 °C	0,95	22,0 °C	0,71	
Hot	38,4 °C	38,4 °C	38,4 °C	0,95	22,0 °C	0,00	
Cold	23,7 °C	23,7 °C	23,7 °C	0,95	22,0 °C	0,00	

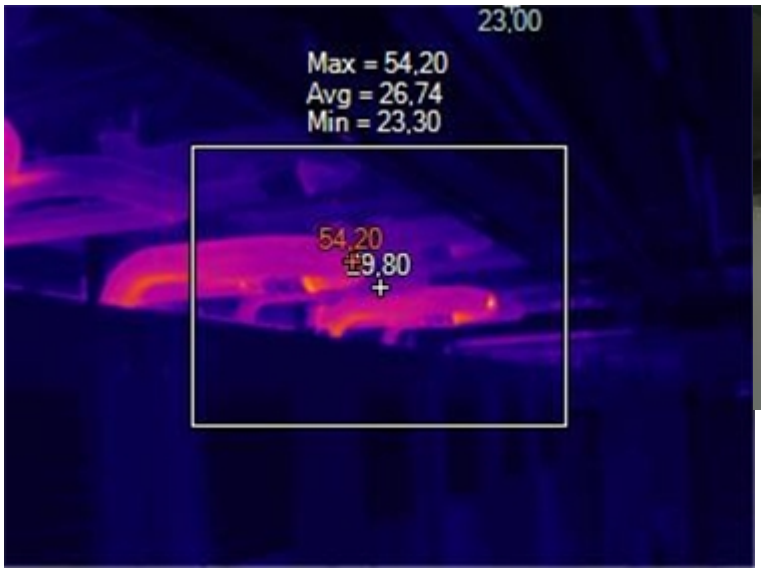




Image Info

Name	IR_00245.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,00 °C to 54,20 °C
Image Time	04/09/2024 11:30:41 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,8 °C	29,8 °C	29,8 °C	0,95	22,0 °C	0,00	
Centerbox	54,2 °C	23,3 °C	26,7 °C	0,95	22,0 °C	3,47	
Hot	54,2 °C	54,2 °C	54,2 °C	0,95	22,0 °C	0,00	
Cold	23,0 °C	23,0 °C	23,0 °C	0,95	22,0 °C	0,00	

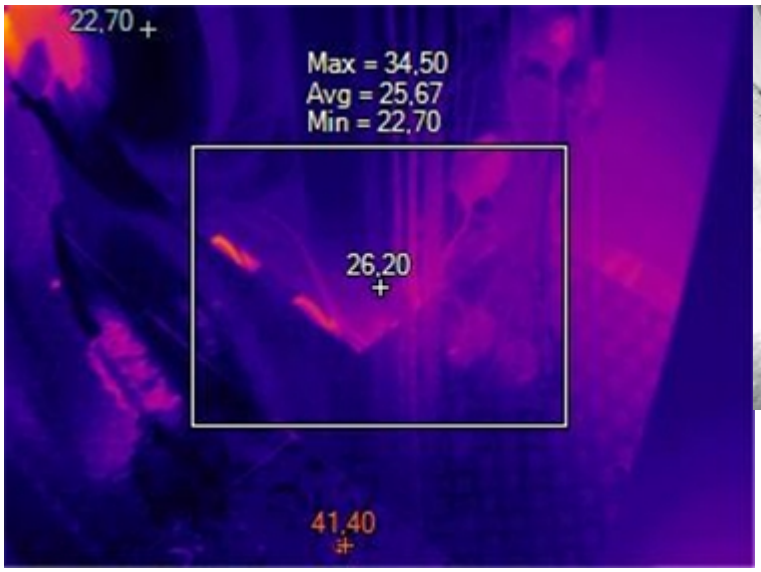




Image Info

Name	IR_00244.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,70 °C to 41,40 °C
Image Time	04/09/2024 11:30:33 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	26,2 °C	26,2 °C	26,2 °C	0,95	22,0 °C	0,00	
Centerbox	34,5 °C	22,7 °C	25,7 °C	0,95	22,0 °C	1,26	
Hot	41,4 °C	41,4 °C	41,4 °C	0,95	22,0 °C	0,00	
Cold	22,7 °C	22,7 °C	22,7 °C	0,95	22,0 °C	0,00	

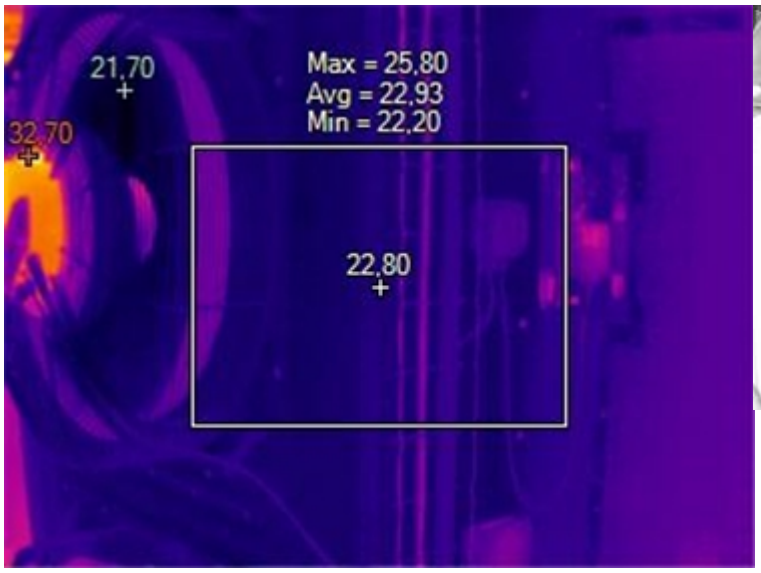




Image Info

Name	IR_00243.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,70 °C to 32,70 °C
Image Time	04/09/2024 11:30:27 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22,8 °C	22,8 °C	22,8 °C	0,95	22,0 °C	0,00	
Centerbox	25,8 °C	22,2 °C	22,9 °C	0,95	22,0 °C	0,44	
Hot	32,7 °C	32,7 °C	32,7 °C	0,95	22,0 °C	0,00	
Cold	21,7 °C	21,7 °C	21,7 °C	0,95	22,0 °C	0,00	

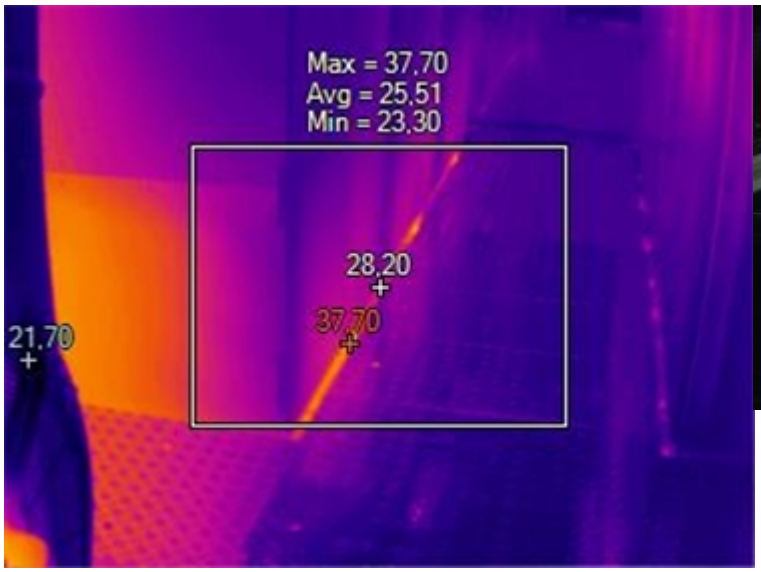




Image Info

Name	IR_00242.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,70 °C to 37,70 °C
Image Time	04/09/2024 11:30:17 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,2 °C	28,2 °C	28,2 °C	0,95	22,0 °C	0,00	
Centerbox	37,7 °C	23,3 °C	25,5 °C	0,95	22,0 °C	1,49	
Hot	37,7 °C	37,7 °C	37,7 °C	0,95	22,0 °C	0,00	
Cold	21,7 °C	21,7 °C	21,7 °C	0,95	22,0 °C	0,00	

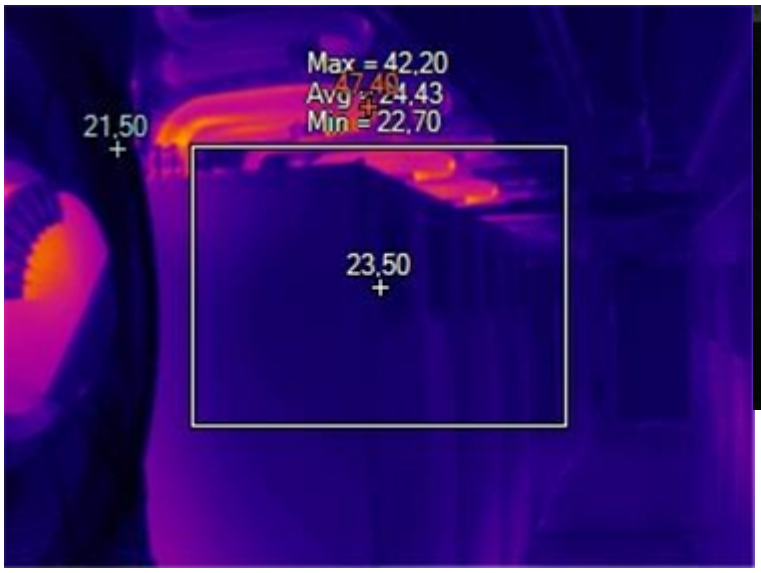




Image Info

Name	IR_00241.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,50 °C to 47,40 °C
Image Time	04/09/2024 11:30:12 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,5 °C	23,5 °C	23,5 °C	0,95	22,0 °C	0,00	
Centerbox	42,2 °C	22,7 °C	24,4 °C	0,95	22,0 °C	1,92	
Hot	47,4 °C	47,4 °C	47,4 °C	0,95	22,0 °C	0,00	
Cold	21,5 °C	21,5 °C	21,5 °C	0,95	22,0 °C	0,00	

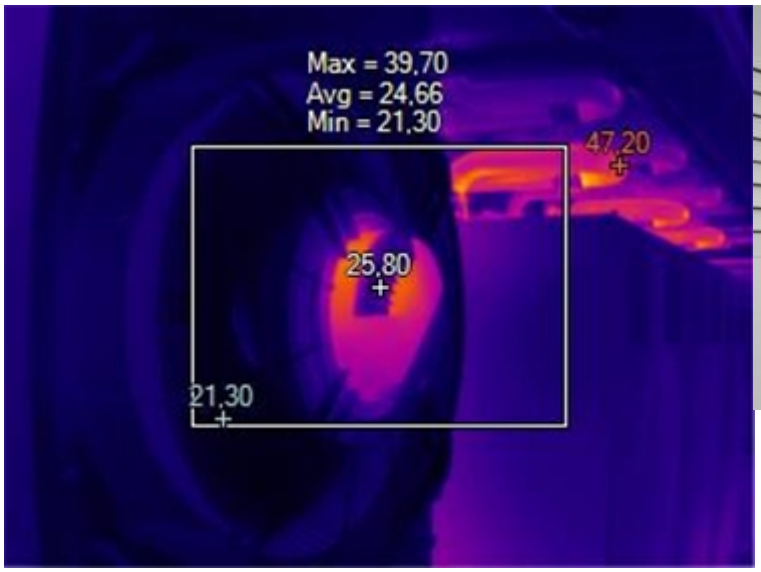




Image Info

Name	IR_00240.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,30 °C to 47,20 °C
Image Time	04/09/2024 11:29:44 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	
Centerbox	39,7 °C	21,3 °C	24,7 °C	0,95	22,0 °C	3,44	
Hot	47,2 °C	47,2 °C	47,2 °C	0,95	22,0 °C	0,00	
Cold	21,3 °C	21,3 °C	21,3 °C	0,95	22,0 °C	0,00	

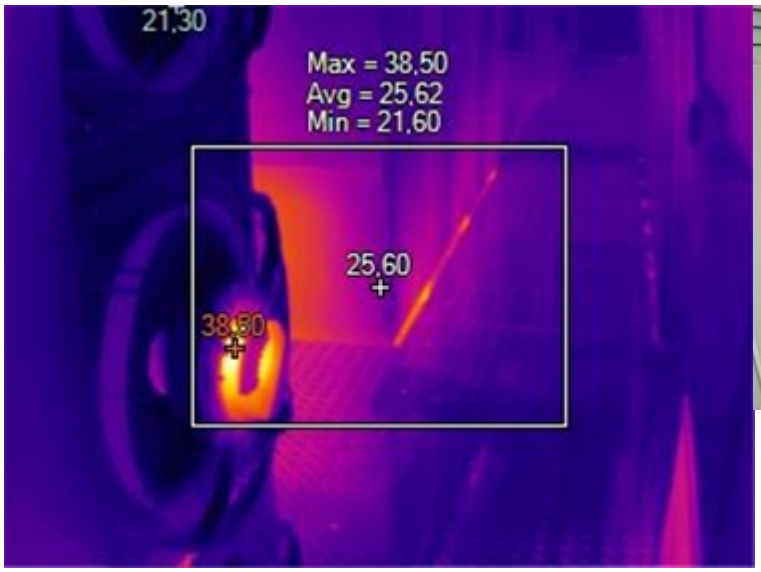




Image Info

Name	IR_00239.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,30 °C to 38,50 °C
Image Time	04/09/2024 11:29:27 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,6 °C	25,6 °C	25,6 °C	0,95	22,0 °C	0,00	
Centerbox	38,5 °C	21,6 °C	25,6 °C	0,95	22,0 °C	2,50	
Hot	38,5 °C	38,5 °C	38,5 °C	0,95	22,0 °C	0,00	
Cold	21,3 °C	21,3 °C	21,3 °C	0,95	22,0 °C	0,00	

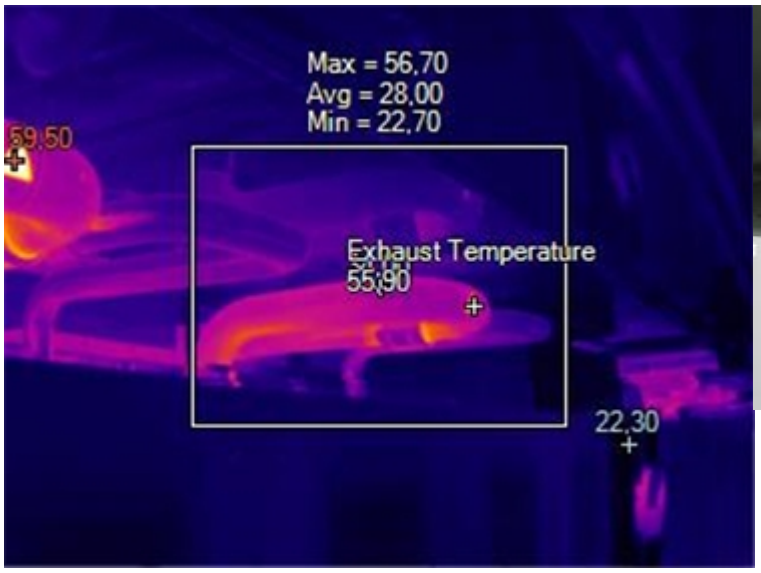




Image Info

Name	IR_00238.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,30 °C to 59,50 °C
Image Time	04/09/2024 11:29:09 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	34,0 °C	34,0 °C	34,0 °C	0,95	22,0 °C	0,00	
Centerbox	56,7 °C	22,7 °C	28,0 °C	0,95	22,0 °C	4,18	
Hot	59,5 °C	59,5 °C	59,5 °C	0,95	22,0 °C	0,00	
Cold	22,3 °C	22,3 °C	22,3 °C	0,95	22,0 °C	0,00	
Exhaust Temperature	55,9 °C	55,9 °C	55,9 °C	0,95	22,0 °C	0,00	

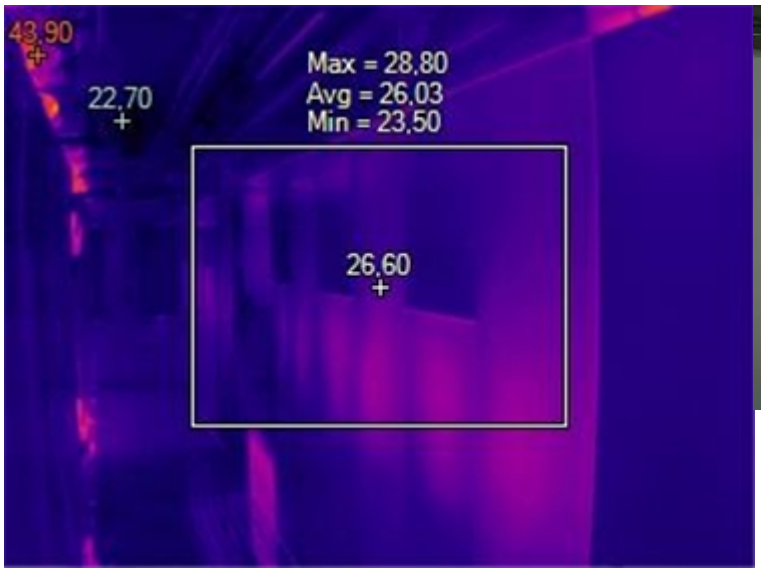




Image Info

Name	IR_00237.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,70 °C to 43,90 °C
Image Time	04/09/2024 11:29:01 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	26,6 °C	26,6 °C	26,6 °C	0,95	22,0 °C	0,00	
Centerbox	28,8 °C	23,5 °C	26,0 °C	0,95	22,0 °C	1,08	
Hot	43,9 °C	43,9 °C	43,9 °C	0,95	22,0 °C	0,00	
Cold	22,7 °C	22,7 °C	22,7 °C	0,95	22,0 °C	0,00	

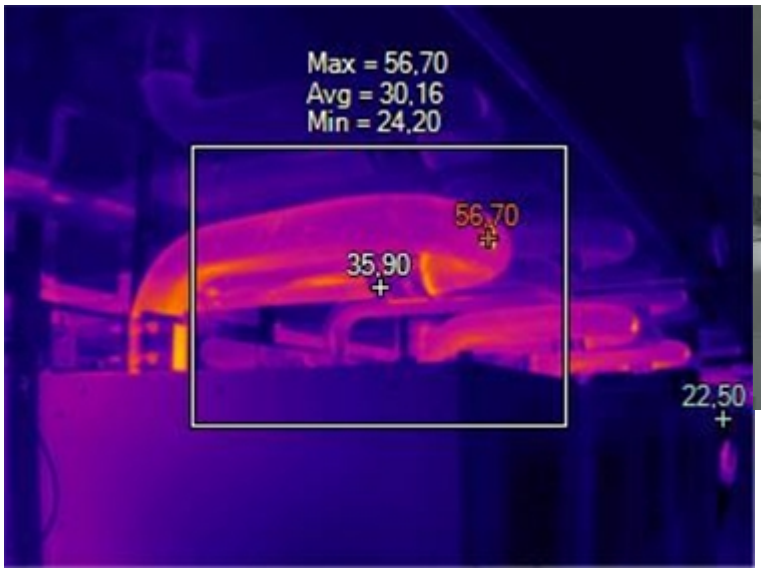




Image Info

Name	IR_00236.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,50 °C to 56,70 °C
Image Time	04/09/2024 11:28:50 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	35,9 °C	35,9 °C	35,9 °C	0,95	22,0 °C	0,00	
Centerbox	56,7 °C	24,2 °C	30,2 °C	0,95	22,0 °C	4,12	
Hot	56,7 °C	56,7 °C	56,7 °C	0,95	22,0 °C	0,00	
Cold	22,5 °C	22,5 °C	22,5 °C	0,95	22,0 °C	0,00	

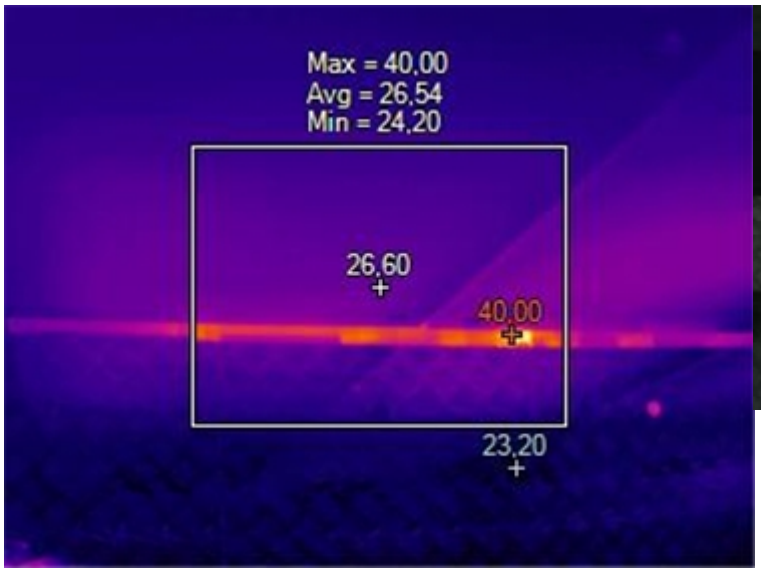




Image Info

Name	IR_00235.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,20 °C to 40,00 °C
Image Time	04/09/2024 11:28:41 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	26,6 °C	26,6 °C	26,6 °C	0,95	22,0 °C	0,00	
Centerbox	40,0 °C	24,2 °C	26,5 °C	0,95	22,0 °C	1,49	
Hot	40,0 °C	40,0 °C	40,0 °C	0,95	22,0 °C	0,00	
Cold	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	

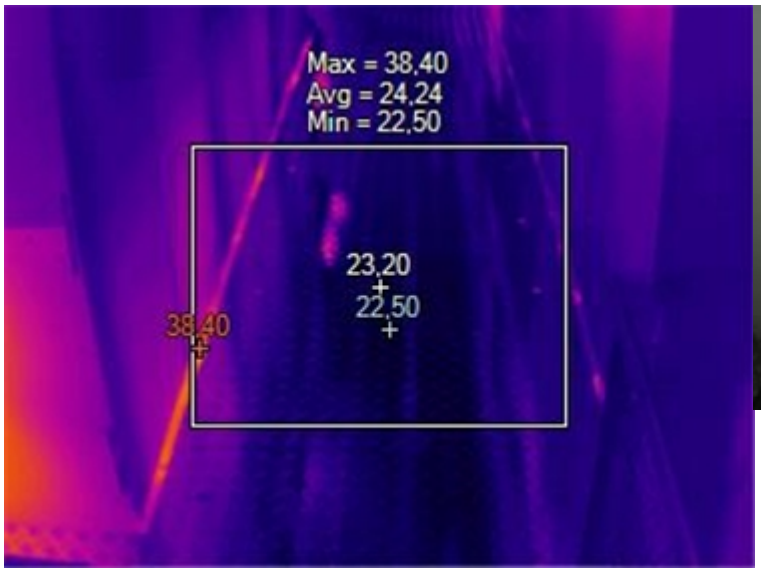




Image Info

Name	IR_00234.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,50 °C to 38,40 °C
Image Time	04/09/2024 11:28:29 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	
Centerbox	38,4 °C	22,5 °C	24,2 °C	0,95	22,0 °C	1,21	
Hot	38,4 °C	38,4 °C	38,4 °C	0,95	22,0 °C	0,00	
Cold	22,5 °C	22,5 °C	22,5 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00233.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,10 °C to 30,70 °C
Image Time	04/09/2024 11:28:14 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,8 °C	23,8 °C	23,8 °C	0,95	22,0 °C	0,00	
Centerbox	30,7 °C	23,2 °C	25,4 °C	0,95	22,0 °C	1,64	
Hot	30,7 °C	30,7 °C	30,7 °C	0,95	22,0 °C	0,00	
Cold	21,1 °C	21,1 °C	21,1 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00232.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,20 °C to 37,00 °C
Image Time	04/09/2024 11:28:09 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	
Centerbox	34,0 °C	22,8 °C	24,6 °C	0,95	22,0 °C	1,91	
Hot	37,0 °C	37,0 °C	37,0 °C	0,95	22,0 °C	0,00	
Cold	22,2 °C	22,2 °C	22,2 °C	0,95	22,0 °C	0,00	

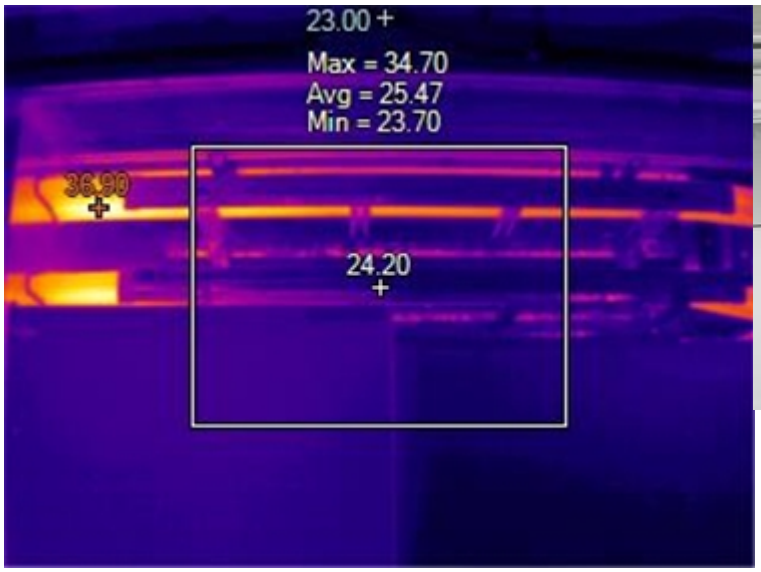




Image Info

Name	IR_00231.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	23.00 °C to 36.90 °C
Image Time	04/09/2024 11:27:56 AM
Asset Name	UC50 Aux AC Cabinet

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.2 °C	24.2 °C	24.2 °C	0.95	22.0 °C	0.00	
Centerbox	34.7 °C	23.7 °C	25.5 °C	0.95	22.0 °C	1.52	
Hot	36.9 °C	36.9 °C	36.9 °C	0.95	22.0 °C	0.00	
Cold	23.0 °C	23.0 °C	23.0 °C	0.95	22.0 °C	0.00	

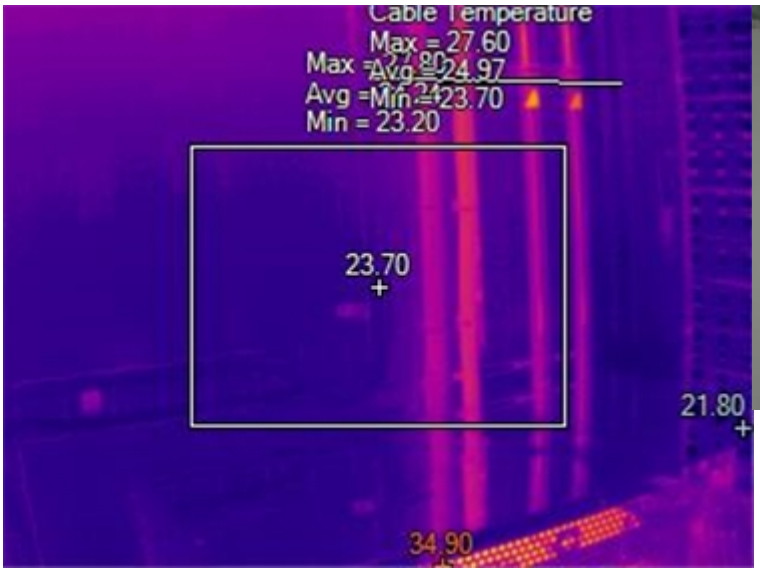




Image Info

Name	IR_00230.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	21.80 °C to 34.90 °C
Image Time	04/09/2024 11:27:50 AM
Asset Name	UC50 Aux AC Cabinet

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	27.8 °C	23.2 °C	24.2 °C	0.95	22.0 °C	0.90	
Hot	34.9 °C	34.9 °C	34.9 °C	0.95	22.0 °C	0.00	
Cold	21.8 °C	21.8 °C	21.8 °C	0.95	22.0 °C	0.00	
Cable Temperature	27.6 °C	23.7 °C	25.0 °C	0.95	22.0 °C	0.94	

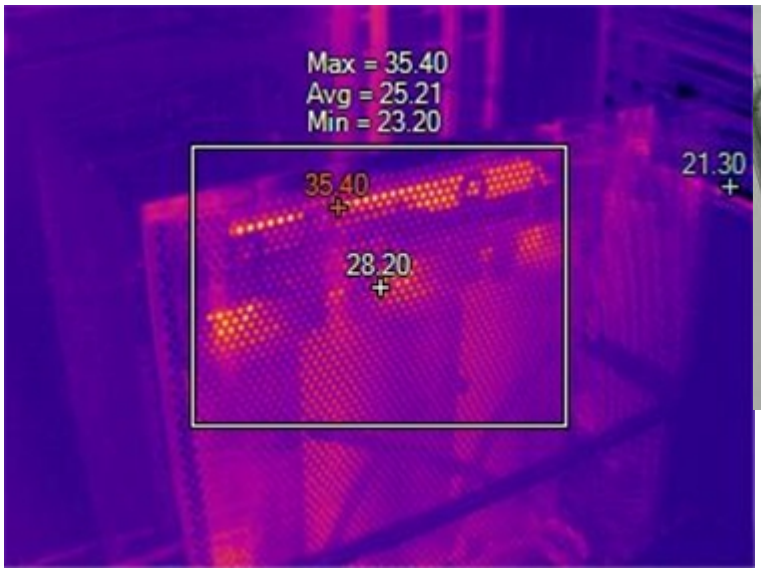




Image Info

Name	IR_00229.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	21.30 °C to 35.40 °C
Image Time	04/09/2024 11:27:38 AM
Asset Name	UC50 Aux AC Cabinet

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.2 °C	28.2 °C	28.2 °C	0.95	22.0 °C	0.00	
Centerbox	35.4 °C	23.2 °C	25.2 °C	0.95	22.0 °C	1.37	
Hot	35.4 °C	35.4 °C	35.4 °C	0.95	22.0 °C	0.00	
Cold	21.3 °C	21.3 °C	21.3 °C	0.95	22.0 °C	0.00	

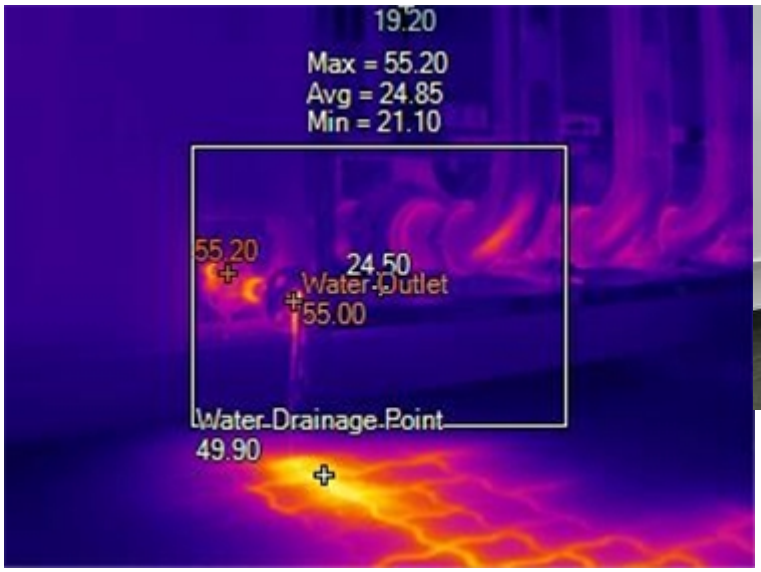




Image Info

Name	IR_00228.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	19.20 °C to 55.20 °C
Image Time	04/09/2024 11:26:59 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.5 °C	24.5 °C	24.5 °C	0.95	22.0 °C	0.00	
Centerbox	55.2 °C	21.1 °C	24.8 °C	0.95	22.0 °C	3.00	
Hot	55.2 °C	55.2 °C	55.2 °C	0.95	22.0 °C	0.00	
Cold	19.2 °C	19.2 °C	19.2 °C	0.95	22.0 °C	0.00	
Water Outlet	55.0 °C	55.0 °C	55.0 °C	0.95	22.0 °C	0.00	
Water Drainage Point	49.9 °C	49.9 °C	49.9 °C	0.95	22.0 °C	0.00	

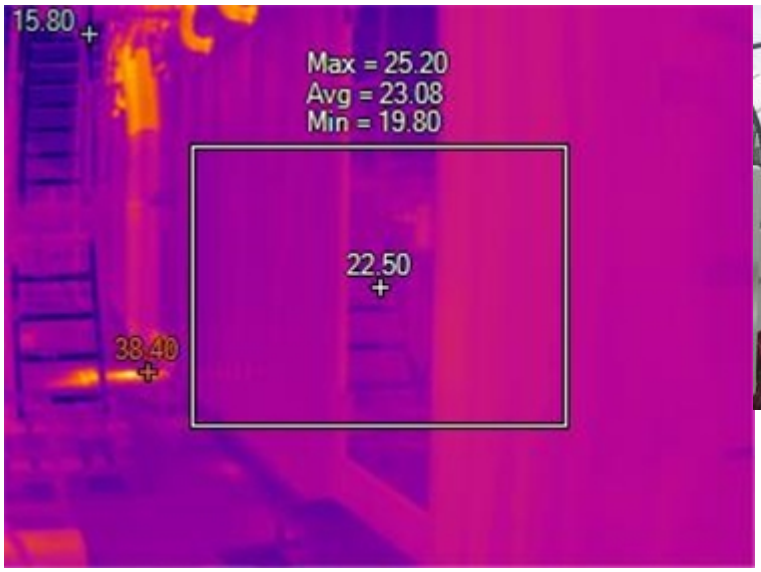




Image Info

Name	IR_00227.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	15.80 °C to 38.40 °C
Image Time	04/09/2024 11:26:38 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22.5 °C	22.5 °C	22.5 °C	0.95	22.0 °C	0.00	
Centerbox	25.2 °C	19.8 °C	23.1 °C	0.95	22.0 °C	1.06	
Hot	38.4 °C	38.4 °C	38.4 °C	0.95	22.0 °C	0.00	
Cold	15.8 °C	15.8 °C	15.8 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00226.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	18,20 °C to 54,70 °C
Image Time	04/09/2024 11:25:55 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	37,9 °C	37,9 °C	37,9 °C	0,95	22,0 °C	0,00	
Centerbox	50,7 °C	21,1 °C	26,1 °C	0,95	22,0 °C	5,37	
Hot	54,7 °C	54,7 °C	54,7 °C	0,95	22,0 °C	0,00	
Cold	18,2 °C	18,2 °C	18,2 °C	0,95	22,0 °C	0,00	

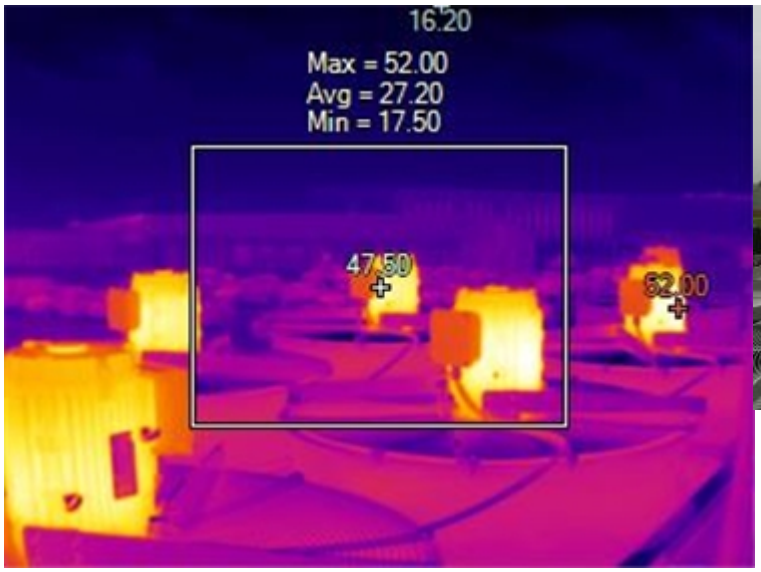




Image Info

Name	IR_00225.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.20 °C to 52.00 °C
Image Time	04/09/2024 11:25:34 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	47.5 °C	47.5 °C	47.5 °C	0.95	22.0 °C	0.00	
Centerbox	52.0 °C	17.5 °C	27.2 °C	0.95	22.0 °C	7.80	
Hot	52.0 °C	52.0 °C	52.0 °C	0.95	22.0 °C	0.00	
Cold	16.2 °C	16.2 °C	16.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00224.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	20.70 °C to 39.50 °C
Image Time	04/09/2024 11:24:49 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.5 °C	28.5 °C	28.5 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	22.5 °C	30.9 °C	0.95	22.0 °C	4.68	
Hot	39.5 °C	39.5 °C	39.5 °C	0.95	22.0 °C	0.00	
Cold	20.7 °C	20.7 °C	20.7 °C	0.95	22.0 °C	0.00	

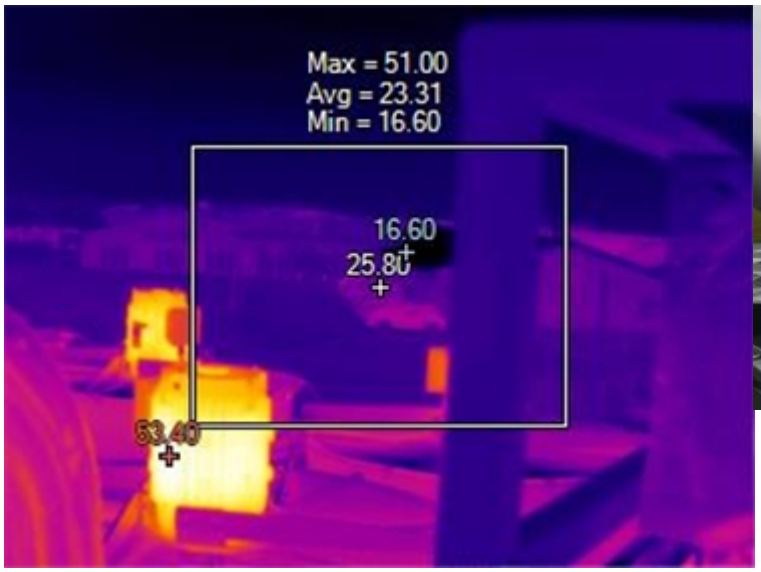




Image Info

Name	IR_00222.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.60 °C to 53.40 °C
Image Time	04/09/2024 11:23:50 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25.8 °C	25.8 °C	25.8 °C	0.95	22.0 °C	0.00	
Centerbox	51.0 °C	16.6 °C	23.3 °C	0.95	22.0 °C	5.36	
Hot	53.4 °C	53.4 °C	53.4 °C	0.95	22.0 °C	0.00	
Cold	16.6 °C	16.6 °C	16.6 °C	0.95	22.0 °C	0.00	

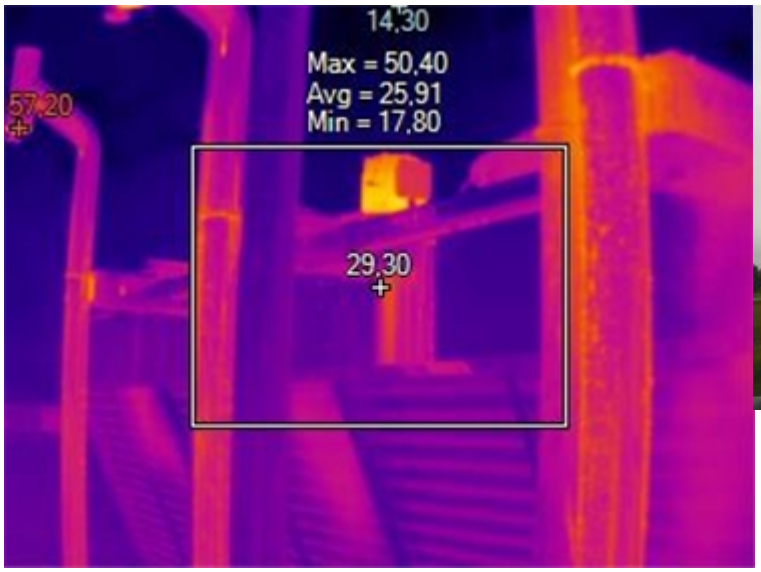




Image Info

Name	IR_00221.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	14,30 °C to 57,20 °C
Image Time	04/09/2024 11:23:38 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,3 °C	29,3 °C	29,3 °C	0,95	22,0 °C	0,00	
Centerbox	50,4 °C	17,8 °C	25,9 °C	0,95	22,0 °C	5,31	
Hot	57,2 °C	57,2 °C	57,2 °C	0,95	22,0 °C	0,00	
Cold	14,3 °C	14,3 °C	14,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00220.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	13,10 °C to 36,20 °C
Image Time	04/09/2024 11:22:30 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27,1 °C	27,1 °C	27,1 °C	0,95	22,0 °C	0,00	
Centerbox	34,2 °C	18,2 °C	25,2 °C	0,95	22,0 °C	2,26	
Hot	36,2 °C	36,2 °C	36,2 °C	0,95	22,0 °C	0,00	
Cold	13,1 °C	13,1 °C	13,1 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00219.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	14.30 °C to 39.70 °C
Image Time	04/09/2024 11:22:14 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.5 °C	28.5 °C	28.5 °C	0.95	22.0 °C	0.00	
Centerbox	32.7 °C	15.3 °C	22.2 °C	0.95	22.0 °C	2.54	
Hot	39.7 °C	39.7 °C	39.7 °C	0.95	22.0 °C	0.00	
Cold	14.3 °C	14.3 °C	14.3 °C	0.95	22.0 °C	0.00	

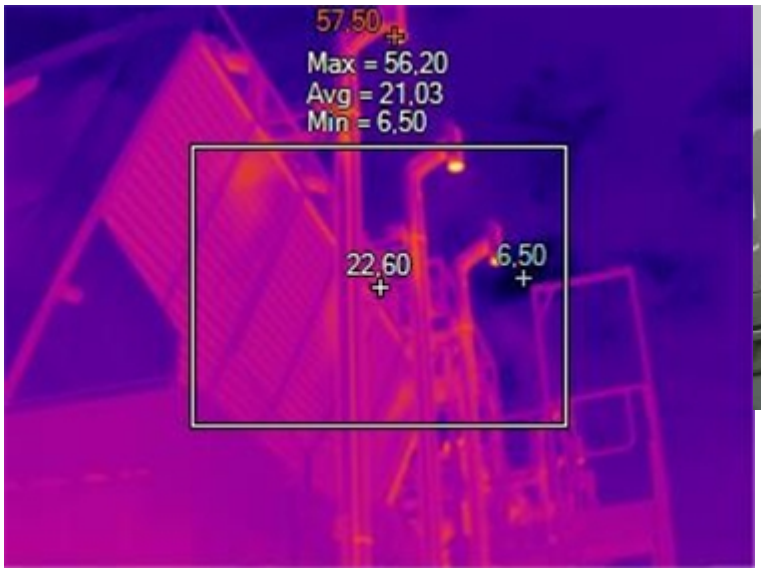




Image Info

Name	IR_00218.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	6,50 °C to 57,50 °C
Image Time	04/09/2024 11:21:25 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22,6 °C	22,6 °C	22,6 °C	0,95	22,0 °C	0,00	
Centerbox	56,2 °C	6,5 °C	21,0 °C	0,95	22,0 °C	5,14	
Hot	57,5 °C	57,5 °C	57,5 °C	0,95	22,0 °C	0,00	
Cold	6,5 °C	6,5 °C	6,5 °C	0,95	22,0 °C	0,00	

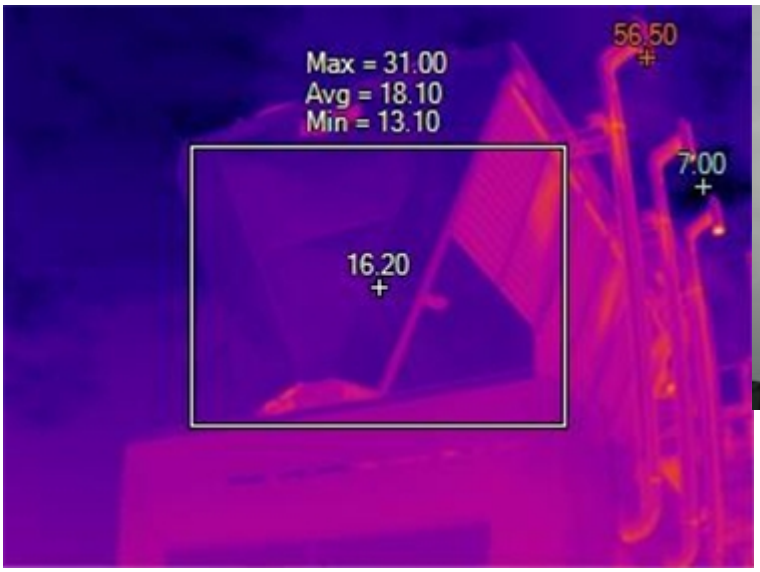




Image Info

Name	IR_00217.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	7.00 °C to 56.50 °C
Image Time	04/09/2024 11:21:15 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	16.2 °C	16.2 °C	16.2 °C	0.95	22.0 °C	0.00	
Centerbox	31.0 °C	13.1 °C	18.1 °C	0.95	22.0 °C	3.33	
Hot	56.5 °C	56.5 °C	56.5 °C	0.95	22.0 °C	0.00	
Cold	7.0 °C	7.0 °C	7.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00216.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	18.20 °C to 144.30 °C
Image Time	04/09/2024 11:20:35 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	21.2 °C	21.2 °C	21.2 °C	0.95	22.0 °C	0.00	
Centerbox	23.7 °C	18.6 °C	21.9 °C	0.95	22.0 °C	0.96	
Hot	144.3 °C	144.3 °C	144.3 °C	0.95	22.0 °C	0.00	
Cold	18.2 °C	18.2 °C	18.2 °C	0.95	22.0 °C	0.00	

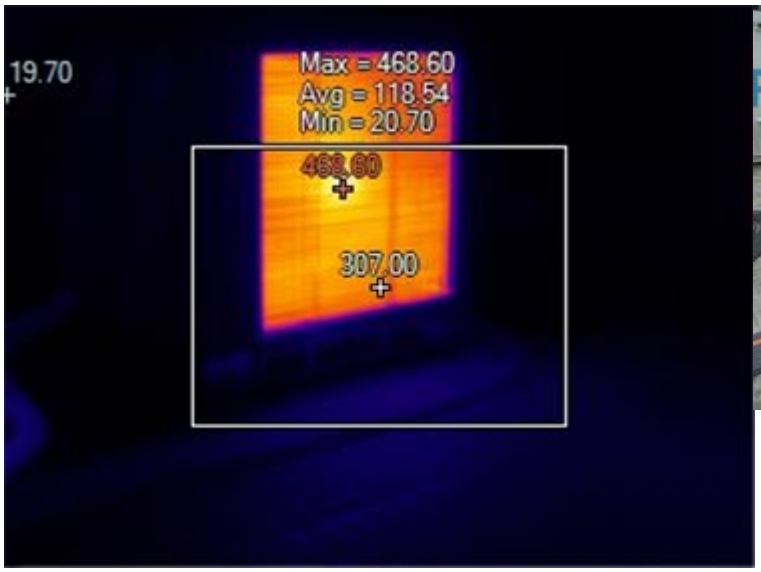




Image Info

Name	IR_00215.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	19.70 °C to 468.60 °C
Image Time	04/09/2024 11:19:20 AM
Asset Name	Test Equipemnt

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	307.0 °C	307.0 °C	307.0 °C	0.95	22.0 °C	0.00	
Centerbox	468.6 °C	20.7 °C	118.5 °C	0.95	22.0 °C	129.65	
Hot	468.6 °C	468.6 °C	468.6 °C	0.95	22.0 °C	0.00	
Cold	19.7 °C	19.7 °C	19.7 °C	0.95	22.0 °C	0.00	

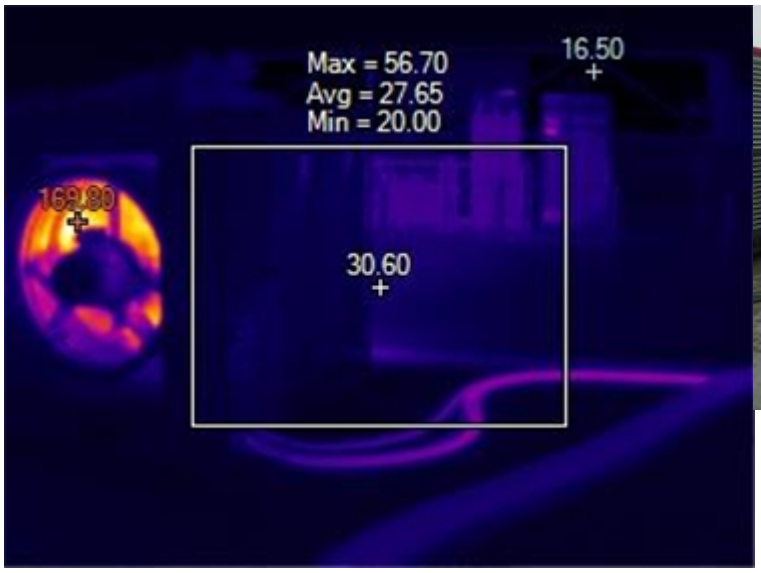




Image Info

Name	IR_00214.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.50 °C to 169.80 °C
Image Time	04/09/2024 11:18:48 AM
Asset Name	Test Equipemnt

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.6 °C	30.6 °C	30.6 °C	0.95	22.0 °C	0.00	
Centerbox	56.7 °C	20.0 °C	27.6 °C	0.95	22.0 °C	6.06	
Hot	169.8 °C	169.8 °C	169.8 °C	0.95	22.0 °C	0.00	
Cold	16.5 °C	16.5 °C	16.5 °C	0.95	22.0 °C	0.00	

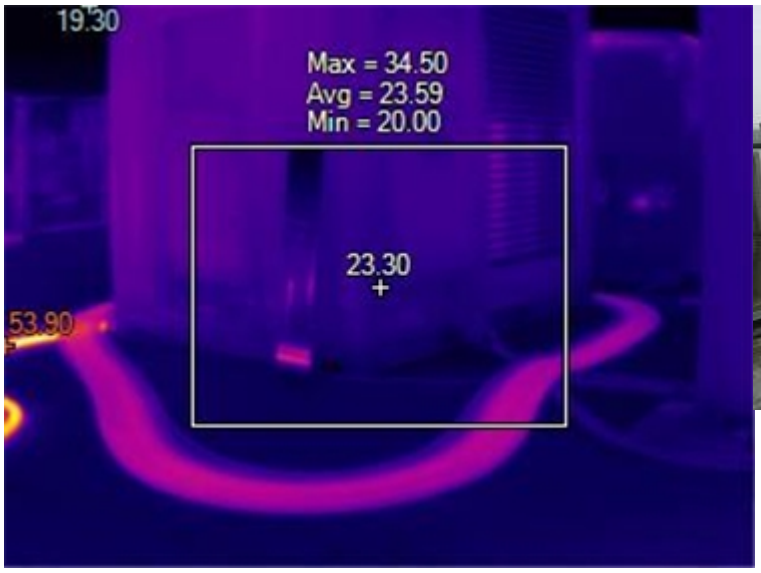




Image Info

Name	IR_00213.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	19.30 °C to 53.90 °C
Image Time	04/09/2024 11:18:26 AM
Asset Name	Test Equipemnt

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.3 °C	23.3 °C	23.3 °C	0.95	22.0 °C	0.00	
Centerbox	34.5 °C	20.0 °C	23.6 °C	0.95	22.0 °C	1.81	
Hot	53.9 °C	53.9 °C	53.9 °C	0.95	22.0 °C	0.00	
Cold	19.3 °C	19.3 °C	19.3 °C	0.95	22.0 °C	0.00	

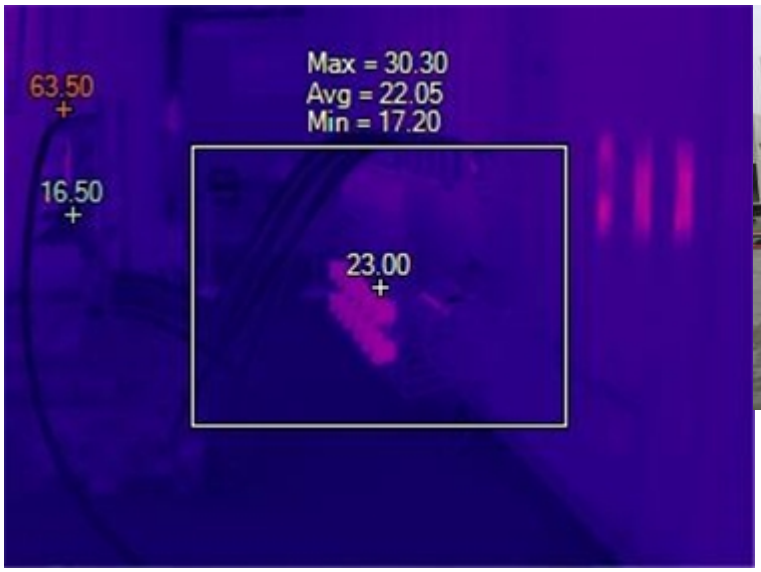




Image Info

Name	IR_00212.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.50 °C to 63.50 °C
Image Time	04/09/2024 11:18:08 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.0 °C	23.0 °C	23.0 °C	0.95	22.0 °C	0.00	
Centerbox	30.3 °C	17.2 °C	22.1 °C	0.95	22.0 °C	1.74	
Hot	63.5 °C	63.5 °C	63.5 °C	0.95	22.0 °C	0.00	
Cold	16.5 °C	16.5 °C	16.5 °C	0.95	22.0 °C	0.00	

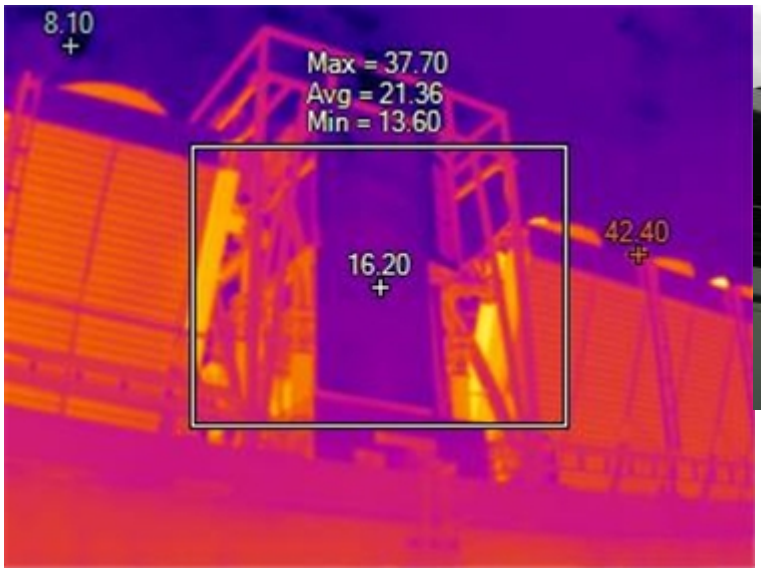




Image Info

Name	IR_00209.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	8.10 °C to 42.40 °C
Image Time	04/09/2024 11:17:23 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	16.2 °C	16.2 °C	16.2 °C	0.95	22.0 °C	0.00	
Centerbox	37.7 °C	13.6 °C	21.4 °C	0.95	22.0 °C	5.11	
Hot	42.4 °C	42.4 °C	42.4 °C	0.95	22.0 °C	0.00	
Cold	8.1 °C	8.1 °C	8.1 °C	0.95	22.0 °C	0.00	

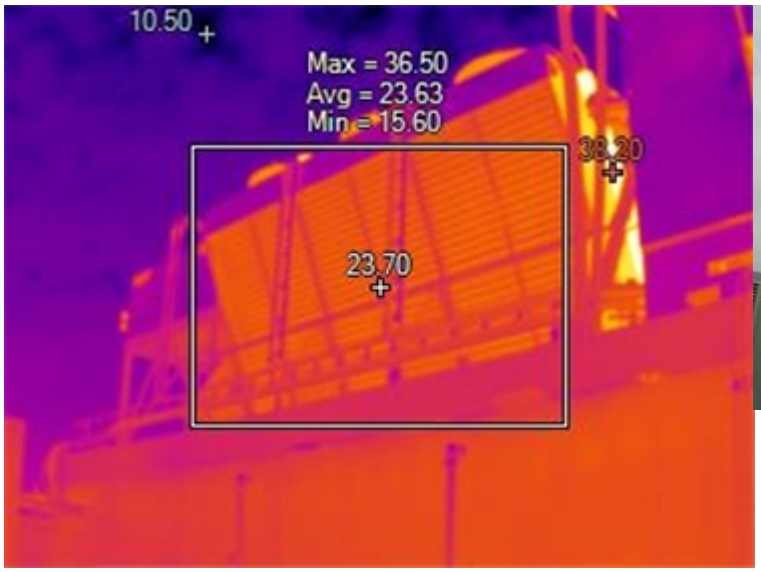




Image Info

Name	IR_00208.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	10.50 °C to 38.20 °C
Image Time	04/09/2024 11:16:35 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	36.5 °C	15.6 °C	23.6 °C	0.95	22.0 °C	2.30	
Hot	38.2 °C	38.2 °C	38.2 °C	0.95	22.0 °C	0.00	
Cold	10.5 °C	10.5 °C	10.5 °C	0.95	22.0 °C	0.00	

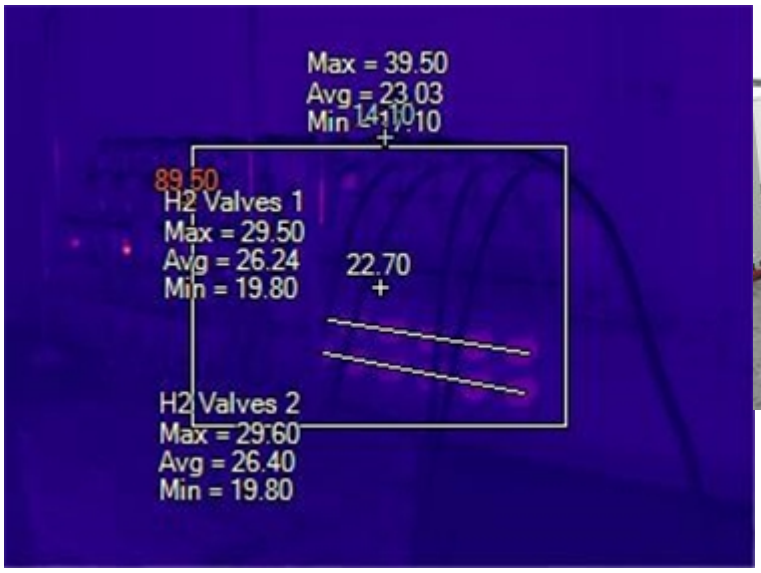




Image Info

Name	IR_00207.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	14.10 °C to 89.50 °C
Image Time	04/09/2024 11:16:21 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22.7 °C	22.7 °C	22.7 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	17.1 °C	23.0 °C	0.95	22.0 °C	1.82	
Hot	89.5 °C	89.5 °C	89.5 °C	0.95	22.0 °C	0.00	
Cold	14.1 °C	14.1 °C	14.1 °C	0.95	22.0 °C	0.00	
H2 Valves 1	29.5 °C	19.8 °C	26.2 °C	0.95	22.0 °C	2.45	
H2 Valves 2	29.6 °C	19.8 °C	26.4 °C	0.95	22.0 °C	2.53	

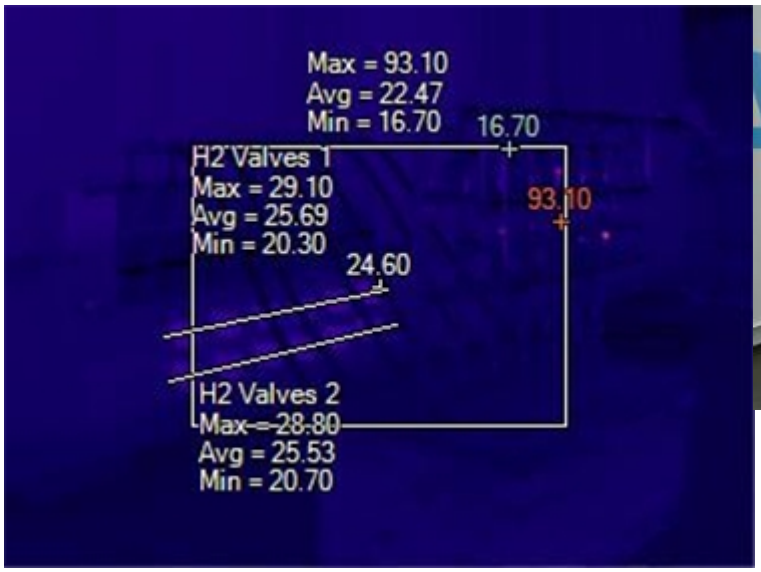




Image Info

Name	IR_00206.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.70 °C to 93.10 °C
Image Time	04/09/2024 11:16:09 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.6 °C	24.6 °C	24.6 °C	0.95	22.0 °C	0.00	
Centerbox	93.1 °C	16.7 °C	22.5 °C	0.95	22.0 °C	1.81	
Hot	93.1 °C	93.1 °C	93.1 °C	0.95	22.0 °C	0.00	
Cold	16.7 °C	16.7 °C	16.7 °C	0.95	22.0 °C	0.00	
H2 Valves 1	29.1 °C	20.3 °C	25.7 °C	0.95	22.0 °C	2.39	
H2 Valves 2	28.8 °C	20.7 °C	25.5 °C	0.95	22.0 °C	2.28	

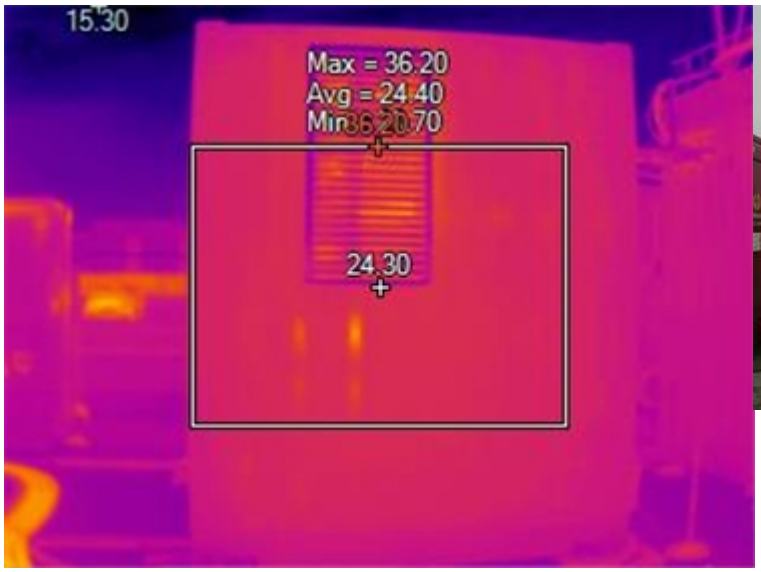




Image Info

Name	IR_00205.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	15.30 °C to 36.20 °C
Image Time	04/09/2024 11:15:41 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.3 °C	24.3 °C	24.3 °C	0.95	22.0 °C	0.00	
Centerbox	36.2 °C	20.7 °C	24.4 °C	0.95	22.0 °C	0.71	
Hot	36.2 °C	36.2 °C	36.2 °C	0.95	22.0 °C	0.00	
Cold	15.3 °C	15.3 °C	15.3 °C	0.95	22.0 °C	0.00	

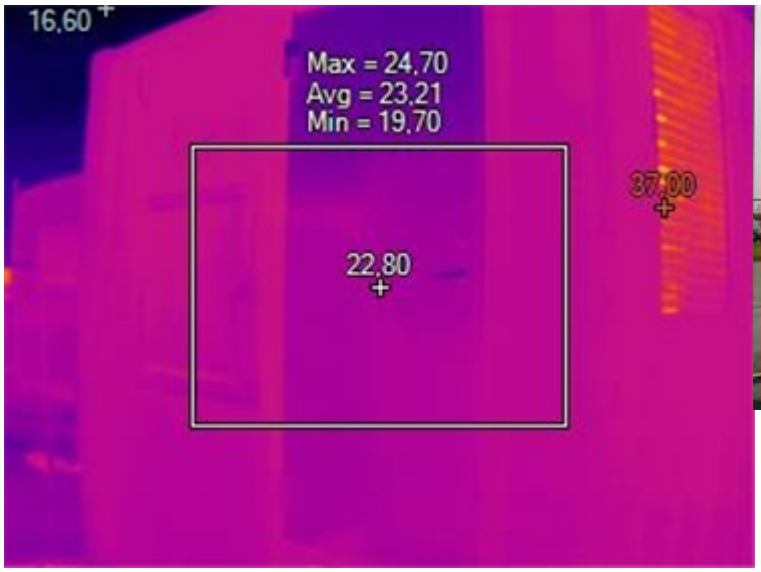




Image Info

Name	IR_00204.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	16,60 °C to 37,00 °C
Image Time	04/09/2024 11:15:27 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22,8 °C	22,8 °C	22,8 °C	0,95	22,0 °C	0,00	
Centerbox	24,7 °C	19,7 °C	23,2 °C	0,95	22,0 °C	0,67	
Hot	37,0 °C	37,0 °C	37,0 °C	0,95	22,0 °C	0,00	
Cold	16,6 °C	16,6 °C	16,6 °C	0,95	22,0 °C	0,00	

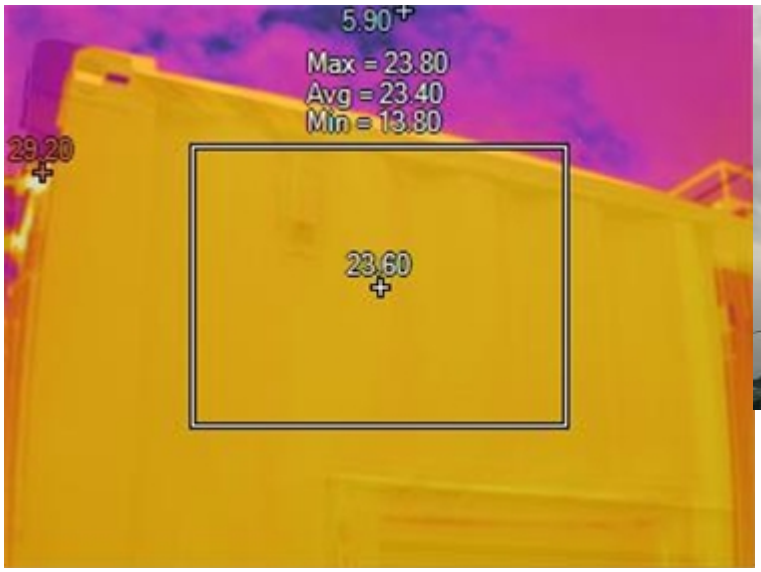




Image Info

Name	IR_00203.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	5.90 °C to 29.20 °C
Image Time	04/09/2024 11:15:10 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.6 °C	23.6 °C	23.6 °C	0.95	22.0 °C	0.00	
Centerbox	23.8 °C	13.8 °C	23.4 °C	0.95	22.0 °C	0.74	
Hot	29.2 °C	29.2 °C	29.2 °C	0.95	22.0 °C	0.00	
Cold	5.9 °C	5.9 °C	5.9 °C	0.95	22.0 °C	0.00	

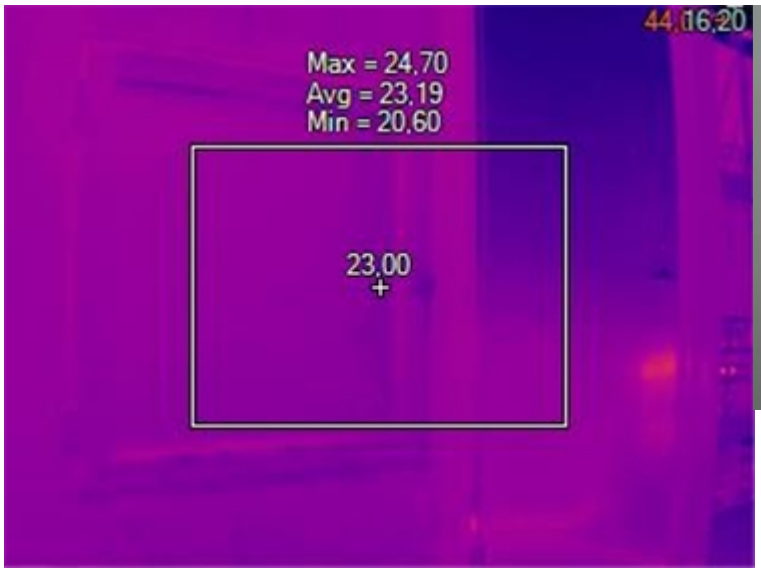




Image Info

Name	IR_00202.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	16,20 °C to 44,00 °C
Image Time	04/09/2024 11:15:01 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,0 °C	23,0 °C	23,0 °C	0,95	22,0 °C	0,00	
Centerbox	24,7 °C	20,6 °C	23,2 °C	0,95	22,0 °C	0,73	
Hot	44,0 °C	44,0 °C	44,0 °C	0,95	22,0 °C	0,00	
Cold	16,2 °C	16,2 °C	16,2 °C	0,95	22,0 °C	0,00	

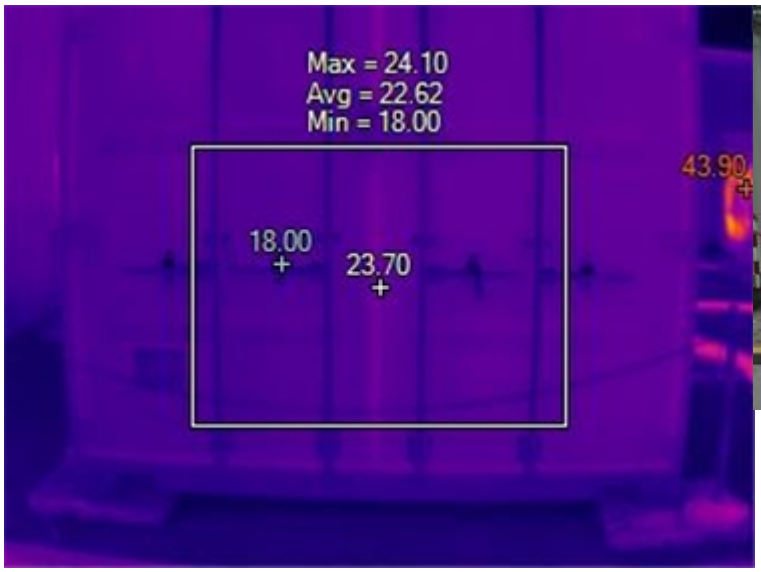




Image Info

Name	IR_00201.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	18.00 °C to 43.90 °C
Image Time	04/09/2024 11:14:23 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	24.1 °C	18.0 °C	22.6 °C	0.95	22.0 °C	0.46	
Hot	43.9 °C	43.9 °C	43.9 °C	0.95	22.0 °C	0.00	
Cold	18.0 °C	18.0 °C	18.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00200.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	9.80 °C to 35.70 °C
Image Time	04/09/2024 11:14:05 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32.9 °C	32.9 °C	32.9 °C	0.95	22.0 °C	0.00	
Centerbox	35.7 °C	13.3 °C	21.7 °C	0.95	22.0 °C	5.19	
Hot	35.7 °C	35.7 °C	35.7 °C	0.95	22.0 °C	0.00	
Cold	9.8 °C	9.8 °C	9.8 °C	0.95	22.0 °C	0.00	

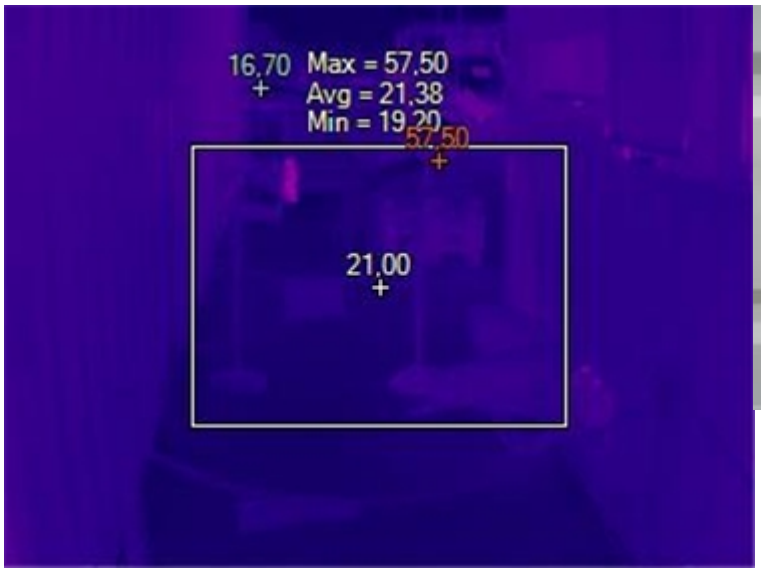




Image Info

Name	IR_00199.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	16,70 °C to 57,50 °C
Image Time	04/09/2024 11:13:51 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	21,0 °C	21,0 °C	21,0 °C	0,95	22,0 °C	0,00	
Centerbox	57,5 °C	19,2 °C	21,4 °C	0,95	22,0 °C	1,03	
Hot	57,5 °C	57,5 °C	57,5 °C	0,95	22,0 °C	0,00	
Cold	16,7 °C	16,7 °C	16,7 °C	0,95	22,0 °C	0,00	

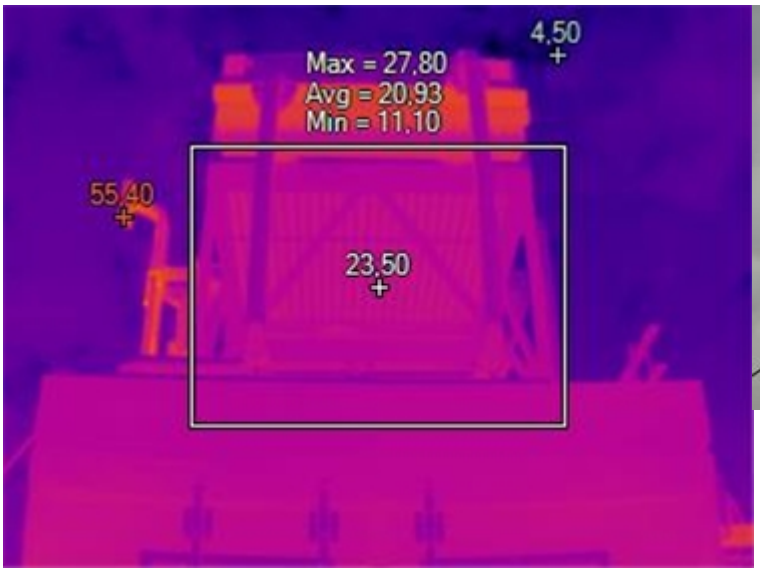




Image Info

Name	IR_00198.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	4,50 °C to 55,40 °C
Image Time	04/09/2024 11:13:37 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,5 °C	23,5 °C	23,5 °C	0,95	22,0 °C	0,00	
Centerbox	27,8 °C	11,1 °C	20,9 °C	0,95	22,0 °C	2,73	
Hot	55,4 °C	55,4 °C	55,4 °C	0,95	22,0 °C	0,00	
Cold	4,5 °C	4,5 °C	4,5 °C	0,95	22,0 °C	0,00	

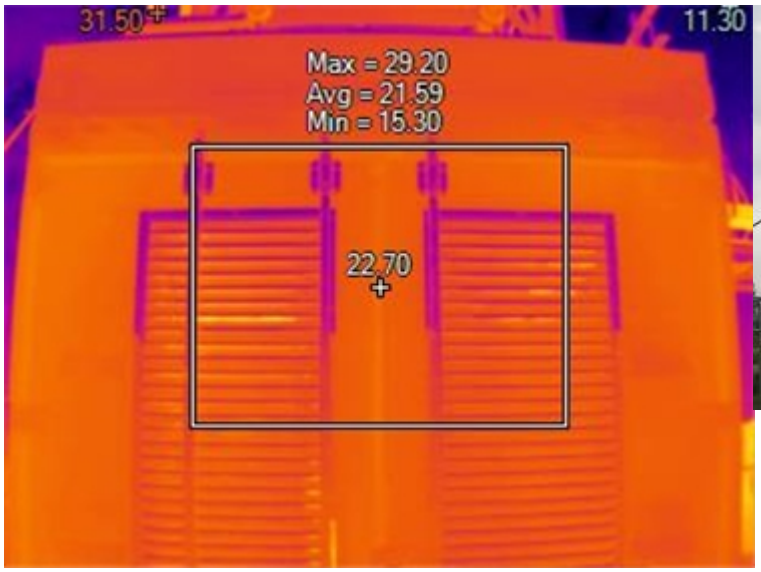




Image Info

Name	IR_00197.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	11.30 °C to 31.50 °C
Image Time	04/09/2024 11:13:10 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22.7 °C	22.7 °C	22.7 °C	0.95	22.0 °C	0.00	
Centerbox	29.2 °C	15.3 °C	21.6 °C	0.95	22.0 °C	1.48	
Hot	31.5 °C	31.5 °C	31.5 °C	0.95	22.0 °C	0.00	
Cold	11.3 °C	11.3 °C	11.3 °C	0.95	22.0 °C	0.00	

Summary:

Date: 09/08/2024

Author: PBL

Ballard Power Systems Europe

Summary:

Thermograhic test of the Crosswind BLPH 1MW system

Entire power train included, from Fuel DCDC converters to AC output transformer.

Hottest item found is DC fuses at 70-75 degrees, which is within expected range.

No items found with elevated temperatures

Some images of test setup is included, but not inside Crosswind scope.

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Image Info

Name	IR_00190.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	14.50 °C to 53.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:39:16 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	36.0 °C	36.0 °C	36.0 °C	0.95	22.0 °C	0.00	
Centerbox	53.5 °C	19.5 °C	31.1 °C	0.95	22.0 °C	4.48	
Hot	53.5 °C	53.5 °C	53.5 °C	0.95	22.0 °C	0.00	
Cold	14.5 °C	14.5 °C	14.5 °C	0.95	22.0 °C	0.00	

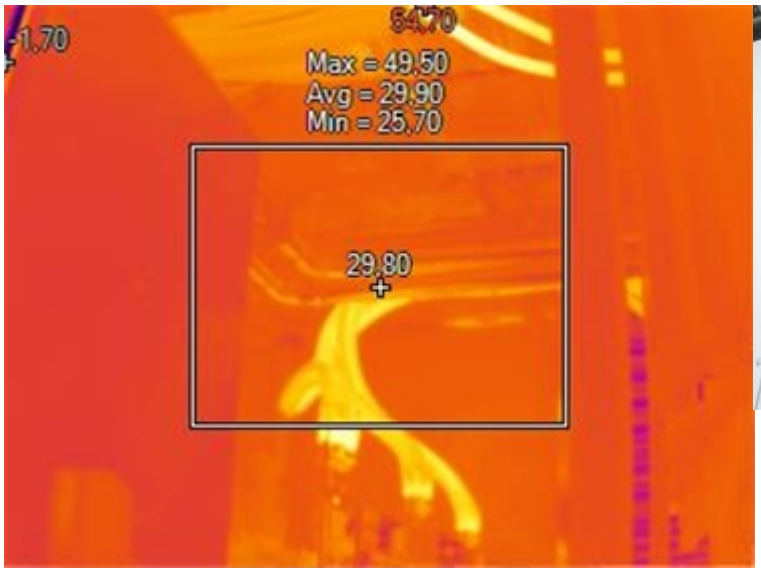




Image Info

Name	IR_00189.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	-1,70 °C to 54,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:39:07 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,8 °C	29,8 °C	29,8 °C	0,95	22,0 °C	0,00	
Centerbox	49,5 °C	25,7 °C	29,9 °C	0,95	22,0 °C	4,28	
Hot	54,7 °C	54,7 °C	54,7 °C	0,95	22,0 °C	0,00	
Cold	-1,7 °C	-1,7 °C	-1,7 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00188.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	17,50 °C to 53,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:39:01 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	52,5 °C	52,5 °C	52,5 °C	0,95	22,0 °C	0,00	
Centerbox	53,0 °C	20,0 °C	30,7 °C	0,95	22,0 °C	5,37	
Hot	53,0 °C	53,0 °C	53,0 °C	0,95	22,0 °C	0,00	
Cold	17,5 °C	17,5 °C	17,5 °C	0,95	22,0 °C	0,00	

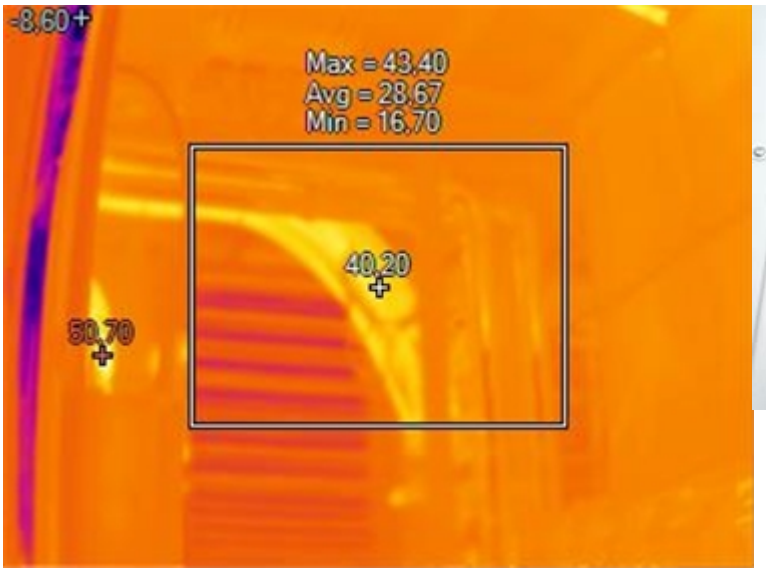




Image Info

Name	IR_00187.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	-8,60 °C to 50,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:43 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	40,2 °C	40,2 °C	40,2 °C	0,95	22,0 °C	0,00	
Centerbox	43,4 °C	16,7 °C	28,7 °C	0,95	22,0 °C	5,00	
Hot	50,7 °C	50,7 °C	50,7 °C	0,95	22,0 °C	0,00	
Cold	-8,6 °C	-8,6 °C	-8,6 °C	0,95	22,0 °C	0,00	

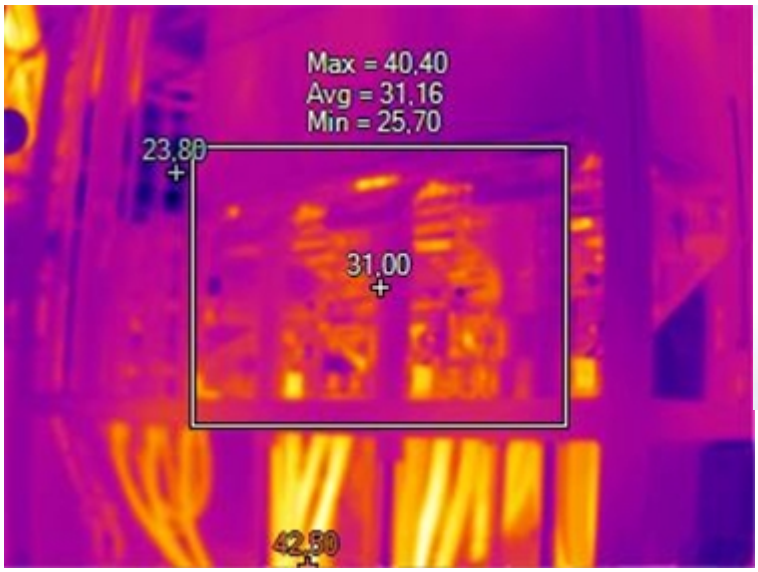




Image Info

Name	IR_00186.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	23,80 °C to 42,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:30 PM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,0 °C	31,0 °C	31,0 °C	0,95	22,0 °C	0,00	
Centerbox	40,4 °C	25,7 °C	31,2 °C	0,95	22,0 °C	1,78	
Hot	42,5 °C	42,5 °C	42,5 °C	0,95	22,0 °C	0,00	
Cold	23,8 °C	23,8 °C	23,8 °C	0,95	22,0 °C	0,00	

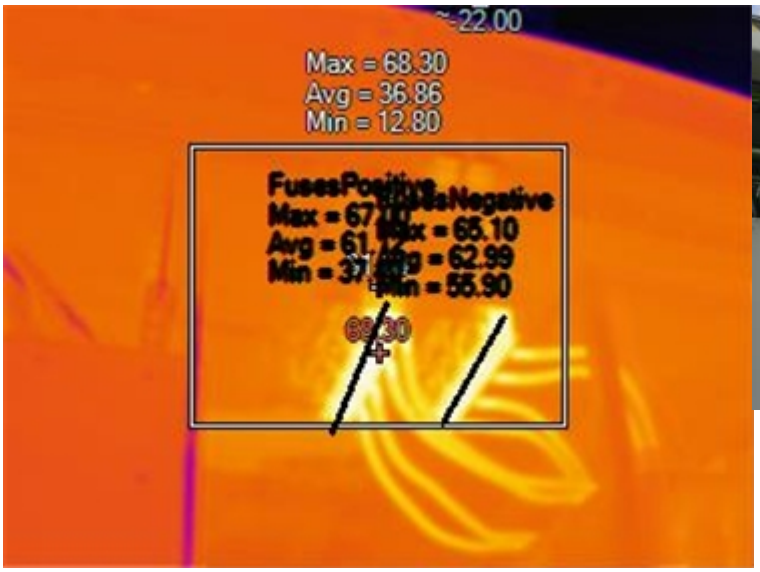




Image Info

Name	IR_00185.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	~-22.00 °C to 68.30 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:21 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.0 °C	31.0 °C	31.0 °C	0.95	22.0 °C	0.00	
Centerbox	68.3 °C	12.8 °C	36.9 °C	0.95	22.0 °C	9.49	
Hot	68.3 °C	68.3 °C	68.3 °C	0.95	22.0 °C	0.00	
Cold	-22.0 °C	-22.0 °C	-22.0 °C	0.95	22.0 °C	0.00	
FusesPositive	67.0 °C	37.4 °C	61.1 °C	0.95	22.0 °C	8.12	
FusesNegative	65.1 °C	55.9 °C	63.0 °C	0.95	22.0 °C	1.76	

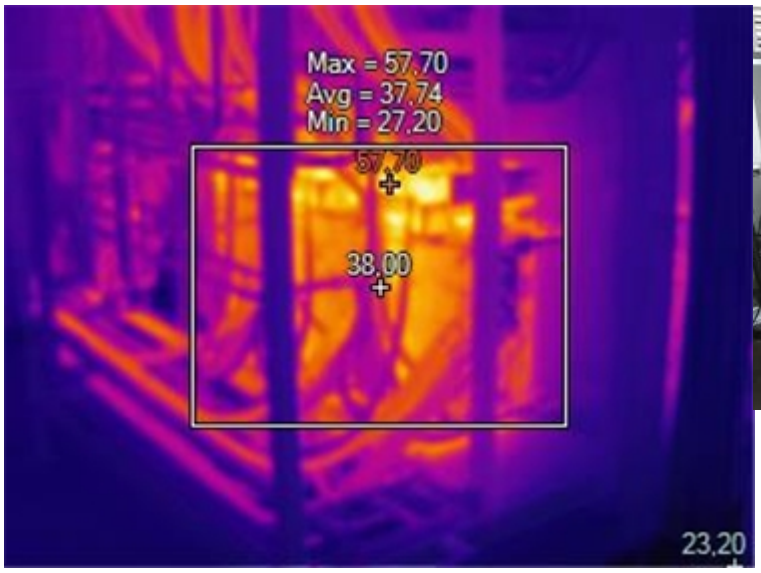




Image Info

Name	IR_00184.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	23,20 °C to 57,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:12 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Centerbox	57,7 °C	27,2 °C	37,7 °C	0,95	22,0 °C	6,38	
Hot	57,7 °C	57,7 °C	57,7 °C	0,95	22,0 °C	0,00	
Cold	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	

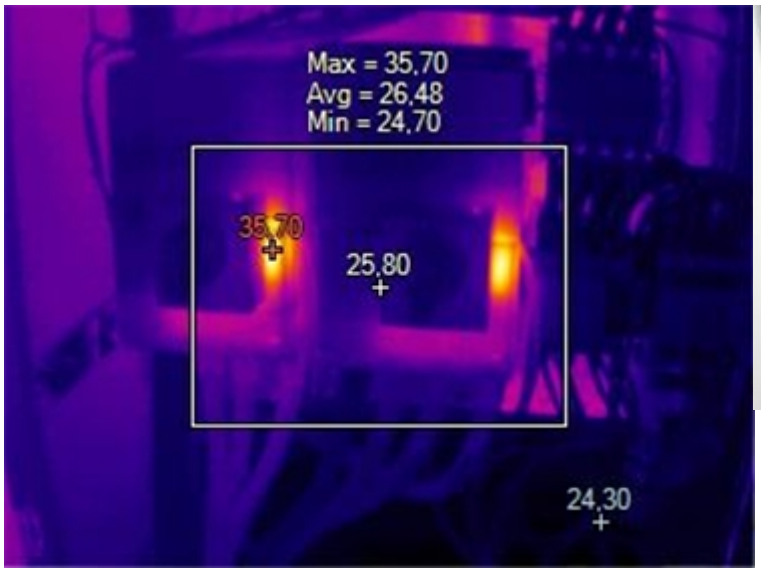




Image Info

Name	IR_00183.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	24,30 °C to 35,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:24 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	
Centerbox	35,7 °C	24,7 °C	26,5 °C	0,95	22,0 °C	1,52	
Hot	35,7 °C	35,7 °C	35,7 °C	0,95	22,0 °C	0,00	
Cold	24,3 °C	24,3 °C	24,3 °C	0,95	22,0 °C	0,00	

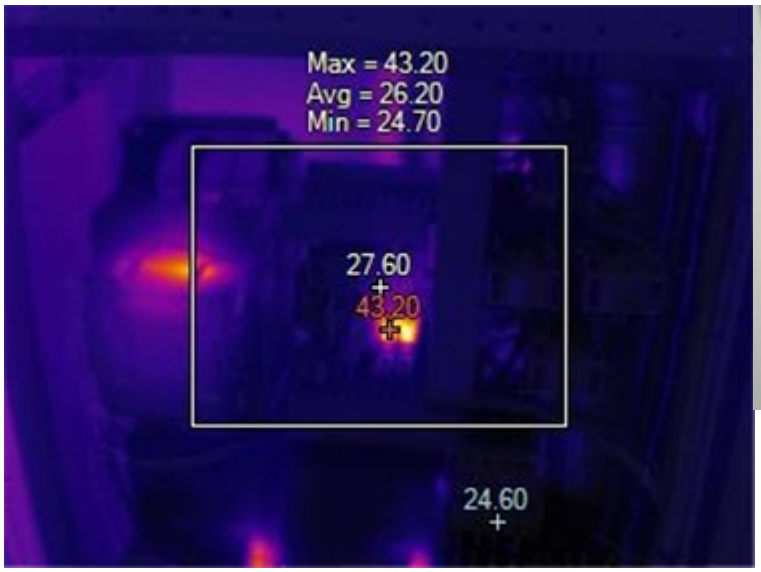




Image Info

Name	IR_00182.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.60 °C to 43.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:15 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27.6 °C	27.6 °C	27.6 °C	0.95	22.0 °C	0.00	
Centerbox	43.2 °C	24.7 °C	26.2 °C	0.95	22.0 °C	1.57	
Hot	43.2 °C	43.2 °C	43.2 °C	0.95	22.0 °C	0.00	
Cold	24.6 °C	24.6 °C	24.6 °C	0.95	22.0 °C	0.00	

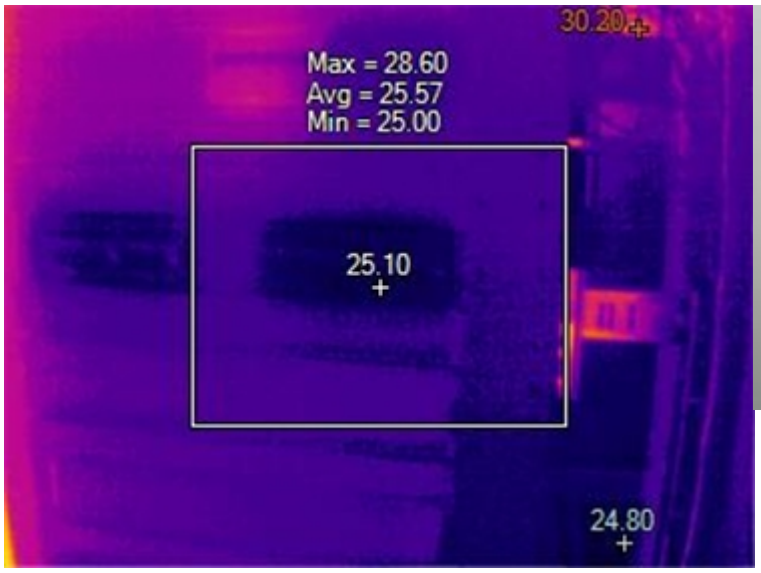




Image Info

Name	IR_00181.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.80 °C to 30.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:10 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25.1 °C	25.1 °C	25.1 °C	0.95	22.0 °C	0.00	
Centerbox	28.6 °C	25.0 °C	25.6 °C	0.95	22.0 °C	0.27	
Hot	30.2 °C	30.2 °C	30.2 °C	0.95	22.0 °C	0.00	
Cold	24.8 °C	24.8 °C	24.8 °C	0.95	22.0 °C	0.00	

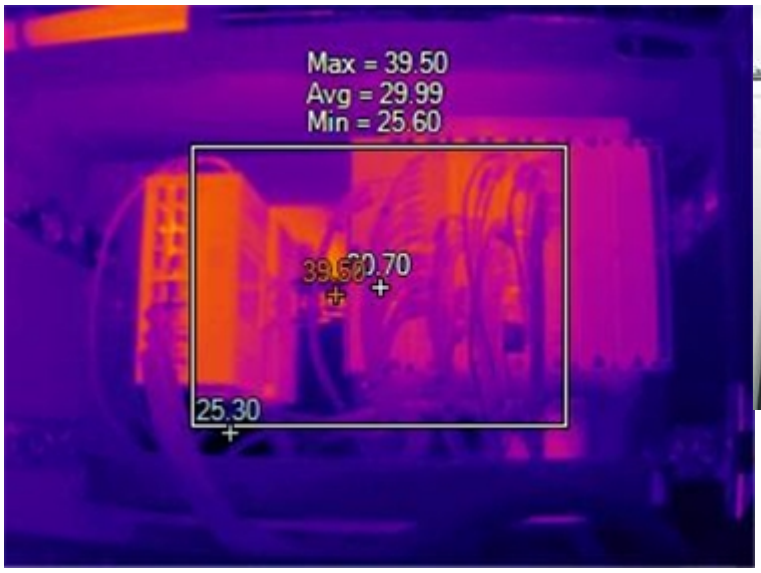




Image Info

Name	IR_00180.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.30 °C to 39.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:04 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.7 °C	30.7 °C	30.7 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	25.6 °C	30.0 °C	0.95	22.0 °C	1.76	
Hot	39.5 °C	39.5 °C	39.5 °C	0.95	22.0 °C	0.00	
Cold	25.3 °C	25.3 °C	25.3 °C	0.95	22.0 °C	0.00	

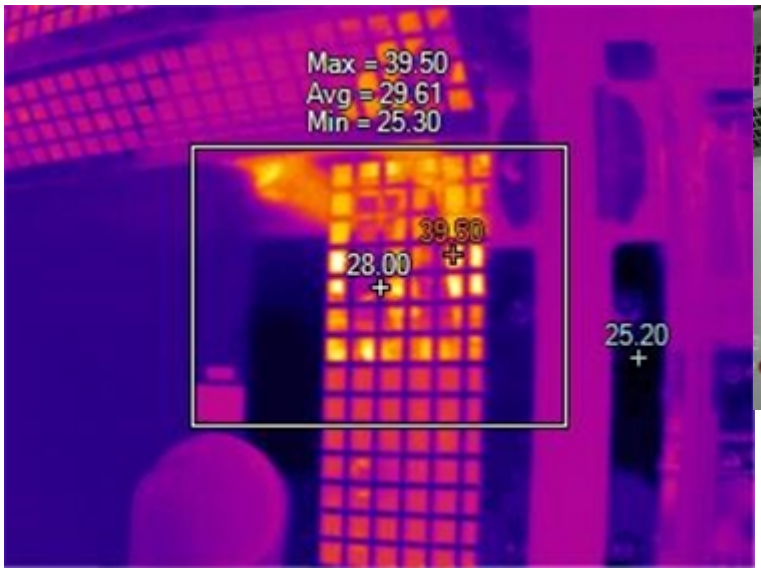


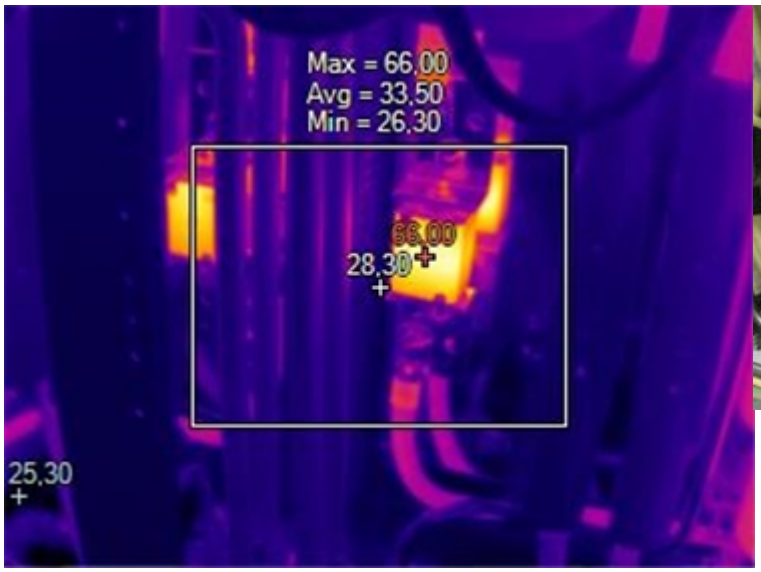


Image Info

Name	IR_00179.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 39.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:35:14 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.0 °C	28.0 °C	28.0 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	25.3 °C	29.6 °C	0.95	22.0 °C	2.95	
Hot	39.5 °C	39.5 °C	39.5 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	



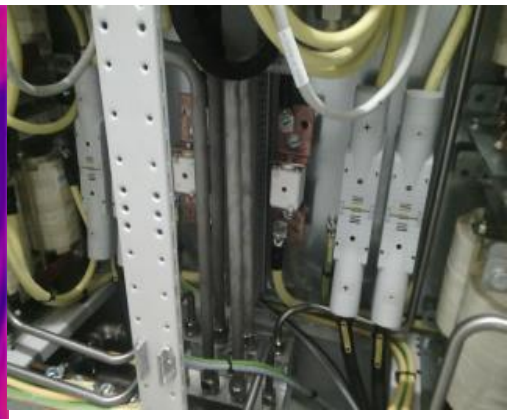
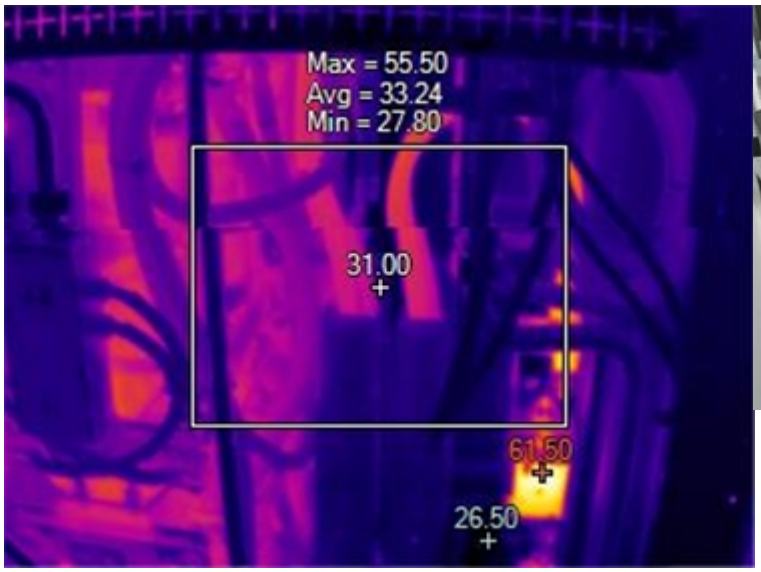


Image Info

Name	IR_00178.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 66,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:35:07 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,3 °C	28,3 °C	28,3 °C	0,95	22,0 °C	0,00	
Centerbox	66,0 °C	26,3 °C	33,5 °C	0,95	22,0 °C	8,35	
Hot	66,0 °C	66,0 °C	66,0 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	



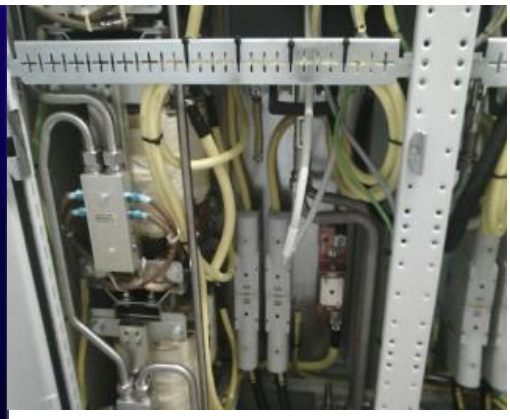


Image Info

Name	IR_00177.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.50 °C to 61.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:35:01 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.0 °C	31.0 °C	31.0 °C	0.95	22.0 °C	0.00	
Centerbox	55.5 °C	27.8 °C	33.2 °C	0.95	22.0 °C	4.10	
Hot	61.5 °C	61.5 °C	61.5 °C	0.95	22.0 °C	0.00	
Cold	26.5 °C	26.5 °C	26.5 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00176.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	26,20 °C to 44,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:34:54 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	34,5 °C	34,5 °C	34,5 °C	0,95	22,0 °C	0,00	
Centerbox	44,0 °C	27,1 °C	34,3 °C	0,95	22,0 °C	3,56	
Hot	44,0 °C	44,0 °C	44,0 °C	0,95	22,0 °C	0,00	
Cold	26,2 °C	26,2 °C	26,2 °C	0,95	22,0 °C	0,00	

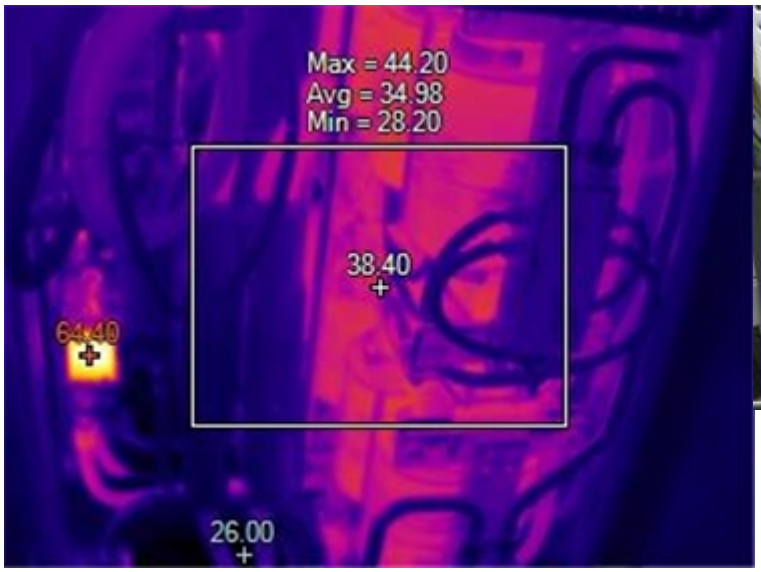




Image Info

Name	IR_00175.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.00 °C to 64.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:34:45 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	38.4 °C	38.4 °C	38.4 °C	0.95	22.0 °C	0.00	
Centerbox	44.2 °C	28.2 °C	35.0 °C	0.95	22.0 °C	4.79	
Hot	64.4 °C	64.4 °C	64.4 °C	0.95	22.0 °C	0.00	
Cold	26.0 °C	26.0 °C	26.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00174.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	27.50 °C to 43.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:34:39 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32.0 °C	32.0 °C	32.0 °C	0.95	22.0 °C	0.00	
Centerbox	43.5 °C	27.7 °C	34.0 °C	0.95	22.0 °C	3.99	
Hot	43.5 °C	43.5 °C	43.5 °C	0.95	22.0 °C	0.00	
Cold	27.5 °C	27.5 °C	27.5 °C	0.95	22.0 °C	0.00	

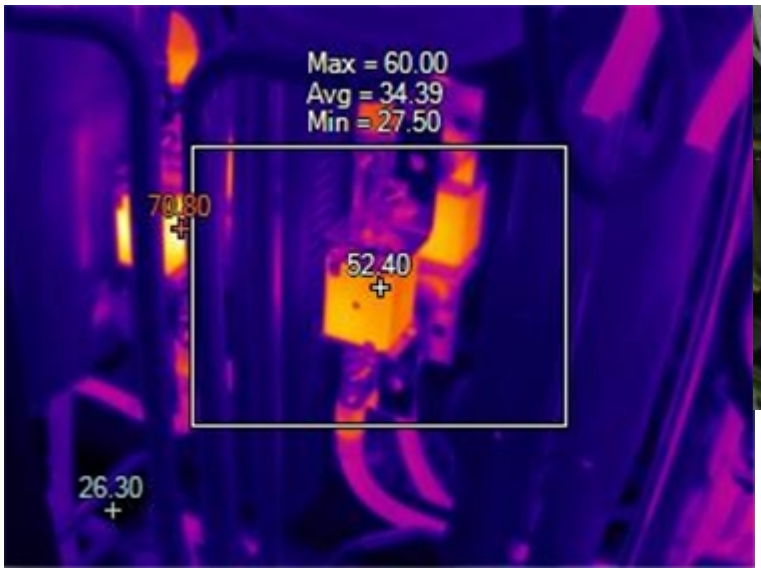


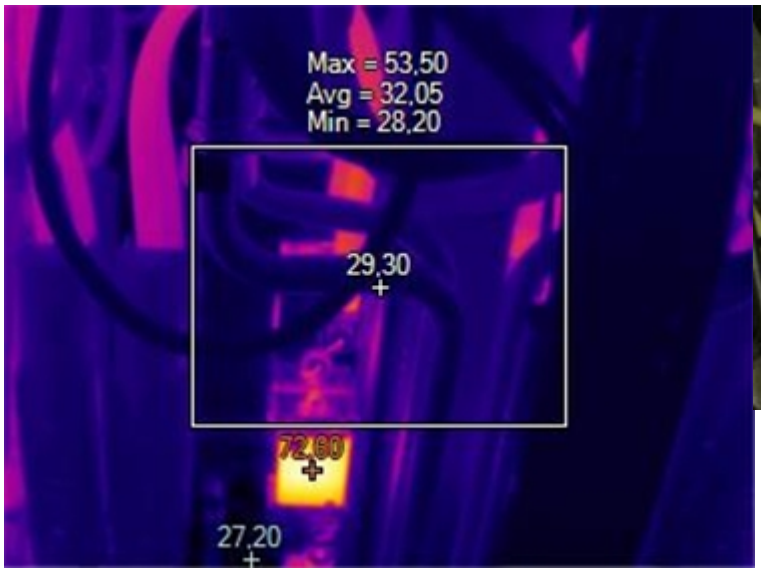


Image Info

Name	IR_00173.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.30 °C to 70.80 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:43 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	52.4 °C	52.4 °C	52.4 °C	0.95	22.0 °C	0.00	
Centerbox	60.0 °C	27.5 °C	34.4 °C	0.95	22.0 °C	7.82	
Hot	70.8 °C	70.8 °C	70.8 °C	0.95	22.0 °C	0.00	
Cold	26.3 °C	26.3 °C	26.3 °C	0.95	22.0 °C	0.00	



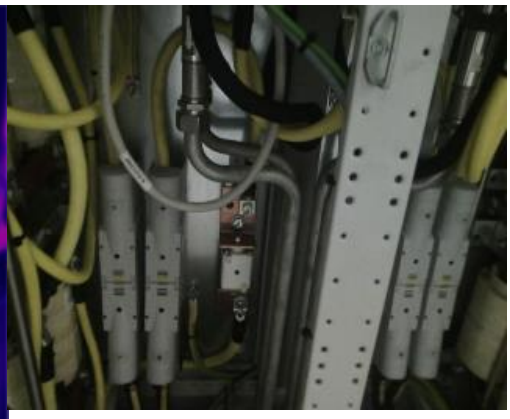


Image Info

Name	IR_00172.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	27,20 °C to 72,60 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:34 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,3 °C	29,3 °C	29,3 °C	0,95	22,0 °C	0,00	
Centerbox	53,5 °C	28,2 °C	32,0 °C	0,95	22,0 °C	3,91	
Hot	72,6 °C	72,6 °C	72,6 °C	0,95	22,0 °C	0,00	
Cold	27,2 °C	27,2 °C	27,2 °C	0,95	22,0 °C	0,00	



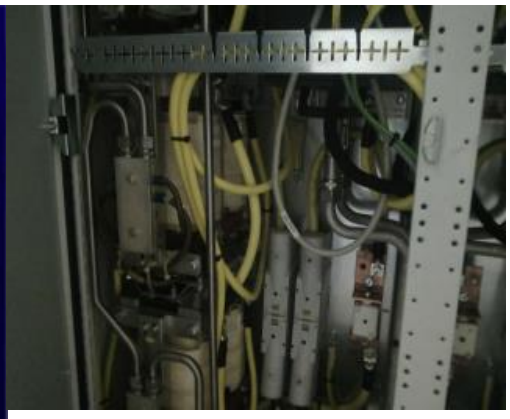


Image Info

Name	IR_00171.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.30 °C to 71.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:25 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	34.5 °C	34.5 °C	34.5 °C	0.95	22.0 °C	0.00	
Centerbox	44.2 °C	27.7 °C	34.6 °C	0.95	22.0 °C	3.91	
Hot	71.5 °C	71.5 °C	71.5 °C	0.95	22.0 °C	0.00	
Cold	26.3 °C	26.3 °C	26.3 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00170.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,80 °C to 44,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:18 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32,0 °C	32,0 °C	32,0 °C	0,95	22,0 °C	0,00	
Centerbox	44,2 °C	28,3 °C	33,5 °C	0,95	22,0 °C	3,59	
Hot	44,7 °C	44,7 °C	44,7 °C	0,95	22,0 °C	0,00	
Cold	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	

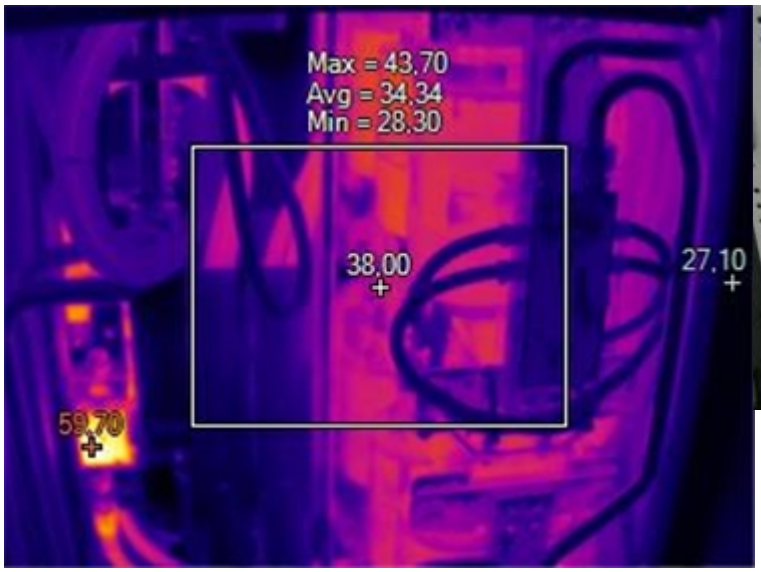




Image Info

Name	IR_00169.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	27,10 °C to 59,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:13 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Centerbox	43,7 °C	28,3 °C	34,3 °C	0,95	22,0 °C	4,34	
Hot	59,7 °C	59,7 °C	59,7 °C	0,95	22,0 °C	0,00	
Cold	27,1 °C	27,1 °C	27,1 °C	0,95	22,0 °C	0,00	

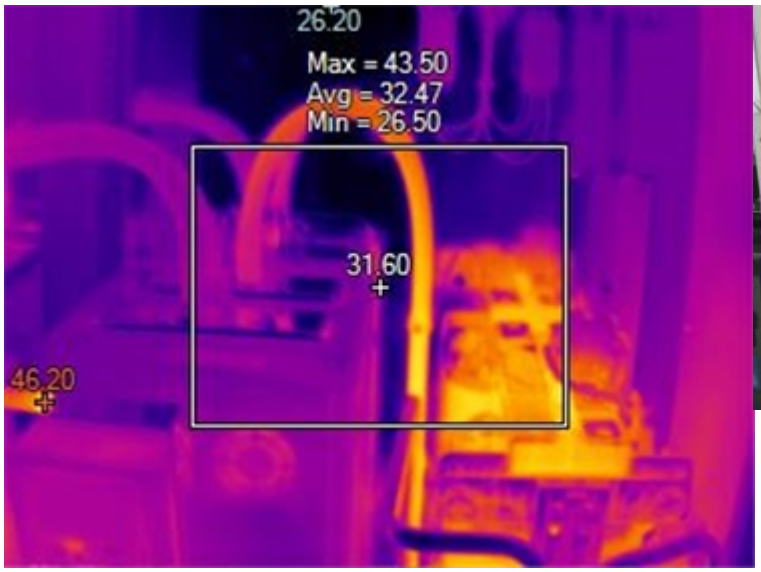




Image Info

Name	IR_00168.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.20 °C to 46.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:07 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.6 °C	31.6 °C	31.6 °C	0.95	22.0 °C	0.00	
Centerbox	43.5 °C	26.5 °C	32.5 °C	0.95	22.0 °C	4.14	
Hot	46.2 °C	46.2 °C	46.2 °C	0.95	22.0 °C	0.00	
Cold	26.2 °C	26.2 °C	26.2 °C	0.95	22.0 °C	0.00	

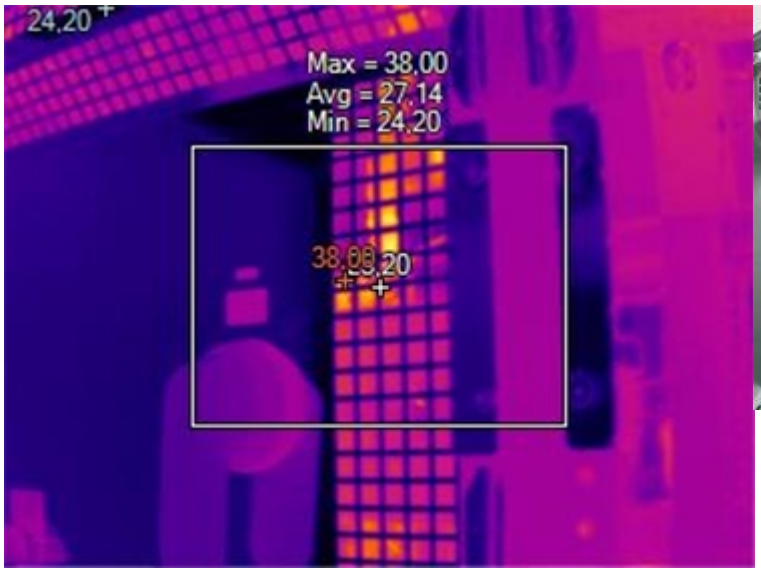




Image Info

Name	IR_00167.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	24,20 °C to 38,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:32:09 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,2 °C	25,2 °C	25,2 °C	0,95	22,0 °C	0,00	
Centerbox	38,0 °C	24,2 °C	27,1 °C	0,95	22,0 °C	1,86	
Hot	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Cold	24,2 °C	24,2 °C	24,2 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00166.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.70 °C to 42.90 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:32:01 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32.7 °C	32.7 °C	32.7 °C	0.95	22.0 °C	0.00	
Centerbox	42.9 °C	25.7 °C	32.0 °C	0.95	22.0 °C	3.97	
Hot	42.9 °C	42.9 °C	42.9 °C	0.95	22.0 °C	0.00	
Cold	25.7 °C	25.7 °C	25.7 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00165.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.50 °C to 43.70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:31:56 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.7 °C	30.7 °C	30.7 °C	0.95	22.0 °C	0.00	
Centerbox	43.7 °C	27.2 °C	32.8 °C	0.95	22.0 °C	3.63	
Hot	43.7 °C	43.7 °C	43.7 °C	0.95	22.0 °C	0.00	
Cold	24.5 °C	24.5 °C	24.5 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00164.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	26,20 °C to 43,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:31:49 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30,3 °C	30,3 °C	30,3 °C	0,95	22,0 °C	0,00	
Centerbox	43,5 °C	26,7 °C	32,6 °C	0,95	22,0 °C	4,36	
Hot	43,5 °C	43,5 °C	43,5 °C	0,95	22,0 °C	0,00	
Cold	26,2 °C	26,2 °C	26,2 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00163.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 43,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:31:43 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32,5 °C	32,5 °C	32,5 °C	0,95	22,0 °C	0,00	
Centerbox	43,0 °C	25,7 °C	32,2 °C	0,95	22,0 °C	3,73	
Hot	43,0 °C	43,0 °C	43,0 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	

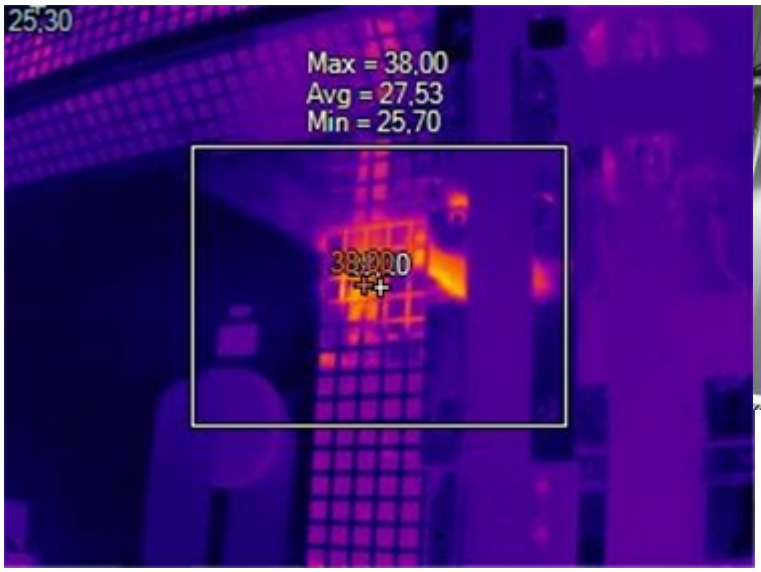




Image Info

Name	IR_00162.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 38,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:34 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,2 °C	28,2 °C	28,2 °C	0,95	22,0 °C	0,00	
Centerbox	38,0 °C	25,7 °C	27,5 °C	0,95	22,0 °C	1,61	
Hot	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	

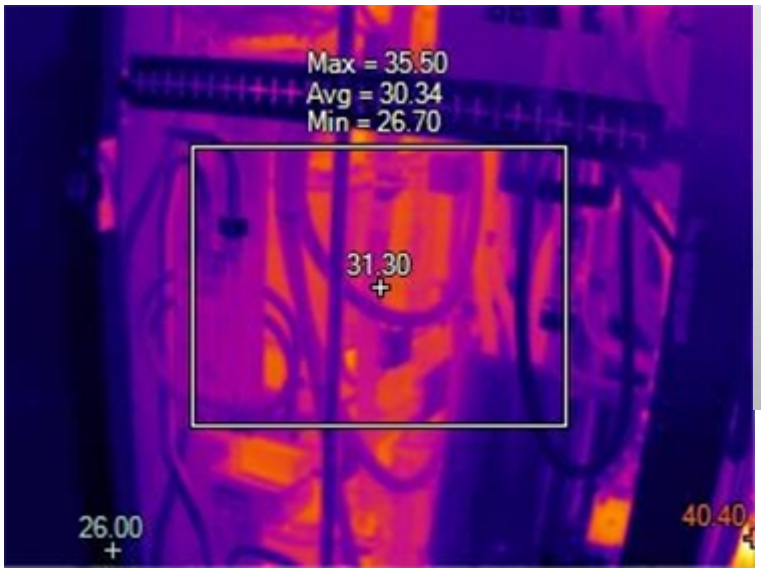




Image Info

Name	IR_00161.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.00 °C to 40.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:22 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.3 °C	31.3 °C	31.3 °C	0.95	22.0 °C	0.00	
Centerbox	35.5 °C	26.7 °C	30.3 °C	0.95	22.0 °C	1.65	
Hot	40.4 °C	40.4 °C	40.4 °C	0.95	22.0 °C	0.00	
Cold	26.0 °C	26.0 °C	26.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00160.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.60 °C to 36.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:16 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.5 °C	28.5 °C	28.5 °C	0.95	22.0 °C	0.00	
Centerbox	36.5 °C	26.7 °C	29.9 °C	0.95	22.0 °C	1.97	
Hot	36.5 °C	36.5 °C	36.5 °C	0.95	22.0 °C	0.00	
Cold	25.6 °C	25.6 °C	25.6 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00159.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 41.00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:07 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27.7 °C	27.7 °C	27.7 °C	0.95	22.0 °C	0.00	
Centerbox	41.0 °C	25.8 °C	29.5 °C	0.95	22.0 °C	2.41	
Hot	41.0 °C	41.0 °C	41.0 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00158.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,10 °C to 34,40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:02 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,7 °C	31,7 °C	31,7 °C	0,95	22,0 °C	0,00	
Centerbox	34,4 °C	26,2 °C	30,1 °C	0,95	22,0 °C	1,63	
Hot	34,4 °C	34,4 °C	34,4 °C	0,95	22,0 °C	0,00	
Cold	25,1 °C	25,1 °C	25,1 °C	0,95	22,0 °C	0,00	

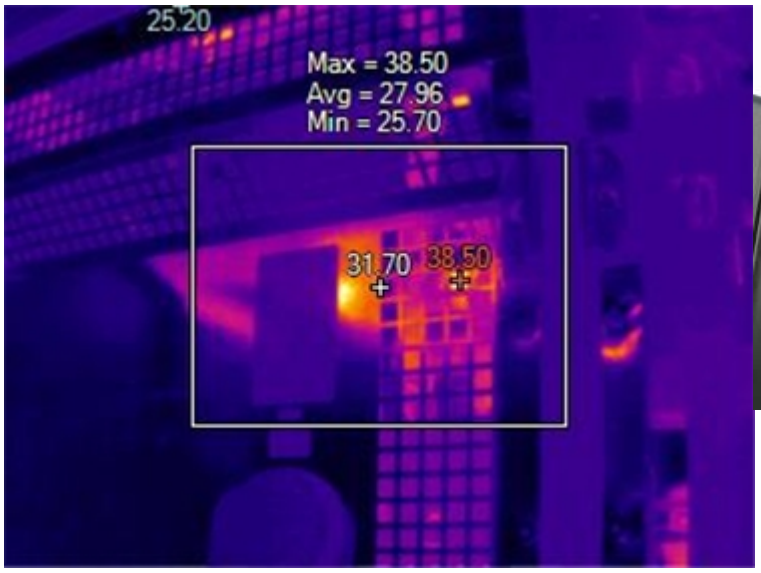




Image Info

Name	IR_00157.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 38.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:25 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.7 °C	31.7 °C	31.7 °C	0.95	22.0 °C	0.00	
Centerbox	38.5 °C	25.7 °C	28.0 °C	0.95	22.0 °C	1.71	
Hot	38.5 °C	38.5 °C	38.5 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00156.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,80 °C to 35,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:13 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,7 °C	31,7 °C	31,7 °C	0,95	22,0 °C	0,00	
Centerbox	34,0 °C	27,1 °C	29,9 °C	0,95	22,0 °C	1,34	
Hot	35,7 °C	35,7 °C	35,7 °C	0,95	22,0 °C	0,00	
Cold	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00155.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 35,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:08 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,8 °C	29,8 °C	29,8 °C	0,95	22,0 °C	0,00	
Centerbox	35,5 °C	27,2 °C	29,7 °C	0,95	22,0 °C	1,43	
Hot	35,5 °C	35,5 °C	35,5 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00154.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.70 °C to 34.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:00 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.0 °C	31.0 °C	31.0 °C	0.95	22.0 °C	0.00	
Centerbox	34.4 °C	25.8 °C	29.5 °C	0.95	22.0 °C	1.64	
Hot	34.4 °C	34.4 °C	34.4 °C	0.95	22.0 °C	0.00	
Cold	24.7 °C	24.7 °C	24.7 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00153.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 34.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:27:54 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.3 °C	30.3 °C	30.3 °C	0.95	22.0 °C	0.00	
Centerbox	33.5 °C	26.5 °C	29.6 °C	0.95	22.0 °C	1.38	
Hot	34.4 °C	34.4 °C	34.4 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	

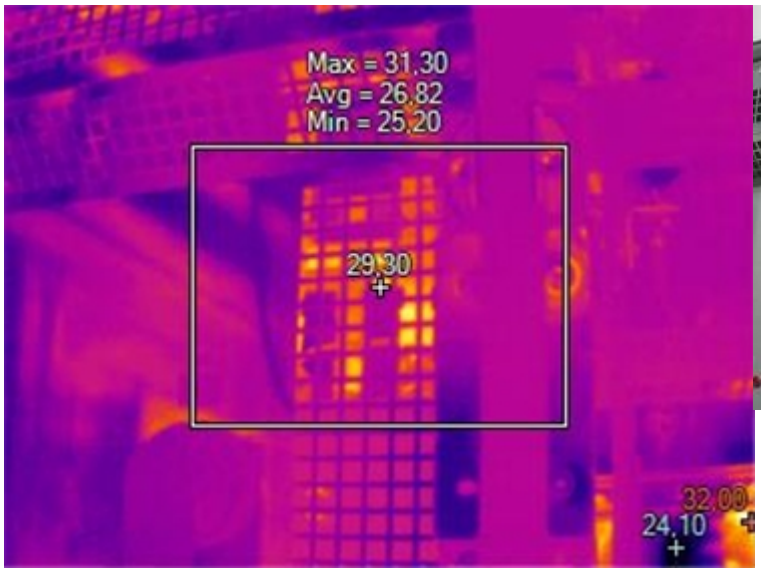




Image Info

Name	IR_00152.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	24,10 °C to 32,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:45 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,3 °C	29,3 °C	29,3 °C	0,95	22,0 °C	0,00	
Centerbox	31,3 °C	25,2 °C	26,8 °C	0,95	22,0 °C	0,81	
Hot	32,0 °C	32,0 °C	32,0 °C	0,95	22,0 °C	0,00	
Cold	24,1 °C	24,1 °C	24,1 °C	0,95	22,0 °C	0,00	

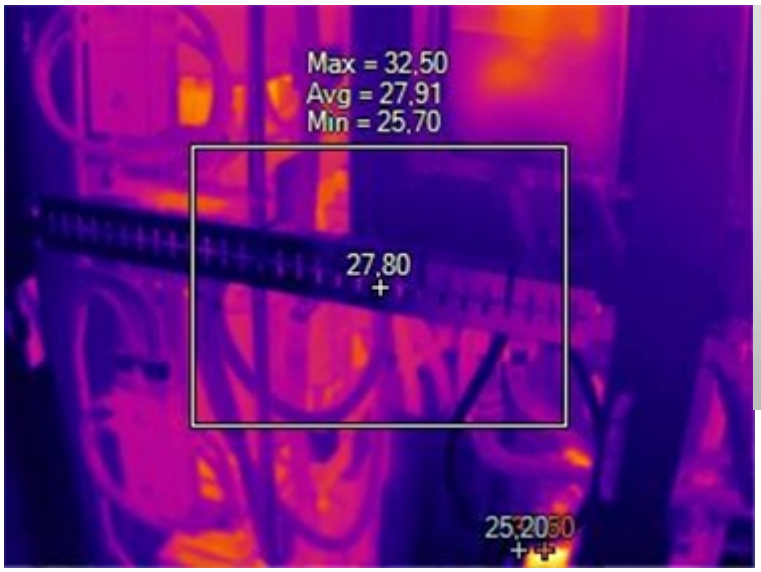




Image Info

Name	IR_00151.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,20 °C to 37,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:31 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27,8 °C	27,8 °C	27,8 °C	0,95	22,0 °C	0,00	
Centerbox	32,5 °C	25,7 °C	27,9 °C	0,95	22,0 °C	1,36	
Hot	37,5 °C	37,5 °C	37,5 °C	0,95	22,0 °C	0,00	
Cold	25,2 °C	25,2 °C	25,2 °C	0,95	22,0 °C	0,00	

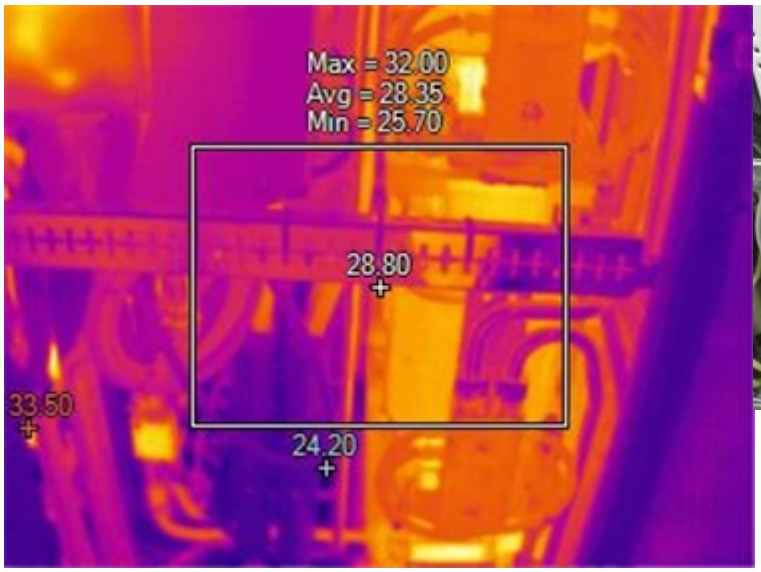




Image Info

Name	IR_00150.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.20 °C to 33.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:26 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.8 °C	28.8 °C	28.8 °C	0.95	22.0 °C	0.00	
Centerbox	32.0 °C	25.7 °C	28.3 °C	0.95	22.0 °C	1.47	
Hot	33.5 °C	33.5 °C	33.5 °C	0.95	22.0 °C	0.00	
Cold	24.2 °C	24.2 °C	24.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00149.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 34,20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:21 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,1 °C	29,1 °C	29,1 °C	0,95	22,0 °C	0,00	
Centerbox	34,2 °C	26,3 °C	28,3 °C	0,95	22,0 °C	1,49	
Hot	34,2 °C	34,2 °C	34,2 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00148.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.00 °C to 33.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:16 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27.1 °C	27.1 °C	27.1 °C	0.95	22.0 °C	0.00	
Centerbox	33.0 °C	26.0 °C	28.5 °C	0.95	22.0 °C	1.51	
Hot	33.5 °C	33.5 °C	33.5 °C	0.95	22.0 °C	0.00	
Cold	25.0 °C	25.0 °C	25.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00147.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	20.60 °C to 448.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:24:21 PM
Asset Name	Test Equipemnt
Asset Group	Test Equipemnt > Test Equipment > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	52.2 °C	52.2 °C	52.2 °C	0.95	22.0 °C	0.00	
Centerbox	356.8 °C	24.7 °C	49.4 °C	0.95	22.0 °C	37.85	
Hot	448.2 °C	448.2 °C	448.2 °C	0.95	22.0 °C	0.00	
Cold	20.6 °C	20.6 °C	20.6 °C	0.95	22.0 °C	0.00	

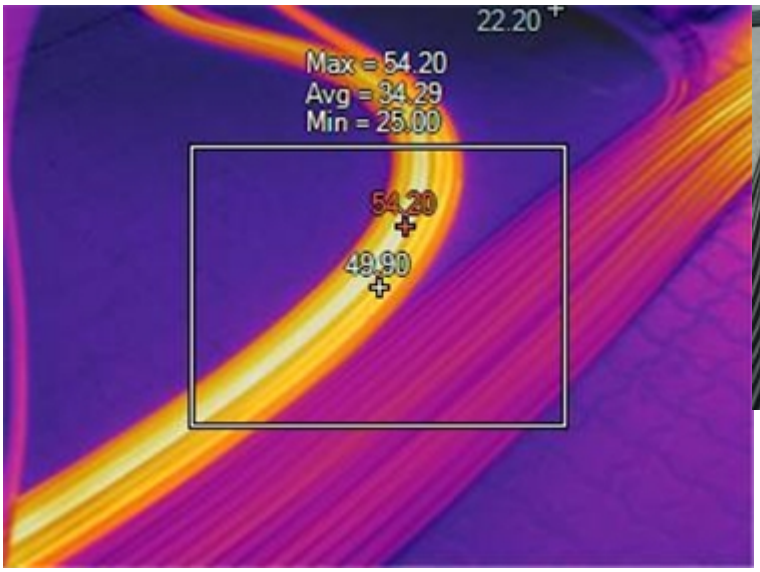




Image Info

Name	IR_00146.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	22.20 °C to 54.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:24:03 PM
Asset Name	Test Equipemnt
Asset Group	Test Equipemnt > Test Equipment > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	49.9 °C	49.9 °C	49.9 °C	0.95	22.0 °C	0.00	
Centerbox	54.2 °C	25.0 °C	34.3 °C	0.95	22.0 °C	8.06	
Hot	54.2 °C	54.2 °C	54.2 °C	0.95	22.0 °C	0.00	
Cold	22.2 °C	22.2 °C	22.2 °C	0.95	22.0 °C	0.00	

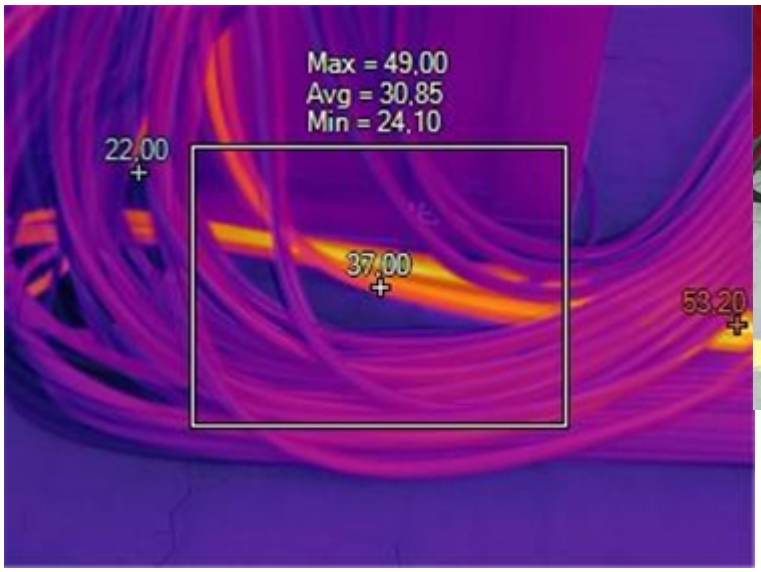




Image Info

Name	IR_00145.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	22,00 °C to 53,20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:23:52 PM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	37,0 °C	37,0 °C	37,0 °C	0,95	22,0 °C	0,00	
Centerbox	49,0 °C	24,1 °C	30,9 °C	0,95	22,0 °C	4,13	
Hot	53,2 °C	53,2 °C	53,2 °C	0,95	22,0 °C	0,00	
Cold	22,0 °C	22,0 °C	22,0 °C	0,95	22,0 °C	0,00	

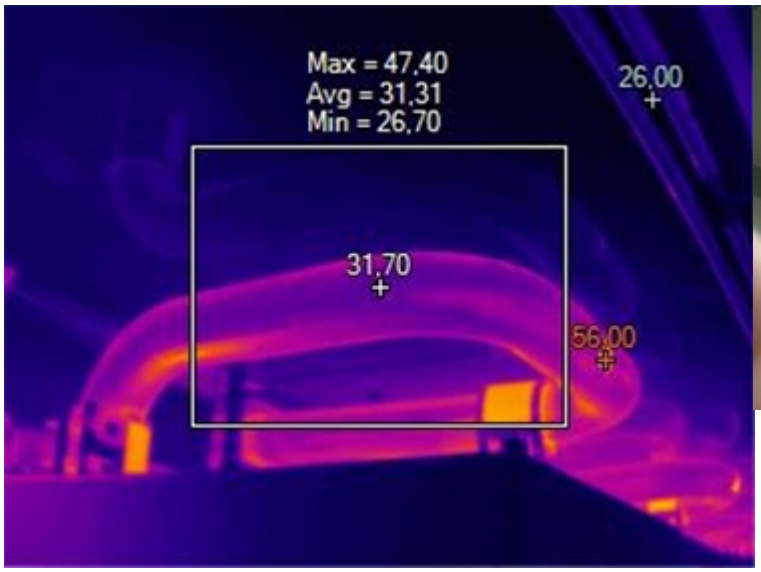




Image Info

Name	IR_00143.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	26,00 °C to 56,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	11/07/2024 12:56:17 PM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,7 °C	31,7 °C	31,7 °C	0,95	22,0 °C	0,00	
Centerbox	47,4 °C	26,7 °C	31,3 °C	0,95	22,0 °C	3,73	
Hot	56,0 °C	56,0 °C	56,0 °C	0,95	22,0 °C	0,00	
Cold	26,0 °C	26,0 °C	26,0 °C	0,95	22,0 °C	0,00	

Summary:

Sub Section K11

Ingress Protection Certificates

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	13/10/2023	First Issue

Document Title:	**BLPH Project - Ingress Protection Certificates**
Document Number:	K559-2254-CWIWP4202202-K11-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K11-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K11
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

TEST REPORT

IP44 test of FCwave 200 kW power cabinet

Ballard Power Systems Europe A/S

Report no.: 122-22396-1

1 appendix

TEST Reg. no. 19

4 Test and results

4.1 Test summary

The following tests were carried out as agreed with the client.

Test name	Standard	Test object
IP 4X (Protected against solid foreign objects of 1,0 mm and greater)	IEC 60529	**OK**
IP X4 (Protected against splashing water)	IEC 60529	**OK**

Sub Section K12

Type Approval Certificates

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	11/08/2023	First Issue
002	01/05/2025	Updated and ABS certificate added

Document Title:	**BLPH Project - Type Approval Certificates**
Document Number:	K559-2254-CWIWP4202202-K12-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K12-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K12
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

TYPE APPROVAL CERTIFICATE

Certificate No:
TAE00004GG
Revision No:
2

This is to certify:

That the Fuel Cell

with type designation(s)
FCwave

Issued to
Ballard Power Systems Europe A/S
Hobro, Nordjylland, Denmark

is found to comply with
DNV rules for classification – Ships

Application :

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV.

Issued at **Hamburg** on **2023-07-14**
This Certificate is valid until **2027-05-31**.
DNV local unit: **Denmark CMC**

Approval Engineer: **Sven Lellesch**

for **DNV**

Olaf Drews
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.

Product description

FCwave™ is a PEM fuel cell power module with rated power of 200 kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinet. The system, lower and upper cabinet, each have individual serial numbers and can be replaced during the service lifetime of the product.

The fuel for the system is pressurized gaseous hydrogen. The hydrogen storage system is not part of Ballard Power Systems Europe scope and therefore not part of the type approval. Oxidant for the reaction is drawn from ambient air and compressed in the internal compressors to feed the fuel cell stacks.
From the stacks, the module will deliver up to 720V direct current to the output of the system. It acts as a load follower electrically. The system needs power from external power source such as the vessels power system to start up, but when running it self-powers the internal Balance of Plant components. The controller and safety system require 24 VDC continuously from the vessels power system to function.
The system requires external water cooling to remove excess heat from the exothermic reaction in the fuel cells. The heat transfer is done with the integrated heat exchanger. The heat can be used in shipboard systems or disposed of as the customer desires. The fuel cells used in the system are Low Temperature PEM fuel cells. Temperatures in the system are below 100°C. The Fuel cell system is built into a cabinet. The cabinet has an ingress protection of IP44. The system is designed to be installed inside a fuel cell installation room. FCwave™ follows the gas safe machinery space concept as per IGF Code.

System Data

Control System Hardware and Software Version

Software	2.X.X	Dated 01/06 2023
Firmware	4.0.4.0	Dated 24/11 2021 (Deif AS)

Safety System Hardware and Software Version

Software	1.1.0	Dated 01/06 2023
Firmware	4.4	01/27 2022 (Siemens)

Independent Safety triggered by

Hydrogen concentration measurement inside fuel cell
External E Stop
Heat Detection inside fuel cell
Smoke Detection inside fuel cell
Ventilation Air Flow inside fuel cell

Interfaces to vessel

Are to be coordinated for each installation
Fuel Cell installation Room and Room requirements
Vessel control system
24VDC safety power supply
24VDC power supply
DC input/output
H2 supply
Low temperature cooling supply
High temperature cooling supply
H2 Enclosure ventilation outlet
Process exhaust outlet
H2 Enclosure ventilation Inlet
Process air inlet
Water drain

Application/Limitation

Fuel cell of type FCwave™ is approved for application as per DNV-RU-SHIP Pt.6 Ch.2 Sec.3.

Installation room
The fuel cell space (H2 enclosure as part of the FCwave™ cabinet) is not equipped with A60 insulation and is not equipped with a fire extinguishing system as indicated in MSC.1/Circ.1647 para 3.1.2 and 3.3.1. Additional installation room requirements shall be defined in the detailed design phase for the vessel.

The installation room is regarded as non-hazardous space.
The free volume of the installation room shall not be less than 10m³.
Gas detection is recommended for the fuel cell installation room and in the ventilation exhaust.

The FCwave™ does not provide an emergency stop button. Adequate and accessible emergency stop buttons shall be provided and integrated to the FCwave™ emergency stop circuit.
Access to the installation room during operation shall be limited to trained service technicians and crew that have received Ballard fuel cell training. Unrestricted access to the installation room can be permitted when all fuel cell modules are powered off and otherwise deemed permissible.

Hydrogen supply
Supply piping to each cabinet shall be carried out as double walled piping following the IGF Code principles.
Each FCwave™ cabinet shall be provided with a shut-off valve with a closing time of less than 2 seconds.
The hydrogen mass flow to each FCwave™ must be restricted by suitable means in all operation scenarios to 4.9g/s.
The dimension (diameter and length) of the hydrogen supply piping from shut-off valve to module interface plate shall not exceed 5000 cm³ as per Integration Manual.

Ventilation
The fuel cell space (H2 enclosure as part of the FCwave™ cabinet) is designed with area classification according to IEC 60079-10:2020, at least suitable for zone 2 installation.
In all cases process air and ventilation exhaust must remain separated, combination of multiple systems exhaust of the same type only. If process and/or ventilation exhausts are combined from multiple systems, they must be equipped with separate isolation dampers, which must close if the module are not operating.
The integration to the vessel shall ensure the exhaust from FC modules (ventilation air) is led to a safe location free of any spark or ignition source.

Approval Conditions
For each delivery to DNV class the following documentation of the fuel cell power installation is to be submitted for approval:

Fuel cell power installation
- Reference to this type approval certificate
- Documents according to DNV RU-SHIP, Pt. 6 Ch. 2 Sec. 3, table 3 for Fuel cell power installation
- G060 Structural fire protection drawing
- G200 Fixed fire protection drawing
- MAN002 Integration Manual

The Type Approval covers hardware and software listed under product description.

When the type approved software is revised (affecting all future deliveries) DNV is to be informed by forwarding updated software version documentation. If the changes are judged to affect functionality for which rule requirements apply a new functional type test may be required and the certificate may have to be renewed to identify the new software version.

Product certificate
Each delivery of the application system is to be certified according to Pt.6, Ch.2, Sec. 3. The certification test is to be performed at the manufacturer of the application system before the system is shipped to the yard. After certification, the clause for application software control will be put into force

Application software control
All changes in software are to be recorded as long as the system is in use on board. Documentation of major changes are to be forwarded to DNV for evaluation and approval before implemented on board

Type Approval documentation

Tests carried out

Marking of product
The components shall be marked for traceability to the Type Approval.

Periodical assessment
For retention of the Type Approval, a periodical assessment as per DNV-CP-0338 Sec.4 shall be performed by a DNV Surveyor in order to verify that the conditions for the Type Approval are complied with.
To check the validity of this certificate, please look it up in https://approvalfinder.dnv.com.

Certificate No: LR23327644TA
Issue Date: 27/07/2023
Expiry Date: 26/07/2028

Type Approval Certificate

This is to certify that the undernoted product(s) has/have been tested with satisfactory results in accordance with the relevant requirements of the Lloyd's Register Type Approval System.

Manufacturer	**Ballard Power Systems Europe A/S**
Address	Majsmarken 1, Hobro, 9500, Denmark
Type	Fuel Cell Module
Description	FCwave™ is a PEM fuel cell power module with rated power of 200 kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinet. The system, lower and upper cabinet, each have individual serial numbers and can be replaced during the service lifetime of the product. The fuel for the system is pressurized gaseous hydrogen. The hydrogen storage system is not part of Ballard Power Systems Europe scope and therefore not part of the type approval. Oxidant for the reaction is drawn from ambient air and compressed in the internal compressors to feed the fuel cell stacks. From the stacks, the module will deliver up to 720V DC to the output of the system. It acts as a load follower electrically. The system needs power from external power source such as the vessels power system to start up, but when running it self-powers the internal Balance of Plant components. The controller and safety system require 24V DC continuously from the vessels power system to function. The system requires external water cooling to remove excess heat from the exothermic reaction in the fuel cells. The heat transfer is done with the integrated heat exchanger. The heat can be used in shipboard systems or disposed of as the customer desires. The fuel cells used in the system are Low Temperature PEM fuel cells. Temperatures in the system are below 100°C. The Fuel cell system is built into a cabinet. The cabinet has an ingress protection of IP 44. The system is designed to be installed inside a fuel cell installation room.

Jin Meng

Electrical & Control - Senior Specialist to
Lloyd's Register EMEA
A member of the Lloyd's Register group

71 Fenchurch Street, London, EC3M 4BS, United Kingdom

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Type Approval Certificate

FCwave™ follows the gas safe machinery space concept as per IGF Code.

Trade Name

FCwave™

Application

Marine, Offshore and Industrial applications for use in environmental categories ENV1, as defined in Lloyd's Register Type Approval System, Test Specification Number 7, Fuel Cell Modules, January 2023.

Specified Standard

-Manufacturer's specification
-IACS UR E10 Rev. 8 / 2021 as applicable

Ratings

-Maximum rated output power: 200kW
-Operating voltage: 350 – 720V DC
-Rated current: 2 x 300A or 1 x 550A

Other Conditions

The Fuel Cell Module is approved subject to the following conditions:

- A risk assessment specific to fuel cell power installations is to be carried out for each installation on board.The risk assessment is to evaluate risks related to the safe operation of the ship and as such is to address the safety of the fuel cell power installation itself and, where the fuel cell installation provides power for propulsion of the ship or other essential services, the dependability of the fuel cell power installation.
- The Fuel Cell Module shall only be used in accordance with the manufacturer's instructions and recommendations.
- The Fuel Cell Module shall be installed and maintained in accordance with the applicable rules, regulations, and standards for marine applications.
- The Fuel Cell Module shall be operated and monitored in accordance with the relevant safety requirements.
- The Fuel Cell Module shall be subject to periodic inspections and maintenance, in accordance with the manufacturer's recommendations and applicable rules and regulations.

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Type Approval Certificate

Type Approval does not eliminate the need for normal inspection and survey procedures required by the Rules and Regulations.
If the specified standards are amended during the validity of this certificate, the product is to be re-approved prior to it being supplied to vessels to which the amended standards apply.

This certificate is not valid for equipment, the design, ratings or operating parameters of which have been varied from the specimen tested. The manufacturer should notify Lloyd's Register EMEA of any modification or changes to the equipment in order to obtain a valid Certificate.

The Design Appraisal Document HPC2262032/JM/PH and its supplementary Type Approval Terms and Conditions form part of this Certificate.

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Confirmation of Product Type Approval

Company Name: BALLARD POWER SYSTEMS EUROPE A/S

Address: MAJSMARKEN 19500 HOBRO Denmark

Product: Fuel Cell

Model(s): FCwave

Endorsements:

Certificate Type	Certificate Number	Issue Date	Expiry Date
Product Design Assessment (PDA)	24-2503176-PDA	01-JUL-2024	30-JUN-2029
Manufacturing Assessment (MA)	24-6556075	26-AUG-2024	25-AUG-2029
Product Quality Assurance (PQA)	NA	NA	NA

Tier
5 - Unit Certification Required

Intended Service
Main & Auxiliary Power Generation for Marine and Offshore Applications

Description
FCwave is a low temperature PEM fuel cell power system with rated power output of 200kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinets, each has individual serial numbers and can be replaced during the service lifetime of the product, as necessary.

Ratings
Power output: 200 KW

H2 Inlet Supply Pressure: 3.5 - 6.5 barg

H2 Design Temperature of operation: 0 - 80°C

Fuel Cell Hydrogen Operating Pressure: 0.2 - 1.0 barg

H2 Flowrate to Valve Block: 4.9 g/s

Ingress Protection of Cabinet: IP44

Operating Ambient Temperature: 0 -45 degree

Service Restrictions
Unit Certification is required for this product as indicated in the 4-9-3/Table 2 and 4-9-9/15.7 of the ABS Rules for Building and Classing Marine Vessels (2024).

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If the manufacturer or purchaser request an ABS Certificate for compliance with a specification or standard, the specification or standard, including inspection standards and tolerances, must be clearly defined.

Comments

1. The Manufacturer has provided a declaration about the control of, or the lack of Asbestos in this product.

2. During final installation the attending Surveyor is to verify that redundant gas detectors able to detect H2 are installed in the appropriate locations and operate properly. Any accumulation of gas to 20% LFL should trigger gas detector alarm and accumulation to 40% LFL should trigger the ESD.

3. During final installation the attending Surveyor is to verify that the FCwave is equipped with anchor mechanisms or other suitable attachments to the base structure or the hull.

4. Upon installation, the Surveyor is to verify that the door air intakes/inlets are clear to minimize the risk of complete blockage.

5. Upon installation, the Surveyor is to verify that the Chassis is properly grounded.

6. After assembled to a complete assembly unit or subassembly unit, each production unit of equipment used in control, monitoring and safety systems is to be tested at the manufacturer’s shop in the presence of the ABS Surveyor according to 4-9-9/15.7 TABLE 2 as follows:

i) Visual inspection

ii) Performance test

iii) External Power supply failure

7. FCwave system has been assigned with a Category II system classification per 4-9-3/Table 1 of the Marine Vessels Rules. Accordingly, the following tests are to be performed and are to be witnessed by the Surveyor at the Factory in accordance with 4-9-3/Table 2 of the Marine Vessels Rules (MVR).

i) 3.6: Fault Simulation.

ii) 3.7: Factory Acceptance Tests.

8. The design applies the Hazardous Zone Classification method of IEC 60079-10. The fuel cell installation room is considered as a Non-Hazardous Zone or Zone 2 with negligible extent in accordance with IEC 60079-10-1/Table D.1, with all hydrogen fuel piping entering the space and leading to or from the non-structural fuel cell space enclosure to be provided with a double-wall containment system appropriate to the fuel used by the piping.

9. Structural fire protection shall apply to the fuel cell installation room boundaries, not the fuel cell space enclosure; fire detection and fire extinguishing system requirements shall apply to the fuel cell installation room, not within the fuel cell space enclosure as per Section 3 of Fuel Cell Power Systems Requirements.

10. For each installation, safety concepts including the hazardous zone of the fuel cell installation room and multiple installation of the fuel cell units are to be declared to the flag administration for further consideration and evaluated during the risk assessment.

Notes, Drawings and Documentation

Drawing No. 120-26421-1, FCE003-4.5 EMC test report, Revision: A, Pages: 1

Drawing No. 28859 O60X2 Stainless steel pipe Cert. no. 40144, Double Wall H2 pipe, Revision: A, Pages: 1

Drawing No. 28914 O20X2 Stainless steel pipe Cert no. 466220, Double Wall H2 pipe, Revision: A, Pages: 2

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Drawing No. 4006956 Datasheet, Fire Wire, Revision: A, Pages: 1

Drawing No. 7000090 - Double Wall pipe drawing, Double Wall H2 pipe, Revision: A, Pages: 3

Drawing No. CMS001, Control and safety system description, Revision: A, Pages: 1

Drawing No. CMS003, Control systems diagrams, Revision: A, Pages: 1

Drawing No. CMS004, Power supply arrangement - Schematics, Revision: A, Pages: 1

Drawing No. CMS004-A, Power supply arrangement, Revision: A, Pages: 1

Drawing No. CMS004-B, High voltage supply arrangement , Revision: A, Pages: 1

Drawing No. CMS004-C, Sensor Single Line Diagram, Revision: A, Pages: 1

Drawing No. CMS004-E, FCWave Circuit Diagrams, Revision: A, Pages: 1

Drawing No. CMS005_SEL005, Instrument Cables and equipment list, Revision: A, Pages: 1

Drawing No. CMS006_SEL004, Electrical Datasheet, Revision: A, Pages: 1

Drawing No. CMS007_SAX001, Control Software Specification, Revision: A, Pages: 1

Drawing No. CMS008, Field Instruments periodic test plan, Revision: A, Pages: 1

Drawing No. CMS008-A, Field Instrument List, Revision: A, Pages: 1

Drawing No. CMS009, Software Quality Plan, Revision: A, Pages: 1

Drawing No. CMS010, Schematic description of input and output circuits, Revision: A, Pages: 1

Drawing No. CMS012, Control Monitoring and Safety Test Procedure, Revision: A, Pages: 1

Drawing No. CMS012-A CMS012 Test Report 4, CMS012-A CMS012 Test Report 4, Revision: -, Pages: -

Drawing No. CMS013, CAN matrix, Revision: A, Pages: 1

Drawing No. CMS014, Control System Alarm List, Revision: A, Pages: 1

Drawing No. CMS015, Safety System Documentation, Revision: A, Pages: 1

Drawing No. Correspondence, PDA Preliminary Comment Responses, Revision: 0, Pages: 26

Drawing No. Correspondence, PDA Application New PDA Fuel Cell Power System, Revision: -, Pages: -

Drawing No. FAT001, System FAT, Revision: A, Pages: 1

Drawing No. FAT002, FAT with surveyor, Revision: A, Pages: 1

Drawing No. FCE003, Test programme, Revision: A, Pages: 1

Drawing No. FCE003-2, Safety Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-3, Performance Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.1, Inclination Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.2, Vibration Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.3, Environmental Climate Chamber Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.4, Power Supply Test Programme, Revision: A, Pages: 1

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Drawing No. FCE003-4.5, EMC Test Programme, Revision: A, Pages: 1

Drawing No. H2E Purge Valve Datasheet, H2E Purge Valve, Revision: A, Pages: 6

Drawing No. INT001 Explosion Analysis Report 1, INT001 Explosion Analysis Report 1, Revision: -, Pages: -

Drawing No. MAN001_SEL003, Service Manual, Revision: A, Pages: 1

Drawing No. MAN002, Integration Manual, Revision: A, Pages: 1

Drawing No. N1424AY6-A1013702, FCE003-4-4 Power supply failure test report, Revision: A, Pages: 1

Drawing No. N1427ES7-A1110380, FCE003-2 2.2 Temperature Test, Revision: A, Pages: 1

Drawing No. N1427X8Y-A1121839-rev01, FCE003-2 2.5 Safety System Test, Revision: A, Pages: 1

Drawing No. N14284B8-A1125744, FCE003-3 DV29 Nameplate power performance test, Revision: A, Pages: 1

Drawing No. N14284YU-A1127125-rev01, FCE003-2 2.3 Back Pressure Test, Revision: A, Pages: 1

Drawing No. N1428BMZ-A1133039, FCE003-2 2.6 Electric Safety Test, Revision: A, Pages: 1

Drawing No. N1428NN3-A1141771, FCE003-3 DV32_33 Response time/start-stop test, Revision: A, Pages: 1

Drawing No. N1428NN4-A1141772, FCE003-2 2.1 Safety Pressure Test, Revision: A, Pages: 1

Drawing No. N1429D4U-A1156670, FCE003-4.1 Inclination test, Revision: A, Pages: 1

Drawing No. N1429EKW-A1157845, FCE003-2 2.4 Block Airways Test, Revision: A, Pages: 1

Drawing No. PRC001…005, Design criteria for pressure containing components, Revision: A, Pages: 1

Drawing No. PWR001, Arrangement Plan, Revision: A, Pages: 1

Drawing No. PWR002, PPHA FCWave, Revision: A, Pages: 1

Drawing No. PWR003, Hazardous Area classification plan, Revision: A, Pages: 1

Drawing No. PWR004, Piping diagram, Revision: A, Pages: 1

Drawing No. PWR005, P&ID, Revision: A, Pages: 1

Drawing No. PWR005, P&ID, Revision: , Pages: 1

Drawing No. PWR006, Functional description, Revision: A, Pages: 1

Drawing No. PWR007_PWR002, Safety description (Risk asessment), Revision: A, Pages: 1

Drawing No. PWR008-C, Commissioning checklist, Revision: A, Pages: 1

Drawing No. PWR008_TES001, Commissioning procedure, Revision: A, Pages: 1

Drawing No. PWR009, Safety concept, Revision: A, Pages: 1

Drawing No. Pipes 106039 1 DOC, Double Wall H2 pipe, Revision: A, Pages: 4

Drawing No. SVE001…003, Ventilation diagram, Revision: A, Pages: 1

Drawing No. Silicon Hose Datasheet, Silicone Hose, Revision: A, Pages: 3

Drawing No. Silicone Hose 7000046 - Fuel outlet manifold, Silicone Hose, Revision: A, Pages: 2

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Drawing No. Silicone Hose 7000047 - Fuel inlet manifold, Silicone Hose, Revision: A, Pages: 3

Drawing No. TAC 44860/B2 BV, BV_Hy-Lok_Tube_Fittings_2022, Revision: -, Pages: -

Drawing No. Tube fittings catalogue, HY-LOK 7000778, Revision: -, Pages: -

Term of Validity
This Product Design Assessment (PDA) Certificate remains valid until 30/Jun/2029 or until the Rules and/or Standards used in the assessment are revised or until there is a design modification warranting design reassessment (whichever occurs first).

Acceptance of product is limited to the "Intended Service" details prescribed in the certificate and as per applicable Rules and Standards.

This Certificate is valid for installation of the listed product on ABS units which exist or are under contract for construction on or previous to the effective date of the ABS Rules and standards applied at the time of PDA issuance. Use of the Product for non-ABS units is subject to agreement between the manufacturer and intended client.

ABS Rules
Rules for Conditions of Classification, Part 1 - 2024 Marine Vessel Rules 1-1-4/7.7, 1-1-A3, 1-1-A4, Which covers the following:

Marine Vessel Rules (MVR) 2024 :4-9-3/Table 1, 4-9-3/Table 2, 4-9-9/15.7, 5C-13-7/3, 5C-13-16/1.1

Requirements for Fuel Cell Power Systems for Marine and Offshore Applications 2023

International Standards
IEC 60079-10: Classification of Area – Explosive Gas Atmosphere

IEC 62282-2-100:2020, Fuel cell technologies - Part 2-100: Fuel cell modules – Safety

IEC 62282-3-100:2019, Fuel cell technologies - Part 3-100: Stationary fuel cell power systems - Safety

EU-MED Standards
NA

National Standards
NA

Government Standards
NA

Other Standards
NA





Corporate ABS Programs
American Bureau of Shipping

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Print Date and Time: 30-Aug-2024 2:49

ABS has used due diligence in the preparation of this certificate, and it represents the information on the product in the ABS Records as of the date and time the certificate is printed.

If the Rules and/or standards used in the PDA evaluation are revised or if there is a design modification (whichever occurs first), a PDA revalidation may be necessary.

The continued validity of the MA is dependent on completion of satisfactory audits as required by the ABS Rules. The validity of both PDA and MA entitles the product to receive a **Confirmation of Product Type Approval**.

Acceptance of product is limited to the “Intended Service” details prescribed in the certificate and as per applicable Rules and Standards.

This Certificate is valid for installation of the listed product on ABS units which exist or are under contract for construction on or prior to the effective date of the ABS Rules and standards applied at the time of PDA issuance. ABS makes no representations regarding Type Approval of the Product for use on vessels, MODUs or facilities built after the date of the ABS Rules used for this evaluation.

Type Approval requires Drawing Assessment, Prototype Testing and assessment of the manufacturer's quality assurance and quality control arrangements. The manufacturer is responsible to maintain compliance with all specifications applicable to the product design assessment. Unless specifically indicated in the description of the product, certification under type approval does not waive requirements for witnessed inspection or additional survey for product use on a vessel, MODU or facility intended to be ABS classed or that is presently in class with ABS.

Due to wide variety of specifications used in the products ABS has evaluated for Type Approval, it is part of our contract that; whether the standard is an ABS Rule or a non-ABS Rule, the Client has full responsibility for continued compliance with the standard.

Questions regarding the validity of ABS Rules or the need for supplemental testing or inspection of such products should, in all cases, be addressed to ABS.

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Section L

Certification Data (Work Review)

Sub Section L01

Material Test Certificates

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	7/19/2024	First Issue
002	12/1/2025	Updated, naming of components and cerrificates

Document Title:	**BLPH Project - Material Test Certificates**
Document Number:	K559-2254-CWIWP4202202-L01-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-L01-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	L01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Material Test Certificates
Full Title	Material Test Certificates

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	July 19, 2024
2.0	Update, naming of components	JTA	Dec 01, 2025

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1.0 General

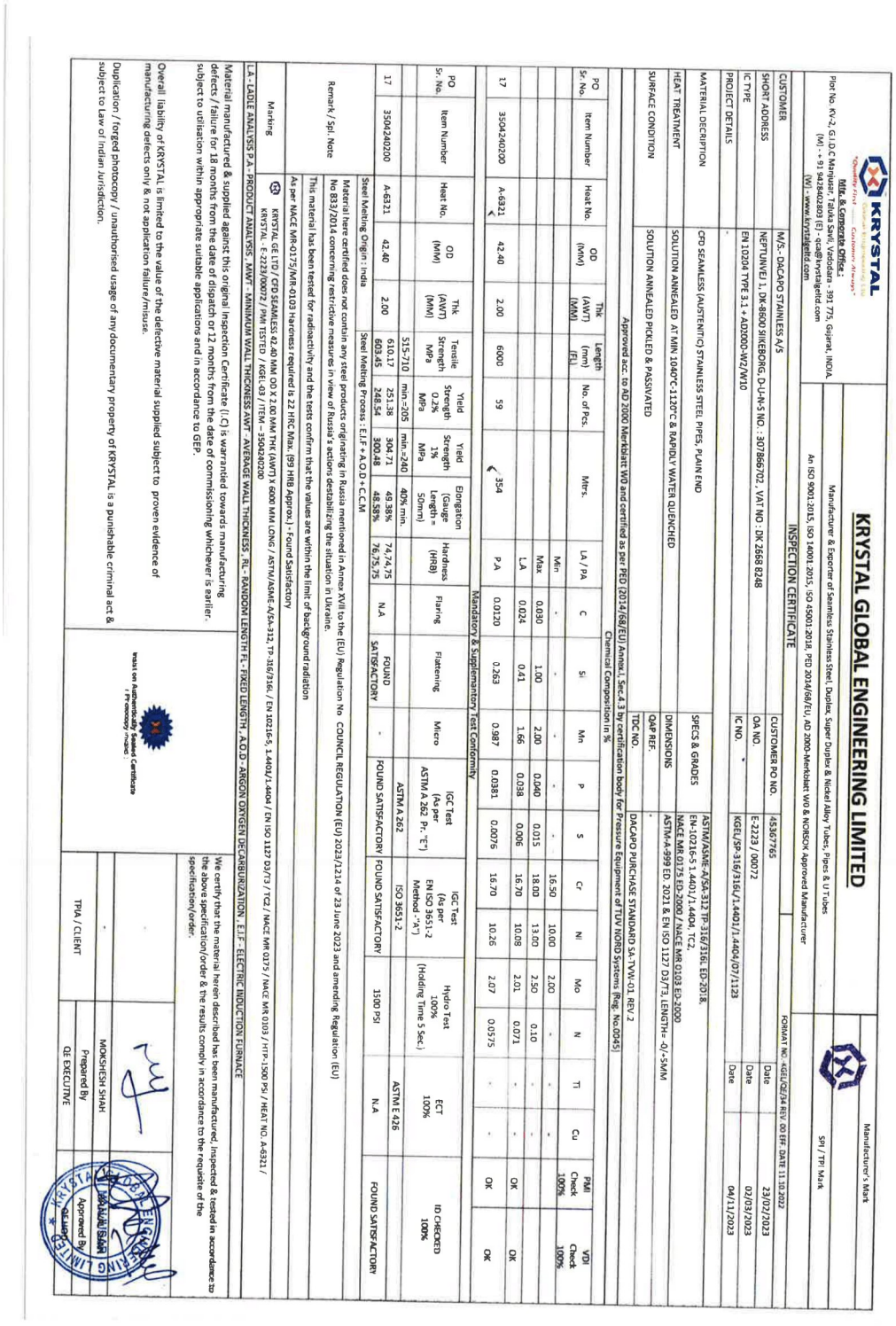
This document contains Material Test Certificates of products supplied to Ballard for the manufacturing of the H2 manifold for 1 MW Fuel Cell Power Container intended for CrossWind.

The Material Test Certificates state the national material specifications that the materials conform to, incl. chemical analysis, specification range analysis mechanical test results, and heat-treated conditions, and are valid for the following products:

- 42.4x2.0 Stainless Steel Cold Finish Seamless Pipes
- 25.0x2.0 Stainless Steel Seamless Pipes
- 42.4 ASME B16.5 Stainless Steel Forged Flanges
- G½ Coupling Stainless
- 42.4x2.0 Stainless Steel End Caps

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1.1 42.4x2.0 Stainless Steel Cold Finish Seamless Pipes



150861

KRYSTAL

Manufacturer & Exporter of Seamless Stainless Steel, Duplex, Super Duplex & Nickel Alloy Tubes, Pipes & U/T-Tubes

An ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, PED 2014/68/EU, AD 2000-Merkblatt W0 & NORSOK Approved Manufacturer

KRYSTAL GLOBAL ENGINEERING LIMITED

Manufacturer's Mark

SPI / TPI Mark

Mfg. & Corporate Office :
Plot No. KV-2, G.I.D.C Manjusar, Taluka Savli, Vadodara - 391 775, Gujarat, INDIA
(M) : - 91 9428402803 (E) - qca@krystalgetd.com
(W) : www.krystalgetd.com

FORMAT NO: KGEL/QE/04 REV. 00 EFF. DATE 11.10.2022

INSPECTION CERTIFICATE

CUSTOMER: M/S.- DACAPO STAINLESS A/S — CUSTOMER PO NO.: 4536765 — Date: 23/02/2023
SHORT ADDRESS: NEPTUNVEJ 1, DK-8600 SILKEBORG, D-U-N-S NO. : 307866702 , VAT NO : DK 2668 8248 — QA NO.: E-2223 / 00072 — Date: 02/03/2023
I.C TYPE: EN 10204 TYPE 3.1 + AD2000-W2/W10 — I.C NO.: KGEL/SP-316/316L/1-4401/1-4404/07/1123 — Date: 04/11/2023
PROJECT DETAILS: -
MATERIAL DESCRIPTION: CFD SEAMLESS (AUSTENITIC) STAINLESS STEEL PIPES, PLAIN END — SPECS & GRADES: ASTM/ASME-A/SA-312 TP-316/316L ED-2018. EN-10216-5 1.4401/1.4404. TC1, NACE MR 0175 ED-2009 / NACE MR 0103 ED-2000
HEAT TREATMENT: SOLUTION ANNEALED AT MIN 1040°C-1120°C & RAPIDLY WATER QUENCHED — DIMENSIONS: ASTM-A-999 ED: 2021 & EN ISO 1127 D3/T3, LENGTH+ -0/+5MM
SURFACE CONDITION: SOLUTION ANNEALED PICKLED & PASSIVATED — Q&P REF.: -
TDC NO.: DACAPO PURCHASE STANDARD SA-TUV-01 REV 2

Approved acc. to AD 2000 Merkblatt W0 and certified as per PED (2014/68/EU) Annex I, Sec.4.3 by certification body for Pressure Equipment of TUV NORD Systems (Reg. No.0045)

Chemical Composition in %

PO Sr. No.	Item Number	Heat No.	OD (MM)	Thk (AWT) (MM)	Length (mm) (FL)	No. of Pcs.	Mtrs.	LA / PA	C	Si	Mn	P	S	Cr	Ni	Mo	N	Ti	Cu	PMI Check 100%	VDI Check 100%
								Min.	-	-	-	-	-	16.50	10.00	2.00	-	-	-		
								Max	0.030	1.00	2.00	0.040	0.015	18.00	13.00	2.50	0.10	-	-		
								LA	0.024	0.41	1.66	0.038	0.006	16.70	10.08	2.01	0.071	-	-	OK	OK
17	3504240200	A-6321	42.40	2.00	6000	59	354	PA	0.0120	0.263	0.987	0.0381	0.0076	16.70	10.26	2.07	0.0575	-	-	OK	OK

Mandatory & Supplementary Test Conformity

PO Sr. No.	Item Number	Heat No.	OD (MM)	Thk (AWT) (MM)	Tensile Strength MPa	Yield Strength 0.2% MPa	Yield Strength 1% MPa	Elongation (Gauge Length – 50mm)	Hardness (HRB)	Flaring	Flattening	Micro	IGC Test (As per ASTM A 262 Pr. "E")	IGC Test (As per EN ISO 3651-2 Method "A")	Hydro Test 100% (Holding Time 5 Sec.)	ECT 100%
					515-710	min-205	min-240	40% min.					ASTM A 262	ISO 3651-2		ASTM E 426
17	3504240200	A-6321	42.40	2.00	610.17 / 603.45	251.38 / 248.54	304.71 / 300.48	49.38% / 48.58%	74,74,75 / 76,75,75	N.A	FOUND SATISFACTORY	-	FOUND SATISFACTORY	FOUND SATISFACTORY	1500 Psi	N.A

Steel Melting Origin : India — Steel Melting Process : E.I.F + A.O.D + C.C.M

Material here certified does not contain any steel products originating in Russia mentioned in Annex XVII to the (EU) Regulation No COUNCIL REGULATION (EU) 2022/1214 of 23 June 2023 and amending Regulation (EU) No 833/2014 concerning restrictive measures in view of Russia's actions destabilizing the situation in Ukraine.

Remark / Spl. Note: This material has been tested for radioactivity and the tests confirm that the values are within the limit of background radiation

As per NACE MR-01/75/MR-0103 Hardness required is 22 HRC Max. (99 HRB Approx.) - Found Satisfactory

Marking: KRYSTAL GE LTD / CFD SEAMLESS 42.40 MM OD X 2.00 MM THK (AWT) X 6000 MM LONG / ASTM/ASME-A/SA-312, TP-316/316L / EN 10216-5, 1.4401/1.4404 / EN ISO 1127 D3/T3 / TC2 / NACE MR 0175 / NACE MR 0103 / HTP-1500 PSI / HEAT NO. A-6321 / KRYSTAL - E-2223/00072 / PMI TESTED / KGEL-03 / ITEM - 3504240200

LA - LADLE ANALYSIS, P.A - PRODUCT ANALYSIS, AWT - MINIMUM WALL THICKNESS, AWT - AVERAGE WALL THICKNESS, RL - RANDOM LENGTH, FL - FIXED LENGTH, A.O.D - ARGON OXYGEN DECARBURIZATION, E.I.F. - ELECTRIC INDUCTION FURNACE

Material manufactured & supplied against this original Inspection Certificate (I.C) is warranted towards manufacturing defects / failure for 18 months from the date of dispatch or 12 months from the date of commissioning whichever is earlier, subject to utilisation within appropriate suitable applications and in accordance to GEP.

Overall liability of KRYSTAL is limited to the value of the defective material supplied subject to proven evidence of manufacturing defects only & not application failure/misuse.

Duplication / forged photocopy / unauthorised usage of any documentary property of KRYSTAL is a punishable criminal act & subject to Law of Indian Jurisdiction.

We certify that the material herein described has been manufactured, inspected & tested in accordance to the above specification/order & the results comply in accordance to the requisite of the specification/order.

TPIA / CLIENT — Prepared By QE EXECUTIVE: MOKSHESH SHAH — Approved By QUALITY CONTROL: MR. ANJU BAAR

KRYSTAL ENGINEERING LIMITED

Inspection Certificate

TA CHEN STAINLESS PIPE CO., LTD.
NO. 125 HSIN-TIEN 2ND ST.,
JENG-TEH, TAINAN, TAIWAN
TEL:(06)2793254 FAX:(06)2701382
COUNTRY ORIGIN:TAIWAN

EN 10204-3.1

Commodity : STAINLESS STEEL WELDED PIPE
Customer : DACAPO STAINLESS B.V.
Specification : ASTM A312/A312M-2022a /ASTM A999-2018
ASME SA312-2021/ASME BPVC.II.A-2021
Destination : ROTTERDAM
Grade : TP316
Customer O/N :31134407 **Certificate No** : XF0200034
Delivery Condition: ANNEALED AND PICKLED
Factory O/N : _____ **Date** : 2023/6/19 **INVOICE No** : HO27XF0200

Item No.	Case No. (Crate No.)	Heat No.	Size		Quantity	Weight	Chemical Composition in %								
					(Pcs)	(Kgs)	C	Si	Mn	P	S	Ni	Cr	Mo	N
01	006	1014299	2-1/2"	SCH40S			0.080	1.000	2.000	0.045	0.030	14.00	18.00	3.000	-
							0.020	0.480	0.917	0.031	0.0012	10.23	16.800	2.063	0.030
02	004	1017422	1"	SCH40S			0.022	0.440	0.940	0.036	0.0057	10.17	16.770	2.100	0.029
03	006	1025545	2"	SCH40S			0.020	0.460	0.990	0.025	0.0009	10.11	16.750	2.040	0.019
04	004	1027133	3/4"	SCH40S			0.009	0.360	0.940	0.032	0.0033	10.06	16.710	2.060	0.021
05	004	1027133	3/4"	SCH40S			0.009	0.360	0.940	0.032	0.0033	10.06	16.710	2.060	0.021
Total															

Item No.	Tensile Test (Gage Lth=50mm)				Hardness	Bend	Flattening	HT TEMP °F	Dimension And	Hydrostatic
	0.2% Yield Strength PSI	1.0% Yield Strength PSI	Tensile Strength PSI	Elongation %	Test HRB	Test	Test	Quenching In Water	Surface Condition	Test PSI
	30000		75000	T25/L35				1900		2500
	-	-	-					-		-
01	43100	-	89000	50	84.00	OK	OK	1904	OK	2100
02	40200	-	88000	51.5	80.00	OK	OK	1904	OK	2500
03	38400	-	84100	55	79.00	OK	OK	1904	OK	1900
04	42800	-	87600	50	80.00	OK	OK	1904	OK	2500
05	42800	-	87600	50	80.00	OK	OK	1904	OK	2500

Remarks
1. EDDY CURRENT TEST : O.K.
2. HARDNESS : MADE WITH ASTM A262
3. P.M.I. TESTED : O.K.
4. LOT MATERIAL ACC. ASTM A262
5. RAW MATERIAL FOR PIPE FITTINGS
6. PED 2014/68/EU

TA CHEN STAINLESS PIPE CO.,LTD. Q/C Dept. NO.125 HSIN-TIEN 2ND STREET, TAINAN, TAIWAN, R.O.C.

We hereby certify the above statement to be true and correct every detail
TA CHEN has established a QMS according to ISO 9001, which is certified by LRQA (ISO 9001-0067066)

George Yang
Manager of Inspection Section/George Yang

Inspection Certificate

TA CHEN STAINLESS PIPE CO., LTD.
NO. 125 HSIN-TIEN 2ND ST.,
JENG-TEH, TAINAN, TAIWAN
TEL:(06)2793254 FAX:(06)2701382
COUNTRY ORIGIN:TAIWAN

EN 10204-3.1

Commodity : STAINLESS STEEL WELDED PIPE
Customer : DACAPO STAINLESS B.V.
Specification : ASTM A312/A312M-2022a /ASTM A999-2018
ASME SA312-2021/ASME BPVC.II.A-2021
Destination : ROTTERDAM
Grade : TP316
Customer O/N :31134407
Certificate No : XF0200035
Delivery Condition: ANNEALED AND PICKLED
Factory O/N :
Date : 2023/6/19
INVOICE No : HO27XF0200

Item No.	Case No. (Crate No.)	Heat No.	Size	Quantity (Pcs)	Weight (Kgs)	Chemical Composition in % C	Si	Mn	P	S	Ni	Cr	Mo	N
06	004	1027136	1" SCH40S		0.080	-	-	-	-	-	10.00	16.00	2.000	-
					0.009	0.420	1.000	2.000	0.045	0.030	14.00	18.00	3.000	-
07	001	1028471	1-1/4" SCH40S		0.016	0.440	0.890	1.110	0.032	0.0033	10.07	16.650	2.070	0.018
08	001	28037601	1/2" SCH40S		0.014	0.350	1.320	0.029	0.029	0.0018	10.08	16.880	2.050	0.021
											10.05	16.110	2.050	-
Total														

Item No.	Tensile Test (Gage Lth=50mm) 0.2% Yield Strength PSI	1.0% Yield Strength PSI	Tensile Strength PSI	Elongation %	Hardness Test HRB	Bend Test	Flattening Test	HT TEMP °F And Quenching In Water	Dimension And Surface Condition	Hydrostatic Test PSI
	30000		75000	T25/L35				1900		2500
	-		-					-		-
06	40300	-	82700	57	82.00	OK	OK	1904	OK	2500
07	41500	-	87100	48.5	78.00	OK	OK	1904	OK	2500
08	34084	-	78610	70	72.00	OK	OK	1904	OK	2500

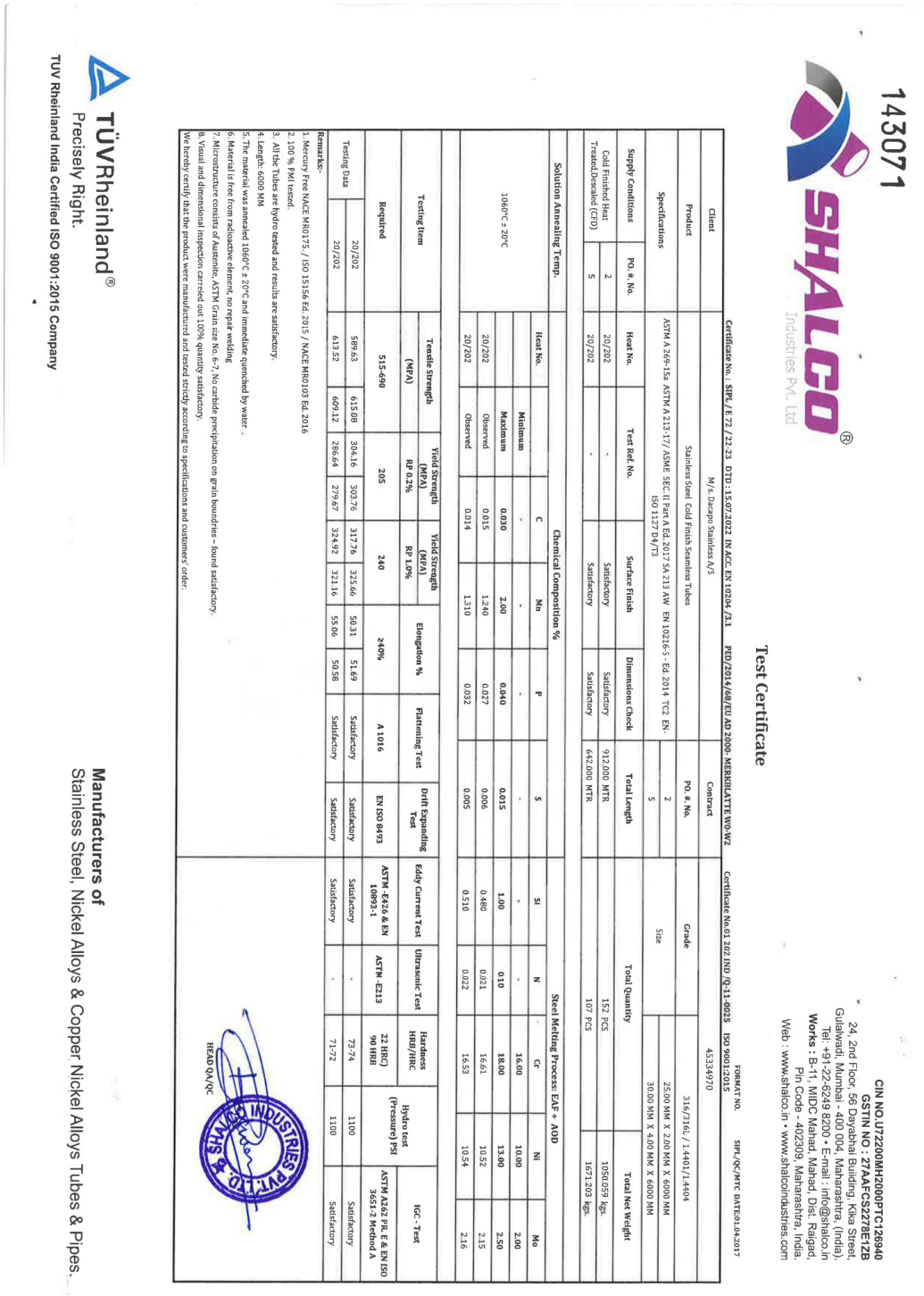
Remarks
1. EDDY CURRENT TEST : O.K.
2. HARDNESS : HRA≤ MRO175-15
3. P. M. I. TESTED : O.K.
4. FLARE TEST ACC. TO ASTM A262
5. RAW MATERIAL FOR PIPE FITTINGS
6. PED 2014/68/EU

TA CHEN STAINLESS PIPE CO. LTD. Q/C Dept. 125 HSIN-TIEN 2ND STREET, TAINAN, TAIWAN, R.O.C.

We hereby certify the above statement to be true and correct every detail
TA CHEN has established a QMS according to ISO 9001, which is certified by LRQA (ISO 9001-0067066)

George Yang
Manager of Inspection Section/George Yang

1.2 25.0x2.0 Stainless Steel Seamless Pipes



143071

SHALCO® Industries Pvt. Ltd

CIN NO.U72200MH2000PTC126940
GSTIN NO : 27AAFCS2278E1ZB
24, 2nd Floor, 56 Dayabhai Building, Kika Street, Gulalwadi, Mumbai - 400 004, Maharashtra, (India).
Tel: +91-22-6249 8200 • E-mail : info@shalco.in
Works : B-11, MIDC Mahad, Mahad, Dist. Raigad, Pin Code - 402309, Maharashtra, India.
Web : www.shalco.in • www.shalcoindustries.com

FORMAT NO. SHPL/QC/MTC DATE:01.04.2017

Test Certificate

Certificate No.: SHPL/E 72 /22-23 DTD :15.07.2022 IN ACC.EN 10204 /3.1 PED/2014/68/EU AD 2000- MERKBLATTE W0-W2 Certificate No.01 202 IND /Q-11-0025 ISO 9001:2015 45334970

Client	M/s. Daraqo Stainless A/S	Contract			
Product	Stainless Steel Cold Finish Seamless Tubes	PO. #. No.	Grade	316/316L / 1.4401/1.4404	
Specifications	ASTM A 269-15a ASTM A 213-17/ ASME SEC. II Part A Ed. 2017 SA 213 AW EN 10216-5 : Ed. 2014 TC2 EN-ISO 1127 D4/T3	2 5	Size	25.00 MM X 2.00 MM X 6000 MM 30.00 MM X 4.00 MM X 6000 MM	

Supply Conditions	PO. #. No.	Heat No.	Test Rel. No.	Surface Finish	Dimensions Check	Total Length	Total Quantity	Total Net Weight
Cold Finished Heat Treated,Descaled (CFD)	2	20/202	-	Satisfactory	Satisfactory	912.000 MTR	152 PCS	1050.059 kgs.
	5	20/202	-	Satisfactory	Satisfactory	642.000 MTR	107 PCS	1671.203 kgs.

Solution Annealing Temp.: 1060°C ± 20°C

Chemical Composition %

Steel Melting Process: EAF + AOD

Heat No.		C	Mn	P	S	Si	N	Cr	Ni	Mo
20/202	Minimum	-	-	-	-	-	-	16.00	10.00	2.00
	Maximum	0.030	2.00	0.040	0.015	1.00	0.10	18.00	13.00	2.50
	Observed	0.015	1.240	0.027	0.006	0.480	0.021	16.61	10.52	2.15
20/202	Observed	0.014	1.310	0.032	0.005	0.510	0.022	16.53	10.54	2.16

Testing Item		Tensile Strength (MPA)	Yield Strength (MPA) RP 0.2%	Yield Strength (MPA) RP 1.0%	Elongation %	Flattening Test	Drift Expanding Test	Eddy Current Test	Ultrasonic Test	Hardness HRB/HRC	Hydro test (Pressure) PSI	IGC - Test
Required		515-690	205	240	≥40%	A 1016	EN ISO 8493	ASTM -E426 & EN 10893-1	ASTM -E213	22 HRC/ 90 HRB		ASTM A262 PR. E & EN ISO 3651-2 Method A
Testing Data	20/202	589.63	615.08	304.16	303.76	317.76	325.66	50.31	51.69	Satisfactory	Satisfactory	-	73.74	1100	Satisfactory
	20/202	613.52	609.12	286.64	279.67	324.92	321.16	55.06	50.58	Satisfactory	Satisfactory	Satisfactory	-	71.72	1100	Satisfactory

Remarks:-
1. Mercury Free NACE MR0175 / ISO 15156 Ed. 2015 / NACE MR0103 Ed. 2016
2. 100 % PMI tested.
3. All the Tubes are hydro tested and results are satisfactory.
4. Length: 6000 MM
5. The material was annealed 1060°C ± 20°C and immediate quenched by water .
6. Material is free from radioactive element, no repair welding
7. Microstructure consists of Austenite, ASTM Grain size No. 6-7, No carbide precipitation on grain boundries - found satisfactory.
8. Visual and dimensional inspection carreied out 100% quantity satisfactory.

We hereby certify that the product were manufactured and tested strictly according to specifications and customers' order.

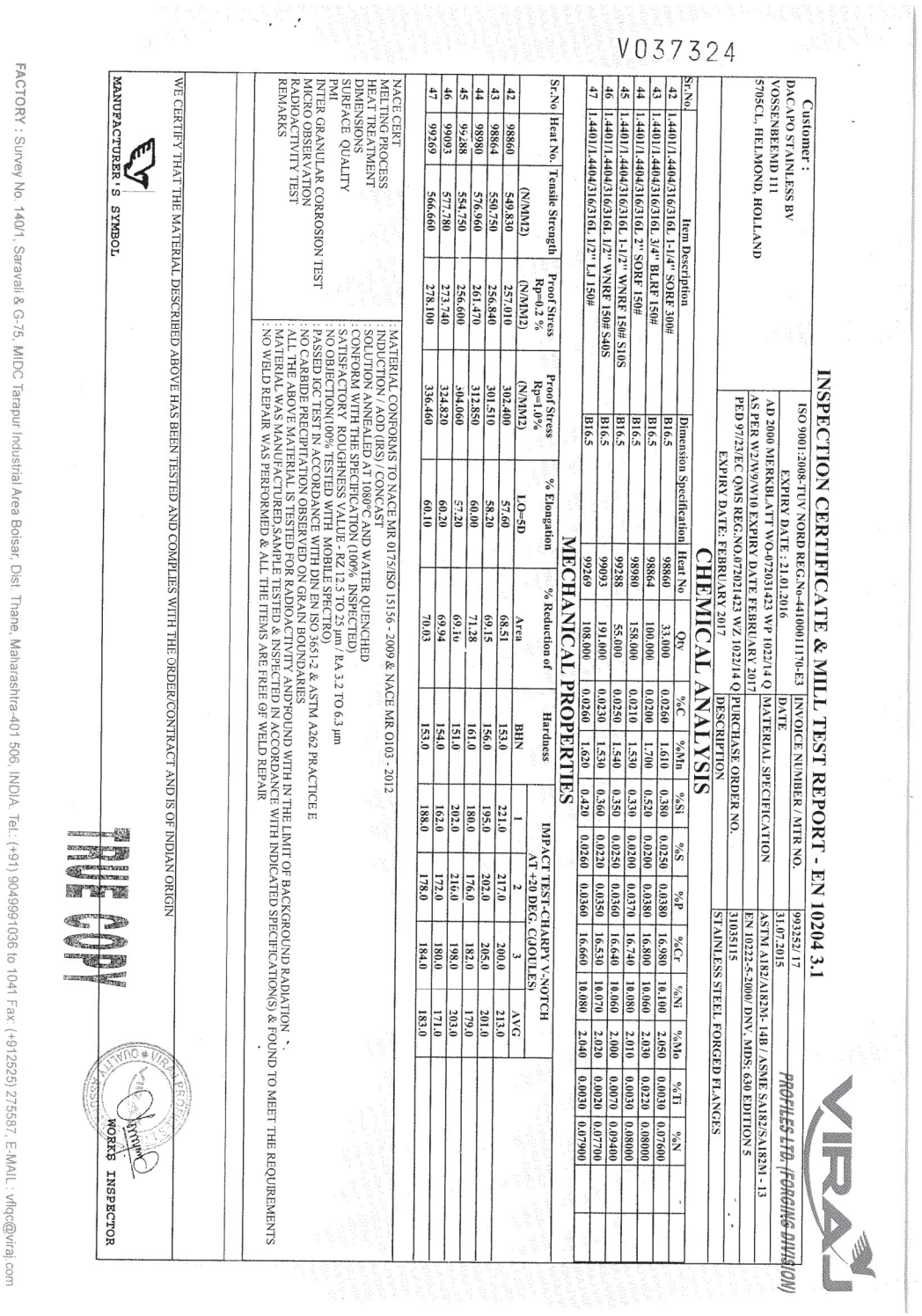
HEAD QA/QC

SHALCO INDUSTRIES PVT. LTD.

TÜVRheinland®
Precisely Right.
TUV Rheinland India Certified ISO 9001:2015 Company

Manufacturers of
Stainless Steel, Nickel Alloys & Copper Nickel Alloys Tubes & Pipes.

1.3 42.4 ASME B16.5 Stainless Steel Forged Flanges



VIRAJ

PROFILES LTD. (FORGING DIVISION)

INSPECTION CERTIFICATE & MILL TEST REPORT - EN 10204 3.1

Customer :
DACAPO STAINLESS BV
VOSSENBEEMD 111
5705CL, HELMOND, HOLLAND

ISO 9001:2008-TUV NORD REG.No-44100011170-E3
EXPIRY DATE : 21.01.2016
AD 2000 MERKBLATT WO-0720314423 WP 1022/14 Q
AS PER W2/W9/W10 EXPIRY DATE FEBRUARY 2017
FED 97/23/EC QMS REG.NO.07202142 WZ 1022/14 Q
EXPIRY DATE: FEBRUARY 2017

INVOICE NUMBER / MTR NO. 993252/ 17
DATE 31.07.2015
MATERIAL SPECIFICATION ASTM A182/A182M- 14B / ASME SA182/SA182M - 13
EN 10222-5-2000/ DNV, MDS: 630 EDITION 5
PURCHASE ORDER NO. 31035115
DESCRIPTION STAINLESS STEEL FORGED FLANGES

V037324

CHEMICAL ANALYSIS

Sr.No	Item Description	Dimension Specification	Heat No.	Qty	%C	%Mn	%Si	%S	%P	%Cr	%Ni	%Mo	%Ti	%N
42	1.4401/1.4404/316/316L 1-1/4" SORF 300#	B16.5	98860	33.000	0.0260	1.610	0.380	0.0250	0.0380	16.980	10.100	2.050	0.0030	0.07600
43	1.4401/1.4404/316/316L 3/4" BLRF 150#	B16.5	98864	100.000	0.0200	1.700	0.520	0.0200	0.0380	16.800	10.060	2.030	0.0220	0.08000
44	1.4401/1.4404/316/316L 2" SORF 150#	B16.5	98980	158.000	0.0210	1.530	0.330	0.0200	0.0370	16.740	10.080	2.010	0.0030	0.08000
45	1.4401/1.4404/316/316L 1-1/2" WNRF 150# S10S	B16.5	99288	55.000	0.0250	1.540	0.350	0.0250	0.0360	16.640	10.060	2.000	0.0070	0.09400
46	1.4401/1.4404/316/316L 1/2" WNRF 150# S40S	B16.5	99093	191.000	0.0230	1.530	0.360	0.0220	0.0350	16.530	10.070	2.020	0.0020	0.07700
47	1.4401/1.4404/316/316L 1/2" LJ 150#	B16.5	99269	108.000	0.0260	1.620	0.420	0.0260	0.0360	16.660	10.080	2.040	0.0030	0.07900

MECHANICAL PROPERTIES

Sr.No	Heat No.	Tensile Strength	Proof Stress Rp=0.2 %	Proof Stress Rp=1.0%	% Elongation	% Reduction of	Hardness	IMPACT TEST-CHARPY V-NOTCH AT +20 DEG. C(JOULES)			
		(N/MM2)	(N/MM2)	(N/MM2)	LO=5D	Area	BHN	1	2	3	AVG
42	98860	549.830	257.010	302.400	57.60	68.51	153.0	221.0	217.0	200.0	213.0
43	98864	550.750	256.840	301.510	58.20	69.15	156.0	195.0	202.0	205.0	201.0
44	98980	576.960	261.470	312.850	60.00	71.28	161.0	180.0	176.0	182.0	179.0
45	99288	554.750	256.600	304.060	57.20	69.16	151.0	202.0	216.0	198.0	203.0
46	99093	577.780	273.740	324.820	60.20	69.94	154.0	162.0	172.0	180.0	171.0
47	99269	566.660	278.100	336.460	60.10	70.03	153.0	188.0	178.0	184.0	183.0

NACE CERT : MATERIAL CONFORMS TO NACE MR 0175/ISO 15156 - 2009 & NACE MR 0103 - 2012
MELTING PROCESS : INDUCTION / AOD (IRS) / CONCAST
HEAT TREATMENT : SOLUTION ANNEALED AT 1080°C AND WATER QUENCHED
DIMENSIONS : CONFORM WITH THE SPECIFICATION (100% INSPECTED)
SURFACE QUALITY : SATISFACTORY ROUGHNESS VALUE - RZ 12.5 TO 25 µm / RA 3.2 TO 6.3 µm
PMI : NO OBJECTION(100% TESTED WITH MOBILE SPECTRO)
INTER GRANULAR CORROSION TEST : PASSED IGC TEST IN ACCORDANCE WITH DIN EN ISO 3651-2 & ASTM A262 PRACTICE E
MICRO OBSERVATION : NO CARBIDE PRECIPITATION OBSERVED ON GRAIN BOUNDARIES
RADIOACTIVITY TEST : ALL THE ABOVE MATERIAL IS TESTED FOR RADIOACTIVITY AND FOUND WITH IN THE LIMIT OF BACKGROUND RADIATION
REMARKS : MATERIAL WAS MANUFACTURED,SAMPLE TESTED & INSPECTED IN ACCORDANCE WITH INDICATED SPECIFICATION(S) & FOUND TO MEET THE REQUIREMENTS
: NO WELD REPAIR WAS PERFORMED & ALL THE ITEMS ARE FREE OF WELD REPAIR

WE CERTIFY THAT THE MATERIAL DESCRIBED ABOVE HAS BEEN TESTED AND COMPLIES WITH THE ORDER/CONTRACT AND IS OF INDIAN ORIGIN

MANUFACTURER'S SYMBOL

TRUE COPY

WORKS INSPECTOR

FACTORY : Survey No. 140/1, Saravali & G-75, MIDC Tarapur Industrial Area Boisar, Dist. Thane, Maharashtra-401 506. INDIA. Tel.: (+91) 9049991036 to 1041 Fax :(+912525) 275587, E-MAIL : vftqc@viraj.com

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1.4 G½ Coupling Stainless Steel

V153121

TA CHEN STAINLESS PIPE CO., LTD.

INSPECTION CERTIFICATE

ISO 9001-2015

Certificate No. 0067066

Commodity : STAINLESS STEEL PIPE NIPPLE

Customer : DACAPO STAINLESS B.V.

EN 10204/3.1

NO.125 HSIN-TIEN 2ND STREET,
HSIN-TIEN JENG-TEH ,TAINAN
TAIWAN, R.O.C.
TEL:+886 6 2701756
FAX:+886 6 2701382 , 2798057

Specification: ASTM A312/A312M 2022a
Grade ____: TP316L

Destination : ROTTERDAM
Customer's O/N : 31134407
Factory O/N : HO27X3741
Invoice No : HO27XF0200

Certificate No : MTR112060059002
Date : 2023/06/19

No.	Size	Article	End Type	Part No.	Qty (pcs)	Heat No.	CHEMICAL ANALYSIS(%) C	Si	Mn	P	S	Ni	Cr	Mo	TENSION TEST Yield Strength MPA	Tensile Strength MPA	Elongation %
							max 0.035	max 1.000	max 2.000	max 0.045	max 0.030	10.00 14.00	16.00 18.00	2.00 3.00	min 170	min 485	min 35
10	1/4"	FULL COUPLING	ISO228-1G	TB03211855	2000	28037601	0.014	0.350	1.320	0.029	0.002	10.05	16.11	2.05	235	542	70
11	1/2"	FULL COUPLING	ISO228-1G	TB03212580	2000	1027133	0.009	0.360	0.940	0.032	0.003	10.06	16.71	2.06	278	594	54
12	1"	FULL COUPLING	ISO228-1G	TB03213590	2100	1028471	0.016	0.440	1.110	0.029	0.004	10.08	16.88	2.05	284	601	50
13	1-1/2"	FULL COUPLING	ISO228-1G	TB03214505	276	1025545	0.020	0.460	0.990	0.025	0.001	10.11	16.75	2.04	265	580	55
14	2"	FULL COUPLING	ISO228-1G	TB03215135	112	1014299	0.020	0.480	0.917	0.031	0.001	10.23	16.80	2.06	286	611	50
15	1/2"	HALF COUPLING	ISO228-1G	TB04212580	2400	1027133	0.009	0.360	0.940	0.032	0.003	10.06	16.71	2.06	278	594	54
16	3/4"	HALF COUPLING	ISO228-1G	TB04213045	64	1017422	0.022	0.440	0.940	0.036	0.006	10.17	16.77	2.10	259	596	54
17	3/4"	HALF COUPLING	ISO228-1G	TB04213045	486	1027136	0.009	0.420	0.890	0.032	0.003	10.07	16.65	2.07	271	598	50.5

REMARK:FULL COUPLINGS(SOCKETS) AND HALF COUPLINGS ARE MADE FROM PIPE.
REMARK:ASTM A262 PRACTICE E:O.K.

TA CHEN STAINLESS PIPE CO., LTD. Q/C Dept. NO.125, HSIN-TIEN 2ND STREET, HSIN-TIEN JENG-TEH, TAINAN, TAIWAN, R.O.C.

Supervisor:

page:2 / 2

1.5 42.4x2.0 Stainless Steel End Caps

V159283

BERCELLESI BERINOX STAINLESS STEEL FITTINGS

Quality Management System certified by LRQA

The QMS supports the requirements of Annex I Sec. 4.3 of PED 2014/68/EU

CERTIFICATO DI COLLAUDO EN 10204 3.1
Inspection certificate
Certificat d'inspection

Num: 22514 / 23 **Data:** 12/12/2023

Cliente Customer Client: DACAPO STAINLESS BV
VOSSENBEEMD 111

5705CL HELMOND -

Specifica prodotto/Product specification/Spécification du produit: EN 10253/4 type A

Pos Item Poste	Qta Qty Qté	Articolo Item Article	Descrizione e dimensione Description and size Désignation et dimension	Grado acciaio Grade Nuance	Colata Heat Coulée
10	250,00		END CAPS 316L 42.4x2	1.4404/316L	0468184
20	100,00		END CAPS 304L 60.3x3	1.4301/304/1.4307/304L	Y210918D41-6
30	100,00		END CAPS 304L 76.1x3	1.4301/304/1.4307/304L	53586
40	50,00		END CAPS 304L 101.6x3	1.4301/304/1.4307/304L	150057
50	30,00		END CAPS 316L 101.6x3	1.4404/316L	22000841
60	500,00		END CAPS 316L 60.3x2	1.4404/316L	0547275

Pos Item Poste	Costruttore materia prima Manufacturer raw material Fabricant matériel de base	Certificato Certificate Certificat	Specifica materia prima Requirement material Spécification matériel de base
10	MARCEGAGLI SPECIALTIES	723284184	EN10028-7 EN10088-2 EN10088-4 ASTM A240 A480
20	PT. INDONESIA GUANG CHING	2021110604	EN10088-2 EN10028-7 EN10088-4 ASTM A240 A480
30	MARCEGAGLI SPECIALTIES	723394949	EN10028-7 EN10088-2 EN10088-4 ASTM A240 A480
40	APERAM GENK BELGIUM	22K0005913	EN10088-2 EN10028-7 ASTM A240 SA240 ADW2 W10
50	LIEN KUO METAL IND. CO.	1091029013	EN10088-2 EN10028-7 ASTM A240 A480
60	MARCEGAGLI SPECIALTIES	723387929	EN10028-7 10088-2 10088-4 ASTM A240 A480 ADW0 W2

Analisi chimica/Chemical composition/Analyse chimique — **Caratteristiche meccaniche/Mechanical properties/Caractéristiques mécaniques**

Colata Heat Coulée	C %	Mn %	Si %	P %	S %	Cr %	Ni %	Mo %	Ti %	Cu%	N%	Snerv. Rp 0,2/1,0 Yield Strength Limite élastique	Rottura Rm Tensile strength Rupture	Allung. A50mm Elongation Allongement	Durezza Hardness Dureté
0468184	0,016	1,100	0,350	0,032	0,00100	16,820	10,080	2,030			0,048	286 / 323 N/mm²	605 N/mm²	53,10	81 HRB
Y210918D41-6	0,022	1,410	0,380	0,029	0,00200	18,130	8,010				0,068	284 /	648 MPa	59,10	86 HRB
53586	0,024	1,300	0,390	0,031	0,00200	18,200	8,000				0,068	320 / 373 N/mm²	640 N/mm²	46,30	84 HRB
150057	0,024	1,510	0,470	0,034	0,00400	18,080	8,010				0,073	298 / 339 MPa	634 MPa	52,00	86 HRB
22000841	0,024	1,210	0,240	0,040	0,00500	16,230	10,050	2,030			0,042	323 /	591 N/mm²	52,00	79 HRB
0547275	0,024	1,090	0,380	0,029	0,00100	16,690	10,030	2,060			0,049	265 / 304 N/mm²	585 N/mm²	56,70	79 HRB

L'analisi chimica e le caratteristiche meccaniche sono conformi al certificato originale rilasciato dal fabbricante di materia prima.
The chemical analysis and mechanical properties fully comply with the certificate issued by the manufacturer of the base material.
L'analyse chimique et les caractéristiques mécaniques sont conformes au certificat émis par le producteur de la matière première.

Doc. di trasporto n. Delivery note n. Bon de livraison n. 62 / d40 **Data** Date Date 07/12/2023 **Ordine n.** Order n. Commande n. 380000477

Si attesta che i prodotti spediti sono conformi ai requisiti dell'ordine.
We certify that delivered products comply with the customer's requirement.
Nous certifions que les produits livrés sont conformes aux spécifications de la commande.

Note / Remarks / Remarques

Test superati con esito positivo:
Test passed successfully / Test passé avec succès

Dimensional	X
Visual	X
Antimixing Test	X
Intergranular Corrosion Test EN ISO 3651-2	X

Test aggiuntivi richiesti nell'ordine:
Additional tests required in order
Tests supplémentaires requis dans la commande

I certificati sono conservati nel nostro archivio.
The certificates are kept in our archives.
Les certificats sont conservés dans nos archives.

Il materiale è conforme alle specifiche di prodotto dichiarate.
The material correspond to the product's specification declared.
Le matériel est conforme aux spécifications du produit declaré.

Per dimensioni diverse alle specifiche è garantita la conformità al ns catalogo.
Size different from the specifications are guaranteed to be in compliance with our catalogue.
Les dimensions différentes de la spécification sont conformes à notre catalogue.

MARCHIO DI FABBRICA:
Trade mark
Marque du producteur

APPROVATO
Approved
Approuvé
P. BERCELLESI

PB

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Sub Section L03

Welder Performance Qualification Certificates

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	19/07/2024	First Issue

Document Title:	**BLPH Project - Welder Performance Qualification Certificates**
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Full Title	Welder Performance Qualification Certificates

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	July 19, 2024

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Table 1. List of Welder Performance Qualification Certificates 4

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1.0 General

This document contains a detailed list of the Welder Performance Qualification Certificates stating the welder's name, identification and positions to be recorded to code requirements with approval by third party inspection authority when applicable, using approved and referenced weld procedures.

2.0 List of Welder Performance Qualification Certificates

Table 1. List of Welder Performance Qualification Certificates.

Name	Welding Passport Nr.	Designation acc. to ISO 9606-1	Procedure	Examining Body	Valid Until
Frederik Faber Jensen	32584	141 P/T FW 5.1 FM3 S t2 D21.3 PH sl	SP141-075	Nordisk Svejse Kontrol A/S	09/06/2025
		141 T BW 8.1 FM5 S s2 D21.3 H-L045 ss gb	SP141-199		09/06/2025
Morten Pedersen	25350	141 P/T FW 8.1 FM5 S t2 D50 PH sl	SP141-123		17/03/2025
		141 T BW 8.1 FM5 S s1.5 D76 H-L045 ss gb	SP141-189		28/10/2024

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Annex – Welder Performance Qualification Certificates

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1: 141 P/T FW 5.1 FM3 S t2 D21.3 PH sl
Designation in accordance with DS/EN ISO 9606-1:

Udført på DS 322-certificeret svejseskole. Navn og adresse: Mercantec
Performed at DS 322 certified welding school. Name and address: H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242580 Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør
Sømtype Type of joint	FW		FW:Kantsøm
Materialegruppe(r) Material group(s)	5.1		All materials acc. EN ISO 15608, Table 1
Tilsatsmateriale Welding consumables	FM3		FM1, FM2, FM3
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 21952-A W CrMo1 Si	S, M
Tabel/table 5	S		
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)			
Strømtype og polaritet Type of current and polarity	DC-		
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW			
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6
Svejseposition Welding position BW tabel/table 9			all FW positions, except vertical dowr
FW tabel/table 10	PH		
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)

Svejseprocedurespecifikations-nr.: SP141-075
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning. Svejseskolens eksaminator (dato/navn/underskrift): 13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing. Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

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Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242580

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

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Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

DS

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s2 D21.3 H-L045 ss gb

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242582 Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145
Plade eller rør Plate or pipe	T		T:Rør
Sømtype Type of joint	BW		BW:Stumpsøm
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1
Tilsatsmateriale Welding consumables	FM5		FM5
Type og betegnelse Type and designation Tabel/table 4 Tabel/table 5	 S	DS EN ISO 14343-A W 19 9 L Si	S, M
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar
Strømtype og polaritet Type of current and polarity	DC-		
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	2		2-4
Materialetykkelse i mm for FW Material thickness in mm for FW			
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6
Svejseposition Welding position BW tabel/table 9 FW tabel/table 10	H-L045		all BW positions, except vertical down
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)

Svejseprocedurespecifikations-nr.:
Welding procedure specification No.: SP141-199

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

PED-APPROVED
NSK NB 2735

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift): 13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

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Bedømmelse af svejsesømme/Evaluation of welds

DS

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242582

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

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Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

DS

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 P/T FW 8.1 FM5 S t2 D50 PH sl

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: DS license No.: 516

Svejsepas-nr.: Welding passport No.: 25350

Svejserens navn: Welder's name: Morten Pedersen

Fødselsdato: Birth date: 21-4-1988

Adresse: Address: Bækkevej 6, 9500 Hobro

Prøvningsinstans: Examining body: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod

Reference-nr./Reference No. 241393 Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør	
Sømtype Type of joint	FW		FW:Kantsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4 Tabel/table 5	 S	DS EN ISO 14343-A W 19 9 L Si	S, M	
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)				
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW				
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4	
Rørdiameter i mm Pipe diameter in mm	50		>=25	
Svejseposition Welding position BW tabel/table 9 FW tabel/table 10	 PH		all FW positions, except vertical dowr	
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)	

Svejseprocedurespecifikations-nr.:
Welding procedure specification No.: SP141-123

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

Svejsning af prøveemne udført/Welding of test piece terminated: 17-03-2022

PED-APPROVED
NSK NB 2735

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift): 18-03-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 17-03-2022 Brian Gravgaard

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Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 241393

Prøveemne undersøgt (dato):
Test piece examined (date): 18-03-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 18-03-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 17-03-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 17-03-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 21-03-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
14/9-22	CEO	
16/3-23	CEO	
11/9-23	CEO	

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Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017
Welders Certificate in accordance with DS/EN ISO 9606-1:2017

DS

Betegnelse i henhold til DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s1.5 D76 H-L045 ss gb
Designation in accordance with DS/EN ISO 9606-1:

Udført på DS 322-certificeret svejseskole. Navn og adresse: Mercantec
Performed at DS 322 certified welding school. Name and address: H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 25350
Welding passport No.:

Svejserens navn: Morten Pedersen
Welder's name:

Fødselsdato: 21-4-1988
Birth date:

Adresse: Bækkevej 6
Address: 9500 Hobro

Prøvningsinstans: Nordisk Svejse Kontrol A/S
Examining body: Stejlundvænget 4 6870 Ølgod

Reference-nr./Reference No. 238073 Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	T		P:Plade T:Rør	
Sømtype Type of joint	BW		BW:Stumpsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4 Tabel/table 5	 S	DS EN ISO 14343-A W 19 9 L Si	S, M	
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar	
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	1.5		1.5-3,0	
Materialetykkelse i mm for FW Material thickness in mm for FW				
Rørdiameter i mm Pipe diameter in mm	76		>=38	
Svejseposition Welding position BW tabel/table 9 FW tabel/table 10	H-L045		all BW positions, except vertical down	
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)	

Svejseprocedurespecifikations-nr.: SP141-189
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

Svejsning af prøveemne udført/Welding of test piece terminated: 28-10-2021

PED-APPROVED
NSK NB 2735

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift): 29-10-2021 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 28-10-2021 Brian Gravgaard

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Bedømmelse af svejsesømme/Evaluation of welds

DS

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 238073

Prøveemne undersøgt (dato):
Test piece examined (date): 29-10-2021

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 29-10-2021 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 28-10-2021

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 28-10-2024

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 01-11-2021 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
27/4-22	CEO	
24/10-22	CEO	
28/4-23	CEO	
23/10-23	CEO	

DS 322:2014 Bilag 1 © Fonden Dansk Standard • Göteborg Plads 1 • DK-2150 Nordhavn • Tel.: +45 39 96 61 01 • www.ds.dk

Sub Section L07

NDE Records (incl. Operator Qual. Certificates and Production Test Results)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	19/07/2024	First Issue

Document Title:	**BLPH Project - NDE Records (incl. NDE Operator Qualification Certificates)**
Document Number:	K559-2254-CWIWP4202202-L07-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-L07-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	L07
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

MoseTechnology
NDT & Welding

DANAK
TEST Reg.nr. 579

NDT Report

Final Report, 23.172.334.NDT.001 Rev.0

Client Ref. No:
122798-614698

Customer:
L-tek A/S
Auningvej 91C
8961 Allingåbro

Location:
Auningvej 91C

Scope.
MoseTechnology ApS has on behalf of our customer, performed NDT Inspection on:

1 pcs 40 FT flatbed – drawing/part no: 4007950

Extent.
Inspection was performed as stated in below list for all welds and according to Technical background also mentioned below.
This report cover both:
Visual inspection (VT)
Magnetic Inspection (MT)

MoseTechnology
NDT & Welding

DANAK
TEST Reg.nr. 579

NDT Report
Technical bagground for VT inspection.

Period of examination/Date 30.11.2023	Appr. by NDT Operator Jan Saugstrup Andersen			
Technician (Init.) JSA	Certificate No. 1823-N2-VT	Assistant (Init.)	Technician (Init.)	Material: FE

Supplementary information (without liability, see at the foot)

Weld preparation ☐ X ☐ Y ☐ U ☐ V ☐ K ☒ I ☒ Fillet	Other ☐ But welds	Heat-treated ☐ Yes ☒ No	Time of examination Hours after weld. > N/A
Welding process ☐ Man.elec. 111 ☐ 121 ☐ 131 MIG ☐ 135 MAG ☒ 136 Fluxcored wire ☐ 141 TIG		Other ☐	
Technipue ☒ **DS/EN ISO 17637:2016**		Other ☐	

Aids
☒ Ruler ☐ Tape measure ☒ Caliper ☐ Feeler gauge ☒ Weld gauge ☐ Contour gauge ☒ Material for replica

Quality requirements (Standard) for finished welds ☒ **DS/EN 5817:2014, Level C**	Other standards ☐ DNV-ST-0378-2019

Time of examination
☐ Before welding ☐ During welding ☒ After welding

☐ Temporarily welded parts ☐ Repairs

Extent of examination ☒ 100 % ☐ Random % ☐ as directed	Surface condition ☐ Ground ☒ Smooth ☐ Coarse

Extent of inspection

100 % VT of all Welds.

Results of examination

All welds were found accepted to quality requirements.

Repairs marked ☐ On object ☐ On sketch	☐ Check after grinding ☐ Repair rechecked ☐ Stamped mk:	Enclosures ☐ sheets	Enclosures ☐

Supplementary information: The grey fields supply available, relevant information for guidance only. The giving of such information in this Field Report should not be considered as verification of its accuracy.

MoseTechnology
NDT & Welding

DANAK
TEST Reg.nr. 579

NDT Report
Technical bagground for MT inspection.

Period of examination/Date 30.11.2023	Appr. by NDT Operator Jan Saugstrup Andersen			
Technician (Init.) JSA	Certificate No. 1823-N2-VT	Assistant (Init.)	Certificate No.	Material: FE

Supplementary information (without liability, see at the foot)

Weld preparation ☐ X ☐ Y ☐ U ☐ V ☐ K ☒ I ☒ Fillet	Other ☐ But welds	Heat-treated ☐ Yes ☒ No	Time of examination Hours after>N/A	
Welding process ☐ Man.elec. 111 ☐ Sub.arc. 121 ☐ MIG 131 ☐ MAG 135 ☒ Fluxcored wire 136 ☐ TIG 141		Other ☐		
Surface condition ☐ Fine ☒ Smooth ☐ General ☐ Primer coated		Reinforcement ☒ As welded ☐ Ground		
Examination procedure ☒ **DS/EN ISO 17638:2016**		Other ☐		

☐ Current magnetizing S max.= mm I eff.= Amp. Reg. No.	☒ Yoke Type **AC 220 V** S max.= **150**mm Reg. No. **240/0303**	☐ Coil magnetizing Current Number of turns = ☐ AC ☐ DC I = Amp. Reg. No.	☐ Permanent magnet S = mm Lifting Power = N Reg. No.	☐ Test bench Longit. Amp. Circular Amp. x turns

Type of prods ☐ Steel ☐ Copper	Other ☐	Arc burns ground out ☐ Yes ☐ No	De-magnetized after examination ☐ Yes ☒ No	
☐ Magnetic ink	☐ Water/black ☐ Water/fluo. ☒ Kerosine/black ☐ Kerosine//fluo.	☐ Dry powder	Background ☒ White ☐ Ground ☐ Non-treated	
Field strength Oerstedm. value	kA/m Oe	Other ☒ **Castrol silver 2**	Lighting ☒ White ☐ UV-lamp No.	

Magnetized for ☐ Longitudinal indications	☐ Transverse indications	☒ Indications in any direction	Object temperature ☒ Ambient
Other ☐			

Acceptance criteria ☒ **DS/EN ISO 23278:2015 Level 2x**	Other ☐ DNV-ST-0378-2019

Extent of inspection

5% MT of But welds.

Results of examination

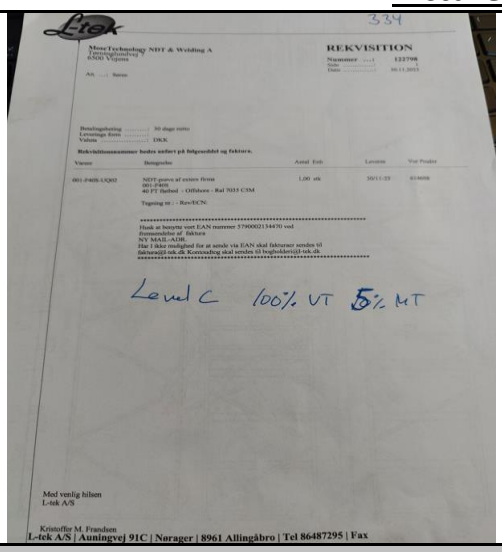
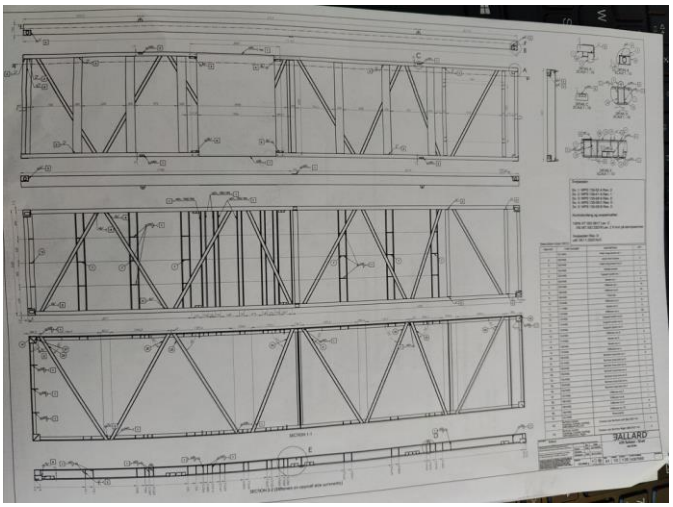
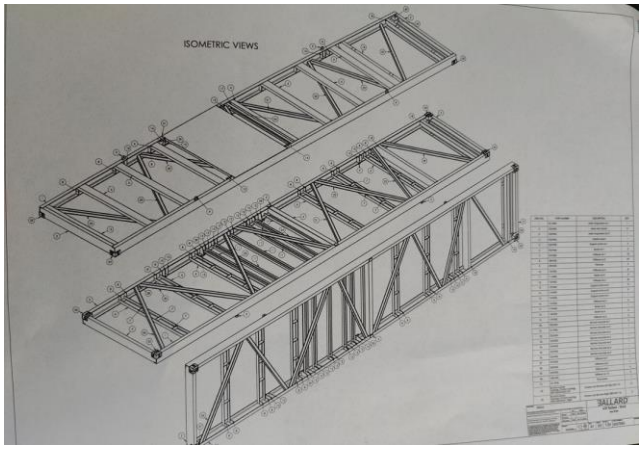
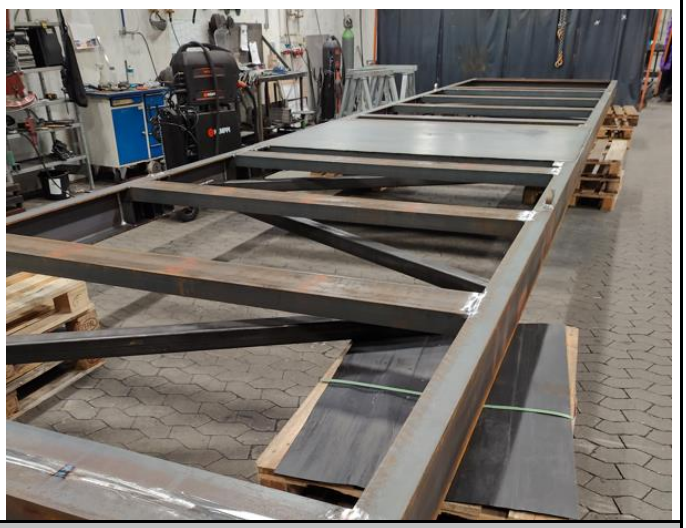
All welds were found acceptable to quality requirements.

Repairs marked ☐ On object ☐ On sketch	☐ Check after grinding ☐ Repair rechecked ☐ Stamped mk:	Enclosures ☐ sheets	Enclosures ☐ sheets

Supplementary information : The grey fields supply available, relevant information for guidance only. The giving of such information in this

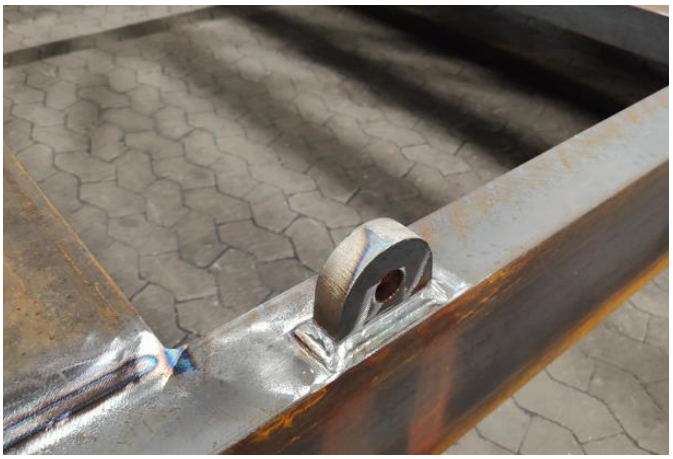
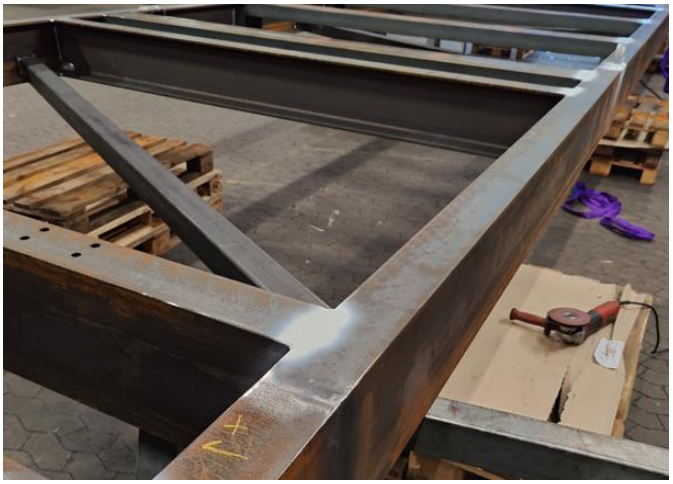
NDT Report

Pictures of inspected Object.

	
Date:	**Date:**
Comment:	Comment:
	
Date:	**Date:**
Comment:	Comment:

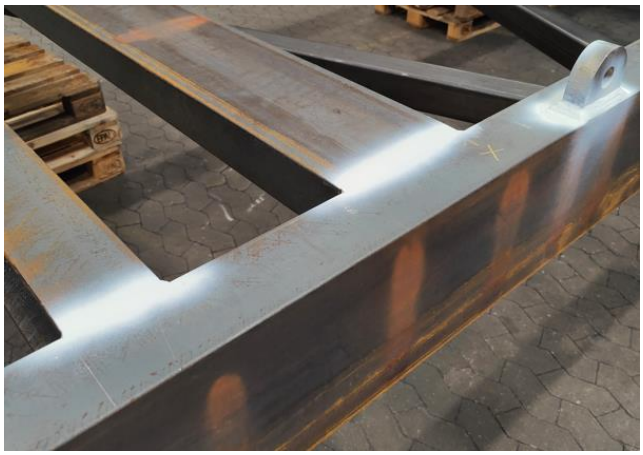
NDT Report

Pictures of inspected Object.

	
Date:	**Date:**
Comment:	Comment:
	
Date:	**Date:**
Comment:	Comment:

NDT Report

Pictures of inspected Object.

	
Date:	**Date:**
Comment:	Comment:
	
Date:	**Date:**
Comment:	Comment:

Signatures:

App. By NDT-Operator **MoseTechnology, ApS Senior NDT engineer.**	App. By Ovner/Reprensative	App. By Certification authority
Jan Saugstrup Andersen 30.11.2023		
Date/signature	Date/signature	Date/signature

Revision table:

Date	Name	Revision	Description / Reason for new revision

Sub Section L09

Name Plate Photos

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	09/09/2024	First Issue
002	11/11/2024	Added additional nameplate as requested.

Document Title:	**BLPH Project - Name Plate photos**
Document Number:	K559-2254-CWIWP4202202-L09-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-L09-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	L09
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BALLARD™	Ballard Power Systems Europe A/S Majsmarken 1, 9500 Hobro - DK Phone: + 45 88435500 E-mail: service@ballardeurope.com	CE

Certification mark:	CE		
Designation of the machinery:	Stationary fuel cell power system		
Product name:	FC PowerGen 1000kW®		
Part number:	601456B-7002362		
Serial number:	601456B		
Combined Sub-assemblies:	Cooling unit, Part number: 601456B-7002973		
	10ft Converter Container, Part number: 601456B-7003716		
Year of construction:	2024		
Range of ambient temperature (°C):	MAX: 25°C	MIN: -10°C	
Fuel:	Type: Hydrogen, Gaseous Fuel Quality: SAE J2719 or ISO 14687, Grade D		
Fuel pressure range:	MIN: 4 barg	MAX: 6,5 barg	
Weight (kg.):		DRY:	WET:
	Fuel cell container, 40ft:	21.320 kg	21.680 kg
	Cooling Unit:	9.060 kg	10.060 kg
	Power Converter container, 10ft:	7.310 kg	7.350 kg
Aux Power Input:	MAX load: 3P+N+PE 400V 50Hz, 40A. Power consumption typ. 10kW		
Rated Power Output:	1000 kW @ 100% duty, within the stated fuel pressure range.		
Electrical Output:	3P 6600V 50Hz, 93 A		
Short circuit capacity (A):	93 A		
Power Factor:	0.95		

Plate size:

Height: 22 cm

Width: 18 cm

Hole size Ø4,3 mm

Corner radius: 0,63mm

Plate material: AISI 316/EN 1.4401 or AISI 316L/EN1.4404

BALLARD™	Ballard Power Systems Europe A/S Majsmarken 1, 9500 Hobro - DK Phone: + 45 88435500 E-mail: service@ballardeurope.com	
Product name:	Cooling unit	
Part number:	601456B-7002973	
Sub-assembly in:	FC PowerGen 1000kW, part number 601456B-7002362	
Range of ambient temperature (°C):	MAX: 25 °C	MIN: -10 °C
Cooling agent:	Ethylene glycol mixture/water 50/50 mix	
Weight (kg):	DRY:	WET:
	9.060 kg.	10.060 kg.
Input Power:	3p+N+PE, 400V, 160A	
Control system voltage (V):	24 V DC	

Plate size:

Height: 13 cm

Width: 18 cm

Hole size Ø4,3 mm

Corner radius: 0,63mm

Plate material: AISI 316/EN 1.4401 or AISI 316L/EN1.4404

BALLARD™	Ballard Power Systems Europe A/S Majsmarken 1, 9500 Hobro - DK Phone: + 45 88435500 E-mail: service@ballardeurope.com	
Product name:	Power converter container	
Part number:	601456B-7003716	
Sub-assembly in:	FC PowerGen 1000kW, part number 601456B-7002362	
Range of ambient temperature (°C):	MAX: 25 °C	MIN: -10 °C
Weight (kg):	DRY:	WET:
	7.310 kg	7.350 kg
Rated Power (kW):	1000 kW @ 100% duty	
Electrical Output:	3P 6600V 50Hz, 93 A	
Short circuit capacity (A):	93 A	
Power Factor:	0.95	

Plate size:

Height: 13 cm

Width: 18 cm

Hole size Ø4,3 mm

Corner radius: 0,63mm

Plate material: AISI 316/EN 1.4401 or AISI 316L/EN1.4404

BALLARD™	Ballard Power Systems Europe A/S Majsmarken 1, 9500 Hobro - DK Phone: + 45 88435500 E-mail: service@ballardeurope.com
PLANT:	BLPH
PROJECT NO.:	2254
PURCHASE ORDER NO.:	CWIWP4202202
VENDORS ORDER NO.:	601456B
EQUIPMENT NO.:	A-80000
DATE OF MANUFACTURE:	2024

Plate size:

Height: 13 cm

Width: 18 cm

Hole size Ø4,3 mm

Corner radius: 0,63mm

Plate material: AISI 316/EN 1.4401 or AISI 316L/EN1.4404

Sub Section L17

Proof Load Certification

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	19/07/2024	First Issue

Document Title:	**BLPH Project - Proof Load Certification**
Document Number:	K559-2254-CWIWP4202202-L17-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-L17-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	L17
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Kontrolrapport for Serviceeftersyn

Denne rapport er udarbejdet I henhold til gældende anvisninger fra AT samt maskindirektivet

Kunde	Placering
DC Supply.dk Virkelyst 6 Nørresundby 9400	DC Supply.dk Virkelyst 6 Nørresundby 9400

Dato for inspektion	Dato for forrige inspektion	Rapport nummer
20/12/2023	**Ukendt**	**DK04542-Tjekafkran/0001**

Light weight crane systems | Letskinnesystem

ID/serie nummer:	**F49667**	**Udført af:**	Thomas Buje
Reference Nr.:		Fabrikant:	CERTEX / NIKO
Emne placering:	NIKOSYSTEM I CONTAINER	Type:	NIKO MONOBANE
Status:	**Approved / Godkendt**	**WLL:**	750 KG

Årsag til eftersyn	Resultat
Eftersyn udført:	Inden for et interval på 12 måneder
Dokumentation / Mærkning	**Resultat**
Dokumentation	Ikke til rådighed
CE mærke / Typeskilt	OK
WLL skilte	OK
Efterset ved service	**Resultat**
Udstyrets generelle tilstand	OK
Manglende eller defekte komponenter	OK
Funktions test	OK
Udløbs dato	N/A
Test	**Resultat**
Detaljer vedrørende eventuelle test foretaget i forbindelse med service inspektionen	
Defekter	**Resultat**
Beskrivelse af eventuelle defekter	
Bemærkninger	

Navn på person der udfylder denne rapport:	Navn på person der verificerer denne rapport:	Seneste dato for næste inspektion:
Thomas Buje Thomas Buje	Søren Tranholm (Service Manager)	20/12/2024

Navn og adresse på arbejdsgiveren for personer, der fremstiller og godkender denne rapport:
CERTEX Denmark A/S,Trekanten 6-8,6500 Vojens

Sub Section L19

Painting/Insulation Inspection Report

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	15/07/2024	First Issue

Document Title:	**BLPH Project - Painting/Insulation Inspection Report**
Document Number:	K559-2254-CWIWP4202202-L19-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-L19-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	L19
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Painting/Insulation Inspection Report
Full Title	L19 – Painting/Insulation Inspection Report

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	July 15, 2024

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2.0 References 4
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4.0 Cooling Flatbed 6
5.0 LT Cooler Support Structure 8

List of Tables

Table 1: Reference Documents 4

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1.0 General

This document gathers all Painting/Insulation Inspection Reports that verify that painting and/or insulation is in accordance with Purchaser's specifications and provided by the painting/insulation contractor for the relevant components corresponding to the CrossWind BLPH Project.

Namely:

1. 40 ft and 10 ft containers
2. 40 ft cooling flatbed
3. LT cooler support structure

Document K559-2254-CWIWP4202202-J04-001 details the Surface Preparation and Painting Specifications.

2.0 References

Table 1: Reference Documents

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	Shell / KBR
K559-2254-CWIWP4202202-J04-001	Surface Preparation and Painting Specification	Ballard

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3.0 Containers

Malerspecifikation PPG Protective Coating

Kunde: Bulegården
Projekt: 40 fod highcube container (udv.)
Område: System CX

Forbehandling: ISO 8501-3 P3
Renhed: ISO 8501-1 Sa 2½
Ruhed: ISO 8503-1 40-70µm RyS
Salt ISO 8502-6 <50mg/m2 NaCl
Støv: ISO 8502-3 Maksimum antal og størrelse rate 2

Udarbejdet af: Claus Refstrup
Dato: 25-10-2023
Udløbsdato: 24-10-2024

	Produkt navn	Generisk type	VS%	TFT (µm)	VFT (µm)	Farve	Overmalings & hærdeinterval 10°C Min	10°C Maks	10°C FC	20°C Min	20°C Maks	20°C FC	30°C Min	30°C Maks	30°C FC	Blande ratio Vol.	Fortynder Blande fortynder	Mængde %	Rense fortynder
1	SigmaZinc 68 GP	Zink epoxy	68	60	88	Grey	3t	3m	15d	1,5t	3m	10d	1t	3h	7d	90/10	91-92	0-5	90-53
2	SigmaFast 278	Epoxy	80	170	213	Div. Ral	4t	Se PDS	8d	2t	Se PDS	4d	1t	Se PDS	3d	75/25	91-92	0-10	90-53
3	SigmaDur 550	Akryl PU	55	50	91	Div. Ral	8t	U/B	6d	6t	U/B	4d	5t	U/B	3d	88/12	21-06	3-5	90-53
				280	392														

Generelle noter

1 Det anbefales at udføre stripe coat for hvert malingslag på svært tilgængelige områder, sevjsesøm Osv.
2 Det anbefales at konsultere tekniske samt sikkerhedsdatablade inden arbejdet påbegyndes.
3 TFT skal være iht. ISO 19840

System noter

1 Alle overflader skal være rene, fri for snavs, forurening og salte.
2 Ovenstående system er iht. ISO 12944-9 CX.
3 -
4 -
5 -

PPG Coatings Belgium BV ved inspektion og teknisk rådgivning, på intet tidspunkt overtager det ansvar for overfladebehandlingen.
PPG Coatings Belgium BVindestår for vores produkters kvalitet, samt at specifikation, datablade og rådgivning er afgivet/udarbejdet efter bedste viden og overbevisning.

4.0 Cooling Flatbed

MK STÅL & MASKINTEKNIK	Paint Report		Page 1 of 1
	Rev. A	19/9 2016	Created by: KSJ
	Doc. Name	Paint Report	Approv.: TS

Item:	Number/Name:	Draw./Specifications:
1 pc. 40ft flatbed	4007950	4007950 Hempel NORSOK Coating Systems

Inspections before blasting:	
Oil or grease removed	OK
Steel work: No spatters, laminations, sharp undercuts, rough welds, sharp edges or welding smoke	OK
Steel original rust rating acc. To ISO 8501-1	A

Sandblasting:	
Blasting material:	Quartz sand size 4 (1,0-2,0 mm)
Blasted to cleanliness acc. To ISO 8501-1	SA 2,5
Roughness acc. ISO 8503-1	Medium (G)

Painting:		
Paint used:	Base	Part B
Hempadur Avantguard 750	043045212	043015553
Hempadur 4774D ral 7035	043076721	043095678
Hempadur 4774D ral 9001	043087366	043095678
Hempathane HS 55610 RAL 7035	043125327-C	043116805
Surface control between each layer acc. To ISO 2801	OK	

Climate Controls:					
	Humidity %	Steel Temp.	Air Temp.	Dew point	Steel - DP
Sandblasting	53,2	8,6	8,1	-0,9	9,5
Hempadur Avantguard 750	29,8	17,6	21,8	3,4	14,2
Hempadur 4774D ral 7035	29,8	22,4	22,0	3,5	18,8
Hempadur 4774D ral 9001	32,8	20,2	20,3	3,4	16,7
Hempathane HS 55610 RAL 7035	30,3	23,3	23,0	4,7	18,5

Date and time of process:				
	Date start	Time Start	Date Stop	Time Stop
Sandblasting	11-12-2023	5.00	11-12-2023	14.00
Hempadur Avantguard 750	12-12-2023	5.30	12-12-2023	8.30
Hempadur 4774D ral 7035	12-12-2023	13.00	12-12-2023	16.00
Hempadur 4774D ral 9001	13-12-2023	5.30	13-12-2023	9.00
Hempathane HS 55610 RAL 7035	13-12-2023	14.00	13-12-2023	17.30

Control of dry film surface:	
Topcoat with uniform, color gloss, no sagging, no running, no spraying dust, no contaminations, full coverage, no pinholes and no rusty spots	OK

Date: 14-12-2023

Approved by:

Kent S. Johansen

Frosio Inspector Level 3

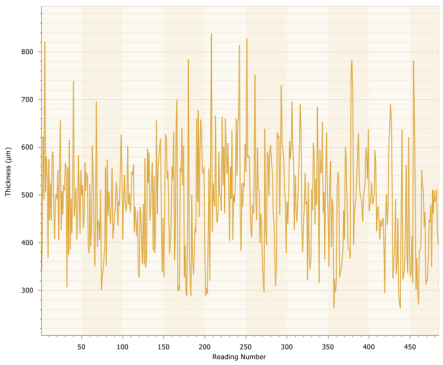
Cert. No. 7545

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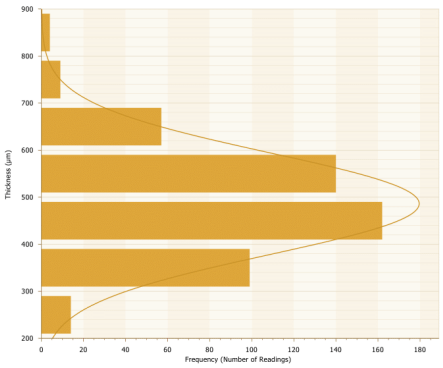
Inspection Report - Dry Film Thickness

LTek\Ballard\
2023-12-13 1 pc. 4007950 - 40 ft flatbed

Individuals / Run Chart



Histogram



Project	
Name	LTek

Gauge	
Type	Elcometer 456/4
Serial #	RH19862

Probe	
Type	F1
Serial #	YA26275

Calibration	
Calibration Method	Smooth
Type	F1
Date	14-12-2023 14:16
Thick Foil	252,0
Thin Foil	0,0

Batch	
Type	Thickness
Name in Gauge	Serie 8
User ID	2023-12-13 1 pc. 4007950 - 40 ft flat
Created Date	14-12-2023 14:17:07
Updated Date	14-12-2023 14:17:07
First Reading Date	14-12-2023 15:20:19
Last Reading Date	14-12-2023 16:42:25

Statistics	
# Readings	485
Mean	486,24 µm
Maximum	838,0 µm
Minimum	263,0 µm
Standard Deviation (σ)	107,75 µm
Mean + 3σ	809,48 µm
Mean - 3σ	163,00 µm
Coefficient of Variation	22,2%
# Readings < NDFT	4 (0,8%)
# Readings >= NDFT	481 (99,2%)

Limits			
High Limit	840,0 µm	# Readings Above	0 (0,0%)
Low Limit	280,0 µm	# Readings Below	4 (0,8%)
NDFT	280,0 µm		

Dry Film Thickness Statistics	
90,0% of NDFT	252,0 µm
# Readings < 90,0% of NDFT	0 (0,0%)

Rules Applied (IMO PSPC)	
(1) No readings are below 90,0% of the NDFT	Pass
(2) No more than 10,0% of readings are below the NDFT	Pass

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5.0 LT Cooler Support Structure

MK STÅL & MASKINTEKNIK	Paint Report		Page 1 of 1
	Rev. A	19/9 2016	Created by: KSJ
	Doc. Name	Paint Report	Approv.: TS

Item:	Number/Name:	Draw./Specifications:
1 pc. LT Cooler Support Structure	002-F40S	002-F40S Hempel NORSOK Coating Systems

Inspections before blasting:	
Oil or grease removed	OK
Steel work: No spatters, laminations, sharp undercuts, rough welds, sharp edges or welding smoke	OK
Steel original rust rating acc. To ISO 8501-1	A

Sandblasting:	
Blasting material:	Quartz sand size 4 (1,0-2,0 mm)
Blasted to cleanliness acc. To ISO 8501-1	SA 2,5
Roughness acc. ISO 8503-1	Medium (G)

Painting:		
Paint used:	Base	Part B
Hempadur Avantguard 750	043045212	043015553
Hempadur 4774D ral 7035	043076721	043095678
Hempadur 4774D ral 9001	043087366	043095678
Hempathane HS 55610 RAL 7035	043125327-C	043116805
Surface control between each layer acc. To ISO 2801	OK	

Climate Controls:					
	Humidity %	Steel Temp.	Air Temp.	Dew point	Steel - DP
Sandblasting	53,2	8,6	8,1	-0,9	9,5
Hempadur Avantguard 750	29,8	17,6	21,8	3,4	14,2
Hempadur 4774D ral 7035	29,8	22,4	22,0	3,5	18,8
Hempadur 4774D ral 9001	32,8	20,2	20,3	3,4	16,7
Hempathane HS 55610 RAL 7035	30,3	23,3	23,0	4,7	18,5

Date and time of process:				
	Date start	Time Start	Date Stop	Time Stop
Sandblasting	11-12-2023	5.00	11-12-2023	14.00
Hempadur Avantguard 750	12-12-2023	5.30	12-12-2023	8.30
Hempadur 4774D ral 7035	12-12-2023	13.00	12-12-2023	16.00
Hempadur 4774D ral 9001	13-12-2023	5.30	13-12-2023	9.00
Hempathane HS 55610 RAL 7035	13-12-2023	14.00	13-12-2023	17.30

Control of dry film surface:	
Topcoat with uniform, color gloss, no sagging, no running, no spraying dust, no contaminations, full coverage, no pinholes and no rusty spots	OK

Date: 14-12-2023

Approved by:

Kent S. Johansen

Frosio Inspector Level 3

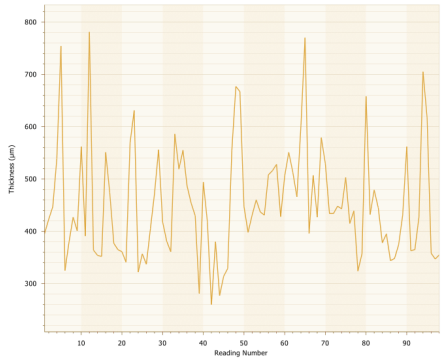
Cert. No. 7545

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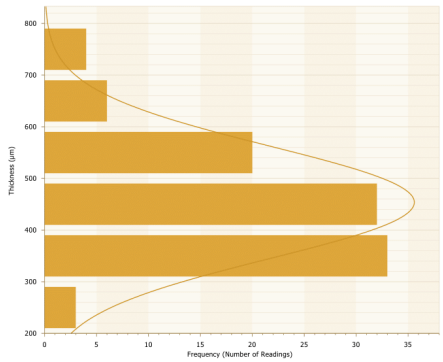
Inspection Report - Dry Film Thickness

LTek\Ballard\
2023-12-13 1 pc. 002-F40S LT Cooler Sup. Struc.

Individuals / Run Chart



Histogram



Project

Name	LTek

Gauge

Type	Elcometer 456/4
Serial #	RH19862

Probe

Type	F1
Serial #	YA26275

Calibration

Calibration Method	Smooth
Type	F1
Date	14-12-2023 14:16
Thick Foil	252,0
Thin Foil	0,0

Batch

Type	Thickness
Name in Gauge	Serie 9
User ID	2023-12-13 1 pc. 002-F40S LT Cooler
Created Date	14-12-2023 16:43:07
Updated Date	14-12-2023 16:43:07
First Reading Date	14-12-2023 16:43:10
Last Reading Date	14-12-2023 16:45:15

Statistics

# Readings	98
Mean	453,76 µm
Maximum	781,0 µm
Minimum	260,0 µm
Standard Deviation (σ)	109,55 µm
Mean + 3σ	782,40 µm
Mean - 3σ	125,11 µm
Coefficient of Variation	24,1%
# Readings < NDFT	2 (2,0%)
# Readings >= NDFT	96 (98,0%)

Limits

High Limit	840,0 µm	# Readings Above	0 (0,0%)
Low Limit	280,0 µm	# Readings Below	2 (2,0%)
NDFT	280,0 µm		

Dry Film Thickness Statistics

90,0% of NDFT	252,0 µm
# Readings < 90,0% of NDFT	0 (0,0%)

Rules Applied (IMO PSPC)

(1) No readings are below 90,0% of the NDFT	Pass
(2) No more than 10,0% of readings are below the NDFT	Pass

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Section M

Compiled Dossiers

Sub Section M99

ATEX Verification Dossier

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	1/27/2023	First Issue
002	2/10/2023	Reordered, missing items added
003	20/08/2025	Updated documents included
004	9/16/2025	Update, including rev in index. As build
005	11/14/2025	Update according comments Oct 2025
006	12/3/2025	Update as agreed with S Bremner.

Document Title:	**BLPH Project - ATEX Verification Dossier**
Document Number:	K559-2254-CWIWP4202202-M99-001
Revision:	Rev006
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-M99-001Rev006
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	M99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BALLARD™ 1 MW Power Container	Customer:	Crosswind C.V.
	Purch. Job:	K559-2254
	Purch. Order:	CWIWP4202202

ATEX Verification Dossier Index

SECTION	SUB SECT.	Doc rev .	ITEM DESCRIPTION
B			**General Arrangement**
	B01	010	General Arrangement (incl. Hazardous Area Layout)
C			**System Data**
	C07	003	Cause and Effects Charts
	C99-001	002	Hydrogen Safety Concept
	C99-002	002	Hydrogen Preheating System Impact Assessment
D			**Data Sheets**
	D99	002	ATEX Components Data Sheets
G			**Calculations**
	G99-001	004	IEC60079-10 Analysis
	G99-002	003	Intrinsically Safe Calculations
K			**Certification Data**
	K01-001	004	Declaration of Conformity (FCwave™)
	K01-002	002	Declaration of Conformity (FC PowerGen 1000kW®)
	K01-003	004	PED Compliance H2 Manifold Addendum (ATEX)
	K02-001	005	Equipment Hazardous Area Certificates & Schedule
	K02-002	007	ATEX Register
	K02-003	005	ATEX Design journal
	K02-004	002	Personal Competences Ex Works
	K03	001	Performance Test Results (FAT)
	K12	002	Type Approval Certificates
Q			**Quality Documentation**
	Q99	002	ATEX inspections during manufacturing

Section B

General Arrangement

Sub Subsection B01

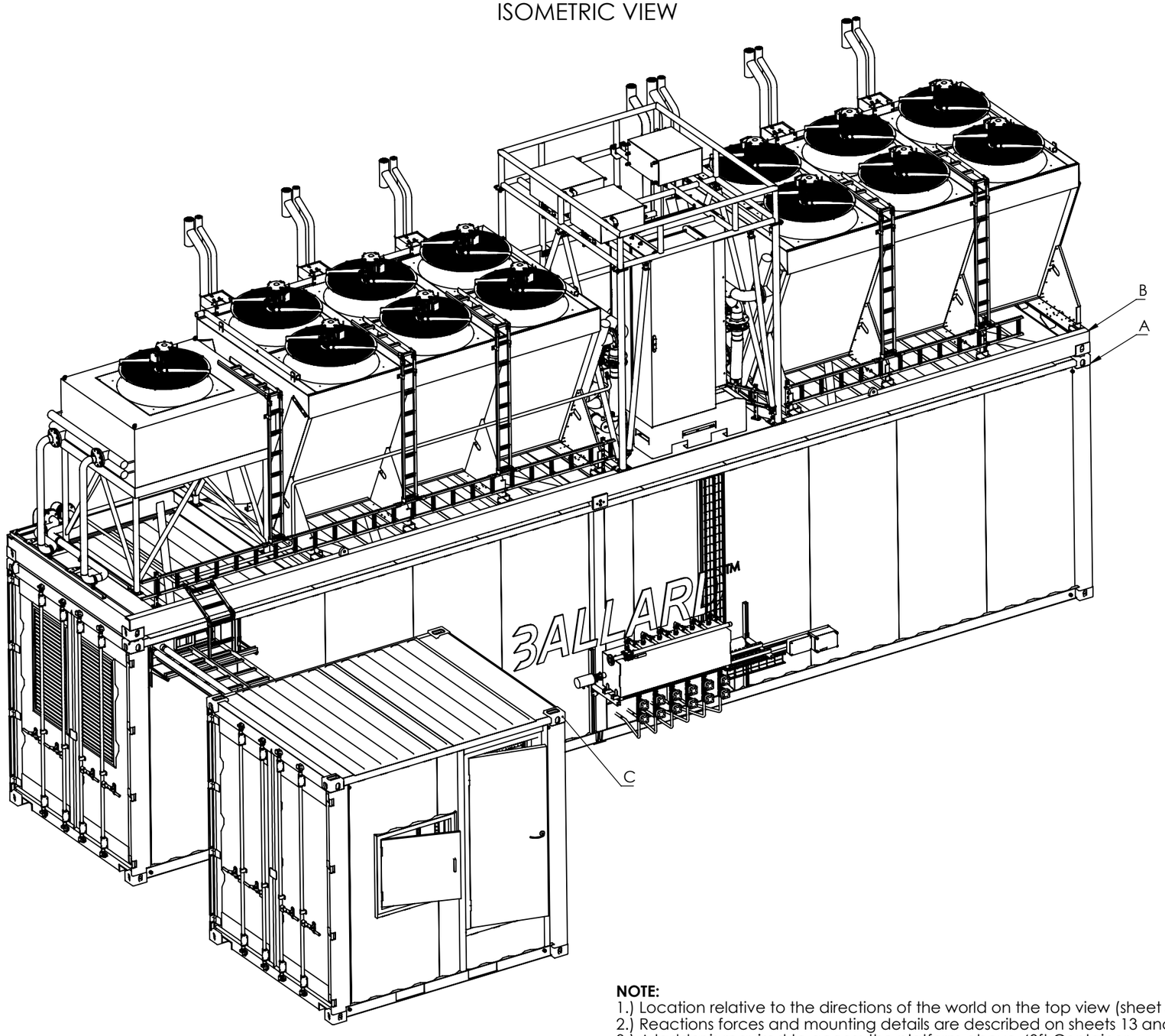
General Arrangement

(incl. Hazardous Area Layout)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	2/10/2023	First Issue
002	3/24/2023	Re-issue according to comments
003	5/30/2023	Re-issue according to comments
004	11/10/2023	Re-issue according to comments
005	11/24/2023	Re-issue according to comments
006	4/2/2024	Re-issue according to comments
007	7/17/2024	Re-issue according to comments
008	9/5/2024	Re-issue (as built)
009	11/21/2024	Re-issue according to comments
10	6/27/2025	Re-issue according to comments
Document Title:		**BLPH Project - General Arrangements**
Document Number:		K559-2254-CWIWP4202202-B01-001
Revision:		Rev010
Sequence Number:		001
File Name:		K559-2254-CWIWP4202202-B01-001Rev010
Purchaser Job:		K559-2254
Purchase Order:		CWIWP4202202
Code:		B01
Requsition Number:		n/a
Customer:		CrossWind C.V., Rotterdam, The Netherlands

ISOMETRIC VIEW



No	Name	Operating Masses	Dry Masses
A	40ft container	21680kg	21320kg
B	40ft fladbed	10060kg	9060kg
C	10ft container	7350kg	7310kg

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

BALLARD™

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

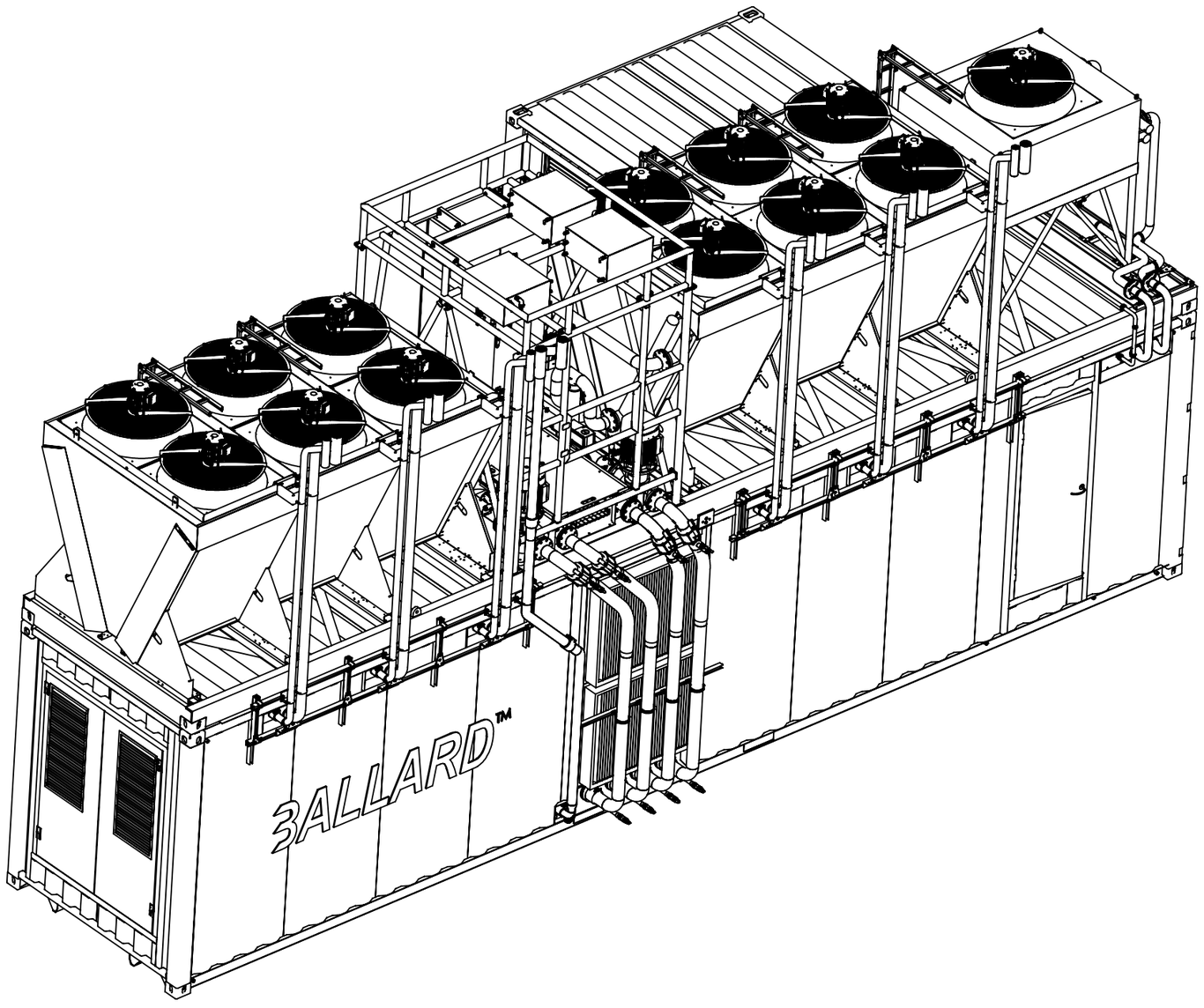
	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	1/14	1:50	601456B	10

ISOMETRIC VIEW



NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

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Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

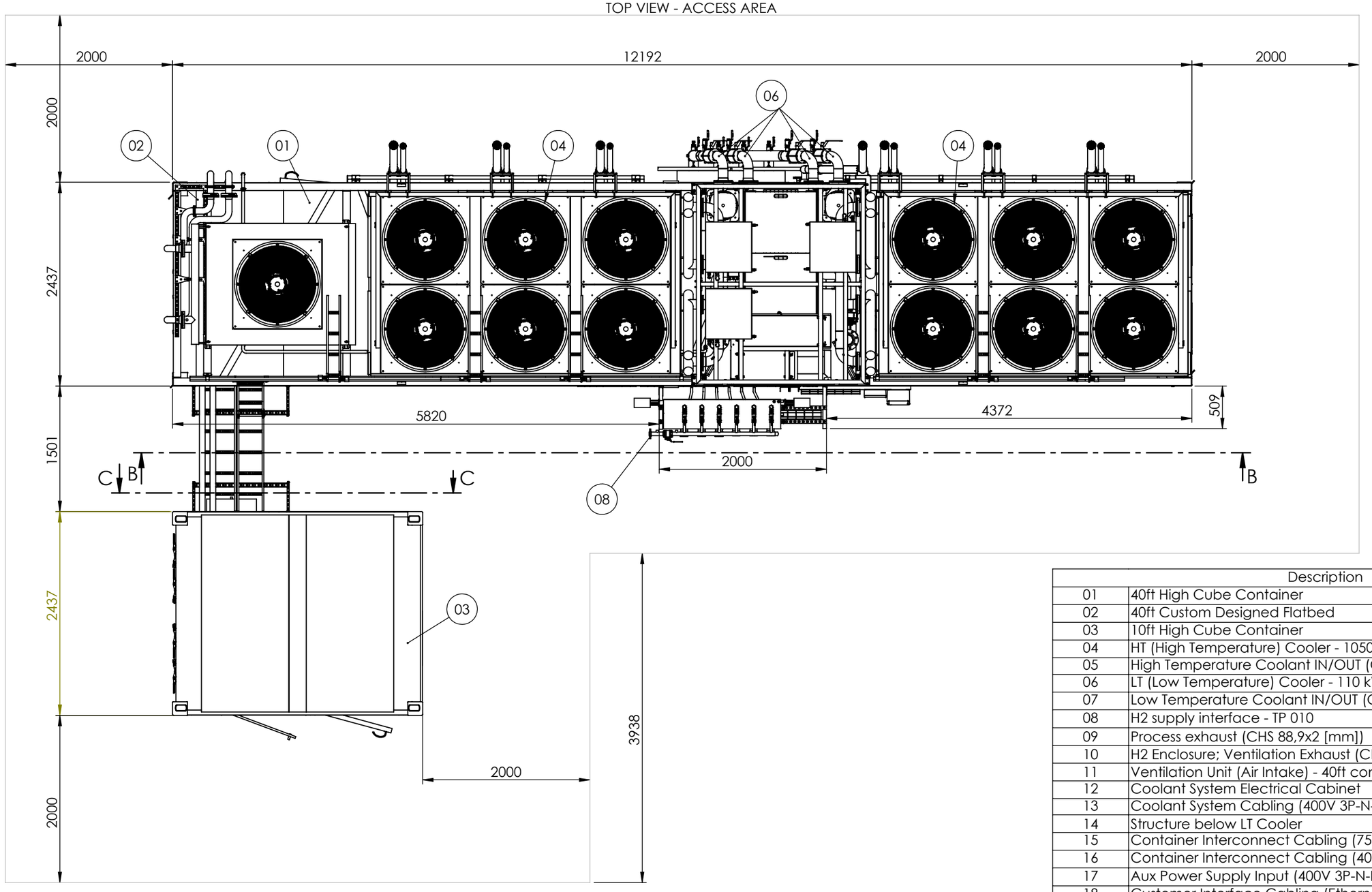
	By	Date
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General arrangement

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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	2/14	1:50	601456B	10

TOP VIEW - ACCESS AREA





	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

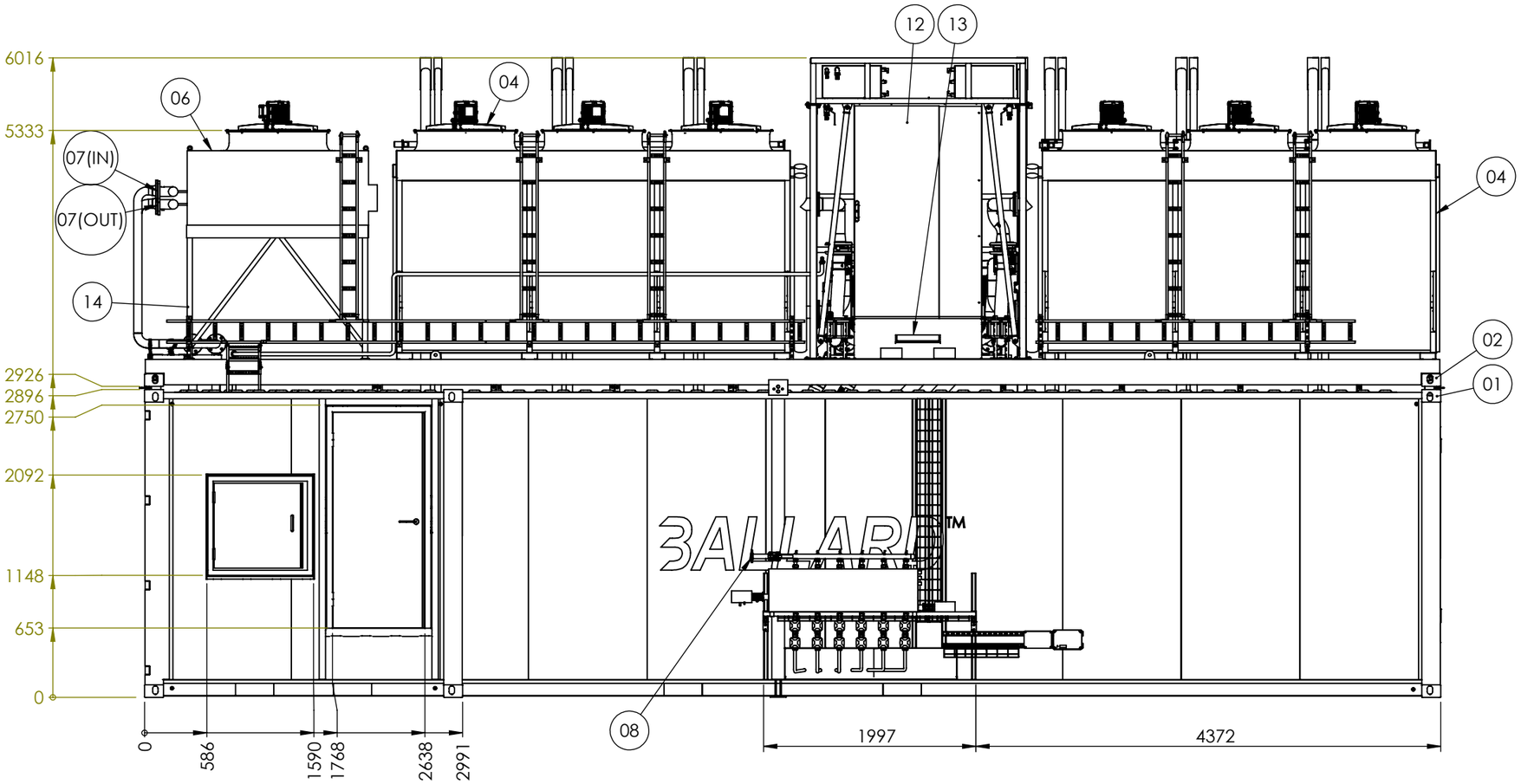
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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	3/14	1:50	601456B	10

FRONT VIEW
(LOOKING SOUTH)



	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

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WEIGHT 25596124 g

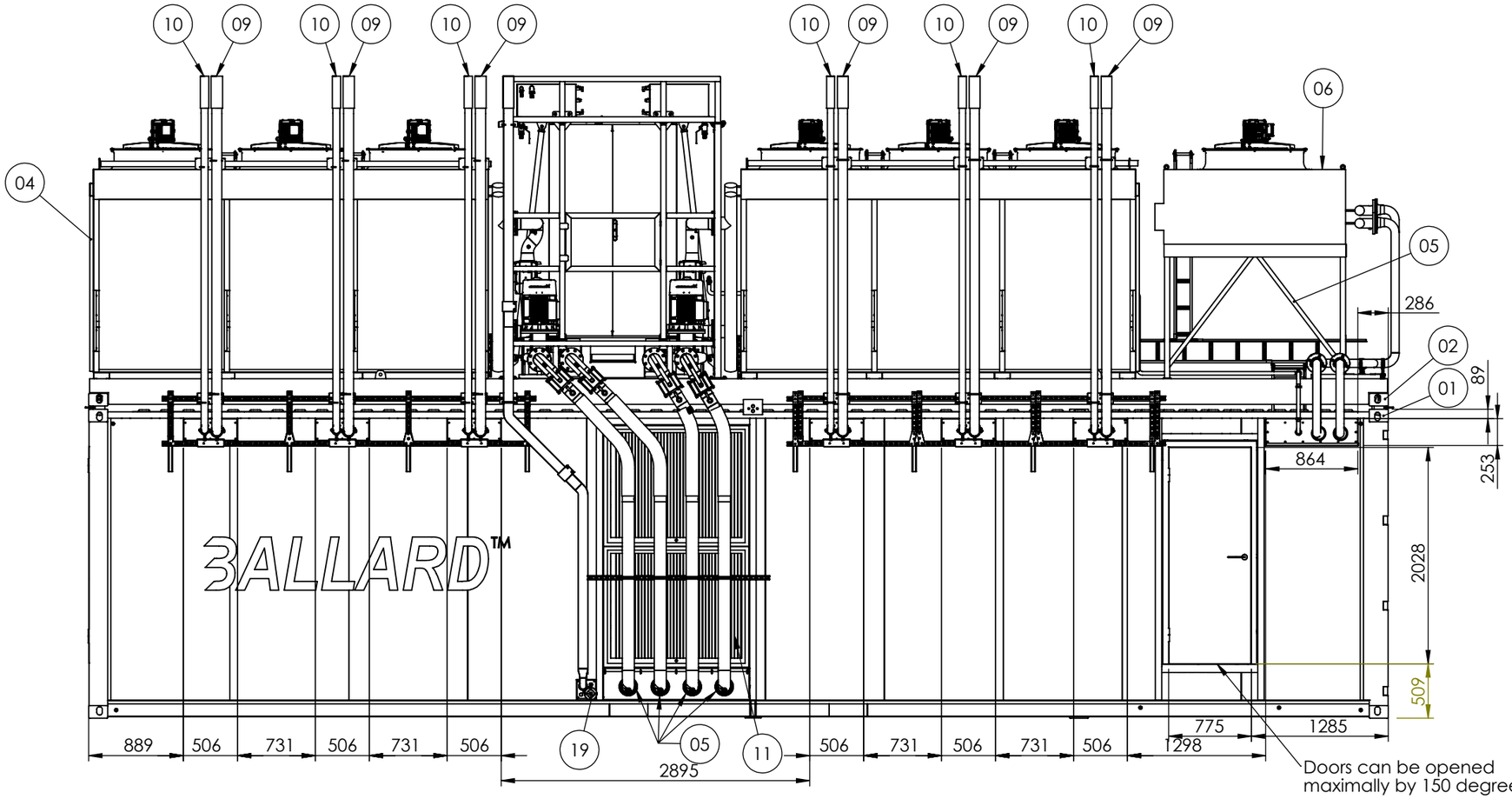
1st angle projection

BALLARD™

General arrangement

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	4/14	1:50	601456B	10

BACK VIEW
(LOOKING NORTH)



	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

BALLARD™

General arrangement

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

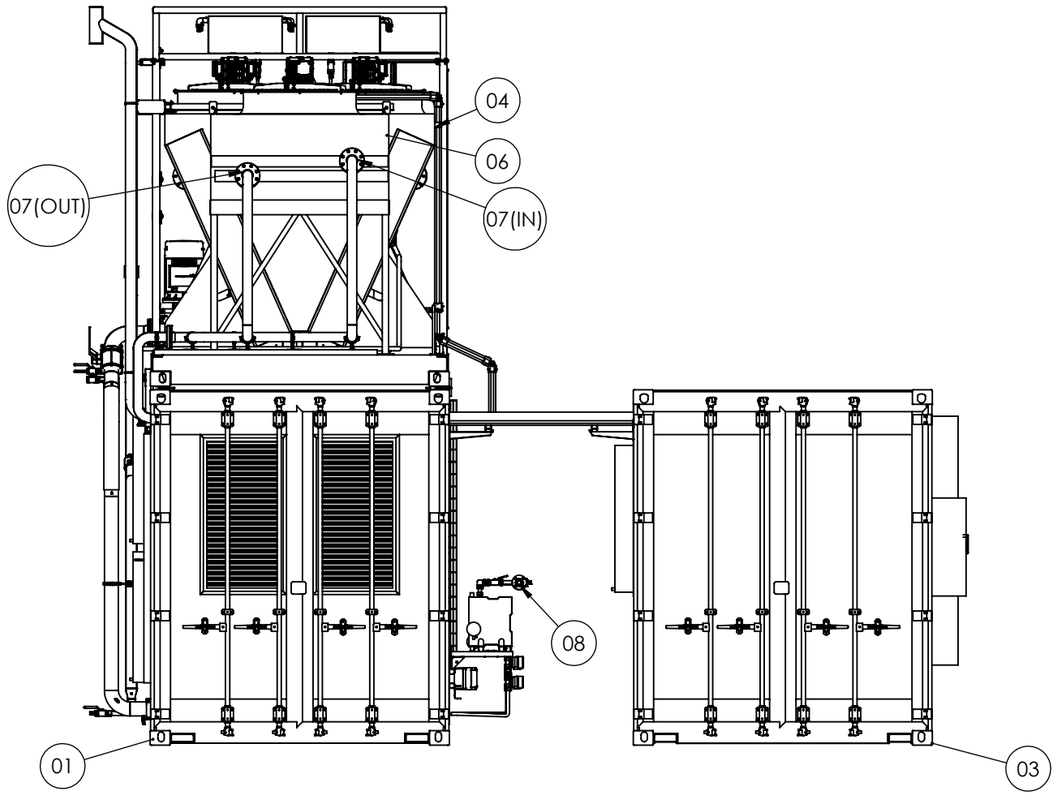
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

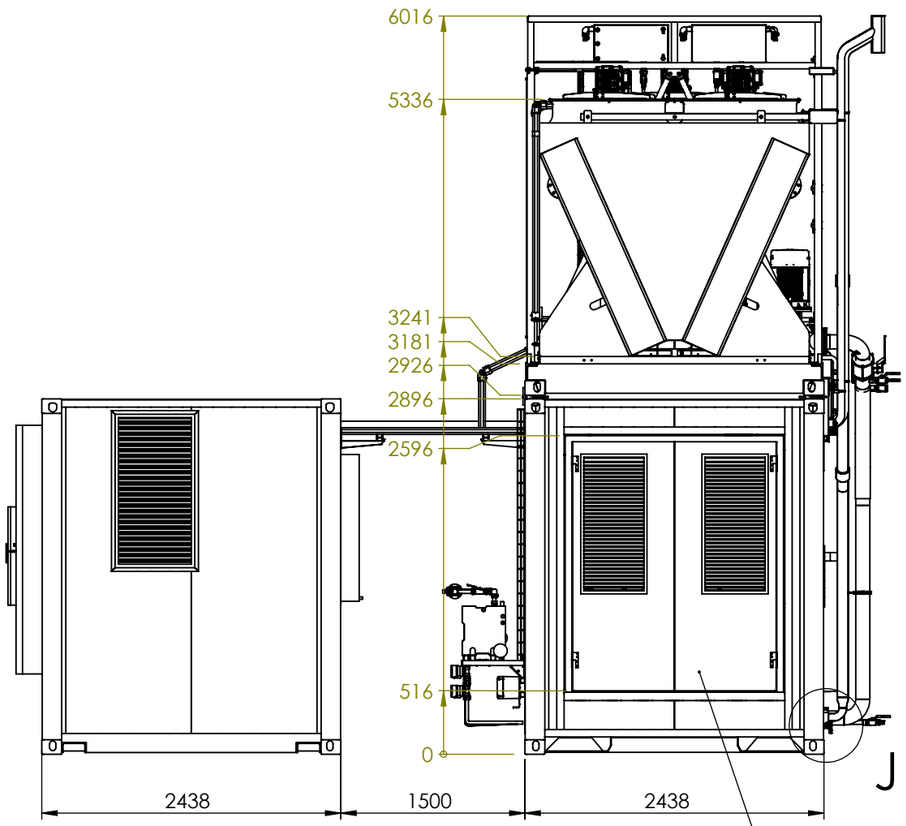
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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	5/14	1:50	601456B	10

RIGHT VIEW
(LOOKING WEST)

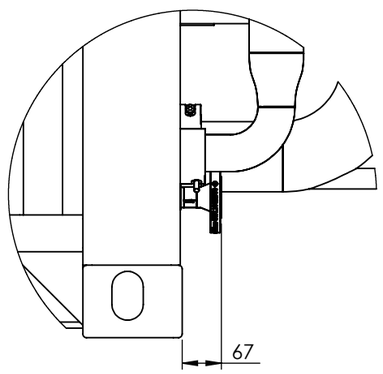


LEFT VIEW
(LOOKING EAST)



Doors can be opened
maximally by 150 degrees

	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		



DETAIL J
SCALE 1 : 10

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

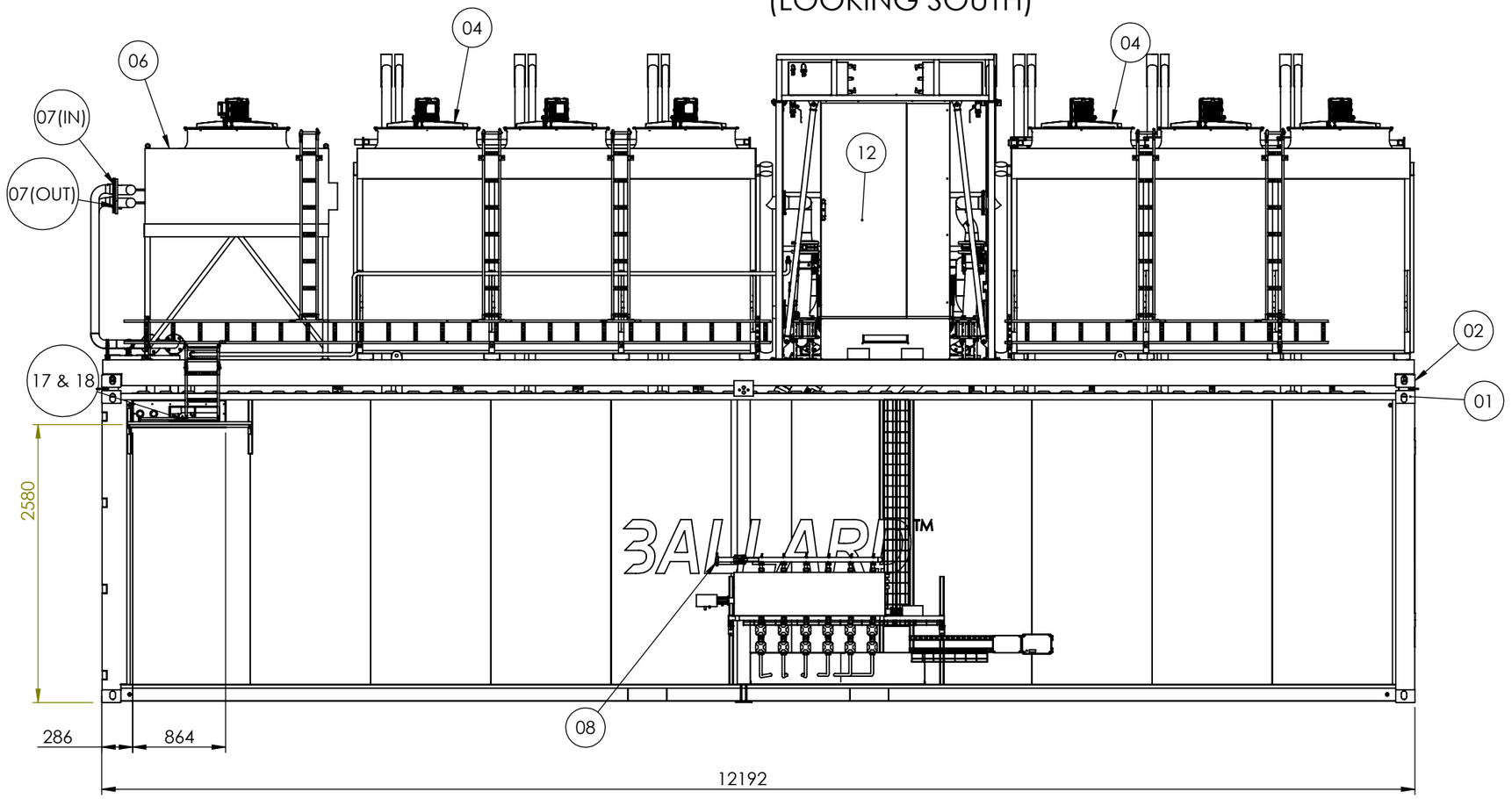
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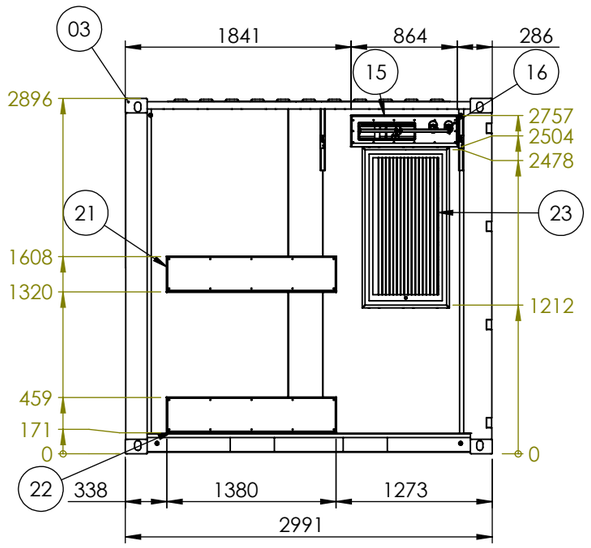
General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	6/14	1:50	601456B	10

FRONT VIEW
(LOOKING SOUTH)



SECTION B-B



SECTION C-C

	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
CHS = Circular Hollow Section		
CIP - Customer Interface Point		

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

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Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

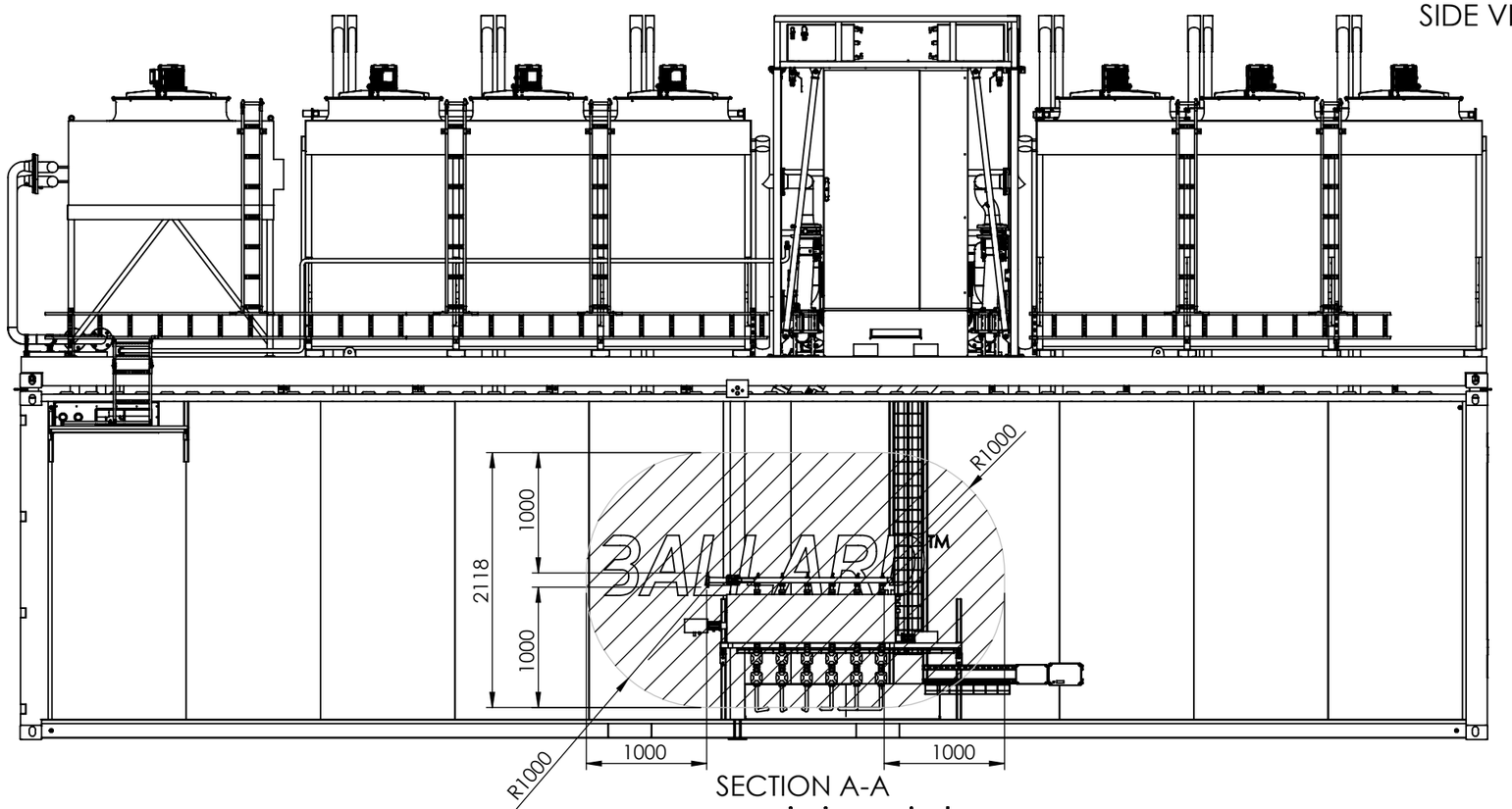
	By	Date
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Revision	JTA	26-06-2025
Released	ASM	26-06-2025

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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
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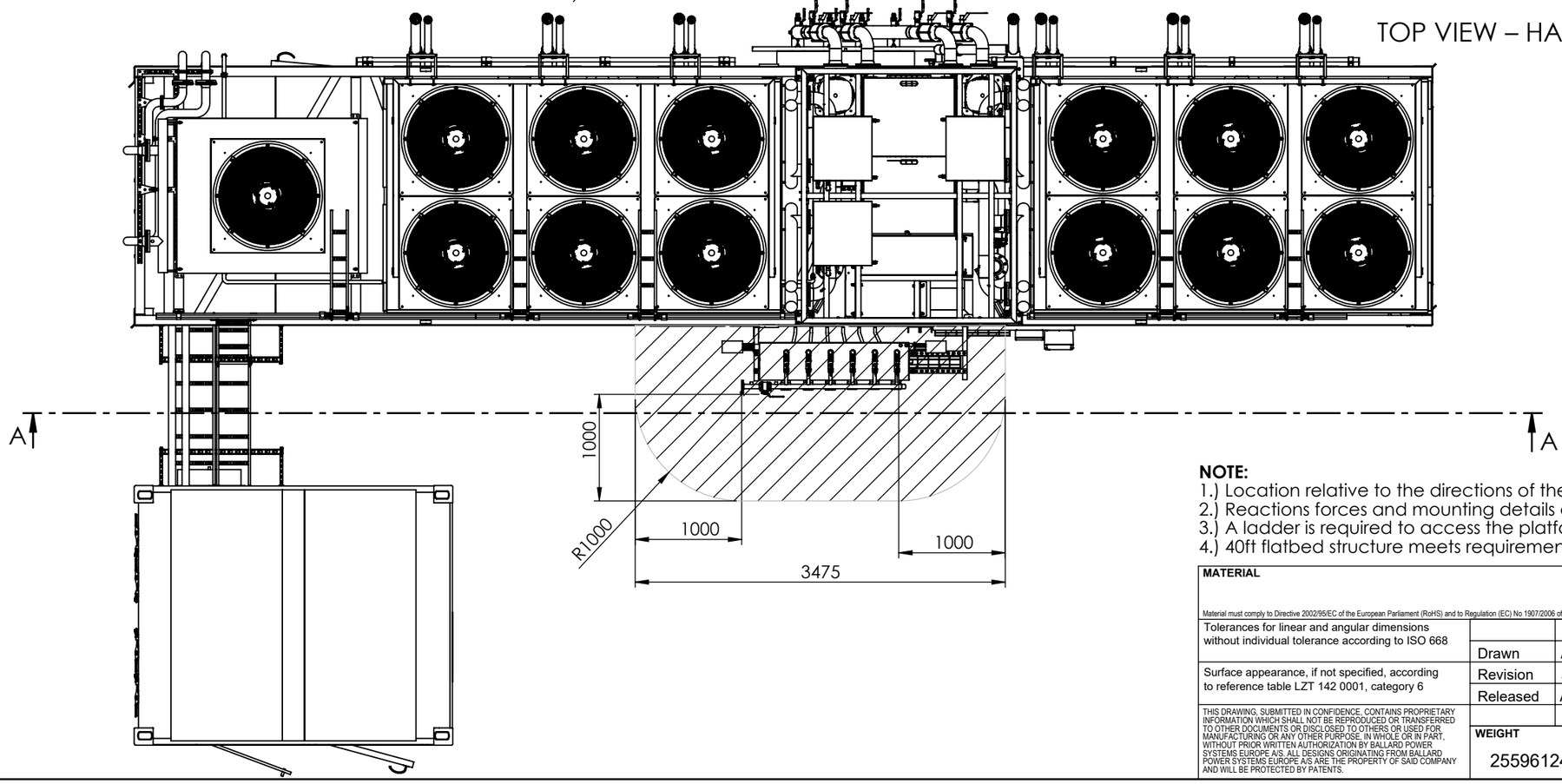
SIDE VIEW - HAZARD AREA



SECTION A-A

Zone 2 Gc IIC T1

TOP VIEW – HAZARD AREA



NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

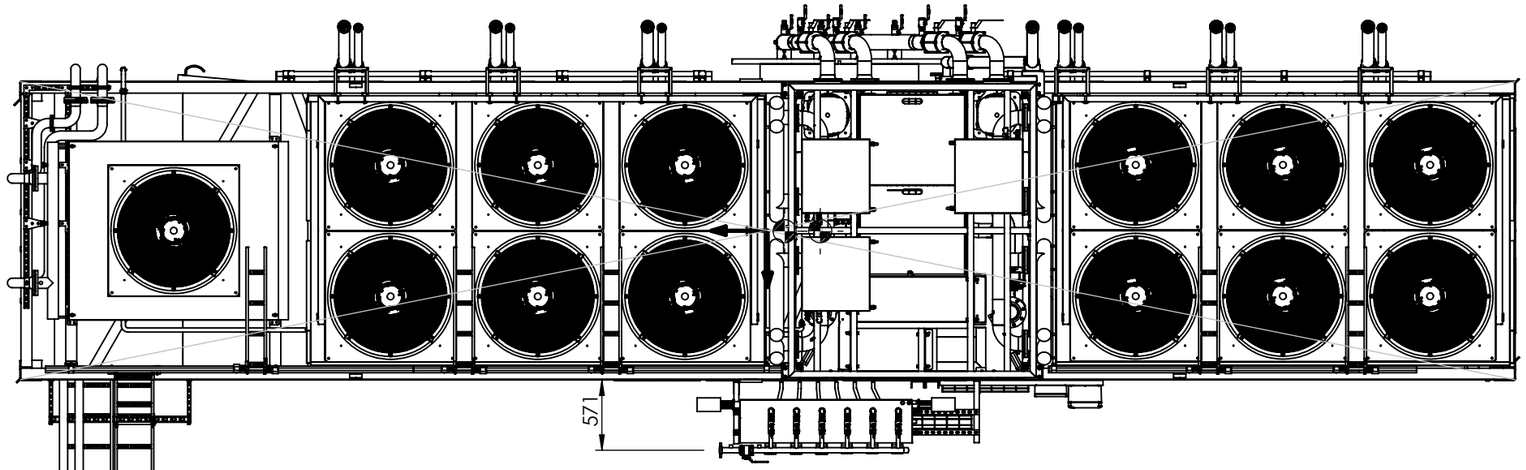
MATERIAL Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)			BALLARD™
Tolerances for linear and angular dimensions without individual tolerance according to ISO 668		By	Date
	Drawn	ASM	20-02-2024
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6	Revision	JTA	26-06-2025
	Released	ASM	26-06-2025
			General arrangement

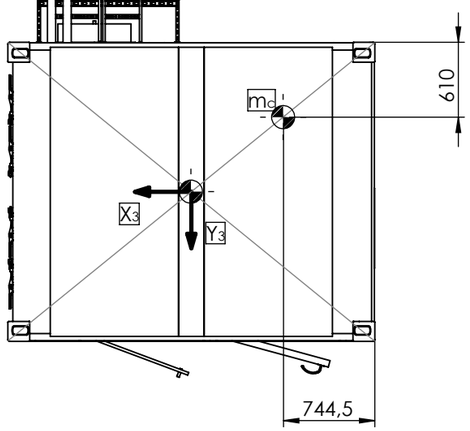
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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
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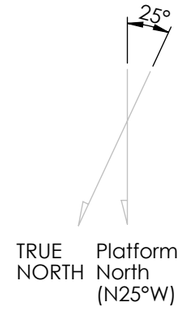
TOP VIEW - Center of Gravity

Access area





Access area



NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to		By	Date
	Drawn	ASM	20-02-2024
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6	Revision	JTA	26-06-2025
	Released	ASM	26-06-2025

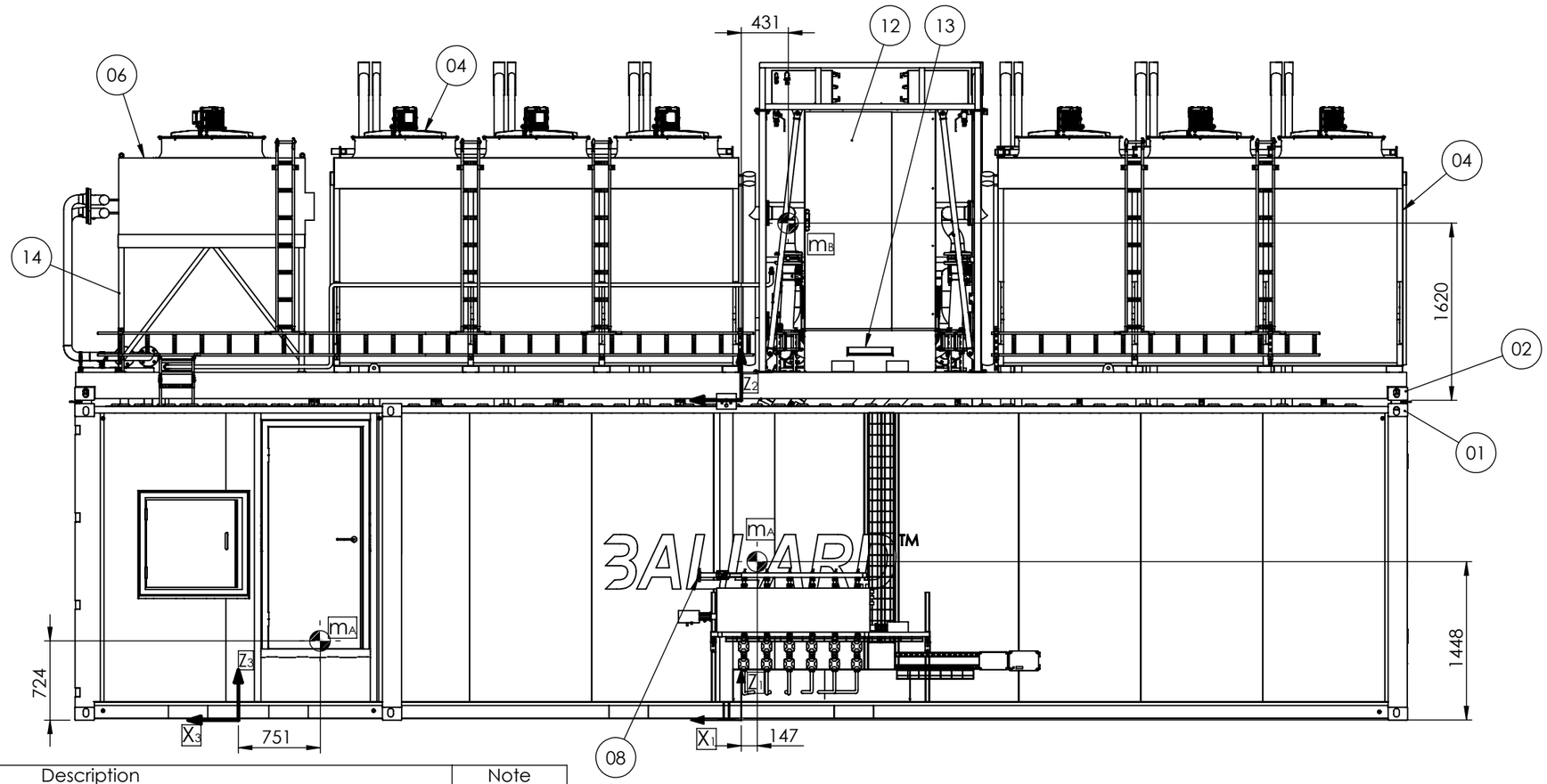
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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	9/14	1:50	601456B	10

FRONT VIEW - Center of Gravity
(LOOKING SOUTH)



	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
	CHS = Circular Hollow Section	
	CIP - Customer Interface Point	

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
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WEIGHT 25596124 g

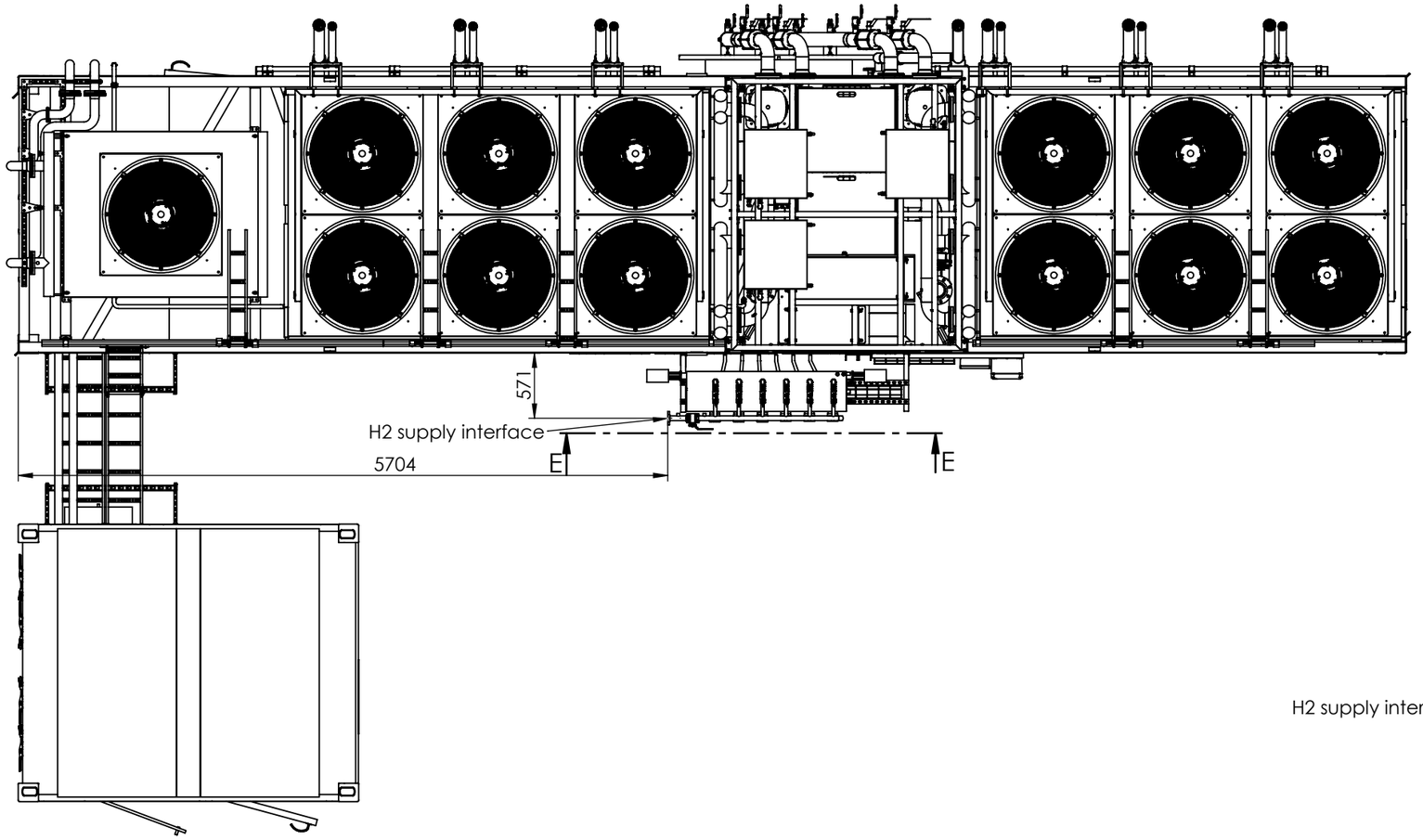
1st angle projection

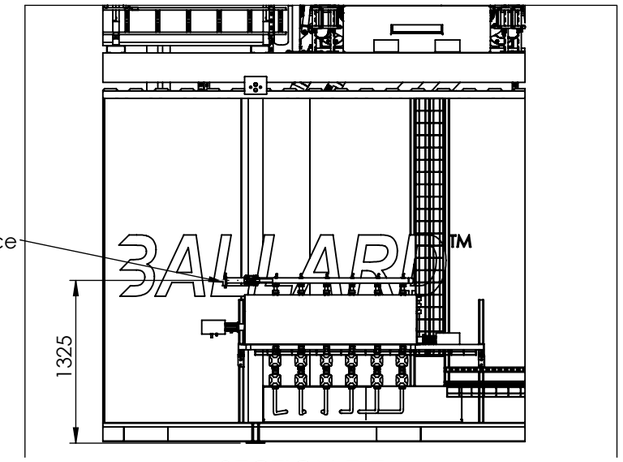
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General arrangement

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	10/14	1:50	601456B	10

TOP VIEW - H2 SUPPLY INTERFACE





SECTION E-E

Reference	Interface	Dimension	Flange Standard	Pressure class	Flange face	Material	Allowable nozzle loads
08	H2 supply interface - TP 010	DN32	EN1759-1	300	RF	ANSI 316	50N*
* All interfacing flanges/connections must be fully supported and compensated for loads and moments.							

MATERIAL

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Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
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WEIGHT 25596124 g

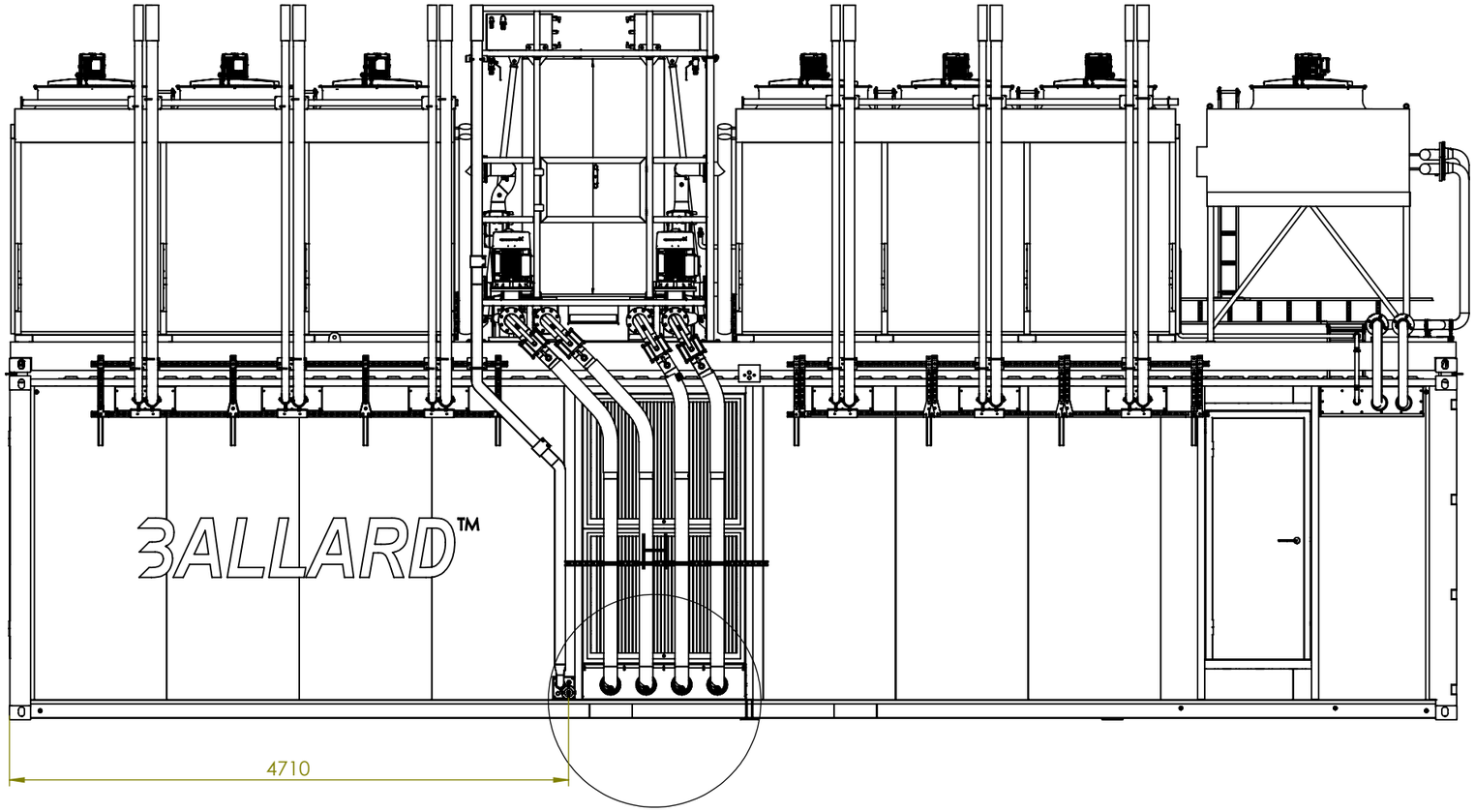
1st angle projection

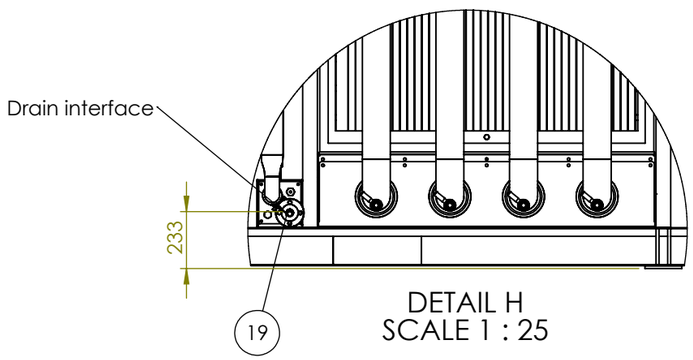
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General arrangement

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	11/14	1:50	601456B	10

FRONT VIEW LOOKING NORTH- DRAIN INTERFACE





DETAIL H
SCALE 1 : 25

Reference	Interface	Dimension	Flange Standard	Pressure class	Flange face	Material	Allowable nozzle loads
19	Drain interface - TP 015	1"	ASME B 16.5	150	RF	ANSI 316	50N*
* All interfacing flanges/connections must be fully supported and compensated for loads and moments.							

MATERIAL

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Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
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Revision	JTA	26-06-2025
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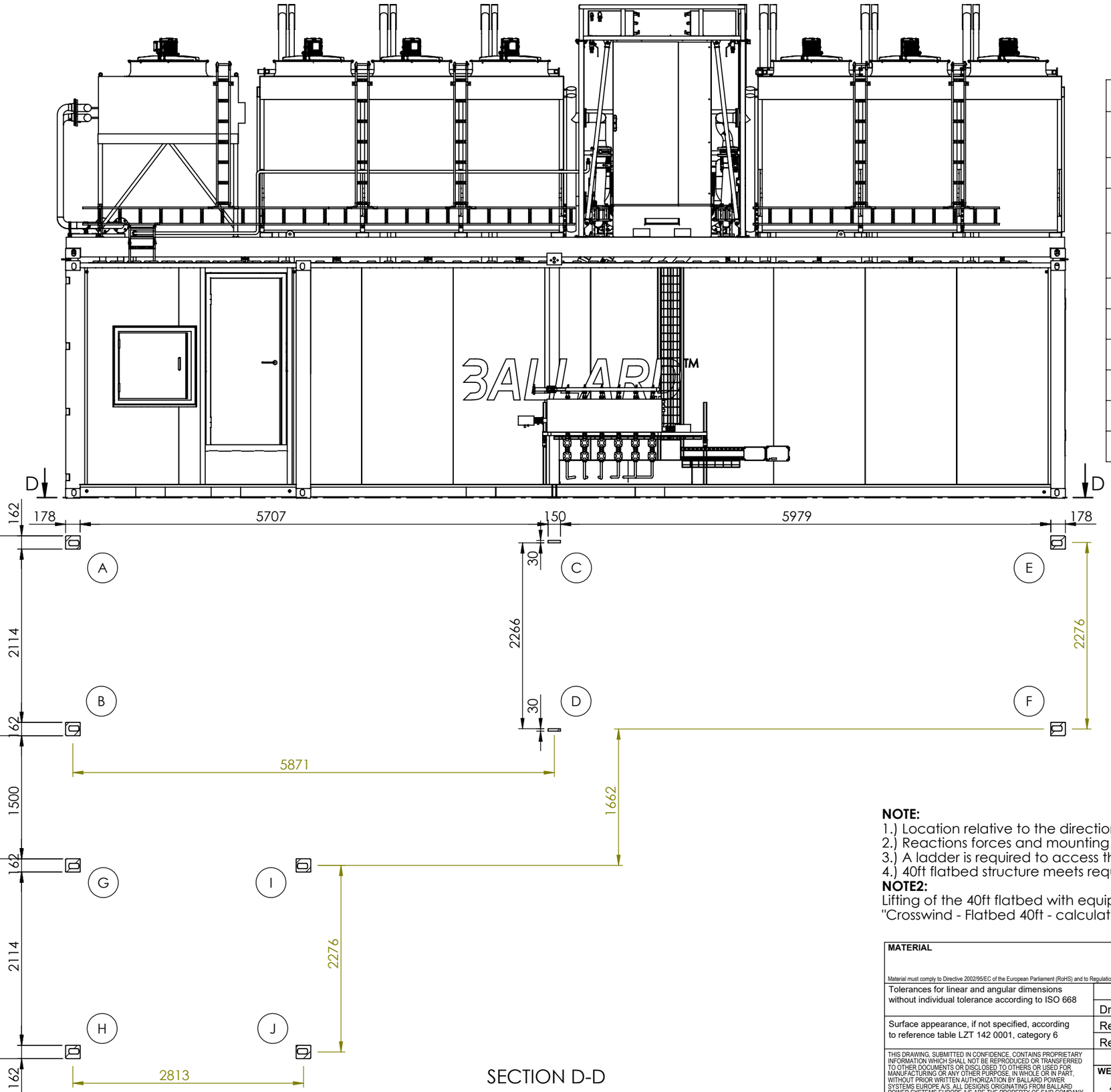
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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	12/14	1:50	601456B	10

REACTIONS BOTTOM



Pointer	Element description	Required support description
A	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
B	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
C	Support plate 12x30x150	Supporting plate 30x150 (blocked movement in direction Z) (no bolts, only compression reaction force)
D	Support plate 12x30x150	Supporting plate 30x150 (blocked movement in direction Z) (no bolts, only compression reaction force)
E	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
F	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
G	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
H	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
I	Bottom right corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)
J	Bottom left corner - ISO1161	Standard Container Twist-Lock (blocked movement in directions X, Y, Z)

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

NOTE2:
Lifting of the 40ft flatbed with equipment in accordance to guidelines specified in structural calculation report: "Crosswind - Flatbed 40ft - calculation report rev_1.pdf"

MATERIAL

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Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

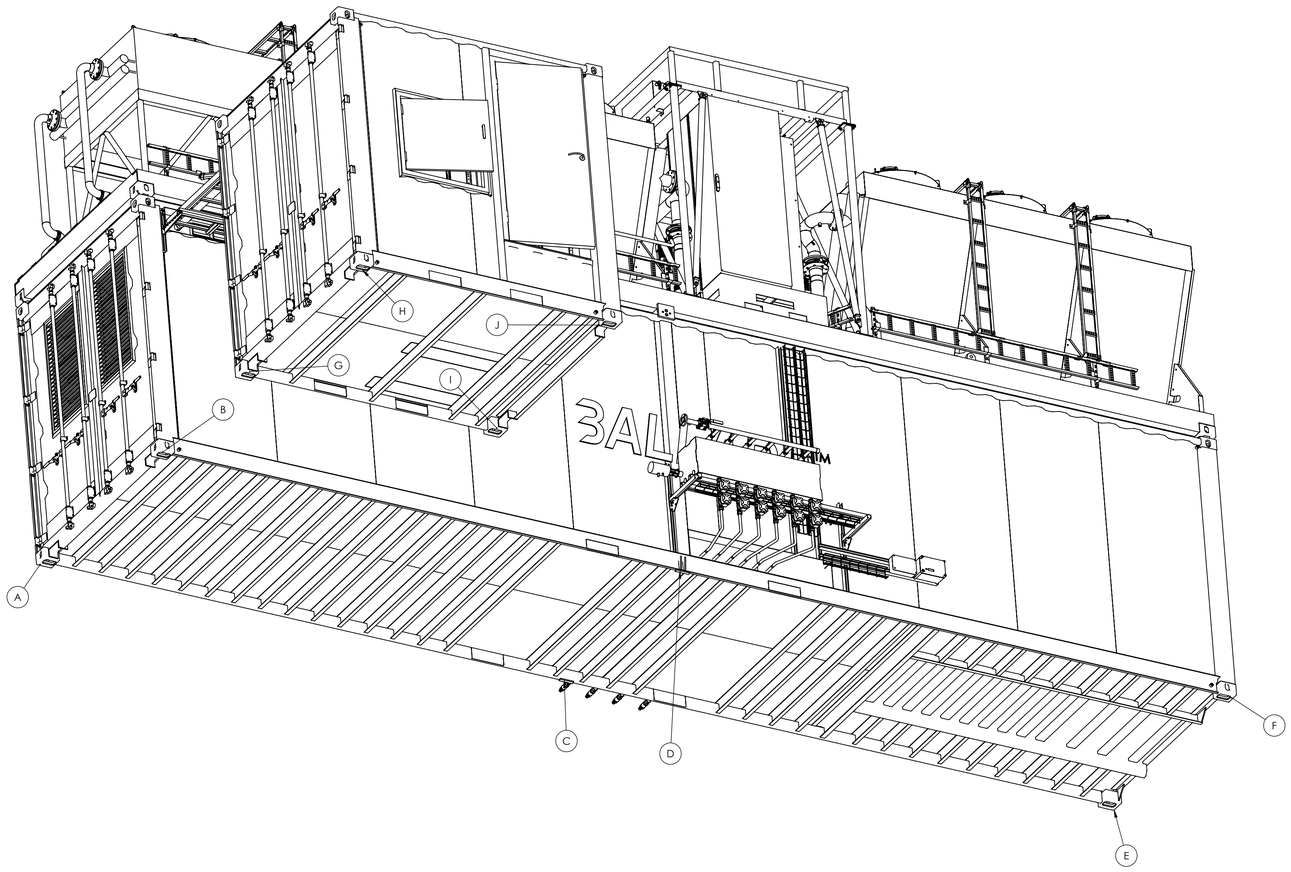
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General arrangement

WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	1st angle projection	A3	13/14	1:50	601456B	10



40ft container							
Ultimate Limit State: LC5 - Lifting of 40ft container with full equipment							
LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]				LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-	-	126	A	-	-	125
B	-	-	133	B	-	-	134
C	-	-	-	C	-	-	-
D	-	-	-	D	-	-	-
E	-	-	133	E	-	-	134
F	-	-	128	F	-	-	128

40ft container							
Ultimate Limit State: LC5 - Lifting of 10ft container with full equipment							
LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]				LC5 - Lifting offshore vertical by 4 bottom ISO 1161 Corners (only 40ft container), [SF=2,34]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-	-	25	G	-	-	25
H	-	-	17	H	-	-	16
I	-	-	100	I	-	-	99
J	-	-	22	J	-	-	23

40ft container + 40ft flatbed (CROSSWIND)							
Ultimate Limit State: LC7-LC14 - Sea transport on barge							
40ft container + 40ft flatbed (max self-weight) LC7 MAX-Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]				40ft container + 40ft flatbed (min self-weight) LC7 MIN-Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	39	-75	-158	A	65	-72	-217
B	-103	-63	300	B	-76	-63	234
C	-	-	113	C	-	-	53
D	-	-	130	D	-	-	24
E	11	-42	27	E	-24	-60	-70
F	53	-83	138	F	35	-67	93
40ft container + 40ft flatbed (max self-weight) LC8 MAX-Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]				40ft container + 40ft flatbed (min self-weight) LC8 MIN-Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-64	-39	-60	A	-42	-37	-98
B	-153	-49	263	B	-131	-50	207
C	-	-	101	C	-	-	34
D	-	-	127	D	-	-	41
E	-45	-33	30	E	-74	-48	-42
F	-37	-44	85	F	-52	-30	21
40ft container + 40ft flatbed (max self-weight) LC9 MAX-Sea transport on the barge Beam sea, bow down, X+ [Roll case 1]				40ft container + 40ft flatbed (min self-weight) LC9 MIN-Sea transport on the barge Beam sea, bow down, X+ [Roll case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-130	9	80	A	-111	10	48
B	-131	-12	141	B	-111	-13	90
C	-	-	99	C	-	-	31
D	-	-	124	D	-	-	47
E	-44	2	70	E	-70	-11	-10
F	-78	2	-4	F	-92	13	-41
40ft container + 40ft flatbed (max self-weight) LC10 MAX-Sea transport on the barge Quatering sea, stern down, X+ Y+ [Quatering 2]				40ft container + 40ft flatbed (min self-weight) LC10 MIN-Sea transport on the barge Quatering sea, stern down, X+ Y+ [Quatering 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-154	51	206	A	-132	53	172
B	-67	31	-6	B	-44	31	-65
C	-	-	105	C	-	-	30
D	-	-	126	D	-	-	49
E	-4	46	127	E	-32	32	61
F	-74	37	-39	F	-90	49	-82
40ft container + 40ft flatbed (max self-weight) LC11 MAX-Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]				40ft container + 40ft flatbed (min self-weight) LC11 MIN-Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-104	68	265	A	-79	71	225
B	33	65	-126	B	61	64	-164
C	-	-	118	C	-	-	23
D	-	-	130	D	-	-	59
E	77	85	178	E	43	67	101
F	-6	43	-13	F	-26	59	-79
40ft container + 40ft flatbed (max self-weight) LC12 MAX-Sea transport on the barge Quatering sea, stern down, X-Y- [Quatering 3]				40ft container + 40ft flatbed (min self-weight) LC12 MIN-Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	0	33	161	A	22	35	129
B	88	51	-101	B	111	51	-166
C	-	-	118	C	-	-	41
D	-	-	120	D	-	-	51
E	129	75	164	E	101	61	99
F	81	6	60	F	66	19	10
40ft container + 40ft flatbed (max self-weight) LC13 MAX-Sea transport on the barge Beam sea, bow down, X- [Roll case 2]				40ft container + 40ft flatbed (min self-weight) LC13 MIN-Sea transport on the barge Beam sea, bow down, X- [Roll case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	69	-14	19	A	88	-13	-13
B	66	14	9	B	87	13	-31
C	-	-	115	C	-	-	47
D	-	-	117	D	-	-	40
E	126	39	120	E	100	25	60
F	122	-38	120	F	107	-27	83
40ft container + 40ft flatbed (max self-weight) LC14 MAX-Sea transport on the barge Quatering sea, stern down, X-Y+ [Quatering 4]				40ft container + 40ft flatbed (min self-weight) LC14 MIN-Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	92	-57	-108	A	113	-55	-150
B	1	-29	170	B	24	-30	116
C	-	-	113	C	-	-	53
D	-	-	120	D	-	-	35
E	88	-5	70	E	59	-20	-5
F	119	-74	154	F	104	-61	116

10ft container (CROSSWIND)							
Ultimate Limit State: LC7-LC14 - Sea transport on barge							
10ft container (max self-weight) LC7 MAX-Sea transport on barge Head sea, bow down, Y+ [Pitch case 1]				10ft container (min self-weight) LC7 MIN-Sea transport on barge Head sea, bow down, Y+ [Pitch case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	3	-3	14	G	5	-7	1
H	-17	-19	15	H	-8	-11	5
I	11	-18	63	I	4	-16	7
J	2	-7	24	J	-1	-14	12
10ft container (max self-weight) LC8 MAX-Sea transport on barge Quatering sea, bow down, X+ Y+ [Quatering 1]				10ft container (min self-weight) LC8 MIN-Sea transport on barge Quatering sea, bow down, X+ Y+ [Quatering 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-23	3	24	G	-21	0	13
H	-27	-26	14	H	-20	-19	6
I	-7	-12	52	I	-13	-10	6
J	-7	5	19	J	-10	-1	10
10ft container (max self-weight) LC9 MAX-Sea transport on barge Beam sea, X+ [Roll case 1]				10ft container (min self-weight) LC9 MIN-Sea transport on barge Beam sea, X+ [Roll case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-33	10	29	G	-32	6	19
H	-27	-23	13	H	-21	-17	5
I	-13	-3	54	I	-19	-1	11
J	-9	16	13	J	-12	11	4
10ft container (max self-weight) LC10 MAX-Sea transport on barge Quatering sea, stern down, X+ Y+ [Quatering 2]				10ft container (min self-weight) LC10 MIN-Sea transport on barge Quatering sea, stern down, X+ Y+ [Quatering 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-29	14	28	G	-28	11	17
H	-21	-15	11	H	-13	-8	3
I	-9	7	63	I	-15	9	17
J	-5	25	8	J	-8	20	-2
10ft container (max self-weight) LC11 MAX-Sea transport on barge Head sea, stern down, Y- [Pitch case 2]				10ft container (min self-weight) LC11 MIN-Sea transport on barge Head sea, stern down, Y- [Pitch case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-8	14	19	G	-5	10	7
H	-6	-2	10	H	3	6	0
I	8	12	80	I	0	14	24
J	5	24	6	J	2	18	-6
10ft container (max self-weight) LC12 MAX-Sea transport on barge Quatering sea, stern down, X-Y- [Quatering 3]				10ft container (min self-weight) LC12 MIN-Sea transport on barge Quatering sea, stern down, X-Y- [Quatering 3]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	18	7	7	G	20	3	-3
H	6	5	10	H	13	12	1
I	25	7	84	I	19	8	37
J	15	12	9	J	12	6	0
10ft container (max self-weight) LC13 MAX-Sea transport on barge Beam sea, X- [Roll case 2]				10ft container (min self-weight) LC13 MIN-Sea transport on barge Beam sea, X- [Roll case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	29	0	3	G	30	-3	8
H	6	3	11	H	13	9	3
I	31	-3	80	I	26	-1	37
J	17	0	15	J	14	-6	6
10ft container (max self-weight) LC14 MAX-Sea transport on barge Quatering sea, stern down, X-Y+ [Quatering 4]				10ft container (min self-weight) LC14 MIN-Sea transport on barge Quatering sea, stern down, X-Y+ [Quatering 4]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	25	-4	4	G	26	-7	7
H	-1	-6	13	H	6	2	5
I	27	-12	73	I	21	-10	26
J	13	-8	21	J	10	14	11

40ft container + 40ft flatbed (CROSSWIND)							
Ultimate Limit State: LC15-LC18 - destination place (Offshore)							
40ft container + 40ft flatbed (max self-weight) LC15 MAX-Destination place - Offshore Wind X+				40ft container + 40ft flatbed (min self-weight) LC15 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-67	2	58	A	-61	3	48
B	-69	-4	99	B	-63	-4	83
C	-	-	84	C	-	-	63
D	-	-	102	D	-	-	78
E	1	10	71	E	-7	6	51
F	-23	-8	20	F	-27	-4	9
40ft container + 40ft flatbed (max self-weight) LC16 MAX-Destination place - Offshore Wind Y+				40ft container + 40ft flatbed (min self-weight) LC16 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	65	-95	-260	A	71	-95	-275
B	-115	-82	362	B	-108	-81	347
C	-	-	103	C	-	-	92
D	-	-	105	D	-	-	80
E	-4	-65	-38	E	-12	-69	-61
F	53	-95	158	F	50	-92	149
40ft container + 40ft flatbed (max self-weight) LC17 MAX-Destination place - Offshore Wind X+				40ft container + 40ft flatbed (min self-weight) LC17 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	16	-7	26	A	21	-6	17
B	13	6	39	B	19	6	21
C	-	-	97	C	-	-	76
D	-	-	102	D	-	-	78
E	69	24	91	E	61	20	72
F	60	-24	78	F	56	-20	66
40ft container + 40ft flatbed (max self-weight) LC18 MAX-Destination place - Offshore Wind Y+				40ft container + 40ft flatbed (min self-weight) LC18 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-117	90	332	A	-111	91	323
B	60	83	-237	B	67	83	-257
C	-	-	98	C	-	-	76
D	-	-	119	D	-	-	106
E	73	98	189	E	65	94	172
F	-17	66	-72	F	-21	69	-88

10ft container (CROSSWIND)							
Ultimate Limit State: LC15-LC18 - destination place (Offshore)							
10ft container (max self-weight) LC15 MAX-Destination place - Offshore Wind X+				10ft container (min self-weight) LC15 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-28	16	32	G	-24	13	28
H	-8	-14	-1	H	-7	-11	-1
I	6	-25	38	I	2	-21	26
J	-7	23	22	J	-8	19	17
10ft container (max self-weight) LC16 MAX-Destination place - Offshore Wind Y+				10ft container (min self-weight) LC16 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-19	0	4	G	-15	-4	0
H	-7	-26	13	H	-6	-23	13
I	21	-30	39	I	16	-26	27
J	6	7	36	J	4	3	31
10ft container (max self-weight) LC17 MAX-Destination place - Offshore Wind X+				10ft container (min self-weight) LC17 MIN-Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-4	6	2	G	1	3	-2
H	6	-10	0	H	7	-7	1
I	27	-16	38	I	22	-12	56
J	8	19	21	J	7	15	16
10ft container (max self-weight) LC18 MAX-Destination place - Offshore Wind Y+				10ft container (min self-weight) LC18 MIN-Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
G	-23	28	35	G	-18	25	30
H	-2	2	-17	H	-1	5	-17
I	21	-10	60	I	17	-6	48
J	3	29	13	J	2	25	8

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach).

Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision	JTA	26-06-2025
Released	ASM	26-06-2025

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General arrangement

WEIGHT	SIZE	SHEET	SCALE	PART NUMBER:	REVISION
25596124 g	A1	14/14	1:30	601456B	10

1st angle projection

Section C

System Data

Sub Section C07

Cause and Effects Charts

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	3/10/2023	First Issue
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003	9/15/2025	Updated, As build

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DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - Cause and Effects Charts**
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Short Title	C07 – Cause and Effect Matrix
Full Title	Cause and effect Matrix for the primary control system for the Fuel Cell container (1MW) for Crosswind Baseload Power Hub

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	PBL	March 2023
2.0	Revision according to comments to K559-2254-CWIWP4202202-C07-001Rev001 Rework from fishbone diagram to C&E matrix	PBL	April 2023
3.0	Update to As-built documentation	PBL	Sept 2025

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1.0 Purpose

The purpose of this document is to provide a cover sheet and explanation of the cause-and-effect matrix attached to this document (Appendix 1).

This diagram illustrates the causal relationship between events that may occur, the inputs registering these events and the resulting effect this will have on the entire fuel cell system, as seen from outside the container.

All specific technical details and further description of causes and effect will be found in the referenced documents.

The reader should refer to this diagram while reading this document.

2.0 References

Table 1: Reference Documents

Document ID	Short ID	Document Title	Source
K559-2254-DM-PRO-001	n/a	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-C03-001	C03	Process and Instrumentation Diagrams	BPSE
K559-2254-CWIWP4202202-C06-001	C06	Electrical Single Line Diagram	BPSE
K559-2254-CWIWP4202202-C08-002	C08-002	FC Package Modbus Map	BPSE
K559-2254-CWIWP4202202-C08-003	C08-003	FC Package Alarm List	BPSE
K559-2254-CWIWP4202202-E06-001	E06	Computer System Documentation	BPSE

3.0 Appendix

Table 2: Appendix Documents

Document ID	Short ID	Document Title	Source
601456B-C07-A1	Appendix 1	Cause and Effect Matrix	BPSE

4.0 Safety

4.1 Introduction

The safety system of the fuel cell system container is physically separate safety rated control system, monitoring the essential safety parameters of the container.

The safety system is powered from an independent 24V supply with battery backup, with a UPS duration exceeding 30 minutes. The primary safety system is located in the control cabinet inside the 40ft container (=LB02+UC30) with a secondary connected safety controller located in the 10ft container (=LB02+UC31) with a safety rated interconnect.

4.2 Safety System Hardware

Please refer to document E06 Computer System Documentation

4.3 Tripping the Safety System

The entire fuel cell system will trip if any single of the inputs to the safety controller is outside acceptable parameters, e.g. hydrogen detection, E-Stop activation or external trip. These are further described in section

"5.0 Cause – Safety".

4.4 System Safe State

The system safe state is defined as the state where sources of energy has been disconnected (gas, electricity) and the process stopped.

- Hydrogen valves are de-energized and shut (normally closed)
- Power converters Safe Torque-Off function is activated.
    - This applies to fuel cell DCDC converters and main DCAC converter.
- Motor drives Safe Torque-Off function is activated.
    - This applies to coolant system pumps.
- Main breaker is opened.
    - Disconnect from the BLPH 6,6kV grid.
- Fuel Cell Modules emergency stop is activated.
    - Closes module internal H2 valves and opens contactors for the fuel cell module.

5.0 Cause – Safety

The section describes the causes related to the safety system.

5.1 Hydrogen Detection

The 40ft container has the following hydrogen sensors:

- 3 Sensors located inside the container, monitoring the inlet and outlet of the ventilation air.
- 2 Sensor inside each FCwave module (12 total), monitoring the hydrogen concentration in the ventilation air

5.2 Fire detection

The 40ft container has the following fire detection sensors:

- 3 smoke detectors inside the container, monitoring the inlet and outlet of the ventilation air.

- Each FCwave module contains an internal smoke detector and linear heat detector.

The 10ft container contains the following fire detection sensor:

- A smoke detector inside the container.

5.3 Emergency Stop

The hardwired emergency stop locations are:

- Control cabinet inside 40ft container
- Inside access door for the 40ft container
- On control panel door for coolant skid control panel

5.4 Physical protection

The access to the 10ft container must be safely restricted, as the container internally has IP00 rated high voltage equipment.

The container end door to the 10ft container is equipped with non-contact safety switches.

6.0 Cause – Fuel Cell Modules and Power Converters

6.1 Introduction

The 6 fuel cell modules inside the 40ft container and the power conversion equipment inside the 40ft and 10ft container may be the cause of derates or loss of production.

6.2 FCwave Internal Warning or Alarm

- The FCwave modules provides a warning when a process parameter is at the edge of allowable parameters.
- FCwave modules may perform a controlled shutdown if a process parameter exceeds allowable limits. This will reduce the maximum available power by 1/6 of the total power. The remaining 5 modules will continue operating.

6.3 DCDC Converter Trip

- Each of the 6 FCwave modules are connected to a pair of DCDC converters managing the power flow from individual modules to the common DC bus.
- If a converter trips, the connected FCwave module is also unavailable for power production. This will reduce the maximum available power by 1/6 of the total power. The remaining 5 modules will continue operating.
- This may be caused by e.g., insufficient cooling.

6.4 DCAC Converter Trip

- The power produced by the fuel cell modules is converted to AC power by a single DCAC power converter, which may also trip offline.

7.0 Cause – Coolant

7.1 Introduction

The coolant systems responsible for rejecting the heat generated by the fuel cell modules and power converters may be unable to dissipate the desired amount of heat or fail entirely

The two coolant systems are designated HT1 and HT2:

- HT1 is responsible for cooling FC1-3
- HT2 is responsible for cooling FC4-6

7.2 HT Coolant Group Derate

3 FCwave modules share a coolant system, which will reduce the power available from the modules if the cooling system is unable dissipate the heat.

- Fan failure
    - A failed fan on the HT cooler will reduce the total available cooling capacity. On days where the full cooling capacity is needed (high ambient temperatures), this may derate the cooling group and subsequently derate the available power from the modules connected to the cooling group.
- Valve failure
    - A valve may fail stuck in a given position and cause reduced cooling capacity.
- Temperature sensor failure
    - A temperature sensor may fail, hindering the control system from correctly regulating the coolant group.
- Coolant Radiator Blockage
    - The radiator fins on the radiators may be blocked by debris or damaged, hindering heat dissipation.

7.3 HT Coolant Group Loss

Some failure scenarios will prevent the coolant group from operating, and prevent the connected FCwave modules from operating, causing the power available from the container to be derated to half

- HT Pump Failure
    - If the pump driving the coolant loop fails, the coolant group is unable to dissipate any heat from the attached modules.
- Loss of coolant media
    - If a damaged or burst hose or pipe causes total loss of the coolant media, the cooling group is unable to function.
- Valve failure
    - If a valve fails stuck in certain positions, the flow of coolant through the cooler is prevented and the coolant group is unable to function.
- Fan failure
    - Fan failures may prevent correct airflow over the cooling surfaces or insufficient air flow at high ambient temperatures.

7.4 LT Coolant Group Derate

The LT coolant system provides liquid cooling to power electronics in the container and FCwave modules. If this coolant system cannot dissipate the required heat, the container will need to derate its output.

- Fan failure
    - A failed fan on the LT cooler will reduce the total available cooling capacity. On days where the full cooling capacity is needed (high ambient temperatures), this may derate the cooling group and subsequently derate the available power from the modules connected to the cooling group.

- Valve failure
    - A valve may fail stuck in a given position and cause reduced cooling capacity.
- Temperature sensor failure
    - A temperature sensor may fail, hindering the control system from correctly regulating the coolant group.
- Coolant Radiator Blockage
    - The radiator fins on the radiators may be blocked by debris or damaged, hindering heat dissipation.

7.5 LT Coolant Group Loss

Some failure scenarios will prevent the LT coolant group from operating, and prevent the fuel cell modules and power electronics from working.

- LT Pump Failure
    - If the pump driving the coolant loop fails, the coolant group is unable to dissipate any heat from the attached modules.
- Loss of coolant media
    - If a damaged or burst hose or pipe causes total loss of the coolant media, the cooling group is unable to function.
- Valve failure
    - If a valve fails stuck in certain positions, the flow of coolant through the cooler is prevented and the coolant group is unable to function.
- Fan failure
    - Fan failures may prevent correct airflow over the cooling surfaces or insufficient air flow at high ambient temperatures.

7.6 Process Water Drain Blockage

The process water drain serves as the drain for the water produced by the fuel cell modules during operation.

If this drain is blocked, the fuel cell package cannot operate. The most probable cause is a blockage in the downstream drain system.

8.0 Cause – Ventilation

8.1 Introduction

The ventilation system provides air for the container ventilation and process air for the fuel cells. The ventilation system maintains the interior of the fuel cell container at 20 Pa above ambient pressure.

If insufficient air is available, the fuel cell package will derate or shut down.

8.2 Ventilation Derate

If the ventilation system is unable to provide the full amount of air required for correct operation, the package will attempt to remain operational by derating the available power. Many ventilation derate functions are impacted by higher ambient temperatures.

- Intake damper blockage
    - The intake dampers may be blocked or stuck, preventing sufficient airflow.

- Intake ventilation failure
    - One or more of the intake ventilators may fail to operate, limiting the available air flow.
- Outlet louvre blockage
    - The ventilation outlets may be blocked, preventing egress of the ventilation air.
- Air filter blockage
    - The filters maintaining the air quality inside the container will get clogged over time, restricting the available airflow.

8.3 Ventilation Failure

Many of the causes for ventilation derate may progressively cause a ventilation failure, exacerbated by high ambient temperatures.

9.0 Cause – Integrator

9.1 Introduction

The connections to the integrator (BLPH) are required for correct operation of the fuel cell package. An exception may exist for the Aux supply connection during operation.

9.2 Integrator Aux Supply Failure

If the supply from the integrator is interrupted, one of two events will occur:

1. If the 6.6kV connection is not active, the fuel cell package is able to continue operating on battery supplies for a limited time. An alarm is raised to the BLPH control system.
2. If the 6.6kV connection is active, the fuel cell package will continue operating, supplied off the fuel cell power train. A warning is raised to the BLPH control system.

9.3 Integrator Communication Failure

If the communication is lost to the integrator (BLPH), the fuel cell package will perform a controlled shutdown and enter an idle state.

9.4 Integrator Safety Connection Failure / Trip

If the safety interlock is disabled or wires broken, the safety system is activated. This is also the case when it is intentionally triggered.

10.0 Effects - Safety

10.1 Introduction

This section describes the effects managed by the safety system, which will be caused by some of the abovementioned causes.

10.2 Fuel Cell Module Safety Trip

The fuel cell modules can be brought to a guaranteed safe state where energy sources are disconnected and the reaction is immediately stopped.

10.3 Hydrogen Valve Safety Override

The safety system has a safety-rated relay as a part of the supply to the solenoid valves, which enables the safety system to override and guarantee that the hydrogen valves are shut.

10.4 Power Converters STO

The safety system is connected to the Safe Torque-Off (STO) function on the power converters, which is a safety rated way of guaranteeing the power converters are shut down.

10.5 Motor Drives STO

The safety system is connected to the Safe Torque-Off (STO) function on the motor drives, which is a safety rated way of guaranteeing the drives are shut down.

11.0 Effects – Hydrogen Valve

11.1 Introduction

The hydrogen valves located on the outside of the container are electrically actuated, and of the normally-closed type.

11.2 Hydrogen Valves

Each of the 6 FCwave modules has a separate hydrogen string, with each string having a pair of direct acting solenoid valves in series. Each string is also fitted with a manual, lockable shutoff fitting.

12.0 Effects – FCwave Fuel Cell Modules

12.1 Introduction

This section describes the effects from the fuel cell modules, which may be derated or stopped, with a single module or multiple modules.

12.2 FCwave – Single Module Controlled Stop

Some causes may result in a single module performing its controlled stop sequence, where it signals stop of power production, ramps down and disconnects from the DC bus and H2 supply.

12.3 FCwave – Multiple Modules Controlled Stop

Some causes may result in multiple modules doing a controlled stop simultaneously. This is identical to the effect above but occurs for multiple modules.

12.4 FCwave – All Modules Controlled Stop

Some causes may result in all modules stopping. This is identical to the effect above but occurring for all modules.

12.5 FCwave – Single Module Derate

Some causes may result in a single module derating its output, until all process parameters return to normal ranges. The limited power productions is communicated to the package control system.

12.6 FCwave – Multiple Modules Derate / All Modules Derate

Some causes may result in multiple modules derating their output, e.g. high coolant temperatures.

13.0 Effects – Power Converters

13.1 Introduction

The power converters primary function is to control and condition the power from the fuel cells to match the power requested from the BLPH. The power converters require cooling to continue operating.

13.2 Power Converter Derate

Some causes limit the amount of cooling available for the power converters, which in turn limits their available performance. Inside the fuel cell package, there are both liquid and air-cooled power converters.

13.3 Power Converter Stop

The power converters may be stopped entirely if they reach a protection value or cooling is not available for them.

14.0 Effects – Integrator

14.1 Introduction

This section describes the signals and effects directly communicated to the integrator.

Please refer to documents C08-002 and C08-003 (*FC Package Modbus Map* and *FC Package Alarm List*) for details on the communication.

14.2 Information

The fuel cell package will communicate to the integrator when an internal situation occurs, which does not require action from the integrator, but would be of interest. This would be events such as warnings from the fuel cell modules or derate information due to coolant or temperature issues.

Communication method is Modbus connection.

14.3 Alarm Information

The fuel cell package will communicate to the integrator when an internal alarm has occurred, and some or all fuel cell modules are unable to function.

Communication method is Modbus connection.

14.4 Safety Trip

The fuel cell package will communicate any eventual safety system trip to the integrator.

Communication method is hardwired connections.

14.5 Power Output – Derate

If internal components are derating their performance, this is communicated to the integrator as a reduction in the total amount of power available.

Communication method is Modbus connection.

14.6 Power Output – Loss of production

If an internal fault prevents the fuel cell package from producing any power, this is communicated to the integrator.

Communication method is Modbus connection

					Safety					Hydrogen	FCwave						Power Converters		Integrator				
Control System	**Segment**	**Sensors**	**Cause**	**Effect**	**FCwave All Modules Safety Trip**	**Hydrogen Valve Safety Override**	**Power Converters STO**	**Motor Drives STO**	**Main Breaker Trip Coil**	**Hydrogen Valves Closed**	**FCwave Single Module Controlled Stop**	**FCwave Multiple Modules Controlled Stop**	**FCwave All modules Controlled Stop**	**FCwave Single Module Derate**	**FCwave Multiple Modules Derate**	**FCwave All Modules Derate**	**Power Converter Derate**	**Power Converter Stop**	**To Integrator - Information**	**To Integrator - Alarm Information**	**To Integrator - Safety Trip**	**Power Output - Derate**	**Power Output - Loss of production**
Safety	Hydrogen	=JA01+DA01+BQ01..03 =RE01+GB01..03-SAFE_H2 =RE02+GB04..06-SAFE_H2	**Hydrogen Detection**		X	X	X	X	X	X (2)											X		X
Safety	Ventilation	=JA01+DA01-BQ04..BQ06 =JA01+DA03-BQ01 =RE01+GB01..03-SAFE_FIRE =RE02+GB04..06-SAFE_FIRE	**Fire Detection**		X	X	X	X	X	X (2)											X		X
Safety	Safety	=LA01+UC20-SG01	**Emergency Stop**		X	X	X	X	X	X (2)											X		X
Safety	Container	=LB02+DA03-BG01..02	**Physcial Protection (Door Sensors)**		X	X	X	X	X	X (2)											X		X
MCU	FCM	=RE01+GB01..03-MCU =RE02+GB04..06-MCU	**FCwave Module Internal Warning**											X (5)					X				
MCU	FCM	=RE01+GB01..03-MCU =RE02+GB04..06-MCU	**FCwave Module Internal Alarm**								X									X		X	
MCU	Power Converters	=BA01+UC01-TA01..02 =BA01+UC02-TA03..04 =BA01+UC03-TA05..06 =BA02+UC04-TA07..08 =BA02+UC05-TA09..10 =BA02+UC06-TA11..12	**DCDC Converter Trip**								X							X	X			X	
MCU	Power Converters	=BA03+DA03-TB30	**DCAC Converter Trip**							X			X					X		X			X
MCU	Coolant	=HE01+DA01-<all> =HE01+DA02-<all> =HE02+DA01-<all> =HE02+DA02-<all>	**HT Coolant Group Derate**												X (4)				X			X	
MCU	Coolant	=HE01+DA01-<all> =HE01+DA02-<all> =HE02+DA01-<all> =HE02+DA02-<all>	**HT Coolant Group Loss**									X (4)								X		X	
MCU	Coolant	=HE03+DA01-<all> =HE03+DA04-<all>	**LT Coolant Group Derate**													X	X		X			X	
MCU	Coolant	=HE03+DA01-<all> =HE03+DA04-<all>	**LT Coolant Group Loss**							X			X					X		X			X
MCU	Ventilation	=JA01+DA01-QM01 =JA01+DA01-QM02 =JA01+DA01-GQ06 =JA01+DA01-GQ07	**Ventilation Derate**													X	X (1)		X			X	
MCU	Ventilation	=JA01+DA01-QM01 =JA01+DA01-QM02 =JA01+DA01-GQ06 =JA01+DA01-GQ07	**Ventilation Failure**							X			X					X (1)		X			X
MCU	Coolant	=JB01+DA01-BL01	**Process Water Tank Full / Drain blocked**							X			X							X			X
MCU	Integrator	=BA20+UC20-XB01	**Integrator Aux Supply Failure (3)**																	X	X		
MCU	Integrator	=LA01+UC30-XG01	**Integrator Communication Failure**							X			X					X		X			X
Safety	Integrator	=LB02+UC30-XD03	**Integrator Safety Connection Failure / Trip**		X	X	X	X															X
MCU	Hydrogen	=HA01+DA02-BT01	**Hydrogen Supply Outside Spec**							X			X							X			X

1: Some power converters are air cooled.
2: See also column H - Valve Override
3: While supplied from the 6.6kV connection, this is warning. If 6.6kV is not connected, this causes an Alarm.
4: HT1 Coolant system is relevant for FC 1-3, HT2 Coolant System is relevant for FC 4-6
5: Only some warnings cause derate, see C08-003

Sub Section C99-001

Hydrogen Safety Concept

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Revision history		
Rev.	**Date.**	**Description**
001	10/05/2023	First official issue
002	16/04/2024	Updated to include H2 Pre-heater

Document Title:	**Megablock Hydrogen Safety Concept**
Document Number:	K559-2254-CWIWP4202202-C99-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-C99-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Megablock Hydrogen Safety Concept
Full Title	Introduction to Hydrogen Safety Concept for Ballard Megablock Solution
Abstract	This document provides an introduction to the hydrogen safety concept employed in the Ballard Megablock solution. This document documents the location of hydrogen manifolds, valves and couplings, and how the safety is handled for each (the Safety Concept). This document does not describe other parts of the safety for the Megablock, such as electrical safety and personal protective means. The fuel cell module (Ballard FCgen 200kW Fuel Cell Module) has an internal hydrogen safety concept, which is also described.

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Revision Record

Rev #	Description	Revised By	Date
0.1	Initial draft	EZE	April 2023
1.0	First official release	PBL	April 2023
2.0	Update to include hydrogen heater	PBL	April 2024

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1.0 Purpose and Scope

The purpose of this document is to introduce the hydrogen safety concept employed in the Ballard Megablock solution. This document will document the location of hydrogen manifolds, valves and couplings, and how the safety is handled for each (the Safety Concept).

This document does not describe other parts of the safety for the Megablock, such as electrical safety and personal protective means.

The fuel cell module (Ballard FCgen 200kW Fuel Cell Module) has an internal hydrogen safety concept, which will also be described.

The reader is expected to have basic familiarity with gas safety and hydrogen safety.

2.0 References

Table 1: Reference Documents

Document ID	Document Title	Source
IEC 62282-3-100:2020	Stationary Fuel Cell System – Safety	IEC
K559-2254-CWIWP4202202-C03-001	BLPH Project – P&IDs	BPSE
B01	BLPH Project – General Arrangement	BPSE
Directive 2014/34/EU	ATEX Directive	European Commission

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3.0 Hydrogen Supply Overview

3.1 Introduction

This section provides an overview of where hydrogen is supplied to the Megablock, how it is transported to the fuel cell system and how the fuel cell modules handle hydrogen safety. Each of these items is described in further details in following sections.

3.2 Hydrogen Flow

The hydrogen flow for the Megablock container is illustrated in Figure 1, below:

Figure 1: Hydrogen Overview for the Megablock Container

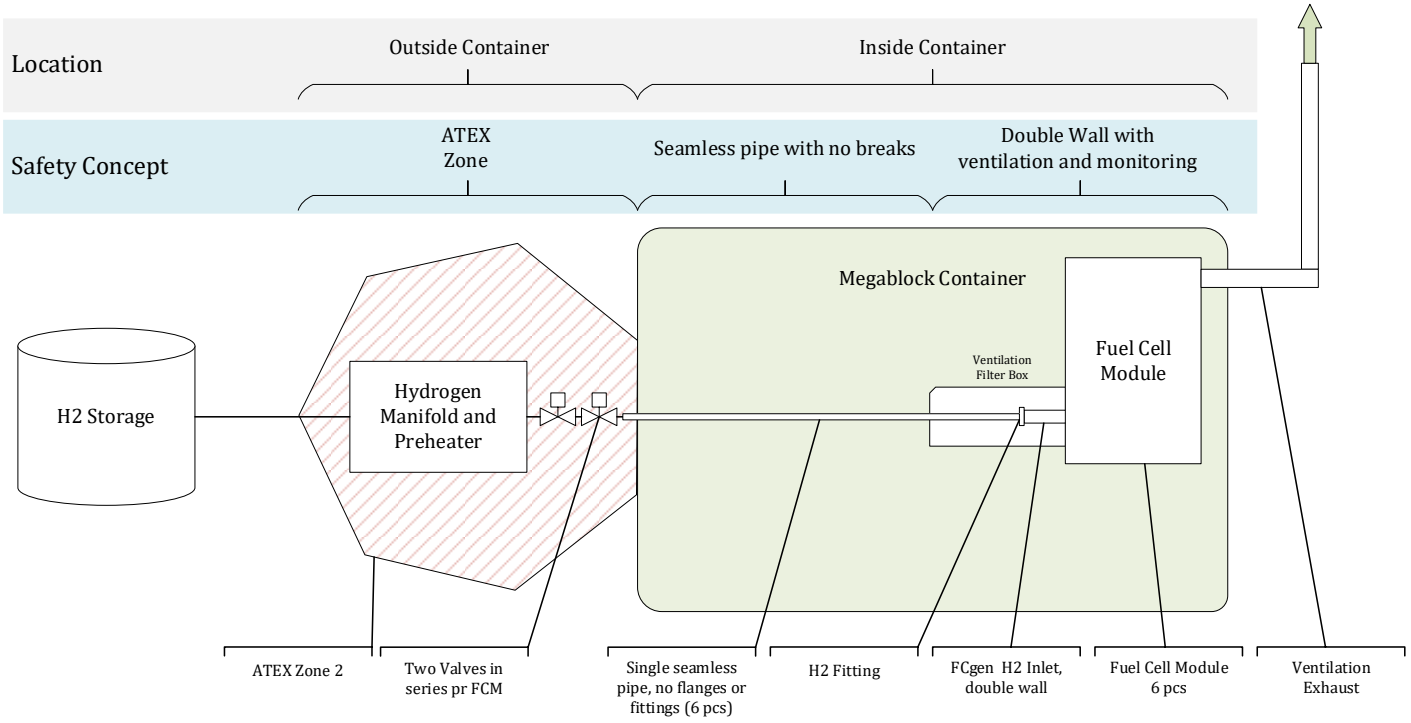


Illustration of the components in the hydrogen supply for the Megablock and the safety concept applicable for each segment.

The main components are:

- Hydrogen Inlet, Manifold and Preheater
  - Connection point for the hydrogen storage system.
  - Pressure transducer to monitor inlet pressure.
  - Hydrogen preheating system.

- Hydrogen Shutoff Valves
    - Direct acting solenoid valves, with each module having two in series.
- Module Supply Pipe
    - Seamless stainless-steel pipe, which carries hydrogen from the shutoff valves to the fuel cell module connection point. One pipe pr module, 6 pcs in total.
    - Pipe has no breaks or fittings outside of the Ventilation Filter Box.
- Ventilation Filter Box
    - Interface between single walled pipe inside container and dual wall inside Fuel Cell module. Ventilated and monitored space, with rapid air change. One filter box pr module, 6 in total.
- Fuel Cell Module
    - FCgen Fuel Cell Module.
    - Contains internal double-wall hydrogen containment system with rapid air changes and dual hydrogen detection sensors.

3.3 Overview Drawings

Better CAD Drawings

4.0 Safety Concepts

This section describes the different safety concepts applicable to parts of the hydrogen supply system for the Megablock.

4.1 ATEX Zone

For an ATEX zone, the safety concept is to follow the recommendations and requirements laid out in the Directive 2014/34/EU, commonly known as the ATEX directive. This results in all electrical components inside the zone having the “EX” marking, covering the zone class, gas type and expected temperature.

4.2 Seamless piping with no breaks

The piping between the ATEX zone and the ventilation filter box is a stainless-steel pipe with no fittings or other breaks between the ATEX zone and the controlled space in the

4.3 Double wall with ventilation and monitoring

The double wall concept is based around the idea of surrounding the hydrogen carrying pipe with a secondary pipe, with the space between the primary and secondary pipe being ventilated and a hydrogen detector measuring the hydrogen concentration. In this case, a leakage is drawn past the detectors by the ventilation air stream.

5.0 Hydrogen Supply Interface and Valve Array

Please refer to document C03 Process and Instrumentation Diagrams.

The interface for the external hydrogen connection is located on the outside of the container. This hydrogen supply inlet contains a pressure transducer and a distribution manifold to the valve array.

The valve array is comprised of two shutoff valves in series for each fuel cell module, providing a redundant method of interrupting the hydrogen supply to the individual modules. There is also installed a manual lockable shutoff fitting for each fuel cell module, facilitating lock-out, tag-out procedures before maintenance activities on the fuel cell modules.

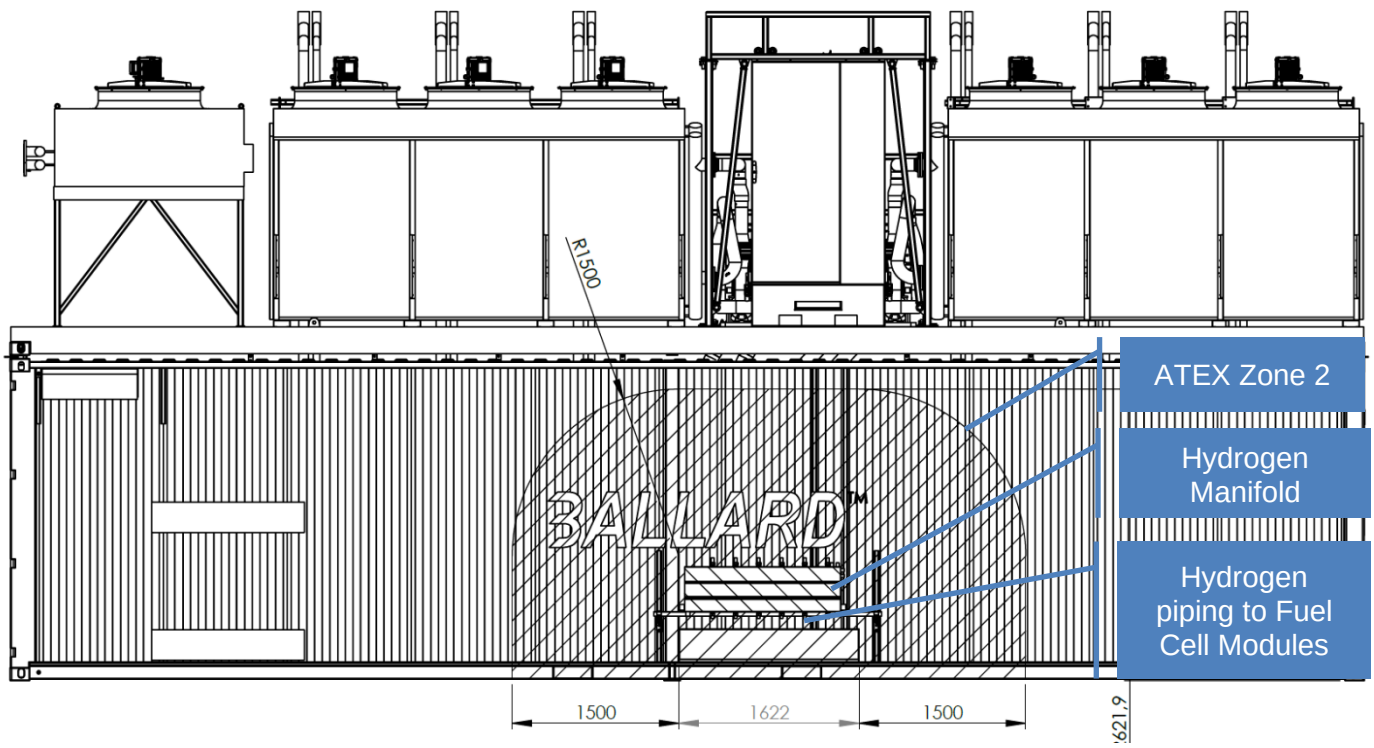
5.1 Hazardous Zone surrounding the Hydrogen Supply Interface and Valve Array

The area surrounding the hydrogen supply interface and the valve array is classified as ATEX Zone 2, where a hazardous mixture will not likely be present in normal operation, and if so, only for a short period.

The document describing the hazardous zone extent is K559-2254-CWIWP4202202-E99-002, with excerpts reproduce below in Figure 2.

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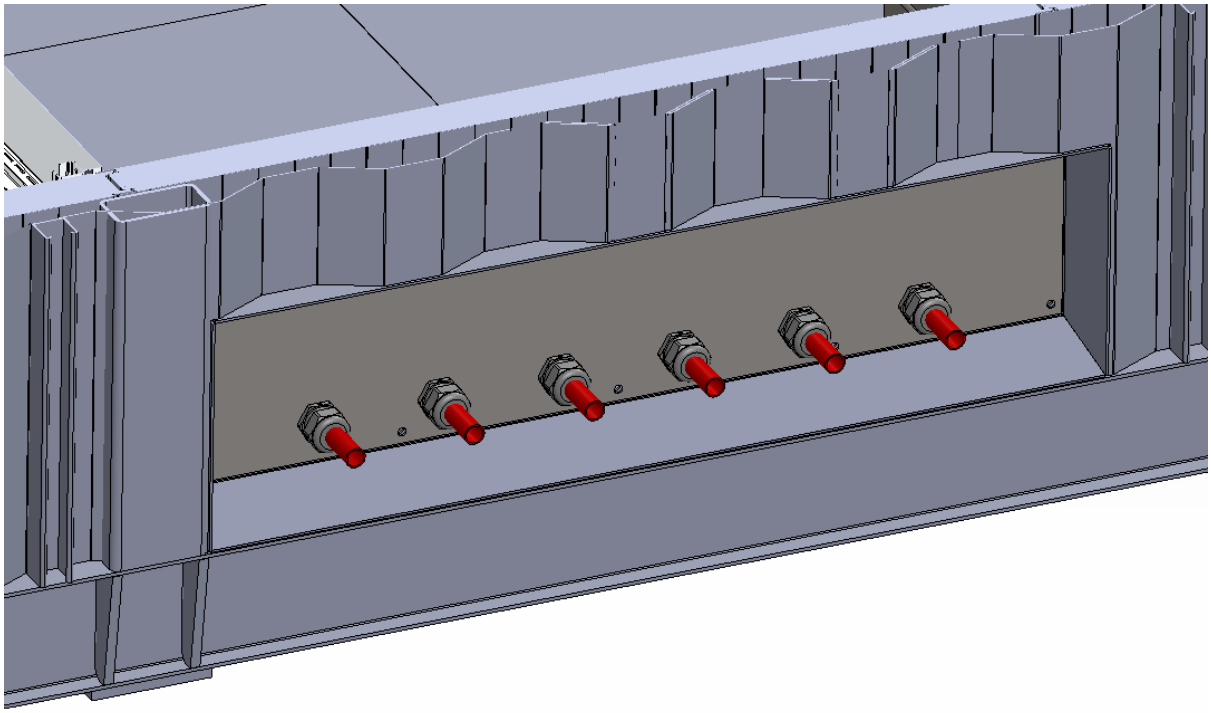
Figure 2: Hazardous Area



*Hazardous area on one side of the 40ft container (opposite air intake). Hydrogen intake and manifold shown above hydrogen piping to the fuel cell modules. Taken from **B01 General Arrangement**.*

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Figure 3: Hydrogen Piping – Container Entry



The piping entry into the container is show here, with the 6 hydrogen pipes shown in red. Each pipe is fixated with Ex-rated pipe gland.

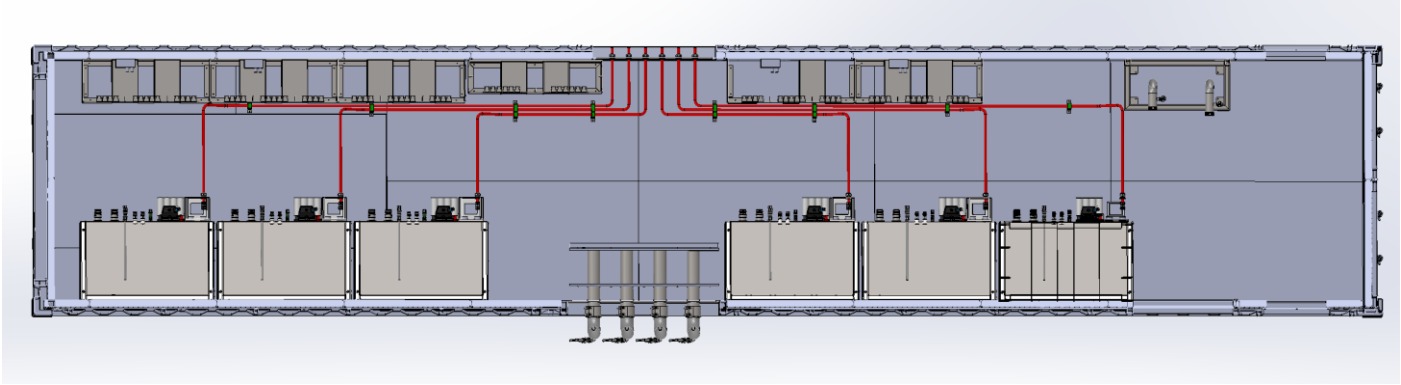
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6.0 Hydrogen Piping to Fuel Cell Modules

The hydrogen is transported from the hydrogen supply interface and the valve array to the fuel cell module in individual, seamless pipes with no breaks or fittings outside the controlled area of the valve array and the ventilation filter box (see section 7.0 Interface to Fuel Cell Module)

The routing of the hydrogen piping is illustrated in Figure 4: Hydrogen Piping.

Figure 4: Hydrogen Piping



Top down view of the 40ft container, with the piping between the valve array and the fuel cell module interface shown, highlighted in red.

The piping is placed below a metal grating floor, protecting it from impacts and incidental damage.

7.0 Interface to Fuel Cell Module

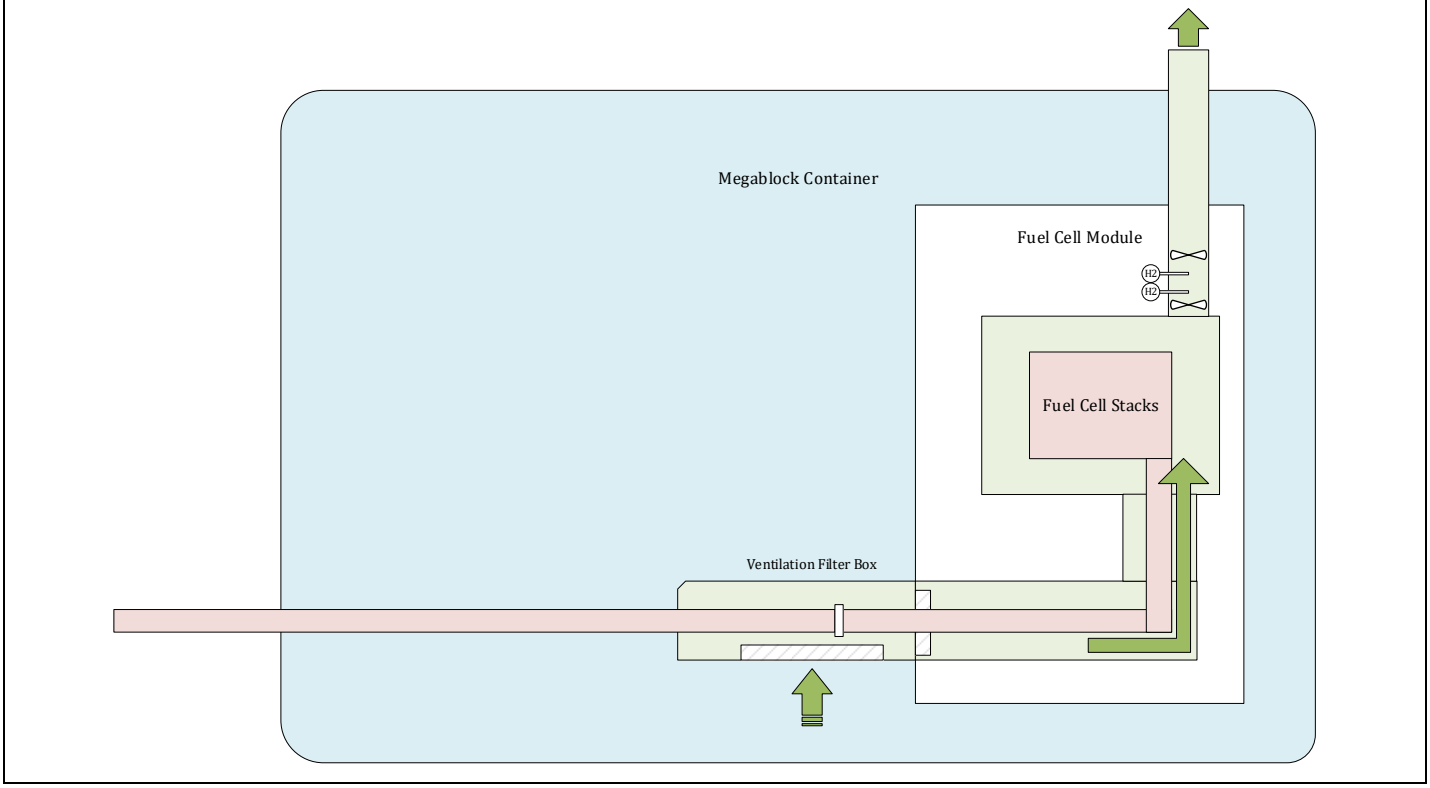
The hydrogen piping interface to the fuel cell module is a connected with double compression ring fitting, contained in a double wall shell, ventilated and monitored, as described in section “4.3 Double wall with ventilation and monitoring”.

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7.1 Ventilation Filter Box

The connection between the hydrogen piping and the fuel cell module is contained in the ventilation filter box, with the concept shown in Figure 5.

Figure 5: Ventilation filter box with airflow indications



Concept drawing for the ventilation filter box. Air is drawn in through the bottom of the filter box and drawn past all hydrogen containing components by redundant fans. The airstream is monitored by two hydrogen detectors

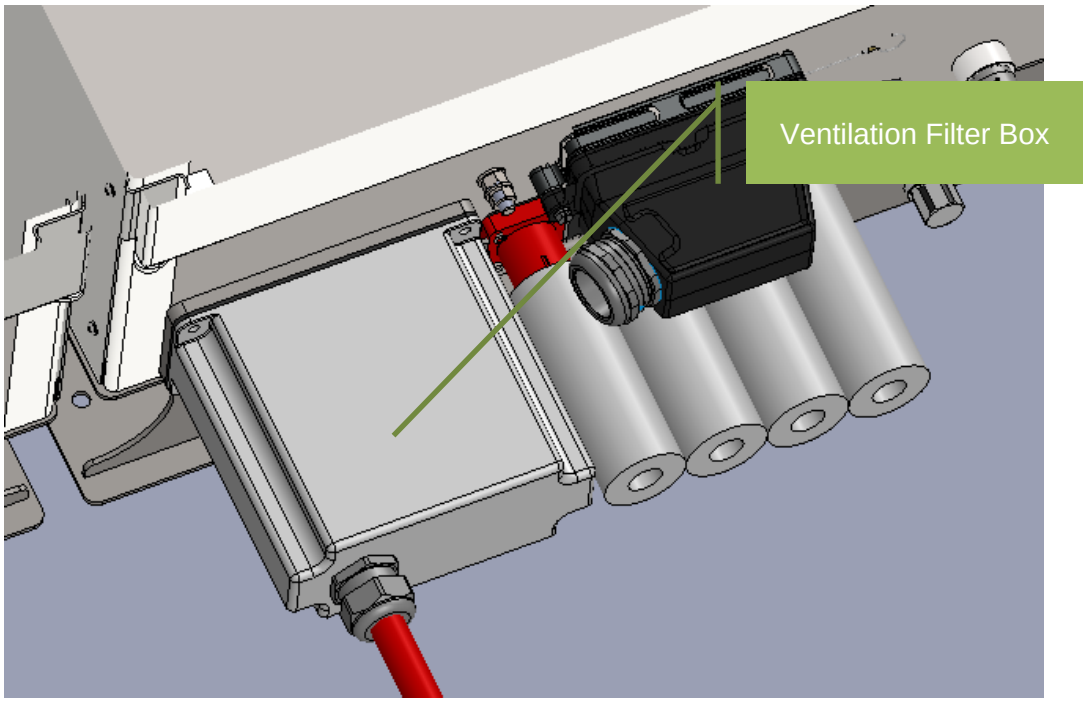
This box is shown in Figure 6 and as a cutaway in Figure 7. The pipe fitting connecting the pipe from the module to the supply pipe is shown in Figure 8.

The ventilation filter box serves the following purpose:

- Enclosure around the hydrogen fitting, enclosing the possible leakage point.
    - Kept at lower than ambient pressure by the module ventilation fans.
    - Airflow over the fitting is carried past module hydrogen sensors, detecting leakages.
- Filter the incoming air
    - Prevents buildup of dust and debris.

- Filter is located on the bottom of the box.

Figure 6: Ventilation Filter Box



The ventilation filter box, mounted of the front of the fuel cell module. Pipe gland fixates pipe to box structure. Air intake at the bottom of the box.

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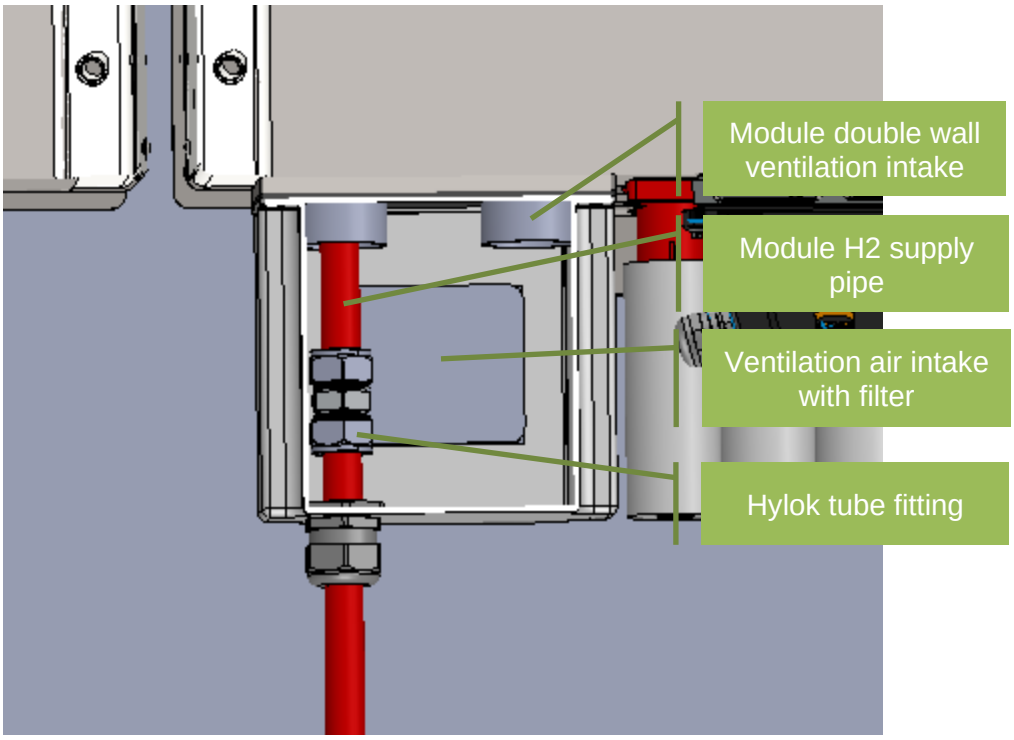
7.2 Ventilation Filter Box internal contents

The internal contents of the ventilation filter box is shown in Figure 7, below:

The air flow path is:

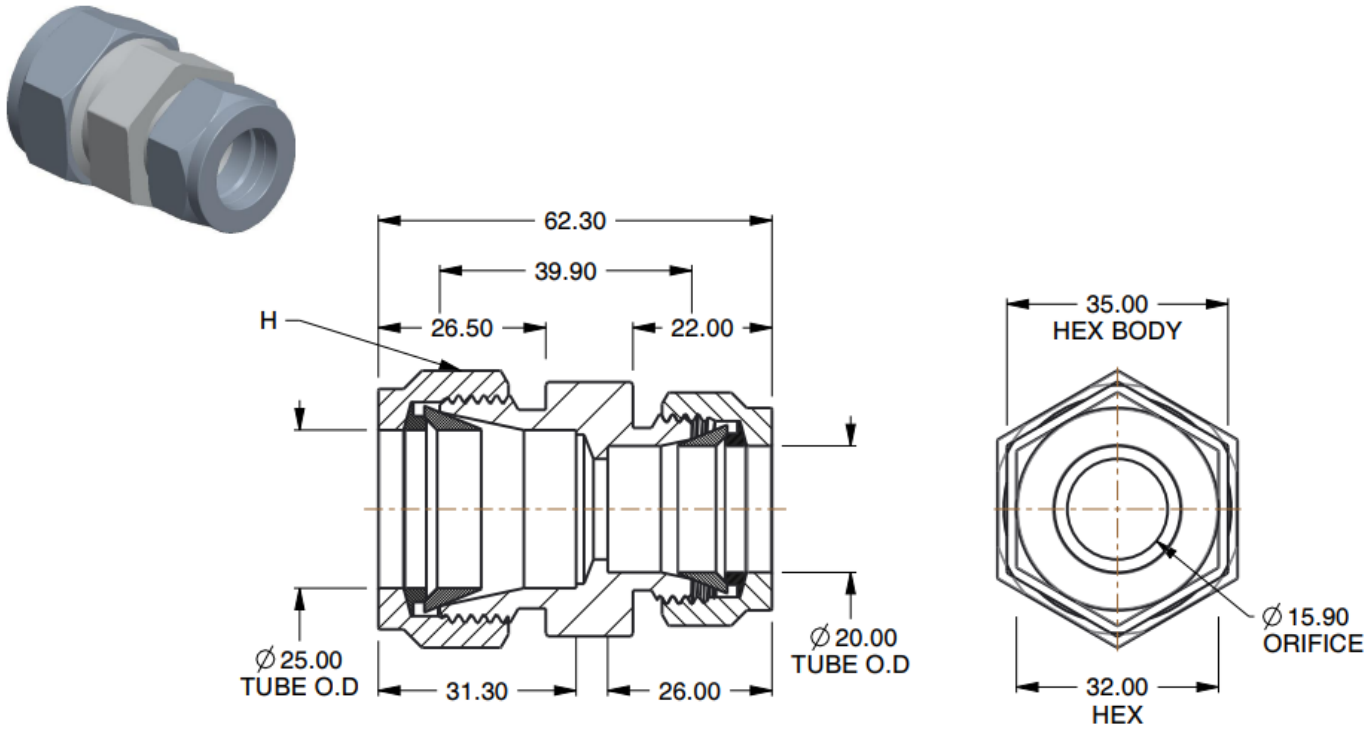
1. Air is drawn in through ventilation air intake through filter.
2. Air is drawn through the module double wall ventilation intake
3. Inside module, air is drawn past all hydrogen containing components (pipes, Valveblock and fuel cell stacks)
4. Redundant fans draw air out of the double wall structure and exhaust it to the module ventilation exhaust.
5. Hydrogen sensors are placed in the ventilation exhaust, monitoring the airstream for leakages.

Figure 7: Ventilation Filter box cutaway



Top-down cutaway view of the ventilation filter box, showing the hydrogen connection fitting and ventilation intake with module air inlet

Figure 8: Double compression ring reducing fitting



Mechanical drawing of double compression ring fitting for hydrogen. Reducing union from 25 to 20 mm OD shown. Material is SS316.

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8.0 Fuel Cell Module

The FCwave™ has 3 levels of safety:

1. Safety in normal operation
    a. Ventilation of hydrogen enclosure volume to prevent any build-up of hydrogen to a combustible level.
2. Safety in probable leakage scenarios
    a. Supervision of the fuel cell and shutting off hydrogen supply in the event of unsafe conditions.
3. Safety in catastrophic events
    a. Encapsulation in the event of a hydrogen explosion.

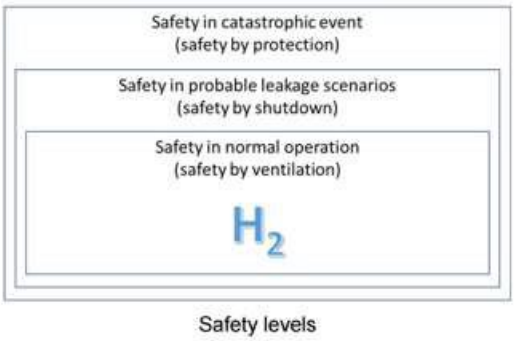


Figure 9. Safety levels of the FCwave™

Safety measures in place:

- Active ventilation through the enclosure
    - 100% redundant ventilation fan
    - No dead pockets for hydrogen – verified with CFD analysis
    - Ventilation flow monitored by safety controller
    - Flow switch
    - Tacho feedback from fans
- Negative pressure inside the enclosure
    - Differential pressure sensor
    - Enclosure sealed with a gasket at all possible openings
- Twin hydrogen sensors (range 0-4%) in ventilation air connected to:
    - Fuel cell controller
    - Safety controller

9.0 Container Hydrogen Detection

The container itself contains hydrogen sensors to detect hydrogen leakages.

The three hydrogen detectors are located at the following locations:

- Container Ventilation intake
    - Sensor located at the ventilation intake of the container and midpoint.
- Container ventilation outlet
    - Two sensors, one at each end of the container at the container ventilation outlets.

The ventilation outlet sensors detect and alarm in case of internal leakages. If a leakage is detected, the safety system shuts off the hydrogen supply valves and trigger emergency shutdown of the fuel cell modules and power converters inside the module.

See document “C07 Cause and Effect Charts” for details.

10.0 External Hydrogen Hazard

One hazard that the container can detect but not mitigate, is an external release of hydrogen impinging on the container and being drawn in with the ventilation system.

The planned mitigations are:

- Placement of the container outside hazardous areas from gas storage systems
- Orientation of the ventilation intake system, facing away from the gas storage system
- Installation of hydrogen detector on the ventilation intake, to detect the hazard and trigger internal emergency stop if hydrogen detection exceeds limit values.

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Sub Section C99-002

Hydrogen Preheating System Impact Assessment

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Revision history		
Rev.	**Date.**	**Description**
001	02/04/2024	First official issue
002	23/01/2025	Updated according to CRS

Document Title:	**Hydrogen Preheating System Impact Assessment**
Document Number:	K559-2254-CWIWP4202202-C99-002
Revision:	Rev002
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-C99-002Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	C99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Hydrogen Preheating System Impact
Full Title	Crosswind/Baseload Power Hub Fuel Cell Hydrogen Preheating System Impact Assessment
Abstract	This document presents the hydrogen preheating system and its impact compared to excluding it. The hydrogen preheater conditions the hydrogen in cold ambient temperatures, to meet environmental specifications. For the preheater, a block diagram, functional description, and main components are outlined. Impacts are assessed for the fuel cell modules, physical plant and control system.

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Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	PBL	February 2024
1b	Update and expansion to clarify impact of proposed change on system scope	PBL	March 2024
1c	Added impact of increased pressure loss in the system due to the H2 heater	PBL	Apr 2024
2	Updates clarify to Code 2 response	PBL	Jan 2025

Checked by: MHA/ RKN	Date: 02-04-2024
Approved by: PBL	Date: 02-04-2024

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1.0 Purpose and Scope

The purpose of this document is to introduce the concept and outline the execution of the hydrogen preheating system installed on the Crosswind Baseload Power Hub Fuel Cell Package (FC Package).

The purpose of the preheating system is to condition (heat) the hydrogen gas flowing to the Fuel Cell Modules inside the FC Package.

Following the introduction of the preheating system, the impact of the inclusion or exclusion of the preheater is assessed.

2.0 Background

The Fuel Cell Modules (FCwave) use hydrogen gas to produce electricity. The intake of gas has been specified to be acceptable between 0 and 80 degrees centigrade. Initial acceptance was given to intake hydrogen gas down to -10 degrees.

Further testing from the product development team showed that stability and performance of the module internal gas regulation was impacted when the hydrogen gas was below 12 degrees.

Ballard has designed and integrated a hydrogen preheating system, which will be installed on the FC Package.

The preheating system uses a heated water bath surrounding pipe coils leading to the fuel cell modules.

3.0 Impact of the hydrogen preheating system

This section details the impact of the inclusion of the preheating system, as well as expected impact on system performance if the preheating system is not installed.

3.1 Fuel Cell Module

The primary reason for including the preheating system is to avoid a corner case for the hydrogen pressure regulation system inside the fuel cell module, which in cold media temperatures, low inlet pressure and high flow combination may oscillate and limit the maximum output of the fuel cell module.

Including the preheater ensures the corner case is avoided, and the system will provide full power in all ambient conditions.

Not including the preheater can limit the power output of the fuel cell modules in some ambient conditions and cause increased wear on the hydrogen regulation components in the fuel cell modules.

3.2 Hydrogen manifold

The hydrogen manifold is impacted by the addition of the preheater, mainly by the physical inclusion of the device. From hydrogen flow perspective, the heater is a passive flow restriction and heating device, with no ability to actively control the flow of hydrogen.

The flow restriction will add ~200 mbar of pressure droop at full flow. Considerations for expansion of trapped gas is covered in Appendix 3 – Thermal Expansion of Trapped Gas.

The mass of the hydrogen heater and the internal liquid will add approximately 200 kg to the weight of the container.

3.3 Internal control system

The control system of the FC package will control the heater, by switching on and off the heating elements inside the preheater.

This is done via solid-state contactors, which have excellent operational lifetime, even with a high number of switching cycles. The control system has been programmed, tested, and verified with previous Megablock projects.

3.4 Time to start

The startup time for fuel cell package is not impacted in a Hot Standby scenario, where the hydrogen preheater is kept at operational temperature (for power consumption, see “E14 – Load List”).

In case the fuel cell package is at cold standby, the time to readiness depends on the ambient temperature. The heater can increase its temperature at approximately 2 degrees pr minute.

From an ambient temperature of -8 (Worst case), the heater requires about 20 minutes to reach initial operating temperature.

3.5 Impact to customer

The hydrogen heater materials and engineering is added as an integrated part of the FC package by Ballard.

The hydrogen interface point shifts from the no-heater position to the with-heater location. This is covered by existing TQs.

3.6 Service

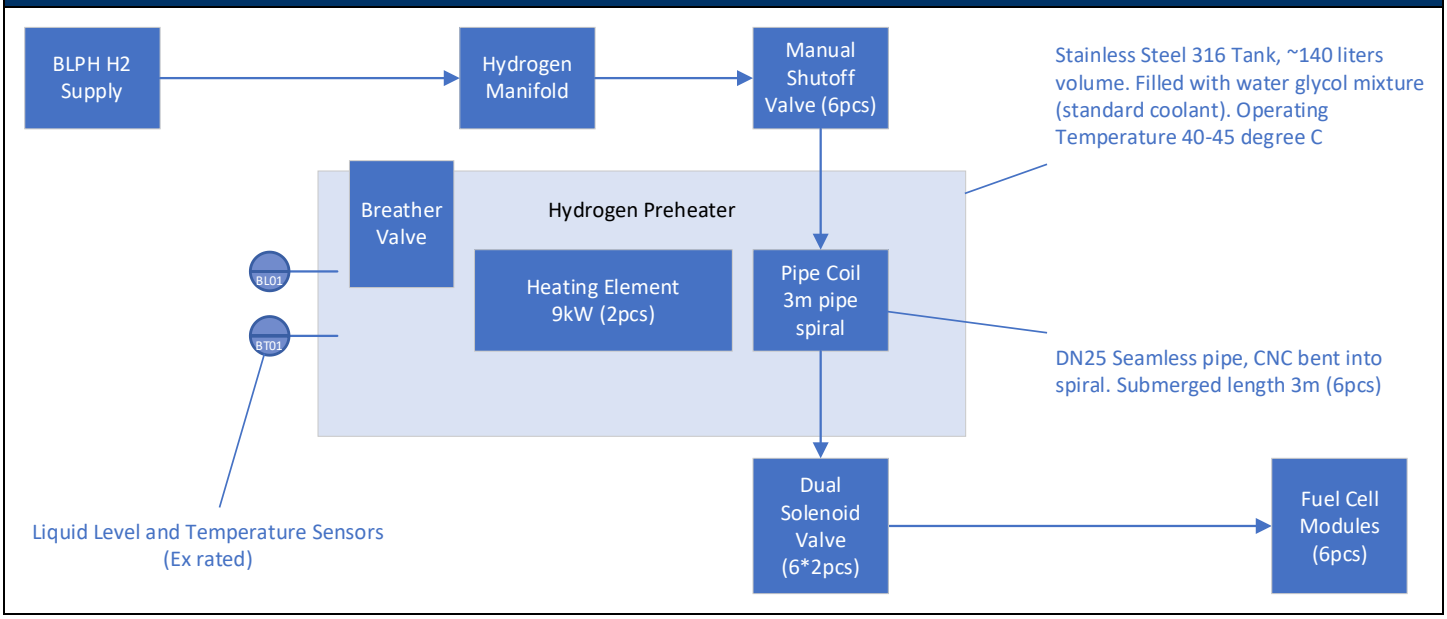
During ordinary service visits, the service technician shall top-up the contents of the preheater tank so evaporative losses are covered. No other service is expected.

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4.0 Block Diagram and Functional Description

The block diagram for the Hydrogen preheating system is shown in Figure 1. The method of operation is described below.

Figure 1: Hydrogen Preheater Block Diagram



The H2 preheating system uses heat from a pair of 9kW heating elements transferred via water/glycol mixture immersion to the pipe coils, carrying hydrogen to the fuel cell modules.

The hydrogen preheating system is used when the ambient temperature is below 10 degrees centigrade.

- Ambient temperature is sensed by the FC package controller (“controller”) via a sensor exposed to the ambient air (not shown on diagram).
- When the FC package is in Cold Standby, the hydrogen preheating system is inactive.
- When the FC package is in Hot Standby or Running, the hydrogen preheating system is active.
- The level of liquid inside the preheating system is monitored via a point level switch, ensuring that heaters are not activated without coolant to transfer the heat.
- When activated, a PID controller regulates the power to the heating elements to maintain a steady temperature inside the preheater. The operational temperature setpoint is 30 °C.
- The warm liquid transfers heat to the pipe coil and through the pipe wall to the gas stream, ensuring an optimal gas temperature to the FCwave fuel cell modules.

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5.0 Detailed P&ID and Image

For a detailed P&ID, refer to most recent version of “C03 P&ID.”

Figure 2: Hydrogen Preheater



Hydrogen preheater mounted to the side of a Megablock system. This configuration of the preheater has valves and shutoffs mounted elsewhere.

6.0 Components of the Hydrogen Heater

Note: ATEX considerations moved to the ATEX Dossier, document M99.

The following sections describe the components of the preheater.

6.1 Coolant Media

The heater contains Glad Long Life Ethylene Glycol Premix 50%, for details refer to document N07. This coolant is a premix, also used in the HT and LT coolant systems for the lowest amount of different coolant mediums.

Service for the above-mentioned chemicals is done every 20,000 hours or 2 years, whichever comes first. Under normal operation, there will be no direct consumption of the coolant. However, coolant level will be topped up during general service on the overall system. Coolant premix is either pre-positioned on platform or brought with service technician.

6.2 Hydrogen Pipe Coils

The pipe inside the hydrogen preheater is a single piece of seamless tubing, bent using a CNC bending machine. This ensures that there are no joints or other leakage points inside the preheater assembly.

All fittings are outside the preheater assembly, where any possible leakages may vent to open air, in a ATEX area.

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Figure 3: Hydrogen Pipe Coil



Half-length pipe coil used in testing setup. The production coils have double the length of piping. Made from seamless SS316 DN25 pipe on CNC bending machine.

6.3 Heating Elements

The heating elements in the system is 2 pieces 3 phase 400V, 9kW flanged immersion heaters. The heaters are Ex rated.

6.4 Temperature Sensor

The temperature sensor is a PT1000 sensor with a Ex barrier module between sensor and PLC.

6.5 Level Switch

The level switch is a sensor for point level detection in hazardous areas, manufactured by IFM. It is also installed with a Ex barrier module between sensor and PLC.

7.0 Appendix 2 – Energy Consumption

The hydrogen heater switches the pair of 9kW heating elements with a solid-state contactor.

The heating-up phase of the system will run a single 9kW heating element at 100% duty cycle (consuming 9kW of electricity off the AUX supply).

When at operating temperature, the heat transfer from the hydrogen heater to the surroundings is approximately 2kW with worst possible ambient conditions (-20°C ambient, rain and wind).

When the FC package is asked to operate and it switches from AUX supply to primary supply, it may use up to 18kW of power to maintain temperature.

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8.0 Appendix 3 – Thermal Expansion of Trapped Gas

One hazard of the system may be that cold gas is trapped inside the heater and subsequently expands when the heater is started, this heating expands the gas and leads to higher pressure.

The length of tubing is 3 meters inside the heater and less than 20 cm on each side, so a length of 4 meter is considered. The tube is 25mm outside diameter with 2mm wall thickness, so an internal diameter of 21mm is used.

The minimum operating temperature is -20°C and highest temperature conceivable is 100°C with an initial pressure of 10 barg (11 barA).

Volume of trapped gas:

$$V = \pi * r^2 * h \rightarrow V = \pi * (0{,}00105\ m)^2 * 4\ m = 0{,}00139\ m^3 = \ 1{,}39\ L$$

Moles of gas at -20°C (253,15 K):

$$n = \frac{PV}{RT} \rightarrow n = \frac{11\ barA\ * 1{,}39\ L}{0{,}08314\ \frac{L * barA}{K * mol} * 253{,}15\ K} = 0{,}726\ mol$$

Pressure of 0,726 mol of hydrogen at 100 °C (373,15 K), same volume:

$$P = \frac{nRT}{V} \rightarrow P = \frac{0{,}726\ mol * 0{,}08314\ \frac{L * barA}{K * mol} * 373{,}15\ K}{1{,}39\ L} = 16{,}2\ barA$$

Thus, the pressure increase is:

$$\Delta P = P_{100°C} - P_{-20°C} = 16{,}2\ barA - 11\ barA = 5{,}2\ bar$$

A pressure increase of 5,2 bar is well within materials specifications and valve limitations.

Section G

Calculations

Sub Section D99

ATEX Components Data Sheets

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Revision history		
Rev.	**Date.**	**Description**
001	30/08/2024	First Issue
002	15/11/2024	Expanded following ATEX Register (K02-002)

Document Title:	**BLPH Project - ATEX Components Data Sheets**
Document Number:	K559-2254-CWIWP4202202-D99-001
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Code:	D99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	D99 – ATEX Components Data Sheets
Full Title	Data Sheets of equipment for hazardous area of 1MW hydrogen fuel cell container for Crosswind
Abstract	

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Revision Record

Rev #	Description	Revised By	Date [dd/mm/yyyy]
1.0	Initial Release	RBS	19/09/2024
2.0	Expanded following ATEX Register (K02-002)	RBS	15/11/2024

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1.0 Purpose

The purpose of this document is to provide the data sheets of the equipment for hazardous area of the 1MW fuel cell container (MEGABLOCK) provided by Ballard Power Systems Europe to CrossWind.

2.0 References

Table 1 – List of references.

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-K02-002	ATEX Register	Ballard

3.0 List of ATEX Equipment

The ATEX Register lists the following ATEX equipment as shown in the table below. For more details please refer to the ATEX Register.

Table 2 – List of ATEX equipment (extract from document K559-2254-CWIWP4202202-K02-002).

No.	Revision	Tag Number	Description	Location	Manufacturer	Model Type Catalogue Number	Serial Number	ATEX Certification Marking
1	04	BL01	Electronic level sensor; Operating voltage 18…30 DC V; ATEX; M12 Connector; Gold-plated contacts	=HA01+DA02 - H2 Supply System	IFM Electronic AS	LMT01A LMACE-A12E-QSKG-1/US/3D/3G	10000160523	II 3G Ex nA IIC T4 Gc
2	04	BL01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Black	=HA01+DA02 - H2 Supply System	IFM Electronic AS	EVC14A ADOGH040VAT0025H04/3G/2D	N/A	II 3G EX ec IIC Gc
3	04	BP01	Pressure Transducer, 0-10 barg, 4-20mA, ATEX, -25 to 85°C Ta, M12 Connector, 10..30 VDC, 2-wire, G1/2 Process Connection, FPM Seal	=HA01+DA02 - H2 Supply System	HUBA Controls AG	Pressure Transducer 520 Series	N/A	Ex II 1/2G Ex ia IIC T4 Ga/Gb
4	04	BP01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	II 2G Ex ia IIC T6 Gb
5	04	TF01	BP01 - Pressure Sensor – Ex Barrier (9113B-U9)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U9	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA
6	04	BT01	Temperature sensor: liquids and gases Connection: stainless steel (1.4404 / 316L) Ambient temperature: -25…80 °C	=HA01+DA02 - H2 Supply System	IFM Electronic AS	TT1050 TT-100KBBD10-...../US/	100000113592	N/A
7	04	BT02-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	Ex ia IIC T6 Gb
8	04	TF01	BT01 - Temperature Sensor – Ex Barrier (9113B-U9)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U8	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA
9	04	EA01	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-1	Ex d IIC T4 Gb
10	04	EA01-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 135 CH	N/A	N/A
11	04	EA01	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB
12	04	EA02	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-2	Ex d IIC T4 Gb
13	04	EA02-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 135 CH	N/A	N/A
14	04	EA02	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB
15	04	QM1.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb
16	04	QM1.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
17	04	QM1.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
18	04	QM2.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
19	04	QM2.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
20	04	QM2.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
21	04	QM1.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb
22	04	QM1.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
23	04	QM1.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
24	04	QM2.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
25	04	QM2.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
26	04	QM2.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
27	04	QM1.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb
28	04	QM1.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
29	04	QM1.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
30	04	QM2.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
31	04	QM2.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
32	04	QM2.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
33	04	QM1.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
34	04	QM1.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
35	04	QM1.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
36	04	QM2.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
37	04	QM2.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
38	04	QM2.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
39	04	QM1.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
40	04	QM1.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
41	04	QM1.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
42	04	QM2.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
43	04	QM2.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
44	04	QM2.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
45	04	QM1.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
46	04	QM1.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
47	04	QM1.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
48	04	QM2.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb
49	04	QM2.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
50	04	QM2.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
51	04	XT01	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
52	04	XT02	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
53	04	XT03	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
54	04	XT04	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
55	04	XT05	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
56	04	XT06	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb
57	04	XT07	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Non EX Box	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
58	04	XT07	M32 to M20 Ex Reducer	=HA01+DA02 - Non EX Box	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
59	04	XT08	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
60	04	XT08	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
61	04	XT09	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
62	04	XT09	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
63	04	XT10	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
64	04	XT10	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb
65	04	XT11	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydrogen supply	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb
66	04	XT11	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydrogen supply	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb

4.0 Equipment Data Sheets

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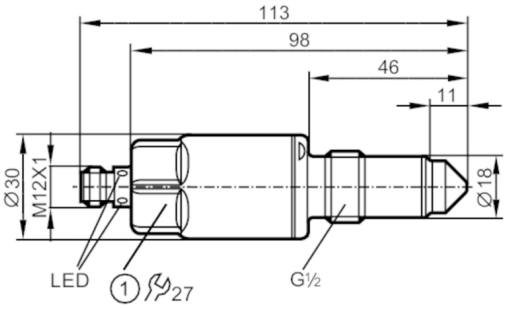
4.1 BL01 – Electronic Level Sensor, LMT01A

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LMT01A

Sensor for point level detection in hazardous areas

LMACE-A12E-QSKG-1/US/3D/3G



1 Tightening torque 20...25 Nm

CE EC 1935/2004 EHEDG Certified Ex FDA IO-Link UKCA

Product characteristics		
Number of inputs and outputs		Number of digital outputs: 2
Factory setting		oils; oil-based media; powder
Process connection		threaded connection G 1/2 sealing cone
Application		
Special feature		Gold-plated contacts
Media		Liquids; viscous media; powder
Cannot be used for		See the operating instructions, chapter "Function and features".
Medium temperature	[°C]	-20...85
Probe length	[mm]	11
Tank pressure	[bar]	-1...40
Electrical data		
Operating voltage	[V]	18...30 DC
Current consumption	[mA]	< 50
Protection class		III
Reverse polarity protection		yes
Measuring principle		capacitive
Inputs / outputs		
Number of inputs and outputs		Number of digital outputs: 2
Outputs		
Total number of outputs		2
Output signal		switching signal; IO-Link
Electrical design		PNP/NPN
Number of digital outputs		2
Output function		normally open / normally closed; (parameterisable)
Max. voltage drop switching output DC	[V]	2.5
Permanent current rating of switching output DC	[mA]	100

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LMT01A

Sensor for point level detection in hazardous areas

LMACE-A12E-QSKG-1/US/3D/3G

Short-circuit protection		yes	
Type of short-circuit protection		pulsed	
Overload protection		yes	
Measuring/setting range			
Factory setting		oils; oil-based media; powder	
Response times			
Response time	[s]	< 0.5	
Interfaces			
Communication interface		IO-Link	
Transmission type		COM2 (38,4 kBaud)	
IO-Link revision		1.1	
SDCI standard		IEC 61131-9	
Profiles		Smart Sensor: Process Data Variable; Device Identification	
SIO mode		yes	
Required master port type		A	
Process data analogue		1	
Process data binary		2	
Min. process cycle time	[ms]	2.3	
Supported DeviceIDs		**Type of operation**	**DeviceID**
		default	305
Operating conditions			
Ambient temperature	[°C]	-20...60	
Storage temperature	[°C]	-40...85	
Protection		IP 67; (when used outside the hazardous area: IP 68 / IP 69)	
Tests / approvals			
ATEX marking		II 3D Ex tc IIIC T90°C Dc X	
		II 3G Ex nA IIC T4 Gc X	
EMC		DIN EN 61000-6-2	
		DIN EN 61000-6-4	open tanks
		DIN EN 61000-6-3	closed tanks
Shock resistance		DIN EN 68000-2-27	50 g (11 ms)
Vibration resistance		DIN EN 68000-2-6	20 g (10...2000 Hz)
MTTF	[years]	223	
Mechanical data			
Weight	[g]	218	
Dimensions	[mm]	Ø 30 / L = 113	
Materials		stainless steel (316L/1.4404); PEEK; PEI; FKM	
Materials (wetted parts)		PEEK; surface characteristics: Ra < 0,8 / Rz 4	
Process connection		threaded connection G 1/2 sealing cone	
Displays / operating elements			
Display		switching status	LED, yellow
		operating status	LED, green

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LMT01A

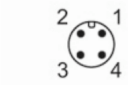
Sensor for point level detection in hazardous areas

LMACE-A12E-QSKG-1/US/3D/3G

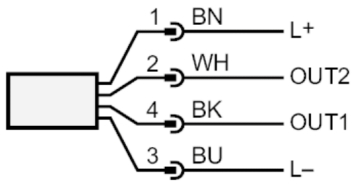
Remarks	
Pack quantity	1 pcs.

Electrical connection

Connector: 1 x M12; coding: A; Contacts: gold-plated



Connection



OUT1:	switching output IO-Link Teach
OUT2:	switching output
	colours to DIN EN 60947-5-2
	Core colours :
BK =	black
BN =	brown
BU =	blue
WH =	white

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4.2 BL01-WG01 – Connecting Cable with Socket for Level Sensor, EVC14A

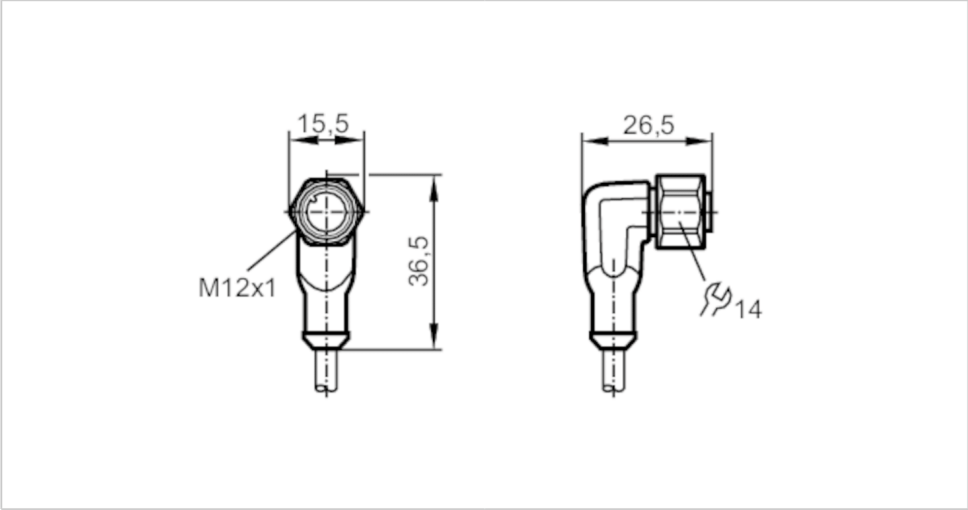
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EVC14A

Forbindelseskabel med hunstik

ADOAH040VAT0025H04/3G/2D



Applikation		
Special funktion		Halogenfri; guldbelagte kontakter
Kompatibel med maling		ja
Elektriske Data		
Driftspænding	[V]	< 60 AC/DC
Kapslingsklasse		II
Max strømbelastning total	[A]	2
Omgivende forhold		
Omgivelsestemperatur	[°C]	-20...60
Kapslingsklasse		IP 67; (ved brug udenfor ATEX området: IP 68 / IP 69K)
Godkendelser / Tests		
Godkendelse		BVS 08 ATEX E 109 U; IECEx BVS 08.0041 U
ATEX mærkning		II 3G Ex ec IIC Gc; II 2D Ex tb IIIC Db IP65/IP67
Mekaniske data		
Vægt	[g]	833
Dimensioner	[mm]	26,5 x 15,5 x 36,5
Materiale		Kapsling: TPU orange; pakning: FKM
Materiale - omløber		rustfri stål (1.4404 / 316L)
Bemærkning		
Emballage-enheder		1 stk.

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EVC14A

Forbindelseskabel med hunstik

ADOAH040VAT0025H04/3G/2D

Elektrisk tilslutning

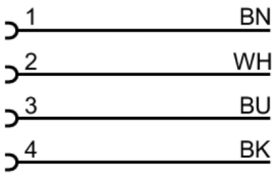
Kabel: 25 m, PUR, Halogenfri, sort, Ø 4,9 mm; 4 x 0,34 mm² (42 x Ø 0,1 mm)

Elektrisk tilslutning - Hunstik

Stik: 1 x M12, vinklet; kodning: A; Låsning: rustfri stål (1.4404 / 316L); Kontakter: guldbelagt; tilspændingsmoment: 1,2...1,5 Nm



Tilslutning



	Ledningsfarver :
BK =	sort
BN =	brun
BU =	blå
WH =	hvid

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4.3 BP01 – Pressure Sensor, 520 Series

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Huba Control

Relative pressure transmitter
Type 520

The compact type 520 pressure transmitter is based upon the Huba Control developed thick film technology where the pressure measuring cell is fully welded.
This transmitter meets the high burst protection demands and is suitable for the use in all types of refrigerants including ammonia.

Pressure range
-1 ... 9 bar /
0 ... 2.5 – 1000 bar

+ Compact, rugged construction
+ Welded without sealing parts, no elastomer seals
+ Large selection of connections available.
+ Saving time by quick cable mounting by the customer with swift connector

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Technical overview

Pressure range

Relative	-1 ... 9 bar / 0 ... 2.5 – 1000 bar

Operating conditions

Medium	Liquids, gases and refrigerants (incl. ammonia)	
Temperature	Medium -40 ... +135 °C	(Ex) -30 ... +120 °C)
	Ambient -30 ... +85 °C	(Ex) -25 ... +85 °C)
	Storage -50 ... +100 °C	
Tolerable overload	≤ 6 bar 5 x fs	
	> 6 bar 3 x fs (max. 1500 bar)	
Rupture pressure	≤ 6 bar 10 x fs	
	> 6 bar 6 x fs (max. 2500 bar)	

Materials

Cover		Stainless steel 1.4404 / AISI 316L (inside thread Schrader 1.4305 / AISI 303 only)
Plug accommodation		Polyarylamide 50% GF UL 94 V-0
Materials in contact with medium	Pressure connection	Stainless steel 1.4404 / AISI 316L (inside thread Schrader 1.4305 / AISI 303 only)
	Sensor	Stainless steel

Electrical overview

		Output	Power supply	Load	Current consumption
2 wire		4 ... 20 mA	7 ... 33 VDC	$< \frac{\text{supply voltage} - 7\,V}{0.02\,A}$ [Ohm]	< 23 mA
	(Ex)	4 ... 20 mA	10 ... 30 VDC	$< \frac{\text{supply voltage} - 10\,V}{0.02\,A}$ [Ohm]	< 23 mA
3 wire		0 ... 5 V	7 ... 33 VDC	>10 kOhm / < 100 nF	< 7 mA
		1 ... 6 V	8 ... 33 VDC	>10 kOhm / < 100 nF	< 7 mA
		0 ... 10 V	12 ... 33 VDC	>10 kOhm / < 100 nF	< 7 mA
		0 ... 10 V	12 ... 33 VDC / 24 VAC ± 15%	>10 kOhm / < 100 nF	< 7 mA
		ratiom. 10 ... 90%	5 VDC ± 10%	>10 kOhm / < 100 nF	< 7 mA
	(Ex)	ratiom. 10 ... 90%	5 VDC ± 10%	>10 kOhm / < 100 nF	< 7 mA
Polarity reversal protection		Short circuit proof and protected against polarity reversal. Each connection is protected against crossover up to max. supply voltage.			
Insulation voltage				standard	500 VDC

Dynamic response

Response time	< 2 ms, 1 ms typ.
Load cycle	< 100 Hz

Electrical connection	**Protection standard**	**Protection class**
Swift connector with or without cable 1.5 / 2.0 / 3.0 / 5.0 m (PVC spec.)	IP 67	III
Connector DIN EN 175301-803-A or C (industrial standard 9.4 mm)	IP 65	III
Metri Pack Serie 150	IP 67	III
Connector M12x1	IP 67	III
Braids	IP 65	III
Connector RAST 2.5 (3 wire, only)	IP 00	III

Pressure connection

Inside thread	7/16 - 20 UNF	without or with Schrader
	½ -14 NPT	(≤ 60 bar)
	G ¼	with O-Ring seal FPM (-30 ... +135 °C)
Outside thread	7/16 - 20 UNF	sealing cone 45°
	¼ -18 NPT	
	7/16 - 20 UNF	sealed at back SAE 4 with O-Ring seal FPM (-20 ... +135 °C)
	G ¼	sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM (-30 ... +135 °C)
	G ¼	sealed at back and manometer (combi) with profile seal ring in FPM (-30 ... +135 °C) (≤ 60 bar)
	R ¼	EN 10226
	G ½	sealed at back and manometer (combi) with profile seal ring in FPM (-30 ... +135 °C)
	⅛ - 27 NPT	(≤ 60 bar)
	G ⅛	sealed at front (≤ 60 bar)
	G ⅛	sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM (-30 ... +135 °C) (> 60 bar - without ATEX certificate)
	M10x1	sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM (-30 ... +135 °C) (≤ 60 bar)
	M20x1.5	sealed at front and manometer (combi)
	G ½, G ¼	sealed at front

Installation arrangement

Unrestricted

Tests / Admissions

Electromagnetic compatibility	CE conformity acc. EN 61326-2-3
Enhanced EMC protection	EN 50121-3-2
Shock acc. IEC 68-2-27	100 g, 11 ms half sine wave, all 6 directions, free fall from 1 m on concrete (6x)
Constant shock acc. IEC 68-2-29	40 g for 6 ms, 1000x all 3 directions
Vibration acc. IEC 68-2-6	20 g, 15 ... 2000 Hz, 15 ... 25 Hz with amplitude ± 15 mm, 1 Octave/min. all 3 directions, 50 constant load
UL	ANSI/UL 61010-1 acc. E325110
Drinking water approval	NSF/ANSI 61/372 acc. MH60087
	WRAS
EAC	

Protection against explosion (Ex)	**ratiom. 10 ... 90%**	**4 ... 20 mA**
Intrinsic safety «i»	Ex II 1/2 G Ex ia IIC T4 Ga/Gb	Ex II 1/2 G Ex ia IIC T4 Ga/Gb
	Ex II 1/2 D Ex ia IIIC T125°C Da/Db	Ex II 1/2 D Ex ia IIIC T125°C Da/Db
EC type examination certificate	SEV 15 ATEX 0173	SEV 10 ATEX 0145
Connection to certified intrinsically safe resistive circuits with maximum values	Ui ≤ 15 VDC; Ii ≤ 200 mA; Pi ≤ 750 mW	Ui ≤ 30 VDC; Ii ≤ 100 mA; Pi ≤ 750 mW
Effective internal inductance and capacitance for versions with plugs complying with EN 175301-803-A or M12x1	Li = 0 nH; Ci ≤ 150 nF	Li = 0 nH; Ci = 0 nF
IECEx		SEV 16.0007

Weight

~ 90 g

Packaging (Please state on order)

Single packaging in cardboard	accessories integrated
Multiple packaging in cardboard (25 pcs)	

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TEMPLATE FRM5100236 0H

Ballard Confidential

Printed on: Friday, November 15, 2024

Accuracy

Parameter		Unit	
Characteristic line a [1]		% fs	± 0.3
Resolution		% fs	0.1
Thermal characteristic [2]	max.	% fs/10K	± 0.2
Long term stability acc. EN 60770-1	max.	% fs	± 0.25

Test conditions: 25 °C, 45% RH, power supply 24 VDC

Order code selection table in bar

			520.	1 X	2 X	3 X	4 X	5 X	6 X	7 X	8 X	9 X	10 X	11 X
Pressure range [3]	-1 ... 9 bar			9	0	6								
	0 ... 2.5 bar			9	1	4								
	0 ... 4 bar			9	1	5								
	0 ... 6 bar			9	1	7								
	0 ... 10 bar			9	3	0								
	0 ... 16 bar			9	3	1								
	0 ... 25 bar			9	3	2								
	0 ... 40 bar			9	3	3								
	0 ... 60 bar			9	4	0								
	0 ... 100 bar			9	4	1								
	0 ... 160 bar			9	4	2								
	0 ... 250 bar			9	4	3								
	0 ... 400 bar			9	5	4								
	0 ... 600 bar			9	5	5								
	0 ... 1000 bar			9	5	7								
Application	standard						S	0						
	for oxygen applications						S	1				0		
	with drinking water approval NSF/ANSI 61/372, WRAS						S	4				0	1	
Output / power supply	0 ... 5 V	7 ... 33 VDC							1					
	1 ... 6 V	8 ... 33 VDC							6					
	0 ... 10 V	12 ... 33 VDC							2					
		12 ... 33 VDC Enhanced EMC protection							C	1,2,3				
		12 ... 33 VDC / 24 VAC ±15% *(not possible with M12x1, metri Pack, RAST, braids)*							8					
	ratiom. 10 ... 90%	5 VDC ±10%							7					
		5 VDC ±10% Ex protection						0,4	9	1,3			1	
	4 ... 20 mA	7 ... 33 VDC							3					
		7 ... 33 VDC Enhanced EMC protection *(not possible with Braids)*							A					
		10 ... 30 VDC Ex protection						0,4	4	1,3			1	
Electrical connection	Connector [4]	DIN EN 175301-803-A								1				
		DIN EN 175301-803-C (industrial standard 9.4 mm)								2				
		M12x1 *2w: IN=1 / OUT=3 3w: IN=1 / OUT=4 / GND=3*								3				
		M12x1 *2w: IN=1 / OUT=4 3w: IN=1 / OUT=3 / GND=4*								M				
		M12x1 *2w: IN=1 / OUT=2 3w: IN=1 / OUT=2 / GND=3*								P				
		RAST 2.5						0,4	7	4				
		Metri Pack Serie 150						0,4		5				
	Braids	80 ±10 mm						0,4		6				
		290 ±10 mm						0,4		7				
		480 ±10 mm						0,4		8				
		730 ±10 mm						0,4		9				
	Swift connector	without cable								0				
		with cable 1.5 m								L				
		with cable 2.0 m								N				
		with cable 3.0 m								Q				
		with cable 5.0 m								R				
Pressure connection [2]	Inside thread	7/16"-20 UNF sealing cone with schrader						0,4			0	0	N	
		7/16"-20 UNF sealing cone									K		1	
		½ -14 NPT [5]									D		1	
		G ¼ with O-Ring seal FPM									1		1	
	Outside thread	7/16"-20 UNF sealing cone									2		1	
		¼ -18 NPT									3		1	
		G ¼ sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM									4		1	
		G ¼ sealed at back and manometer with profile seal ring in FPM									5	0	1	
		R ¼ acc. to EN 10226									7		1	
		G ½ sealed at back and manometer with profile seal ring in FPM						0,1			8		1	
		7/16"-20 UNF sealed at back SAE 4 with O-Ring seal FPM						0,1			G		1	
		⅛ - 27 NPT [5]									A		1	
		G ⅛ sealed at front [3]									M		1	
		G ⅛ sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM [6]						0,1			H		1	
		M10x1 sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM [5]						0,1			F		1	
		M20x1.5 sealed at front and manometer (combi)									E		1	
		G ¼ sealed at front									J		1	
		G ½ sealed at front									9		1	
Pressure orifice	without (inclusive pressure tip orifice from 100 bar on)											0		
	with											2		
Material pressure connection	Stainless steel 1.4305 / AISI 303												N	
	Stainless steel 1.4404 / AISI 316L												1	
Pressure range variation (optional)	Indicate W and state range on order (e.g.: W0... + 3bar/OUT0...5V)													W

[1] typ. ; max. 0.5% fs (incl. zero point, full scale, linearity, hysteresis and repeatability) [2] -15 ... 85 °C [3] Other pressure ranges or pressure connections on request
[4] Delivery without female connector [5] Pressure range ≤ 60 bar [6] Pressure range ≤ 250 bar (max. rupture pressure 1000 bar)

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Order code selection table in psi			520.	1 X	2 X	3 X	4 X	5 X	6 X	7 X	8 X	9 X	10 X	11 X
Pressure range [1]	-15 ... 130 psi			9	A	6								
	0 ... 30 psi			9	B	4								
	0 ... 60 psi			9	B	5								
	0 ... 100 psi			9	B	7								
	0 ... 200 psi			9	C	1								
	0 ... 300 psi			9	C	2								
	0 ... 500 psi			9	C	3								
	0 ... 750 psi			9	D	0								
	0 ... 1000 psi			9	D	1								
	0 ... 2000 psi			9	D	2								
	0 ... 3000 psi			9	D	3								
	0 ... 5000 psi			9	E	4								
	0 ... 7500 psi			9	E	5								
	0 ... 14500 psi			9	E	7								
Application	standard						S	0						
	for oxygen applications						S	1				0		
	with drinking water approval NSF/ANSI 61/372, WRAS						S	4				0	1	
Output / power supply	0 ... 5 V	7 ... 33 VDC							1					
	1 ... 6 V	8 ... 33 VDC							6					
	0 ... 10 V	12 ... 33 VDC							2					
		12 ... 33 VDC Enhanced EMC protection							C	1,2,3				
		12 ... 33 VDC / 24 VAC ±15% *(not possible with M12x1, metri pack, RAST, braids)*							8					
	ratiom. 10 ... 90%	5 VDC ±10%							7					
		5 VDC ±10% Ex protection						0,4	9	1,3			1	
	4 ... 20 mA	7 ... 33 VDC							3					
		7 ... 33 VDC Enhanced EMC protection *(not possible with Braids)*							A					
		10 ... 30 VDC Ex protection						0,4	4	1,3			1	
Electrical connection	Connector [2]	DIN EN 175301-803-A								1				
		DIN EN 175301-803-C (industrial standard 9.4 mm)								2				
		M12x1 *2w: IN=1 / OUT=3 3w: IN=1 / OUT=4 / GND=3*								3				
		M12x1 *2w: IN=1 / OUT=4 3w: IN=1 / OUT=3 / GND=4*								M				
		M12x1 *2w: IN=1 / OUT=2 3w: IN=1 / OUT=2 / GND=3*								P				
		RAST 2.5						0,4	7	4				
		Metri Pack Serie 150						0,4		5				
	Braids	80 ±10 mm						0,4		6				
		290 ±10 mm						0,4		7				
		480 ±10 mm						0,4		8				
		730 ±10 mm						0,4		9				
	Swift connector	without cable								0				
		with cable 1.5 m								L				
		with cable 2.0 m								N				
		with cable 3.0 m								Q				
		with cable 5.0 m								R				
Pressure connection [1]	Inside thread	7/16-20 UNF sealing cone with schrader						0,4			0	0	N	
		7/16-20 UNF sealing cone									K		1	
		½ -14 NPT [3]									D		1	
		G ¼ with O-Ring seal FPM									1		1	
	Outside thread	7/16-20 UNF sealing cone									2		1	
		¼ -18 NPT									3		1	
		G ¼ sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM									4		1	
		G ¼ sealed at back and manometer with profile seal ring in FPM									5	0	1	
		R ¼ acc. to EN 10226									7		1	
		G ½ sealed at back and manometer with profile seal ring in FPM						0,1			8		1	
		7/16-20 UNF sealed at back SAE 4 with O-Ring seal FPM						0,1			G		1	
		⅛ - 27 NPT [3]									A		1	
		G ⅛ sealed at front [3]									M		1	
		G ⅛ sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM [4]						0,1			H		1	
		M10x1 sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM [3]						0,1			F		1	
		M20x1.5 sealed at front and manometer (combi)									E		1	
		G ¼ sealed at front									J		1	
		G ½ sealed at front									9		1	
Pressure orifice	without (inclusive pressure tip orifice from 2000 psi on)											0		
	with											2		
Material pressure connection	Stainless steel 1.4305 / AISI 303												N	
	Stainless steel 1.4404 / AISI 316L												1	
Pressure range variation (optional)	Indicate W and state range on order (e.g.: W0... + 400psi/OUT0...5V)													W

[1] Other pressure ranges or pressure connections on request
[2] Delivery without female connector
[3] Pressure range ≤ 870 psi
[4] Pressure range ≤ 3000 psi (max. rupture pressure 14500 bar)

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Order code selection table in MPa			520.	1 X	2 X	3 X	4 X	5 X	6 X	7 X	8 X	9 X	10 X	11 X
Pressure range [1]	-0.1 ... 0.9 MPa			9	F	6								
	0 ... 0.25 MPa			9	G	4								
	0 ... 0.4 MPa			9	G	5								
	0 ... 0.6 MPa			9	G	7								
	0 ... 1 MPa			9	H	0								
	0 ... 1.6 MPa			9	H	1								
	0 ... 2.5 MPa			9	H	2								
	0 ... 4 MPa			9	H	3								
	0 ... 6 MPa			9	K	0								
	0 ... 10 MPa			9	K	1								
	0 ... 16 MPa			9	K	2								
	0 ... 25 MPa			9	K	3								
	0 ... 40 MPa			9	L	4								
	0 ... 60 MPa			9	L	5								
	0 ... 100 MPa			9	L	7								
Application	standard						S	0						
	for oxygen applications						S	1				0		
	with drinking water approval NSF/ANSI 61/372, WRAS						S	4				0	1	
Output / power supply	0 ... 5 V	7 ... 33 VDC							1					
	1 ... 6 V	8 ... 33 VDC							6					
	0 ... 10 V	12 ... 33 VDC							2					
		12 ... 33 VDC Enhanced EMC protection							C	1,2,3				
		12 ... 33 VDC / 24 VAC ±15% *(not possible with M12x1, metri Pack, RAST, braids)*							8					
	ratiom. 10 ... 90%	5 VDC ±10%							7					
		5 VDC ±10% Ex protection						0,4	9	1,3				
	4 ... 20 mA	7 ... 33 VDC							3					
		7 ... 33 VDC Enhanced EMC protection *(not possible with Braids)*							A					
		10 ... 30 VDC Ex protection						0,4	4	1,3				
Electrical connection	Connector [2]	DIN EN 175301-803-A								1				
		DIN EN 175301-803-C *(industrial standard 9.4 mm)*								2				
		M12x1 *2w: IN=1 / OUT=3 3w: IN=1 / OUT=4 / GND=3*								3				
		M12x1 *2w: IN=1 / OUT=4 3w: IN=1 / OUT=3 / GND=4*								M				
		M12x1 *2w: IN=1 / OUT=2 3w: IN=1 / OUT=2 / GND=3*								P				
		RAST 2.5						0,4	7	4				
		Metri Pack Serie 150						0,4		5				
	Braids	80 ±10 mm						0,4		6				
		290 ±10 mm						0,4		7				
		480 ±10 mm						0,4		8				
		730 ±10 mm						0,4		9				
	Swift connector	without cable								0				
		with cable 1.5 m								L				
		with cable 2.0 m								N				
		with cable 3.0 m								Q				
		with cable 5.0 m								R				
Pressure connection [1]	Inside thread	7/16-20 UNF sealing cone with schrader						0,4			0	0	N	
		7/16-20 UNF sealing cone									K		1	
		½ -14 NPT [3]									D		1	
		G ¼ with O-Ring seal FPM									1		1	
	Outside thread	7/16-20 UNF sealing cone									2		1	
		¼ -18 NPT									3		1	
		G ¼ sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM									4		1	
		G ¼ sealed at back and manometer with profile seal ring in FPM									5	0	1	
		R ¼ acc. to EN 10226									7		1	
		G ½ sealed at back and manometer with profile seal ring in FPM						0,1			8		1	
		7/16-20 UNF sealed at back SAE 4 with O-Ring seal FPM						0,1			G		1	
		⅛ - 27 NPT [3]									A		1	
		G ⅛ sealed at front [3]									M		1	
		G ⅛ sealed at back DIN EN ISO 1179-2 with Profile seal ring in FPM [4]						0,1			H		1	
		M10x1 sealed at back DIN EN ISO 1179-2 with profile seal ring in FPM [3]						0,1			F		1	
		M20x1.5 sealed at front and manometer (combi)									E		1	
		G ¼ sealed at front									J		1	
		G ½ sealed at front									9		1	
Pressure orifice	without (inclusive pressure tip orifice from 10 MPa on)											0		
	with											2		
Material pressure connection	Stainless steel 1.4305 / AISI 303												N	
	Stainless steel 1.4404 / AISI 316L												1	
Pressure range variation (optional)	Indicate W and state range on order (e.g.: W0... + 0.3MPa/OUT0...5V)													W

[1] Other pressure ranges or pressure connections on request
[2] Delivery without female connector
[3] Pressure range ≤ 6 MPa
[4] Pressure range ≤ 25 MPa (max. rupture pressure 100 MPa)

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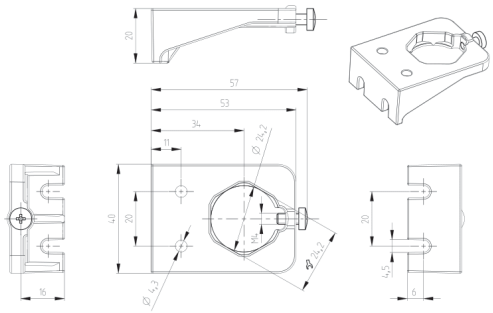
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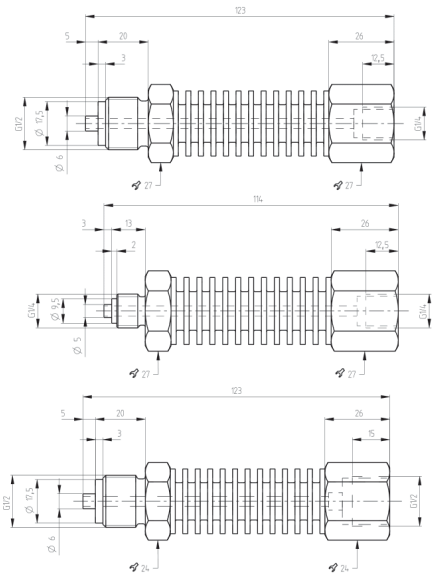
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Accessories *(supplied loose)*	Order number
Swift connector	117312
Female connector DIN EN 175301-803-A with seal	103510
Female connector DIN EN 175301-803-C with seal	104244
Corner-wire box for connector M12x1	106975
Corner-wire box for connector M12x1 with cable 2.0 m	114604
Straight-wire box for connector M12x1	114570
Straight-wire box for connector M12x1 with cable 2.0 m	114605
Mounting bracket with screw	118716
Heat sink with outside thread G ½ sealed at front - inside thread G ½	105631
Heat sink with outside thread G ½ sealed at front - inside thread G ¼	105073
Heat sink with outside thread G ¼ sealed at front - inside thread G ¼	105074
Calibration certificate (≤ 600 bar)	104551

Mounting bracket



Heat sink



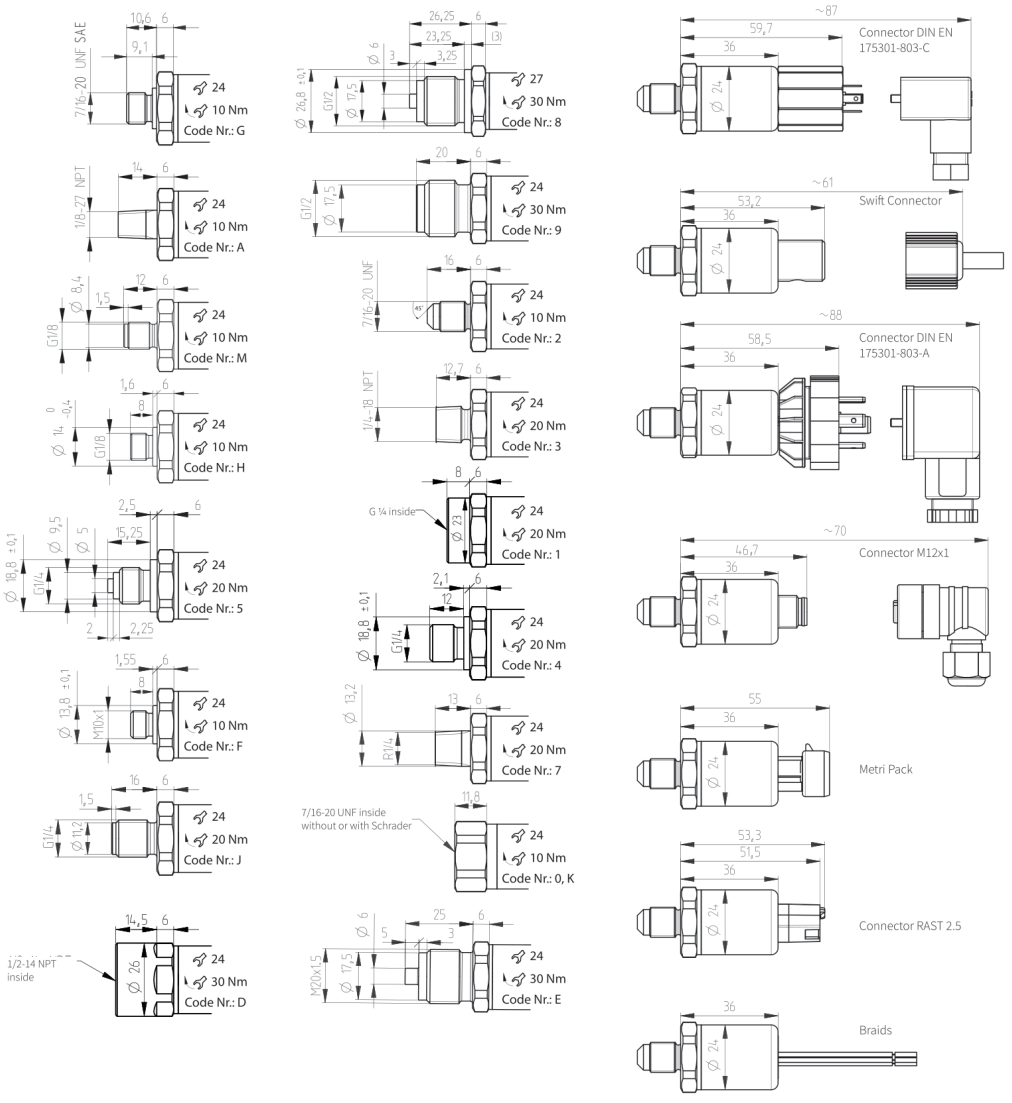
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Dimensions in mm



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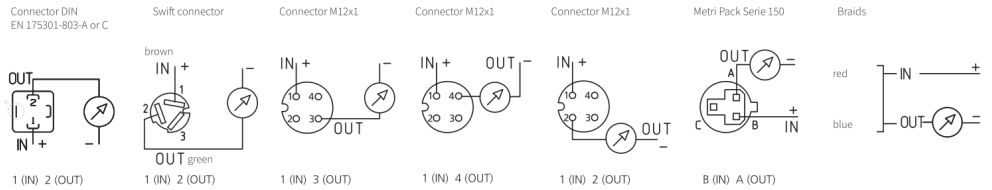
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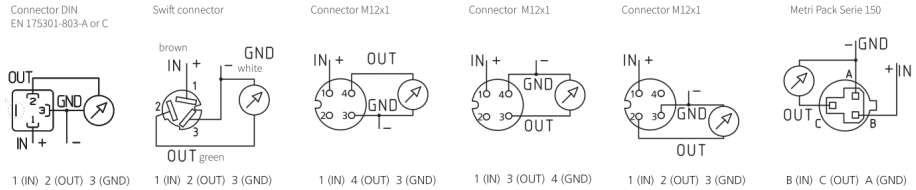
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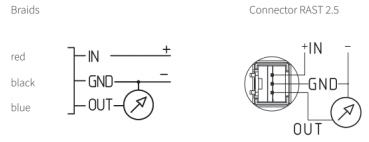
Electrical connections

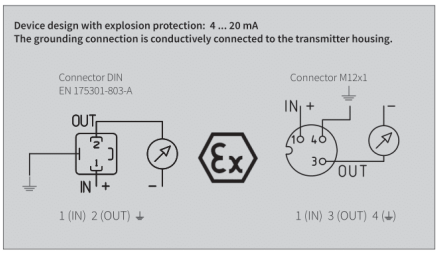
2 wire

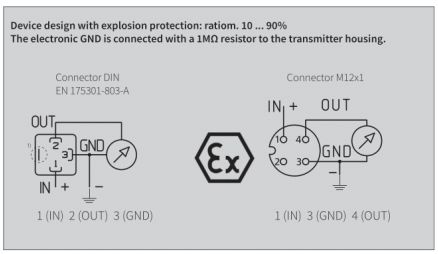


3 wire









[1] Not connected with transmitter housing

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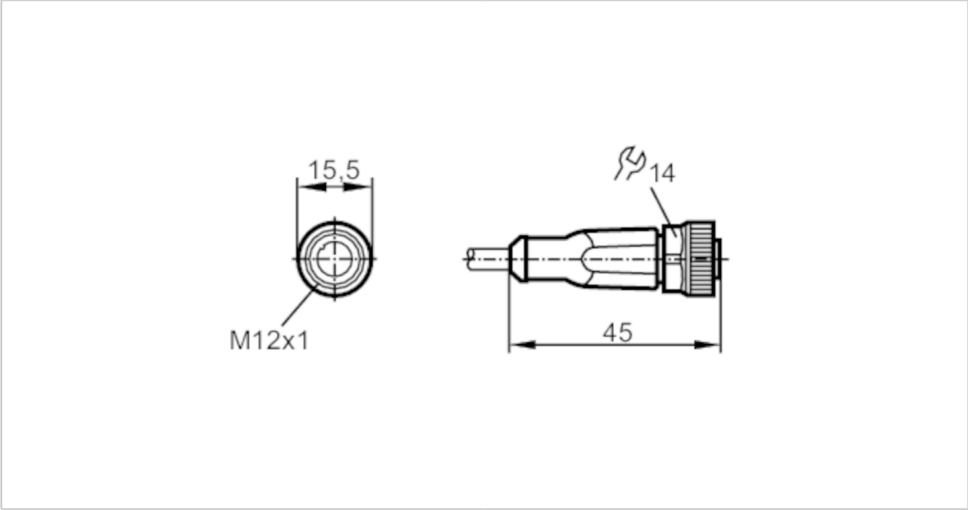
4.4 BP01-WG01 – Connecting Cable with Socket for Pressure Sensor, ENC03A

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ENC03A

Female cordset

ADOGH040MSN0010H04/1G/1D



Application		
System		Free from silicone; Halogen-free; gold-plated contacts
Free from silicone		yes
Compatible with paint		yes
Electrical data		
Operating voltage	[V]	< 30 DC
Protection class		II
Max. input power	[mW]	group II: 1000; group III: 1000
Max. current load total	[A]	1
Operating conditions		
Ambient temperature	[°C]	-25...85
Note on ambient temperature		for use in hazardous areas: ambient temperature according to unit marking
Protection		IP 67; (when used outside the hazardous area: IP 68 / IP 69K)
Tests / approvals		
Approval		BVS 11 ATEX E 009 X; IECEx BVS 11.0002 X
ATEX marking		II 1G Ex ia IIB T6 Ga Ta: -25...75°C
		II 2G Ex ia IIC T6 Gb Ta: -25...75°C
		II 1G Ex ia IIB T5 Ga Ta: -25...85°C
		II 2G Ex ia IIC T5 Gb Ta: -25...85°C
		II 1D Ex ia IIIB T200 85°C Da Ta: -25...75°C
		II 1D Ex ia IIIB T200 95°C Da Ta: -25...85°C
		II 1D Ex ia IIIC T200 70°C Da Ta: -20...60°C

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ENC03A

Female cordset

ADOGH040MSN0010H04/1G/1D

Safety classification		
Max. internal capacitance	[nF]	1
Max. internal inductance	[µH]	20
Mechanical data		
Weight	[g]	351.7
Dimensions	[mm]	15.5 x 15.5 x 45
Material		housing: TPU (urethane) orange; sealing: FKM
Material nut		brass, nickel-plated
Remarks		
Remarks		Special conditions for safe operation apply for use in hazardous areas. Observe the corresponding notes in the operating instructions (Ex protection related part).
Pack quantity		1 pcs.

Electrical connection

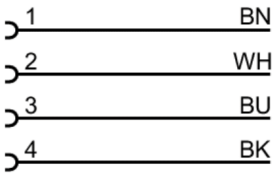
Cable: 10 m, PUR, Halogen-free, blue, Ø 4.9 mm; 4 x 0.34 mm² (42 x Ø 0.1 mm)

Electrical connection - Socket

Connector: 1 x M12, straight; coding: A; Locking: brass, nickel-plated; Contacts: gold-plated; Tightening torque: 0.6...1.5 Nm



Connection



	Core colors :
BK =	black
BN =	brown
BU =	blue
WH =	white

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4.5 TF01 – Pressure Sensor Ex Barrier, 9113B-U9

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PR electronics

PERFORMANCE MADE SMARTER



Temperature / mA converter

9113B

- Input for RTD, TC and mA
- Active / passive mA output via the same two terminals
- 1 or 2 channels
- Can be supplied separately or installed on power rail, PR type 9400
- SIL 2-certified via Full Assessment

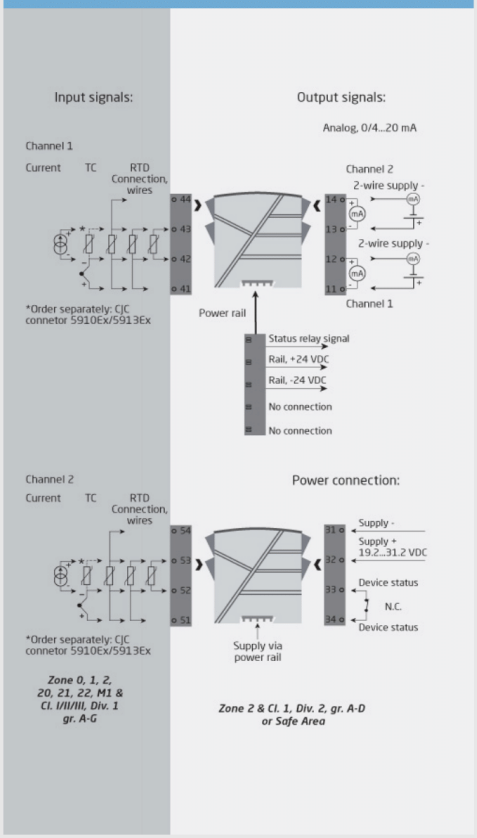
Advanced features
- Configuration and monitoring by way of detachable display front (PR 4500); process calibration and signal simulation.
- Copying of the configuration from one device to others of the same type via the display front.
- TC inputs can use either the internal CJC or a terminal with a built-in Pt100 sensor (PR 5910Ex, channel 1 / PR 5913Ex, channel 2) for higher accuracy.
- Advanced monitoring of internal communication and stored data.
- SIL 2 functionality is optional and must be activated in a menu point.

Application
- 9113Bxx can be mounted in the safe area or in zone 2 / Class 1, Division 2 and receive signals from zone 0, 1, 2 and zone 20, 21, 22 including mining / Class I/II/III, Division 1, Gr. A-G.
- Conversion and scaling of temperature (Pt, Ni and TC) and active current signals.
- The 9113 has been designed, developed and certified for use in SIL 2 applications according to the requirements of IEC 61508.
- Suitable for the use in systems up to Performance Level "d" according to ISO-13849.

Technical characteristics
- 1 green and 2 red front LEDs indicate operation status and malfunction.
- 2.6 kVAC galvanic isolation between input, output and supply.

Mounting
- The devices can be mounted vertically or horizontally without distance between neighbouring units.

Applications



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Order

Type	Channels	I.S. / Ex approvals
9113B	Single : A	ATEX, IECEx, FM, INMETRO, EAC-Ex, UKEX : -
	Double : B	UL 913, ATEX, IECEx, FM, INMETRO, EAC-Ex, UKEX : -U9
		KCs, ATEX, IECEx, FM, INMETRO, EAC-Ex, UKEX : -KCs

Example: 9113BB

Environmental Conditions

Operating temperature	-20°C to +60°C
Storage temperature	-20°C to +85°C
Calibration temperature	20...28°C
Relative humidity	< 95% RH (non-cond.)
Protection degree	IP20
Installation in	Pollution degree 2 & meas. / overvoltage cat. II

Mechanical specifications

Dimensions (HxWxD)	109 x 23.5 x 104 mm
Dimensions (HxWxD) w/ PR 4500	109 x 23.5 x 131 mm
Weight approx.	250 g
DIN rail type	DIN EN 60715/35 mm
Wire size	0.13...2.08 mm^2 AWG 26...14 stranded wire
Screw terminal torque	0.5 Nm
Vibration	IEC 60068-2-6
2...13.2 Hz	±1 mm
13.2...100 Hz	±0.7 g

Common specifications

Supply

Supply voltage	19.2...31.2 VDC
Fuse	400 mA SB / 250 VAC
Max. required power	≤ 0.8 W/≤ 1.4 W (1 ch./2 ch.)
Max. power dissipation, 1 / 2 ch.	≤ 0.8 W / ≤ 1.4 W

Isolation voltage

Test /working: Input to any	2.6 kVAC / 300 VAC reinforced isolation
Analog output to supply	2.6 kVAC / 300 VAC reinforced isolation
Status relay to supply	1.5 kVAC / 150 VAC reinforced isolation

Response time

Temperature input, programmable (0...90%, 100...10%)	1...60 s
mA / V input (programmable)	0.4...60 s
Programming	PR 4500 communication interfaces
Signal / noise ratio	Min. 60 dB (0...100 kHz)
Signal dynamics, input	24 bit
Signal dynamics, output	16 bit
Accuracy	Better than 0.1% of sel. range
EMC immunity influence	< ±0.5% of span
Extended EMC immunity: NAMUR NE21, A criterion, burst	< ±1% of span

Input specifications

RTD input

RTD type	Pt10/20/50/100/200/250; Pt300/Pt400/500/1000; Ni50/100/120/1000
Cable resistance per wire	50 Ω (max.)
Sensor current	Nom. 0.2 mA
Effect of sensor cable resistance (3-/4-wire)	< 0.002 Ω / Ω
Sensor error detection	Programmable ON / OFF

TC input

Thermocouple type	B, E, J, K, L, N, R, S, T, U, W3, W5, LR
Cold junction compensation (CJC) via ext. sensor in 5910	20...28°C ≤ ±1°C, -20...20°C / 28...70°C ≤ 2°C
CJC via int. mounted sensor	±(2.0°C + 0.4°C * Δt)
Sensor error detection	Programmable ON or OFF (only wire breakage)
Sensor error current: When detecting / else	Nom. 2 µA / 0 µA

Current input

Measurement range	0...23 mA
Programmable measurement ranges	0...20 and 4...20 mA
Input resistance	Nom. 20 Ω + PTC 50 Ω
Sensor error detection	Programmable ON / OFF

Output specifications

Current output

Signal range	0...23 mA
Programmable signal ranges	0...20/4...20/20...0/20...4 mA
Load (@ current output)	≤ 600 Ω
Load stability	≤ 0.01% of span / 100 Ω
Sensor error indication	0 / 3.5 / 23 mA / none
NAMUR NE43 Upscale/Downscale	23 mA / 3.5 mA
Output limitation, on 4...20 and 20...4 mA signals	3.8...20.5 mA
Output limitation, on 0...20 and 20...0 mA signals	0...20.5 mA
Current limit	≤ 28 mA

Passive 2-wire mA output

Max. external 2-wire supply	26 VDC
Effect of external 2-wire supply voltage variation	< 0.005% of span / V

Status relay

Max. voltage	125 VAC / 110 VDC
Max. current	0.5 AAC / 0.3 ADC
Max. AC power	62.5 VA / 32 W

Observed authority requirements

EMC	2014/30/EU & UK SI 2016/1091
LVD	2014/35/EU & UK SI 2016/1101
ATEX	2014/34/EU & UK SI 2016/1107
RoHS	2011/65/EU & UK SI 2012/3032
EAC	TR-CU 020/2011
EAC Ex	TR-CU 012/2011
EAC LVD	TR-CU 004/2011

9113B-080724

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Approvals

ATEX	KEMA 07ATEX0148 X
IECEx	KEM 09.0052X
UKEX	DEKRA 21UKEX0175X
UKEX	DEKRA 23UKEX0109X
c FM us	FM19US0059X / FM19CA0032X
INMETRO	DEKRA 23.0005X
c UL us, UL 61010-1	E314307
c UL us, UL 913	E233311 (only 9113xx-U9)
KCs	21_AV4BO_0173X / 21_AV4BO_0174X (only 9113Bx-KCs)
EAC Ex	RU C-DK.HA65.B.00355/19
DNV Marine	TAA00000JD
ClassNK	TA24034M
SIL	SIL 2 certified & fully assessed acc. to IEC 61508

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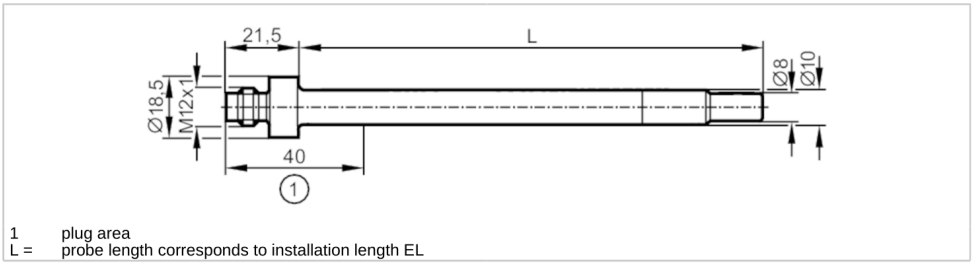
4.6 BT01 – Temperature Sensor, TT1050

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TT1050

Temperature probe sensor

TT-100KBBD10-...../US/



1 plug area
L = probe length corresponds to installation length EL

Product characteristics			
Measuring range		-40...150 °C	-40...302 °F
Process connection		Ø 10 mm	
Installation length EL	[mm]	160	
Application			
Special feature		Gold-plated contacts	
Measuring element		1 x Pt 1000; (to DIN EN 60751, class A)	
Media		liquids and gases	
Pressure rating	[bar]	160	
Minimum installation depth	[mm]	15	
Electrical data			
Protection class		III	
Measuring/setting range			
Probe length L	[mm]	160	
Measuring range		-40...150 °C	-40...302 °F
Accuracy / deviations			
Accuracy	[K]	± (0,15 K + 0,002 x|t|)	
Response times			
Dynamic response T05 / T09	[s]	1 / 3; (to DIN EN 60751)	
Operating conditions			
Ambient temperature	[°C]	-25...80	
Note on ambient temperature		plug area	
Storage temperature	[°C]	-40...100	
Protection		IP 68; IP 69K	
Tests / approvals			
Shock resistance		DIN EN 60068-2-27	50 g (11 ms)
Vibration resistance		DIN EN 60068-2-6	10 g (10...2000 Hz)
MTTF	[years]	22831	
Mechanical data			
Weight	[g]	54.3	
Dimensions	[mm]	Ø 10	
Materials		stainless steel (316L/1.4404)	

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TT1050

Temperature probe sensor

TT-100KBBD10-...../US/

Materials (wetted parts)		stainless steel (316L/1.4404)
Process connection		Ø 10 mm
Probe diameter	[mm]	10
Installation length EL	[mm]	160

Remarks

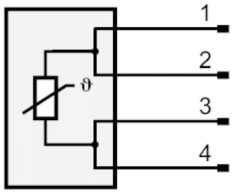
Remarks	The values for accuracy apply to flowing water.
Pack quantity	1 pcs.

Electrical connection

Connector: 1 x M12; coding: A; Contacts: gold-plated



Connection



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4.7 BT02-WG01 – Connecting Cable with Socket for Temperature Sensor, ENC03A

[Please refer to data sheet from Section 4.4.]

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4.8 TF01 – Temperature Sensor Ex Barrier, 9113B-U9

[Please refer to data sheet from Section 4.5.]

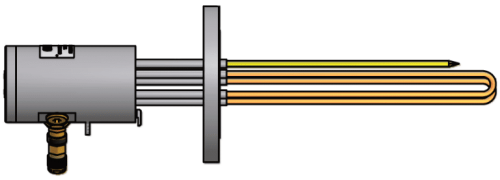
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4.9 EA01..02 – Immersion Heater, D-8640

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Explosion-proof Immersion Heater Type D-8640

Sinus Jevi has developed explosionproof Ex 'de' heating equipment, for hazardous area. The flame-proof (d) enclosures have been designed for non save areas to protect the environment against gas-explosions, caused by sparking by electrical connections of the heating elements and control devices.



SINUS JEVI

Liquids Gasses Solids Spaces Resistors

Sinus-Jevi Electric Heating B.V. Aambeeld 19 1671 NT Medemblik +31 (0) 227 549 100 www.sinusjevi.com

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Catalogue Immersion Heaters type D-8640

Gas and Dust flame-proof immersion heater type D-8640
For hazardous areas, Sinus Jevi has developed explosion-proof Ex 'de' heating equipment, designed and manufactured in accordance with EN-IEC 60079-0, EN-IEC 60079-1, EN 60079-7 and EN-IEC 60079-31 certified by the independent testing institute ISSeP. The certificates cover zone 1 and zone 2 for hazardous areas. Gas groups II A, II B and II C and temperature classes T6-T1. Dust group Ex tb zone 21.

The flame-proof (d) enclosures have been designed for non save areas to protect the environment against gas-explosions, caused by sparking by electrical connections of the heating elements and control devices. Several types of enclosures for immersion heaters, flanged or screwed, have been described on the next pages.
Each type covers a range of a maximum number of installed hairpin shaped heating elements and giving a range of installed capacities.

The screwed types for dimensions up to 3".
The terminal enclosures have a IP66 degree of protection.
Standard the enclosure is coated with two layers, a zinc silicate primer and a top coating. Other coatingsystems on request.

All heaters are standard internal wired on terminals.

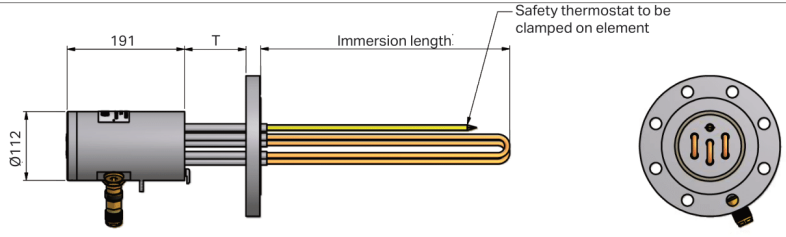
The maximum temperature for the terminal enclosure during operation is 80°C (based on maximum 50°C ambient temperature). If cable entry exceeds 70°C, high temperature cables must be used. The required minimum distance between enclosure and connection flange, to ensure the temperature limit of 80°C in the enclosure, is listed in the following table as a function of temperature classes. Maximum number of cable entries: 2 pcs M25/M20

Marking ATEX	Ex II 2 G D	
	Ex d IIC T6-T1 Gb	EN/IEC 60079-1
	Ex tb IIIC T110°C Db	EN/IEC 60079-31

Type D-8640 Ex II 2G D - Ex d IIC T6-T1 Gb - Ex tb IIIC T110°C Db

Type	Flange 150 LBS	Elements Ø8.5	Elements Ø10.2	Elements Ø12.7	Elements Ø16	Immersion length (mm)	Maximum capacity in oil (Watt)	Maximum capacity in water (Watt)	Maximum capacity in gases (Watt)
D-8640-D021-05	2"	Number of elements depend on diameter, pitch and material				500	1.000	3.000	800
D-8640-D021-07	2"					750	1.700	5.000	1.000
D-8640-D021-10	2"					1.000	2.300	7.000	2.000
D-8640-D021-15	2"					1.500	3.600	11.000	3.000
D-8640-D021-20	2"					2.000	4.900	12.000	4.000
D-8640-D021-25	2"					2.500	6.200	12.000	5.000
D-8640-D021-30	2"					3.000	7.500	12.000	6.000
D-8640-F031-05	3"					500	1.500	4.500	1.200
D-8640-F031-07	3"					750	2.500	7.000	2.000
D-8640-F031-10	3"					1.000	3.500	10.000	3.000
D-8640-F031-15	3"					1.500	5.500	15.000	4.500
D-8640-F031-20	3"					2.000	7.000	20.000	6.000
D-8640-F031-25	3"					2.500	9.000	25.000	7.500
D-8640-F031-30	3"					3.000	11.500	30.000*	9.000
D-8640-H061-05	4"					500	3.000	9.000	2.400
D-8640-H061-07	4"					750	5.000	14.000	4.000
D-8640-H061-10	4"					1.000	7.000	20.000	6.000
D-8640-H061-15	4"					1.500	11.000	30.000*	9.000
D-8640-H061-20	4"					2.000	14.000	30.000*	12.000
D-8640-H061-25	4"					2.500	18.000	30.000*	15.000
D-8640-H061-30	4"					3.000	23.000	30.000*	18.000

* Limitation power by cable entry



- Flange connection with tubular type heating element

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Description
Suitable for heating of fluids both liquids and gases and also solids. The heater consists of a certified flameproof enclosure D-8640, containing:
- certified electric heating elements (Ex e II) tubular, ceramic or cartridge heating elements.
- one manually protective thermostat with manual reset or one thermocouple or pt100 as a safety device. Thermocouple and pt100 are only applicable in combination with an external temperature controller executed with a manual reset.
- threaded holes for cable entries and/or plugs of a certified flameproof model Ex d II B or Ex d II C.

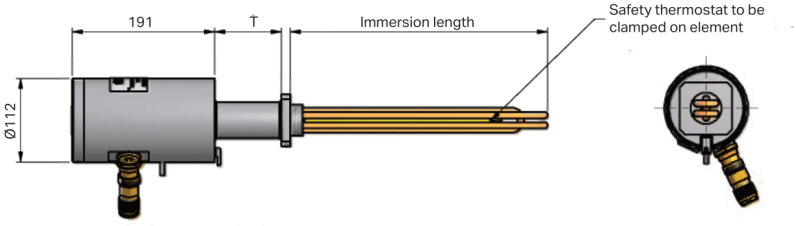
The flame-proof enclosure has been built up out of a seamless body, a top cover and base plate. Each cover and base plate has been provided with 6 screw thread windings with a total length of 18 mm. The connection length of the threaded joint between cover or base plate and body should always be 5 thread windings minimum. The cover has been locked with an M4 screw and the base plate with an M6 screw. In the base plate of the enclosure spacer tubes can be welded in which the heating elements are brazed or welded.

Temperature class		Distance enclosure to heater (T)
T6	85°C	50 mm
T5	100°C	75 mm
T4	135°C	100 mm
T3	200°C	150 mm
T2	300°C	200 mm
T1	450°C	250 mm

Technical specification
- Tubular heating elements with a diameter of Ø8.5 mm up to and including Ø16 mm and cartridge heating elements of Ø12.5 mm up to including Ø31.5 mm can be applied, also ceramic elements from Ø26 mm up to including Ø46 mm.
- Material of the enclosure: carbon, low alloy steel, or ferrous steel.
- Material of heating elements: stainless steels AISI 304, AISI 321, AISI 316, AISI 904L, Inconel 600, Incoloy 800, Incoloy 825, Titanium, SMO, Copper alloy or Nickel alloy.
- Degree of protection of the enclosure: IP66.
- The maximum allowable energy-dissipation of the heating elements has been based on a maximum Watt density, determined by the temperature class, type of medium and process conditions.

The temperature setting of the thermostat, thermocouple or pt100, as stated in the EC type Examination Certificate, is applicable only for heaters immersed into a hazardous fluid flow.

If the heater has not been immersed into a hazardous fluid but forms a part of an apparatus located in a hazardous zone, the temperature setting has to prevent the maximum temperature of the outside of the apparatus to exceed the temperature according to the temperature classification.



- Threaded boss from 1½" G BSP up to 3" G BSP with tubular type heating element.

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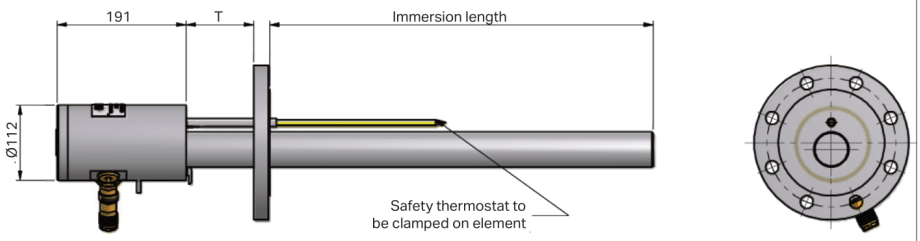
Catalogue Immersion Heaters type D-8640

Flame-proof immersion heater type D-8640 for high working temperatures

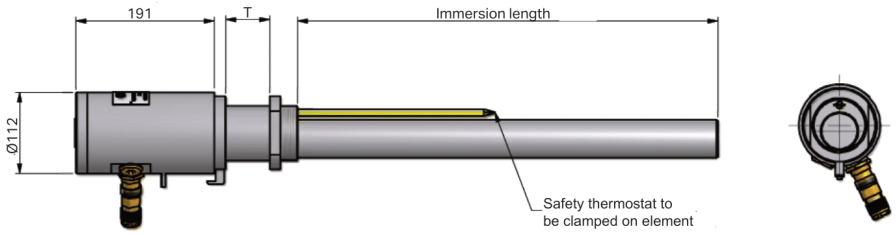
Flame-proof immersion heaters with retractable ceramic core elements.
Single or multi core heaters. For horizontal installation (vertical installation available on request).
The ceramic core elements can be withdrawn for inspection or replacement without having to drain the system.

- Ambient temperature -30°C - +50°C (-50°C ... +50°C on request)
- The maximum allowable voltage is 690 Volt.

Marking ATEX Ex II 2 G D
Ex d IIC T6-T1 Gb EN/IEC 60079-1
Ex tb IIIC T110°C Db EN/IEC 60079-31



- Flange connection with cartridge or retractable ceramic heating element



- Threaded boss from 1½" G BSP up to 3" G BSP with cartridge or retractable ceramic heating element.

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Gas and Dust flame-proof immersion heater type D-8640 VARIATION for relative low working temperatures

Description
The heater serie D-8640 variation is designed to heat a wide range of liquids, gases and solids.
The heater consists of a certified flameproof enclosure Ex d II C T6 - T1 Gb, certified electric heating elements Ex e II and a manually reset protective safety device. Unheated length heating elements into the medium is 30 mm minimum.
The surface loading of the elements in the heater is determined by the thermal characteristics of the fluid or gas being heated and its operating temperature and pressure.
The heaters are designed to operate within an ambient temperature range of -30°C to +50°C.

Heating elements
The heater consists of certified electric heating elements Ex e II which can be tubular heating elements with a diameter up to Ø16 mm or cartridge heating elements up to a diameter of Ø31.5 mm or retractable ceramic core elements Ø26 mm - Ø46 mm placed in a metal sheath with welded end plate.
Voltage supply up to 690 Volt.

Mounting
Threaded boss or flange connection in carbon steel or high alloy steel.

Set point safety thermostat
Set point on safety thermostat in medium:

Temperature class T1 to T4:	110°C
Temperature class T5:	90°C
Temperature class T6:	75°C

Set point on safety thermostat inside the terminal enclosure:

Temperature class T1 to T4:	90°C
Temperature class T5:	85°C
Temperature class T6:	70°C

If the cable entries exceed 70°C suitable high temperature cabling methods must be used. A warning label on the outside of the enclosure next to the cable gland shows the maximum allowable temperature. By a working temperature of more than 90°C the terminal enclosure will be at a distance from the heater. See table on page 3.

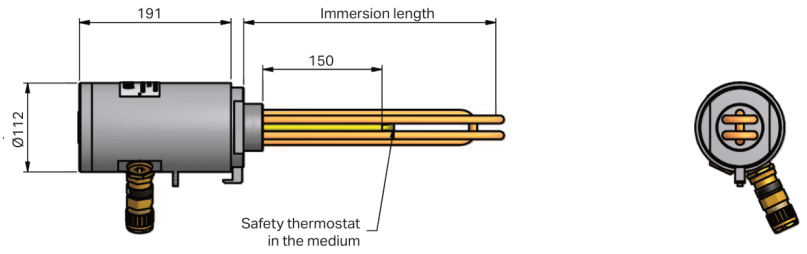
Temperature safety
Minimum of 1 over temperature thermostat or thermocouple or pt100 must be installed for guarding flange, plate or screw head and junction box temperature and must be either:
- Manually reset at the control panel by key switch or special tool
- Manually reset unit inside the terminal enclosure (klixon)
- Possibly with added manually reset unit on the highest surface temperature of the apparatus

When the electric heater type D-8640 and his variation does not have a temperature regulation of its own, the process medium temperature for each combination must be regulated with a seperate flameproof control thermostat, thermocouple or Pt100 and a seperate safety thermostat, thermocouple or Pt100 with manual reset. Both devices shall guarantee the temperature limit and the temperature class.

Special note
The end user must ensure that the heating elements are always inserted into the liquid or gas.
The end user must ensure that there is always a protection against an incorrect direction of flow (e.g. an one way valve). The lowest temperature of the liquid or gas flow is always at the end where the terminal enclosure is situated.

Terminal enclosure
The terminal enclosure can be either direct on or stand off depending on the process temperature.

Marking ATEX	Ex II 2 G D	
	Ex d IIC T6-T1 Gb	EN/IEC 60079-1
	Ex tb IIIC T110°C Db	EN/IEC 60079-31



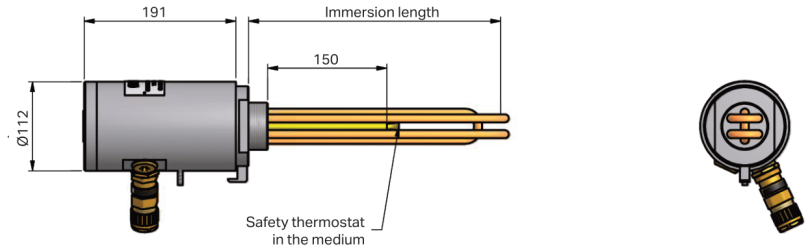
- Threaded boss from 1½" G BSP up to 3" G BSP with tubular heating element.

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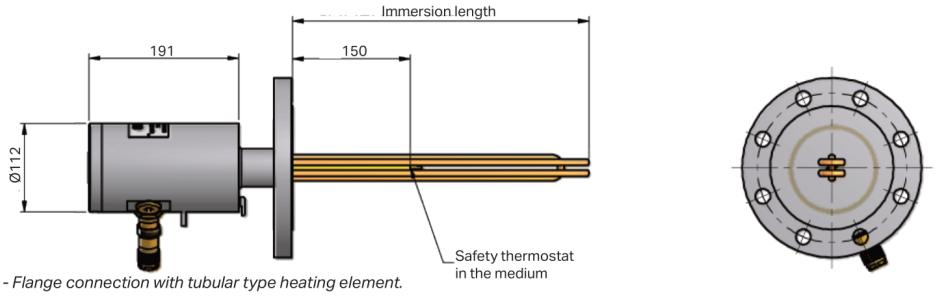
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Catalogue Immersion Heaters type D-8640

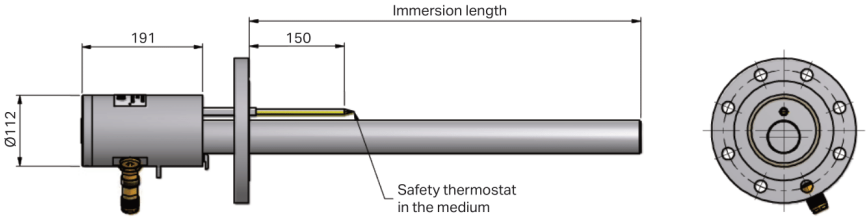
Flame-proof immersion heater type D-8640 VARIATION for low working temperatures



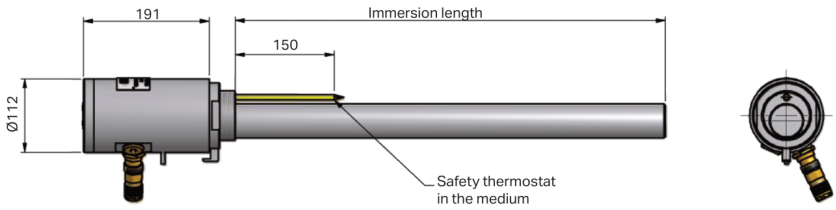
- Threaded boss from 1½" G BSP up to 3" G BSP with tubular heating element.



- Flange connection with tubular type heating element.



- Flange connection with cartridge or retractable ceramic heating element.



- Threaded boss from 1½" G BSP up to 3" G BSP with cartridge or retractable ceramic heating element.

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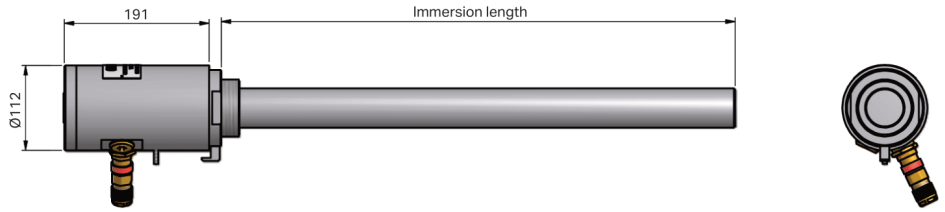
TEMPLATE FRM5100236 0H

Ballard Confidential

Printed on: Friday, November 15, 2024

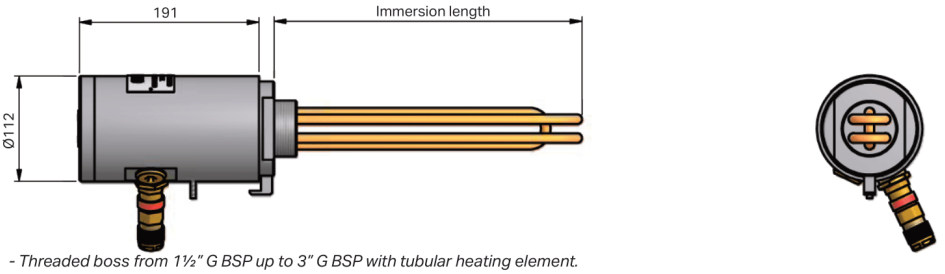
Flame-proof immersion heater type D-8640 VARIATION for low working temperatures

Note: safety thermostat in the enclosure



- Threaded boss from 1½" G BSP up to 3" G BSP with cartridge type heating element.

Note: safety thermostat in the enclosure



- Threaded boss from 1½" G BSP up to 3" G BSP with tubular heating element.

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Sinus is one of the pioneers in the field of explosion proof heating equipment, today we are still operating at the forefront. We manufacture according to ATEX as well as IECEx and EAC directives.

For the production of Ex-proof equipment a PQAN (Product Quality Assurance Notification) is issued by TUV-Nord. Our ISO-9001 and ISO-14001 systems are also monitored by this organisation.

NIBE

953A.1101E • 10-14

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4.10 EA01-WD01 and EA02-WD01 – Control Cable for Immersion Heater, CLASSIC 135 CH

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1123460	DATA SHEET	LAPP
valid from: 15.01.2024	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	

Application

ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV are screened halogen free, highly flame retardant power and control cables designed for the European and North American market, for occasional flexible use and fixed installation subject to normal mechanical load conditions. They are also suitable for use in dry or damp areas. They are suitable for outdoor use if the indicated temperature range is observed. They are suitable for occasional, non-automated movements. The maximum tensile load is 15 N/mm² of conductor cross-section during installation and operation. Compulsory guidance is not permitted.
The screening braid protects against interference from electrical fields.

Application range:
Public buildings, plant engineering, industrial machinery, heating and air-conditioning systems and particularly where human and animal life as well as valuable property exposed to high risk of fire hazards

USE gem. UL: FRPE sheathed cable for internal wiring of appliances or external interconnection

Design

Design	acc. to UL AWM Style 21156, UL 758 based on EN 50525-3-11
Certification	UL AWM Style 21156 (File No. E63634), UL 758 EN 13501-6 and EN 50575 Classification of fire behaviour (article/dimension range see www.lappkabel.com/cpr)
Conductor	fine wire strands of bare copper, acc. to IEC 60228 resp. EN 60228, Class 5
Insulation	halogen free compound TI6, acc. to EN 50363-7, with increased requirements
Core identification code	acc. to VDE 0293-1 up to 5 cores: colour-coded acc. to HD 308 S2, with or without GN/YE ground conductor starting at 6 cores: black cores with white numbers, with or without GN/YE ground conductor, acc. to EN 50334
Stranding	cores are stranded in layers
Wrapping	plastic foil
Screen	braid of tinned copper, coverage = 85% (nominal value)
Outer sheath	halogen free compound TM7 acc. to EN 50363-8 colour: black, similar RAL 9005

Electrical properties at 20 °C

Nominal voltage	EN U_0/U: 600/1000 V UL: 1000 V
Test voltage	core / core: 4000 V AC core / screen: 3000 V AC

Mechanical and thermal properties

Minimum bending radius	occasional flexing: 20 x outer diameter fixed installation: 6 x outer diameter
Temperature range	occasional flexing (EN): -25 °C up to +70 °C max. conductor temp. occasional flexing (UL): up to +75 °C max. conductor temp. fixed installation (EN): -40 °C up to +80 °C max. conductor temp. fixed installation (UL): up to +75 °C max. conductor temp.
Flammability	flame retardant acc. to IEC 60332-1-2 resp. EN 60332-1-2 UL: Cable flame test acc. to UL 1581 §1061 no flame-propagation acc. to IEC 60332-3-24 resp. EN 60332-3-24 or acc. to IEC 60332-3-25 resp. EN 60332-3-25
Halogen free	acc. to IEC 60754-1 resp. EN 60754-1
Corrosivity of gases	acc. to IEC 60754-2 resp. EN 60754-2
Smoke density	acc. to IEC 61034-2 resp. EN 61034-2
Toxicity	acc. to EN 50306-1 (≤ 6)

We reserve all rights according to DIN ISO 16016.
PDC 0019/06_03.23EN

1123460	DATA SHEET	LAPP
valid from: 15.01.2024	ÖLFLEX® CLASSIC 135 CH BK 0,6/1 kV	

UV resistance	acc. to EN 50525-1 cables with black sheath are suitable for permanent outdoor use. acc. to EN 50618 acc. to EN 50620 acc. to EN ISO 4892-2-2013, method A (change of colour allowed)
Ozone resistance	acc. to EN 50396, method B
Tests	acc. to IEC 60811 resp. EN 60811, EN 50395, EN 50396, UL 1581
General requirements	These cables are conform to the EU-Directive 2014/35/EU (Low Voltage Directive). A part of these cables (see www.lappkabel.com/cpr) are classified in accordance with the EU-Regulation no. 305/2011 (CPR).
Environmental information	These cables meet the substance-specific requirements of the EU Directive 2011/65/EU (RoHS).

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PDC 0019/06_03.23EN

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4.11 EA01..02 – Cable Gland for Immersion Heater, ICG 653 UNIV Os M20

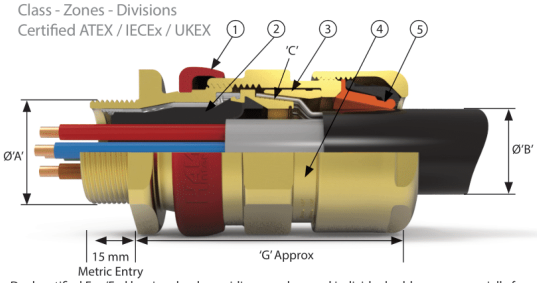
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CABLE GLAND BARRIER SERIES

ICG/653/UNIV

Flameproof, Increased Safety, Dust Protection and Restricted Breathing
Class - Zones - Divisions
Certified ATEX / IECEx / UKEX



- 1 Inspectable Deluge Seal
  - Offering IP66, IP67, IP68 & IP69 Ingress Protection
- 2 Transparent Elastomeric Fully Inspectable Compound Pot – compatible with both injectable resin and 2 part compound
- 3 Reversible Armour Clamp
  - For all types of armour and braid
- 4 Patented Cable Gland Tightening Guide
  - Helps prevent damage caused by over tightening
- 5 Unique Rear Seal - Offering ultimate sealing over an extremely wide cable acceptance range

International Approvals

Dual certified Exe/Exd barrier gland, providing a seal around individual cable cores, especially for cables that exhibit "cold flow" characteristics, are not effectively filled, have hygroscopic fillers or contains fibre optic cores. For use with single wire armour 'W', wire braid 'X', steel tape armour 'Z' elastomer and plastic insulated cables. The ICG/653/UNIVERSAL is available with either ExPress liquid barrier resin or QSP 2-part hand mix compound, both with a cure time 30 minutes

Cable Gland Selection Table

Size Ref.	Entry Thread Size 'A'		Cable Acceptance Details								'G'	Hexagon Dimensions	
			Inner Sheath/Cores				Outer Sheath 'B'		Armour/Braid 'C'				
	Metric	NPT*	Max Inner Sheath Dia	Max Over Core Dia	Max No of Cores	Max No of Fibre Optic	Min	Max	Orientation 1	Orientation 2		Across Flats	Across Corners
Os	M20[2]	½"	8.1**	8	12	48	5.5	12	0.8 / 1.25	0.0 / 0.8	58.4	24	26.5
O	M20[2]	½"	11.7	8.8	12	48	9.5	16	0.8 / 1.25	0.0 / 0.8	58.4	24	26.5
A	M20	¾" or ½"	14	10.8	15	72	12.5	20.5	0.8 / 1.25	0.0 / 0.8	60.6	30	32.5
B	M25	1" or ¾"	19.9	15.9	30	144	16.9	26	1.25 / 1.6	0.0 / 0.7	67.3	36	39.5
C	M32	1¼" or 1"	26.2	21.9	42	-	22	33	1.6 / 2.0	0.0 / 0.7	73.2	46	50.5
C2	M40	1½" or 1¼"	32.3	26.7	60	-	28	41	1.6 / 2.0	0.0 / 0.7	78.3	55	60.6
D	M50	2" or 1 1½"	44.2	37.7	80	-	36	52.6	1.8 / 2.5	0.0 / 1.0	97.5	65	70.8
E	M63	2½" or 2"	56	49	100	-	46	65.3	1.8 / 2.5	0.0 / 1.0	93.5	80	88
F	M75	3" or 2½"	68	59.8	120	-	57	78	1.8 / 2.5	0.0 / 1.0	104.5	95	104

[1] All dimensions in millimetres (except * where dimensions are in inches). Metric entry threads are 1.5mm pitch as standard, 15mm length of thread.
[2] Are available with M16 entry thread, which reduces Max Over Core Diameter to 7mm.

***Recommended value to suit integrated Express resin stop. May be increased to 10.0 if QSP compound or alternative Express resin stop method are used.*

Technical Data

Material Options	Manufactured in Brass, Nickel Plated Brass or 316L Stainless Steel
Ingress Protection	IP66, IP67, IP68 (30 metres for 7 days, special instruction apply), IP69 to IEC/EN 60529 and NEMA 4X
Enclosure Protection	IK10 to IEC 62262
Deluge Protection	to DTS01
Operating Temperature	-60°C to +80°C
Applications	Suitable for use in Zone 1, Zone 21, Zone 2 and Zone 22
Approvals	
Protection Class	Ex II 2GD Ex db IIC Gb; Ex eb IIC Gb; Ex nR IIC Gc; Ex tb IIIC Db
ATEX Certificate No	CML 18ATEX1268X CML 19ATEX4507 (Ex nR)
IECEx Certificate No	CML 18.0131X CML 21.0012X (Ex nR)
UKEX Certificate No	CML 21UKEX1132X CML 21UKEX4133X (Ex nR)
Construction & Test Standards	IEC/EN 62444 (Anchorage Type D), IEC/EN 60079-0, 1, 7, 15, 31
Marine Approvals	ABS: 19-LD1876514-1-PDA BV: 43523/B0 DNV: TAE0000BS
Additional Certifications	CCC: 2020312313000317 EAC: No EA3C RU C-GB.HA91.B.00264/21 EQM: 20-11-27224/Q20-11-000979/NB0007 Inmetro: IEx 14.0272X KCs: 17-KA4BO-0159X to 0167X PESO: P450038 SONCAP: LCOGB049552-0500
NEC/CEC	
NEC Protection Class	Class I Div 1 ABCD Class II Div 2 EFG and Class III Class I, Zone I, AEx db IIC Gb, AEx eb IIC Gb; Zone 21, AEx tb IIIC Db
CEC Protection Class	Class I Div 1 ABCD Class II Div 2 EFG and Class III Ex db IIC Gb; Ex eb IIC Gb; Ex tb IIIC Db
c CSA us Certificate	1024328
Construction & Test Standards	UL2225, UL1203, UL514B, CSA C22.2 NO. 0-10, CSA C22.2 NO. 174-18, CSA 22.2 60079-0, CSA 22.2 60079-1, CSA 22.2 60079-7 and CSA 22.2 60079-31

HAWKE International

Contact Hubbell T: +44 (0)141 882 5555 E: getintouchuk@hubbell.com
www.hubbell.com/hawke

HUBBELL Harsh & Hazardous

HHI-HKE-Multi-ICG-653-UNIV-COLDFLOW-AND-BARRIER-GLAND-SPEC-UK-2023 V1.3

Alternative Reversible Armour Clamping Ring Size Selection

Size Ref	Orientation 1	Orientation 2
B	0.9 - 1.25	0.5 - 0.9
C	1.2 - 1.6	0.6 - 1.2
C2	1.2 - 1.6	0.6 - 1.2
D	1.45 - 1.8	1.0 - 1.45
E	1.45 - 1.8	1.0 - 1.45
F	1.45 - 1.8	1.0 - 1.45

Ordering Information

If brass is required please omit material selection
Format for ordering is as follows: Alternative Ring (R), add suffix R to ordering information
All barrier glands are supplied with Express resin as standard. If QSP (Quick Set Putty) is required please select Q in compound selection

Cable Gland Type	Size	Thread	Material	(Optional)	Compound
653U	C	M32		R	
653U	C	1.25	NP	R	Q

Example Code: 653UCM32R
Assembly instructions are supplied with the cable gland
Please note all NPT entries should be state as a decimal
Please refer to part code logic information page for further details on product options

ExPress Barrier Resin

Specify your barrier gland with our ExPress injectable resin for faster, easier installation
A liquid injectable and fast curing resin, allowing for faster installation time than traditional 2-part compounds. Utilising a unique clear compound chamber for full visibility of the flameproof seal during installation and inspection, the ExPress barrier resin is unparalleled as a global solution, with a 30 minute gel time and unrivalled ease of use.
All barrier glands are now supplied with Express Resin as standard.





EXPRESS

Cable Gland **Tightening Guide**

Whilst Hawke International goes to great lengths to ensure products are designed to be as simple to install, inspect and maintain as is possible, differing levels of competency, training and understanding can lead to glands being incorrectly installed. With hazardous area products, any poor installation issues can not only lead to expensive equipment failure, but also potential explosion risks and associated risk to life.

To help address issues with the overtightening of cable glands and the resultant damage to cables and seals, Hawke International has developed the patented **INBUILT TIGHTENING GUIDE**.

Without the need for fiddly measuring systems, the guide provides a permanent visual indication of the gland tightness through installation, inspection and maintenance.

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4.12 QM1.1..1.6 and QM2.1..2.6 – Solenoid Valve, NF X E210D488E 24/DC

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ASCO™

OPERATORS

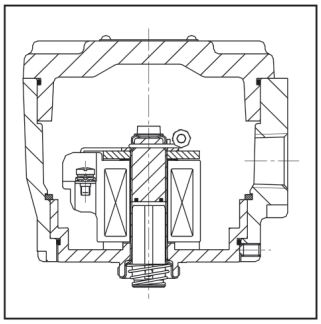
for potentially explosive atmospheres
flameproof enclosure
II 2G/D Ex **d** IIC T6..T4 Gb / Ex **tb** IIIC Db IP66/IP67
aluminium or stainless steel enclosure

Series
NF
WSNF

FEATURES

- *Explosionproof operator for use in potentially explosive atmospheres according to ATEX-Directive 2014/34/EU*
  EC type examination certificate no.: ***LCIE 00 ATEX 6008 X***
  IECEx Certificate of Conformity no.: ***IECEx LCI 07.0015X***
- *Compliance with the Essential Health and Safety Requirements has been assured by compliance with the International and European Standards EN-IEC 60079-0, EN-IEC 60079-1 and EN-IEC 60079-31*
- *Easy electrical installation by means of a screw terminal coil*
- *Enclosure provided with a 1/2 NPT threaded entry hole (M20 x 1,5 in option) for a broad range of cable entries*
- *Ingress protection degree IP66/67*
- *A wide range of valves can be supplied with the operator*





CONSTRUCTION

Solenoid enclosure	NF	Chromated aluminium, epoxy coated
	WSNF	Stainless steel (AISI 316L)
Bonnet	NF	Steel (zinc plated)
	WSNF	Stainless steel (nickel plated)
Core, core tube and plugnut	all	Stainless steel
Shading coil	all	Copper or silver
Nameplate	NF	Stainless steel
	WSNF	Stainless steel
Coil connection	all	Embedded screw terminals
Fasteners & screws	all	Stainless steel
Safety code		IECEx / Ex II 2G Ex d IIC T6..T4 Gb
		IECEx / Ex II 2D Ex tb IIIC 85°C..135°C Db IP66/67

ELECTRICAL CHARACTERISTICS

Standard voltages	DC (=) : 24V - 48V
(Other voltages and 60 Hz on request)	AC (~) : 24V - 48V - 115V - 230V(3) / 50 Hz

TEMPERATURE CLASSIFICATION TABLES

AC (~) solenoids

Pn (watt)	solenoid size MXX	solenoid size M12			maximum ambient °C (1) surface temperature T6 85°C	T5 100°C	T4 135°C	T3 200°C
insulation class F/H (155°C/180°C) 100% E.D.								
1,85(2)(3)		●			75	80		
3,7 (2)		●			60	75	100	
5,8 (2)		●			60	75	100	
10,0 (2)	●				40	60	75	
10,0 (2)		●			40	60	100	
10,5	●				25	40	60	
13,4 (2)	●				40	60	75	
14,1 (2)		●			40	60	90	
15,4		●			25	40	60	
16,5		●			40	60	75	
16,7	●					25	40	
20,0		●				25	40	
20,5	●						25	
28,0		●					25	

DC (=) solenoids

Pn (watt)	solenoid size MXX	solenoid size M12			maximum ambient °C (1) surface temperature T6 85°C	T5 100°C	T4 135°C	T3 200°C
insulation class F/H (155°C/180°C) 100% E.D.								
1,8		●			75	80		
3,6		●			60	75	100	
5,7		●			60	75	100	
10,0		●			40	60	100	
11,2	●				40	60	75	
14,0		●			40	60	90	
16,8		●			40	60	75	
19,7	●				25	40	60	
23,0		●			25	40	60	
26,6		●			25	40	60	
29,5		●				25	40	
36,2		●				25	40	

Check the wattage compatibility with the product selected.
(1) **The minimum allowable ambient temperature is -60°C for the operator.** Actual temperature range can be limited depending on valve operation limits.
(2) AC (~): rectified coil construction.
(3) 230 V AC does not exist (Pn 1,85 W).

ORDERING INFORMATION

A valve supplied with the explosionproof operator will be identified with prefix NF or WSNF before the catalogue number.

Example: **NF** E 210D095 230V/50 Hz

- **NF** — operator
- E — pipe thread ISO 7/1
- 210D095 — basic number
- 230V/50 Hz — voltage

A valve supplied with the explosionproof operator will be identified with electrical interface FN, FS, FT or FU in the 15-digit product code.

15-DIGIT PRODUCT CODE

E 262 K 232 **FN** V00 H1

- E — Thread connection
- 262 — Product series
- K — Revision letter
- 232 — Valves version
- **FN** — Electrical interface
- V00 — Options
- H1 — Voltage - class

Electrical interface
FN = NF
FS = WSNF
FT = NFET
FU = WSNFET

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ASCO™

OPERATORS SERIES NF/WSNF

OPTIONS

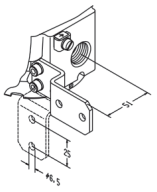
- Operators for mining, I M2 Ex d I, contact us

ORDERING EXAMPLES:

NF	B	327 B 001		230V / 50 Hz
NF	G	551 B 405		230V / 50 Hz
NFET	G	327 B 001	V	230V / 50 Hz
WSNF	E	272 A 047	MS	24V / DC
WSNF	B	320 A 184	E	24V / DC

prefix
pipe thread
basic number
voltage
suffix

MOUNTING BRACKET



Bracket kit no. **C139824**
contains: Stainless steel 304 SS screws and bracket

15-DIGIT PRODUCT CODE

E	262	K	232	**FN**	V00	H1
E	262	K	232	**FS**	V00	F8
E	262	K	232	**FT**	V00	FT
E	262	K	232	**FU**	V00	H9

Thread connection
Product series
Revision letter
Valves version
Electrical interface
Voltage - class
Options

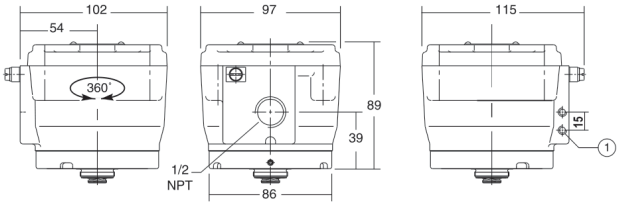
CONNECTIONS

- Any ATEX approved cable entry device can be fitted in the 1/2 NPT threaded entry hole (M20 x 1.5 in option). Refer to the nameplate for identification of the maximum cable temperature
- Internal and external earthing connection
- The operator can be rotated through 360° to select the most favourable position for cable entry

DIMENSIONS (mm), **WEIGHT** (kg)



TYPE NF-WSNF
Prefix "NF" , "WSNF" Solenoid / Electrical interface FN/FS/FT/FU
Aluminium, stainless steel
(NF, epoxy coated)
EN-IEC 60079-1 and EN-IEC 60079-31
II 2G Ex d IIC Gb, II 2D Ex tb IIIC Db IP66/67



series	weight
NF	1,4
WSNF	2,7

(1) 2 mounting holes M5, depth 9 mm

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4 - Explosionproof equipment

4.13 QM1.1..1.6 and QM2.1..2.6 – 1/2" NPT to M20 Adaptor, ADU102904

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Metallic (Exd/Exe) adaptors and reducers - AD-U / RD-U Series



Type AD-U



Type RD-U

Redapt AD-U and RD-U series of explosion-proof metallic adaptors and reducers provide a method of matching electrical thread forms on hazardous area approved equipment whilst ensuring the integrity and Ex approval of the installation is maintained.

Manufactured from hexagon material to facilitate easy installation, they are also supplied complete with a captive O-ring seal. The O-ring is located within a recess on the face of the product, helping to protect the O-ring from the environmental damage and ensuring it is not displaced during installation. Designed for hazardous area applications and the range is certified to protection concepts Exd "Flameproof" and Exe "Increased Safety" for use in Zone 1 and Zone 2 applications. Also certified Ex tb "dust tight" for use in Zone 21 & 22 applications.

Materials

- Brass CZ121
- 316 stainless steel
- Aluminium
- Mild steel

Threadforms

- Metric
- NPT
- PG
- ISO Pipe (BSP)
- ET

Plating options

- Electroless nickel
- Zinc
- Chromated
- Others on application

Technical specifications

Code of protection categories
ATEX: I M2/II 2 GD
IECEx: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/Gb, Ex tb IIIC Db (Aluminium not mining)
CSA: RD-U Ex db / Ex eb IIC Gb IP66/67/68; Cl I Zn 1 AEx eb / AEx db IIC Gb IP54; Cl I Div1 Gr ABCD Cl II Gr EFG Cl III; Type 3 AD-U Ex db / Ex eb IIC Gb IP66/67/68; Cl I Zn 1 AEx eb / AEx db IIC Gb IP54; Cl I Div1 Gr ABCD Cl II Gr EFG Cl III; Type 3
Compliance standards
ATEX: EN 60079-0, EN 60079-1, EN 60079-7, EN 60079-31
IECEx: IEC 60079-0, IEC 60079-1, IEC 60079-7, IEC 60079-31
CSA: CAN/CSA C22.2 No. 60079-0, No. 60079-1, No. 60079-7, ANSI/UL 60079-0, 60079-1, 60079-7, UL1203
Certificate details
ATEX: ITS16ATEX101339X
IECEx: IECEx ITS 16.0013X
EAC: RU C-GB.M**Ю**62.B.06225
CSA: CSA01CA1248014X
INMETRO: NCC 18.0133 X
CCoE: P362565/1 (AD-U) ; P485509 (RD-U)
Temperature
Temperature will depend on the type of O-ring used:
None: -60°C to +200°C
Nitrile: -30°C to +80°C (supplied as standard)
EPDM: -50°C to +100°C
Neoprene: -40°C to +80°C
Viton: -20°C to +180°C
Silicone: -60°C to +180°C
Fluorosilicone: -60°C to +130°C
The maximum temperature is limited to +150°C for Group I applications
Ingress protection (IP):
IP64 when fitted without sealing washer. IP66/IP68 when fitted with O-ring or thread sealant according to manufacturer's instructions.
Part number:
Please refer to part numbering system below

Download certificates and documents here

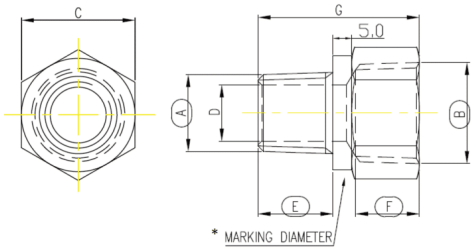
Available thread sizes and corresponding bore size

Metric	Bore	NPT	Bore	ISO Pipe	Bore	ET	Bore	PG	Bore
M16	10.00	-	-	3/8"	10.00	5/8"	10.00	PG7	8.00
M20	14.00	½"	15.00	½"	15.00	¾"	14.00	PG9	10.00
M25	18.00	¾"	19.00	¾"	19.00	1"	18.00	PG11	13.50
M32	24.00	1"	25.00	1"	25.00	1 ¼"	24.00	PG13.5	14.00
M40	32.00	1 ¼"	32.00	1 ¼"	32.00	1 ½"	32.00	PG16	16.00
M50	41.00	1 ½"	38.00	1 ½"	38.00	2"	41.00	PG21	21.00
M63	53.00	2"	49.00	2"	49.00	2 ½"	53.00	PG29	29.00
M75	64.00	2 ½"	60.00	2 ½"	60.00	3"	64.00	PG36	38.00
M80 x 2.0	69.00	3"	75.00	3"	75.00	-	-	PG42	45.00
M85 x 2.0	73.00	3 ½"	88.00	3 ½"	88.00	-	-	PG48	50.00
M90 x 2.0	78.00	4"	100.00	4"	100.00	-	-	-	-

Sizes M12 to M120 available.

Metallic (Exd/Exe) adaptors and reducers - Dimensions

AD-U



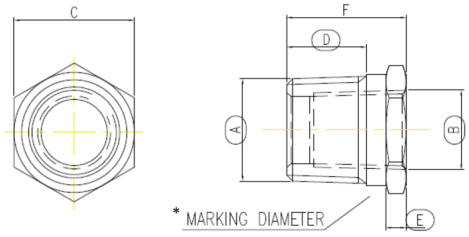
A	B	C	D	E	F	G
Male	Female	A/F	Bore	Thread length	Thread depth	Total length
M16	M16	23.4	10.0	16.0	17.0	38.5
	M20	23.4	10.0	16.0	17.0	38.5
M20	M20	27.0	14.0	16.0	17.0	38.5
	M25	30.5	14.0	16.0	17.0	38.5
M25	M25	31.8	18.0	16.0	17.0	38.5
	M32	37.6	18.0	16.0	17.0	38.5
M32	M32	37.6	24.0	16.0	17.0	38.5
	M40	47.2	24.0	16.0	17.0	38.5
M40	M40	47.2	32.0	16.0	16.5	38.5
	M50	55.9	32.0	16.0	17.0	39.5
M50	M50	57.2	41.0	16.0	17.0	39.5
	M63	70.1	41.0	16.0	17.0	39.5
M63	M63	70.1	53.0	16.0	17.0	39.5
	M75	90.2	53.0	16.0	17.0	39.5
M75	M75	90.2	64.0	16.0	16.5	39.5
	M90	106.4	64.0	16.0	22.0	45.0
M90	M90	106.4	78.0	20.0	22.0	49.0
	M100	114.3	78.0	20.0	22.0	49.0
M100	M100	114.3	88.0	20.0	22.0	49.0

A	B	C	D	E	F	G
Male	Female	A/F	Bore	Thread length	Thread depth	Total length
1/2 NPT	1/2 NPT	23.4	15.0	20.0	20.0	46.0
	3/4 NPT	30.5	15.0	20.0	20.0	46.0
3/4 NPT	3/4 NPT	30.5	19.0	20.0	20.0	46.0
	1 NPT	37.6	19.0	20.0	25.0	51.0
1 NPT	1 NPT	37.6	25.0	25.0	25.0	56.0
	1. 1/4 NPT	47.2	25.0	25.0	25.0	56.0
1. 1/4 NPT	1. 1/4 NPT	47.2	32.0	25.0	25.0	56.0
	1. 1/2 NPT	55.9	32.0	25.0	25.0	57.0
1. 1/2 NPT	1. 1/2 NPT	55.9	38.0	25.0	25.0	57.0
	2 NPT	70.1	38.0	25.0	25.0	57.0
2 NPT	2 NPT	70.1	49.0	25.0	25.0	57.0
	2. 1/2 NPT	80.0	49.0	25.0	35.0	67.0
2. 1/2 NPT	2. 1/2 NPT	80.0	60.0	35.0	35.0	77.0
	3 NPT	106.4	60.0	35.0	35.0	77.0
3 NPT	3 NPT	106.4	75.0	35.0	35.0	77.0
	3. 1/2 NPT	114.3	75.0	35.0	35.0	78.0
	4 NPT	127.0	75.0	35.0	35.0	78.0
3. 1/2 NPT	3. 1/2 NPT	114.3	88.0	35.0	35.0	78.0
	4 NPT	127.0	88.0	35.0	35.0	78.0
4 NPT	4 NPT	127.0	100.0	35.0	35.0	78.0

*Note: stainless steel may not have the roll marking diameter.

Metallic (Exd/Exe) adaptors and reducers - Dimensions

RD-U



A	B	C	D	E	F
Male	Female	A/F	Thread length	Hexagon length	Total length
M20	M16 & below	27.0	16.0	5.0	26.0
M25	M20 & below	31.8	16.0	5.0	26.0
M32	M25 & below	37.6	16.0	5.0	26.0
M40	M32 & below	47.2	16.0	5.0	26.0
M50	M40 & below	57.2	16.0	6.0	27.0
M63	M50 & below	70.1	16.0	6.0	27.0
M75	M63 & below	90.2	16.0	6.0	27.0
M80	M75 & below	90.2	20.0	6.0	31.0
M85	M75 & below	106.4	20.0	6.0	31.0
M90	M80 & below	106.4	20.0	6.0	31.0
M100	M90 & below	114.3	20.0	6.0	31.0
M110	M90 & below	120.7	20.0	7.0	32.0

A	B	C	D	E	F
Male	Female	A/F	Thread length	Hexagon length	Total length
3/4 NPT	1/2 NPT & below	27.9	20.0	5.0	30.0
1 NPT	3/4 NPT & below	34.9	25.0	5.0	35.0
1. 1/4 NPT	1 NPT & below	44.5	25.0	5.0	35.0
1. 1/2 NPT	1.1/4 NPT & below	52.1	25.0	5.0	35.0
2 NPT	1.1/2 NPT & below	61.2	25.0	6.0	36.0
2. 1/2 NPT	2 NPT & below	80.0	35.0	6.0	46.0
3 NPT	2.1/2 NPT & below	90.2	35.0	6.0	46.0
3. 1/2 NPT	3 NPT & below	106.4	35.0	6.0	46.0
4 NPT	3.1/2 NPT & below	120.7	35.0	7.0	47.0

*Note: stainless steel may not have the roll marking diameter.

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Metallic (Exd/Exe) adaptors and reducers - Product coding

Product	Digits 1 & 2
Exd/Exe ADAPTOR	**AD**
Exd/Exe REDUCER	**RD**

Certification	Digit 3
U	Exd I and IIC & Exe I and IIC

Material	Digit 4
1	Brass
2	Mild steel
3	Stainless steel
5	Aluminium

Plating	Digit 5
0	Unplated
1	Electroless nickel
2	Zinc
6	Chromated

Digits 6 & 7, Male thread – Digits 8 & 9, Female thread

Metric	ET imperial conduit	NPT	NPSM	ISO pipe parallel (BSPP)	ISO pipe taper (BSPT)	PG
02 M12						
03 M16	17 5/8" ET	**29 ½" NPT**	42 ½" NPSM	55 ½" BSPP	68 ½" BSPT	79 PG7
04 M20	18 ¾" ET	30 ¾" NPT	43 ¾" NPSM	56 ¾" BSPP	69 ¾" BSPT	80 PG9
05 M25	19 1" ET	31 1" NPT	44 1" NPSM	57 1" BSPP	70 1" BSPT	81 PG11
06 M32	20 1¼" ET	32 1¼" NPT	45 1¼ " NPSM	58 1¼" BSPP	71 1¼" BSPT	82 PG13.5
07 M40	21 1½" ET	33 1½" NPT	46 1½" NPSM	59 1½" BSPP	72 1½" BSPT	83 PG16
08 M50	22 2" ET	34 2" NPT	47 2" NPSM	60 2" BSPP	73 2" BSPT	84 PG21
09 M63	23 2½" ET	35 2½" NPT	48 2½" NPSM	61 2½" BSPP	74 2½" BSPT	85 PG29
10 M75	24 3" ET	36 3" NPT	49 3" NPSM	62 3" BSPP	75 3" BSPT	86 PG36
11 M80 x 2.0	ET Special	37 3½" NPT	50 3½" NPSM	63 3½" BSPP	76 3½" BSPT	87 PG42
12 M85 x 2.0		38 4" NPT	51 4" NPSM	64 4" BSPP	77 4" BSPT	88 PG48
13 M90 x 2.0		NT Special	NS Special	BP Special	BT Special	PG Special
14 M100 x 2.0						
15 M110 x 2.0						
BZ M120 x 2.0						

Example

Digits 1 & 2		Digit 3		Digit 4		Digit 5		Digits 6 & 7		Digits 8 & 9
AD	-	**U**	-	**1**	-	**1**	-	**29**	-	**04**
Adaptor		Exd/e certified		Brass		Nickel-plated		1/2" NPT (male)		M20 (female)

Notes:
- Always quote male thread first
- Threadform codes below to be used for both male and female threads.

Adaptors and reducers selection guide

STEP 1 – To obtain the correct reference number, select the male size from the left hand column, then refer horizontally across the page to the female size (i.e. M32 (male) x M40 (female) = 208). Reference numbers in blue are adaptors; other references are reducers.

Female Size

	Metric													NPT								PG							
Male	M16	M20	M25	M32	M40	M50	M63	M75	M80	M85	M90	M100	M110	M120	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	PG7&9	PG11	PG13.5	PG16	PG21	PG29	PG36	PG42
M16	201	201													216										201	201	201					
M20	301	202	203												217	218									301	202	202	202	204			
M25	303	303	257	206											303	219	221								303	303	303	257	204			
M32	305	305	305	206	208										305	305	221	223							305	305	305	305	207	258		
M40	307	307	307	307	208	209									307	307	307	223	224						307	307	307	307	307	208	209	
M50	309	309	309	309	309	259	211								309	309	309	309	225	226					309	309	309	309	309	309	210	210	211
M63	310	310	310	310	310	310	211	212							310	310	310	310	310	226	227				310	310	310	310	310	310	310	310	211
M75	311	311	311	311	311	311	311	212	261	213	213				311	311	311	311	311	311	360	228			311	311	311	311	311	311	311	311	311
M80	311	311	311	311	311	311	311	261	261	214	214																					
M85	312	312	312	312	312	312	312	214	214	214	214																					
M90	312	312	312	312	312	312	312	312	214	214	214	215			312	312	312	312	312	312	312	229	230	231								
M100	313	313	313	313	313	313	313	313	313	313	215	215	262	263	313	313	313	313	313	313	313	313	230	231								
M110	325	325	325	325	325	325	325	325	325	325	325	262	262	263																		
M120	326	326	326	326	326	326	326	326	326	326	326	326	263	263																		

	Metric										NPT										PG									
NPT	M16	M20	M25	M32	M40	M50	M63	M75	M90	M100	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	5"	PG7&9	PG11	PG13.5	PG16	PG21	PG29	PG36	PG42	PG48
1/2"	314	232	234								245	246										314	232	232	232	265				
3/4"	315	315	234	235							315	246	247									315	315	315	234	235				
1"	316	316	316	236	237						316	316	248	249								316	316	316	316	236	237			
1 1/4"	317	317	317	317	237	238					317	317	317	249	250							317	317	317	317	317	237	238		
1 1/2"	318	318	318	318	318	238	240				318	318	318	318	250	251						318	318	318	318	318	318	238	239	240
2"	319	319	319	319	319	319	240	241			319	319	319	319	319	251	252					319	319	319	319	319	319	319	319	240
2 1/2"	320	320	320	320	320	320	320	242	243		320	320	320	320	320	320	253	254				320	320	320	320	320	320	320	320	320
3"	321	321	321	321	321	321	321	321	243	244	321	321	321	321	321	321	321	254	255			321	321	321	321	321	321	321	321	321
3 1/2"	322	322	322	322	322	322	322	322	322	244	322	322	322	322	322	322	322	322	255	256		322	322	322	322	322	322	322	322	322
4"	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	256	264	323	323	323	323	323	323	323	323	323
5"	–	–	–	–	–	–	–	–	–	–	327	327	327	327	327	327	327	327	327	327	–	–	–	–	–	–	–	–	–	–

	Metric								NPT							PG									
PG	M16	M20	M25	M32	M40	M50	M63	M75	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	PG7&9	PG11	PG13.5	PG16	PG21	PG29	PG36	PG42	PG48
7&9	201	201							216							201	201	201						
11	202	202	203						217	218						301/202	202	202	202					
13.5	301	202	203						217	218						301	202	202	202	204				
16	302	203	203						218	218	221					302	302	203	203	204				
21	304	304	205	206	206				304	220	221					304	304	304	304	205	258			
29	306	306	306	306	208	209			306	306	223	223	224			306	306	306	306	208	209			
36	308	308	308	308	308	209	211		308	308	308	224	224			308	308	308	308	308	209	210	211	
42	324	324	324	324	324	210	211		324	324	324	324	324	226		324	324	324	324	324	324	210	211	
48	310	310	310	310	310	310	211	211	310	310	310	310	310	226	227	310	310	310	310	310	310	310	211	

Adaptors and reducers selection guide

STEP 2 – Having obtained the reference number, go to the relevant column within the dimension tables to obtain the adaptor or reducer's dimensions. Please note that these dimensions refer to metallic products only.

Adaptors

Metric x metric, metric x PG, PG x metric, PG x PG																			
Reference numbers	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	257	258	259
Hex across flats	23.4	27.0	30.5	33.0	36.0	37.6	37.6	47.2	55.9	61.2	70.1	90.2	106.4	106.4	114.3	23.4	31.8	41.3	57.2
Hex across corners	26.8	31.0	35.0	38.0	41.5	43.2	43.2	53.4	64.3	70.4	81.8	103.7	122.4	122.4	131.4	26.8	36.1	47.7	66.0
Male thread length	16	16	16	16	16	16	16	16	16	16	16	16	16	20	20	15	16	16	16
Female thread length	17	17	17	17	17	17	17	17	17	17	17	17	22	22	22	20	17	17	17
Total length	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	39.5	39.5	39.5	39.5	45.0	49.0	49.0	42.0	38.5	38.5	39.5

Metric x NPT, PG x NPT																			
Reference numbers	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	261	262	263	-
Hex across flats	27.0	30.5	32.0	37.6	37.6	41.3	47.2	55.9	57.2	70.1	80.0	106.4	106.4	114.3	127.0	90.2	120.7	139.7	-
Hex across corners	31.0	35.0	36.7	43.2	43.2	47.5	53.4	64.3	66.0	81.8	92.0	122.4	122.4	131.4	147.0	104.1	139.4	161.3	-
Male thread length	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	20	20	-
Female thread length	20	20	20	20	25	25	26	26	26	27	40	35	42	42	44	22	22	22	-
Total length	42	42	42	42	47	47	47	48	48	48	58	58	62	62	62	48	48	49	-

NPT x metric, NPT x PG																			
Reference numbers	232	233	234	235	236	237	238	239	240	241	242	243	244	260	265	-	-	-	-
Hex across flats	23.4	28.6	30.5	37.6	37.6	44.5	55.9	70.1	70.1	90.2	90.2	106.4	114.3	90.2	33.0	-	-	-	-
Hex across corners	26.8	32.9	35.0	43.2	43.2	51.1	64.3	70.4	81.8	103.7	103.7	122.4	131.4	103.7	38.0	-	-	-	-
Male thread length	20	20	20	20	25	25	25	25	25	25	35	35	35	16	20				
Female thread length	17	17	17	17	17	17	17	17	17	17	17	22	22	35	77	-	-	-	-
Total length	43	43	43	43	48	48	49	49	49	49	59	64	64	58	43	-	-	-	-

NPT x NPT																			
Reference numbers	245	246	247	248	249	250	251	252	253	254	255	256	264	-	-	-	-	-	-
Hex across flats	23.4	30.5	37.6	37.6	47.2	55.9	70.1	80.0	80.0	106.4	114.3	127.0	158.8	-	-	-	-	-	-
Hex across corners	26.8	35.0	43.2	43.2	53.4	64.3	81.8	92.0	92.0	122.4	131.4	146.0	183.3	-	-	-	-	-	-
Male thread length	20	20	20	25	25	25	25	25	35	35	35	35	35	-	-	-	-	-	-
Female thread length	20	20	25	25	25	25	25	35	35	35	35	35	47	-	-	-	-	-	-
Total length	46	46	51	56	56	57	57	67	77	77	78	78	81	-	-	-	-	-	-

Reducers

Metric and PG																			
Reference numbers	301	302	303	304	305	306	307	308	309	310	311	312	313	324	325	326	-	-	-
Hex across flats	27.0	30.5	31.8	36.0	37.6	44.5	47.2	55.9	57.2	70.1	90.2	106.4	114.3	61.2	120.7	127.0	-	-	-
Hex across corners	31.0	35.0	36.7	41.5	43.2	51.1	53.4	64.3	66.0	81.8	103.7	122.4	131.0	70.7	139.4	146.6	-	-	-
Male thread length	16	16	16	16	16	16	16	16	16	16	16	20	20	16	16	16	-	-	-
Total length	26	26	26	26	26	26	26	27	27	27	27	31	31	27	28	28	-	-	-

NPT																			
Reference numbers	314	315	316	317	318	319	320	321	322	323	327	-	-	-	-	-	-	-	-
Hex across flats	23.4	27.9	34.9	44.5	52.1	61.2	80.0	90.2	106.4	120.7	146.0	-	-	-	-	-	-	-	-
Hex across corners	26.8	32.1	40.2	51.1	59.9	70.4	92.0	103.7	122.4	138.8	168.6	-	-	-	-	-	-	-	-
Male thread length	20	20	25	25	25	25	35	35	35	35	35	-	-	-	-	-	-	-	-
Total length	30	30	35	35	35	36	46	46	46	47	47	-	-	-	-	-	-	-	-

Thread dimension chart

ISO metric

BS 3643 1.5mm pitch

Size	Major dia.	TPI
M12	11.97	16.93
M16	15.97	16.93
M20	19.97	16.93
M25	24.97	16.93
M32	31.97	16.93
M40	39.97	16.93
M50	49.97	16.93
M63	62.97	16.93
M75	74.97	16.93
2.0mm pitch		
M80	79.97	12.70
M85	84.97	12.70
M90	89.97	12.70
M100	99.97	12.70
M110	109.97	12.70
M120	119.97	12.70

NPT

ANSI.ASME B1.20.1

Size	Pipe dia.	TPI
½"	21.34	14.00
¾"	26.67	14.00
1"	33.40	11.50
1¼"	42.16	11.50
1½"	48.26	11.50
2"	60.33	11.50
2½"	73.03	8.00
3"	88.90	8.00
3½"	101.60	8.00
4"	114.30	8.00

PG

DIN 40430

Size	Major dia.	TPI
PG7	12.50	20.00
PG9	15.20	18.00
PG11	18.60	18.00
PG13.5	20.40	18.00
PG16	22.50	18.00
PG21	28.30	16.00
PG29	37.00	16.00
PG36	47.00	16.00
PG42	54.00	16.00
PG48	59.30	16.00

Alternate ISO pipe thread designations

UK	**BSP P**arallel or **T**aper BS2279 (BS21)
Europe	**G** (Parallel) **GK** (Taper) **R** (Parallel) **RK** (Taper)
Japan	**PF** (Parallel) JIS B 303
CIS	**K mpy** (Taper)

BSP ISO pipe thread

ISO R/7; UNI 6125

Size	Pipe Dia.	TPI
⅜"	16.66	19.00
½"	20.96	14.00
¾"	26.44	14.00
1"	33.25	11.00
1¼"	41.91	11.00
1½"	47.80	11.00
2"	59.61	11.00
2½"	75.18	11.00
3"	87.88	11.00

ET imperial conduit

BS31

Size	Major dia.	TPI
⅝"	15.88	18.00
¾"	19.05	16.00
1"	25.40	16.00
1¼"	31.75	16.00
1½"	38.10	14.00
2"	50.80	14.00
2½"	63.50	14.00
3"	76.20	14.00

Thread dimension substitution chart

Metric	NPT (or NPS)	PG	BSP ISO Pipe	ET
M16	–	7, 9	–	⅝"
M20	½"	11, 13.5	½"	¾"
M25	¾"	16	¾"	1"
M32	1"	21	1"	1¼"
M40	1¼"	29	1¼"	1½"
M50	1½"	36	1½"	2"
M63	2"	42, 48	2"	2½"
M75	2½"	–	2½"	3"
M90 x 2.0	3"	–	3"	–
M100 x 2.0	3½"	–	–	–
M110 x 2.0	–	–	–	–
M120 x 2.0	–	–	–	–

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Part numbering system

Codes

Page No.	Product	Digits 1 & 2
Adaptors and reducers		
14-17	**AD**	Adaptor
14-17	RD	Reducer
18	TA	Swivel - in-line male to female
18	TC	Swivel - in-line female to female
18	TD	Swivel - in-line male to male
18	TP	Swivel - 90° male to female
18	TQ	Swivel - 90° female to female
18	TR	Swivel - 90° male to male
19	AY	'Y' adaptor
20	AT	'T' adaptor
21	AR	90° adaptor
22	AM	Male to male adaptor
23	AF	Female to female adaptor
24-25	DB	Insulated adaptor
Stopping Plugs		
26-27	PD	Dome head plug
28	PA	Type A plug
28	PB	Type B plug
Breather Drains		
31	DP	Breather drain (Exe)
32	BD	Breather drain (Exde)
Other products		
34	UN	Union - male to female
34	UF	Union - female to female
35	AE	Earth lead adaptor

Certification	Digit 3
U	Exd I and IIC & Exe I and IIC
D	Exd I and IIC
E	Exe I and IIC
F	Industrial (marked product)

Material	Digit 4
1	Brass
2	Mild steel
3	Stainless steel
4	Glass filled nylon
5	Aluminium
6	Nylon 6
7	Red fibre

Plating	Digit 5
0	Unplated
1	Electroless nickel
2	Zinc
6	Chromated

Example

Digits 1 & 2		Digit 3		Digit 4		Digit 5		Digits 6 & 7		Digits 8 & 9
AD	-	**U**	-	**1**	-	**1**	-	**29**	-	**04**
Adaptor		Exd/e certified		Brass		Nickel-plated		1/2" NPT (male)		M20 (female)

Always quote male thread first.

EATON
Powering Business Worldwide

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4.14 QM1.1..QM1.6 and QM2.1..QM2.6 – Cable Gland for Solenoid Valve, 501/421 O M20 Brass

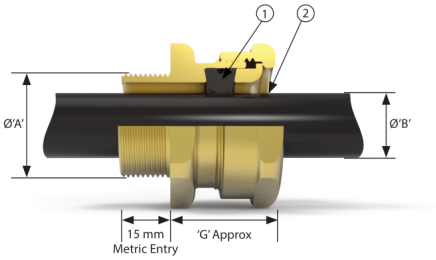
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CABLE GLAND COMPRESSION SERIES

501/421

Flameproof, Increased Safety, Dust Protection and Restricted Breathing
Class - Zones
Certified ATEX / IECEx / UKEX / c CSA us

International Approvals



■1 Elastomeric Exd Flameproof and Exe Increased Safety seal on cable outer sheath

■2 Rounded Cable entry to prevent cable damage

The 501/421 dual certified Exe/Exd cable gland is intended for use on non-armoured elastomer and plastic insulated cables.
This cable gland may be used with braided cables where the braid and outer sheath pass into the enclosure.
The braid must then be suitably terminated inside the enclosure. For Exd applications, the cable must be suitable in compliance with with BS EN 60079-14.

Cable Gland Selection Table

Size Ref.	Entry Thread Size		Cable Acceptance Details – Outer Sheath 'B'				Max Length 'G'	Hexagon Dimensions	
			Standard Seal		Alternative Seal (S)				
	Metric	NPT*	Min.	Max.	Min.	Max.		Across Flats	Across Corners
2K	M16	–	3.2	8.0	–	–	23.5	19.0	21.2
Os	M20[2]	½"	3.2	8.0	–	–	23.8	24.0	26.5
O	M20[2]	½"	6.5	11.9	–	–	23.8	24.0	26.5
A	M20	¾" or ½"	10.0	14.3	9.0	13.4	24.8	30.0	32.5
B	M25	1" or ¾"	13.0	20.2	9.5	15.4	25.8	36.0	39.5
C	M32	1¼" or 1"	19.5	26.5	15.5	21.2	29.2	46.0	50.5
C2	M40	1½" or 1¼"	25.0	32.5	22	28	30.5	55.0	60.6
D	M50	2" or 1½"	31.5	44.4 / 42.3[1]	27.5	34.8	40.4	65.0	70.8
E	M63	2½" or 2"	42.5	56.3 / 54.3[1]	39	46.5	38.2	80.0	88.0
F	M75	3" or 2½"	54.5	68.2 / 65.3[1]	49.5	58.3	40.5	95.0	104.0
G	M80	3½"	67.0	73.0	–	–	41	106.4	115.0
H	M90	3½"	67.0	77.6	–	–	41.0	115.0	130.0
J	M100	4"	77.0	91.6	–	–	41.0	127.0	142.0

All dimensions in millimetres (except * where dimensions are in inches)
Os - F size metric entry threads are 1.5mm pitch as standard, 15mm length of thread
G - J size metric entry threads are 2mm pitch as standard, 20mm length of thread

[1] *Smaller value is applicable when selecting reduced NPT entry option.*
[2] *Sizes Os and O are available with an M16 thread size. For O size with M16 thread, the maximum cable outer sheath diameter is 10.9mm*

HAWKE International

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HUBBELL Harsh & Hazardous

HH-HKE-Multi-501-421-COMPRESSION-GLAND-SPEC-UK-2023 V8

CABLE GLAND COMPRESSION SERIES

Technical Data

Material Options	Manufactured in Brass, Nickel Plated Brass or 316L Stainless Steel
Ingress Protection	IP66, IP67 and IP68 (30 metres for 7 days, special instructions apply) to IEC/EN 60529 and NEMA 4X
Enclosure Protection	IK10 to IEC 62262
Deluge Protection	Deluge Protection to DTS01
Operating Temperature	-60°C to +100°C
Applications	Suitable for use in Zone 1, Zone 21, Zone 2 and Zone 22
Approvals	
Protection Class	Ex II 2GD Ex db IIC Gb; Ex eb IIC Gb; Ex nR IIC Gc; Ex tb IIIC Db
ATEX Certificate No	CML 19ATEX1167X CML 19ATEX4507X (Ex nR)
IECEx Certificate No	CML 19.0045X CML 21.0012X (Ex nR)
UKEX Certificate No	CML 21UKEX1161X CML 21UKEX4133X (Ex nR)
Construction & Test Standards	IEC/EN 62444 (Anchorage Type B), IEC/EN 60079-0, 1, 7, 15, 31
Marine Approvals	ABS: 19-LD1876514-1-PDA BV: 43523/B0 DNV: TAE0000BS
Additional Certifications	CCC: 2020312313000315 EAC: No EA3C RU C-GB.HA91.B.00264/21 EQM: 20-11-27224/Q20-11-000979/NB0007 Inmetro: IEx 14.0272X KCs: KTL 17-KA4BO-0120X to 0128X India: PESO P450038 SONCAP: LCOGB049552-0500
NEC / CEC	
NEC Protection Class	Class I, Zone I, AEx eb IIC Gb; Zone 21, AEx tb IIIC Db
CEC Protection Class	Class I, Div.2 Groups ABCD; Class II Div.2, Groups EFG; Class III Ex db IIC Gb; Ex eb IIC Gb
c CSA us Certificate Number	CSA1015065
Construction & Test Standards	UL 60079-0, UL 60079-7, UL 60079-31, CSA 22.2 No: 60079-0, CSA 22.2 No: 60079-1, CSA 22.2 No: 60079-7, CSA 22.2 No: 60079-31, UL514B; UL1203; UL 2225

Ordering Information

Format for ordering is as follows: Alternative Seal (S), add suffix S to ordering information

Cable Gland Type	Size	Thread	Material	(Optional)
501/421	C	M32	Brass	S
501/421	C	1¼" NPT	Brass	S

Order Example: 501/421 C M32 Brass S

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4.15 XT01..06 – Compression Seal for Wall Penetration, Roxtec RS 50 B Ex-kit

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Roxtec RS B Ex kit

The Roxtec RS B Ex is a round entry seal including a sleeve for bolting. The seal consists of two halves and an adaptable center with removable layers. Compression is integrated in the seal.

- For use in hazardous locations
- Attachment by bolting



RS 100 B Ex AISI 316 woc/primed



RS 75 B Ex AISI 316/AISI 316

Galvanized mild steel

Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 25 B Ex AISI316/GALV	3.6 - 12	36 - 36	0.43	EXRSB0250002118
RS 43 B Ex AISI316/GALV	4 - 23	54 - 54	0.9	EXRSB0430002118
RS 50 B Ex AISI316/GALV	8 - 30	65 - 65	1.4	101918
RS 75 B Ex AISI316/GALV	24 - 54	91 - 91	2	EXRSB0750002118
RS 100 B Ex AISI316 WOC/GALV	48 - 70	116 - 116	2.9	EXRSB0100102118
RS 100 B Ex AISI316/GALV	48 - 70	116 - 116	3	EXRSB1000002118
RS 125 B Ex AISI316 WOC/GALV	66 - 98	142 - 142	3.6	EXRSB0125102118
RS 125 B Ex AISI316/GALV	66 - 98	142 - 142	4.3	EXRSB1250002118
RS 150 B Ex AISI316 WOC/GALV	93 - 119	166 - 166	4.5	EXRSB0150102118

Primed mild steel

Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 100 B Ex AISI316 WOC/PRIMED	48 - 70	116 - 118	2.9	EXRSB0100102112
RS 125 B Ex AISI316 WOC/PRIMED	66 - 98	142 - 144	3.4	EXRSB0125102112
RS 150 B Ex AISI316 WOC/PRIMED	93 - 119	166 - 168	4.2	EXRSB0150102112

Stainless steel

Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 25 B Ex AISI316/AISI316	3.6 - 12	36 - 38	0.48	EXRSB0250002121
RS 43 B Ex AISI316/AISI316	4 - 23	54 - 56	0.9	EXRSB0430002121
RS 50 B Ex AISI316/AISI316	8 - 30	65 - 67	1.4	EXRSB0500002121

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Product	For cable/pipe Ø (mm)	Aperture dimension Ø (mm)	Weight (kg)	Art. No
RS 75 B Ex AISI316/AISI316	24 - 54	91 - 93	2.1	EXRSB0750002121
RS 100 B Ex AISI316 WOC/AISI316	48 - 70	116 - 118	2.7	EXRSB0100102121
RS 100 B Ex AISI316/AISI316	48 - 70	116 - 116	4.4	EXRSB1000002121
RS 125 B Ex AISI316 WOC/AISI316	66 - 98	142 - 144	3.6	EXRSB0125102121
RS 125 B Ex AISI316/AISI316	66 - 98	142 - 142	3.9	163616
RS 150 B Ex AISI316 WOC/AISI316	93 - 119	166 - 168	4.1	EXRSB0150002121

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4.16 XT07..09 – Cable Gland for Wall Penetration, 501/421 O M20 Brass

[Please refer to data sheet from Section 4.14.]

4.17 XT07..09 – M32 to M20 Reducer, RDU100604

[Please refer to data sheet from Section 4.13.]

4.18 XT10..11 – Cable Gland for Wall Penetration, 501/421 A M20 Brass

[Please refer to data sheet from Section 4.14.]

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4.19 XT10..11 – M40 to M20 Reducer, RDU100704

[Please refer to data sheet from Section 4.13.]

Section G

Calculations

Sub Section G99-001

IEC60079-10 Analysis

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Revision history		
Rev.	Date.	Description
001	28/08/2024	First Issue
002	29/11/2024	Updated according to comments and implemented exhaust and drainage
003	19/03/2025	Corrected according to Code 2 comments
004	01/05/2025	Corrected rev 003 according to comments

Document Title:	BLPH Project - IEC60079-10 Analysis
Document Number:	K559-2254-CWIWP4202202-G99-001
Revision:	Rev003
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-G99-001Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	G99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

IEC 60079-10 Analysis 601456B Crosswind

Full Title: EN IEC 60079-10-1 Analysis, Crosswind 1MW MEGAblock

Abstract: EN IEC 60079-10-1:2021 is intended to be applied where there may be a presence of flammable gas or vapor mixed with air. This is done by classifying areas where gas/air mixtures may be present into zones. Suitable design choices can be made based on the analysis, to eliminate the ignition hazard in the identified zones.

In this report, two areas are evaluated: the fuel connection to FCwave and External hydrogen handling unit.

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1.0 Executive Summary

Two areas were evaluated using the methodology described in EN IEC 60079-10-1:2021:

1. Fuel connection to FCwave: due to the presence of continuous ventilation, and the quality of the ventilation as well as the ventilation speed surrounding the connection the area is considered non-hazardous. Those are discussed in further detail in this report.
2. External hydrogen handling unit: this area contains several fittings, flanges and valves fittings, which are considered potential sources of a secondary grade of release. Using natural ventilation present in the external location and the methodology in the standard, it is determined that the fuel connection area should be classified as Zone 2 for hydrogen gas with 1 meter radius.

2.0 Reference documents

Table 2-1: Reference documents

Document no.:	Document name:
ATEX 114	Directive 2014/34/EU – equipment and protective systems intended for potentially explosive atmospheres
K559-2254-CWIWP4202202-E99-002	BLPH Project - Specials: Hazardous Area Layout
EN IEC 60079-10-1:2021	Classification of areas - Explosive gas atmospheres
IEC 62282-3-100:2020	Stationary fuel cell power systems - Safety
K559-2254-CWIWP4202202-C03-001	BLPH Project - P&IDs
MAN002	Integration manual FCWave
K559-2254-CWIWP4202202-B01-001	General arrangement
K559-2254-CWIWP4202202-C99-001	Megablock Hydrogen Safety Concept
EX calc 0B	ATEX zone definition calculations

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3.0 Definitions and Acronyms

Table 3-1: Definitions and Acronyms

Document no.:	Document name:
AC	Alternating Current
BOP	Balance Of Plant
DC	Direct Current
GA	General arrangement
LFL	Lower flammability limit
LEL	Lower Explosion Limit
LT	Low Temperature
HT	High Temperature
PLC	Programmable logic controller
P&ID	Process and Instrumentation Diagram
SIS	Safety instrumented system
HAC	Hazardous area classification
Secondary grade of release (Grade: S)	*Release, which is not expected to occur in normal operation and, if it does occur, is likely to do so only infrequently and for short periods*[1].
Primary Grade of Release	Release which can be expected to occur periodically or occasionally under normal operation[2]
Continuous grade of release	Release which is continuous or is expected to occur frequently or for long periods[2].

4.0 Hydrogen Properties

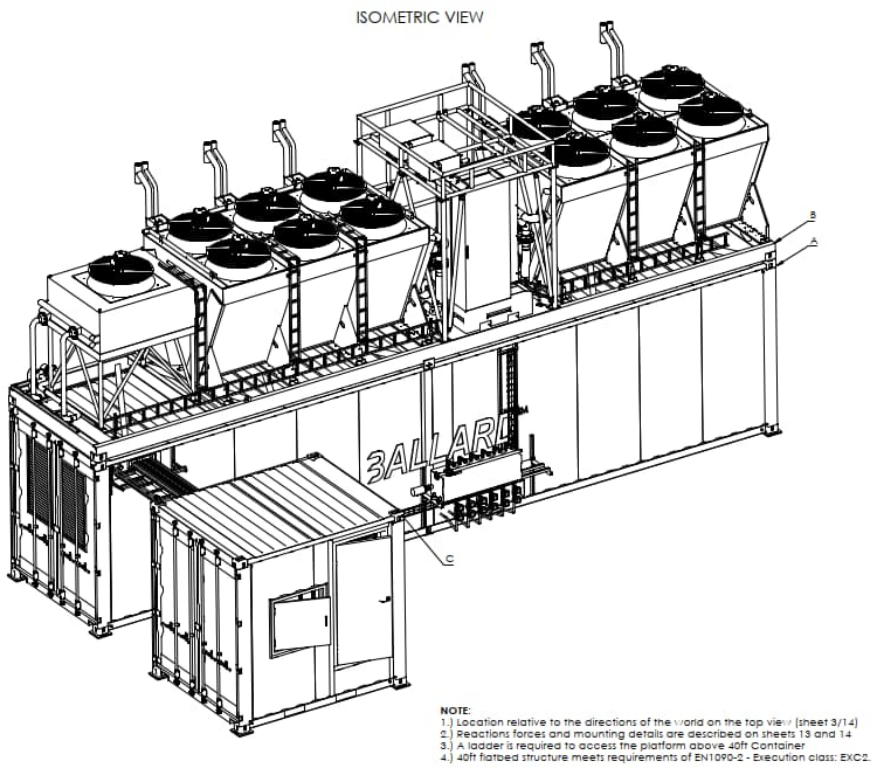
- Refer to Appendix A, Table 10-1
- Critical Pressure 192.1 kPa
- Hydrogen Density 0.08988 kg/m^3 @ 0 ℃

[1] From the definitions given in EN IEC 60079-10-1:2021.

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5.0 Background Information

Figure 1: System installation with auxiliary equipment



System overview of the complete assembled system

5.1 Crosswind 1MW MEGAblock

The FC PowerGen 1000kW® system is comprised of 3 main components:

1. Fuel cell container, 40ft: is an area for installation of the Ballard FCwave module and DCDC converters. Inside the container distribution of HT and LT cooling is done, as well as control system for all BOP components.
2. Power Converter container, 10ft: All the power electronic converting the DC from the FCwaves into AC to the customer, build up in a separate container. The Customer AC connections as well as switchgear and controls for equipment are included in this container.
3. Cooling Unit: An external skid frame containing dry coolers and pumps for cooling the FCwave and power electronic. The skid includes a control cabinet for controlling of valves and fans on the cooling.

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5.2 EN IEC 60079-10-1:2021

Specific terms used in this report are related to EN IEC 60079-10-1:2021, where a specific technical definition is given. Grade of release, zone type, and ventilation class are examples. Please refer to the standard for these definitions.

The standard provides a number of methods for classification of hazardous zones inside and outside of equipment containing flammable gases. The analysis performed and described through this report, follows the “classification by sources of release method” as described in Section 5.2 of the standard.

The general steps are:

- Is a flammable substance present (As described in Annex F, figure F.1.)
- Identify and specify grade of release sources (Continuously, Primary, Secondary).
- Determine the release rate for each source based on likely frequency and duration of release (as described in Annex F, figure F.4.).
- Assess ventilation or dilution conditions and effectiveness.
- Determine zone, based on grade of release and ventilation or dilution effectiveness.
- Determine extent of zone

For secondary grades of release, a process to determine the estimated leak rate and release characteristic is provided. The process relies on a number of calculations which are mentioned in this report but performed in a separate workbook. Results are shown in figures and tables included in this report.

5.3 Safety instrumented system

The safety instrumented system is comprised of a number of safety monitoring devices coupled with a safety controller which, in the event of a faulty condition being detected, stops the flow of hydrogen into the system. The monitoring devices include hydrogen detectors and smoke detectors, Further information on the Megablock Hydrogen Safety Concept referred to in document K559-2254-CWIWP4202202-C99-001.

5.4 P&ID

Several components are mentioned in this report that serve important functions with respect to hydrogen safety. These components and their relative location in the system can be found in the process and instrumentation diagram K559-2254-CWIWP4202202-C03-001 referenced in Section 2. For further details refer to the P&ID documentation.

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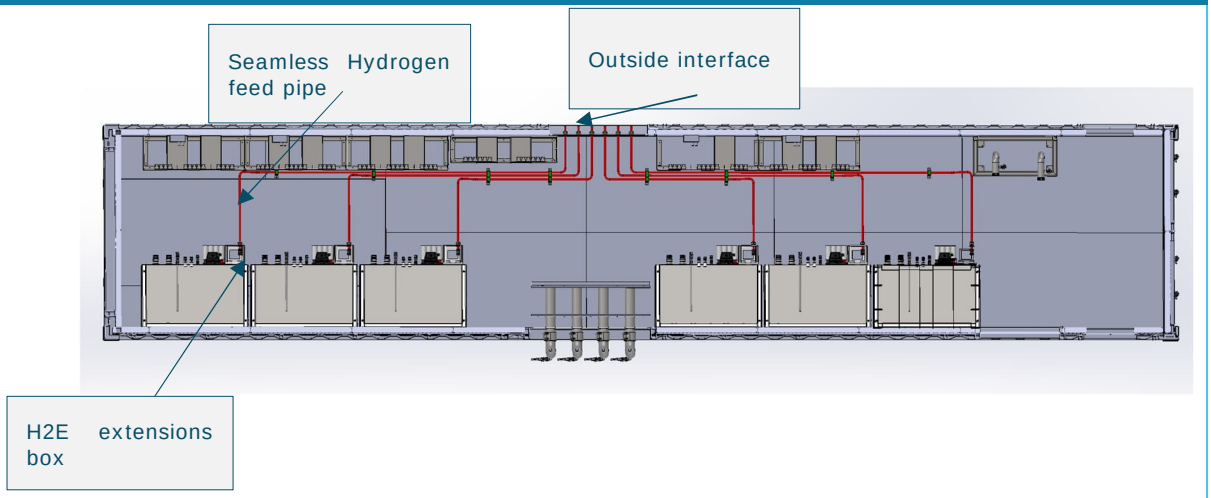
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6.0 Fuel connection to FCwave

Figure 2: Cross section of hydrogen extension box



Top view of the Fuel cell container. The red pipes are the unbroken seamless stainless-steel pipes, for hydrogen. The inlet connection is outside the container, and the outlet (inlet to FCwave) is enclosed in a ventilated space. See details in Figure 3.

6.1 Safety Approach

The hydrogen feed pipes are the connection pipes between the hydrogen interface pipe and the fuel cell module. All pipes are seamless stainless steel. The feed pipe is connected in both ends with a double-ferrule compression fitting. The pipe is a one-piece bended pipe with no welds or connections throughout the full length of the pipe, as illustrated on Figure 2 and Figure 3.

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Figure 3: Cross section of hydrogen extension box

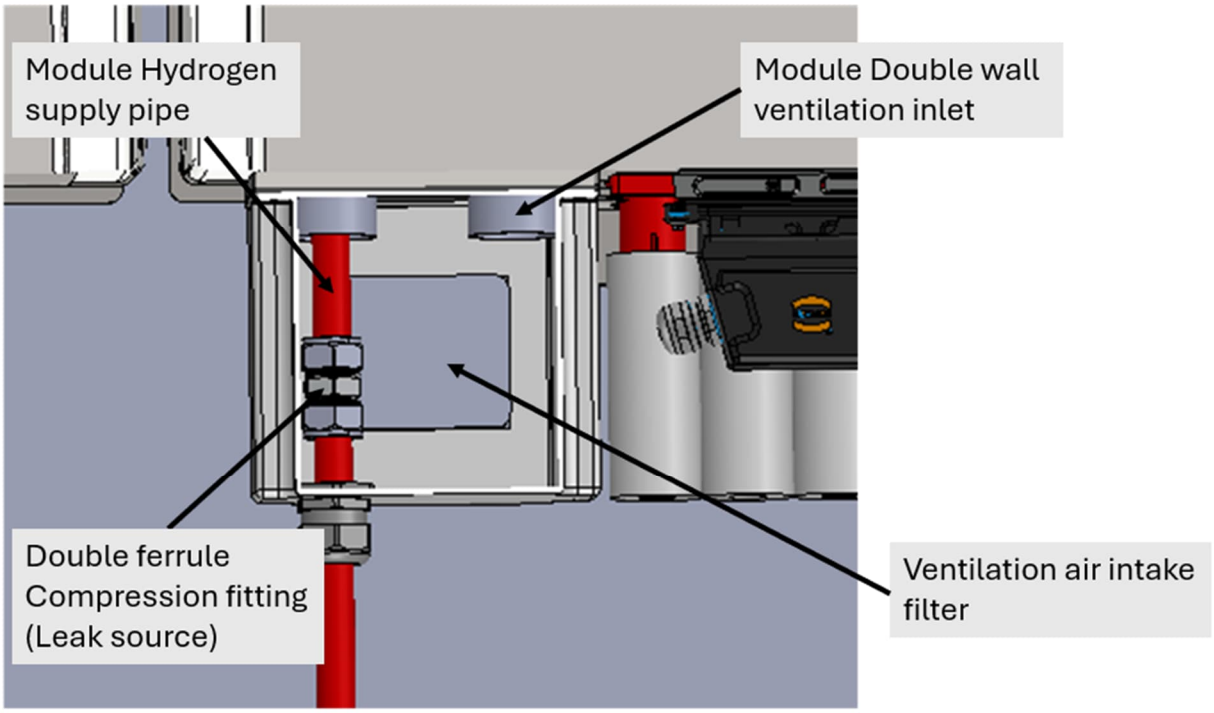


Figure shows a cross cut of the hydrogen enclosure extension. The prime component is the double ferrule compression fitting which is the potential leak

The connection to the fuel cell, from the hydrogen feed pipe, is made with a double-ferrule compression fitting, encapsulated in a ventilated space (box) as an extension of the fuel cell hydrogen ventilation system and the "double walled piping" approach, applied in the FCwave. Hereby transferring all the safety features from the module to this connection.

The FCwave module does not introduce any further risk of leakage due to the construction and certification on the product. For details on this refer to the safety Strategy for the FCwave in document MAN002.

Additionally, the container is equipped with 3 hydrogen sensors. 2 of these hydrogen sensors are located on the roof and near the point where the ventilated air from the container passes by to exhaust the container, so a leak anywhere in the container space will be detected here. The third is located next to the fresh air intake, making sure no hydrogen is introduced into the container from the outside.

The following chapter 6.2 to 6.6 are an assessment of the potential individual leak sources inside the container to determine if there is a local zone or area which requires further consideration.

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6.2 Sources of Release

There is one connection inside the container, hence this will be the only potential source of release. This potential leak will be defined as a secondary grade of release.

6.3 Degree of Dilution

The potential leak (1) in Table 6 1, on the connection to the FCwave module is inside the extension of the hydrogen enclosure, surrounded by forced ventilation. The air velocity in the enclosure surrounding the potential leak is defined: The area of the box is calculated to be: 0,0205m2, with the minimum ventilation flow from the FCwave integration manual (MAN002) being 0,0125m^3/s, resulting in a total air velocity of the ventilation surrounding the potential leak: 0,4062m/s.

Table B.1 from EN IEC 60079-10-1:2021 is used to determine the theoretical hole size (cross section) to estimate the release rate. Input data for the calculation and results are listed in Table 6-1.

Using the equations provided in the standard (ex. B.7.2.3.2 and B.7.2.3.3), release rates are determined for each group. Factoring in the lower flammability limit for hydrogen (4%), the release characteristics are calculated.

Based on the Ventilation velocity and the release characteristics, the degree of dilution is determined to be high, as shown in Figure 4, where the green square indicates the value from the leak source.

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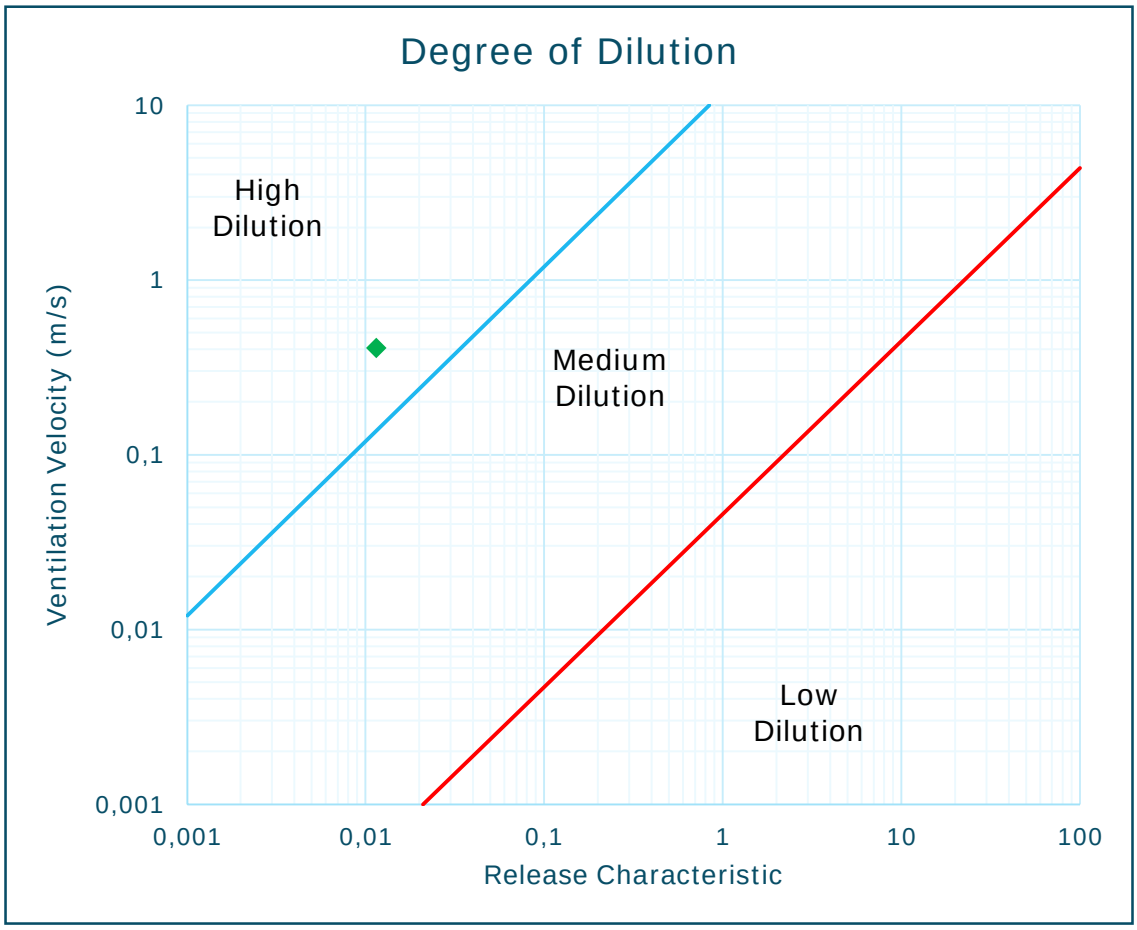
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Figure 4: Degree of Dilution Chart for release sources inside the container



The green point above corresponds to the data in Table 6-1. Points to the left of the blue line have a high degree of dilution, points between the blue and red lines have a medium degree of dilution.

6.4 Classification of Zone

Based on the schematic approach described in Figure F.4 of EN IEC 60079-10-1:2021, the zone classification of a *secondary grades of release* is assessed. The release characteristic and the degree of dilution, as described in Figure 4 and Table 6-1, “Leak 1”, results in a Non-Hazardous zone.

6.5 Extent of Zone

As the potential leak in “Leak 1” is classified to be a non-Hazardous zone, the extent is not calculated.

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6.6 Summary of Fuel connection to FCwave

The process fuel connection to the FCwave is considered non-hazardous due to the safety approach described in Table 6-1.

Table 6-1: *Release sources inside the container (not including FCwave).*

1	2	3	4	5	6	B.1	8	11	12	13	14
	Description	Location	Grade	Rate of Release (kg/s)	Release Characteristic (m^3/s)	Estimate Size of Hole (mm^2)	Operating Pressure (Barg)	Degree of Dilution	Availability	type	Extent (m)
1	M20-M25 Hy-lok double ferrule compression fitting reducer	Connection to FC wave module inside H2E extension box	S	3,62E-05	0,0115	0.1	10	High	Good	Non-Hazardous	none

The table is built up after the "Hazardous Area Classification data sheet" from Table A.2 – EN IEC 60079-10-1:2021. The data listed is equivalent to the "ATEX zone definition calculation document". Not all columns from Table A.2 are given in this table. Notes to columns:

1. The release source has reference "Leak 1" in the calculation document.

4. Grade: S. the Hy-lock connection is one of the tightest pipe connection methods on the market, hence only rare leakages are to be expected from this connection type.

5,6. Calculated based amongst others on the estimated hole size (after table B.1) and the maximum operation pressure in the pipes (8). (same as 6, but another unit)

B.1: from table B.1 in EN IEC 60079-10-1:2021 and based on sealing element type.

8. The maximum operating pressure is used in the calculations.

9. Releases are all "G" for gas type

10. Ventilation type is "Forced ventilation"

11. Based on the release characteristics and the available ventilation, figure C.1 from the standard, points to a "High" dilution.

12. The availability is specified as good, due to the safety/redundancy built into the ventilation pf the given space.

13. looking at table D.1 from the standard, the conditions: Secondary release, high dilution, good availability of ventilation points to "non-hazardous".

14. as the zone is classified to be "Non-hazardous", based on dilution and ventilation, the extend is Not applicable.

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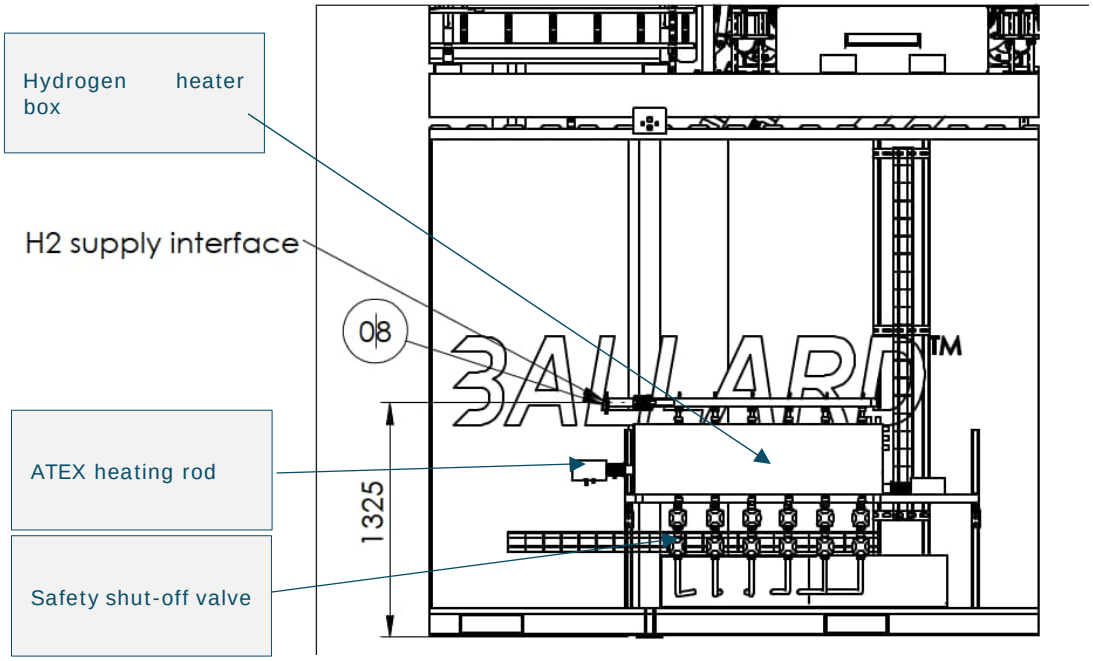
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7.0 External hydrogen handling unit

The fuel connection area is where the customer connects the hydrogen fuel supply to the fuel cell container. The external hydrogen handling unit also contains two in series safety shutoff valves as well as hydrogen heater for preheating the hydrogen in subzero conditions.

Figure 5: External hydrogen handling unit



The fuel connection area and safety shutoff valves are placed outside of the container, in free air.

The key elements of the "hydrogen handling unit" is pointed out in the figure.

7.1 Safety Approach

The fuel connection area outside the container contains a large number of fittings, flanges, and valves which may cause a secondary grade of release, at some point in the life of the product. As a hazardous zone is determined through the analysis, proper zone identification shall be made and the component and equipment in the area must be of the appropriate equipment category (EX approved). The extend and placement of the identified zone will be communicated to the integrator and end user in a general arrangement drawing K559-2254-CWIWP4202202-B01-001.

7.2 Sources of Release

There are three types of components which qualify as a potential source of release;

- fittings, flanges and valve stem packing.

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The Hydrogen handling unit consists of several individual fittings, flanges and connections, which are grouped in Table 7-1 below. Background hydrogen concentrations is not considered, as the system is not allowed to be installed in an already existing EX zone. All leaks are rated to be “secondary grade of release”, so according to EN IEC 60079-10-1:2021 Annex B section B4, one leak at a time is only considered.

7.3 Degree of Dilution

For outdoor locations where natural ventilation is available, a minimum ventilation velocity (for dilution) can be determined based on the location of the sources of release. Using Table C.1 from the standard, an estimated wind velocity or speed of buoyancy of worst case 0.5 m/s was determined based on:

- release of lighter than air gas.
- obstructed area less than 2 meters above ground.

Combined with the release characteristics from Table 7-1, the degree of dilution is determined to be “High” on “Leak 2,3”, and Medium at “Leak 4,5,6”, See Figure 6, where each leak source is plotted in to the diagram.

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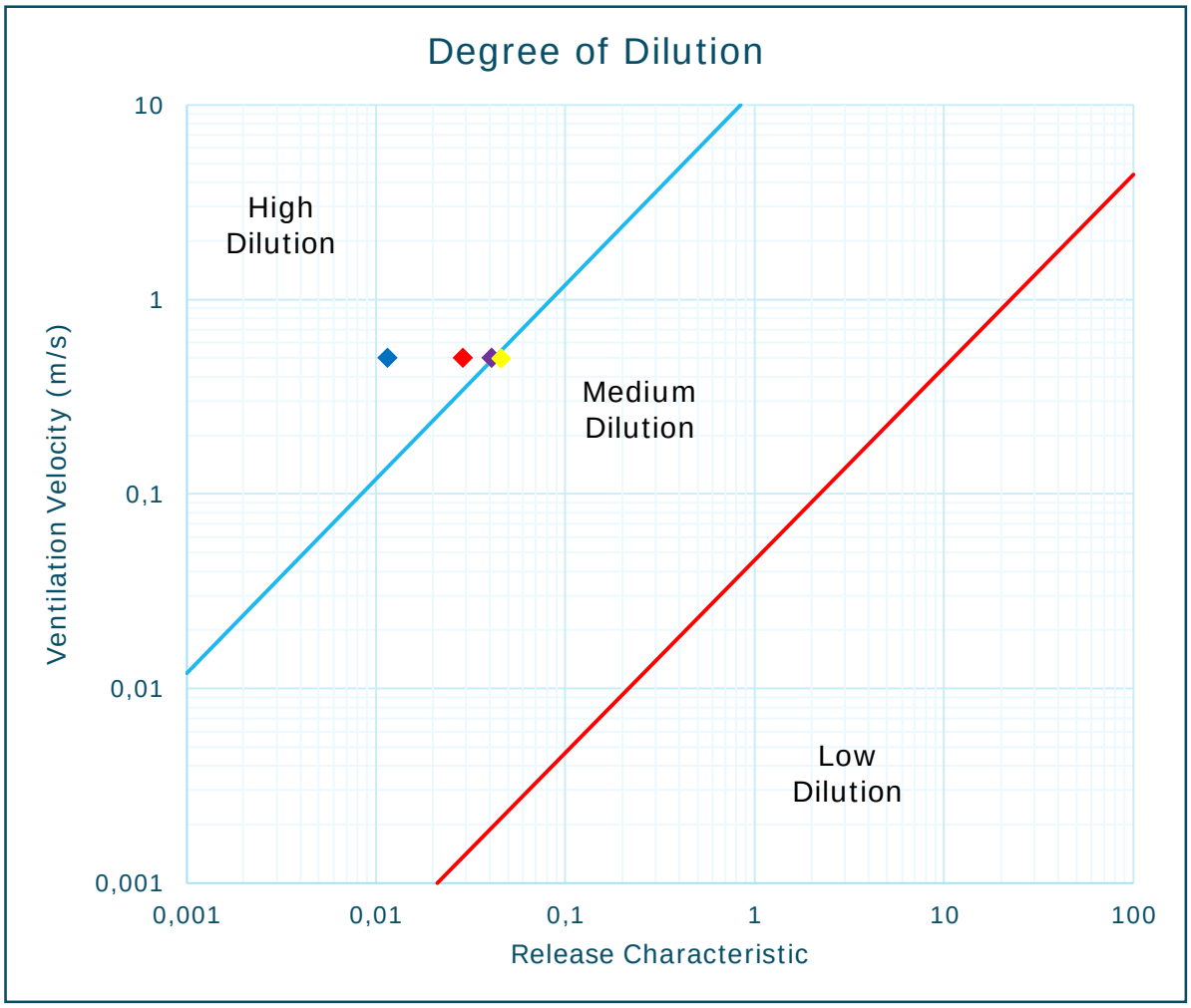
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Figure 6: Degree of dilution chart for connections on hydrogen handling unit.



The colored points in the chart correspond to the color groups in Table 7-1. Points to the left of the blue line have a high degree of dilution, points between the blue and red lines have a medium degree of dilution.

7.4 Classification of Zone

Based on the schematic approached described in Figure F.4 of EN IEC 60079-10-1:2021, the zone classification of a *secondary grades of release* is assessed. The release characteristic and the degree of dilution, as described in Figure 6 and Table 7-1, “Leak 2,3”, results in a Non-Hazardous zone and “Leak 4,5,6” result in a Zone 2, with max 1 m extend.

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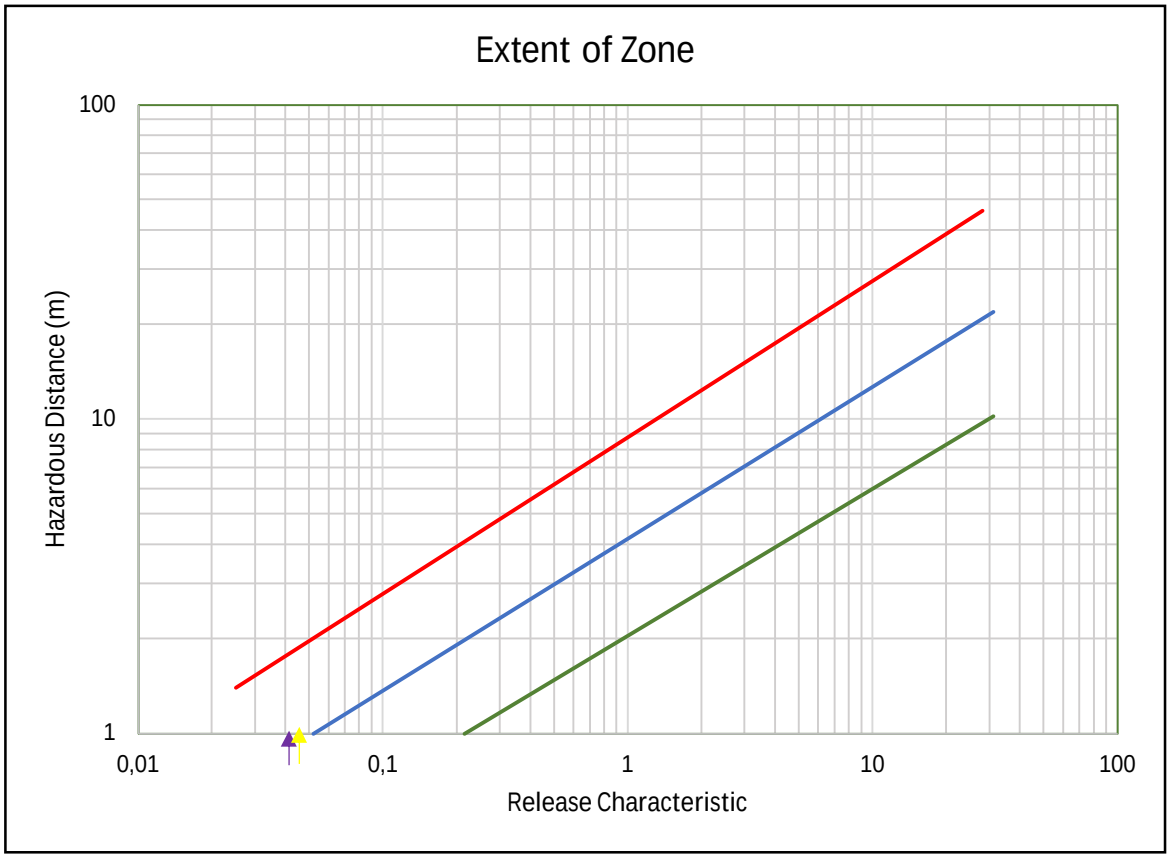
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7.5 Extent of Zone

Figure D.1 from EN IEC 60079-10-1:2021 is used as basics for the zone extend assessment. For the area around the "hydrogen handling unit", it is determined that all potential hydrogen releases will be jet type based, due to the high velocity of the modelled releases and the relative density of hydrogen to air. Based on the release characteristics specified in Table 7-1, it is found that the potential component releases from "Leak 5,6,7,8" would result in a zone that would be less than 1 meter in extent, see Figure 8. Since the minimum distance is 1 meter, the zone is defined to be 1m from the release source.

Figure 7: Extend of zone.



The colored points in the chart correspond to the color groups in Table 7-1. All points are below the line, determine the zone size.

7.6 Summary of External hydrogen handling unit

There are numerous fittings and valves (packing) that could leak at some point over the lifetime of the Fuel cell container. These leaks would generate jet plumes that would be relatively small and would dilute quickly. This analysis shows that adequate dilution would occur within 1 meter of the source. Therefore a 1 meter, Zone 2 setback should be

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established for the fuel connection area and components inside the zone should have the proper ATEX (Ex) rating.

Table 7-1: List of leak sources identified in the External hydrogen handling unit.

1	2	3	4	5	6	B.1	8	11	12	13	14
	Description	Location	Grade	Rate of Release (kg/s)	Release Characteristic (m^3/s)	Estimate Size of Hole (mm^2)	Operating Pressure (Barg)	Degree of Dilution	Availability	Zone type	Extent (m)
2	M25 Hy-lok double ferrule compression fitting	External connection to fuel cell container	S	3,62 E-05	0,0115	0,1	10	High	Fair	Non-Hazardous	<1
3	M25 to 3/4 BSPP + bonded seal Hy-lok double ferrule compression fitting	Connection to SOV	S	9,05 E-05	0,0288	0,25	10	High	Fair	Non-Hazardous	<1
4	Emerson Solenoid valve	Below H2 heater	S	0	0	0	10	NA	NA	Non-Hazardous	NA
5	Hy-lok Manual shut off valve	Above H2 heater	S	1,28 E-04	0,0409	0,25	10	Medium	Fair	Zone 2	<1
6	Flange connection	Customer interface	S	1,43 E-04	0,0457	0,25	10	Medium	Fair	Zone 2	<1
7	DVC main shutoff valve	Above H2 heater	S	1,28 E-04	0,0409	0,25	10	Medium	Fair	Zone 2	<1
8	DVC main shutoff flanges	Above H2 heater	S	1,43 E-04	0,0457	0,25	10	Medium	Fair	Zone 2	<1

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Table 7-1: List of leak sources identified in the External hydrogen handling unit.

The table is built up after the “Hazardous Area Classification data sheet” from Table A.2 – EN IEC 60079-10-1:2021. The data listed is equivalent to the “Atex zone definition calculation document”. Not all columns from Table A.2 are given in this table. Notes to columns:

1. The release source has reference “Leak 2-6” in the calculation document.

4. Grade: S. The Hy-lock connection, fittings and valves are selected due to their qualities in tightness, hence only rare leakages is connection with fault conditions are to be expected from this connection type.

5,6. Calculated based amongst others on the estimated hole size (after table B.1) and the maximum operation pressure in the pipes (8). (same as 6, but another unit)

7. No references used

B.1: from table B.1 in EN IEC 60079-10-1:2021 and based on sealing element type.

8: The maximum allowable operating pressure is applied in the calculations.

9. Releases are all “G” for gas type

10. Ventilation type is “Natural”

11. Based on the release characteristics and the available ventilation, figure C.1 from the standard, points to a “High” dilution from leak 2,3 and a medium dilution from leak 4,5,6.

12. The availability is specified as good, due to the ventilation being “natural”.

13. looking at table D.1 from the standard, the conditions: Secondary release, high dilution, good availability of ventilation points to “non-hazardous”. The conditions: Secondary release, medium dilution, good availability of ventilation points to “Zone 2”.

14. The extent of the zone is in all cases less than 1 m I radius from the leak point.

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8.0 Process exhaust and drain

8.1 Background for evaluation

As stated in the integration manual (MAN0002) for the FCwave module the maximum amount of hydrogen present at all scenarios in the process exhaust is 1%vol. This is equal to 25% LEL of hydrogen.

The composition of gas in the drain is the same as the process exhaust due to the fact that the process exhaust is by "fault" emptying the static air lock (previous referred to as water lock) within the module. This means the maximum content of hydrogen in the drain will be 1%vol equal to the process exhaust.

8.2 Definition of explosive gas atmosphere

Due to the concentration being so low (below LEL) the general foundation of the definition of an Explosive atmosphere is not met. According to the standard IEC 60079-10-1:2021 section 3.2 the definition is:

- *"Explosive gas atmosphere*

  Mixture of air, under atmospheric conditions, of flammable substances in the form of gas or vapor, which, after ignition, permits self-sustaining flame propagation"

As the composition of gas in the drain is below 25% of LEL the gas is not able to self-sustain a flame propagation, meaning it is by definition not an Explosive gas atmosphere. Additionally, the IEC 60079-10-1 section 4.4.2 has a clause for releases which is considered as negligible extend. Either due to the potential explosion being of a negligible consequence, or if the release rate or quantity is of a negligible extent in reference to the volume. Yet the clause still operates with the gas potentially being able to combust or explode, which is not the case for a mixture of 1% vol hydrogen.

Additionally, the mixture is also below 25% LEL making sure no clauses from IEC 60079-10-1 Annex I is applicable.

8.3 Risk mitigation considerations

As part of the IEC 60079-10-1 Zone classification procedure a risk assessment can determine to increase or decrease the zoning and EPL. For this installation, the mitigation for not increasing the zoning from e.g. a non-hazardous to a Zone 2 is mitigated by selection of components for the drain system. Which for this system is converted into gastight fittings, instrumentation and pipe with the weakest component being able to withstand a constant pressure of 69 Barg. In addition to this, the general design eliminates the risk of the hydrogen up-concentrating in unintended areas by making sure the exhaust is at the highest point and with a pressure less system securing hydrogen and steam from the process exhaust gas will be able to escape the system through normal buoyancy.

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9.0 Pressure testing according to IEC 62282-3-100

To make sure the Hazardous Area Classification is not exceeding the specified area of extent, release rate and frequency, the system within the Fuel cell container (from the hydrogen heating unit to the valve block (inside the FCwave)) has a build in function to automatically do a pressure decay test according to 62282-3-100:2020.

To maintain the specified HAC, the allowable maximum release of hydrogen is calculated in relation to the zone to make sure that the system is at all times within the boundaries provided in EN IEC 60079-10-1:2021.

The frequency at which this release can occur is still considered to be a “secondary grade of release” as *the release is not expected to occur in normal operation and, if it does occur, is likely to do so only infrequently and for short periods*[4]. Safety precautions describe in the document: *K559-2254-CWIWP4202202-C99-001 Megablock Hydrogen Safety Concept*, supports this assessment of the grade of release.

All leak sources mentioned in Table 7-1, are considered as a uniform leak, throughout this chapter.

9.1 Maximum release flow in respect to zone extend

As calculated in chapter 7.5, the minimum required extent of the zone 2 is 1m in radius. The maximum allowable leak, from the secondary leak source, is determined by the Figure 8 to have a release characteristic on 0,22m^3/s.

[4] From the definitions given in EN IEC 60079-10-1:2021.

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Figure 8: Extent of Zone

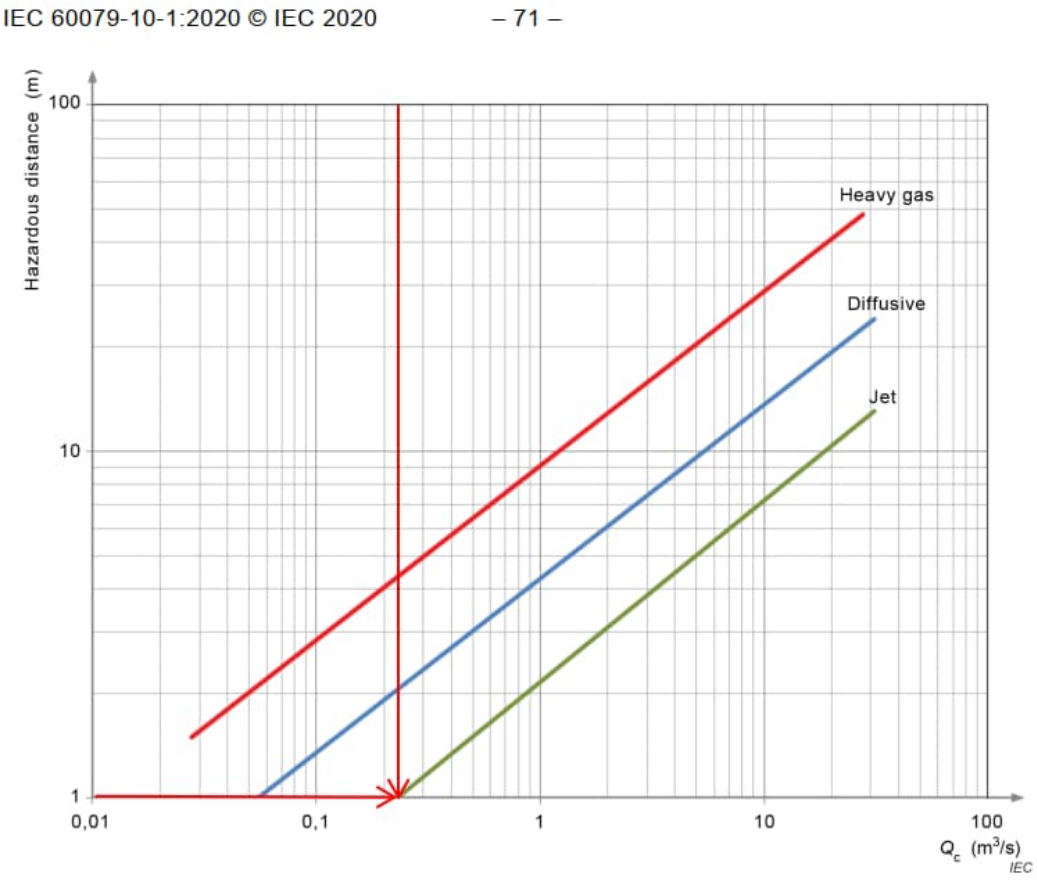


Figure D.1 – Chart for estimating hazardous area distances

Red lines show the assumptions for the minimum requirements to be measured

Converting this into the Release Flow (Wg) using the relative density and LFL, the maximum allowable Release Flow is 6,904x10-7 g/s to still maintain the applicable zone 2. However, considering the leak source a secondary grade of release, as under normal operation there is not expected to be a leak.

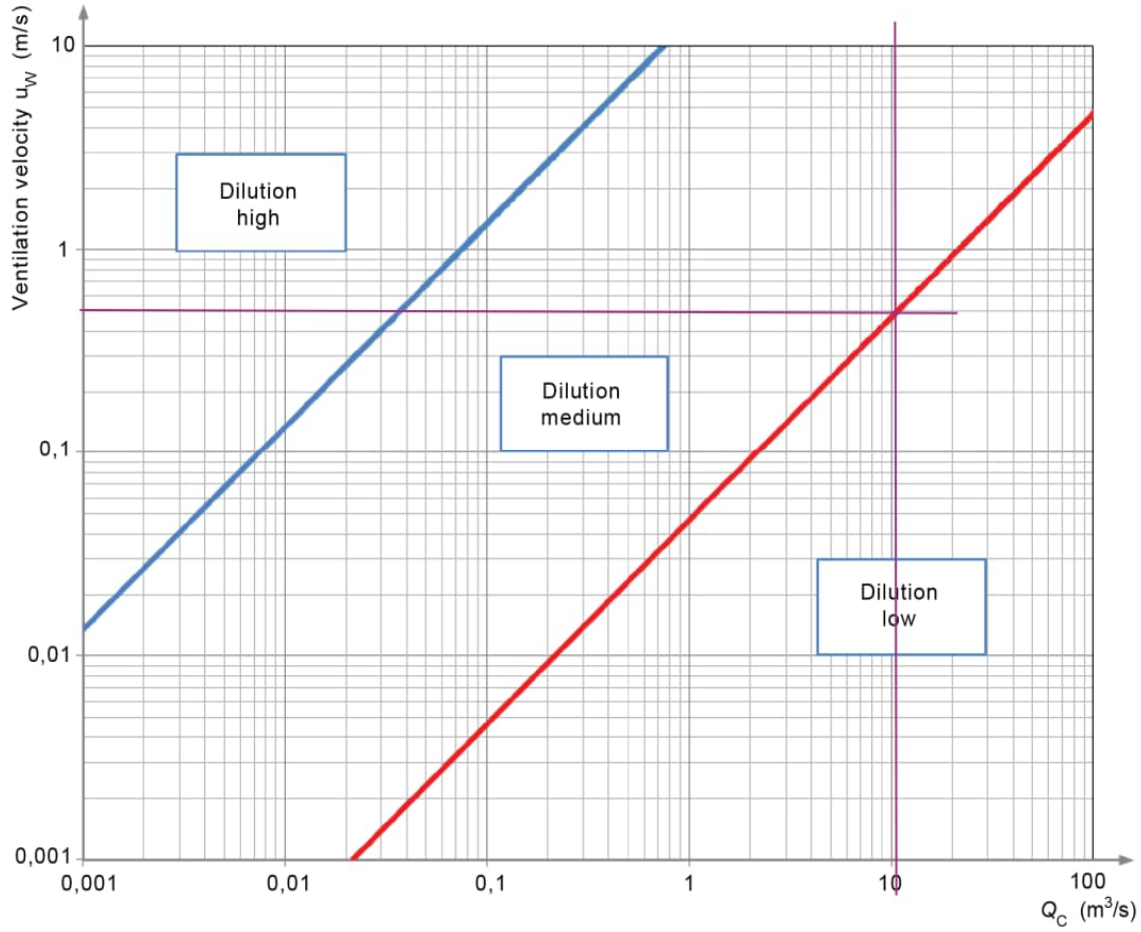
9.2 Maximum release flow in respect to effectiveness of ventilation

To maintain the same applicable zone 2 as calculated in chapter 7.4 the following criteria need to be met to maintain a Zone 2 according to Table D.1 and figure C.1 – EN IEC 60079-10-1:2021:

- Degree of dilution to be at least Medium Dilution
- Availability of ventilation to be at least Fair
- Ventilation speed is fixed by the physical installation to be 0,5m/s
- It is a prerequisite that the leak source is specified as secondary grade of release.

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Figure 9: Degree of dilution and maximum release flow accepted.



Based on C.1 from EN IEC 60079-10-1:2021. Chart for assessing the degree of dilution.

Converting this into the Release Flow (W_g) using the relative density and LFL we will get that the maximum allowable Release Flow is 3,169x10^{-5} g/s to still maintain the applicable zone 2

9.3 Summary of pressure testing value calculation

To make sure the Release Flow submitted to be the dimensioning value according to 60079-10. The value needs to be the one which will be equal or better than the worst Release Flow meaning but conditions for the calculation will be met. For the current installation this is equal to a maximum Release Flow of 6,904x10^{-7} g/s. To convert the value into a pressure, drop, which can be used to e.g. a pressure decay test, the volume, e.g. a pressure decay test, the volume and temperature need to be specified as part of the testing.

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10.0 Appendix

Table 10-1 *Hydrogen Properties*

1	2	3	4	5	6	8	9	11	13	14
	Name	Composition	Molar Mass (kg/kmol)	Relative density gas/air	Polytropic index of adiabatic expansion	Ignition temperature (℃)	Boiling Point (℃)	Vol (%)	Equipment Group	Temperature Class
1	Hydrogen gas (H2)	SAE J2719 ≥99.97%	2.01 (H2)	0.0696 (STP)	1.405	560	-252,8	4%	IIC	T1

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Sub Section G99-002

Intrinsically Safe Calculations

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Revision history		
Rev.	**Date.**	**Description**
001	25/10/2024	First Issue
002	12/02/2025	Updated and corrected according to agreement during meetings
003	19/03/2025	Corrected according to code 2 comments

Document Title:	**BLPH Project - Intrinsically Safe Calculations**
Document Number:	K559-2254-CWIWP4202202-G99-002
Revision:	Rev003
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-G99-002Rev003
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	G99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

1.0 Purpose

The purpose of this document is to highlight the safe design of the simple apparatus circuit on the FC PowerGen 1000kW®. The document will be formed on background of IEC 60079-25.

2.0 Analysis

The following system contains only a pressure transmitter and a temperature transmitter. Since they are connected to different complete independent barriers, two analyses will be made following the Annex A in IEC 60079-25.

Table 2-1: Simple system analysis pressure transmitter.

Step	Item	I.S. interface PR electronic 9106B1B	Pressure sensor HUBA control 520 Series	System
A	Equipment group	IIC	IIC	IIC
B	Level of protection	ic	ia	ic
C	Temperature classification	NA	T4	T4
D	Ambient temperature	-20 to 60°C	-25 to 85°C	-20 to 60°C
E	Parameter comparison			
	Voltage	U_0=27,5V	U_i≤30V	OK
	Current	I_0=92,6mA	I_i≤100mA	OK
	Power	P_0=0,64W	P_i≤0,75W	OK
F	Cable parameters			
	Capacitance	C_0=0,084µF	C_{cabel}=1nF Max	C_0=0,083µF
	Inductance	L_0=4,15mH	L_{cabel}=20µH Max	L_0=4,13mH
	L/R ratio	- µH/Ω	NA	NA
G	Earthing	Isolated	Isolated	Isolated

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Table 2-2: Simple system analysis pressure transmitter.

Step	Item	I.S. interface PR electronic 9113B	IFM 1050 Temperatur transmitter	System
A	Equipment group	IIC	NA[1]	
B	Level of protection	ic	NA[2]	
C	Temperature classification	NA	T4[3]	
D	Ambient temperature	-20 to 60°C	-25 to 80°C	-20 to 60°C
E	Parameter comparison			
	Voltage	U_0=8,7V	NA[4]	Ok
	Current	I_0=18,4mA	NA[4]	Ok
	Power	P_0=40mW	NA[4]	Ok
F	Cable parameters			
	Capacitance	C_0=5nF	C_{cabel}=1nF Max	C_0=4nF
	Inductance	L_0=100mH	L_{cabel}=20µH Max	L_0=98mH
	L/R ratio	892 µH/Ω	NA	892 µH/Ω
G	Earthing	Isolated	Isolated	Isolated

[1]Not applicable for simple apparatus.

[2]Not applicable for simple apparatus.

[3]Acordingly to IEC 60079-25 annex F the temperature rating will be T4 if the power does not exceed 1,2W at the ambient temperature of 60°C, which is applicable for this application. Further explanation is described in IEC 60079-0 section 5.3.3 Table 3 and 4.

[4]As it is a RTD type temperature sensor those values are not applicable.

2.1 Simple apparatus requirements

There are some requirements to apply for a component to be classified as a simple apparatus. The IEC 60079-11 section 5.7 describes the following requirements:

a) *Passive components, for example switches, junction boxes, resistors and simple semiconductor devices;*

b) *Sources of stored energy consisting of single components in simple circuits with well defined parameters, for example capacitors or inductors, whose values shall be considered when determining the overall safety of the system;*

c) *sources of generated energy, for example thermocouples and photocells, which do not generate more than 1.5 V, 100 mA and 25 mW.*

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Sins this temperature sensor is based on the RTD technology the sensor will not be able to induce any current nor voltage to make this a potential ignition source. Hence relying on the associated apparatus being the EX Barriere.

The barrier is built and approved for connection to RTD type of temperature sensors. The following data from the barrier is included in the Table 2-2.

3.0 Conclusion

According to this analysis of both the Pressure transmitter HUBA520 and the corresponding EX barrier PR electronic 9106B1B the conditions for intrinsically safe circuit are being met accordingly to the IEC 60079-25.

Furthermore, the analysis of Temperature transmitter IFM TT1050 and the corresponding EX barrier PR electronic 9113B does also comply with the requirements form intrinsically safe according to the IEC 60079-25. Since this is a simple apparatus the conditions for this are met accordingly to IEC 60079-11.

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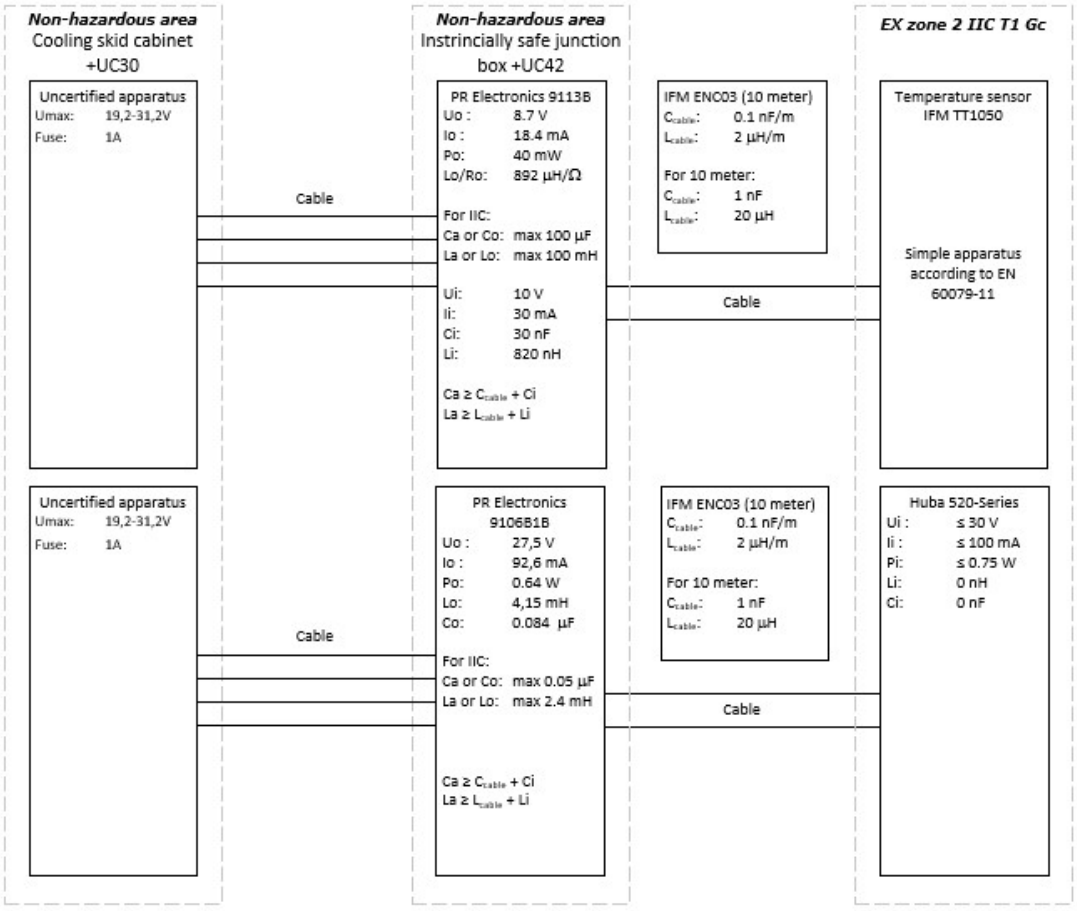
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Figure 1: Intrinsically safe calculations



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Section K

Certification Data

Sub Section K01-001

Declaration of Conformity (FCwave™)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	Date.	Description
001	19/09/2024	First Issue
002	07/02/2025	Latest revision of Declaration replace rev 001
004	28/02/2025	Comments to CrossWind - No corrections

Document Title:	BLPH Project - Declaration of Conformity (FCwave)
Document Number:	K559-2254-CWIWP4202202-K01-001
Revision:	Rev004
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K01-001Rev004
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Declaration of Conformity

As manufacturer, Ballard Power Systems Europe A/S, Majsmarken 1, 9500 Hobro, Denmark, hereby declares that the product(s) mentioned below:

Product no. and name:

Product no.: **7001000** Product name: **FCwave**
Product Designation: **Fuel Cell Power System**

Complies with the requirements of the following Union harmonized legislation, standards and specifications:

Legislation:

- Machinery Directive (2006/42/EC)
- Electromagnetic Compatibility Directive (2014/30/EU)
- RoHS (2011/65/EU)

References:

Directive	Standard	Description
MD	EN 62282-3-100:2020	Fuel cell technologies - Part 3-100: Stationary fuel cell power systems - Safety
EMC	EN 61000-6-2:2019	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments
EMC	EN 61000-6-4:2019	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
RoHS	EN IEC 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Additional:

This declaration is only valid as long as the service and maintenance instructions for the product is followed, and the product is not modified.

The pressurized equipment in the product is out of scope for the PED directive 2014/68/EU, as it is covered by article 4, section 3. Hence the PED directive is not listed.

Hobro, 05.09.2024
Place and date

CEO & President, Jesper Themsen
Ballard Power Systems Europe A/S

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Sub Section K01-002

Declaration of Conformity (FC PowerGen 1000kW®)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001		First Issue
002	14/02/2025	New release of DoC for CrossWind container

Document Title:	**BLPH Project - Declaration of Conformity (Container Solution)**
Document Number:	K559-2254-CWIWP4202202-K01-002
Revision:	Rev002
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-K01-002Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Declaration of Conformity

Ballard Power Systems Europe A/S, Majsmarken 1, 9500 Hobro, Denmark hereby declares that the product(s) mentioned below:

Product no. and name:

Product no.: **601456B-7002362** Product name: **FC PowerGen 1000kW**
Product designation: **Stationary Fuel Cell Power System**

Complies with the requirements of the following directives and standards:

Accessories/sub-assemblies:
The following accessories/sub-assemblies are also cowered by this DoC (If any):

Product no.:	**601456B-7002362**	Product name:	**40ft Fuel Cell Container**
Product no.:	**601456B-7002973**	Product name:	**Cooling unit**
Product no.:	**601456B-7003716**	Product name:	**10ft Converter container**

Directives:

- Machinery Directive (2006/42/EC)
- Pressure equipment (2014/68EU)
- ATEX Directive (2014/34/EU)
- Low voltage Directive (2014/35/EU)
- Electromagnetic Compatibility (EMC) (2014/30/EU)

Additional:

This declaration is only valid as long as the service and maintenance instructions for the product is followed, and the product is not modified.
Hydrogen Manifold compliance to PED is covered by K599-2254-CWIWP4202202-K01-003.

Hobro, 13022025

Henrik Rise Christensen
Digitally signed by Henrik Rise Christensen
DN: cn=Henrik Rise Christensen, c=DK, ou=Ballard Power Systems Europe, email=hri@ballardeurope.com
Date: 2025.02.13 20:11:12 +01'00'

Director, Operations & Business
Henrik Rise Christensen
Ballard Power Systems Europe A/S

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Sub Section K01-003

PED Compliance H2 Manifold Addendum (ATEX)

Ballard Power Systems Europe A/S
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001		First Issue
002		Drawing added
003		Revision corrected
004	12/2/2025	Updated according to agreement with Brenmer and Kyle

Document Title:	**BLPH Project - PED Compliance H2 Manifold Addendum**
Document Number:	K559-2254-CWIWP4202202-K01-3
Revision:	Rev004
Sequence Number:	3
File Name:	K559-2254-CWIWP4202202-K01-3Rev004
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

PED compliance H2 manifold

Full Title: *Addendum – PED compliance H2 manifold for DoC*

Abstract: The following document will contain an internal walk through of the compliance of the Pressure equipment directive and the technical dossier for Declaration of conformity

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1.0 Executive Summary

The document will contain a walkthrough of the analysis of Pressure equipment directive compliance according to 2008/68/EU. The analysis concluded that the maximum pipe diameter is a DN32 and a pressure of 6,5 Barg. Due to this the conformity category is "category 1" which leads to "Module A" conformity assessment procedure. Documentation according to this is described, and/or combined in a PED dossier to verify compliance with PED module A.

2.0 Reference documents

Table 2-1: Reference documents

Document no.:	Document name:
2014/68/EU	Pressure equipment directive
K559-2254-CWIWP4202202-K01-002	Declaration of Conformity (Container Solution)
K559-2254-CWIWP4202202-J09-001	Leak Test Procedure
K559-2254-CWIWP4202202-L01-001	Material Test Certificates
K559-2254-CWIWP4202202-J02-001	WPS and PQR Records (incl. J03 - NDE Procedures)

3.0 Definitions and Acronyms

Table 3-1: Definitions and Acronyms

Document no.:	Document name:
PED	Pressure Equipment directive
DoC	Declaration of Conformity

4.0 Purpose

The following document will contain the PED analysis of the H2 manifold as an add on part to the FC PowerGen 1000kW®. The document is created based on the process described in the PED 2014/68/EU

The following part which is not a part of the document 550002 and will be covered by this PED statement: **DN32 H2 collector manifold**

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5.0 Analysis of technical demands in relation to 2010/68/EU

5.1 Background for analysis

Table 5-1: Background for *conformity assessment*

Item	**Document name:**
Dimensioning pipe size	DN32
Maximum operating pressure	6,5 Barg
Fluida groupe[1]	Hydrogen Groupe 1

[1] According to article 13 a)

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5.2 Analysis of conformity category.

According to article 4 section C, the category for Fluida groupe 1 is defined in following table 6 in the PED shown in Figure 1.

Figure 1: Conformity category PED 2008/68/EU Tabel 6

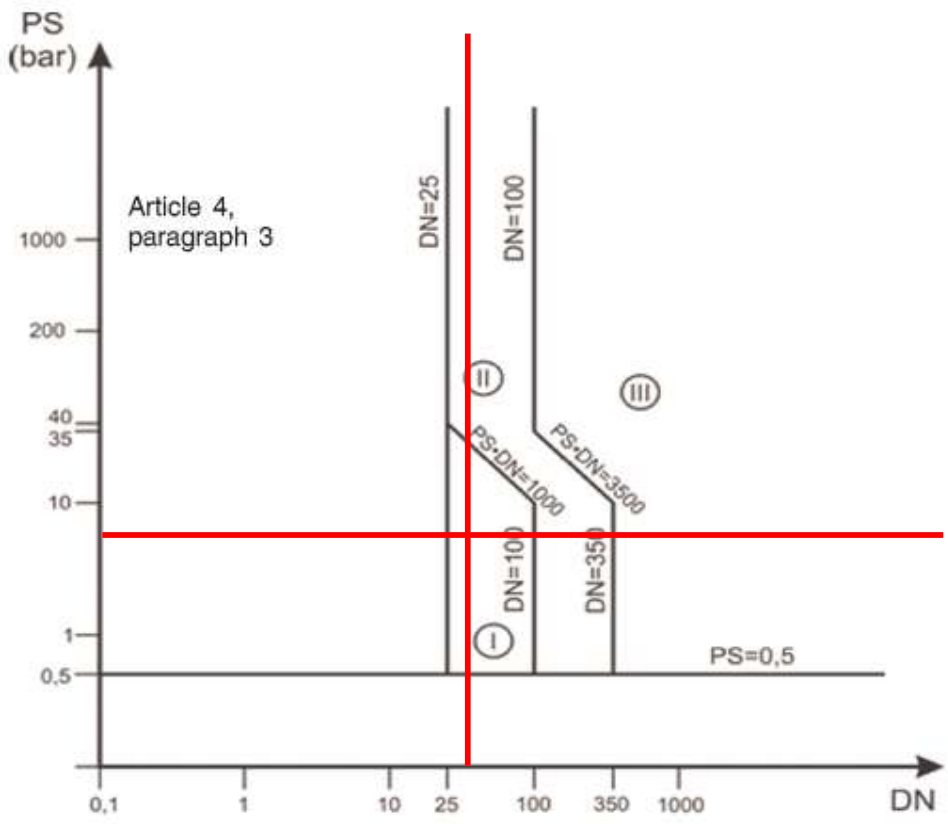


Table 6

Piping referred to in Article 4(1)(c)(i), first indent

The Red lines is an approximate line of the Size and pressure of the part. The intersection will define the point defining the category.

As visualized in the Figure 1, the category applicable for the part will be **Category 1.** As shown in the diagram from PED Annex II section 1. The "Conformity group I" will refer to a "module A" Conformity assessment procedure according to PED Annex III. The following procedure will be described in the following sections of this document.

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6.0 Technical documentation

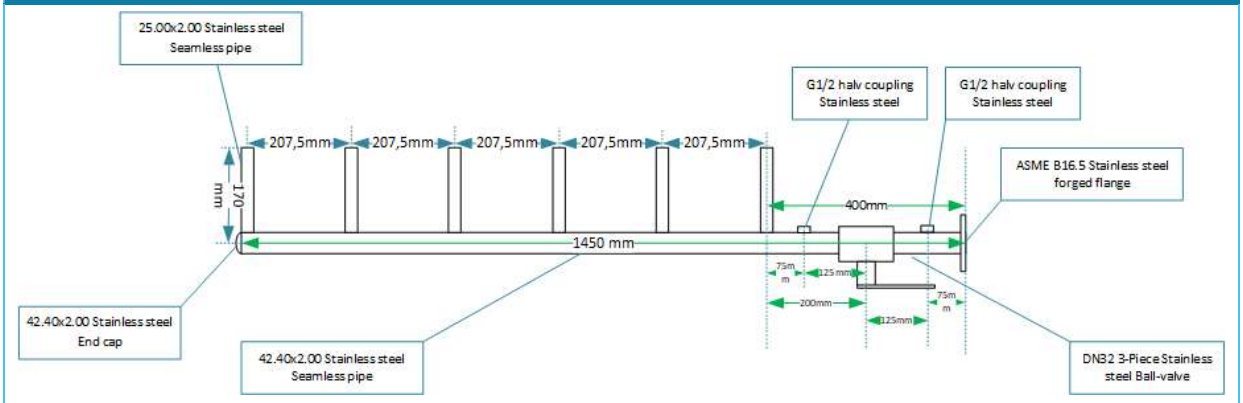
6.1 General description of the product

The product is a hydrogen manifold capable of distributing hydrogen from a single input into 6 independent outputs. The product contains an ASME B16.5 flange for connecting the input. A DN32 pipe with 25mm branches all in stainless steel. There is installed a 3-part welded ball valve type DVC 131150032 suitable for hydrogen 6,5 Barg. The valve is for manually blocking the hydrogen supply during e.g. service.

The product may not be installed in applications where a non-sufficient pressure relief valve set to 10 Barg is not installed.

6.2 Drawings of the Construction

Figure 2: Technical drawing of H2 Manifold



6.3 Results of construction calculations and examination

As the part is not relying on any structural strength since the pipe is not holding any weight, the only relevant construction is the pipe pressure rating. The following pipes are used:

- DN32 42.40x2.00mm EN-10216-5 1.4401/1.4404 TC2 pressure tested to 1500 PSI
- 25.00x2.00mm EN-10216-5 TC2 A269 213 pressure tested to 199 Barg

All assessment is done according to "module A" requirements in PED

#	Component	Material Certificate
1	42.4x2.0 Stainless Steel Cold Finish Seamless Pipes	K559-2254-CWIWP4202202-L01-001
2	25.0x2.0 Stainless Steel Seamless Pipes	K559-2254-CWIWP4202202-L01-001

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3	42.4 ASME B16.5 Stainless Steel Forged Flanges	K559-2254-CWIWP4202202-L01-001
4	G½ Coupling Stainless	K559-2254-CWIWP4202202-L01-001
5	42.4x2.0 Stainless Steel End Caps	K559-2254-CWIWP4202202-L01-001

6.4 Inspection and test

6.4.1 Hydrogen pressure test

The hydrogen manifold has gone through several tests to verify the tightness of the system, even though the material used for manufacturing the hydrogen manifold is certified at a higher pressure than the intended maximum pressure of the Hydrogen manifold.

To sum up the test:

- Individual test of component. Procedure according to 62282-3-100:2020 section 6.2 Leakage test)
- Complete assembly test Formier gas 5% H2. Procedure according to 62282-3-100:2020 section 6.2 Leakage test and "Leak Test Procedure" K559-2254-CWIWP4202202-J09-001
- Complete test pure H2. Procedure according to 62282-3-100:2020 section 6.2 Leakage test and "Leak Test Procedure" K559-2254-CWIWP4202202-J09-001

6.4.2 Welding testing

The following welds on the hydrogen manifold has been tested according to the certificates included in the Certificate dossier.

Welding procedure and welding test results are described in document "WPS and PQR Records (incl. J03 - NDE Procedures)" K559-2254-CWIWP4202202-J02-001

7.0 Appendix documents

Appendix	Document name	Document number
Appendix A	WPS and PQR Records (incl. J03 - NDE Procedures)	K559-2254-CWIWP4202202-J02-001
Appendix B	Material Test Certificates	K559-2254-CWIWP4202202-L01-001

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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	6/5/2024	First Issue
002	9/2/2025	Welder certificate added

Document Title:	**BLPH Project - WPS and PQR Records**
Document Number:	K559-2254-CWIWP4202202-J02-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-J02-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	J02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Svejseprocedureprøvedokumentation

Welding Procedure Qualification Record

Complete documentation

DS/EN ISO 15613:2005

WPQR nr.:	141 T/T BBW 8.1 01
Dimension:	Rør: Ø20x3,0 - Ø50x2 mm
Materiale:	1.4301 - 1.4301

Udarbejdet af

weldadvice

Europæisk Svejse Rådgivning

For

TJ TECHNOLOGY

Ågade 65
7850 Stoholm

Indholdsfortegnelse / Table of contents

Svejseprocedureprøveattest / Welding procedure qualification record

141 T/T BBW 8.1 01

Visuel Kontrol 2015554-VT 01

Ikke Destruktiv Kontrol / Non Destructive Testing
Radiographic testing 78961-116-20219
Penetrant testing 78961-116-20219

Destruktiv Kontrol / Destructive Testing
Mechanical test report M026517:1

Materialecertifikater / Material Certificates
Chandan Steel Limited EN 10204, 3.1: Heat No: CH-2861
Siderinox S.p.a. EN 10204, 3.1: Heat No: 0440628

Tilsatsmateriale / Consumables
Hyundai SMT-316LSi, Ø1,6 mm EN 10204, 3.1: Lot No: V9988

weldadvice Europæisk Svejse Rådgivning

TJ TECHNOLOGY

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7850 Stoholm

SVEJSEPROCEDUREPRØVEATTEST
WELDING PROCEDURE QUALIFICATION RECORD

Kvalifikation i henhold til: Qualification i according to: DS/EN ISO 15613:2005
Standard/Norm: Standard/Code:
Kundens specifikation: Client's specification:

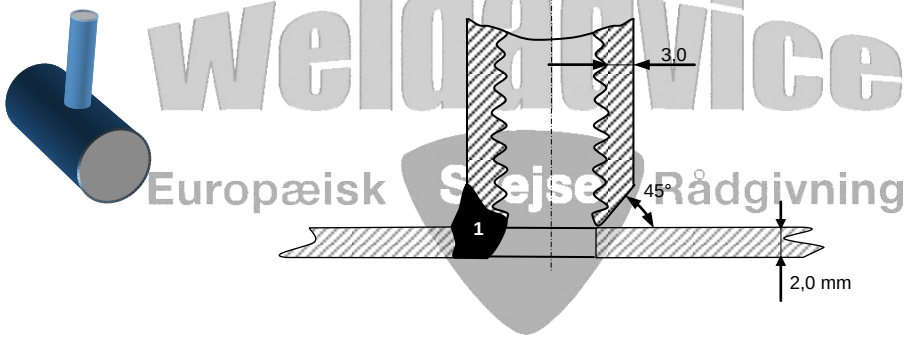
WPQR NO. 141 T/T BBW 8.1 01
Date: 15/01-2016
Blad/Sheet 1/ 1
Side/Page 1 / 2

Kunde/Client | Projekt/Project

Svejsning udført af /Welding carried out by: Brian Ravn | Mærke nr./Stamp no.

Standard/Code: EN 10217-7			Grundmaterialer/Base Materials	Standard/Code: EN 10088-3		
Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -		Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -
Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8	til/to	Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 3,0	Dia. mm: 20,0

Fugedetaljer og sømopbygning (Skitse)
Joint details and welding sequence (Sketch)



weldadvice
Europæisk Svejse Rådgivning

Svejsestilling/ Welding position: PC

Hæftning/Tacking:	Som Streng 1 / As run no. 1
Min. Forvarmetemp.: Min. preheat temp.:	16 °C
Længde: Length:	2 stk. af 4 mm
Antal strenge: No of runs:	1
Andre data: Other data:	
2. side: Fugning/Gouging:	☐ Ja Yes ☒ Nej No
Forvarmetemp.: Preheat temp.:	°C
Elektrode dia.: Electrode dia.:	mm
Lufttryk: Air pressure:	bar
2. side: Slibning/Grinding:	☐ Ja Yes ☒ Nej No

Streng No. / Run No.	Svejse-proces / Weld. proces	G Gas, T Tråd/Wire, P Pulver/Flux, E Electrode; ∇ Fabrikat og betegnelse / Manufacture and trade mark	Dimension: Diameter -Længde/ Diameter -Length mm	Standard: Klassifikation/ Classification (G EN ISO 14175:2008, T EN ISO 14343-A, E EN ISO 6848)	H_2 Skala/ Scale EN 1011	Beskyttelsesgas Shielding Gas: l/min	Dyse/ Nozzle mm Ø	Baggas Back shielding gas: Type/ l/min	Bem. Note No.
1	141	G *Strandmøllen, Pro Line H_2*	-	*R1*	-	*9*	*7*	*Formier* / *10*	-
1	141	T *Hyundai SMT-316LSi*	*1,6*	*G 19 12 3 L Si*	*D*	-	-	- / -	-
1	141	E *Wolframelektrode LaO_2*	*1,6*	*WL20*	-	-	-	- / -	-
								/	
								/	
								/	

Streng No. / Run No.	Program nr. / Program No.	AC DC / Pol.	Strøm/Current Amp	Tråd-hast. / Wire speed m/min	mm	Svejsehast mm/min. eller strækkelængde mm / Travel speed mm/min. or run-out length mm: Volt		S: XX: ∇ U.pendling/stringer pendling/weaving Strengbredde/ run width Max. mm	Heat input KJ/mm	Forvarme/ Preheat °C / Interpass-temp.	Bem. Note No.
1	-	*DC-*	*75*	-	-	*9,0*	*40*	*5,6*	*0,61*	*16* / -	-
										/	
										/	
										/	
										/	
										/	
										/	

Efterfølgende varmebeh./PWHT: ☒ Nej No ☐ Ja, se bilag nr.: Yes, see enclosure No.:

Bemærkninger-andre oplysninger/Notes-other informations

Vi bekræfter, at de givne oplysninger er korrekte og at prøven er tildannet, svejst og varmebehandlet i.h.t. ovennævnte standard/norm og/eller kundens specifikation./We confirm that the statements in this record are correct and that the test was prepared, welded and heat treated according to the above specified standard/code and/or client's specification.

Sted/Place | Dato/Date

Producentens underskrift
Contractor's signature

Prøvesvejsningen var mærket: The test coupon was marked: 2015544-01A, PC H.H. 15/01-2016

Charge/Heat: CH-2861
Charge/Heat: 0440628
Filler metal Lot: V9988

weldadvice
Europæisk Svejse Rådgivning
Messingvej 32 B DK 8940 Randers SV
Tlf.: +45 8640 6805 - Fax: +45 8640 6807

Gennemgået/bevidnet
Reviewed/witnessed by

Repræsenterende
Representing

Prøvningsresultat og godkendelse; Se bagside / Test results and approvals; See revers side

NON-DESTRUCTIVE EXAMINATION	WPQR No.: 141 T/T BBW 8.1 01	Blad/Sheet 1/1	Side/Page 2/2

Metode/ Method - resultat / result	Standard	Rapport nr./ Report no.
1. Visual examination Result: ***Accepteret/ Accepted***	Procedure standard: ***DS/EN ISO 17637:2011*** according to: ***DS/EN ISO 5817, Level B (C)***	***2015544-VT-01***
2. Radiographic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17636-1:2013 Class B*** according to: ***EN ISO 10675-1:2013, Level 1***	***78961-116-20219***
3. Ultrasonic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17640:2011 class B*** according to: ***EN 11666:2011- level 2***	
4. Magnetic particle testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17638:2009*** according to: ***DS/EN ISO 23278:2009 Level 2x***	
5. Dye penetrant testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 3452-1:2013*** according to: ***DS/EN 23277:2009- Level 2x***	***78961-116-20219***
6. Other examination Procedure: Result:	Type: according to:	

Place Randers	Date 19/01-2016	Witnessed/reviewed by (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature		Representing (Examiner or Notified Body)

Heino Harstad

MECHANICAL TESTING

According to DS/EN ISO 15614-1:2004/A1:2008/A2:2012; PED 97/23/EC

1. Tensile tests

EN ISO 6892-1:2009; EN ISO 4136:2012

Specified Y.S. min. *N/mm²* Specified U.T.S. min. *N/mm²*

Test no.	Dim.	Area	Gauge length	Yield Load	$R_{P0,2}$ N/mm²	$R_{P1,0}$ Load	R_{eH} N/mm²	R_m N/mm²	Elong A %	Remarks

2. Bend tests

DS/EN ISO 5173:2010 / EN ISO 7438:2005

Specified degr. 180° Former dia. mm

Type and dimensions	Bend angel	Results	Type and dimensions	Bend angel	Results

3. Impact tests

EN ISO 148-1:2013/ ISO 9016

Dim.: mm Specified type of test : V-notch Specified: J Testing temp. °C

Test no. VWT	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J
Average WM		Average FL		Average FL+2		Average FL+5		Average FL		Average FL+2		Average FL+5	

4. Macro Examination

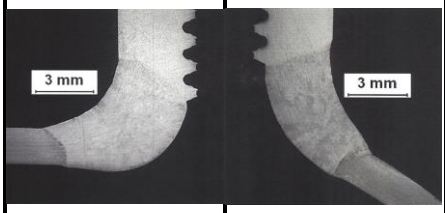
Separate sheet with picture ☐ Yes ☒ No Results:

5. Hardness tests

ISO 9015-1, EN ISO 6507-1:2006

Specified type of test: HV10 Req. max.

Sketch showing indentations



	Base metal (2mm)			HAZ (0,5 mm)				Weld metal			HAZ (0,5mm)				Base metal (2mm)		
A																	
B																	
C																	
D																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

6. Other/Supplementary Tests.

☒ No ☐ Yes See enclosures:

7. Further enclosures:

M026517:1

Place Randers	22/01-2016	Witnessed/reviewed (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature		Representing (Examiner or Test Body)

Heino Harstad

Vi godkender herved denne svejseprocedure til svejsning på omtalte projekt under de begrænsninger, der er givet i standarden/normen og/eller kundens specifikation.

We hereby approve this welding procedure for welding on the referring projekt within the limitations given in the standard/code and/or client´s specifikation.

Place Date

Underskrift af kunde/kunderepræsentant
Client´s or representative´s signature

Markrapport
Visuel kontrol af svejsesømme

Rekvirent TJ Technology, Ågade 65, 7850 Stoholm	**Sag nr.** 2015544	**Rapport nr.** VT-01
Entreprenør	**Dato.** 15/01-2016	**side af** 1 / 1
Emne Branch Connection Ø20x3 mm – Ø50,8x2 mm	**Tegning ref.:** 222446-D1324559	
Mrk. 2015544-01A	**Materiale:** X5 CrNi18-10	

Fugetype ☒ Stumpsøm	☐ Kantsøm	☐ Andet	☐ Slebet	**PWHT** ☐ Ja	☒ Nej	**Timer efter svejsning**
Undersøgelsesprocedure / klasse ☒ EN ISO 17637	☐ NS 10250	☐ ASME Sect. V	☐ Andet:			
Kvalitetskrav ☒ EN ISO 5817 Level B (C)	☐ ASME Sect.	☐ Andet:				
Udstyr ☒ Hulspejl	☒ Lygte	☐ Skydelære	☐ Kantsømlære	☐ Andet:		
Undersøgelsesomfang ☒ Kontrol før svejsning	☒ Kontrol under udførelse	☒ Kontrol efter svejsning	☐			
Omfang ☐ Visuel besigtigelse %	☒ Visuel kontrol 100 %	☐ Tilfældigt udvalgt	☐ Udpeget			

Undersøgelsens resultat

Accepteret / Accepted

Rep. opmærkning. ☐ På emne ☐ På skitse	**Kontrol af** ☐ Opslibning ☐ Reparation	**Bilag vedlagt** ☐ Ingen ☐ Stk.	**Inspektø**	**Certifikat type. / nr.** IWT-NO/0147

Attestationer	**Tekniker**	**Certifikat type / nr.**
	Tekniker	**Certifikat type / nr.**

9-11-01-L

Weldadvice I/S · Messingvej 32B · DK-8940 Randers SV · Tlf.: +45 8640 6805 · Fax: +45 8640 6807
CVR nr.: 2768 9620 · E-Mail: mail@weldadvice.dk ·Internet: www.weldadvice.dk/ www.weldadvice.com

Prøvningsrapport - Ikke-destruktiv Prøvning

KUNDE Weldadvice, Europæisk Svejse Rådgivning I/S, Messingvej 32 B, 8940 Randers SV, Denmark

KONTAKT Heino Harstad, Weldadvice, Europæisk Svejse Rådgivning I/S, Messingvej 32 B, 8940 Randers SV, Denmark

ENTREPRENØR

BYGHERRE

ARBEJDSSTED Force - Lab.

REKVISITIONS ID. 2015544-01

Rekvisitions Beskrivelse	Specifik Job Information
	6. Stk. svejseprøver/ kantsømme

78961-KHC A

Sammenfatning

Svejsninger, ingen sporbarhed, EN ISO 15614-1:2006/A2:2012

NDT Metode	Prøvningsspecifikation	Acceptkriterie	Andre krav
Penetrant (PT)	EN/ISO 3452-1:2013	EN/ISO 23277:2009 - 2X	
Radiografi (RT)	EN/ISO 17636-1:2013 - B	EN/ISO 10675-1:2013 - 1	

PRØVNINGSRESULTAT

	Svejsning Status	
	Acceptkriterie opfyldt	6 svejsninger

Detaljer om prøvningsresultat kan findes i "PRØVNINGSRESULTAT DETALJER" sektionen.

Tekniske data, NDT informationer, identifikation af udstyr, kalibreringsdata for udstyr, og andre relevante data, er registreret for hver NDT-metode i sektionen for Prøvningsmetode Detaljer. Uddrag fra Prøvningsrapporten må kun gengives efter skriftlig tilladelse fra FORCE Technology. Den elektroniske version af Prøvningsrapporten, som er gemt i "FORCE NDT Online", er defineret som originalen. Prøvningsresultaterne gælder kun for de emner som er testet. FORCE Technology - Almindelige betingelser er en integreret del af aftalen, medmindre andet er skriftligt aftalt.

PRØVNINGSRESULTAT - DETALJER

	Svejsninger hvor acceptkriterie er opfyldt		
Reference	**Svejsning Id. (Rep./Udv.)**	**Svejser(e)**	**Prøvningsmetode(r)**
2015544-01	01A-1	-	PT, RT
	01A-2	-	PT, RT
	02B-1	-	PT, RT
	02B-2	-	PT, RT
	03C	-	PT, RT
	04D	-	PT, RT

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PRØVNINGSOMFANG

RT. og PT. af 6. stk. svejseprøver, i muligt omfang.

SVEJSNING DETALJER

Reference	Svejsning Id. (Rep./Udv.)	Materialer	Overfladebeskaffenhed	Varmebehandling
		Dimensioner	Tidspunkt for prøvning	Temperatur (ca.)
		Nominel tykkelse	Timer efter sidste fremstillingstrin	Svejsningstype-fugeform-metode(r)
2015544-01	01A-1, 01A-2	Rustfrit stål	Som svejst	Ingen information
		20 mm	Ingen information	-
		3 mm	-	Ingen information-Ingen information-Ingen information
	02B-1, 02B-2	Rustfrit stål	Som svejst	Ingen information
		50 mm	Ingen information	-
		2 mm	-	Ingen information-Ingen information-Ingen information
	03C	Rustfrit stål	Som svejst	-
		50 mm	Ingen information	-
		2-2 mm	-	Ingen information-Ingen information-Ingen information
	04D	Rustfrit stål	Som svejst	-
		50 mm	Ingen information	-
		1,6-15 mm	-	Ingen information-Ingen information-Ingen information

Ovenstående oplysninger er til information og angives kun i den udstrækning, de er tilgængelige og relevante. Deres angivelse i denne prøvningsrapport kan ikke betragtes som en verifikation af deres rigtighed og de er ikke omfattet af nogen akkreditering.

PRØVNINGSMETODE - DETALJER

Penetrant Prøvning (PT) **Prøvningstidspunkt 19-01-2016 - 19-01-2016**

Personale

Navn (Tekniker Nr.)	Certifikattype	Certifikat nr.	Reference [Svejsning Ids]
Keld Hald Christensen (1)	EN ISO 9712 PT (EN 473) Level 2	0063-N2-P	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]

Produkter

Type	Parti Nr.	Produkt	Prøvningstekniske oplysninger Nr.
Halogenfri Opløsningsmiddel Fremkalder		Spotcheck SKD-S2	1
Vandafvaskelig/Opløsningsmiddel Rød Penetrant		Spotcheck SKL-WP	1
Halogenfri Rensevæske/Afrensning af Overskudspenetrant		Spotcheck SKC-S	1

Prøvningstekniske oplysninger

Nr.	Reference [Svejsning Ids]	For-rengøring	Penetreringstid	Fremkaldertid	Lysforhold
		Betegnelse	Emulgeringstid	-	Lys intensitet
1	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]	Penetrant Rensemiddel	15 min.	15 min.	Hvidt lys - kunstig
		IICd2	-	-	> 1000 LUX

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Radiografi Prøvning (RT) **Prøvningstidspunkt 19-01-2016 - 19-01-2016**

Personale

Navn (Tekniker Nr.)	Certifikattype	Certifikat nr.	Reference [Svejsning Ids]
Keld Hald Christensen (1)	EN ISO 9712 RT (EN 473) Level 2 (incl. aluminium)	0063-N2-R	2015544-01 [01A-1, 01A-2, 02B-1, 02B-2, 03C, 04D]

Udstyr

Type	Id.	Andre data	Prøvningstekniske oplysninger Nr.
RT X-RAY TUBE, SMART 225	XRL-10	FOCAL SPOT 3 MM, EN 12543, (DIRECT BEAM), 70-225 kV, 4,0 mA	1-4
RT FILM VIEWING UNIT, WILNOSOL	VGA-110	H UNIVERSAL, DENSITY D UP TO 3,7	1-4
RT DENSITOMETER, WILNOS LCD 51	PDE-21	MAXIMUM DENSITY D = 5,0	1-4

Prøvningstekniske oplysninger

Nr.	Optageteknik	Fremkaldelse	IQI (Certifikat nr.)	Spænding
	Antal film per svejsning/objekt	Folietype (tykkelse)	IQI placering	Strøm / Aktivitet
	Filmtype	Kilde/Brændplet størrelse	Gennemstrålet tykkelse	Eksponeringstid
	Kilde / detektor eller film afstand (SFD / SDD)	Kilde / objekt afstand (f/D)	Objekt / film afstand (b/d)	Opløsning
1	Dobbeltvæg/Enkeltbillede - Rør, Kontakt (DV/EB)	Maskine	10 FE EN ()	140 kV
	1	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	750.0 mm	50.0 mm	-
2	Dobbeltvæg/Dobbeltbillede - Rør, Ellipse (DV/DB)	Maskine	10 FE EN ()	140 kV
	2	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	750.0 mm	50.0 mm	-
3	Enkeltvæg/Enkeltbillede - Plade (EV/EB)	Maskine	10 FE EN ()	140 kV
	4	Pb (0.02 / 0.02 mm)	Kildeside	4.0 mA
	Foma / Indux R5	3.0 mm	2.0 mm	55 sek
	800.0 mm	790.0 mm	10.0 mm	-
4	Enkeltvæg/Enkeltbillede - Plade (EV/EB)	Maskine	13 FE EN ()	200 kV
	4	Pb (0.02 / 0.02 mm)	Filmside	4.0 mA
	Foma / Indux R5	3.0 mm	15.0 mm	90 sek
	800.0 mm	785.0 mm	15.0 mm	-

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Film

Film id.	Prøvningstekniske oplysninger Nr.	Sværtning	IQI Nr.	Følsomhed	Ug
01, 02, 05	1	2,5	16	5.00 %	0.20 mm
03, 04	2	2,5	16	5.00 %	0.20 mm
06-09	3	2,5	16	5.00 %	0.04 mm
10-13	4	2,5	13	1.33 %	0.06 mm

Svejsning på film

Reference	Svejsning Id [Film Id'er]
2015544-01	01A-1 [01], 01A-2 [02], 02B-1 [03,04], 02B-2 [05], 03C [06-09], 04D [10-13]

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PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

SWEDAC ACKREDITERING 5622 ISO/IEC 17025

SAFE CONTROL MATERIALTEKNIK

Beställare / Ordered by Weldadvice Messingvej 32B DK-8940 Randers SV	**Orderdatum / Date of order** 2016-01-20	**Reg. nummer / Reg. number** M026517:1
Er referens / Your reference Heino Harstad	**Inlämningsdatum / Object (-s) received** 2016-01-20	**Sidnummer / Page** 1(2)
Ordernummer / Order number 2015544-02	**Rapportdatum / Date of report** 2016-01-25	**Vår referens / Our reference** Johan Ageryd

Assignment:	Procedure qualification test according to EN ISO 15 614-1:2004.	
Test object(s):	Branch connection. Half V- groove.	
Material:	1.4301/ 1.4307	1.4301/ 1.4307
Group:	8.1	8.1
Dimension:	Ø 20 x 3.0 mm	Ø 50 x 2.0 mm
Heat number:	CH-2861	0440628
pWPS:	WPS TJ Tech 02	
Procedure number:	2015544-01A	
Identification mark:	2015544-01A	
Weld method:	141	
Position:	PC	
Filler metal:	Hyundai SMT-316LSi, Ø 1.6 mm	
Note:	-	
Result:	Accepted according to referenced standard.	
Signature:	SAFE CONTROL Johan Ageryd	

"Laboratorier ackrediteras av Styrelsen för ackreditering och teknisk kontroll (SWEDAC) enligt svensk lag. Den ackrediterade verksamheten vid laboratoriet uppfyller kraven i SS-EN ISO/IEC 17 025 (2005). Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänner annat". Provningsresultaten i denna rapport avser endast provade objekt.

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Safe Control Materialteknik AB • Tillgängligheten 1 • S-417 01 Göteborg
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E-mail: info@safecontrol.se • www.safecontrol.se

PROVNINGSRAPPORT

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TEST REPORT issued by an Accredited Testing Laboratory

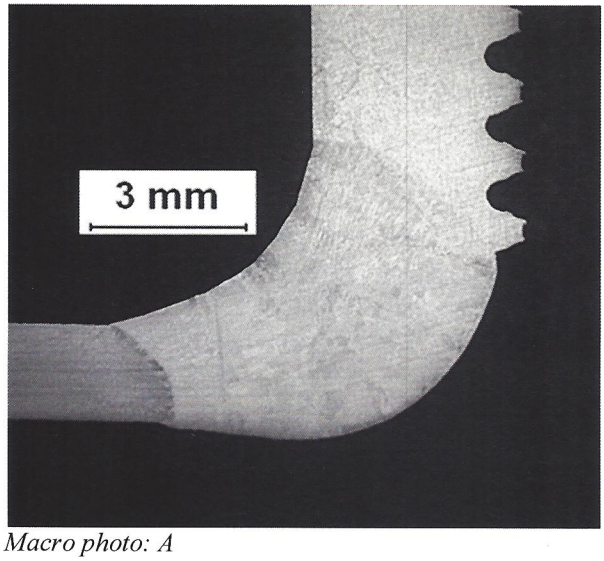
Teknisk instruktion / Technical instruction	Märkning / Marking	Reg. nummer / Reg. number
Macroscopic and microscopic examination of welds	2015544-01A	M026517:1
TI Dokumentnr./ TI Document no.	**Provningsutrustning / Testing equipment**	**Sidnummer / Page**
SCMM1	SCM 9	2(2)
Provning enligt / Testing according to	**Provningsdatum / Testing date**	**Utfört av / Performed by**
SS-EN 1321	2016-01-22	Johan Ageryd

Macroscopic examination:

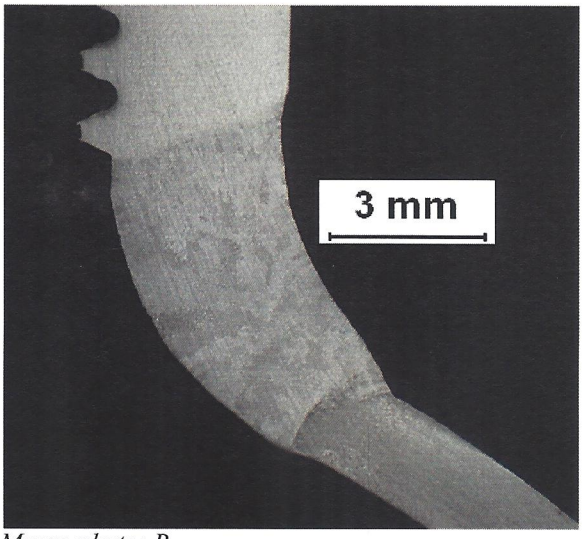
Two macro samples were cut out for macroscopic examination of weld metal, HAZ and base metal. The macro samples were ground (to 2000- paper) and examined in not etched and etched condition at magnification of 1× - 20×.

Macro sample			Base metal		Filler metal	Etchant *(acc. to SIS-CEN/CR 12361:1996)*
ID / No	Position	Orientation	Horizontal	Vertical		
2015544-01A	PC	Perpendicular to the weld direction	1.4301/ 1.4307	1.4301/ 1.4307	Hyundai SMT-316LSi	B.5 (Kalling´s)
Examined macro samples are assessed to fulfil the requirements in EN ISO 5817:2014. See macro photos below.						

Macro photos:



Macro photo: A



Macro photo: B

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurement: ± 1.5 %

Not.: Avsteg från punkt 10 i SS-EN 1321 har gjorts. Beteckning har ej redovisats i enlighet med exemplifierade versioner.
Note: Deviation from clause 10 in SS-EN 1321 has been done. Description has not been presented in accordance with exemplified versions.

Signatur/ Signature:

SAFE CONTROL
Johan Ageryd

CHANDAN STEEL LIMITED

(GOVT. OF INDIA RECOGNISED EXPORT HOUSE)

ISO 9001 : 2008 CERTIFICATE No. 04 100 011022-E3

ADM. OFFICE: 504, SUKH SAGAR, N. S. PATKAR MARG, MUMBAI 400 007, INDIA

Tel.: 91-22- 66290600. Fax.: 91-22-66290633/34

Website : www.chandansteel.net

Email : csl@chandansteel.net

WORKS: Plot No. 35, G. I. D. C., Umbergaon

Dist Valsad, Gujarat - 396 171.

Tel.: 91-260- 308 9999 Fax.: 91-260 308 9872

E-mail : exports@chandansteel.net

CE 0045 14 0045-CPR-1394

L/c. No.:

L/c. Date:

F824 QC 09A / 02 / 10.12.2012

MILL TEST /INSPECTION CERTIFICATE 3.1

ACCORDING TO EN 10204 : 2005

Consignee		Test Certificate No.	: EXP/00645 - 09/2015-2016
DACAPO STAINLESS A/S		Date of Issue	: 22.09.2015
NEPTUNVEJ 1		P. O. No.	: 45060220
8600 SILKEBORG		SC_No. & Date	: 15-16/00345, Dt.01.08.2015
DENMARK		Invoice No. & Date	: EXP/00645/2015-16 Dt.22.09.2015
PRODUCT DESCRIPTION		LENGTH	Net Wt.
STAINLESS STEEL ROUND BARS		Ordered	Actual
[CONDITION - 1D & 2D]		6.0 - 6.1 Mtrs.	6.0 - 6.1 Mtrs.
			2731 Kgs.

Article No.	Item No.	Heat No.	Material/Grade	Size mm	Tolerance	Process Route
-	5000200006	CH-2861	1.4301/1.4307	20.00 mm	h9	Electric Melting, A.O.D. Refining, Continuous Casting

CHEMICAL COMPOSITION (Weight %)

	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Ti	Co	N
Min.	-	-	-	-	-	18.00	-	8.00	-	-	-	-
Max.	0.030	1.00	2.00	0.045	0.030	19.50	-	10.50	-	-	-	0.1000
Results	0.029	0.43	1.65	0.045	0.028	18.30	-	8.03	-	-	-	0.0650

MECHANICAL PROPERTIES

Specified Values	Test Method :- EN ISO 6892-1					Hardness EN ISO 6506-1	Test Method :- DIN EN ISO 148 - 1 Charpy (V) Impact Test (2mm) at 20 °C (Joules) Sample Size - 10 x 10 x 55 mm			
	Proof Strength N/mm² /MPa		Tensile Strength N/mm²/MPa (Rm)	Elongation after Fracture A %	Reduction of Area %					
	0.2%(Rp0.2)	1%(Rp1.0)				(BHN)	I	II	III	Avg.
Results	448	485	715	44	65	222-225	230	240	245	238

Remarks:

1. Condition : 1D & 2D (Bright drawn & Polished).
2. Solution annealed at 1050 °C.
3. PMI test done 100% & found Satisfactory.
4. Both ends Chamfered.
5. The material is fully killed and calcium treated.
6. Material has improved machinability.
7. Material is free from radio-active contamination.
8. Intergranular Corrosion test carried out as per EN/ISO 3651-2-1998 (Test method A) found satisfactory.
9. Surface Defects found satisfactory as per EN 10277-1 Class 3.
10. The material conforms to DIN EN 10088-3:2005, EN 10088-5:2009, EN 10272-2008, AD2000 W2/W10, ASTM A276-13/A182-13/A479-13a, ASME SA276-10/ SA182-10/SA 479- 2010 SECTION II, PART A Specification.
11. Location of sample - off centre, Direction - Longitudinal, Test Temp - Room Temp., Shape of Test Piece - Round.
12. Marking details - Company Logo, Size, Grade & Heat No.
13. The material is manufactured /melt in Chandan Steel Mill and is of Indian Origin.

BUNDLE NO.: 64, 65, 67 to 69 COLOUR : BLUE

Intended use : Building construction or civil engineering.

Regulated substance : No performance determined.

It is hereby certified that the above results are true and correct in every details and are meeting the requirements of specification & purchase order.

D.O.P. No.: 1.4301/ROUND BAR

D.O.P. can be seen here: www.chandansteel.net

BSR

B. S. RAUTELA

MANAGER - Q.A./WORKS INSPECTOR

SIDERINOX

Siderinox S.p.a. Frazione Caselle 20081 Morimondo (MI) Italia
Ufficio Commerciale: Tel. 02 9498151 - Fax 02 949815250/251
Ufficio Amministrativo: Tel. 02 9498161 - Fax 02 949816350
Ufficio Spedizioni: Tel. 02 949816222 - Fax 02 949815350
Ufficio Acquisti : Tel. 02 949816345 - Fax 02 949816350
Casella e-mail: sx@siderinox.it Sito web: www.siderinox.it

Capitale Sociale Euro 3.300.000 i.v.
Cod. Fiscale e Reg. Imp. MI N. 01825510157
R.E.A. Milano N. 878116
Centro Meccanografico n. MI074282
Partita IVA 01825510157

AZIENDA CON SISTEMA
DI GESTIONE QUALITÀ
CERTIFICATO DA DNV GL
=ISO 9001=

INSPECTION CERTIFICATE EN 10204 3.1 N° 424885 of 02.02.2015

Purchaser **INOX STAAL A/S**

DDT	SIDERINOX order number	Customer's order
N 8 of 02.02.2015	N 5 of 22.01.2015	N 15836-1 of 22.01.2015

Product description

Stainless steel round pipe Ø 50,8 x 2 mm AISI 304/304L brushed EN 10217-7 Longitudinally welded

Dimension	Steel type	Quantity (m)	Weight (kg)
50,8 x 2 mm	EN 1.4301/1.4307 / AISI 304/304L	366	815

Production Norm	Rolling	Tolerances	Welding factor
EN 10217-7	Hot rolled	D3 \ T3	V=1

Marking MANUFACTURER'S MARK - DIMENSION - STEELGRADE - HEAT N. - PRODUCTION NORM - EXECUTION - E.C. INSPECTOR - WORK INSPEKTOR

Manufacturing process — Surface finishing W0

CHEMICAL COMPOSITION

Heat	% C	%Mn	%P	% S	%Si	%Cr	% Ni	% Mo	% Ti
	0,000 - 0,030	0,000 - 2,000	0,000 - 0,040	0,000 - 0,010	0,000 - 1,000	17,500 - 19,500	8,000 - 10,000	0,000 - 0,000	0,000 - 0,000
0440628	0,022	1,680	0,027	0,001	0,380	18,240	8,090		

The chemical values refer to the certificate issued by the steel mill according to EN 10088 / 10028-7 / ASTM A 240 and stored at our office.

TEST RESULTS

* (D) Direction: (L) Longitudinal, (T) Transverse - ** (P) Position: (W) Welding, (M) Material

Test unit	Test Class	(D) *	(P) **	TENSILE TEST in Nmm2=MPa				HARDNESS
				Yield Strength		Tensile Strength	Elongation	
				Rp 0,2%	Rp 1%	Rm	A %	HRB
				195 -	230 -	500 - 740	40 -	
T14100996	TC1	L	M	246	330	658	48	
T14100998	TC1	L	M	235	314	627	49	

Visual inspection	OK	Drift expanding test		Sealing test	
		UNI EN ISO 8493	OK	UNI EN ISO 10893-1	OK
Check on dimensions	OK	Flattenning test		Non destructive Eddy Current test	
		UNI EN ISO 8492	OK	UNI EN ISO 10893-2	OK
Antimixing test	OK	Weld bend test		Intergranular corrosion test	
		EN 910	OK	N. P.	N. P.

WE CERTIFY THAT THE MATERIAL SUPPLIED COMPLIES WITH THE REQUIREMENTS AGREED ON THIS ORDER

Remarks:

Cerfications:
UNI EN ISO 9001
Dir. PED 97/23/EC Encl. 1, Point 4.3, Comma 3
AQUAP from Nr. 7293-06-TU to Nr 7298-06-TU

Qualifications:
WPS/WPAR: UNI EN ISO 15609-1/UNI EN ISO 15614-11
WLD: UNI EN ISO 14732 operator
NDT: UNI EN ISO 9712 operator

Document issued by the mill's Inspector
D. Ricco

Document confirmed by the authorized company responsible
W. Amodeo

CERTIFIED MATERIAL REPORT

CMR No. : 1502253500015 Date of Issue : 2015-02-25

Customer	HYUNDAI WELDING EUROPE OFFICE		
Trade Name	SMT-316LSi Inox	Size	1.6mm*1000mm*5kg
Lot No.	V9988	Purchaser's Order No.	
Applicable Specification	AWS A5.9 ER316LSi	* According to EN 10204-2004 : 3.1	

Welding Current		Shielding Gas		Post Weld Heat Treatment (℃ × hr.)	

Mechanical Properties	Tensile Test			Impact Test (CVN - Joule)				
	YS(MPa)	TS(MPa)	EL(%)	Temp.(℃)	X1	X2	X3	Avg.
	-	-	-		-	-	-	-
Spec.								

Chemical Composition (%)

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo		
(WIRE)	0.021	0.97	1.71	0.027	0.011	0.20	11.33	18.30	2.57		
Spec.	≤0.03	0.65 ~1.00	1.0 ~2.5	≤0.03	≤0.03	≤0.75	11.0 ~14.0	18.0 ~20.0	2.0 ~3.0		

We hereby certifies that the material covered by this report has been inspected in accordance with and been found to meet the applicable requirements of specification and customer's requirements.

Approved by

K.W. Park

QA Manager Park K. W.

HYUNDAI HYUNDAI WELDING CO., LTD.
Head Office #507,Teheran-ro,Gangnam-gu,Seoul,Republic of Korea
Pohang Plant #100,Daesong-ro,Nam-gu,Pohang,Republic of Korea

Svejseprocedureprøvedokumentation

Welding Procedure Qualification Record

Complete documentation

DS/EN ISO 15614-1:2006/A1:2008/A:2:2012

WPQR nr.:	141 T BW 8.1 02
Dimension:	Rør: Ø50,8x2,0 mm
Materiale:	1.4301 - 1.4301

Udarbejdet af

weldadvice

Europæisk Svejse Rådgivning

For

TJ TECHNOLOGY

Ågade 65
7850 Stoholm

Indholdsfortegnelse / Table of contents

Svejseprocedureprøveattest / Welding procedure qualification record

141 T BW 8.1 02

Visuel Kontrol 2015554-VT 02

Ikke Destruktiv Kontrol / Non Destructive Testing
Radiographic testing 78961-116-20219
Penetrant testing 78961-116-20219

Destruktiv Kontrol / Destructive Testing
Mechanical test report M026517:2

Materialecertifikater / Material Certificates
Siderinox S.p.a. EN 10204, 3.1: Heat No: 0440628

Tilsatsmateriale / Consumables
Hyundai SMT-316LSi, Ø1,6 mm EN 10204, 3.1: Lot No: V9988

weldadvice Europæisk Svejse Rådgivning

TJ TECHNOLOGY
Ågade 65
7850 Stoholm

SVEJSEPROCEDUREPRØVEATTEST
WELDING PROCEDURE QUALIFICATION RECORD

Kvalifikation i henhold til: Qualification i according to: DS/EN ISO 15614-1:2006/A1:2008/A:2:2012
Standard/Norm: Standard/Code:
Kundens specifikation: Client's specification:

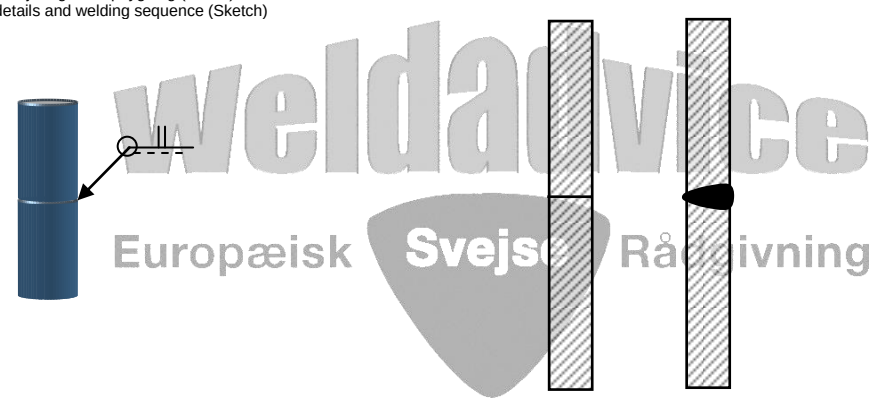
WPQR NO. 141 T BW 8.1 02
Date: 15/01-2016
Blad/Sheet 1/ 1
Side/Page 1 / 2

Kunde/Client | Projekt/Project

Svejsning udført af /Welding carried out by: Brian Ravn | Mærke nr./Stamp no.

Standard/Code: EN 10217-7			Grundmaterialer/Base Materials	Standard/Code: EN 10217-7		
Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -		Betegnelse Designation/grade: 1.4301 X5CrNi18-10	Gruppe nr. / Group no. DS/CEN ISO/TR 15608: 8.1	Ceqv. actual: -
Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8	til/to	Plade/rør Plate/pipe: Rør/pipe	Tykkelse/WT mm Thickness/WT mm: 2,0	Dia. mm: 50,8

Fugedetaljer og sømopbygning (Skitse)
Joint details and welding sequence (Sketch)



weldadvice Europæisk Svejse Rådgivning

Svejsestilling/Welding position: PC

Hæftning/Tacking:	Som Streng 1 / As run no. 1
Min. Forvarmetemp.: Min. preheat temp.:	16 °C
Længde: Length:	4 stk. 2-4 mm
Antal strenge: No of runs:	1
Andre data: Other data:	
2. side: Fugning/Gouging:	☐ Ja Yes ☒ Nej No
Forvarmetemp.: Preheat temp.:	°C
Elektrode dia.: Electrode dia.:	mm
Lufttryk: Air pressure:	bar
2. side: Slibning/Grinding:	☐ Ja Yes ☒ Nej No

Streng No. / Run No.	Svejse-proces / Weld. proces	G T P E ∇	Gas, Tråd/Wire, Pulver/Flux, Electrode; Fabrikat og betegnelse / Manufacture and trade mark	Dimension: Diameter -Længde/ Diameter -Length mm	Standard: Klassifikation/ Classification G T E	H_2 Skala/ Scale EN 1011	Beskyttelsesgas Shielding Gas: l/min	Dyse/ Nozzle mm Ø	Baggas Back shielding gas: Type/ l/min	Bem. Note No.
1	141	G	Strandmøllen, Pro Line H_2	-	EN ISO 14175:2008 / EN ISO 6848: R1	-	9,0	7	Formier / 10	-
1	141	E	Wolframelektrode LaO_2	1,6	WL20	-	-	-	- / -	-
									/ -	-
									/	
									/	
									/	

Streng No. / Run No.	Program nr. / Program No.	AC DC Pol.	Strøm/Current Amp	Tråd-hast. Wire speed m/min	mm	Svejsehast mm/min. eller strækkelængde mm. Travel speed mm/min. or run-out length mm	Volt	S: XX: ∇ U.pendling/stringer pendling/weaving Strengbredde/ run width Max. mm	Heat input KJ/mm	Forvarme/ Preheat /Interpass-temp. °C	Bem. Note No.
1	Pulsed		82	-	-	9,0	99		0,27	16 / -	1*)
										/	
										/	
										/	
										/	
										/	
										/	

Efterfølgende varmebeh./PWHT: ☒ Nej No ☐ Ja, se bilag nr.: Yes, see enclosure No.:

Bemærkninger-andre oplysninger/Notes-other informations
1*) Welding without filler metal

Vi bekræfter, at de givne oplysninger er korrekte og at prøven er tildannet, svejst og varmebehandlet i.h.t. ovennævnte standard/norm og/eller kundens specifikation./We confirm that the statements in this record are correct and that the test was prepared, welded and heat treated according to the above specified standard/code and/or client's specification.

Sted/Place | Dato/Date

Producentens underskrift
Contractor's signature

Prøvesvejsningen var mærket: The test coupon was marked: 2015544-02B, PC H.H. 15/01-2016

Charge/Heat:
Charge/Heat: 0440628
Filler metal Lot: Welded without filler metal

weldadvice Europæisk Svejse Rådgivning
Messingvej 32 B DK 8940 Randers SV
Tlf.: +45 8640 6805 - Fax: +45 8640 6807

Gennemgået/bevidnet
Reviewed/witnessed by

Repræsenterende
Representing

Prøvningsresultat og godkendelse; Se bagside / Test results and approvals; See revers side

NON-DESTRUCTIVE EXAMINATION	WPQR No.: 141 T BW 8.1 02	Blad/Sheet 1/1	Side/Page 2/2

Metode/ Method - resultat / result	Standard	Rapport nr./ Report no.
1. Visual examination Result: ***Accepteret/ Accepted***	Procedure standard: ***DS/EN ISO 17637:2011*** according to: ***DS/EN ISO 5817, Level B (C)***	***2015544-VT-02***
2. Radiographic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17636-1:2013 Class B*** according to: ***EN ISO 10675-1:2013, Level 1***	***78961-116-20219***
3. Ultrasonic examination Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17640:2011 class B*** according to: ***EN 11666:2011- level 2***	
4. Magnetic particle testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 17638:2009*** according to: ***DS/EN ISO 23278:2009 Level 2x***	
5. Dye penetrant testing Result: ***Accepteret/ Accepted***	Procedure standard: ***EN ISO 3452-1:2013*** according to: ***DS/EN 23277:2009- Level 2x***	***78961-116-20219***
6. Other examination Procedure: Result:	Type: according to:	

Place Randers	Date 19/01-2016	Witnessed/reviewed by (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature Heino Harstad		Representing (Examiner or Notified Body)

MECHANICAL TESTING

According to DS/EN ISO 15614-1:2004/A1:2008/A2:2012; PED 97/23/EC

1. Tensile tests

EN ISO 6892-1:2009; EN ISO 4136:2012

Specified Y.S. min. *≥195; ≥230 N/mm²* Specified U.T.S. min. *500 - 700 N/mm² - 470 670 N/mm²*

Test no.	Dim.	Area mm²	Gauge length	Yield Load	$R_{P0,2}$ N/mm²	$R_{P1,0}$ Load	R_{eH} N/mm²	R_m N/mm²	Elong A %	Remarks
TT/1	12.01x1.58	19.16						638		HAZ
TT/2	12.02x1.77	21.49						632		HAZ

2. Bend tests

DS/EN ISO 5173:2010 / EN ISO 7438:2005

Specified degr. 180° Former dia. 4x2 mm

Type and dimensions	Bend angel	Results	Type and dimensions	Bend angel	Results
TFBB/1 (2x18 mm)	180	Accepteret / Accepted	TRBB/1 (2x19 mm)	180	Accepteret / Accepted
TFBB/2 (2x21 mm)	180	Accepteret / Accepted	TRBB/2 (2x19 mm)	180	Accepteret / Accepted

3. Impact tests

EN ISO 148-1:2013/ ISO 9016

Dim.: mm Specified type of test : V-notch Specified: J Testing temp. °C

Test no. VWT	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J	Test no. VHT 0/1	Result J	Test no. VHT 2/1	Result J	Test no. VHT 5/1	Result J
Average WM		Average FL		Average FL+2		Average FL+5		Average FL		Average FL+2		Average FL+5	

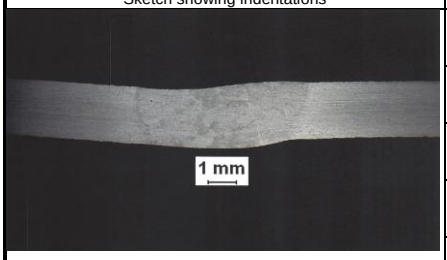
4. Macro Examination

Separate sheet with picture ☒ Yes ☐ No Results: Accepteret / Accepted

5. Hardness tests

ISO 9015-1, EN ISO 6507-1:2006

Specified type of test: HV10 Req. max.

Sketch showing indentations		Base metal (2mm)			HAZ (0,5 mm)				Weld metal			HAZ (0,5mm)				Base metal (2mm)		
	A																	
	B																	
	C																	
	D																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

6. Other/Supplementary Tests.

☒ No ☐ Yes See enclosures:

7. Further enclosures:

M026517:2

Place Randers	25/01-2016	Witnessed/reviewed (Name/Signature)
Laboratory signature ***or*** Data transferred from enclosed laboratory report by- Signature Heino Harstad		Representing (Examiner or Test Body)

Vi godkender herved denne svejseprocedure til svejsning på omtalte projekt under de begrænsninger, der er givet i standarden/normen og/eller kundens specifikation.

We hereby approve this welding procedure for welding on the referring projekt within the limitations given in the standard/code and/or client´s specifikation.

Place Date

Underskrift af kunde/kunderepræsentant
Client´s or representative´s signature

Markrapport
Visuel kontrol af svejsesømme

Rekvirent TJ Technology, Ågade 65, 7850 Stoholm	**Sag nr.** 2015544	**Rapport nr.** VT-02
Entreprenør	**Dato.** 15/01-2016	**side af** 1 / 1
Emne Rør: Ø50,8x2 mm	**Tegning ref.:** 222446-D1324560	
Mrk. 2015544-02B	**Materiale:** X5 CrNi18-10	

Fugetype
☒ Stumpsøm ☐ Kantsøm ☐ Andet ☐ Slebet

PWHT
☐ Ja ☒ Nej

Timer efter svejsning

Undersøgelsesprocedure / klasse
☒ EN ISO 17637 ☐ NS 10250 ☐ ASME Sect. V ☐ Andet:

Kvalitetskrav
☒ EN ISO 5817 Level B (C) ☐ ASME Sect. ☐ Andet:

Udstyr
☒ Hulspejl ☒ Lygte ☐ Skydelære ☐ Kantsømlære ☐ Andet:

Undersøgelsesomfang
☒ Kontrol før svejsning ☒ Kontrol under udførelse ☒ Kontrol efter svejsning ☐

Omfang
☐ Visuel besigtigelse % ☒ Visuel kontrol 100 % ☐ Tilfældigt udvalgt ☐ Udpeget

Undersøgelsens resultat

Accepteret / Accepted

Rep. opmærkning.	**Kontrol af**	**Bilag vedlagt**	**Inspektør**	**Certifikat type. / nr.**
☐ På emne ☐ På skitse	☐ Opslibning ☐ Reparation	☐ Ingen ☐ Stk.		IWT-NO/0147

Attestationer	**Tekniker**	**Certifikat type / nr.**
	Tekniker	**Certifikat type / nr.**

9-11-01-L

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

SWEDAC ACKREDITERING 5022 ISO/IEC 17025

SAFE CONTROL MATERIALTEKNIK

Beställare / Ordered by
Weldadvice
Messingvej 32B
DK-8940 Randers SV

Orderdatum / Date of order
2016-01-20

Reg. nummer / Reg. number
M026517:2

Er referens / Your reference
Heino Harstad

Inlämningsdatum / Object (-s) received
2016-01-20

Sidnummer / Page
1(4)

Ordernummer / Order number
2016544-02

Rapportdatum / Date of report
2016-01-25

Vår referens / Our reference
Johan Ageryd

Assignment:	Procedure qualification test according to EN ISO 15 614-1:2004.
Test object(s):	Butt weld. Two welded pipes.
Material:	1.4301/1.4307
Group:	8.1
Dimension:	Ø 50.8 x 2 mm
Heat number:	0440628 – C1309304
pWPS:	WPS TJ Tech 01
Procedure number:	2015544-02B
Identification mark:	2015544-02B
Weld method:	141
Position:	PC
Filler metal:	Hyundai SMT-316LSi, Ø1,6 mm.
Note:	-
Result:	Accepted according to referenced standard.
Signature:	SAFE CONTROL Johan Ageryd

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Safe Control Materialteknik AB • Tillgängligheten 1 • S-417 01 Göteborg
Tel. +46 (0)31 65 64 70 • Fax +46 (0)31 65 64 80
E-mail: info@safecontrol.se • www.safecontrol.se

SWEDAC ACKREDITERING 5622 ISO/IEC 17025

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

Teknisk instruktion / Technical instruction
Tensile testing

Märkning / Marking
2015544-02B

Reg. nummer / Reg. number
M026517:2

TI Dokumentnr./ TI Document no.
SCDR1

Provningsutrustning / Testing equipment
SCM 1, 39, UTM V.2.10.02
SCM 107 extensometer L_e 50 mm

Sidnummer / Page
2(4)

Provning enligt / Testing according to
SS-EN ISO 6892-1:2009B10

Provningsdatum / Testing date
2016-01-21

Utfört av / Performed by
Harald Fredriksson

Tensile testing:

Pipe strip acc. to ISO 4136 / No	Dimensions		Square-area	Yield strength				Tensile strength	Elongation	Location of fracture
	Diameter/ width	Thickness		$R_{p0.2}$	$R_{p1.0}$	R_{eL}	R_{eH}	R_m	A_5	
	mm		mm^2	MPa					%	
TT/1	12.01	1.58	19.16	-	-	-	-	638	-	HAZ
TT/2	12.02	1.77	21.49	-	-	-	-	632	-	HAZ
SS-EN 10217-7:2005 1.4307:				≥180	≥215	-	-	470-670	≥35 T ≥40 L	-
SS-EN 10217-7:2005 1.4301:				≥195	≥230	-	-	500-700	≥35 T ≥40 L	-

Result: Satisfactory according to the requirement for the base material.

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

R_m: 2.0 % *$R_{p0.2}$ / $R_{p1.0}$:3.0 %* *R_{eH} / R_{eL}: 2.0 %*

Signatur/ Signature:

SAFE CONTROL Harald Fredriksson

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

Teknisk instruktion / Technical instruction	Märkning / Marking	Reg. nummer / Reg. number
Bend testing	2015544-02B	M026517:2
TI Dokumentnr./ TI Document no.	**Provningsutrustning / Testing equipment**	**Sidnummer / Page**
SCSP1	SCM 1 and mandrel Ø 8mm	3(4)
Provning enligt / Testing according to	**Provningsdatum / Testing date**	**Utfört av / Performed by**
SS-EN ISO 7438:2005	2016-01-21	Harald Fredriksson

Bend testing:

Sample type acc. to SS-EN ISO 5173 / No	Dimensions		Bending-angle	Diameter of mandrel	Observations and result
	Thickness (a)	Width (b)			
	mm	mm	°		
TFBB/1	2	18	180	4 x Test thickness (a)	Satisfactory, without remarks.
TFBB/2	2	21	180	4 x Test thickness (a)	Satisfactory, without remarks.
TRBB/1	2	19	180	4 x Test thickness (a)	Satisfactory, without remarks.
TRBB/2	2	19	180	4 x Test thickness (a)	Satisfactory, without remarks.

Result: Satisfactory according to the requirement in EN ISO 15614-1.

Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurment: ± 0.2mm

Signatur/ Signature: SAFE CONTROL Harald Fredriksson

PROVNINGSRAPPORT

utfärdad av ackrediterat provningslaboratorium

TEST REPORT issued by an Accredited Testing Laboratory

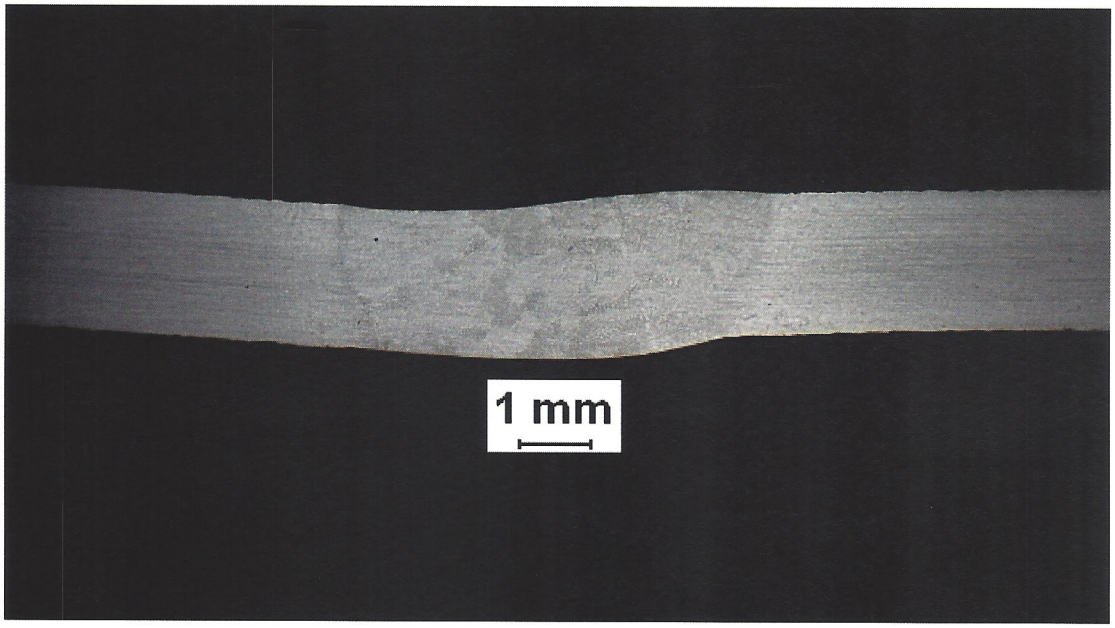
Teknisk instruktion / Technical instruction Macroscopic and microscopic examination of welds	**Märkning / Marking** 2015544-02B	**Reg. nummer / Reg. number** M026517:2
TI Dokumentnr./ TI Document no. SCMM1	**Provningsutrustning / Testing equipment** SCM 9	**Sidnummer / Page** 4(4)
Provning enligt / Testing according to SS-EN 1321	**Provningsdatum / Testing date** 2016-01-21	**Utfört av / Performed by** Johan Ageryd

Macroscopic examination:

One macro sample was cut out for macroscopic examination of weld metal, HAZ and base metal. The macro sample was ground (to 2000- paper) and examined in not etched and etched condition at magnification of 1× - 20×.

Macro sample			Base metal		Filler metal	Etchant *(acc. to SIS-CEN/CR 12361:1996)*
ID / No	Position	Orientation	Left	Right		
2015544-02B	PC	Perpendicular to the weld direction	1.4301/1.4307	1.4301/1.4307	Hyundai SMT-316LSi	B.5 (Kalling´s)
Examined macro sample is assessed to fulfil the requirements in EN ISO 5817:2014. See macro photo below.						

Macro photo:



Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, k=2, vilket för en normaldistribution motsvarar en sannolikhet med ca 95 %. Mätosäkerhetsberäkningarna är utförda i enlighet med EA-4/16:2003.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The uncertainty evaluation was carried out in accordance with EA-4/16:2003.

Length measurement: ± 1.5 %

Not.: Avsteg från punkt 10 i SS-EN 1321 har gjorts. Beteckning har ej redovisats i enlighet med exemplifierade versioner.
Note: Deviation from clause 10 in SS-EN 1321 has been done. Description has not been presented in accordance with exemplified versions.

Signatur/ Signature:

SAFE CONTROL
Johan Ageryd

SIDERINOX

Siderinox S.p.a. Frazione Caselle 20081 Morimondo (MI) Italia
Ufficio Commerciale: Tel. 02 9498151 - Fax 02 949815250/251
Ufficio Amministrativo: Tel. 02 9498161 - Fax 02 949816350
Ufficio Spedizioni: Tel. 02 949816222 - Fax 02 949815350
Ufficio Acquisti : Tel. 02 949816345 - Fax 02 949816350
Casella e-mail: sx@siderinox.it Sito web: www.siderinox.it

Capitale Sociale Euro 3.300.000 i.v.
Cod. Fiscale e Reg. Imp. MI N. 01825510157
R.E.A. Milano N. 878116
Centro Meccanografico n. MI074282
Partita IVA 01825510157

AZIENDA CON SISTEMA
DI GESTIONE QUALITÀ
CERTIFICATO DA DNV GL
=ISO 9001=

INSPECTION CERTIFICATE EN 10204 3.1 N° 424885 of 02.02.2015

Purchaser **INOX STAAL A/S**

DDT	SIDERINOX order number	Customer's order
N 8 of 02.02.2015	N 5 of 22.01.2015	N 15836-1 of 22.01.2015

Product description

Stainless steel round pipe Ø 50,8 x 2 mm AISI 304/304L brushed EN 10217-7 Longitudinally welded

Dimension	Steel type	Quantity (m)	Weight (kg)
50,8 x 2 mm	EN 1.4301/1.4307 / AISI 304/304L	366	815

Production Norm	Rolling	Tolerances	Welding factor
EN 10217-7	Hot rolled	D3 \ T3	V=1

Marking MANUFACTURER'S MARK - DIMENSION - STEELGRADE - HEAT N. - PRODUCTION NORM - EXECUTION - E.C. INSPECTOR - WORK INSPEKTOR

Manufacturing process — Surface finishing W0

CHEMICAL COMPOSITION

Heat	% C	%Mn	%P	% S	%Si	%Cr	% Ni	% Mo	% Ti
	0,000 - 0,030	0,000 - 2,000	0,000 - 0,040	0,000 - 0,010	0,000 - 1,000	17,500 - 19,500	8,000 - 10,000	0,000 - 0,000	0,000 - 0,000
0440628	0,022	1,680	0,027	0,001	0,380	18,240	8,090		

The chemical values refer to the certificate issued by the steel mill according to EN 10088 / 10028-7 / ASTM A 240 and stored at our office.

TEST RESULTS

* (D) Direction: (L) Longitudinal, (T) Transverse - ** (P) Position: (W) Welding, (M) Material

Test unit	Test Class	(D) *	(P) **	TENSILE TEST in Nmm2=MPa				HARDNESS
				Yield Strength		Tensile Strength	Elongation	
				Rp 0,2%	Rp 1%	Rm	A %	HRB
				195 -	230 -	500 - 740	40 -	
T14100996	TC1	L	M	246	330	658	48	
T14100998	TC1	L	M	235	314	627	49	

Visual inspection	OK	Drift expanding test		Sealing test	
		UNI EN ISO 8493	OK	UNI EN ISO 10893-1	OK
Check on dimensions	OK	Flattenning test		Non destructive Eddy Current test	
		UNI EN ISO 8492	OK	UNI EN ISO 10893-2	OK
Antimixing test	OK	Weld bend test		Intergranular corrosion test	
		EN 910	OK	N. P.	N. P.

WE CERTIFY THAT THE MATERIAL SUPPLIED COMPLIES WITH THE REQUIREMENTS AGREED ON THIS ORDER

Remarks:

Cerfications:
UNI EN ISO 9001
Dir. PED 97/23/EC Encl. 1, Point 4.3, Comma 3
AQUAP from Nr. 7293-06-TU to Nr 7298-06-TU

Qualifications:
WPS/WPAR: UNI EN ISO 15609-1/UNI EN ISO 15614-11
WLD: UNI EN ISO 14732 operator
NDT: UNI EN ISO 9712 operator

Document issued by the mill's Inspector
D. Ricco

Document confirmed by the authorized company responsible
W. Amodeo

CERTIFIED MATERIAL REPORT

CMR No. : 1502253500015 Date of Issue : 2015-02-25

Customer	HYUNDAI WELDING EUROPE OFFICE		
Trade Name	SMT-316LSi Inox	Size	1.6mm*1000mm*5kg
Lot No.	V9988	Purchaser's Order No.	
Applicable Specification	AWS A5.9 ER316LSi	* According to EN 10204-2004 : 3.1	

Welding Current		Shielding Gas		Post Weld Heat Treatment (℃ × hr.)	

Mechanical Properties	Tensile Test			Impact Test (CVN - Joule)				
	YS(MPa)	TS(MPa)	EL(%)	Temp.(℃)	X1	X2	X3	Avg.
	-	-	-		-	-	-	-
Spec.								

Chemical Composition (%)

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo		
(WIRE)	0.021	0.97	1.71	0.027	0.011	0.20	11.33	18.30	2.57		
Spec.	≤0.03	0.65 ~1.00	1.0 ~2.5	≤0.03	≤0.03	≤0.75	11.0 ~14.0	18.0 ~20.0	2.0 ~3.0		

We hereby certifies that the material covered by this report has been inspected in accordance with and been found to meet the applicable requirements of specification and customer's requirements.

Approved by

K.W. Park

QA Manager Park K. W.

HYUNDAI HYUNDAI WELDING CO., LTD.
Head Office #507,Teheran-ro,Gangnam-gu,Seoul,Republic of Korea
Pohang Plant #100,Daesong-ro,Nam-gu,Pohang,Republic of Korea

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 P/T FW 5.1 FM3 S t2 D21.3 PH sl

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242580 Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør	
Sømtype Type of joint	FW		FW:Kantsøm	
Materialegruppe(r) Material group(s)	5.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM3		FM1, FM2, FM3	
Type og betegnelse Type and designation Tabel/table 4 Tabel/table 5	 S	DS EN ISO 21952-A W CrMo1 Si	S, M	
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)				
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW				
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4	
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6	
Svejseposition Welding position BW tabel/table 9 FW tabel/table 10	 PH		all FW positions, except vertical dowr	
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)	

Svejseproceduresspecifikations-nr.:
Welding procedure specification No.: SP141-075

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):
13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242580

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s2 D21.3 H-L045 ss gb

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 32584
Welding passport No.:

Svejserens navn: Frederik Faber Jensen
Welder's name:

Fødselsdato: 9-7-1995
Birth date:

Adresse: Firkløvervej 4B, 8830 Tjele
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 242582

Fornyelse/Revalidation ☐

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	T		T:Rør	
Sømtype Type of joint	BW		BW:Stumpsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar	
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	2		2-4	
Materialetykkelse i mm for FW Material thickness in mm for FW				
Rørdiameter i mm Pipe diameter in mm	21.3		21.3-42,6	
Svejseposition Welding position BW tabel/table 9	H-L045		all BW positions, except vertical down	
FW tabel/table 10				
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)	

Svejseprocedurespecifikations-nr.: SP141-199
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 09-06-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):
13-06-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 09-06-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 242582

Prøveemne undersøgt (dato):
Test piece examined (date): 10-06-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 10-06-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 09-06-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 09-06-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 15-06-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
8/12-22	CEO	
6/6-23	CEO	
4/12-23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 P/T FW 8.1 FM5 S t2 D50 PH sl

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec
H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 25350
Welding passport No.:

Svejserens navn: Morten Pedersen
Welder's name:

Fødselsdato: 21-4-1988
Birth date:

Adresse: Bækkevej 6
Address: 9500 Hobro

Prøvningsinstans: Nordisk Svejse Kontrol A/S
Examining body: Stejlundvænget 4 6870 Ølgod

Reference-nr./Reference No. 241393

Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	P/T		P:Plade T:Rør	
Sømtype Type of joint	FW		FW:Kantsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)				
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW				
Materialetykkelse i mm for FW Material thickness in mm for FW	2		2 - 4	
Rørdiameter i mm Pipe diameter in mm	50		>=25	
Svejseposition Welding position BW tabel/table 9			all FW positions, except vertical dowr	
FW tabel/table 10	PH			
Svejsetekniske detaljer og lag Weld details and layer	sl		(sl)	

Svejseprocedurespecifikations-nr.:
Welding procedure specification No.: SP141-123

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED
NSK NB 2735

Svejsning af prøveemne udført/Welding of test piece terminated: 17-03-2022

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift): 18-03-2022 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 17-03-2022 Brian Gravgaard

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 241393

Prøveemne undersøgt (dato):
Test piece examined (date): 18-03-2022

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	-	-	-	Ikke udført
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	ENISO17639	ENISO5817B	-	Godkendt
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 18-03-2022 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 17-03-2022

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 17-03-2025

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 21-03-2022 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	Underskrift/Signature
14/9-22	CEO	
16/3-23	CEO	
11/9-23	CEO	

Bedømmelse af svejsesømme/Evaluation of welds

Prøvningsinstans:
Examining body: Nordisk Svejse Kontrol A/S

Sags-nr.:
Job No.:

Identifikation af prøveemne:
Identification of test piece: 238073

Prøveemne undersøgt (dato):
Test piece examined (date): 29-10-2021

med de anførte metoder i henhold til anførte standarder og acceptkriterier med nedenstående resultater:
with the referred method in accordance to the referred standards and accept criteria with the following results:

Bemærkninger Remarks				
Prøvningsmetode Type of test	Prøvningsstandard Testing standard	Acceptkriterier Acceptance requirements	Modsvarende acceptkriterier Corresponding acceptance criteria	Godkendt/ikke udført Acceptable/not performed
Visuel Visual	ENISO17637	ENISO5817B(C)	-	Godkendt
Radiografi Radiography	ENISO17636	ENISO5817B	ENISO10675-1	Godkendt
Ultralyd Ultrasonic	-	-	-	Ikke udført
Magnetpulver Magnetic particles	-	-	-	Ikke udført
Penetrant Dye penetrant	-	-	-	Ikke udført
Makro Macro	-	-	-	Ikke udført
Brudprøve Fracture	-	-	-	Ikke udført
Bøjeprøve Bend	-	-	-	Ikke udført
Kærvtrækprøvning Notch tensile test	-	-	-	Ikke udført

Prøvningsinstans (dato/underskrift):
Examining body (date/signature): 29-10-2021 Nordisk Svejse Kontrol A/S Gert S Pedersen

Kvalifikation gyldig fra (dato):
Qualification valid from (date): 28-10-2021

Fornyelsesmetode
Revalidation method EN ISO 9606-1, 9.3 a) ☒

Kvalifikation gyldig til (dato):
Qualification valid until (date): 28-10-2024

Svejseskolens eksaminator (dato/underskrift):
Welding coordinator of the welding school (date/signature): 01-11-2021 Brian Gravgaard

Forlængelse/Prolongation

Bekræftelse af gyldigheden ved arbejdsgiver eller virksomhedens svejseansvarlig for de følgende 6 måneder Confirmation of the validity by employer/welding coordinator for the following 6 months		
Dato/Date	Stilling eller titel/Position or title	~~Underskrift~~/Signature
27/4 - 22	CEO	
24/10 - 22	CEO	
28/4 - 23	CEO	
23/10 - 23	CEO	

Certifikat for svejsere i henhold til DS/EN ISO 9606-1:2017

Welders Certificate in accordance with DS/EN ISO 9606-1:2017

Betegnelse i henhold til DS/EN ISO 9606-1:
Designation in accordance with DS/EN ISO 9606-1: 141 T BW 8.1 FM5 S s1.5 D76 H-L045 ss gb

Udført på DS 322-certificeret svejseskole. Navn og adresse:
Performed at DS 322 certified welding school. Name and address: Mercantec, H.C. Andersens Vej 9 8800 Viborg

DS-licens-nr.: 516
DS license No.:

Svejsepas-nr.: 25350
Welding passport No.:

Svejserens navn: Morten Pedersen
Welder's name:

Fødselsdato: 21-4-1988
Birth date:

Adresse: Bækkevej 6, 9500 Hobro
Address:

Prøvningsinstans: Nordisk Svejse Kontrol A/S, Stejlundvænget 4 6870 Ølgod
Examining body:

Reference-nr./Reference No. 238073

Fornyelse/Revalidation ☒

Variabler Variables	Anvendte data Actual data used		Gyldighedsområde Range of approval	
Svejsemetode(r)/Dråbeovergang Welding process(es)/Transfer mode	141		ISO 4063 - 141,142,143,145	
Plade eller rør Plate or pipe	T		P:Plade T:Rør	
Sømtype Type of joint	BW		BW:Stumpsøm	
Materialegruppe(r) Material group(s)	8.1		All materials acc. EN ISO 15608, Table 1	
Tilsatsmateriale Welding consumables	FM5		FM5	
Type og betegnelse Type and designation Tabel/table 4		DS EN ISO 14343-A W 19 9 L Si	S, M	
Tabel/table 5	S			
Beskyttelsesgas Shielding gas	I1	DS/EN ISO 14175	--	
Tilbehør (fx baggas) Auxiliaries (e.g. backing gas)	DS/EN ISO 14175 N5		Same or similar	
Strømtype og polaritet Type of current and polarity	DC-			
Nedsmeltet tykkelse i mm for BW Deposit thickness in mm for BW	1.5		1.5-3,0	
Materialetykkelse i mm for FW Material thickness in mm for FW				
Rørdiameter i mm Pipe diameter in mm	76		>=38	
Svejseposition Welding position BW tabel/table 9	H-L045		all BW positions, except vertical down	
FW tabel/table 10				
Svejsetekniske detaljer og lag Weld details and layer	ss gb		(ss,mb) (bs) (ss,gb)	

Svejseprocedurespecifikations-nr.: SP141-189
Welding procedure specification No.:

Jobkundskab/Job knowledge: Bestået/Accepted ☒ Omprøve/Retest ☐

PED-APPROVED

Svejsning af prøveemne udført/Welding of test piece terminated: 28-10-2021

NSK NB 2735

Den praktiske prøve er gennemført tilfredsstillende og er indstillet til prøvning.
Svejseskolens eksaminator (dato/navn/underskrift):

29-10-2021 Frank Jeppesen

The welder's approval test is accepted and released for testing.
Welding coordinator of the welding school (date/name/signature): 28-10-2021 Brian Gravgaard

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	7/19/2024	First Issue
002	12/1/2025	Updated, naming of components and cerrificates

Document Title:	**BLPH Project - Material Test Certificates**
Document Number:	K559-2254-CWIWP4202202-L01-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-L01-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	L01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Material Test Certificates
Full Title	Material Test Certificates

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	EZE	July 19, 2024
2.0	Update, naming of components	JTA	Dec 01, 2025

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1.0 General

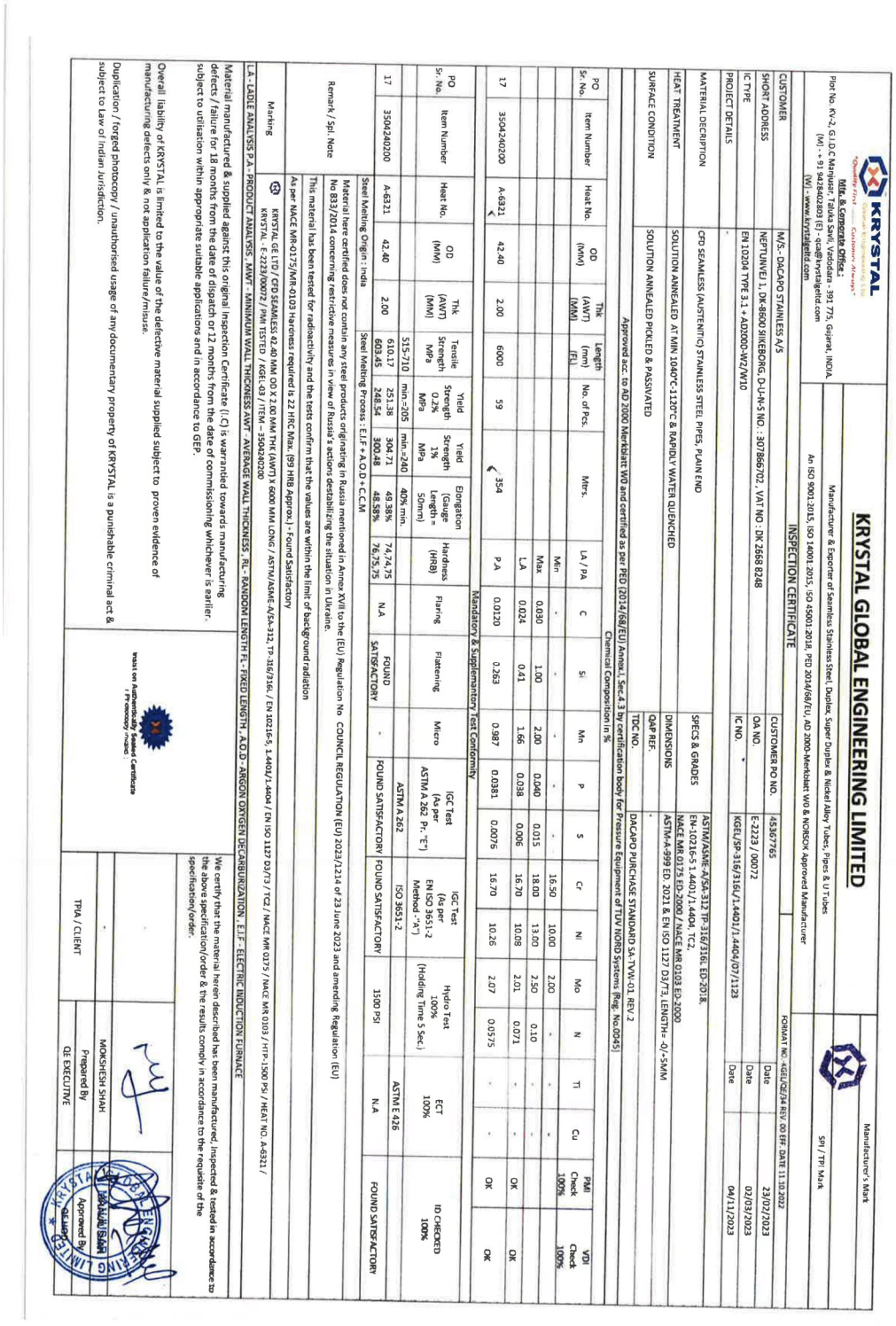
This document contains Material Test Certificates of products supplied to Ballard for the manufacturing of the H2 manifold for 1 MW Fuel Cell Power Container intended for CrossWind.

The Material Test Certificates state the national material specifications that the materials conform to, incl. chemical analysis, specification range analysis mechanical test results, and heat-treated conditions, and are valid for the following products:

- 42.4x2.0 Stainless Steel Cold Finish Seamless Pipes
- 25.0x2.0 Stainless Steel Seamless Pipes
- 42.4 ASME B16.5 Stainless Steel Forged Flanges
- G½ Coupling Stainless
- 42.4x2.0 Stainless Steel End Caps

THIS DOCUMENT IS VALID ONLY AT TIME OF PRINTING.
ANY COPIES MADE ARE CONSIDERED UNCONTROLLED UNLESS STAMPED OTHERWISE IN RED.

1.1 42.4x2.0 Stainless Steel Cold Finish Seamless Pipes



150861

KRYSTAL

Manufacturer & Exporter of Seamless Stainless Steel, Duplex, Super Duplex & Nickel Alloy Tubes, Pipes & U/T-Tubes

An ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, PED 2014/68/EU, AD 2000-Merkblatt W0 & NORSOK Approved Manufacturer

KRYSTAL GLOBAL ENGINEERING LIMITED

Manufacturer's Mark

SPI / TPI Mark

Mfg. & Corporate Office :
Plot No. KV-2, G.I.D.C Manjusar, Taluka Savli, Vadodara - 391 775, Gujarat, INDIA
(M) : - 91 9428402803 (E) - qca@krystalgetd.com
(W) : www.krystalgetd.com

FORMAT NO: KGEL/QE/04 REV. 00 EFF. DATE 11.10.2022

INSPECTION CERTIFICATE

CUSTOMER: M/S.- DACAPO STAINLESS A/S — CUSTOMER PO NO.: 4536765 — Date: 23/02/2023
SHORT ADDRESS: NEPTUNVEJ 1, DK-8600 SILKEBORG, D-U-N-S NO. : 307866702 , VAT NO : DK 2668 8248 — QA NO.: E-2223 / 00072 — Date: 02/03/2023
I.C TYPE: EN 10204 TYPE 3.1 + AD2000-W2/W10 — I.C NO.: KGEL/SP-316/316L/1-4401/1-4404/07/1123 — Date: 04/11/2023
PROJECT DETAILS: -
MATERIAL DESCRIPTION: CFD SEAMLESS (AUSTENITIC) STAINLESS STEEL PIPES, PLAIN END — SPECS & GRADES: ASTM/ASME-A/SA-312 TP-316/316L ED-2018. EN-10216-5 1.4401/1.4404. TC1, NACE MR 0175 ED-2009 / NACE MR 0103 ED-2000
HEAT TREATMENT: SOLUTION ANNEALED AT MIN 1040°C-1120°C & RAPIDLY WATER QUENCHED — DIMENSIONS: ASTM-A-999 ED: 2021 & EN ISO 1127 D3/T3, LENGTH+ -0/+5MM
SURFACE CONDITION: SOLUTION ANNEALED PICKLED & PASSIVATED — Q&P REF.: -
TDC NO.: DACAPO PURCHASE STANDARD SA-TUV-01 REV 2

Approved acc. to AD 2000 Merkblatt W0 and certified as per PED (2014/68/EU) Annex I, Sec.4.3 by certification body for Pressure Equipment of TUV NORD Systems (Reg. No.0045)

Chemical Composition in %

PO Sr. No.	Item Number	Heat No.	OD (MM)	Thk (AWT) (MM)	Length (mm) (FL)	No. of Pcs.	Mtrs.	LA / PA	C	Si	Mn	P	S	Cr	Ni	Mo	N	Ti	Cu	PMI Check 100%	VDI Check 100%
								Min.	-	-	-	-	-	16.50	10.00	2.00	-	-	-		
								Max	0.030	1.00	2.00	0.040	0.015	18.00	13.00	2.50	0.10	-	-		
								LA	0.024	0.41	1.66	0.038	0.006	16.70	10.08	2.01	0.071	-	-	OK	OK
17	3504240200	A-6321	42.40	2.00	6000	59	354	PA	0.0120	0.263	0.987	0.0381	0.0076	16.70	10.26	2.07	0.0575	-	-	OK	OK

Mandatory & Supplementary Test Conformity

PO Sr. No.	Item Number	Heat No.	OD (MM)	Thk (AWT) (MM)	Tensile Strength MPa	Yield Strength 0.2% MPa	Yield Strength 1% MPa	Elongation (Gauge Length – 50mm)	Hardness (HRB)	Flaring	Flattening	Micro	IGC Test (As per ASTM A 262 Pr. "E")	IGC Test (As per EN ISO 3651-2 Method "A")	Hydro Test 100% (Holding Time 5 Sec.)	ECT 100%
					515-710	min-205	min-240	40% min.					ASTM A 262	ISO 3651-2		ASTM E 426
17	3504240200	A-6321	42.40	2.00	610.17 / 603.45	251.38 / 248.54	304.71 / 300.48	49.38% / 48.58%	74,74,75 / 76,75,75	N.A	FOUND SATISFACTORY	-	FOUND SATISFACTORY	FOUND SATISFACTORY	1500 Psi	N.A

Steel Melting Origin : India — Steel Melting Process : E.I.F + A.O.D + C.C.M

Material here certified does not contain any steel products originating in Russia mentioned in Annex XVII to the (EU) Regulation No COUNCIL REGULATION (EU) 2022/1214 of 23 June 2023 and amending Regulation (EU) No 833/2014 concerning restrictive measures in view of Russia's actions destabilizing the situation in Ukraine.

Remark / Spl. Note: This material has been tested for radioactivity and the tests confirm that the values are within the limit of background radiation

As per NACE MR-01/75/MR-0103 Hardness required is 22 HRC Max. (99 HRB Approx.) - Found Satisfactory

Marking: KRYSTAL GE LTD / CFD SEAMLESS 42.40 MM OD X 2.00 MM THK (AWT) X 6000 MM LONG / ASTM/ASME-A/SA-312, TP-316/316L / EN 10216-5, 1.4401/1.4404 / EN ISO 1127 D3/T3 / TC2 / NACE MR 0175 / NACE MR 0103 / HTP-1500 PSI / HEAT NO. A-6321 / KRYSTAL - E-2223/00072 / PMI TESTED / KGEL-03 / ITEM - 3504240200

LA - LADLE ANALYSIS, P.A - PRODUCT ANALYSIS, AWT - MINIMUM WALL THICKNESS, AWT - AVERAGE WALL THICKNESS, RL - RANDOM LENGTH, FL - FIXED LENGTH, A.O.D - ARGON OXYGEN DECARBURIZATION, E.I.F. - ELECTRIC INDUCTION FURNACE

Material manufactured & supplied against this original Inspection Certificate (I.C) is warranted towards manufacturing defects / failure for 18 months from the date of dispatch or 12 months from the date of commissioning whichever is earlier, subject to utilisation within appropriate suitable applications and in accordance to GEP.

Overall liability of KRYSTAL is limited to the value of the defective material supplied subject to proven evidence of manufacturing defects only & not application failure/misuse.

Duplication / forged photocopy / unauthorised usage of any documentary property of KRYSTAL is a punishable criminal act & subject to Law of Indian Jurisdiction.

We certify that the material herein described has been manufactured, inspected & tested in accordance to the above specification/order & the results comply in accordance to the requisite of the specification/order.

TPIA / CLIENT — Prepared By QE EXECUTIVE: MOKSHESH SHAH — Approved By QUALITY CONTROL: MR. ANJU BAAR

KRYSTAL ENGINEERING LIMITED

Inspection Certificate

TA CHEN STAINLESS PIPE CO., LTD.
NO. 125 HSIN-TIEN 2ND ST.,
JENG-TEH, TAINAN, TAIWAN
TEL:(06)2793254 FAX:(06)2701382
COUNTRY ORIGIN:TAIWAN

EN 10204-3.1

Commodity : STAINLESS STEEL WELDED PIPE
Customer : DACAPO STAINLESS B.V.
Specification : ASTM A312/A312M-2022a /ASTM A999-2018
ASME SA312-2021/ASME BPVC.II.A-2021
Destination : ROTTERDAM
Grade : TP316
Customer O/N :31134407 **Certificate No** : XF0200034
Delivery Condition: ANNEALED AND PICKLED
Factory O/N : _____ **Date** : 2023/6/19 **INVOICE No** : HO27XF0200

Item No.	Case No. (Crate No.)	Heat No.	Size		Quantity	Weight	Chemical Composition in %								
					(Pcs)	(Kgs)	C	Si	Mn	P	S	Ni	Cr	Mo	N
01	006	1014299	2-1/2"	SCH40S			0.080	1.000	2.000	0.045	0.030	14.00	18.00	3.000	-
							0.020	0.480	0.917	0.031	0.0012	10.23	16.800	2.063	0.030
02	004	1017422	1"	SCH40S			0.022	0.440	0.940	0.036	0.0057	10.17	16.770	2.100	0.029
03	006	1025545	2"	SCH40S			0.020	0.460	0.990	0.025	0.0009	10.11	16.750	2.040	0.019
04	004	1027133	3/4"	SCH40S			0.009	0.360	0.940	0.032	0.0033	10.06	16.710	2.060	0.021
05	004	1027133	3/4"	SCH40S			0.009	0.360	0.940	0.032	0.0033	10.06	16.710	2.060	0.021
Total															

Item No.	Tensile Test (Gage Lth=50mm)				Hardness	Bend	Flattening	HT TEMP °F	Dimension And	Hydrostatic
	0.2% Yield Strength PSI	1.0% Yield Strength PSI	Tensile Strength PSI	Elongation %	Test HRB	Test	Test	Quenching In Water	Surface Condition	Test PSI
	30000		75000	T25/L35				1900		2500
	-	-	-					-		-
01	43100	-	89000	50	84.00	OK	OK	1904	OK	2100
02	40200	-	88000	51.5	80.00	OK	OK	1904	OK	2500
03	38400	-	84100	55	79.00	OK	OK	1904	OK	1900
04	42800	-	87600	50	80.00	OK	OK	1904	OK	2500
05	42800	-	87600	50	80.00	OK	OK	1904	OK	2500

Remarks
1. EDDY CURRENT TEST : O.K.
2. HARDNESS : MADE WITH ASTM A262
3. P.M.I. TESTED : O.K.
4. LOT MATERIAL ACC. ASTM A262
5. RAW MATERIAL FOR PIPE FITTINGS
6. PED 2014/68/EU

TA CHEN STAINLESS PIPE CO.,LTD. Q/C Dept. NO.125 HSIN-TIEN 2ND STREET, TAINAN, TAIWAN, R.O.C.

We hereby certify the above statement to be true and correct every detail
TA CHEN has established a QMS according to ISO 9001, which is certified by LRQA (ISO 9001-0067066)

George Yang
Manager of Inspection Section/George Yang

Inspection Certificate

TA CHEN STAINLESS PIPE CO., LTD.
NO. 125 HSIN-TIEN 2ND ST.,
JENG-TEH, TAINAN, TAIWAN
TEL:(06)2793254 FAX:(06)2701382
COUNTRY ORIGIN:TAIWAN

EN 10204-3.1

Commodity : STAINLESS STEEL WELDED PIPE
Customer : DACAPO STAINLESS B.V.
Specification : ASTM A312/A312M-2022a /ASTM A999-2018
ASME SA312-2021/ASME BPVC.II.A-2021
Destination : ROTTERDAM
Grade : TP316
Customer O/N :31134407
Certificate No : XF0200035
Delivery Condition: ANNEALED AND PICKLED
Factory O/N :
Date : 2023/6/19
INVOICE No : HO27XF0200

Item No.	Case No. (Crate No.)	Heat No.	Size	Quantity (Pcs)	Weight (Kgs)	Chemical Composition in % C	Si	Mn	P	S	Ni	Cr	Mo	N
06	004	1027136	1" SCH40S		0.080	-	-	-	-	-	10.00	16.00	2.000	-
					0.009	0.420	1.000	2.000	0.045	0.030	14.00	18.00	3.000	-
07	001	1028471	1-1/4" SCH40S		0.016	0.440	0.890	1.110	0.032	0.0033	10.07	16.650	2.070	0.018
08	001	28037601	1/2" SCH40S		0.014	0.350	1.320	0.029	0.029	0.0018	10.08	16.880	2.050	0.021
											10.05	16.110	2.050	-
Total														

Item No.	Tensile Test (Gage Lth=50mm) 0.2% Yield Strength PSI	1.0% Yield Strength PSI	Tensile Strength PSI	Elongation %	Hardness Test HRB	Bend Test	Flattening Test	HT TEMP °F And Quenching In Water	Dimension And Surface Condition	Hydrostatic Test PSI
	30000		75000	T25/L35				1900		2500
	-		-					-		-
06	40300	-	82700	57	82.00	OK	OK	1904	OK	2500
07	41500	-	87100	48.5	78.00	OK	OK	1904	OK	2500
08	34084	-	78610	70	72.00	OK	OK	1904	OK	2500

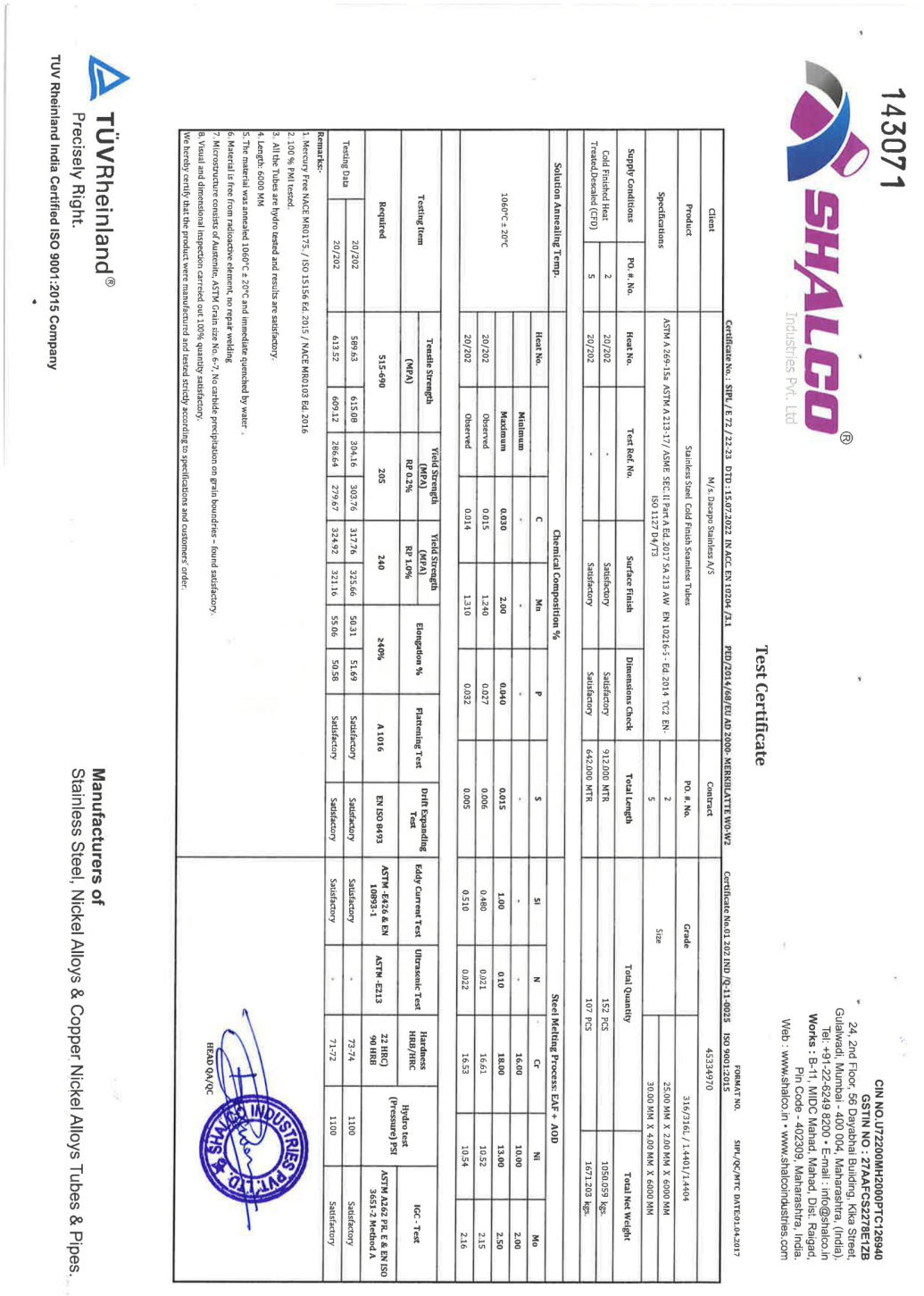
Remarks
1. EDDY CURRENT TEST : O.K.
2. HARDNESS : HRA≤ MRO175-15
3. P. M. I. TESTED : O.K.
4. FLARE TEST ACC. TO ASTM A262
5. RAW MATERIAL FOR PIPE FITTINGS
6. PED 2014/68/EU

TA CHEN STAINLESS PIPE CO. LTD. Q/C Dept. 125 HSIN-TIEN 2ND STREET, TAINAN, TAIWAN, R.O.C.

We hereby certify the above statement to be true and correct every detail
TA CHEN has established a QMS according to ISO 9001, which is certified by LRQA (ISO 9001-0067066)

George Yang
Manager of Inspection Section/George Yang

1.2 25.0x2.0 Stainless Steel Seamless Pipes



143071

SHALCO® Industries Pvt. Ltd

CIN NO.U72200MH2000PTC126940
GSTIN NO : 27AAFCS2278E1ZB
24, 2nd Floor, 56 Dayabhai Building, Kika Street, Gulalwadi, Mumbai - 400 004, Maharashtra, (India).
Tel: +91-22-6249 8200 • E-mail : info@shalco.in
Works : B-11, MIDC Mahad, Mahad, Dist. Raigad, Pin Code - 402309, Maharashtra, India.
Web : www.shalco.in • www.shalcoindustries.com

FORMAT NO. SHPL/QC/MTC DATE:01.04.2017

Test Certificate

Certificate No.: SHPL/E 72 /22-23 DTD :15.07.2022 IN ACC.EN 10204 /3.1 PED/2014/68/EU AD 2000- MERKBLATTE W0-W2 Certificate No.01 202 IND /Q-11-0025 ISO 9001:2015 45334970

Client	M/s. Daraqo Stainless A/S	Contract			
Product	Stainless Steel Cold Finish Seamless Tubes	PO. #. No.	Grade	316/316L / 1.4401/1.4404	
Specifications	ASTM A 269-15a ASTM A 213-17/ ASME SEC. II Part A Ed. 2017 SA 213 AW EN 10216-5 : Ed. 2014 TC2 EN-ISO 1127 D4/T3	2 5	Size	25.00 MM X 2.00 MM X 6000 MM 30.00 MM X 4.00 MM X 6000 MM	

Supply Conditions	PO. #. No.	Heat No.	Test Rel. No.	Surface Finish	Dimensions Check	Total Length	Total Quantity	Total Net Weight
Cold Finished Heat Treated,Descaled (CFD)	2	20/202	-	Satisfactory	Satisfactory	912.000 MTR	152 PCS	1050.059 kgs.
	5	20/202	-	Satisfactory	Satisfactory	642.000 MTR	107 PCS	1671.203 kgs.

Solution Annealing Temp.: 1060°C ± 20°C

Chemical Composition %

Steel Melting Process: EAF + AOD

Heat No.		C	Mn	P	S	Si	N	Cr	Ni	Mo
20/202	Minimum	-	-	-	-	-	-	16.00	10.00	2.00
	Maximum	0.030	2.00	0.040	0.015	1.00	0.10	18.00	13.00	2.50
	Observed	0.015	1.240	0.027	0.006	0.480	0.021	16.61	10.52	2.15
20/202	Observed	0.014	1.310	0.032	0.005	0.510	0.022	16.53	10.54	2.16

Testing Item		Tensile Strength (MPA)	Yield Strength (MPA) RP 0.2%	Yield Strength (MPA) RP 1.0%	Elongation %	Flattening Test	Drift Expanding Test	Eddy Current Test	Ultrasonic Test	Hardness HRB/HRC	Hydro test (Pressure) PSI	IGC - Test
Required		515-690	205	240	≥40%	A 1016	EN ISO 8493	ASTM -E426 & EN 10893-1	ASTM -E213	22 HRC/ 90 HRB		ASTM A262 PR. E & EN ISO 3651-2 Method A
Testing Data	20/202	589.63	615.08	304.16	303.76	317.76	325.66	50.31	51.69	Satisfactory	Satisfactory	-	73.74	1100	Satisfactory
	20/202	613.52	609.12	286.64	279.67	324.92	321.16	55.06	50.58	Satisfactory	Satisfactory	Satisfactory	-	71.72	1100	Satisfactory

Remarks:-
1. Mercury Free NACE MR0175 / ISO 15156 Ed. 2015 / NACE MR0103 Ed. 2016
2. 100 % PMI tested.
3. All the Tubes are hydro tested and results are satisfactory.
4. Length: 6000 MM
5. The material was annealed 1060°C ± 20°C and immediate quenched by water .
6. Material is free from radioactive element, no repair welding
7. Microstructure consists of Austenite, ASTM Grain size No. 6-7, No carbide precipitation on grain boundries - found satisfactory.
8. Visual and dimensional inspection carreied out 100% quantity satisfactory.

We hereby certify that the product were manufactured and tested strictly according to specifications and customers' order.

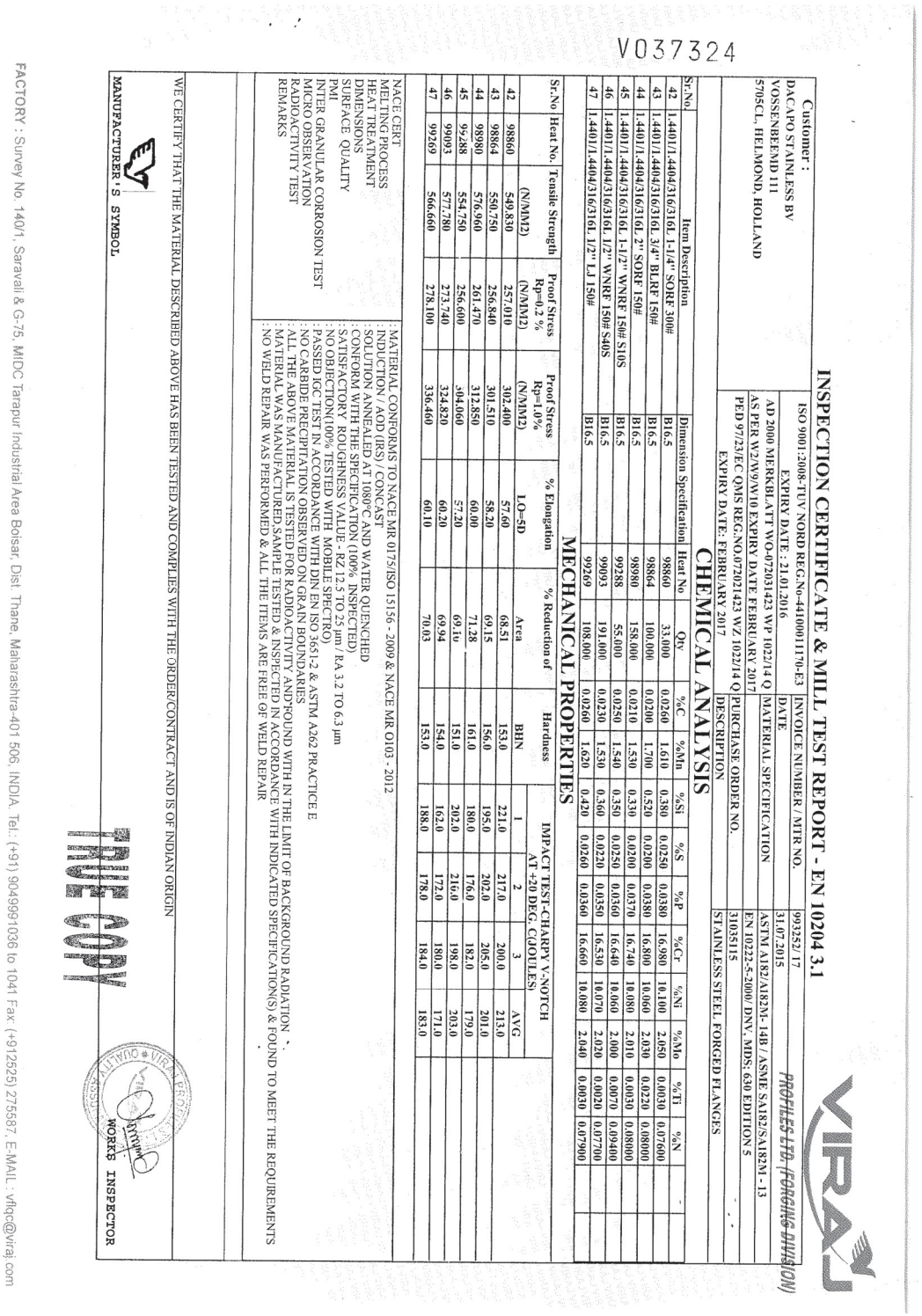
HEAD QA/QC

SHALCO INDUSTRIES PVT. LTD.

TÜVRheinland®
Precisely Right.
TUV Rheinland India Certified ISO 9001:2015 Company

Manufacturers of
Stainless Steel, Nickel Alloys & Copper Nickel Alloys Tubes & Pipes.

1.3 42.4 ASME B16.5 Stainless Steel Forged Flanges



VIRAJ

PROFILES LTD. (FORGING DIVISION)

INSPECTION CERTIFICATE & MILL TEST REPORT - EN 10204 3.1

Customer :
DACAPO STAINLESS BV
VOSSENBEEMD 111
5705CL, HELMOND, HOLLAND

ISO 9001:2008-TUV NORD REG.No-44100011170-E3
EXPIRY DATE : 21.01.2016
AD 2000 MERKBLATT WO-0720314423 WP 1022/14 Q
AS PER W2/W9/W10 EXPIRY DATE FEBRUARY 2017
FED 97/23/EC QMS REG.NO.07202142 WZ 1022/14 Q
EXPIRY DATE: FEBRUARY 2017

INVOICE NUMBER / MTR NO. 993252/ 17
DATE 31.07.2015
MATERIAL SPECIFICATION ASTM A182/A182M- 14B / ASME SA182/SA182M - 13
EN 10222-5-2000/ DNV, MDS: 630 EDITION 5
PURCHASE ORDER NO. 31035115
DESCRIPTION STAINLESS STEEL FORGED FLANGES

V037324

CHEMICAL ANALYSIS

Sr.No	Item Description	Dimension Specification	Heat No.	Qty	%C	%Mn	%Si	%S	%P	%Cr	%Ni	%Mo	%Ti	%N
42	1.4401/1.4404/316/316L 1-1/4" SORF 300#	B16.5	98860	33.000	0.0260	1.610	0.380	0.0250	0.0380	16.980	10.100	2.050	0.0030	0.07600
43	1.4401/1.4404/316/316L 3/4" BLRF 150#	B16.5	98864	100.000	0.0200	1.700	0.520	0.0200	0.0380	16.800	10.060	2.030	0.0220	0.08000
44	1.4401/1.4404/316/316L 2" SORF 150#	B16.5	98980	158.000	0.0210	1.530	0.330	0.0200	0.0370	16.740	10.080	2.010	0.0030	0.08000
45	1.4401/1.4404/316/316L 1-1/2" WNRF 150# S10S	B16.5	99288	55.000	0.0250	1.540	0.350	0.0250	0.0360	16.640	10.060	2.000	0.0070	0.09400
46	1.4401/1.4404/316/316L 1/2" WNRF 150# S40S	B16.5	99093	191.000	0.0230	1.530	0.360	0.0220	0.0350	16.530	10.070	2.020	0.0020	0.07700
47	1.4401/1.4404/316/316L 1/2" LJ 150#	B16.5	99269	108.000	0.0260	1.620	0.420	0.0260	0.0360	16.660	10.080	2.040	0.0030	0.07900

MECHANICAL PROPERTIES

Sr.No	Heat No.	Tensile Strength	Proof Stress Rp=0.2 %	Proof Stress Rp=1.0%	% Elongation	% Reduction of	Hardness	IMPACT TEST-CHARPY V-NOTCH AT +20 DEG. C(JOULES)			
		(N/MM2)	(N/MM2)	(N/MM2)	LO=5D	Area	BHN	1	2	3	AVG
42	98860	549.830	257.010	302.400	57.60	68.51	153.0	221.0	217.0	200.0	213.0
43	98864	550.750	256.840	301.510	58.20	69.15	156.0	195.0	202.0	205.0	201.0
44	98980	576.960	261.470	312.850	60.00	71.28	161.0	180.0	176.0	182.0	179.0
45	99288	554.750	256.600	304.060	57.20	69.16	151.0	202.0	216.0	198.0	203.0
46	99093	577.780	273.740	324.820	60.20	69.94	154.0	162.0	172.0	180.0	171.0
47	99269	566.660	278.100	336.460	60.10	70.03	153.0	188.0	178.0	184.0	183.0

NACE CERT : MATERIAL CONFORMS TO NACE MR 0175/ISO 15156 - 2009 & NACE MR 0103 - 2012
MELTING PROCESS : INDUCTION / AOD (IRS) / CONCAST
HEAT TREATMENT : SOLUTION ANNEALED AT 1080°C AND WATER QUENCHED
DIMENSIONS : CONFORM WITH THE SPECIFICATION (100% INSPECTED)
SURFACE QUALITY : SATISFACTORY ROUGHNESS VALUE - RZ 12.5 TO 25 µm / RA 3.2 TO 6.3 µm
PMI : NO OBJECTION(100% TESTED WITH MOBILE SPECTRO)
INTER GRANULAR CORROSION TEST : PASSED IGC TEST IN ACCORDANCE WITH DIN EN ISO 3651-2 & ASTM A262 PRACTICE E
MICRO OBSERVATION : NO CARBIDE PRECIPITATION OBSERVED ON GRAIN BOUNDARIES
RADIOACTIVITY TEST : ALL THE ABOVE MATERIAL IS TESTED FOR RADIOACTIVITY AND FOUND WITH IN THE LIMIT OF BACKGROUND RADIATION
REMARKS : MATERIAL WAS MANUFACTURED,SAMPLE TESTED & INSPECTED IN ACCORDANCE WITH INDICATED SPECIFICATION(S) & FOUND TO MEET THE REQUIREMENTS
: NO WELD REPAIR WAS PERFORMED & ALL THE ITEMS ARE FREE OF WELD REPAIR

WE CERTIFY THAT THE MATERIAL DESCRIBED ABOVE HAS BEEN TESTED AND COMPLIES WITH THE ORDER/CONTRACT AND IS OF INDIAN ORIGIN

MANUFACTURER'S SYMBOL

TRUE COPY

WORKS INSPECTOR

FACTORY : Survey No. 140/1, Saravali & G-75, MIDC Tarapur Industrial Area Boisar, Dist. Thane, Maharashtra-401 506. INDIA. Tel.: (+91) 9049991036 to 1041 Fax :(+912525) 275587, E-MAIL : vftqc@viraj.com

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1.4 G½ Coupling Stainless Steel

V153121

TA CHEN STAINLESS PIPE CO., LTD.

INSPECTION CERTIFICATE

ISO 9001-2015

Certificate No. 0067066

Commodity : STAINLESS STEEL PIPE NIPPLE

Customer : DACAPO STAINLESS B.V.

EN 10204/3.1

NO.125 HSIN-TIEN 2ND STREET,
HSIN-TIEN JENG-TEH ,TAINAN
TAIWAN, R.O.C.
TEL:+886 6 2701756
FAX:+886 6 2701382 , 2798057

Specification: ASTM A312/A312M 2022a
Grade ____: TP316L

Destination : ROTTERDAM
Customer's O/N : 31134407
Factory O/N : HO27X3741
Invoice No : HO27XF0200

Certificate No : MTR112060059002
Date : 2023/06/19

No.	Size	Article	End Type	Part No.	Qty (pcs)	Heat No.	CHEMICAL ANALYSIS(%) C	Si	Mn	P	S	Ni	Cr	Mo	TENSION TEST Yield Strength MPA	Tensile Strength MPA	Elongation %
							max 0.035	max 1.000	max 2.000	max 0.045	max 0.030	10.00 14.00	16.00 18.00	2.00 3.00	min 170	min 485	min 35
10	1/4"	FULL COUPLING	ISO228-1G	TB03211855	2000	28037601	0.014	0.350	1.320	0.029	0.002	10.05	16.11	2.05	235	542	70
11	1/2"	FULL COUPLING	ISO228-1G	TB03212580	2000	1027133	0.009	0.360	0.940	0.032	0.003	10.06	16.71	2.06	278	594	54
12	1"	FULL COUPLING	ISO228-1G	TB03213590	2100	1028471	0.016	0.440	1.110	0.029	0.004	10.08	16.88	2.05	284	601	50
13	1-1/2"	FULL COUPLING	ISO228-1G	TB03214505	276	1025545	0.020	0.460	0.990	0.025	0.001	10.11	16.75	2.04	265	580	55
14	2"	FULL COUPLING	ISO228-1G	TB03215135	112	1014299	0.020	0.480	0.917	0.031	0.001	10.23	16.80	2.06	286	611	50
15	1/2"	HALF COUPLING	ISO228-1G	TB04212580	2400	1027133	0.009	0.360	0.940	0.032	0.003	10.06	16.71	2.06	278	594	54
16	3/4"	HALF COUPLING	ISO228-1G	TB04213045	64	1017422	0.022	0.440	0.940	0.036	0.006	10.17	16.77	2.10	259	596	54
17	3/4"	HALF COUPLING	ISO228-1G	TB04213045	486	1027136	0.009	0.420	0.890	0.032	0.003	10.07	16.65	2.07	271	598	50.5

REMARK:FULL COUPLINGS(SOCKETS) AND HALF COUPLINGS ARE MADE FROM PIPE.
REMARK:ASTM A262 PRACTICE E:O.K.

TA CHEN STAINLESS PIPE CO., LTD. Q/C Dept. NO.125, HSIN-TIEN 2ND STREET, HSIN-TIEN JENG-TEH, TAINAN, TAIWAN, R.O.C.

Supervisor:

page:2 / 2

1.5 42.4x2.0 Stainless Steel End Caps

V159283

BERCELLESI BERINOX STAINLESS STEEL FITTINGS

Quality Management System certified by LRQA

The QMS supports the requirements of Annex I Sec. 4.3 of PED 2014/68/EU

CERTIFICATO DI COLLAUDO EN 10204 3.1
Inspection certificate
Certificat d'inspection

Num: 22514 / 23 **Data:** 12/12/2023

Cliente Customer Client: DACAPO STAINLESS BV
VOSSENBEEMD 111

5705CL HELMOND -

Specifica prodotto/Product specification/Spécification du produit: EN 10253/4 type A

Pos Item Poste	Qta Qty Qté	Articolo Item Article	Descrizione e dimensione Description and size Désignation et dimension	Grado acciaio Grade Nuance	Colata Heat Coulée
10	250,00		END CAPS 316L 42.4x2	1.4404/316L	0468184
20	100,00		END CAPS 304L 60.3x3	1.4301/304/1.4307/304L	Y210918D41-6
30	100,00		END CAPS 304L 76.1x3	1.4301/304/1.4307/304L	53586
40	50,00		END CAPS 304L 101.6x3	1.4301/304/1.4307/304L	150057
50	30,00		END CAPS 316L 101.6x3	1.4404/316L	22000841
60	500,00		END CAPS 316L 60.3x2	1.4404/316L	0547275

Pos Item Poste	Costruttore materia prima Manufacturer raw material Fabricant matériel de base	Certificato Certificate Certificat	Specifica materia prima Requirement material Spécification matériel de base
10	MARCEGAGLI SPECIALTIES	723284184	EN10028-7 EN10088-2 EN10088-4 ASTM A240 A480
20	PT. INDONESIA GUANG CHING	2021110604	EN10088-2 EN10028-7 EN10088-4 ASTM A240 A480
30	MARCEGAGLI SPECIALTIES	723394949	EN10028-7 EN10088-2 EN10088-4 ASTM A240 A480
40	APERAM GENK BELGIUM	22K0005913	EN10088-2 EN10028-7 ASTM A240 SA240 ADW2 W10
50	LIEN KUO METAL IND. CO.	1091029013	EN10088-2 EN10028-7 ASTM A240 A480
60	MARCEGAGLI SPECIALTIES	723387929	EN10028-7 10088-2 10088-4 ASTM A240 A480 ADW0 W2

Analisi chimica/Chemical composition/Analyse chimique — **Caratteristiche meccaniche/Mechanical properties/Caractéristiques mécaniques**

Colata Heat Coulée	C %	Mn %	Si %	P %	S %	Cr %	Ni %	Mo %	Ti %	Cu%	N%	Snerv. Rp 0,2/1,0 Yield Strength Limite élastique	Rottura Rm Tensile strength Rupture	Allung. A50mm Elongation Allongement	Durezza Hardness Dureté
0468184	0,016	1,100	0,350	0,032	0,00100	16,820	10,080	2,030			0,048	286 / 323 N/mm²	605 N/mm²	53,10	81 HRB
Y210918D41-6	0,022	1,410	0,380	0,029	0,00200	18,130	8,010				0,068	284 /	648 MPa	59,10	86 HRB
53586	0,024	1,300	0,390	0,031	0,00200	18,200	8,000				0,068	320 / 373 N/mm²	640 N/mm²	46,30	84 HRB
150057	0,024	1,510	0,470	0,034	0,00400	18,080	8,010				0,073	298 / 339 MPa	634 MPa	52,00	86 HRB
22000841	0,024	1,210	0,240	0,040	0,00500	16,230	10,050	2,030			0,042	323 /	591 N/mm²	52,00	79 HRB
0547275	0,024	1,090	0,380	0,029	0,00100	16,690	10,030	2,060			0,049	265 / 304 N/mm²	585 N/mm²	56,70	79 HRB

L'analisi chimica e le caratteristiche meccaniche sono conformi al certificato originale rilasciato dal fabbricante di materia prima.
The chemical analysis and mechanical properties fully comply with the certificate issued by the manufacturer of the base material.
L'analyse chimique et les caractéristiques mécaniques sont conformes au certificat émis par le producteur de la matière première.

Doc. di trasporto n. Delivery note n. Bon de livraison n. 62 / d40 **Data** Date Date 07/12/2023 **Ordine n.** Order n. Commande n. 380000477

Si attesta che i prodotti spediti sono conformi ai requisiti dell'ordine.
We certify that delivered products comply with the customer's requirement.
Nous certifions que les produits livrés sont conformes aux spécifications de la commande.

Note / Remarks / Remarques

Test superati con esito positivo:
Test passed successfully / Test passé avec succès

Dimensional	X
Visual	X
Antimixing Test	X
Intergranular Corrosion Test EN ISO 3651-2	X

Test aggiuntivi richiesti nell'ordine:
Additional tests required in order
Tests supplémentaires requis dans la commande

I certificati sono conservati nel nostro archivio.
The certificates are kept in our archives.
Les certificats sont conservés dans nos archives.

Il materiale è conforme alle specifiche di prodotto dichiarate.
The material correspond to the product's specification declared.
Le matériel est conforme aux spécifications du produit declaré.

Per dimensioni diverse alle specifiche è garantita la conformità al ns catalogo.
Size different from the specifications are guaranteed to be in compliance with our catalogue.
Les dimensions différentes de la spécification sont conformes à notre catalogue.

MARCHIO DI FABBRICA:
Trade mark
Marque du producteur

APPROVATO
Approved
Approuvé
P. BERCELLESI

PB

Questo certificato costruito da un processo di trattamento dei dati informatici è applicabile senza firme in originale. La sua emissione attesta che il processo di costruzione e controllo degli articoli in oggetto è stato eseguito conformemente alle prescrizioni del sistema./ This certificate was built from a data processing system and can be applied without an original signature. Its release certifies that the process of construction and inspection of the items mentioned was executed in accordance with the requirements of the system./ Ce certificat a été conçu à partir d'un procédé de traitement des données et peu être diffusé sans signature originale. Son émission certifie que le procédé de construction et d'inspection des articles en question e été mené en conformément aux exigences du système.

BERCELLESI BERINOX SRL - Via per Carpiano, 24 - 20077 Melegnano (Mi) - Tel.(02) 98.23.10.72 ra Fax (02) 98.39.103

Sub Section K02-001

Equipment Hazardous Area Certificates & Schedule

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	23/05/2023	First Issue
002	18/09/2023	Updated according to comments
003	30/08/2024	Updated according to comments
004	15/11/2024	Updated following ATEX Register (K02-002)
005	19/03/2025	Updatad in accordance with Code 2 corrections

Document Title:	**BLPH Project - Equipment Hazardous Area Certificates & Schedule**
Document Number:	BPSE-INN-BPH-CER-00006
Legacy Number:	K559-2254-CWIWP4202202-K02-001
Revision:	Rev005
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K02-001Rev005
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	K02-001 - Equipment Hazardous Area Certificates and Schedule
Full Title	Certificates and documentation of equipment for hazardous area of 1MW hydrogen fuel cell container for Crosswind
Abstract	

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Revision Record

Rev #	Description	Revised By	Date [dd/mm/yyyy]
1.0	Initial Release	RBS	23/05/2023
2.0	Updated to address review comments	EZE	18/09/2023
3.0	Expanded to include components from H2 Pre-heating System	EZE	30/08/2024
4.0	Updated following ATEX Register (K02-002)	RBS	15/11/2024
5.0	Updated following ATEX Register	KHE	18/03/2025

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1.0 Purpose

The purpose of this document is to provide the ATEX certificates of the equipment for hazardous area of the 1MW fuel cell container (MEGABLOCK) provided by Ballard Power Systems Europe to CrossWind.

2.0 References

Table 1 – List of references.

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
K559-2254-CWIWP4202202-K02-002	ATEX Register	Ballard

3.0 List of ATEX Equipment

The ATEX Register lists the following ATEX equipment as shown in the table below. For more details, please refer to the ATEX Register.

Table 2 – List of ATEX equipment (extract from document K559-2254-CWIWP4202202-K02-002).

Location	Manufacturer	Model Type Catalogue Number	Serial Number	ATEX Certification Marking	Reference Document	ATEX Certificate Number	Installation Zone	Notes / Comments	P.O	Vendor	Skid /Package	Barrier Calculation ref.	Non-electrical Equipment	Special Conditions for Safe Use	
=HA01+DA02 - H2 Supply System	IFM Electronic AS	LM701A LMACE-E12E-Q9KG-1/US/3D/3G	10000160523	II 3G Ex nA IIC T4 Gc	K559-2254-CWIWP4202202-C03-001	8003330	Zone 2		8517643	IFM Electronic AS	A-80000	No	No	No	
=HA01+DA02 - H2 Supply System	IFM Electronic AS	EVC14A ADOGH040VAT0025H04/3G/2D	N/A	II 3G Ex ec IIC Gc	K559-2254-CWIWP4202202-E03-003	BVS 08ATEX E 109U	Zone 2		8520141	IFM Electronic AS	A-80000	No	No		
=HA01+DA02 - H2 Supply System	HUBA Controls AG	Pressure Transducer 520 Series	N/A	Ex II 1/2G Ex ia IIC T4 Ga/Gb	K559-2254-CWIWP4202202-C03-001	SEV 10 ATEX 0145	Zone 2		8516809	HUBA Controls AG	A-80000	K559-2254-CWIWP420220	No	No	
=LA01+UC42 - EX Barrier Box	IFM Electronic AS	EN C03A ADOGH040MSN0010H04/1G/1D	N/A	II 2(1) Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=LA01+UC42 - EX Barrier Box	PR Electronics AS	9106-B1B	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA	K559-2254-CWIWP4202202-E03-008	DEKRA 11ATEX0244 X	No Zone		146113-1	PR Electronics AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=HA01+DA02 - H2 Supply System	IFM Electronic AS	TT1050 TT-100KBBD10……/US/	100000113592	N/A	K559-2254-CWIWP4202202-C03-001	N/A	Zone 2	Simple apparatus acc	8516509	IFM Electronic AS	A-80000	K559-2254-CWIWP420220	No	No	
=LA01+UC42 - EX Barrier Box	IFM Electronic AS	EN C03A ADOGH040MSN0010H04/1G/1D	N/A	Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U9	N/A	II (1) G [Ex ia Ga] IIC/IIB/IIA	K559-2254-CWIWP4202202-E03-008	IECEx 07ATEX0148 X	No Zone		8520371	PR Electronics AS	A-80000	K559-2254-CWIWP420220	No	Yes	
=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-1	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements AS	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Lapp Group	OLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No	
=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-2	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements AS	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Lapp Group	OLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No	
=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes	
=HA01+DA02 - Non EX Box	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Non EX Box	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semcomaritime	A-80000	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80001	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	IECEx CML 19.0045X	Zone 2		CD3034021	Semcomaritime	A-80002	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80003	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034021	Semcomaritime	A-80004	No	No	Yes	
=HA01+DA02 - Exterior location, hydroj	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semcomaritime	A-80005	No	No	Yes	

4.0 ATEX Certificates

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4.1 BL01 – Electronic Level Sensor, LMT01A

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ifm electronic

EU – Konformitätserklärung

EU declaration of conformity

Déclaration de conformité UE

ifm electronic gmbh
Friedrichstraße 1
45128 Essen
Germany

Telefon: +49 (0)201 / 24 22 - 0
Telefax: +49 (0)201 / 24 22 - 1200
Internet: www.ifm.com

Die EU-Konformitätserklärung gilt für folgende Geräte:	The EU declaration of conformity applies to the following units:	La déclaration de conformité UE s'applique aux appareils suivants:

Elektronische Füllstandssensoren der Produktfamilie
Electronic level sensors of the product family
Capteurs des niveau électroniques de la famille de produits

LMTxxA

Die alleinige Verantwortung für die Ausstellung dieser Konformitäts-erklärung trägt der Hersteller.	This declaration of conformity is issued under the sole responsibility of the manufacturer.	La présente déclaration de conformité est établie sous la seule responsabilité du fabricant.
Wir bestätigen die Übereinstimmung mit den wesentlichen Anforderungen der europäischen Richtlinie(n):	We confirm the conformity to the essential requirements of the European directive(s):	Nous confirmons la conformité aux exigences essentielles de la (des) directive(s) européenne(s):
2011/65/EU **2014/30/EU** **2014/34/EU**	**2011/65/EU** **2014/30/EU** **2014/34/EU**	**2011/65/UE** **2014/30/UE** **2014/34/UE**
Folgende Norm(en) wurde(n) angewandt:	The following standard(s) was (were) applied:	La (Les) norme(s) suivante(s) a (ont) été appliquée(s):

EN IEC 63000: 2018
EN 61000-6-3: 2007 +A: 2011 + AC: 2012
EN 61000-6-4: 2007 +A1: 2011
EN IEC 61000-6-2: 2019
EN 60079-15: 2010
EN 60079-31: 2014
EN IEC 60079-0: 2018

Kennzeichnung	Marking	Marquage
	Ⓔx II 3D Ex tc IIIC T90°C Dc **Ⓔx II 3G Ex nA IIC T4 Gc**	

Artikel - Nr.: 80304277

Tettnang, 20.07.2021
(Ort und Datum der Ausstellung)
(Place and date of issue)
(Lieu et date de l'établissement)

(Unterschrift) i.V. Alfred Wagner /
(Signature) Head of development
(Signature)

Dokument-Nr.: 8003330

ifm electronic

Declaración UE de conformidad

Dichiarazione di conformità UE

EU – försäkran om överensstämmelse

ifm electronic gmbh
Friedrichstraße 1
45128 Essen
Germany

Telefon: +49 (0)201 / 24 22 - 0
Telefax: +49 (0)201 / 24 22 - 1200
Internet: www.ifm.com

La declaración UE de conformidad se aplica a los siguientes productos:	La dichiarazione di conformità UE si applica ai seguenti dispositivi:	EU-försäkran om överensstämmelse gäller för följande enheter:

Sensores electrónicos de nivel de la gama de productos
Sensori elettronici di livello della serie
Elektroniska nivågivare i produktfamiljen

LMTxxA

La presente declaración de conformidad se expide bajo la exclusiva responsabilidad del fabricante.	La presente dichiarazione di conformità è rilasciata sotto la responsabilità esclusiva del fabbricante.	Tillverkaren har ensam ansvar för utfärdandet av denna försäkran om överensstämmelse.
Certificamos la conformidad con los requisitos esenciales de la(s) directiva(s) europea(s):	Confermiamo la conformità con i requisiti essenziali della(e) direttiva(e) europea(e):	Vi intygar att alla väsentliga krav i den (de) europeiska direktivet (direktiven) är uppfyllda:
2011/65/UE **2014/30/UE** **2014/34/UE**	**2011/65/UE** **2014/30/UE** **2014/34/UE**	**2011/65/EU** **2014/30/EU** **2014/34/EU**
Se ha(n) aplicado la(s) siguiente(s) norma(s):	La(e) seguente(i) norma(e) è(sono) stata(e) applicata(e):	Följande standard(er) tillämpas:

EN IEC 63000: 2018
EN 61000-6-3: 2007 +A: 2011 + AC: 2012
EN 61000-6-4: 2007 +A1: 2011
EN IEC 61000-6-2: 2019
EN 60079-15: 2010
EN 60079-31: 2014
EN IEC 60079-0: 2018

Marcado	Contrassegno	Märkning
	Ⓔx II 3D Ex tc IIIC T90°C Dc Ⓔx II 3G Ex nA IIC T4 Gc	

N° de artículo: 80304277

Tettnang, 20.07.2021
(Lugar y fecha de expedición)
(Luogo e data del rilascio)
(Ort och datum för utfärdande)

(Firma) i.V. Alfred Wagner /
(Firma) Head of development
(Underskrift)

Nº de documento: 8003330

4.2 BL01-WG01 – Connecting Cable with Socket for Level Sensor, EVC14A

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DEKRA

1 # EU-Baumusterprüfbescheinigung

2 **Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014**

3 Nr. der EU-Baumusterprüfbescheinigung: **BVS 08 ATEX E 109 U** Ausgabe: **01**

4 Komponente: **Kabeldosen und -stecker Typ EVC** A**

5 Hersteller: **ifm electronic gmbh**

6 Anschrift: **Friedrichstraße 1, 45128 Essen, Deutschland**

7 Die Bauart dieses Produktes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

8 Die Zertifizierungsstelle der DEKRA Testing and Certification GmbH, benannte Stelle Nr. 0158 gemäß Artikel 17 der Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014, bescheinigt, dass das Produkt die wesentlichen Gesundheits- und Sicherheitsanforderungen für die Konzeption und den Bau von Produkten zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie erfüllt.
Die Ergebnisse der Prüfung sind in dem vertraulichen Prüfprotokoll BVS PP 08.2137 EU niedergelegt.
Diese Ausgabe der EU-Baumusterprüfbescheinigung ersetzt die bisherige Ausgabe der EG-Baumusterprüfbescheinigung BVS 08 ATEX E 109 U inklusive der Nachträge 1 bis 2.

9 Die Einhaltung der Grundlegenden Sicherheits- und Gesundheitsanforderungen wurde überprüft durch Berücksichtigung von:

EN IEC 60079-0:2018	**Allgemeine Anforderungen**
EN IEC 60079-7:2015 + A1:2018	**Erhöhte Sicherheit „e“**
EN 60079-31:2014	**Schutz durch Gehäuse „t“**

10 Das Zeichen „U“ hinter der Zertifikatsnummer weist darauf hin, dass dieses Zertifikat nicht mit Zertifikaten für Geräte oder Schutzsysteme verwechselt werden darf. Diese Teilzertifizierung kann als Grundlage für die Zertifizierung eines Geräts oder Schutzsystems verwendet werden. Die „Einschränkungen für die Verwendung“ ist unter Punkt 17 dieser Bescheinigung aufgeführt.

11 Diese EU-Baumusterprüfbescheinigung bezieht sich nur auf den technischen Entwurf des angegebenen Produkts gemäß der Richtlinie 2014/34/EU.
Weitere Anforderungen der Richtlinie gelten für den Herstellungsprozess und die Bereitstellung dieses Produkts. Diese sind nicht Gegenstand der Zertifizierung.

12 Die Kennzeichnung des Produktes muss die folgenden Angaben enthalten:

Ex **II 2D Ex tb IIIC Db**
II 3G Ex ec IIC Gc

DEKRA Testing and Certification GmbH
Bochum, 17.02.2023

Geschäftsführer

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
Zertifizierungsstelle: Dinnendahlstraße 9, 44809 Bochum
Telefon +49.234.3696-400, Fax +49.234.3696-401, DTC-Certification-body@dekra.com

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13 **Anlage zur**

14 **EU-Baumusterprüfbescheinigung**

BVS 08 ATEX E 109 U Ausgabe 01

15 **Beschreibung des Produktes**

15.1 **Gegenstand und Typ**

Kabeldosen und -stecker Typ EVC**A

** - Kabellänge (0,1 ...100 m)

15.2 **Beschreibung**

Die 90° abgewinkelten M12 Kabeldosen Typ EVC0*A haben 4 Kontakte und ein angespritztes 4-adriges Kabel. Sie sind mit einer Edelstahl-Überwurfmutter versehen, die zur mechanischen Befestigung des Kabels an den Betriebsmitteln verwendet wird. Die Fixierung wird über eine spezielle Befestigungstechnik sichergestellt, die über eine Rasterung ein ungewolltes Lösen der Mutter verhindert. Die Kabeldosen und -stecker Typ EVC**A sind in der Zündschutzart Erhöhte Sicherheit „ec" und Schutz durch Gehäuse „tb" ausgeführt.

Grund für diese Ausgabe

- Umstellung auf die Richtlinie 2014/34/EU
- Aktualisierung der Normen EN IEC 60079-0:2018 und EN 60079-31:2014, sowie Umstellung von EN 60079-15:2010 auf EN IEC 60079-7:2015+A1:2018.

15.3 **Kenngrößen**

Bemessungsspannung		AC/DC 60 V
Stromtragfähigkeit		2 A
Umgebungstemperaturbereich	-	20 °C ≤ T_a ≤ 60 °C
Anzugsdrehmoment der Überwurfmutter		1,2… 1,5 Nm

16 **Prüfprotokoll**

BVS PP 08.2137 EU, Stand 17.02.2023

17 **Einschränkungen für die Verwendung**

Die Kabeldosen und -stecker müssen an ein metallisches Gegenstück angeschlossen werden, das die IP-Anforderungen gemäß EN IEC 60079-7 und EN 60079-31 erfüllt und eine M12-Größe hat.

Die Kabeldosen und -stecker müssen gegen eine Schlagenergie > 4 J geschützt sein.

Die Kabeldosen und -stecker müssen gegen UV-Licht geschützt sein.

Die Kontermutter muss mit einem Anzugsmoment von 1,2...1,5 Nm angezogen werden.

Die Kabel sind fest zu verlegen und gegen mechanische Beschädigungen zu schützen.

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
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DEKRA

18 **Wesentliche Gesundheits- und Sicherheitsanforderungen**

Erfüllt durch Einhaltung der unter Punkt 9 genannten Anforderungen.

19 **Zeichnungen und Unterlagen**

Die Zeichnungen und Unterlagen sind in dem vertraulichen Prüfprotokoll gelistet.

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
Zertifizierungsstelle: Dinnendahlstraße 9, 44809 Bochum
Telefon +49.234.3696-400, Fax +49.234.3696-401, DTC-Certification-body@dekra.com

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Translation

1 # EU-Type Examination Certificate

2 **Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014**

3 EU-Type Examination Certificate Number: **BVS 08 ATEX E 109 U** Issue: **01**

4 Component: **Sockets and plugs type EVC**A**

5 Manufacturer: **ifm electronic gmbh**

6 Address: **Friedrichstraße 1, 45128 Essen, Germany**

7 This product and any acceptable variations thereto are specified in the appendix to this certificate and the documents referred to therein.

8 DEKRA Testing and Certification GmbH, Notified Body number 0158, in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.
The examination and test results are recorded in the confidential Report No. BVS PP 08.2137 EU.
This issue of the EU-Type Examination Certificate replaces the previous issue of the EC-Type Examination Certificate BVS 08 ATEX E 109 U including supplements 1 to 2.

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0:2018	**General requirements**
EN IEC 60079-7:2015 + A1:2018	**Increased Safety "e"**
EN 60079-31:2014	**Protection by Enclosure "t"**

10 The sign "U" placed behind the certificate number indicates that this certificate should not be confounded with certificates issued for equipment or protective systems. This partial certification may be used as a basis for certification of an equipment or protective systems. "Schedule of limitations" is listed under item 17 of this certificate.

11 This EU-Type Examination Certificate relates only to the technical design of the specified product in accordance to the Directive 2014/34/EU. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

12 The marking of the product shall include the following:

II 2D Ex tb IIIC Db
II 3G Ex ec IIIC Gc

DEKRA Testing and Certification GmbH
Bochum, 2023-02-17

Signed: Dr. Rolf Krökel

Managing Director

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DEKRA Testing and Certification GmbH, Handwerkstr. 15, 70565 Stuttgart, Germany
Certification body: Dinnendahlstr. 9, 44809 Bochum, Germany
Phone +49.234.3696-400, Fax +49.234.3696-401, e-mail DTC-Certification-body@dekra.com

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13 **Appendix**

14 **EU-Type Examination Certificate**

BVS 08 ATEX E 109 U issue 01

15 **Product description**

15.1 **Subject and type**

Sockets and plugs type EVC**A

**-length of cable (0.1 ...100 m)

15.2 **Description**

The 90° angled M12 sockets type EVC0*A have 4 pins and a potted 4-wire cable. They are equipped with a stainless steel lock nut to fasten the socket at the equipment. A special fastening technique protects against unintended loosening. The plugs and sockets type EVC**A are built in type of protection Increased Safety “ec” and Protection by Enclosure “tb”.

Reason for this issue

- Change to Directive 2014/34/EU
- The reason of the supplement is the updating to the standards EN IEC 60079-0:2018 and EN 60079-31:2014, as well as change from EN 60079-15:2010 to EN IEC 60079-7:2015+A1:2018.

15.3 **Parameters**

Rated voltage AC/DC	60 V
Current carrying capacity	2 A
Ambient temperature range	-20 °C ≤ T_a ≤ 60 °C
Tightening torque of lock nut	1.2… 1.5 Nm

16 **Report Number**

BVS PP 08.2137 EU, as of 2023-02-17

17 **Schedule of limitations**

The sockets have to be connected to a metallic counterpart which meets the IP requirements according to EN IEC 60079-7 and EN 60079-31 which has a M12 size.

The sockets have to be protected against an impact energy > 4 J.

The sockets have to be protected against UV emitting light.

The lock nut has to be fastened with a tightening torque of 1.2…1.5 Nm.

The cables have to be installed in a fixed manner and have to be protected against mechanical damage.

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18 **Essential Health and Safety Requirements**

Met by compliance with the requirements mentioned in item 9.

19 **Remarks and additional information**

Drawings and documents are listed in the confidential report.

We confirm the correctness of the translation from the German original.
In the case of arbitration only the German wording shall be valid and binding.

DEKRA Testing and Certification GmbH
Bochum, 2023-02-17
BVS-Pz/Mu A 20220792 / 342813900

Managing Director

DEKRA Testing and Certification GmbH, Handwerkstr. 15, 70565 Stuttgart, Germany
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4.3 BP01 – Pressure Sensor, 520 Series

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EU-Type Examination Certificate

(1)

(2) Equipment or protective system intended for use in potentially explosive atmospheres **- Directive 2014/34/EU**

(3) Certificate number: **SEV 10 ATEX 0145**

(4) Product: Pressure transmitter, Types: 520.*, 522.*, 527.*, 528.*

(5) Manufacturer: Huba Control AG

(6) Address: Industriestrasse 17, 5436 Würenlos, Switzerland

(7) The equipment and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) Eurofins, notified body No. 1258, in accordance with article 17 of Directive 2014/34/EU of the European parliament and of the council, dated 26 February 2014, certifies that this product has been found to comply with the essential health and safety requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.
The examination and test results are recorded in confidential report no 21CH-00562.X04

(9) Compliance with the essential health and safety requirements has been assured by compliance with:

EN IEC 60079-0:2018
EN 60079-11:2012
EN 60079-26:2015

Except in respect of those requirements listed at item 18 of the schedule.

(10) If the sign «X» is placed after the certificate number, it indicates that the product is subjected to special conditions for safe use specified in the schedule to this certificate. The sign "U" is placed after the certificate number. It indicates that this certificate must not be mistaken for a certificate intended for an equipment or protective system. This partial certification may be used as a basis for certification of an equipment or protective system.

(11) This EU type examination certificate relates only to design and construction of the specified product. Further requirements of this directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

(12) The marking of the product shall include the following:

II 1/2G Ex ia IIC T4 Ga/Gb
II 1/2D Ex ia IIIC T125 °C Da/Db

Eurofins Electric & Electronic Product Testing AG
Notified Body ATEX

Martin Plüss
Product Certification

www.eurofins.ch Fehraltorf, 2021-12-16 Issue: 4 Page 1 of 2

T8a_V01

eurofins | E&E

(13) # Appendix

(14) **EU-Type Examination Certificate no. SEV 10 ATEX 0145**

(15) **Description of product**

The pressure transmitter is used to measure relative and absolute pressure of gases, liquids and refrigerants (incl. ammonia). The pressure transmitter differ in the pressure measuring cell and the pressure range. For the measuring of the pressure the signal of a pressure measuring cell made of stainless steel (type 520.* / 522.*) or made of ceramic (type 527.* / 528.*) with a membrane is converted into a 4…20 mA output signal by the electronic.
The pressure transmitter can be installed in the partition which separates the area, which requires apparatus of category 1 from the area, which requires apparatus of category 2. The pressure measuring cell may be used only for flammable substances for which the membranes of cells are sufficiently chemically and corrosion resistant.
Effective internal inductance and capacitance for versions with plugs complying with EN 175301-80 A (IP65) or M12x1 (IP67)

Classification of installation and use:	stationary
Ingress protection:	IP65 with connector EN 175301-803A IP67 with connector M12x1
Rated ambient temperature range (°C):	-25 °C ≤ Tamb ≤ +85 °C
Rated medium temperature range (°C):	-30 °C … +120 °C
Rated ambient temperature range (°C) for Ex Components:	N/A

Ratings:
Connection to certified intrinsically safe resistive circuits with maximum values:

Ui ≤ 30 V
Ii ≤ 100 mA
Pi ≤ 750 mW
Ci = 0 nF
Li = 0 µH

Output:
4 … 20 mA

(16) **Report number** 21CH-00562.X04

(17) **"Special conditions for safe use" / "Schedule of limitations"**
None

(18) **Essential health and safety requirements**
In addition to the essential health and safety requirements (EHSRs) covered by the standards listed at item 9, the following are considered relevant to this product, and conformity is demonstrated in the report:

Clause **Subject**
None

(19) **Drawings and Documents**
See test report "Manufacturer's Documents"

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres
for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	**IECEx SEV 16.0007**	Page 1 of 5	Certificate history:
Status:	**Current**	Issue No: 2	Issue 1 (2018-03-12) Issue 0 (2016-05-19)
Date of Issue:	2021-12-16		
Applicant:	**Huba Control AG** Industriestrasse 17 5436 Würenlos **Switzerland**		
Equipment:	**Pressure transmitter Type 520.*, 522.*, 527.*, 528.***		
Optional accessory:			
Type of Protection:	**ia**		
Marking:	Ex ia IIC T4 Ga/Gb Ex ia IIIC T125 °C Da/Db		

SWISS ACCREDITATION sas.admin.ch SCESp 0127

Approved for issue on behalf of the IECEx Certification Body: **Martin Plüss**

Position: **Manager Product Certification**

Signature: (for printed version)

Date: 2021-12-16

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting www.iecex.com or use of this QR Code.

Certificate issued by:

Eurofins Electric & Electronic Product Testing AG
Luppmenstrasse 3
8320 FEHRALTORF .
Switzerland

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IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 2 of 5

Date of issue: 2021-12-16 Issue No: 2

Manufacturer: **Huba Control AG**
Industriestrasse 17
5436 Würenlos
Switzerland

Additional manufacturing locations:

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements.This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-11:2011 Edition:6.0	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"
IEC 60079-26:2014-10 Edition:3.0	Explosive atmospheres – Part 26: Equipment with Equipment Protection Level (EPL) Ga

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Report:

CH/SEV/ExTR16.0008/02

Quality Assessment Report:

CH/SEV/QAR12.0006/06

IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 3 of 5

Date of issue: 2021-12-16 Issue No: 2

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

Pressure transmitter Type 520.*, 522.*, 527.*, 528.*

The pressure transmitter is used to measure relative and absolute pressure of gases, liquids and refrigerants (incl. ammonia). The pressure transmitter differ in the pressure measuring cell and the pressure range. For the measuring of the pressure the signal of a pressure measuring cell made of stainless steel (type 520.* / 522.*) or made of ceramic (type 527.* / 528.*) with a membrane is converted into a 4...20 mA output signal by the electronic.

The pressure transmitter can be installed in the partition which separates the area, which requires apparatus of category 1 from the area, which requires apparatus of category 2. The pressure measuring cell may be used only for flammable substances for which the membranes of cells are sufficiently chemically and corrosion resistant.

Effective internal inductance and capacitance for versions with plugs complying with EN 175301-80 A (IP65) or M12x1 (IP67)

SPECIFIC CONDITIONS OF USE: NO

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IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 4 of 5

Date of issue: 2021-12-16 Issue No: 2

Equipment (continued):

Classification of installation and use ..... : stationary
Ingress protection ..... : IP65 with connector EN 175301-803A
IP67 with connector M12x1
Rated ambient temperature range (°C)..... : -25 °C ≤ Tamb ≤ +85 °C
Rated medium temperature range (°C) ..... : -30 °C ... +120 °C
Rated ambient temperature range (°C) for Ex Components ....: N/A

Rating:
Power Supply:

Connection to certified intrinsically safe resistive circuits with maximum values:

U_i ≤ 30 VDC
I_i ≤ 100 mA
P_i ≤ 0.75 W
L_i = 0 µH
C_i = 0 nF

Output:
4 ... 20 mA

SWISS ACCREDITATION sas.admin.ch SCESp 0008

IECEx Certificate of Conformity

Certificate No.: **IECEx SEV 16.0007** Page 5 of 5

Date of issue: 2021-12-16 Issue No: 2

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above)
All previous addendums have been combined in a new file with current test reports and drawings.

SWISS ACCREDITATION
sas.admin.ch
SCESp 0236

4.4 BP01-WG01 – Connecting Cable with Socket for Pressure Sensor, ENC03A

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DEKRA

EU-Baumusterprüfbescheinigung

Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014

3 Nr. der EU-Baumusterprüfbescheinigung: **BVS 11 ATEX E 009 X** Ausgabe: **01**

4 Gerät: **Steckverbinder Typ ENC**A**

5 Hersteller: **ifm electronic gmbh**

6 Anschrift: **Friedrichstraße 1, 45128 Essen, Deutschland**

7 Die Bauart dieses Produktes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

8 Die Zertifizierungsstelle der DEKRA Testing and Certification GmbH, benannte Stelle Nr. 0158 gemäß Artikel 17 der Richtlinie 2014/34/EU des Europäischen Parlaments und des Rates vom 26. Februar 2014, bescheinigt, dass das Produkt die wesentlichen Gesundheits- und Sicherheitsanforderungen für die Konzeption und den Bau von Produkten zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie erfüllt.
Die Ergebnisse der Prüfung sind in dem vertraulichen Prüfprotokoll BVS PP 11.2018 EU niedergelegt.
Diese Ausgabe der EU-Baumusterprüfbescheinigung ersetzt die bisherige Ausgabe der EG-Baumusterprüfbescheinigung BVS 11 ATEX E 009 X inklusive des Nachtrags 1.

9 Die Einhaltung der Grundlegenden Sicherheits- und Gesundheitsanforderungen wurde überprüft durch Berücksichtigung von:

EN IEC 60079-0:2018	**Allgemeine Anforderungen**
EN 60079-11:2012	**Eigensicherheit „i"**

10 Falls das Zeichen „X" hinter der Bescheinigungsnummer steht, bedeutet dies, dass das Produkt den unter Punkt 17 dieser Bescheinigung aufgeführten „Besondere Bedingungen für die Installation und den Betrieb" unterliegt.

11 Diese EU-Baumusterprüfbescheinigung bezieht sich nur auf den technischen Entwurf des angegebenen Produkts gemäß der Richtlinie 2014/34/EU.
Weitere Anforderungen der Richtlinie gelten für den Herstellungsprozess und die Bereitstellung dieses Produkts. Diese sind nicht Gegenstand der Zertifizierung.

12 Die Kennzeichnung des Produktes muss die folgenden Angaben:

II 1G Ex ia IIB T6 Ga	**II 1G Ex ia IIB T5 Ga**	**II 1D Ex ia IIIC T_{200}70°C Da**
II 2G Ex ia IIC T6 Gb	**II 2G Ex ia IIC T5 Gb**	**for -20 °C ≤ T_a ≤ +60 °C**
II 1D Ex ia IIIB T_{200}85°C Da	**II 1D Ex ia IIIB T_{200}95°C Da**	
for -25 °C ≤ T_a ≤ +75 °C	**for -25 °C ≤ T_a ≤ +85 °C**	

DEKRA Testing and Certification GmbH
Bochum, 06.09.2023

Geschäftsführer

DEKRA Testing and Certification GmbH, Handwerkstraße 15, 70565 Stuttgart
Zertifizierungsstelle: Dinnendahlstraße 9, 44809 Bochum
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13 **Anlage zur**

14 **EU-Baumusterprüfbescheinigung**

BVS 11 ATEX E 009 X Ausgabe 01

15 **Beschreibung des Produktes**

15.1 **Gegenstand und Typ**

Steckverbinder Typ ENC**A

In der vollständigen Bezeichnung werden anstelle der ** Ziffern eingefügt, die Änderungen kennzeichnen wie: Art des Kabels, Länge des Kabels, Konstruktion gerade oder gebogen.

15.2 **Beschreibung**

Der Steckverbinder wird bei eigensicheren Geräten für den Anschluss der eigensicheren Stromkreise verwendet.
Die Steckdose ist ein einfaches elektrisches Betriebsmittel.
Der Steckverbinder hat ein fest angeschlossenes Kabel und ist konstruktionsbedingt in der Lage, zwei verschiedene eigensichere Stromkreise bis zu einer Summe von Spannungen von 30 V zu führen; in diesem Fall muss das Kabel wirksam gegen Beschädigung geschützt werden.

Grund für diese Ausgabe:

- Umstellung auf die Richtlinie 2014/34/EU
- Aktualisierung der Norm EN IEC 60079-0:2018
- Modifikation des Umgebungstemperaturbereichs
- Erweiterung der "Besondere Bedingungen für die Verwendung"

15.3 **Kenngrößen**

Spannung	U_i	DC	30	V
Strom	I_i		1	A
Leistung	P_i			
Für den Einsatz in Gruppe II			1	W
Für den Einsatz in Gruppe III			1	W
Umgebungstemperaturbereich (mit Ausnahme von IIIC)	T_a	-25 °C bis +75 °C / +85 °C		
Für Gruppe IIIC	T_a	-20 °C bis +60 °C		

Für Umgebungstemperaturen bis 75 °C sind die Sensoren als T6 bzw. T_{200} 85 °C klassifiziert (ausgenommen Gruppe IIIC).
Für Umgebungstemperaturen bis 85 °C sind die Sensoren als T5 bzw. T200 95 °C klassifiziert (ausgenommen Gruppe IIIC).

Der Steckverbinder darf zwei verschiedene eigensichere Stromkreise bis zu einer Summe der Spannungen von 30 V führen.

Die Werte der internen Kapazität und Induktivität hängen von der Länge des fest angeschlossenen Kabels ab und werden wie folgt berechnet:

Interne Kapazität	C_i	0,1 nF/m
Interne Induktivität	L_i	2 µH/m

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Zertifizierungsstelle: Dinnendahlstraße 9, 44809 Bochum
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16 **Prüfprotokoll**

BVS PP 11.2018 EU, Stand 06.09.2023

17 **Besondere Bedingungen für die Installation und den Betrieb**

17.1 Die Steckverbinder und das angeschlossene Kabel müssen so installiert werden, dass intensive elektrostatische Aufladung ausgeschlossen ist.

17.2 Aus Platzgründen kann die Kennzeichnung nicht vollständig auf dem Gerät angebracht werden. Die vollständige Kennzeichnung ist der Betriebsanleitung zu entnehmen.

17.3 Das Kabel und der Steckverbinder müssen fest verlegt und wirksam gegen mechanische Beschädigungen geschützt werden.

17.4 Für Gruppe IIIC:

- Der Betrieb des Steckverbinders ohne ein geeignetes M12-Gegenstück ist nicht zulässig. Das M12-Gegenstück muss die IP-Anforderungen nach IEC 60079-11 erfüllen.
- Beim Öffnen des Steckverbinders muss das Eindringen von Staub vermieden werden.
- Der Steckverbinder muss vor UV-Strahlung geschützt werden.
- Die Überwurfmutter muss mit einem Anzugsdrehmoment von 1,2...1,5 Nm angezogen werden.

18 **Wesentliche Gesundheits- und Sicherheitsanforderungen**

Erfüllt durch Einhaltung der unter Punkt 9 genannten Anforderungen.

19 **Zeichnungen und Unterlagen**

Die Zeichnungen und Unterlagen sind in dem vertraulichen Prüfprotokoll gelistet.

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Translation

1 # EU-Type Examination Certificate

2 **Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014**

3 EU-Type Examination Certificate Number: **BVS 11 ATEX E 009 X** Issue: **01**

4 Equipment: **Socket type ENC**A**

5 Manufacturer: **ifm electronic gmbh**

6 Address: **Friedrichstraße 1, 45128 Essen, Germany**

7 This product and any acceptable variations thereto are specified in the appendix to this certificate and the documents referred to therein.

8 DEKRA Testing and Certification GmbH, Notified Body number 0158, in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.
The examination and test results are recorded in the confidential Report No. BVS PP 11.2018 EU.
This issue of the EU-Type Examination Certificate replaces the previous issue of the EC-Type Examination Certificate BVS 11 ATEX E 009 X including supplement 1.

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0:2018	**General requirements**
EN 60079-11:2012	**Intrinsic Safety "i"**

10 If the sign "X" is placed after the certificate number, it indicates that the product is subject to the "Specific Conditions of Use" listed under item 17 of this certificate.

11 This EU-Type Examination Certificate relates only to the technical design of the specified product in accordance with the Directive 2014/34/EU. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

12 The marking of the product shall include the following:

II 1G Ex ia IIB T6 Ga **II 2G Ex ia IIC T6 Gb** **II 1D Ex ia IIIB T_{200}85°C Da** **for -25 °C ≤ T_a ≤ +75 °C**	**II 1G Ex ia IIB T5 Ga** **II 2G Ex ia IIC T5 Gb** **II 1D Ex ia IIIB T_{200}95°C Da** **for -25 °C ≤ T_a ≤ +85 °C**	**II 1D Ex ia IIIC T_{200}70°C Da** **for -20 °C ≤ T_a ≤ +60 °C**

DEKRA Testing and Certification GmbH
Bochum, 2023-09-06

Signed: Oliver Brumm

Managing Director

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13 **Appendix**

14 **EU-Type Examination Certificate**

BVS 11 ATEX E 009 X issue 01

15 **Product description**

15.1 **Subject and type**

Steckverbinder type ENC**A

In the complete denomination instead of the ** numerals will be inserted which characterize modifications as: kind of cable, length of cable, construction straight or bent.

15.2 **Description**

The socket is used as intrinsically safe apparatus for the connection of the intrinsically safe circuits.
The socket is a simple apparatus.
The socket has a permanently connected cable and is due to construction able to carry two different intrinsically safe circuits up to a sum of voltages of 30 V; in this case the cable must be effectively protected against damage.

Reason for this issue:

- Change to Directive 2014/34/EU
- Standards update EN IEC 60079-0:2018
- Modification of the ambient temperature range
- Extension of the "Special conditions for use"

15.3 **Parameters**

Voltage	U_i	DC	30	V
Current	I_i		1	A
Power	P_i			
For use in Group II			1	W
For use in Group III			1	W
Ambient temperature range (except IIIC)	T_a	-25 °C up to +75 °C / +85 °C		
For Group IIIC	T_a	-20 °C up to 60 °C		

For ambient temperatures up to 75 °C, the sensors are classified as T6 resp. T_{200} 85 °C (except Group IIIC).
For ambient temperatures up to 85 °C, the sensors are classified as T5 resp. T_{200} 95 °C (except Group IIIC).

The socket may carry two different intrinsically safe circuits up to a sum of voltages of 30 V.

The values of internal capacitance and inductance depend on the length of the permanently connected cable and be calculated as:

Internal capacitance	C_i	0.1	nF/m
Internal inductance	L_i	2	µH/m

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16 **Report Number**

BVS PP 11.2018 EU, as of 2023-09-06

17 **Specific Conditions of Use**

17.1 The connectors and the connected cable must be installed in a way that an intensive electrostatic charge is excluded.

17.2 Due to space restriction the markings may not be applied completely to the unit. See operating instructions for the compete marking.

17.3 The cable and socket must be installed fixed and effectively protected against mechanical damage.

17.4 For Group IIIC:

- The operation of the sockets without a suitable M12 counterpart is not permissible.
  The M12 counterpart has to meet the IP requirements according to IEC 60079-11.
- When the socket is opened, the ingress of dust must be avoided.
- The sockets have to be protected against UV emitting light.
- The lock nut has to be fastened with a tightening torque of 1.2…1.5 Nm.

18 **Essential Health and Safety Requirements**

Met by compliance with the requirements mentioned in item 9.

19 **Remarks and additional information**

Drawings and documents are listed in the confidential report.

We confirm the correctness of the translation from the German original.
In the case of arbitration only the German wording shall be valid and binding.

DEKRA Testing and Certification GmbH
Bochum, 2023-09-06
BVS-Fro/Mu A 20220779 / 342812500

Managing Director

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4.5 TF01 – Pressure Sensor Ex Barrier, 9106B

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CERTIFICATE

EU-Type Examination

(1)

(2) **Equipment or protective systems intended for use in potentially explosive atmospheres - Directive 2014/34/EU**

(3) EU-Type Examination Certificate Number: **DEKRA 11ATEX0244 X** Issue Number: **4**

(4) Product: **HART-Transparent Repeater, Types 9106B1A, 9106B1B, 9106B2A , 9106B2B and Types 9106A1A, 9106A1B, 9106A2A , 9106A2B**

(5) Manufacturer: **PR electronics A/S**

(6) Address: **Lerbakken 10, 8410 Rønde, Denmark**

(7) This product and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) DEKRA Certification B.V., Notified Body number 0344 in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.

The examination and test results are recorded in confidential test report number NL/DEK/ExTR11.0097/04.

(9) Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0 : 2018 **EN 60079-11 : 2012**

EN 60079-15 : 2019 **EN 60079-7 : 2015 + A1 : 2018**

except in respect of those requirements listed at item 18 of the Schedule.

(10) If the sign "X" is placed after the certificate number, it indicates that the product is subject to the Specific Conditions of Use specified in the schedule to this certificate.

(11) This EU-Type Examination Certificate relates only to the design and construction of the specified product. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

(12) The marking of the product shall include the following:

II (1) G [Ex ia Ga] IIC/IIB/IIA
II (1) D [Ex ia Da] IIIC
I (M1) [Ex ia Ma] I

Date of certification: 23 June 2020

DEKRA Certification B.V.

R. Schuller
Certification Manager

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DEKRA Certification B.V. Meander 1051, 6825 MJ Arnhem P.O. Box 5185, 6802 ED Arnhem The Netherlands
T +31 88 96 83000 F +31 88 96 83100 www.dekra-product-safety.com Registered Arnhem 09085396

DEKRA

(13) **SCHEDULE**

(14) **to EU-Type Examination Certificate DEKRA 11ATEX0244 X** Issue No. **4**

(15) **Description**

HART-Transparent Repeater, Types 9106B1A, 9106B1B, 9106B2A, 9106B2B and Types 9106A1A, 9106A1B, 9106A2A, 9106A2B for rail mounting, are 24 V powered isolating barriers that serve as a repeater.
The repeater transfers the intrinsically safe 4 - 20 mA current signal (with HART communication) of either a loop powered transmitter or an active current source to a non-intrinsically safe 4 - 20 mA output signal (with HART communication).
The Repeater is supplied via terminals at the front of the module, or via Power Rail Type 9400.
Removable display module 4501 can be used for programming of the Repeater.

The HART-Transparent Repeater, Types 9106B*A, 9106A*A are one channel version and Types 9106B*B, 9106A*B are two channel version.

Ambient temperature range -20 °C to +60 °C.

Marking

The equipment marking may additionally include the code II 3 G Ex ec nC IIC T4 Gc.

Electrical data

All Repeater Types

Supply (terminals 31, 32 and rear contacts): U = 19,2 ... 31,2 Vdc.

Status-Relay output (terminals 33, 34):
U ≤ 32 Vac or 32 Vdc, I ≤ 0,5 Aac or I ≤ 1 Adc respectively.
If the Repeater is installed outside the hazardous area, the following data for the relay contacts apply: U ≤ 110 Vdc or 125 Vac, I ≤ 0,3 Adc or I ≤ 0,5 Aac respectively.

Outputs (terminals 11, 12 resp. 13, 14): I = 4 ... 20 mA.

For all circuits above: U_m = 253 Vac (max. frequency 400 Hz).

Repeater Types 9106B1A, 9106B1B, 9106B2A, 9106B2B

Loop current input (terminals 43, 44 resp. terminals 53, 54):
in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, with following maximum values:
for Type 9106B1A and Type 9106B1B:
U_o = 27,5 V; I_o = 92,6 mA; P_o = 0,64 W;
C_o = 0,084 µF (IIC) or 0,67 µF (IIB) or 2,23 µF (IIA) or 3,94 µF (I) ;
L_o = 4,15 mH (IIC) or 16,59 mH (IIB) or 33,17 mH (IIA) or 54,42 mH (I);
L_o/R_o = 223 µH/Ω (IIB) or 447 µH/Ω (IIA) or 733 µH/Ω (I)

for Type 9106B2A and Type 9106B2B:
U_o = 25,3 V; I_o = 96 mA; P_o = 0,61 W;
C_o = 0,104 µF (IIC) or 0,818 µF (IIB) or 2,85 µF (IIA) or 4,74 µF (I);
L_o = 3,86 mH (IIC) or 15,43 mH (IIB) or 30,86 mH (IIA) or 50,64 mH (I).
L_o/R_o = 234 µH/Ω (IIB) or 468 µH/Ω (IIA) or 769 µH/Ω (I)
For group IIIC, the parameters of group IIB apply.

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DEKRA

(13) **SCHEDULE**

(14) **to EU-Type Examination Certificate DEKRA 11ATEX0244 X** Issue No. **4**

Current input (terminals 41, 42 resp. terminals 51, 52):
in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, for connection to a certified intrinsically safe circuit, with following maximum values:
U_i = 30 V; I_i = 120 mA; P_i = 0,85 W; $_{Ci}$ = 2 nF; L_i = 0 µH;
U_o = 0 V; I_o = 0 mA; P_o = 0 mW.

Current input and Loop current input of one channel are not applied simultaneously.

Both channels (terminals 41...44 and terminals 51...54) are infallibly galvanically isolated from each other and from the non-intrinsically safe supply and output circuits

Combination of Loop current input of channel 1 (terminals 43, 44) and Current input of channel 2 (terminals 51, 52) in series, where terminal 43 is connected to terminal 51:
Loop current circuit (terminals 44 and 52) is in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, with following maximum values:
for Type 9106B1A and Type 9106B1B:
U_o = 27,5 V; I_o = 92,6 mA; P_o = 0,64 W;
C_o = 0,084 µF (IIC) or 0,67 µF (IIB) or 2,23 µF (IIA) or 3,94 µF (I) ;
L_o = 4,15 mH (IIC) or 16,59 mH (IIB) or 33,17 mH (IIA) or 54,42 mH (I);
L_o/R_o = 223 µH/Ω (IIB) or 447 µH/Ω (IIA) or 733 µH/Ω (I)

for Type 9106B2A and Type 9106B2B:
U_o = 25,3 V; I_o = 96 mA; P_o = 0,61 W;
C_o = 0,104 µF (IIC) or 0,818 µF (IIB) or 2,85 µF (IIA) or 4,74 µF (I);
L_o = 3,86 mH (IIC) or 15,43 mH (IIB) or 30,86 mH (IIA) or 50,64 mH (I).
L_o/R_o = 234 µH/Ω (IIB) or 468 µH/Ω (IIA) or 769 µH/Ω (I)
For group IIIC, the parameters of group IIB apply.

Combination of both Current inputs (terminals 41, 42 resp. 51, 52) in series, where terminal 41 is connected to terminal 52:
Current input (terminals 42 and 51) is in type of protection intrinsic safety Ex ia IIC/IIB/IIA/IIIC/I, for connection to a certified intrinsically safe circuit, with following maximum values:
U_i = 30 V; Ii = 120 mA; Pi = 0,85 W; C_i = 4 nF; L_i = 0 µH;
U_o = 0 V; I_o = 0 mA; P_o = 0 mW.

Installation instructions

The instructions provided with the product shall be followed in detail to assure safe operation.

(16) **Report Number**

No. NL/DEK/ExTR11.0097/04.

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DEKRA

(13) **SCHEDULE**

(14) **to EU-Type Examination Certificate DEKRA 11ATEX0244 X** Issue No. **4**

(17) **Specific conditions of use**

The HART Transparent Repeater shall be installed in a controlled environment with suitably reduced pollution, limited to pollution degree 2 or better.

The non intrinsically safe circuits shall be limited to overvoltage category I/II as defined in EN 60664-1.

If the HART-Transparent Repeater is installed in an explosive atmosphere where the use of apparatus of equipment category 3 G is required, the following specific conditions of use apply:

The HART Transparent Repeater shall be installed in an enclosure in type of protection Ex n or Ex e, providing a degree of protection of at least IP54. Cable entry devices and blanking elements shall fulfil the same requirements.

Removable Display Module 4501, when connected to the Repeater, may not be damaged and shall be free of dust and moisture.

(18) **Essential Health and Safety Requirements**

Covered by the standards listed at item (9)

(19) **Test documentation**

As listed in Report No. NL/DEK/ExTR11.0097/04.

(20) **Certificate history**

Issue 1 -	214940700	initial certificate
Issue 2 -	215635200	changes to the construction and standards update
Issue 3 -	219950900	changes to the electrical data
Issue 4 -	224396500	assesed per latest edition of the standards addition of 9106Axx models

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Form 227A
Version 1 (2016-04)

4.6 BT01 – Temperature Sensor, TT1050

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ifm electronic

EU – Konformitätserklärung

EU declaration of conformity

Déclaration de conformité UE

ifm electronic gmbh
Friedrichstraße 1
45128 Essen
Germany

Telefon: +49 (0)201 / 24 22 - 0
Telefax: +49 (0)201 / 24 22 - 1200
Internet: www.ifm.com

Die EU-Konformitätserklärung gilt für folgende Geräte:	The EU declaration of conformity applies to the following units:	La déclaration de conformité UE s'applique aux appareils suivants:

Temperatursensoren der Produktfamilie
Temperature sensors of the product family
Capteurs de température de la famille de produits

TTxxxx/ TMxxxx/ TSxxxx/ TXxx81/ TX4511/ TX9920/ TY9159

Wir bestätigen die Übereinstimmung mit den grundlegenden Anforderungen der europäischen Richtlinie(n):	We confirm the conformity to the essential requirements of the European directive(s):	Nous confirmons la conformité aux exigences essentielles de la (des) directive(s) européenne(s):
2011/65/EU	**2011/65/EU**	**2011/65/UE**

Folgende Norm(en) wurde(n) angewandt:	The following standard(s) was (were) applied:	La (Les) norme(s) suivante(s) a (ont) été appliquée(s):

EN IEC 63000: 2018

Malvern, July 22nd , 2021
(Ort und Datum der Ausstellung)
(Place and date of issue)
(Lieu et date de l'établissement)

(Unterschrift) i.V. Peter Breh
(Signature) Director of Technology
(Signature)

Dokument-Nr.: 8003349

4.7 BT02-WG01 – Connecting Cable with Socket for Temperature Sensor, ENC03A

[Please refer to certificate from Section 4.4.]

4.8 TF01 – Temperature Sensor Ex Barrier, 9113B-U9

[Please refer to certificate from Section 4.5.]

4.9 EA01..02 – Immersion Heater, D-8640

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ISSeP
Institut scientifique de service public
Métrologie environnementale
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site web :
http://www.issep.be

(1) EC TYPE EXAMINATION CERTIFICATE

(2) **Equipment or protective system intended for use in potentially explosive atmospheres**
Directive 94/9/EC

(3) EC type examination certificate number: **ISSeP08ATEX008X**

(4) Equipment or protective system: housing for electrical heating apparatus
Type: D-8640

(5) Applicant – Manufacturer :
Sinus Jevi Electric Heating B.V.

(6) Address: Nijverheidsweg 2
1671 GC Medemblik

(7) This equipment or protective system and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) ISSeP, notified body n^{r} 492 in accordance with article 9 of the Council Directive 94/9/EC of 23 March 1994, certifies that this equipment or protective system has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective systems intended for use in potentially explosive atmospheres given in annex II to the Directive.

The examination and test results are recorded in confidential report no 06090

(9) Compliance with the Essential Health and Safety Requirements has been assured by compliance with:
EN 60079-0: 2006 (IEC 60079-0: 2004) EN 60079-1: 2007 (IEC 60079-1: 2007)
EN 60079-7: 2007 (IEC 60079-7:2006)
EN 61241-0: 2006 (IEC 61241-0: 2004) EN 61241-1: 2004 (IEC 61241-1: 2004)

(10) If the symbol "X" is placed after the certificate number, it indicates that the equipment or protective system is subject to special conditions for safe use specified in the schedule to this certificate

(11) This EC TYPE EXAMINATION CERTIFICATE relates only to the design, examination and tests of the specified equipment or protective system in accordance to the Directive 94/9/EC. Further requirements of this Directive may apply to the manufacturing process and supply of this equipment or protective system. These are not covered by this certificate.

(12) The marking of the equipment or protective system shall include the following indications:
Ex II 2 G D Ex de IIC T6 to T1 Ex tD A21 IP66 T110°C

Colfontaine, the 07.03.2008

INSTITUT SCIENTIFIQUE DE SERVICE PUBLIC
Zoning A. Schweitzer - B7340 Colfontaine (Wasmes)
Tél: ++ 32 65 610811 – Fax: ++ 32 65 610808

Marcel Lambert,
Manager.

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RÉGION WALLONNE

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(13) SCHEDULE

(14) **EC TYPE EXAMINATION CERTIFICATE No ISSeP08ATEX008X**

(15) Description of the equipment :
Electrical heating apparatus allotted to the heating of inert liquids and gases. This apparatus bears the type designation D-8640 and consists of:

- a certified flameproof connection box
- certified electrical heating elements
- a manually rearmed protective device

The length "H" (to see drawing 953.D8640-01) required to not exceed the temperature limit of 80°C inside the connection box in accordance with the different temperature classes is listed in the here-below table

Temperature class	Length "H" (mm)
T6	50
T5	75
T4	100
T3	150
T2	200
T1	250

Remark :
When the heating elements are fitted on the bottom plate of the housing, the temperature is limited by a safety thermostat and an additional marking is foreseen for the cables (to see drawing 953.D8521-04)

Temperature classes

TEMPERATURE CLASS	TEMPERATURE SETTING OF THE THERMOSTAT (°C)					
	Inert liquids	Gases				
	Power dissipated by the heating element (W/cm^2)	Power dissipated by the heating element (W/cm^2)				
	7,5	2	1,5	1	0,5	0,2
T6	90	-----	-----	-----	-----	-----
T5	110	-----	-----	-----	-----	65
T4	145	-----	-----	-----	70	85
T3	210	-----	-----	90	110	130
T2	310	130	135	150	190	250
T1	-------	230	250	300	-----	-----

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SCHEDULE

EC TYPE EXAMINATION CERTIFICATE No ISSeP08ATEX008X

Electrical parameters
Voltage supply: 110 up to 690 V
Eventual prescriptions
The ambient temperature range: -30 °C to + 50°C
Routine tests
The manufacturer shall make the routine verifications and tests to ensure that the electrical apparatus produced complies with the specification submitted to the testing station together with the prototype.
Each empty enclosure shall be submitted to a routine test under the pressure of 10.5 bar maintained during at least 10 seconds (maximum 60 seconds)

(16) Report n° 06090 of 5.03.2008 composed of 29 pages
The descriptive and technical note from the manufacturer dated of 25.05.2007 related to heating apparatus – size 6" (6 and 3 pages)
The additional descriptive note dated 1.08.2007 (2 pages)
The notices of instruction (8 pages)
A data sheet related to the sealing gasket dated 1.09.2006
The drawings
953.D6150-10 of 19.11.2002 Rev.1 of 28.01.2008
953.D8521-04 of 14.08.2006
953.D8615-20 of 18.02.2008
953.D8640-01 of 29.08.2002
953.D8640-03 of 9.12.2002
953.D8640-05 of 10.01.2005
953.D8640-11 of 11.05.2000
953.D8640-12 of 24.10.2000 – Rev.1 of 21.01.2008
953.D8640-13 of 20.05.2005
953.D8640-20 of 8.12.2003
953.D8640-22 of 7.05.2007 – Rev.1 of 18.02.2008
953.D8640-23 of 7.05.2007 – Rev.1 of 18.02.2008

(17) Special conditions for safe use: symbol X
- The layer of dust accumulated on the housing shall not exceed 5 mm.
- The ignition temperature of the dust shall be higher than 185°C
- The setting of the protective device to the limit temperature ensuring the temperature class shall be realised for each apparatus under the responsibility of the manufacturer. Furthermore this device shall be sealed and its setting shall not be modified later.
- The temperature sensor of the protective device shall be placed as nearest as possible to the tube containing the heating elements.
- When the apparatus is energised the tube containing the heating elements shall be completely immersed in the liquid – the depth of immersion above the tube is at least 50 mm.
- The values of the power dissipated by the heating elements mentioned in the table (page 2) cannot be exceeded

(18) Essential Health and Safety Requirements: covered by the standards listed at 9 and by the descriptive documents of the manufacturer

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VARIATION

EC TYPE EXAMINATION CERTIFICATE N° ISSeP08ATEX008X/1

(14) Equipment: housing for electrical heating apparatus type D-8640

(15) Subject to the variation:
To allow the manufacturing of this equipment under the name of the mother company JEVI A/S located at Godthaabsvej 7 – 7100 Vejle – Denmark

Marking : Unchanged except the addition of the name and address of the mother company

Eventual Prescriptions :
Ambient temperature range: -30°C ≤ Tamb ≤ +50°C

(16) Report n°09103 of 5.10.2009 (5 pages) completed by the descriptive documents below:
The drawings
953.D8615-11 of 10.09.2009
953.D8640-22 of 7.05.2007 – Rev.2 of 2.10.2009
953.D8640-23 of 7.05.2007 – Rev.2 of 2.10.2009

(17) Special conditions for safe use: unchanged

(18) Essential Health and Safety Requirements: covered by the standards listed at point 9 of the initial certificate and by the descriptive documents of the manufacturer.

Colfontaine, 07.10.2009

Marcel Lambert,
Manager.

INSTITUT SCIENTIFIQUE DE SERVICE PUBLIC
Zoning A. Schweitzer - B 7340 Colfontaine (Wasmes)
Tél: ++ 32 65 610811 – Fax: ++ 32 65 610808

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VARIATION

EC TYPE EXAMINATION CERTIFICATE N° ISSeP08ATEX008X/2

(14) Apparatus: Housing for electrical heating apparatus type D-8640.

(15) Subject of the variation

- To permit the extension of the ambient temperature range. This one becomes: -50 °C ≤ Ta ≤ +50 °C.
- To permit the updating of the certificate according to the latest edition of the standards in force. (IEC 60079-0: 2011 – EN 60079-1: 2007 – EN 60079-7: 2007 – EN 60079-31: 2009)

Marking: Unchanged, except the code « Ex de IIC T6 to T1 / Ex tD A21 IP66 T110°C » which is now « Ex d IIC T6…T1 Gb / Ex tb IIIC T110°C Db ».

Eventual prescriptions: Unchanged.

(16) Report N° 12032 completed by 10 documents.

(17) Special conditions for safe use: Unchanged.

(18) Essential Health and Safety Requirements

- Covered by the standards listed at point 9 of the initial certificate.

Colfontaine, 27.08.2012.

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Marcel LAMBERT,
Director.

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4.10 EA01-WD01 and EA02-WD01 – Control Cable for Immersion Heater, CLASSIC 135 CH

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LAPP

LEISTUNGSERKLÄRUNG
Gemäß Anhang III der Verordnung (EU) Nr. 305/2011

Declaration of Performance
According to Annex III of Regulation (EU) no. 305/2011

Dokument-Nr.
Document-no.

UILCPRDoP17_1123460-1_C

1. Eindeutiger Kenncode des Produkttyps
Unique identification code of the product type

OELFLEX_CLASSIC_135_CH_BK-1

2. Verwendungszweck
Usage
Kabel und Leitungen für allgemeine Anwendungen in Bauwerken in Bezug auf die Anforderungen an das Brandverhalten
Cables for general applications in construction works subject to reaction to fire requirements

3. Hersteller
Manufacturer

U.I. Lapp GmbH
Schulze-Delitzsch-Straße 25
D-70565 Stuttgart

4. System zur Bewertung und Überprüfung der Leistungsbeständigkeit
System of assessment and verification of constancy of performance

System 3

5. Harmonisierte Norm
Harmonised standard

EN 50575:2014 + A1:2016

6. Produktzertifizierungsstelle
Product certification body

No. 0366

7. Erklärte Leistung
Declared Performance

Wesentliche Merkmale *Essential characteristics*	Leistung *Performance*	Harmonisierte technische Spezifikation *Harmonized technical standard*
Brandverhalten *Reaction to fire*	**Dca-s3-d2-a3**	**EN 50575:2014 + A1:2016**
Gefährliche Stoffe *Hazardous substances*	**NPD**	

8. Die Leistung des in Nummer 1 genannten Produkts ist in Übereinstimmung mit der erklärten Leistung in Punkt 7.
The performance of the referred product in paragraphs 1 is in conformity with the declared performance in Section 7.

Diese Leistungserklärung ist ausgestellt unter der allgemeinen Verantwortung des unter Punkt 3 genannten Herstellers.
This declaration of performance is issued under the general responsibilities listed in section 3. Manufacturer.

Unterzeichnet für und im Namen des Herstellers von:
Signed for and in name of the manufacturer by:

Stuttgart, 12.05.2021
U.I.Lapp GmbH
Leiter Kabelentwicklung
Head of Cable Development

i.V. Alexander Terpe

U.I. Lapp GmbH
Schulze-Delitzsch-Straße 25
70565 Stuttgart
Tel.: +49 (0)7 11/78 38-01
Fax: +49 (0)7 11/78 38-26 40
E-Mail: info@lappkabel.de
www.lappkabel.de

Registergericht
Stuttgart HRB 12720

Geschäftsführer
Matthias Lapp, Dr. Matthias Kirchherr,
Boris Katic, Lutz Grotebrune

Vorsitzende des Aufsichtsrats
Andreas Lapp

Niederlassung
Hannover

Ein Unternehmen der Lapp Gruppe

Lapp Insulator ist kein
Unternehmen der Lapp Gruppe

FM PD 0802/02_04.21

Seite 1 von 1

4.11 EA01..02 – Cable Gland for Immersion Heater, ICG 653 UNIV Os M20

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	**IECEx CML 18.0131X**	Page 1 of 4	Certificate history:
Status:	**Current**	Issue No: 4	Issue 3 (2021-09-29) Issue 2 (2020-04-20) Issue 1 (2020-02-11) Issue 0 (2019-05-10)
Date of Issue:	2024-03-26		

Applicant: **Hawke International (A Division of Hubbell Limited) (A Member of the Hubbell group of companies)**
Oxford Street West
Ashton under Lyne
OL7 0NA
United Kingdom

Equipment: **Ranges of Barrier and Diaphragm Seal Hybrid Cable Glands**

Optional accessory:

Type of Protection: **Flameproof "db", Increased Safety "eb", Restricted Breathing "nR", Dust Ignition "tb"**

Marking: Ex db IIC Gb
Ex eb IIC Gb
Ex tb IIIC Db

-60°C to +80°C

Approved for issue on behalf of the IECEx Certification Body: **H M Amos**

Position: **Technical Specialist**

Signature: (for printed version)

Date: (for printed version) March, 26, 2024

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2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting www.iecex.com or use of this QR Code.

Certificate issued by:

Eurofins E&E CML Limited
Unit 1, Newport Business Park
New Port Road
Ellesmere Port, CH65 4LZ
United Kingdom

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 18.0131X** Page 2 of 4

Date of issue: 2024-03-26 Issue No: 4

Manufacturer: **Hawke International (A Division of Hubbell Limited) (A Member of the Hubbell group of companies)**
Oxford Street West
Ashton under Lyne
OL7 0NA
United Kingdom

Manufacturing locations:

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements.This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-1:2014 Edition:7.0	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
IEC 60079-31:2013 Edition:2	Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t"
IEC 60079-7:2017 Edition:5.1	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Reports:

GB/CML/ExTR18.0186/00
GB/CML/ExTR19.0255/00
GB/CML/ExTR20.0050/00
GB/CML/ExTR21.0018/00
GB/CML/ExTR23.0028/00

Quality Assessment Report:

GB/BAS/QAR06.0061/10

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 18.0131X** Page 3 of 4

Date of issue: 2024-03-26 Issue No: 4

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

Refer to Annex for full description and conditions of manufacture.

SPECIFIC CONDITIONS OF USE: YES as shown below:
Refer to Annex for specific conditions of use.

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 18.0131X** Page 4 of 4

Date of issue: 2024-03-26 Issue No: 4

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above)
Refer to certificate annex for details of changes.

Annex:

Certificate Annex IECEx CML 18.0131X Issue 4.pdf

eurofins cml

Annexe to:	IECEx CML 18.0131X Issue 4
Applicant:	Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of companies)
Apparatus:	Ranges of Barrier and Diaphragm Seal Hybrid Cable Glands

Description

The ranges of cable glands are designed in two versions: barrier and diaphragm seal. Hybrid configurations of these glands are also described.

All cable glands within the ranges are manufactured in brass, nickel plated brass, stainless steel, or aluminium.

Both barrier and diaphragm seal type glands internal parts marked with an asterisk (*) in the description below are interchangeable with respect to the type of application. When parts are interchanged, these assemblies may be dual marked with both product types on the stamp band. The "Deluge Boot" colour indicates the internal component that is used, the ICG/653/UNIV being indicated by a red deluge boot. This does not apply to the ICG 653 UNIV J-Size.

Cable glands may be fitted with an optional external clamp or a Hawke Gland Mounted Clamp (GMC) accessory. When fitted, no additional clamping is required on the barrier or diaphragm sealed glands.

Items in *italic* are optional and may be omitted from the cable gland dependent on the application.

Hybrid cable glands are available for the gland types ICG/653/UNIV and 501/453/UNIV. These types are fitted with the middle nut and back nut components of any smaller trade size compared to the entry. Glands may combine entries and seals with small armour clamping rings and back nut seals. Hybrid gland marking to include second size reference with no spaces e.g. for example C2 to C hybrid size reference would be C2C.

The use of Hawke IP sealing washers may be considered a suitable sealing method to maintain IP rating to the enclosure (see conditions of use) and will maintain the service temperature.

Where marked IIC or IIIC, the equipment can also be marked for gas groups IIA or IIB and for dust groups IIIA or IIIB.

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Type 501/453/UNIV Cable Gland

501/453/UNIV cable gland is a diaphragm seal cable gland the glands are fitted with a diaphragm silicone rubber seal and are designed for effectively filled type cable when used for flameproof applications. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes Os (M16) up to and including F(M75). The entry thread form can either be metric or NPT equivalent. They are used with cables that are circular and armoured, un-armoured or braided cables. The cable gland comprises the following components:

a) Entry
b) Deluge boot *
c) Diaphragm seal *
d) Spigot *
e) Armour clamping ring
f) Middle nut
g) Back nut
h) Back nut clamp
i) Back nut seal

Type ICG/653/UNIV Cable Gland

The ICG/653/UNIV Cable Gland is a barrier seal type gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or corrugated cables. This cable gland is available in sizes Os (M16) up to and including J (M100). The entry thread form is either metric or NPT equivalent. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. Trade size J is IP66 only.
The cable gland comprises the following components:

a) Entry
b) Deluge boot*
c) Compound chamber*
*d) Resin dam **
e) Spigot*
*f) VBL Clip **
g) Armour/braid clamping ring
h) Middle nut
i) Back nut
j) Back nut clamp
k) Back nut seal

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Type 710 Cable Gland

The 710 Cable gland is a barrier cable gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or corrugated cables. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes Os (M16) up to and including F (M75). The entry thread form is either metric or NPT equivalent. The cable gland comprises the following components:

a) Entry
b) Deluge boot
c) Compound chamber
d) Resin dam
e) Spigot
f) Middle nut
g) Back nut
h) Back nut clamp
i) Back nut seal

Type 711 Cable Gland

711 Cable gland is a barrier cable gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or corrugated cables. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes A (M20) up to and including F (M75). The entry thread form is either metric or NPT equivalent. The cable gland comprises the following components:

a) Entry
b) Deluge boot
c) Compound chamber
d) Resin dam
e) Front diablo support
f) Diablo cage
g) Rear diablo support
h) Middle nut
i) Back nut
j) Back nut clamp
k) Back nut seal

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TEMPLATE FRM5100236 0H

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Printed on: Wednesday, March 19, 2025

Type 753 Cable Gland

753 cable gland Cable gland is a barrier cable gland designed for sealing around individual cores and are for use with circular cables of armoured, un-armoured or braided cables. This gland type is rated for ingress protection IP66, 67, 69 and IPX8 size Os to C only at 10m for 24 hours. This cable gland is available in sizes Os (M16) up to and including F(M75). The entry thread form is either metric or NPT equivalent. The cable gland comprises the following components:

a) Entry
b) Deluge boot
c) Compound chamber
d) Resin dam
e) Spigot
f) Middle nut
g) Back nut
h) Back nut clamp
i) Back nut seal

Cable glands types ICG/653/UNIV, 710, 711 and 753, in trade sizes Os to F, have been subjected to overpressure test up to 62bar/900 Psi.

Variation 1

1. To update the certification drawing with minor dimensional corrections.
2. To include the type of protection “Ex nR” Restricted Breathing.
3. To include an additional specific condition of use for braided cables.

Variation 2

1. Introduction of undersize compound pot for gland size Os, O, D, E and F.
2. Introduction of thread size M16 for size Os and O, except from gland type 711.
3. Adding NPT thread size: 1½”, 2”, 2½” for gland size D, E and F respectively.

Variation 3

1. To amend the specific conditions of safe use.
2. Update GA drawings.
3. Add accessory optional item GMC 'Gland Mounted Clamp'.
4. Clarify the Ingress Protections IP ratings.
5. To review and update the cable glands against the latest standard.
6. Hybrid Gland Combinations to permit flexibility.
7. Update the marking.
8. To revise the equipment title.
9. To revise the product description.

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Variation 4

1. To introduce and update the certification product description to include type ICG 653 oversize cable gland J-Size.
2. Removal of Ex nR from IECEx CML 18.0131X.
3. To review and assess the ICG 653 Oversize cable glands J-Size against the latest technical knowledge IEC 60079-0:2017 Ed.7.
4. To review the ICG 653 Oversize cable gland J-Size against the latest Increase Safety requirements "Ex eb".
5. To amend the specific condition of safe use.
6. To remove the condition of manufacture.
7. Introduction of new set of certification drawings.

Conditions of Manufacture

None

Specific Conditions of Use

The following conditions relate to safe installation and/or use of the equipment.

i. 501/453/UNIV when used with unarmoured or braided cables are only suitable for fixed installations, the cable for which shall be effectively clamped to prevent pulling and twisting (does not apply when fitted with rear clamping device or Hawke Gland Mounted Clamp (GMC)).

ii. Barrier glands of sizes C2, D, E and F and containing (Express) XO99-41-2 resin when used with unarmoured or braided cables are only suitable for fixed installations, the cable for which must be effectively clamped to prevent pulling and twisting. No clamping is required on barrier cable glands sizes Os-C2, or if containing 2122 Hawkeseal or 2132 QSP compound.

iii. The entry thread shall be suitably sealed (in accordance with IEC 60079-14) to maintain the ingress protection rating of the associated enclosure. This condition does not apply if the Hawke International nylon sealing washer is installed as part of the gland assembly.

Components covered by Ex Certificates issued to older editions of Standards

None

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4.12 QM1.1..1.6 and QM2.1..2.6 – Solenoid Valve, NF X E210D488E 24/DC

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ATTESTATION D'EXAMEN UE DE TYPE
EU TYPE EXAMINATION CERTIFICATE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

	Directive 2014/34/UE	**Directive 2014/34/EU**
2	Appareil ou Système de Protection destiné à être utilisé en Atmosphères Explosibles	Equipment or Protective System Intended for use in Potentially Explosive Atmospheres
3	Produit : Tête magnétique	Product : Magnetic head
	Type: *NF-*	
4	Fabricant :	Manufacturer :
	ASCO SAS	
5	Adresse :	Address :
	53 rue de Beauce 28110 Lucé FRANCE	
6	Ce produit et ses variantes éventuelles acceptées sont décrits dans l'annexe de la présente attestation et dans les documents descriptifs cités en référence.	This product and any acceptable variations thereto are specified in the schedule to this certificate and the documents therein referred to.
7	Le LCIE, Organisme Notifié sous la référence 0081 conformément à l'article 17 de la directive 2014/34/UE du Parlement européen et du Conseil du 26 février 2014, certifie que ce produit est conforme aux Exigences Essentielles de Sécurité et de Santé pour la conception et la construction de produits destinés à être utilisés en atmosphères explosibles, données dans l'annexe II de la Directive.	LCIE, Notified Body number 0081 in accordance with article 17 of the Directive 2014/34/EU of the European Parliament and the Council of 26 February 2014 certifies that product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres, given in Annex II to the Directive.
	Les résultats des vérifications et essais figurent dans le(s) rapport(s) confidentiel(s) N° :	The examination and test results are recorded in confidential report(s) N°:
	19 547 010 ; 36439010 ; 43226010 ; 60014591-507770 ; 60054967-555404/01 ; 84176-574816 ; 90110-581349 ; 96896-592747 ; 99828-598318 ; 106456-611161 ; 117816-635598-01 ; 120216-640042 ; 140308-682225 ; 143136-689151 – CR22/05/17 ; 158525-730110	
8	Le respect des Exigences Essentielles de Sécurité et de Santé est assuré par la conformité à :	Compliance with the Essential Health and Safety Requirements has been assured by compliance with :
	EN 60079-0:2012 + A11:2013 ; EN 60079-1:2014 ; EN 60079-31:2014	
9	Le signe « X » lorsqu'il est placé à la suite du numéro de l'attestation, indique que cet appareil est soumis aux conditions particulières d'utilisation, mentionnées dans l'annexe de cette attestation.	If the sign "X" is placed after the certificate number, it indicates that the product is subject to the Specific Conditions of Use specified in the schedule to this certificate.
10	Cette Attestation d'Examen UE de Type concerne uniquement la conception et la construction du produit spécifié. Des exigences supplémentaires de la directive sont applicables pour la fabrication et la fourniture du produit. Ces dernières ne sont pas couvertes par la présente attestation.	This EU Type Examination Certificate relates only to the design and construction of the specified product. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.
11	Le marquage du produit est mentionné dans l'annexe de cette attestation.	The marking of the product is specified in the schedule to this certificate.

Fontenay-aux-Roses, le 31 janvier 2019

Responsable de Certification
Certification Officer
Julien Gauthier

LABORATOIRE CENTRAL DES INDUSTRIES ELECTRIQUES
S.A.S au capital de 15.745.984 €
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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

12 **DESCRIPTION DU PRODUIT**

Le produit est constitué d'une enveloppe en aluminium ou en acier inoxydable contenant une bobine et deux bornes de connexions.

Il fonctionne sur différentes puissances (AC-DC). Il est conçu pour être utilisé avec des vannes avec 2, 3, 4 ou 5 voies.

Les types de protection sont « d » (enveloppe antidéflagrante) et « t » (protection contre l'inflammation des poussières).

Il y a également 2 versions spéciales où les caractéristiques électriques sont différentes, à la demande de clients.

DESCRIPTION OF PRODUCT

The product is made of an aluminium or stainless steel enclosure including a coil and two connections terminals.

It operates on different wattage (AC-DC). It is designed to be used in conjunction with valves with 2, 3, 4 or 5 channels.

The types of protection are "d" (flameproof enclosure) and "t" (dust ignition protection).

There is also 2 specific version where the electrical ratings are different, at customer's request.

DETAIL DE LA GAMME

* | NF | - | *

Modèle de la bobine
MXX
M12-I
M12-II

Matière de l'enveloppe
WS = Acier inoxydable
Vide = Aluminium

Note : les bobines se distinguent par leurs dimensions.

Pour la version spéciale NF 14462403.24/DC :

* | NF | - | M12-II

Modèle de la bobine
M12-II

Matière de l'enveloppe
WS = Acier inoxydable
Vide = Aluminium

Pour la version spéciale X263429069235F1:

* | NF | - | MXX

Modèle de la bobine
MXX

Matière de l'enveloppe
WS = Acier inoxydable
Vide = Aluminium

RANGE DETAILS

* | NF | - | *

Model of coil
MXX
M12-I
M12-II

Material enclosure
WS = Stainless steel
Blank = Aluminium

Note: the coils are distinguished by their dimension.

For the specific version NF 14462403.24/DC :

* | NF | - | M12-II

Model of coil
M12-II

Material enclosure
WS = Stainless steel
Blank = Aluminium

For the specific version X263429069235F1:

* | NF | - | MXX

Model of coil
MXX

Material enclosure
WS = Stainless steel
Blank = Aluminium

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
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1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

CARACTERISTIQUES

Tension d'alimentation :
6 à 250 V DC / rectifié ou 6 à 380 V AC.

Pour la version spéciale NF 14462403.24/DC :

Tension d'alimentation : 24 V DC
Puissance maximale : 36.2 W
Fonctionnement électrique intermittent :
- Temps de fonctionnement = 2 minutes
- Temps à l'arrêt = 5 minutes
Température maximale du fluide : 55°C.

Pour la version spéciale X263429069235F1 :

Tension d'alimentation : 24 V DC
Puissance maximale : 11.2 W
Fonctionnement électrique intermittent :
- Temps de fonctionnement = 2 minutes
- Temps à l'arrêt = 15 minutes
Température maximale du fluide : 70°C.

RATINGS

Supply voltage :
6 to 250 V DC / rectified or 6 to 380 V AC.

For the specific version NF 14462403.24/DC :

Supply voltage : 24 V DC
Maximum power : 36.2W
Electric operation intermittent :
- Time on = 2 minutes
- Time off = 5 minutes.
Maximum fluid temperature: 55°C.

For the specific version X263429069235F1 :

Supply voltage : 24 V DC
Maximum power : 11.2W
Electric operation intermittent :
- Time on = 2 minutes
- Time off = 15 minutes.
Maximum fluid temperature: 70°C.

MARQUAGE

Le marquage du produit doit comprendre :

ASCO SAS ou ASCO™
Adresse : …
Type : *NF-* (1)
N° de fabrication : …
Année de fabrication : …
Ⓔx II 2 G D
Ex db IIC T6…220°C (T2) Gb (2)
Ex tb IIIC T85°C…T220°C Db (2)
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +…°C (2)
AVERTISSEMENTS –
NE PAS OUVRIR SOUS TENSION.
APRES MISE HORS TENSION, ATTENDRE 35 MINUTES AVANT L'OUVERTURE.
Sur la plaque de marquage :
T câble : …°C (2)
U = ….V ; I = …. A ; P = …. W (3)

(1) : complété par la désignation du type.
(2) : voir les tableaux des températures.
(3) : complété par les paramètres électriques.

MARKING

The marking of the product shall include the following :

ASCO SAS or ASCO™
Address: …
Type : *NF-* (1)
Serial number: …
Year of construction: …
Ⓔx II 2 G D
Ex db IIC T6…220°C (T2) Gb (2)
Ex tb IIIC T85°C…T220°C Db (2)
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +…°C (2)
WARNINGS –
DO NOT OPEN WHEN ENERGIZED.
AFTER DE-ENERGIZING, DELAY 35 MINUTES BEFORE OPENING.
On the marking plate :
T cable : …°C (2)
U = ….V; I = …. A; P = …. W (3)

(1): completed with type designation.
(2): see temperatures tables.
(3): completed by electrical parameters.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

MARQUAGE (suite)

Tables des températures :

- Pour une température de fluide plus basse que la température ambiante :

Classe de température *Temperature class* (Gaz / *Gas*)	Température de surface *Surface temperature* (Poussière / *Dust*)	Température ambiante max. *Max. Amb. Temp.* (°C)	Puissance maximale / *Maximum power* (W)	
			Courant alternatif *Alternating current (AC) supply*	Courant continu ou rectifié *Direct current (DC) supply or rectified*
T6	T85°C	25	17	31,5
		40	11,5	20
		60	5,5	8,5
		75	1	2,5
T5	T100°C	25	21	40,5
		40	15	32,5
		60	10,5	18
		75	6	10
T4	T135°C	25	28,5	40,5
		40	22,5	37,5
		60	19,5	32,5
		75	16,5	31
		80	15,4	25
		100	10,5	20

- Pour une température de fluide plus haute que la température ambiante :

Température ambiante max. *Max. Amb. Temp.* (°C)	Puissance maximale / *Maximum power* (W)		Température maximale du fluide *Maximum fluid temperature* (°C)			
	Courant alternatif *Alternating current (AC) supply*	Courant continu ou rectifié *Direct current (DC) supply or rectified*				
25	17	31,5	40	75	140	-
40	11,5	20	55	90	155	-
60	5,5	8,5	75	110	175	-
75	1	2,5	90	125	180	-
25	21	40,5	-	60	125	-
40	15	32,5	-	75	140	-
60	10,5	18	-	95	160	-
75	6	10	-	110	175	-
25	28,5	40,5	-	-	90	-
40	22,5	37,5	-	-	105	-
60	19,5	32,5	-	-	125	-
75	16,5	31	-	-	140	-
80	15,4	25	-	-	145	160
100	10,5	20	-	-	165	-
Classe de température / *Temperature class* (G)			T5	T4	T3	220°C
Température de surface / *Surface temperature* (D)			T100°C	T125°C	T200°C	T220°C

MARKING (continued)

Temperatures tables :

- For a fluid temperature lower than ambient temperature :

- For a fluid temperature higher than ambient temperature :

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

MARQUAGE (suite)

- Table de température pour le choix des câbles :

Température ambiante max. *Max. Amb. Temp.* (°C)	Température du câble *Cable temperature* (°C)	Puissance maximale / *Maximum power* (W)	
		Courant alternatif *Alternating current (AC)* supply	Courant continu ou rectifié *Direct current (DC) supply or rectified*
25	70	26	40,5
	80	30	-
40	70	16	23
	80	22,5	37,5
60	70	4	6
	80	10	14
	90	17	27
	100	25	40,5
75	80	1,5	4
	90	7,5	13
	100	14	24
	105	18	32
80	120	15,4	25
100	105	3	5
	110	6,5	10
	120	13,5	23,5

Pour la version spéciale NF 14462403.24/DC :

ASCO SAS ou ASCO™
Adresse : …
Type : *NF-M12-II (1)
N° de fabrication : …
Année de fabrication : …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X

-60°C ≤ Tamb ≤ +55°C

AVERTISSEMENTS –
NE PAS OUVRIR SOUS TENSION.
APRES MISE HORS TENSION, ATTENDRE 35 MINUTES AVANT L'OUVERTURE.

U = ….V ; I = …. A ; P = …. W (2)

(1) : complété par la désignation du type.
(2) : complété par les paramètres électriques.

MARKING (continued)

- Temperature table for choosing cable :

For the specific version NF 14462403.24/DC :

ASCO SAS or ASCO™
Address: …
Type : *NF-M12-II (1)
Serial number: …
Year of construction: …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X

-60°C ≤ Tamb ≤ +55°C

WARNINGS –
DO NOT OPEN WHEN ENERGIZED.
AFTER DE-ENERGIZING, DELAY 35 MINUTES BEFORE OPENING.

U = ….V; I = …. A; P = …. W (2)

(1): completed with type designation.
(2): completed by electrical parameters.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

MARQUAGE (suite)

Pour la version spéciale X263429069235F1 :

ASCO SAS ou ASCO™
Adresse : …
Type : *NF-MXX (1)
N° de fabrication : …
Année de fabrication : …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +70°C

AVERTISSEMENTS –
NE PAS OUVRIR SOUS TENSION.
APRES MISE HORS TENSION, ATTENDRE 35 MINUTES AVANT L'OUVERTURE.
U = ….V ; I = …. A ; P = …. W (2)

(1) : complété par la désignation du type.
(2) : complété par les paramètres électriques.

L'appareil doit également comporter le marquage normalement prévu par les normes de construction qui le concernent sous la responsabilité du fabricant.

MARKING (continued)

For the specific version X263429069235F1 :

ASCO SAS or ASCO™
Address: …
Type : *NF-MXX (1)
Serial number: …
Year of construction: …
Ⓔx II 2 G D
Ex db IIC T6 Gb
Ex tb IIIC T85°C Db
LCIE 00 ATEX 6008 X
-60°C ≤ Tamb ≤ +70°C

WARNINGS –
DO NOT OPEN WHEN ENERGIZED.
AFTER DE-ENERGIZING, DELAY 35 MINUTES BEFORE OPENING.
U = ….V; I = …. A; P = …. W (2)

(1): completed with type designation.
(2): completed by electrical parameters.

The equipment shall also bear the usual marking required by the product standards applying to such equipment under the manufacturer responsibility.

13 **CONDITIONS PARTICULIERES D'UTILISATION**

a. Les joints antidéflagrants ne sont pas destinés à être réparés.

b. Les fermetures spéciales du couvercle sont des vis hexagonales à six pans creux conformes à l'ISO 4762. La classe de propriété minimale des vis doit être A4-70. Le cas échéant, les vis du couvercle doivent être remplacées par des vis identiques.

c. Le classement en température dépend de la température ambiante. Voir tableaux des températures.

SPECIFIC CONDITIONS OF USE

The flameproof joints are not intended to be repaired.

The special fasteners of the cover are hexagon socket head cap screws conforming to ISO 4762. The minimum grade of screws must be A4-70. If any, the screws shall only be replaced with identical ones.

The temperature class depend on ambient temperature. See temperature tables.

14 **EXIGENCES ESSENTIELLES DE SANTE ET DE SECURITE**

Couvertes par les normes listées au point 8.

ESSENTIAL HEALTH AND SAFETY REQUIREMENTS

Covered by standards listed at 8.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** — **LCIE 00 ATEX 6008 X** — **Issue : 15**

15 **DOCUMENTS DESCRIPTIFS** / **DESCRIPTIVE DOCUMENTS**

N°	Description	Reference	Rev.	Date	Page(s)
1.	Dossier technique, tête magnétique type (WS)NF. *Technical file, magnetic solenoid (WS)NF type.*	293584	M	2018/11/22	37
2.	Notice d'instruction ((WS)NF – MXX) *Installation and maintenance instruction, Flameproof solenoid operator ((WS)NF – MXX)*	AJN 123620-794	--	--	--
3.	Notice d'instruction ((WS)NF – M12 – II) *Installation and maintenance instruction, Flameproof solenoid operator ((WS)NF – M12 – II)*	AJN 123620-793	--	--	--
4.	Notice d'instruction ((WS)NF – M12 – I) *Installation and maintenance instruction, Flameproof solenoid operator ((WS)NF – M12 – I)*	AJN 123620-795	--	--	--
5.	Notice d'instruction NF/WSNF – MXX (Version X263429069235F1) *Installation and maintenance instruction, Flameproof solenoid operator NF/WSNF – MXX (Version X263429069235F1)*	536657-001	--	--	--

16 **INFORMATIONS COMPLEMENTAIRES** / **ADDITIONAL INFORMATIONS**

Essais individuels

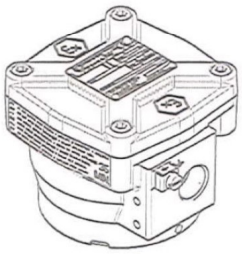
N/A

Routine tests

N/A

Vue générale

Apparatus overview



Sites de fabrication additionnels

ASCO SAS
53 rue de Beauce
28110 LUCE, FRANCE

ASCO JOUCOMATIC Ltd
2 Pit Hey Place
West Pimbo
SKELMERSDALE Lancashire WN8 9PG,
ROYAUME-UNI

ASCO CONTROLS B.V.
Neonstraat 3
6718 WX Ede, PAYS-BAS

Additional manufacturing locations

ASCO SAS
53 rue de Beauce
28110 LUCE, France

ASCO JOUCOMATIC Ltd
2 Pit Hey Place
West Pimbo
SKELMERSDALE Lancashire WN8 9PG,
UNITED KINGDOM

ASCO CONTROLS B.V.
Neonstraat 3
6718 WX Ede, The NETHERLANDS

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CERT-ATEX-FORM 04 Rev. 05

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

INFORMATIONS COMPLEMENTAIRES (suite)

Sites de fabrication additionnels (suite)

ASCO NUMATICS SP .Z.O.O
Kurczaki 132
93331 Lodz, POLOGNE

ASCO L.P.
160 Park Avenue, Florham Park
New Jersey 07932, USA

ASCO L.P.
1561 Colombia Highway
Aiken, South Carolina 29801, USA

ASCOTECH, SA de C.V
Circuito del progresso, #27
Parque Industrial Progresso, Mexicali
Baja California 21190 MEXIQUE

ASCO NUMATICS (India) Pvt.Ltd,
57, Kundrathur Main Road,
Gerugambakkam,Porur
Chennai. 600128, Tamilnadu, INDE

ASCO VALVE (Shanghai) Co. Limited
No. 480, Xin Miao N°.3 Road, Xia Qiao Town,
Song Jiang District
Shanghai 201612, P.R. CHINE

ASCO Japan Co, Ltd
1-20 Takahata-cho, Nishinomiya, Hyogo
663-8202, JAPON

ASCO ASIA
Block 4008, Ang Mo Kio Avenue 10
#04- 08/10/17/22, Techplace 1
569625, SINGAPOUR

Conditions de certification

Les détenteurs d'attestations d'examen UE de type doivent également satisfaire les exigences de contrôle de production telles que définies à l'article 13 de la Directive 2014/34/UE.

En accord avec l'Article 41 de la Directive 2014/34/UE, les attestations d'examen CE de type mentionnant la Directive 94/9/CE émises avant la date d'application de la Directive 2014/34/UE (20 avril 2016) peuvent être considérées comme émises en accord avec la Directive 2014/34/UE. Les nouvelles versions de ces attestations peuvent conserver le numéro de l'attestation d'origine émise avant le 20 avril 2016.

ADDITIONAL INFORMATIONS (continued)

Additional manufacturing locations (continued)

ASCO NUMATICS SP .Z.O.O
Kurczaki 132
93331 Lodz, POLAND

ASCO L.P.
160 Park Avenue, Florham Park
New Jersey 07932, USA

ASCO L.P.
1561 Colombia Highway
Aiken, South Carolina 29801, USA

ASCOTECH, SA de C.V
Circuito del progresso, #27
Parque Industrial Progresso, Mexicali
Baja California 21190 MEXICO

ASCO NUMATICS (India) Pvt.Ltd,
57, Kundrathur Main Road,
Gerugambakkam,Porur
Chennai. 600128, Tamilnadu, INDIA

ASCO VALVE (Shanghai) Co. Limited
No. 480, Xin Miao N°.3 Road, Xia Qiao Town,
Song Jiang District
Shanghai 201612, P.R. CHINA

ASCO Japan Co, Ltd
1-20 Takahata-cho, Nishinomiya, Hyogo
663-8202, JAPAN

ASCO ASIA
Block 4008, Ang Mo Kio Avenue 10
#04- 08/10/17/22, Techplace 1
569625, SINGAPORE

Conditions of certification

Holders of EU type examination certificates are also required to comply with the production control requirements defined in article 13 of Directive 2014/34/EU.

In accordance with Article 41 of Directive 2014/34/EU, EC-Type Examination Certificates referring to Directive 94/9/EC that were in existence prior to the date of application of Directive 2014/34/EU (20 April 2016) may be referenced as if they were issued in accordance with Directive 2014/34/EU. New issues of such certificates may continue to bear the original certificate number issued prior to 20 April 2016.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

17 **DETAILS DES MODIFICATIONS DE L'ATTESTATION**

Version 00 : 02/03/2001	Version initiale selon les normes suivantes : - EN 50014:1997, - EN 50018:1994.
Version 01 : 18/01/2002	Possibilité d'utiliser l'équipement en atmosphère poussières.
Version 02 : 10/09/2002	Modification du dossier technique.
Version 03 : 28/11/2003	Diminution de la température ambiante minimale à -60°C.
Version 04 : 10/09/2007	Mise à jour normative suivant les normes suivantes : - EN 60079-0:2006, - EN 60079-1:2004, - EN 61241-0:2006, - EN 61241-1:2004. Mise à jour des classements en température.
Version 05 : 23/10/2008	Ajout de sites de production.
Version 06 : 05/03/2009	Ajout d'un site de production.
Version 07 : 25/02/2010	Ajout d'un site de production. Modification du dossier technique.
Version 08 : 12/10/2010	Mise à jour normative suivant les normes suivantes : - EN 60079-0:2009, - EN 60079-1:2007, - EN 61241-1:2004. Mise à jour des classements en température.
Version 09 : 27/12/2011	Mise à jour normative suivant la norme EN 60079-31:2009.
Version 10 : 08/03/2013	Mise à jour de la liste des sites de production.
Version 11 : 25/04/2013	Ajout d'un nouveau site de production.
Version 12 : 25/02/2016	Changement du nom de la société. Mise à jour normative suivant les normes suivantes : - EN 60079-0:2012 + A11:2013, - EN 60079-31:2014. Ajout d'un nouveau site de production.
Version 13 : 25/10/2016	Ajout d'une version spéciale codifiée NF 14462403.24/DC, pour le type *NF-M12-II. Mise à jour suivant la norme EN 60079-1:2014.

DETAILS OF CERTIFICATE CHANGES

Issue 00 : 2003/03/02	Initial issue according to following standards: - EN 50014:1997, - EN 50018:1994.
Issue 01 : 2002/01/18	Possibility to use the equipment in dust atmosphere.
Issue 02 : 2002/09/10	Technical file modification.
Issue 03 : 2003/11/28	Decrease of minimal ambient operating temperature to -60°C.
Issue 04 : 2007/09/10	Normative update according to following standards : - EN 60079-0:2006, - EN 60079-1:2004, - EN 61241-0:2006, - EN 61241-1:2004. Update of temperature classes.
Issue 05 : 2008/10/23	Addition of manufacturing locations.
Issue 06 : 2009/03/05	Addition of a manufacturing location.
Issue 07 : 2010/02/25	Addition of a new manufacturing location. Technical file modification.
Issue 08 : 2010/10/12	Normative update according to following standards : - EN 60079-0:2009, - EN 60079-1:2007, - EN 61241-1:2004. Update of temperature tables.
Issue 09 : 2011/12/27	Normative update according to standard EN 60079-31:2009.
Issue 10 : 2013/03/08	Update of manufacturing locations list.
Issue 10 : 2013/04/25	Addition of a new manufacturing location.
Issue 12 : 2016/02/25	Change of company name. Normative update according to following standards : - EN 60079-0:2012 + A11:2013, - EN 60079-31:2014. Addition of a new manufacturing location.
Issue 13 : 2016/10/25	Addition of a specific version, codified NF 14462403.24/DC for type *NF-M12-II. Normative update according to standard EN 60079-1:2014.

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ATTESTATION D'EXAMEN UE DE TYPE - ANNEXE
EU TYPE EXAMINATION CERTIFICATE - SCHEDULE

1 **Version : 15** **LCIE 00 ATEX 6008 X** **Issue : 15**

DETAILS DES MODIFICATIONS DE L'ATTESTATION (suite)

Version 14 : 26/07/2017	Correction de la version 13 (mise à jour du marquage et de la description du produit). Nouvelle détermination de la pression d'explosion. Mise à jour des conditions particulières d'utilisation. Mise à jour de la liste des sites de production.
Version 15 :	Ajout d'une version spéciale codifiée X263429069235F1, pour le type *NF-MXX. Mise à jour de la liste des sites de production. Clarification sur la définition du type.

DETAILS OF CERTIFICATE CHANGES (continued)

Issue 14 : 2017/07/26	Correction of the issue 13 (update marking and description of product). New determination of explosion pressure. Update of specific conditions of use. Update of manufacturing locations list.
Issue 15 :	Addition of a specific version, codified X263429069235F1, for type *NF-MXX. Update list of manufacturing locations. Clarification of type definition.

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4.13 QM1.1..1.6 and QM2.1..2.6 – 1/2" NPT to M20 Adaptor, ADU102904

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intertek
Total Quality. Assured.

EU TYPE-EXAMINATION CERTIFICATE

1. **EU type-examination Certificate (Module B)**
2. **Equipment or Protective System intended for use in potentially explosive atmospheres (Directive 2014/34/EU)**
3. **EU type examination certificate Nr** **ITS16ATEX101339X R.1**
4. **Product:** AD-U, AM-D/AM-U, AF-U, AD-E4 Thread Adapters, RD-U, RD-E4 Reducers and AE-E Earthlead Adapters, Reducers, UN-D / UN-U, UF-D / UF-U, FB and FL Unions
5. **Manufacturer:** EATON ELECTRICAL SYSTEMS Ltd Trading as Eaton, Raxton, Redapt or Capri
   Applicant: EATON ELECTRICAL SYSTEMS Ltd Trading as Eaton, Raxton, Redapt or Capri
6. **Address:** Kingsway South Westgate, Aldridge West Midlands WS9 8FS
   Address: Kingsway South Westgate, Aldridge West Midlands WS9 8FS
7. This product and any acceptable variation thereto are specified in the schedule to this certificate and therein referred to.
8. INTERTEK ITALIA S.p.A., Notified Body n° 2575 in accordance with article 17 of the Directive 2014/34/EU of the European Parliament and Council of the 26 February 2014, certifies that the equipment or protective system has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective system intended for use in potentially explosive atmosphere, given in Annex II of the Directive.

   The examination and tests results are recorded in confidential technical evaluation Intertek Report Nr. 105332195LHD-001 dated 31st August 2023.
9. Compliance with the Essential Health and Safety Requirements has been assured by compliance with EN IEC 60079-0:2018, EN 60079-1:2014, EN IEC 60079-7:2015+A1:2018 and EN 60079-31:2014 except in respect of those requirements referred to at item 16 of the Schedule.
10. If the sign X is placed after the certificate number, it indicates that the product is subject to Specific Conditions of Use specified in the schedule to this certificate.
11. This EU-Type Examination Certificate relates only to the design and construction of the specified product. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.
12. The marking of the product shall include the following:

Types AD-U, AM-D/AM-U, AF-U Thread Adapters, RD-U Reducers and UN-D / UN-U, UF-D / UF-U, FB and FL Unions (Mining not applicable to Aluminium version)

I M2 Ex db I Mb
II 2 G Ex db IIC Gb
I M2 Ex eb I Mb
II 2 G Ex eb IIC Gb
II 2D Ex tb IIIC Db

Type AE-E earth lead Adapters, Reducers (Mining not applicable to Aluminium version)

I M2 Ex eb I Mb,
II 2G Ex eb IIC Gb,
II 2D Ex tb IIIC Db

Type AD-E 4 Thread Adapters or RD-E4 Reducers

II 2G Ex eb IIC Gb,
II 2D Ex tb IIIC Db

Certificate issue date

1st September 2023

Mark Newman
Certification Officer
Intertek Italia S.p.A. (NB 2575)

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

PDR N° 277B

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC

Signatory of EA, IAF and ILAC Mutual Recognition Agreements

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Intertek Italia S.p.A. Via Miglioli, 2/A - 20063 Cernusco sul Naviglio, Milano - Italy

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SCHEDULE

EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

13. **DESCRIPTION OF THE EQUIPMENT OR PROTECTIVE SYSTEM**

Adaptors and Reducers
The ranges of thread adaptors and reducers each comprise a hollow body with an external male thread and an internal female thread. The devices are used to convert an existing cable entry aperture thread to a different thread form and / or size. The adaptors and reducers may optionally be machined with a groove to fit an 'o' ring seal. An increase of up to two step thread sizes is permitted on the AD-U series.

AD-U and RD-U Series – Metallic hexagonal or round bodied adaptors (AD-U) or reducers (RD-U)
Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/ Gb Ex tb IIIC Db
M12 TO M120 (or equivalent thread forms)

The **AM-D / AM-U** range of Male to Male thread adaptors each comprises a hexagon body with a male thread form at each end. The devices are used to convert an existing cable entry aperture thread to a different thread form and/or size. Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/ Gb Ex tb IIIC Db
M16 TO M90 (or equivalent thread forms)

The **AF-U** range of Female to Female thread adaptors each comprises a hexagon body with a female thread form at each end. The devices are used to convert an existing cable entry aperture thread to a different thread form and/or size. Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/ Gb Ex tb IIIC Db
M16 TO M120 (or equivalent thread forms)

Types **AD-E4** Adaptors and Types **RD-E4** Reducers are glass fibre nylon versions, 30% Glass filled Nylon is the standard material type and 40% Glass filed Nylon is a specific type. They are designed to convert an existing cable entry aperture in the associated apparatus to a different thread form and/or size. Each device comprises a hollow body with a male thread at one end and a female thread at the other. The AD-E4 is a hexagon type adaptor. The RD-E4 is a hexagon type reducer.
Coded: Ex eb IIC Gb, Ex tb IIIC Db

The **AE-E** Series range of earth lead adaptors and reducers each comprise a hexagon body with a male thread at one end and a female thread machined into the other. The devices are designed to provide a connection from a cable gland or termination to earth via a 300mm long earth lead cable riveted and soldered to the body and additionally may be used to convert an existing cable entry aperture thread to a different thread form and/or size. Coded Ex eb I/IIC Mb/Gb Ex tb IIIC Db IP6X
M16 TO M75 (or equivalent thread forms)

Type **UN-D / UN-U and FB** Male to Female Unions and **UF-D / UF-U and FL** Female to Female Unions each comprise a hexagon body, an internally threaded cone and an external nut. The devices are designed for connection when a conventional adaptor is impractical. Additionally, they may be used to convert an existing cable entry to a different thread form and/or size.
Coded: Ex db I/IIC Mb/Gb, Ex eb I/IIC Mb/Gb Ex tb IIIC Db IP6X
M16 TO M75 for FB-FL (or equivalent thread forms)
UN-D / UN-U and **UF-D / UF-U** are between M20 and M75 (or equivalent thread forms)

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TEMPLATE FRM5100236 0H **Ballard Confidential** Printed on: Wednesday, March 19, 2025

SCHEDULE

EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

Thread forms Options:

ISO Metric (to BS3463), PG to DIN40430, NPT (ANSI/ASME B1.20.1), NPS (ANSI/ASME B1.20.1), ISO Pipe Thread (BS21) BSPP/BSPT, Imperial conduit ET BS31 BSP to BS21 or thread forms complying with standard EN 60079-1.

As an option for AD-E4 & ADU adaptors (Ex eb or tb application only), male threads can be drilled with holes to drain the water (when assembled with a breather drain for instance).

Material options:

Brass to BS 2874:1985
Brass to BS 2872:1989
Lead-free brass: CW724R Stainless
steel to BS 970: part4 Mild steel to
BS 970: Part 1: 1983 Aluminium
(Not for Group I) 30 % Glass filled
Nylon
40% Glass filled Nylon

CE Marking shall be accompanied by the identification number of the Notified Body responsible for surveillance of production.

14. **DRAWINGS AND DOCUMENTS**

TITLE	DOCUMENT Nr	LEVEL	DATE
*Ex d I&IIC AND Exe I&II ADAPTORS	AD-U	2	24-05-2021
*Ex accessories Safety Instructions	CAP184267	2022-03b	-
*Technical Specification	SPEC-ADAPT-RD-Rev-I-0.docx	0	2023/03/09
*Ex Accessories – Adaptors & Reducers – ATEX & IECEx (2 Pages)	MARK-ADAPT-RD-Rev-I-0.docx	0	2023/03/09
Ex e II CERTIFIED G.F.N ADAPTORS & REDUCERS	AD / RD-E4	2	09-07-2019
Ex e II CERTIFIED EARTH LEAD ADAPTORS	AE-E Adaptor	1	09-03-2016
Ex e II CERTIFIED EARTH LEAD REDUCER	AE-E Reducer	1	09-03-2016
Ex d I&IIC & Ex e I&II F x F ADAPTOR/ REDUCER	AF-U	1	08-03-2016
MALE x MALE ADAPTOR / REDUCER	AM-U	1	08-03-2016
Ex d I&IIC & Exe I &II REDUCERS	RD-U	1	08-03-2016
Exd/ Exe IIC UNIONS	UN-U/ UF-U	1	08-03-2016
FB-FL SERIES UNIONS	FB-FL	1	05-04-2016
Marking Drawing	IECExITS16.0013X ITS16ATEX101339X	1	15-11-2016

Documents marked with a '*' have been modified or added as part of the revision. Copies of the above listed documents are kept at Intertek Italia S.p.A. archive.

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SCHEDULE

EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

15. **SPECIFIC CONDITIONS OF USE**

1. When used in flameproof applications. only one adaptor or reducer is to be used with any single cable entry on the associated equipment.
2. The interfaces between these devices and the associated enclosure cannot be defined; therefore, it is the user's responsibility to ensure that the appropriate ingress protection level is maintained at these interfaces.
3. Aluminum variants are not permitted for Group I applications
4. At their point of mounting, these devices are suitable for use at the following temperatures dependent on the type of 'o'-ring:

O-ring Service temp

Material	Service Temperature
None fitted	-60°C to 200°C*
EPDM	-50°C to +100°C
Nitrile	-30°C to +80°C
Neoprene	-40°C to +80°C
Viton	-20°C to +180°C*
Silicone	-60°C to +180°C *
Fluorosilicone	-60°C to +130°C
30% Glass Filled Nylon	-30°C to +90°C
40% Glass Filled Nylon	-20°C to +45°C

Note:. The limiting temperatures specified above are de-rated by 20K according to Clause 7.2.2 'Material Selection' of EN 60079-0

Note: The maximum temperature is limited to 150°C in Group I application (Coal dust, Mining) O-ring materials affect marked with '*' above.

Note: Unless fitted with an interface sealing O-ring with lower properties, temperatures shall then be limited as per the manufacturer's instructions.

Conditions specific to type:

AD-U Adaptors and RD-U Reducers

1. When installed in Group I applications, the ADU M12 (M) to M20 (F) adaptor manufactured in brass shall be installed where the risk of impact is low

AE-E Earth Lead Adaptors and Reducer

2. At their point of mounting, these devices are suitable for use at -20°C to +40°C.

AD-E4, RD-E4

3. The adaptors/reducers, made from non-metallic material, are only suitable for installation in areas considered to be a low risk from mechanical impact.
4. The adaptors/reducers, made from non-metallic material 40% Glass Filled Nylon, shall be adequately protected from direct exposure to sunlight.

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TEMPLATE FRM5100236 0H **Ballard Confidential** Printed on: Wednesday, March 19, 2025

SCHEDULE

EU TYPE EXAMINATION CERTIFICATE NUMBER: ITS16ATEX101339X R.1

16. **ESSENTIAL HEALTH AND SAFETY REQUIREMENTS**

The relevant essential Health and Safety Requirements have been identified and assessed in Intertek Report Nr. 105332195LHD-001 dated 31st August 2023.

17. **ROUTINE (FACTORY) TESTS**

None.

18. **DETAIL OF CERTIFICATE CHANGES**

R.1 (?? August 2023):

- Add holes into threads for the Adaptors & Reducers AD-U / AD-E4 in order to drain moisture when associated with a breather.
- Update of some drawings.
- Update to EN IEC 60079-0:2018.

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TEMPLATE FRM5100236 0H **_Ballard Confidential_** Printed on: Wednesday, March 19, 2025

4.14 QM1.1..QM1.6 and QM2.1..QM2.6 – Cable Gland for Solenoid Valve, 501/421 O M20 Brass

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cml B.V. certification management

EU Type Examination Certificate CML 19ATEX1167X Issue 3

1 Equipment intended for use in Potentially Explosive Atmospheres Directive 2014/34/EU

2 Equipment **A Range of Cable Glands with Compression Seals**

501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474

3 Manufacturer **Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)**

4 Address **Oxford Street West, Ashton-under-Lyne, Lancashire, OL7 0NA United Kingdom**

5 The equipment is specified in the description of this certificate and the documents to which it refers.

6 CML B.V., Chamber of Commerce No 67386717, Koopvaardijweg 32, 4906CV Oosterhout, The Netherlands, Notified Body Number 2776, in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this equipment has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment intended for use in potentially explosive atmospheres given in Annex II to the Directive.

The examination and test results are recorded in the confidential reports listed in Section 12.

7 If an 'X' suffix appears after the certificate number, it indicates that the equipment is subject to conditions of safe use (affecting correct installation or safe use). These are specified in Section 14.

8 This EU Type Examination certificate relates only to the design and construction of the specified equipment or component. Further requirements of Directive 2014/34/EU Article 13 apply to the manufacture of the equipment or component and are separately certified.

9 Compliance with the Essential Health and Safety Requirements, with the exception of those listed in the confidential report, has been demonstrated through compliance with the following documents:

EN IEC 60079-0:2018 EN 60079-1:2014 EN 60079-31:2014

EN IEC 60079-7:2015+A1:2018

10 The equipment shall be marked with the following:

Ex II 2 G D

Ex db IIC Gb

Ex eb IIC Gb

Ex tb IIIC Db
IP 66/67/X8 – 10m/24h
See conditions of use for service temperature range

RvA C 640 PRODUCTS

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L A Brisk
Assistant Certification Manager

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CML 19ATEX1167X
Issue 3

11 Description

Each of the following gland types may be manufactured in brass, nickel plated brass, stainless steel or aluminium and may be supplied with agreed alternative entry thread forms.

The Type 501/421 Cable Gland is intended for use with an effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component in the size range Os to J
b) A compressible sealing ring
c) A compression spigot
d) A back nut
e) An optional earth continuity device for use with metallic sheathed cables

The Type 501/421 'Size 2K' Gland comprises the following components only: -

a) A dedicated entry component
b) A compressible sealing ring
c) A nylon skid washer
d) A threaded compression spigot

The Type 501/423 Cable Gland is intended for use with effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component, in the size range Os to J
b) Two compressible sealing rings
c) Two compression spigots
d) A middle nut
e) A back nut
f) An optional earth continuity device for use with metallic sheathed cables

The Type 501/453 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cable and comprises the following components:

a. An entry component, in the size range Os to J
b. A compressible sealing ring.
c. A combined compression spigot and armour clamping cone.
d. A reversible armour clamping ring.
e. A middle nut
f. An outer seal assembly (sleeve seal and support cage)
g. A back nut
h. An optional earth continuity device for use with metallic inner sheathed cables

The Type PSG 553 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cables of unspecified construction and comprises the following components: -

a) An entry component in the size range Os to C
b) A compressible seal designed to accept a number of individual conductors
c) A combined compression spigot and armour clamping cone
d) A reversible armour clamping ring.
e) A middle nut
f) An outer seal assembly (sleeve seal and support cage)
g) A back nut

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CML 19ATEX1167X
Issue 3

The Type 501/414 Conduit Stopping Gland is intended for use with an effectively filled and circular unarmoured cable enclosed within a conduit and comprises the following components: -

a) An entry component in the size range Os to F
b) A compressible sealing ring
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut

The Type SB474 Conduit Stopping Gland is intended for use with a number of circular conductors enclosed within a conduit and comprises the following components: -

a) An entry component in the size range O to C
b) A compressible seal designed to accept a number of individual conductors
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut.

Design option

1. The use of a 3M cold Shrink tubing to be fitted to the outer sheath of specific non-circular cables as specified in the drawing 320000, and fitted into 'Os', 'O' and 'A' sizes of the 501/453 cable glands. To ensure that the IP sealing arrangement utilizing the cable shrink tube assembly does not affect the assigned IP rating of the glands. The selection of the relevant cable gland to meet the protection concept for the cable and the enclosure it is fitted on to as detailed in EN 60079-14 remain un-affected.
2. The gland assemblies as described above are rated for ingress protection IP66 and 67.
3. Cable glands may be fitted with an optional external clamp or a second accessory option type Hawke Gland Mounted Clamp (GMC).
4. Where marked IIC or IIIC, the equipment can also be marked for gas groups IIA or IIB and for dust groups IIIA or IIIB.

Variation 1

This variation introduces the following modifications:

i. Update GA drawings.
ii. Add accessory optional item GMC 'Gland Mounted Clamp'.
iii. Clarify the ingress protection, IP ratings.
iv. To review and update the cable glands against the latest standard.
v. To include the 501/453 RAC type cable Gland.
vi. To permit the update to gland sizes.
vii. Update the marking.
viii. To revise the equipment title.
ix. To revise the product description.
x. To revise the specific conditions of use.

Variation 2

This variation introduces the following modifications, and it is is applicable to Type PSG 553 RAC Cable Gland and Type SB474 Conduit Stopping Gland.

i. To introduce a new seal design for PSG/553/RAC, sizes Os to C and SB 474, sizes O to C; as a result the product description was amended.

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CML 19ATEX1167X
Issue 3

ii. To introduce a new compressible seal which has an increased service temperature of -60°C to +100°C; to reflect this modification the product description and Specific Conditions of Use were updated.
iii. To permit minor editorial updates to the Product Description.
iv. To permit changes to the Specific Conditions of Use.
v. To remove cable gland types 501/452 RAC and PSG 421; as a result, the product description was amended.

Variation 3
This variation introduces the following modifications:

i. To modify the core diameter range on sizes O/A/B/C and B-ALT of the PSG 553 RAC and SB474 gland types and modify certification documentation.

12 Certificate history and evaluation reports

Issue	Date	Associated report	Notes
0	04 June 2019	R11908A/00	The issue of the prime certification.
1	28 Sept 2021	R13593A/00	The introduction of variation 1. (UKEX)
2	31 Mar 2022	R14930A/00	The introduction of variation 2
3	23 Aug 2023	R16380A/00	The introduction of variation 3

Note: Drawings that describe the equipment or component are listed in the Annex.

13 Conditions of Manufacture

None

14 Specific Conditions of Use (Special Conditions)

The following conditions relate to safe installation and/or use of the equipment.

i. The PSG/553/RAC and SB 474 cables glands are limited to an operating temperature range of -60°C to +80°C, unless marked “P PSG/553/RAC” and “P SB 474” respectively. In these cases, they are suitable for use with an operating temperature range of -60°C to +100°C. All other cable gland types are suitable for use with an operating temperature range of -60°C to +100°C.

ii. When the glands are used for increased safety or dust protection the entry thread shall be suitably sealed (in accordance with IEC 60079-14) to maintain the ingress protection rating of the associated enclosure. Not applicable when Hawke IP 66/67 seal is used.

iii. Glands for use with conduit, unarmoured or braided cables are only suitable for fixed installations, the cable for which must be effectively clamped to prevent pulling and twisting (does not apply when fitted with rear clamping device or Hawke Gland Mounted Clamp (GMC)).

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Certificate Annex

Certificate Number	**CML 19ATEX1167X**
Equipment	**A Range of Cable Glands with Compression Seals** **501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474**
Manufacturer	**Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)**

The following documents describe the equipment or component defined in this certificate:

Issue 0

Drawing No	Sheets	Rev	Approved date	Title
501 421	1 to 2	L	04 June 2019	General Arrangement for Unarmoured 501 421 Gland
501 421 Oversized	1 of 1	H	04 June 2019	General Arrangement for Unarmoured 501 421 Oversized Gland
501 423	1 of 1	L	04 June 2019	General Arrangement for 501/423 Gland
501 423 Oversized	1 of 1	H	04 June 2019	General Arrangement for 501/423 Oversized Gland
501 414	1 of 1	L	04 June 2019	General Arrangement for 501/414 Conduit Stopper Box (using Compression Seal)
501 452 RAC X	1 of 1	A	04 June 2019	General Arrangement of Gland Type 501/452/RAC-X
501 453 RAC X	1 of 1	A	04 June 2019	General Arrangement of Gland Type 501/453/RAC-X
PSG 553 RAC X	1 of 1	A	04 June 2019	General Arrangement for PSG 553 Gland
PSG 421	1 of 1	B	04 June 2019	General Arrangement for Unarmoured PSG 421 Glan
SB 474	1 of 1	L	04 June 2019	General Arrangement for SB 474 Gland

Issue 1

Drawing No.	Sheets	Rev	Approved date	Title
320016*	1 of 1	A	28 Sept 2021	501/453/RAC
320021*	1 of 1	A	28 Sept 2021	501/421 schedule drawing
320026*	1 of 1	A	28 Sept 2021	501/423 schedule drawing
320028*	1 of 1	A	28 Sept 2021	501/452/RAC schedule drawing
320035*	1 of 1	A	28 Sept 2021	PSG/421 schedule drawing
320037*	1 of 1	A	28 Sept 2021	PSG/553/RAC schedule drawing
320038*	1 of 1	A	28 Sept 2021	501/414 schedule drawing
320040*	1 of 1	A	28 Sept 2021	SB 474 schedule drawing

The following component drawings are common to each of the cable gland as indicated.

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Certificate Annex

Certificate Number CML 19ATEX1167X

Equipment A Range of Cable Glands with Compression Seals

501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474

Manufacturer Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)

	Drawing No.	Sheets	Rev	Approved /issued date	Title	501/421	501/423	501/452/RAC	PSG/421	PSG/553/RAC	501/414	SB 474	CSB 656N	501/453/RAC
a	320002	1 of 1	A	28-09-2021	Armour clamping ring			x		x				x
b	320009	1 of 1	A	28-09-2021	Middle nut			x		x				x
c	320003	1 of 1	A	28-09-2021	Back nut seal					x				x
d	320010	1 of 1	A	28-09-2021	Back nut					x				x
e	320011	1 of 1	A	28-09-2021	Thread forms		x	x	x	x	x	x	x	x
f	320012	1 of 1	A	28-09-2021	External clamp	x				x				x
g	320082	1 of 1	A	28-09-2021	GMC	x	x			x				x
h	320031	1 of 1	A	28-09-2021	ALT Compound Chamber Entry								x	
i	320032	1 of 1	A	28-09-2021	ALT Compound Chamber								x	
j	320017	1 of 1	A	28-09-2021	Compression seal entry	x	x	x	x	x	x	x		x
k	320018	1 of 1	A	28-09-2021	Compression seal	x	x	x			x			x
l	320022	1 of 1	A	28-09-2021	Compression spigot	x	x		x					
m	320023	1 of 1	A	28-09-2021	Tail nut	x	x		x		x	x	x	
n	3027 2k	1 of 1	A	28-09-2021	Nylon skid washer	x								
o	3077 Os-2K	1 of 1	A	28-09-2021	Spigot 411/321/421 2K Gland	x								
p	320027	1 of 1	A	28-09-2021	Body nut		x							
q	320036	1 of 1	A	28-09-2021	PSG Seal				x	x		x		
r	320039	1 of 1	A	28-09-2021	Conduit gland body						x	x	x	

Issue 2

	Drawing No.	Sheets	Rev	Approved date	Title
01	320036	1 of 1	B	31 Mar 2022	PSG Seal Schedule Drawing
02	320037	1 of 1	B	31 Mar 2022	PSG/553/RAC Schedule Drawing
03	320040	1 of 1	B	31 Mar 2022	SBS474 Schedule Drawing
04	320091	1 of 1	A	31 Mar 2022	PPSG Seal Schedule Drawing

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Certificate Annex

Certificate Number	**CML 19ATEX1167X**
Equipment	**A Range of Cable Glands with Compression Seals** **501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474**
Manufacturer	**Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)**

Issue 3

Drawing No	Sheets	Rev	Approved date	Title
320091	1 of 1	B	23 Aug 2023	PPSG Seal Schedule Drawing

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	**IECEx CML 19.0045X**	Page 1 of 4	Certificate history:
Status:	**Current**	Issue No: 3	Issue 2 (2022-03-31) Issue 1 (2021-09-28) Issue 0 (2019-06-04)
Date of Issue:	2023-08-23		

Applicant: **Hawke International**
A Division of Hubbell Limited
A Member of the Hubbell Group of Companies
Oxford Street West
Ashton-under-Lyne
Lancashire OL7 0NA
United Kingdom

Equipment: **A Range of Cable Glands with Compression Seals 501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474**

Optional accessory:

Type of Protection: **Flameproof Ex "db", Increased Safety Ex "eb" and Dust Protection by Enclosure Ex "tb"**

Marking: Ex db IIC Gb

Ex eb IIC Gb

Ex tb IIIC Db

IP 66/67/X8-10m/24h

See conditions of use for service temperature range

Approved for issue on behalf of the IECEx Certification Body: **L A Brisk**

Position: **Assistant Certification Manager**

Signature: (for printed version)

Date: (for printed version) 23 Aug 2023

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New Port Road
Ellesmere Port, CH65 4LZ
United Kingdom

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 19.0045X** Page 2 of 4

Date of issue: 2023-08-23 Issue No: 3

Manufacturer: **Hawke International**
A Division of Hubbell Limited
A Member of the Hubbell Group of Companies
Oxford Street West
Ashton-under-Lyne, Lancashire, OL7 0NA
United Kingdom

Manufacturing locations: **Hawke International**
A Division of Hubbell Limited
A Member of the Hubbell Group of Companies
Oxford Street West
Ashton-under-Lyne, Lancashire, OL7 0NA
United Kingdom

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements.This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-1:2014 Edition:7.0	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
IEC 60079-31:2022 Edition:3.0	Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure "t"
IEC 60079-7:2017 Edition:5.1	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Reports:

GB/CML/ExTR19.0096/00 GB/CML/ExTR21.0018/00 GB/CML/ExTR21.0314/00
GB/CML/ExTR23.0191/00

Quality Assessment Report:

GB/BAS/QAR06.0061/10

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 19.0045X** Page 3 of 4

Date of issue: 2023-08-23 Issue No: 3

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

Each of the gland types may be manufactured in brass, stainless steel or aluminium and may be supplied with agreed alternative entry thread forms.

Refer to Certificate Annex for full product description.

SPECIFIC CONDITIONS OF USE: YES as shown below:
Refer to Certificate Annex for list of specific conditions of use.

IECEx Certificate of Conformity

Certificate No.: **IECEx CML 19.0045X** Page 4 of 4

Date of issue: 2023-08-23 Issue No: 3

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above)
Issue 1
This issue introduces the following changes:

1. Update GA drawings.
2. Add accessory optional item GMC 'Gland Mounted Clamp'.
3. Clarify the ingress protection, IP
4. To review and update the cable glands against the latest standard.
5. To include the 501/453 RAC type cable Gland.
6. To permit the update to gland sizes.
7. Update the marking.
8. To revise the equipment title.
9. To revise the product description.
10. To revise the specific conditions of use.

Issue 2
This issue introduces the following changes and it is applicable to Type PSG 553 RAC Cable Gland and Type SB474 Conduit Stopping Gland.

1. To introduce a new seal design for PSG/553/RAC, sizes Os to C and SB 474, sizes O to C; as a result the product description was amended.
2. To introduce a new compressible seal which has an increased service temperature of -60°C to +100°C; to reflect this modification the product description and Specific Conditions of Use were updated.
3. To permit minor editorial updates to the Product Description.
4. To permit changes to the Specific Conditions of Use.
5. To remove cable gland types 501/452 RAC and PSG 421; as a result, the product description was amended.

Issue 3
This issue introduces the following changes:

1. To modify the core diameter range on sizes O/A/B/C and B-ALT of the PSG 553 RAC and SB474 gland types and modify certification documentation.
2. To review and update the equipment against the latest requirement of IEC 60079-31:2022 Ed.3.

Annex:

Certificate Annex IECEx CML 19.0045X Iss 3.pdf

Annexe to:	IECEx CML 19.0045X, Issue 3
Apparatus:	A Range of Cable Glands with Compression Seals 501/421; 501/421 "Size 2K"; 501/423; 501/453 RAC; PSG 553 RAC; 501/414; SB474
Applicant:	Hawke International (A Division of Hubbell Limited) (A member of the Hubbell group of Companies)

Description

Each of the following gland types may be manufactured in brass, nickel plated brass, stainless steel or aluminium and may be supplied with agreed alternative entry thread forms.

The Type 501/421 Cable Gland is intended for use with an effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component in the size range Os to J
b) A compressible sealing ring
c) A compression spigot
d) A back nut
e) An optional earth continuity device for use with metallic sheathed cables

The Type 501/421 'Size 2K' Gland comprises the following components only: -

a) A dedicated entry component
b) A compressible sealing ring
c) A nylon skid washer
d) A threaded compression spigot

The Type 501/423 Cable Gland is intended for use with effectively filled and circular unarmoured cables and comprises the following components: -

a) An entry component, in the size range Os to J
b) Two compressible sealing rings
c) Two compression spigots
d) A middle nut
e) A back nut
f) An optional earth continuity device for use with metallic sheathed cables

The Type 501/453 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cable and comprises the following components:

a. An entry component, in the size range Os to J
b. A compressible sealing ring.
c. A combined compression spigot and armour clamping cone.
d. A reversible armour clamping ring.
e. A middle nut
f. An outer seal assembly (sleeve seal and support cage)
g. A back nut
h. An optional earth continuity device for use with metallic inner sheathed cables

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Printed on: Wednesday, March 19, 2025

The Type PSG 553 RAC Cable Gland is intended for use with armoured, unarmoured, or braided cables of unspecified construction and comprises the following components: -

a) An entry component in the size range Os to C
b) A compressible seal designed to accept a number of individual conductors
c) A combined compression spigot and armour clamping cone
d) A reversible armour clamping ring.
e) A middle nut
f) An outer seal assembly (sleeve seal and support cage)
g) A back nut

The Type 501/414 Conduit Stopping Gland is intended for use with an effectively filled and circular unarmoured cable enclosed within a conduit and comprises the following components: -

a) An entry component in the size range Os to F
b) A compressible sealing ring
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut

The Type SB474 Conduit Stopping Gland is intended for use with a number of circular conductors enclosed within a conduit and comprises the following components: -

a) An entry component in the size range O to C
b) A compressible seal designed to accept a number of individual conductors
c) A compression assembly comprising a compression spigot with a female thread at the rear and integral back nut.

Design option

1. The use of a 3M cold Shrink tubing to be fitted to the outer sheath of specific non-circular cables as specified in the drawing 320000, and fitted into 'Os', 'O' and 'A' sizes of the 501/453 cable glands. To ensure that the IP sealing arrangement utilizing the cable shrink tube assembly does not affect the assigned IP rating of the glands. The selection of the relevant cable gland to meet the protection concept for the cable and the enclosure it is fitted on to as detailed in EN 60079-14 remain un-affected.
2. The gland assemblies as described above are rated for ingress protection IP66 and 67.
3. Cable glands may be fitted with an optional external clamp or a second accessory option type Hawke Gland Mounted Clamp (GMC).
4. Where marked IIC or IIIC, the equipment can also be marked for gas groups IIA or IIB and for dust groups IIIA or IIIB

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Conditions of Manufacture

None

Specific Conditions of Use

The following conditions relate to safe installation and/or use of the equipment.

i. The PSG/553/RAC and SB 474 cables glands are limited to an operating temperature range of -60°C to +80°C, unless marked "P PSG/553/RAC" and "P SB 474" respectively. In these cases, they are suitable for use with an operating temperature range of -60°C to +100°C. All other cable gland types are suitable for use with an operating temperature range of -60°C to +100°C.

ii. When the glands are used for increased safety or dust protection the entry thread shall be suitably sealed (in accordance with IEC 60079-14) to maintain the ingress protection rating of the associated enclosure. Not applicable when Hawke IP 66/67 seal is used.

iii. Glands for use with conduit, unarmoured or braided cables are only suitable for fixed installations, the cable for which must be effectively clamped to prevent pulling and twisting (does not apply when fitted with rear clamping device or Hawke Gland Mounted Clamp (GMC)).

Components used which are covered by Ex Certificates issued to older editions of Standards

None

Eurofins E&E CML Limited
Newport Business Park, New Port Road
Ellesmere Port, CH65 4LZ, UK

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4.15 XT01..06 – Compression Seal for Wall Penetration, Roxtec RS 50 B Ex-kit

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Attestation of Conformity for Components

We, Roxtec International AB, declare under sole responsibility that the products to which this declaration relates is in accordance with the provisions of the Directive 2014/34/EU
The products complies following harmonized stancards:

EN IEC 60079-0:2018, EN IEC 60079-7:2015/A1:2018 and EN 60079-31:2014

The standards listed in the EC-Type Examination Certificate are no longer harmonized, the revised (now harmonized) standards have been compared to the standards used for certification purposes and no changes in the "state of the art" apply to the equipment.

Cable Transit Device:
G...W Ex, S Ex, S...S0...Ex, SRC Ex, SK Ex, S BTB Ex, S...WM Ex,
SF...W Ex, R...W Ex, RO...W Ex, RS...W Ex and B...C Ex

Certificate:
No.12ATEX1279U issued by Nemko (id.no. 0470), based on EC-type Examination performed by them.
No. SP03ATEX7102 issued by RISE - Research Institutes of Sweden
(id.no 0402), based on assessment of the quality system performed by them.

Characteristics and how the components shall be incorporated into equipment:
Stated in EC-type Examination certificate and the instructions which accompany the components.

Marking:
CE 0402 Ex II 2G Ex e IIC Gb
CE 0402 Ex II 2D Ex tb IIIC Db

Karlskrona 2021-02-11

Roxtec International AB
Box 540
S-371 23 Karlskrona
SWEDEN

Jörgen Åkesson
Explosion Protection Manager

EU Declaration of Conformity

We, Roxtec International AB, declare under sole responsibility that the products to which this declaration relates is in accordance with the provisions of the Directive 2014/34/EU.
The products complies with following harmonized standards:

EN IEC 60079-0:2018, EN IEC 60079-7:2015/A1:2018 and EN 60079-31:2014
The standards listed in the EC-Type Examination Certificate are no longer harmonized, the revised (now harmonized) standards have been compared to the standards used for certification purposes and no changes in the "state of the art" apply to the equipment.

Cable Transit Device:
CF 16 Ex, CF 8/32 Ex, G Ex, G BG Ex, SF Ex, SF BG Ex, SFX...B Ex, R...B Ex, RO...B Ex, RS...B Ex, B...B Ex and C RS T- Ex

Certificate:
No.12ATEX1278X issued by Nemko (id.no. 0470), based on EC-Type Examination performed by them.
No. SP03ATEX7102 issued by RISE - Research Institutes of Sweden
(id.no 0402), based on assessment of the quality system performed by them.

Marking:
CE 0402 Ex II 2G Ex e IIC Gb
CE 0402 Ex II 2D Ex tb IIIC Db

Karlskrona 2021-02-11
Roxtec International AB
Box 540
SE-371 23 Karlskrona
SWEDEN

Jörgen Åkesson
Explosion Protection Manager

EU Declaration of Conformity

Document number: DOC-000575 revision F

We, Roxtec International AB, declare under sole responsibility that the products to which this declaration relates is in accordance with the provisions of the Directive 2014/34/EU.
The products complies with following harmonized standards:

EN IEC 60079-0:2018, EN IEC 60079-7:2015/A1:2018 and EN 60079-31:2014

The standard EN 60079-7:2015 listed in the EC-Type Examination Certificate are no longer harmonized. The revised (now harmonized) EN IEC 60079-7:2015/A1:2018 have been compared to the standard used for certification purposes and no changes in the "state of the art" apply to the equipment.

Cable Transit Device:
HD 16 Ex, HD 24 Ex, HD 32 Ex, HDLC Ex

Certificate:
No.15 ATEX6419X issued by Presafe (id. No 2460), based on EC-Type Examination performed by them.
No. SP03ATEX7102 issued by RISE - Research Institutes of Sweden (id.no 0402), based on assessment of the quality system performed by them.

Marking:
CE 0402 Ex II 2G Ex eb IIC Gb
CE 0402 Ex II 2D Ex tb IIIC Db

Karlskrona 2021-02-11
Roxtec International AB
Box 540
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SWEDEN

Jörgen Åkesson
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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification Scheme for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	IECEx NEM 12.0014X	Issue No: 4	Certificate history:
Status:	**Current**	Page 1 of 5	Issue No. 4 (2015-11-04) Issue No. 3 (2015-07-08) Issue No. 2 (2015-05-07) Issue No. 1 (2015-01-27) Issue No. 0 (2013-03-15)
Date of Issue:	**2015-11-04**		

Applicant: **Roxtec International AB**
Rombvägen 2
Box 540
SE-371 23 Karlskrona
Sweden

Equipment: **Cable Transit Device**
Optional accessory:

Type of Protection: **Ex e IIC Ex tb IIIC**

Marking:

Ex e IIC Gb, Ta -40°C To +80°C for CF 8 and CF 32.
Ex e IIC Gb, Ta -60°C To +80°C for all other variants.
Ex tb IIIC Db, Ta -40°C To +80°C for CF 8 and CF 32.
Ex tb IIIC Db, Ta -60°C To +80°C for all other variants.

Approved for issue on behalf of the IECEx Certification Body: Bjørn Spongsveen

Position: Certification Manager, Ex-products

Signature:
(for printed version)

Date:

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting the Official IECEx Website.

Certificate issued by:

NEMKO
Gaustadelleen 30
Oslo N-0314
Norway

IECEx Certificate of Conformity

Certificate No:	IECEx NEM 12.0014X	Issue No: 4
Date of Issue:	**2015-11-04**	Page 2 of 5
Manufacturer:	**Roxtec International AB** Rombvägen 2 Box 540 SE-371 23 Karlskrona **Sweden**	
Additional Manufacturing location(s):		

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS:

The electrical apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

IEC 60079-0 : 2011 Edition:6.0	Explosive atmospheres - Part 0: General requirements
IEC 60079-31 : 2008 Edition:1	Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure 't'
IEC 60079-7 : 2006-07 Edition:4	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

*This Certificate **does not** indicate compliance with electrical safety and performance requirements other than those expressly included in the Standards listed above.*

TEST & ASSESSMENT REPORTS:

A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in

Test Report:

NO/NEM/ExTR12.0016/00 NO/NEM/ExTR12.0016/01 NO/NEM/ExTR12.0016/02
NO/NEM/ExTR12.0016/03 NO/NEM/ExTR12.0016/04

Quality Assessment Report:

SE/SP/QAR09.0001/04 SE/SP/QAR09.0001/03

IECEx Certificate of Conformity

Certificate No: IECEx NEM 12.0014X Issue No: 4

Date of Issue: **2015-11-04** Page 3 of 5

Schedule

EQUIPMENT:

Equipment and systems covered by this certificate are as follows:

The Cable Transit Devices 'CTDs'(see Type Designation below), for use with circular cables both armoured and non-armoured or corrugated cables (see Corrugated cables below) of non-interrupted and non-metallic outer jacket type or conduits. The CTDs consists of multi diameter sealing modules (type RM Ex and CM Ex as standard or with EMC properties) that depending on each individual size, accepts a limited number of cable diameters in applicable types of frames or sleeves and shall be marked with the Ex symbol.

The modules are made of mirrored rubber profiles and each part has a number of thin rubber layers that are ending up with a solid rubber core. The layers are made with two different colours to make the adaption to a cable exactly same on both halves and are allowed to differ one layer at most. To achieve appropriate sealing and mechanical properties to prevent the cables from slippage there shall always be a visible separation between the sealing module halves.

The modules made of EPDM are available with layers and core, but some greater sizes are also available without the core. In addition there are also single diameter- and solid modules.

The correct sizes and procedure of assembling the cables to the modules are described in detail in the enclosed installation instructions. Ex Compression devices are used to achieve appropriate compression of the modules and solids some CTDs uses compression units that expands inside the CTDs and some others have incorporated solid rubber profiles that achieve the expansion.

There are also two types of CTDs that incorporates both the compression device and multi diameter modules as a single unit, but still with two halves. The method to assemble the compression devices etc. and to achieve sealing of the CTDs is described in detail in the enclosed installation instructions.

Most CTDs that has a rectangular opening with or without rounded corners with modules of type RM Ex are all available for different combinations with several openings in width and/or in high. CTDs for use with rectangular openings with CM Ex modules (one type with dual opening) and round sleeves are only available with single openings.

The CTDs installation instructions listed in this report will define each variant in detail and all applicable parts that are approved for use within that variant.

CONDITIONS OF CERTIFICATION: YES as shown below:

Conditions for safe use

1. For maintaining the explosion protection, the installation instructions that accompany the products shall be considered.
2. Only cable for fixed installation is permitted for the cable transit device.
3. For optimum reliability wait 24 hours or longer after installation before exposing the cables/pipes to strain or pressure.

IECEx Certificate of Conformity

Certificate No: IECEx NEM 12.0014X Issue No: 4

Date of Issue: **2015-11-04** Page 4 of 5

EQUIPMENT (continued):

Type Designations:
CF 8 Ex, CF 32 Ex, CF 16 Ex, C RS T… Ex, RS…B Ex, G… Ex, SF… Ex, SFX...B Ex, B…B Ex, R…B Ex and RO…B Ex
Temperature Range:
CF 8 Ex and CF 32 Ex , -40°C to +80°C
CF 16, C RS T…, RS…B, G…, SF…, SFX...B, B…B, R…B and RO…B, -60°C to +80°C
Corrugated cables for use with: CF 8, CF 32, SF… and G…
ACIC (Armoured Control and Instrumentation Cable) according to C22.1-06 CEC,
ACWU (Armoured Cable for Wet locations) according to UL4,
TECK90 according to C22.2 No. 131-07
MC (Metal Clad) according to UL1569

IECEx Certificate of Conformity

Certificate No:	IECEx NEM 12.0014X	Issue No: 4
Date of Issue:	2015-11-04	Page 5 of 5

DETAILS OF CERTIFICATE CHANGES (for issues 1 and above):

New revisions added and corrections to mistyping in previous descriptive document list, issue No. 4.0.

4.16 XT07..09 – Cable Gland for Wall Penetration, 501/421 O M20 Brass

[Please refer to certificate from Section 4.14.]

4.17 XT07..09 – M32 to M20 Reducer, RDU100604

[Please refer to certificate from Section 4.13.]

4.18 XT10..11 – Cable Gland for Wall Penetration, 501/421 A M20 Brass

[Please refer to certificate from Section 4.14.]

4.19 XT10..11 – M40 to M20 Reducer, RDU100704

[Please refer to certificate from Section 4.13.]

Sub Section K02-002

ATEX Register

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
007	21/07/2025	Updated

KBR
ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

ACCEPTED	(Code 1)
ACCEPTED WITH COMMENTS	(Code 2)
NOT ACCEPTED	(Code 3)
NOT REVIEWED	(Code 4)

ACCEPTANCE DOES NOT RELIEVE SUPPLIER FROM FURNISHING MATERIAL IN CONFORMANCE WITH ORDER. REFER TO SDR-1 FOR FULL DEFINITION OF ACCEPTANCE CONDITIONS.

DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - ATEX Register**
Document Number:	K559-2254-CWIWP4202202-K02-002
Revision:	007
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-K02-002007
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

No.	Revision	Tag Number	Description	Location	Manufacturer	Model Type Catalogue Number	Serial Number	ATEX Certification Marking	Reference Document	ATEX Certificate Number	Installation Zone	Notes / Comments	P.O	Vendor	Skid /Package	Barrier Calculation ref.	Non-electrical Equipment	Special Conditions for Safe Use
1	04	BL01	Electronic level sensor; Operating voltage 18...30 DC V; ATEX; M12 Connector; Gold-plated contacts	=HA01+DA02 - H2 Supply System	IFM Electronic AS	LMT01A LMACE-A12E-QSKG-1/US/3D/3G	100000160523	II 3G Ex nA IIC T4 Gc	K559-2254-CWIWP4202202-C03-001	8003330	Zone 2		8517643	IFM Electronic AS	A-80000	No	No	No
2	04	BL01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Black	=HA01+DA02 - H2 Supply System	IFM Electronic AS	EVC14A ADOGH040VAT0025H04/3G/2D	N/A	II 3G EX ec IIC Gc	K559-2254-CWIWP4202202-E03-003	BVS 08ATEX E 109U	Zone 2		8520141	IFM Electronic AS	A-80000	No	No	No
3	04	BP01	Pressure Transduer, 0-10 barg, 4-20mA, ATEX, -25 to 85°C Ta, M12 Connector, 10..30 VDC, 2-wire, G1/2 Process Connection, FPM Seal	=HA01+DA02 - H2 Supply System	HUBA Controls AG	Pressure Transducer 520 Series	N/A	Ex II 1/2G Ex ia IIC T4 Ga/Gb	K559-2254-CWIWP4202202-C03-001	SEV 10 ATEX 0145	Zone 2		8516809	HUBA Controls AG	A-80000	K559-2254-CWIWP42022(	No	No
4	04	BP01-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	II 2G Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP42022(	No	Yes
5	04	TF01	BP01 - Pressure Sensor – Ex Barrier (9106-B1B)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9106-B1B	N/A	II (1) G [Ex ia Ga] IIC//IB/IIA	K559-2254-CWIWP4202202-E03-008	DEKRA 11ATEX0244 X	No Zone		146131-1	PR Electronics AS	A-80000	K559-2254-CWIWP42022(	No	Yes
6	04	BT01	Temperature sensor: liquids and gases Connection: stainless steel (1.4404 / 316L) Ambient temperature: -25...80 °C	=HA01+DA02 - H2 Supply System	IFM Electronic AS	TT1050 TT-100KBBD10-...../US/	100000113592	N/A	K559-2254-CWIWP4202202-C03-001	N/A	Zone 2	Simple apparatus acco	8516509	IFM Electronic AS	A-80000	K559-2254-CWIWP42022(	No	No
7	04	BT02-WG01	Connecting cable with socket; 4x0.34mm2, AC/DC < 50 V; 10 m M12 to open end, Light blue	=LA01+UC42 - EX Barrier Box	IFM Electronic AS	ENC03A ADOGH040MSN0010H04/1G/1D	N/A	Ex ia IIC T6 Gb	K559-2254-CWIWP4202202-E03-008	BVS 11ATEX E 009X	Zone 2		8520269	IFM Electronic AS	A-80000	K559-2254-CWIWP42022(	No	Yes
8	04	TF01	BT01 - Temperature Sensor – Ex Barrier (9113B-U9)	=LA01+UC42 - EX Barrier Box	PR Electronics AS	9113B-U9	N/A	II (1) G [Ex ia Ga] IIC//IB/IIA	K559-2254-CWIWP4202202-E03-008	KEMA 07ATEX0148 X	No Zone		8520371	PR Electronics AS	A-80000	K559-2254-CWIWP42022(	No	Yes
9	04	EA01	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2" , ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-1	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements A	A-80000	No	No	Yes
10	04	EA01-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No
11	04	EA01	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes
12	04	EA02	Immersion Heater, 3x400V, 9kW, ATEX, IP66, Screw plug 2", ASTM A182 F316, Element Length 600m	=HA01+DA02 - H2 Supply System	JEVI Heating Elements AS	D-8640	340386-2	Ex d IIC T4 Gb	K559-2254-CWIWP4202202-C03-001	ISSeP 08 ATEX 008X	Zone 2		8517682	JEVI Heating Elements A	A-80000	No	No	Yes
13	04	EA02-WD01	Screened halogen free, highly flame retardant control cable, 4G 2.5mm2, 300/500V	=HA01+DA02 - H2 Supply System	Lapp Group	ÖLFLEX® CLASSIC 130H	N/A	N/A	K559-2254-CWIWP4202202-E03-003	N/A	Zone 2		N/A	Lapp Group	A-80000	No	No	No
14	04	EA02	Cable Gland	=HA01+DA02 - H2 Supply System	HAWKE	ICG 653 UNIV Os M20	N/A	EX db IIC Gb and EX eb IIC GB	K559-2254-CWIWP4202202-C03-001	IECEx_CML18.0131X	Zone 2		8517682	HAWKE	A-80000	No	No	Yes
15	04	QM1.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes
16	04	QM1.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
17	04	QM1.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
18	04	QM2.1	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
19	04	QM2.1	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
20	04	QM2.1	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
21	04	QM1.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes
22	04	QM1.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
23	04	QM1.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
24	04	QM2.2	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
25	04	QM2.2	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
26	04	QM2.2	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
27	04	QM1.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP24068090	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8516694	Emerson ASCO	A-80000	No	No	Yes
28	04	QM1.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
29	04	QM1.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
30	04	QM2.3	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
31	04	QM2.3	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
32	04	QM2.3	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
33	04	QM1.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
34	04	QM1.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
35	04	QM1.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
36	04	QM2.4	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
37	04	QM2.4	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
38	04	QM2.4	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
39	04	QM1.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
40	04	QM1.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
41	04	QM1.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
42	04	QM2.5	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
43	04	QM2.5	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
44	04	QM2.5	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
45	04	QM1.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
46	04	QM1.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
47	04	QM1.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
48	04	QM2.6	Solenoid Valve, Normally Closed, 3/4" Bore, ATEX for Hydrogen, Material: Body and Bonnet SS316, Seal, Diaphragm NBR, Pressure 0 to 16 barg	=HA01+DA02 - H2 Supply System	Emerson ASCO	NF X E210D488E 24/DC	ZP23091327	II 2 G D Ex db IIC T2...T6 Gb	K559-2254-CWIWP4202202-C03-001	LCIE 00 ATEX 6008 X	Zone 2		8514701	Emerson ASCO	A-80000	No	No	Yes
49	04	QM2.6	1/2" NPT to M20 adaptor	=HA01+DA02 - H2 Supply System	Eaton Corporation	ADU102904	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	ITS16ATEX101339X R.1	Zone 2		CD3034021	Semco maritime	A-80000	No	No	Yes
50	04	QM2.6	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - H2 Supply System	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
51	04	XT01	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
52	04	XT02	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
53	04	XT03	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
54	04	XT04	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
55	04	XT05	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
56	04	XT06	Roxtec RS 50 B Ex-kit AISI316/AISI316	=HA01+DA02 - H2 Supply System	Roxtec International AB	EXRSB0500002121	202439	II 2G EX e IIC Gb	K559-2254-CWIWP4202202-C03-001	IECEx NEM 12.0014X	Zone 2		8520214	Roxtec International AB	A-80000	No	No	Yes
57	04	XT07	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Non EX Box	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
58	04	XT07	M32 to M20 Ex Reducer	=HA01+DA02 - Non EX Box	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
59	04	XT08	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
60	04	XT08	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
61	04	XT09	Cable Gland, Ex, M20 501/421 O Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/O M20 421OM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034005	Semco maritime	A-80000	No	No	Yes
62	04	XT09	M32 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100604	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80001	No	No	Yes
63	04	XT10	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	IECEx CML 19.0045X	Zone 2		CD3034021	Semco maritime	A-80002	No	No	Yes
64	04	XT10	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-C06-001	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80003	No	No	Yes
65	04	XT11	Cable Gland, Ex, M20 501/421 A Brass	=HA01+DA02 - Exterior location, hydro	HAWKE	501/421/A M20 421AM20	N/A	Ex db IIC Gb Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	IECEx CML 19.0045X	Zone 2		CD3034021	Semco maritime	A-80004	No	No	Yes
66	04	XT11	M40 to M20 Ex Reducer	=HA01+DA02 - Exterior location, hydro	Eaton Corporation	RDU100704	N/A	II 2G Ex db IIC Gb II 2G Ex eb IIC Gb	K559-2254-CWIWP4202202-E03-002	ITS16ATEX101339X R.1	Zone 2		CD3034005	Semco maritime	A-80005	No	No	Yes

Sub Section K02-003

ATEX Design journal

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003	28/01/2025	updated additional parts added
004	12/02/2025	2.1.2 - 1st paragraph corrected from eb or e to db or d
005	19/03/2025	Updated according to code 2 comments

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ATEX design journal

Full Title: *FC PowerGen 1000kW® - ATEX design journal*

Abstract: The following document will contain an internal walk through of the ATEX related components and philosophies for the installation on the *FC PowerGen 1000kW®*

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1.0 Objectives and Background

The following document contains the design journal and considerations for the EX related system. This document is an internal document stating the decisions and background for a safe system.

This is an addendum to the ATEX dossier containing the following documents.

- ATEX general arrangement
- ATEX register
- ATEX inspection checklist
- ATEX personal competences
- Intrinsically safe calculations
- Datasheet dossier
- Certification dossier

2.0 *FC PowerGen 1000kW®*

2.1 H2 solenoid valve

2.1.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***Emerson ASCO*** valve ***NF X E210D488E 24/DC*** with the following EX approvals: ***II 2 G D Ex db IIC T2..T6 Gb*** hereby confirming that the points above is covered by the certificate.

2.1.2 Cable glands

The cable glands for the installation shall maintain the certificate and appropriate Type of protection as the valve accordingly to section 10.2 in IEC 60079-14, hence the cable gland shall be a type of protection: db or d.

The following component is ***HAWKE* 501/421/O M20 421OM20** *with an adaptor to fit the thread of the valve from* ***Eaton Corporation*** *type* ***ADU102904*** with the following EX approvals: **Ex db IIC Gb Ex eb IIC Gb** for the cable gland, and **II 2G Ex db IIC Gb II 2G Ex eb IIC Gb** hereby confirming that the points above is covered by the certificate.

2.1.3 Cable and installation

The valve is installed with a LAPP 3G1 and resistant to UV light making them suitable for outside use.

The grounding is installed inside the valve to eliminate any risk of corrosion. The cable is in all its length (from valve to terminal box) un-cut

The cable is installed together with the other valves, with at smooth bend before cable glands. The cable will be mechanical fixed to a cable tray making sure no mechanical ware will happen.

The diameter of the cable is according to manufacture 8,4mm which is within the specifications (6,5-11,9mm) provided by the manufacture of the cable glands.

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2.2 H2 pressure transmitter

2.2.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***HUBA controls AG*** type ***520930S04M801*** with the following EX approvals: ***Ex II 1/2G EX ia IIC T4 Ga/Gb*** hereby confirming that the points above are covered by the certificate.

2.2.2 Ex barrier

The component will be installed with an Ex barrier eliminating the potential current going out the component and zone. The following Ex barrier is chosen: ***PR electronic 9106-B1B*** with the following EX approvals: ***II (1) G [Ex ia Ga] IIC/IIB/IIA*** hereby confirming that the points above are covered by the certificate. Installation of the barrier will be covered in section 2.8

2.2.3 Cables

For the connection of the temperature transmitter to the Ex barrier the following cable is used: ***IFM ENC03A*** with the following EX approvals: ***Ex ia IIC T6 Gb*** hereby confirming that the points above are covered by the certificate.

2.3 H2 heater heating element

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***JEVI Heating Elements A/S*** heating element ***D-8640*** with the following EX approvals: ***Ex d IIC T4 Gb*** hereby confirming that the points above is covered by the certificate.

The heating element has a build in over temperature cut off. The heating element is factory tested to make sure to not be able to overheat as part of the EX installation.

The flameproof type of protection is a threaded joint type and is installed according to IEC 60079-1. This means that there are no distances required to obstructions.

2.3.1 Cable glands

The cable glands for the installation shall maintain the certificate and appropriate Type of protection as the valve accordingly to point 16.3 in IEC 60079-0, hence the cable gland shall be a type of protection: d.

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For this component the cable gland was delivered as part of the delivery from the manufacture of the heating element. Following cable glands for the valve is delivered: ***HAWKE*** type ***ICG 653 UNIV Os M20*** with the EX approvals: ***EX db IIC Gb and EX eb IIC GB***

2.3.2 Cable and installation

The Heater unit is installed with a LAPP 4G2.5 and resistant to UV light making them suitable for outside use.

The grounding is installed inside the heating unit to eliminate any risk of corrosion. The cable is in all its length (from heating unit to terminal box) un-cut

The cable is installed together with the other non intrinsically safe components, with at smooth bend before cable glands. The cable will be mechanical fixed to a cable tray making sure no mechanical ware will happen.

The diameter of the cable is according to manufacture 9 mm which is within the specifications (5,5-12mm) provided by the manufacture of the cable glands.

2.4 H2 heater Level sensor

2.4.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***IFM LMT01A*** with the following EX approvals: ***II 3G Ex nA IIC T4 Gc X*** hereby confirming that the points above is covered by the certificate.

2.4.2 Ex barrier

The level sensor does not require a barrier due to the type of protection not being intrinsically safe.

2.4.3 Cables

For the connection of the temperature transmitter to the controller the following cable is used: ***IFM EVC14A*** with the following EX approvals: ***II 3G EX ec IIC Gc*** hereby confirming that the points above is covered by the certificate.

Installation of the cabling will be separated from intrinsically safe sensors, as the cable on this devise is not protected by an ex barrier.

2.5 H2 heater Temperature transmitter

2.5.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

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Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The temperature transmitter is defined as a simple apparatus accordingly to IEC 60079-14 section 16.4 as the type of transmitter is resister type PT1000 hence no possibility for generating any voltage by its own. Hereby eliminating the option of calculating the surface temperature. Since there are no requirement for an Ex certificate for an simple apparatus, there are no code for concluding the match.

2.5.2 Ex barrier

The component will be installed with an Ex barrier eliminating the potential current going out the component and zone. The following Ex barrier is chosen: ***PR electronic 9113B-U9*** with the following EX approvals: ***II (1) G [Ex ia Ga] IIC/IIB/IIA*** hereby confirming that the points above is covered by the certificate. Installation of the barrier will be covered in section 2.8

2.5.3 Cables

For the connection of the temperature transmitter to the Ex barriere the following cable is used: ***IFM ENC03A*** with the following EX approvals: ***Ex ia IIC T6 Gb*** hereby confirming that the points above is covered by the certificate.

2.6 H2 feed pipe container penetration

2.6.1 Selection of component

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is chosen to safe penetrate the container: **Roxtec** cable and pipe penetration type: **RS 50 B Ex-kit AISI316/AISI316** with the following EX approvals**: II 2G EX e IIC Gb** hereby confirming that the points above is covered by the certificate.

2.7 Electrical container penetration within EX zone

The component is to be placed with the following zone: ***EX zone 2 IIC T1***

Following allowable EPL is ok to use in the installation: Ga, Gb and Gc

Type of protection is limited to table 1 in IEC 60079-14

Ignition temperature is T1 for the medium (Hydrogen) in the zone. Hereby accepting the following ratings on the components T1-T6.

The following component is ***HAWKE*** cable gland type **501/421/O M20 and 501/421/A M20** with the following adaptor to compensate for the hole size: **Eaton Corporation** type **RDU100604 and RDU100704** with the following EX approvals: **Ex db IIC Gb Ex eb IIC Gb** for the cable glands and **II 2G Ex db IIC Gb II 2G Ex eb IIC Gb** for the reducers hereby confirming that the points above is covered by the certificate.

2.7.1 Cable and installation

The following type of cables are used in the above-mentioned cable glands:

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- ÖLFLEX CLASSIC 110 CH 4X1 from Mastercontorller in 40' container to cooling skid cabinet. Diameter 8,9mm with an allowable diameter for the cable gland of 6,5mm to 11,9mm
- ETHERLINE® TORSION Cat.6A from mastercontorller in 40' container to cooling skid cabinet. Diameter 8,9mm with an allowable diameter for the cable gland of 6,5mm to 11,9mm
- ETHERLINE® TORSION Cat.6A from mastercontorller in 40' container to cooling skid cabinet. Diameter 8,9mm with an allowable diameter for the cable gland of 6,5mm to 11,9mm
- ÖLFLEX CLASSIC 135 CH 18G0,75 from mastercontroller cabinet in 40' to hydrogen valve box. Diameter 13mm with an allowable diameter for the cable gland of 10,0mm to 14,3mm
- ÖLFLEX CLASSIC 135 CH 18G0,75 from mastercontorller in 40' container to cooling skid cabinet. Diameter 13mm with an allowable diameter for the cable gland of 10,0mm to 14,3mm

2.8 General electrical installation

There are no junction boxes within the zone except the one which is a part of the components. All junction boxes are moved outside the zone.

Cables are all installed below the temperature of the zone and goes uncut through the zone as 60079-14pt. 9.6.1

The intrinsically safe barriers are positioned in a separate junction box outside the Ex Zone. The junction box will contain the components which are described in section 2.2.2 and 2.5.2. The intrinsically safe circuits are separated from the non-safe circuit. Where the one side of the box will contain the non-safe part and the opposite side containing the intrinsically safe circuit hereby following the guidelines/philosophy from the manufacture of the Ex barriers. The circuits are to be installed **50mm** apart from each other according to section 16.5.3 in IEC 60079-14

The junction box will be the following: ***Schneider Electric Thalassa PLS, fiber glass armed polyester cabinet, IP65, 180 x 270 x 180mm, gray*** With the IP rating of IP65. The box will be marked with: *"Warning - Non Intrinsically safe circuits protected by internal IP20 cover"*

The cables will be separated from the non-safe circuits in the cable tray.

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Sub Section K02-004

Personal Competences Ex Works

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Personnel competences Ex work

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1.0 Purpose

The purpose of this document is to highline the competences of the personnel working on Ex related equipment and systems. The following definitions are defined according to IEC 60079-14 Annex A

2.0 Definitions

Definitions of terms or acronyms unique to the Policy.

BPSE: Ballard Power Systems Europe.

3.0 Responsible Persons

As described in IEC 60079-14 Annex A section A.2.1 the following knowledge and skills is required to be approved for being the **Responsible Person** on a EX installation

"Responsible persons who are responsible for the processes involved in the design, selection and erection of explosion protected equipment shall possess, at least, the following:

a) general understanding of relevant electrical engineering;

b) understanding and ability to read and assess engineering drawings;

c) practical understanding of explosion protection principles and techniques;

d) working knowledge and understanding of relevant standards in explosion protection;

e) basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration.

Such persons shall confine their involvement to the management of competent operatives conducting selection and erection duties and not engage themselves directly in the work without ensuring their practical skills at least meet the requirements given in A.2.2."

Besides the knowledge and skills, the following competences are also required in some way to approve for the **Responsible Person** as described in IEC 60079-14 Annex A section A.3.2.

"Responsible persons shall be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified in A.2.1 relevant to the types of protection and/or types of equipment involved."

4.0 Operatives/technicians

As described in IEC 60079-14 Annex A section A.2.2 the following knowledge and skills is required to be approved for being **Operatives** or **technicians** on a EX installation.

"*Operatives/technicians shall possess, to the extent necessary to perform their tasks, the following:*

a) understanding of the general principles of explosion protection;

b) understanding of the general principles of types of protection and marking;

c) understanding of those aspects of equipment design which affect the protection concept;

d) understanding of content of certificates and relevant parts of this standard;

e) general understanding of inspection and maintenance requirements of IEC 60079-17;

f) familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard;

g) understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection."

Besides the knowledge and skills, the following competences are also required in some way to approve for being **Operatives** or **technicians** as described in IEC 60079-14 Annex A section A.3.3.

"*Operatives/technicians shall be able to demonstrate their competency and provide evidence*

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of attaining the knowledge and skill requirements specified in A.2.2 relevant to the types of protection and/or types of equipment involved.

They shall also be able to demonstrate their competency with documentary evidence in the:

a) use of documentation in 4.2;

b) production of reports, e.g. inspection reports, to the user as identified in 4.2;

c) practical skills necessary for the preparation and installation of relevant concepts of protection;

d) use and production of installation records as identified in 4.2."

5.0 Designer

As described in IEC 60079-14 Annex A section A.2.3 the following knowledge and skills is required to be approved for being **Designer** on a EX installation.

"*Designers shall possess, to the extent necessary to perform their tasks, the following:*

a) detailed knowledge of the general principles of explosion protection;

b) detailed knowledge of the general principles of types of protection and marking;

c) detailed knowledge of those aspects of equipment design which affect the protection concept;

d) detailed knowledge of content of certificates and relevant parts of this standard;

e) understanding of practical skills for the preparation and installation of relevant concepts of protection;

f) detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection;

g) detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard;

h) general understanding of inspection and maintenance requirements of IEC 60079-17."

*Besides the knowledge and skills, the following competences are also required in some way to approve for being **Designers** as described in IEC 60079-14 Annex A section A.3.4.*

"Designers shall be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified in A.2.3 relevant to the types of protection and/or types of equipment involved.

They shall also be able to demonstrate their competency with documentary evidence in the:

a) production of documentation specified in 4.2;

b) production of designers certificates to the user as identified in 4.2;

c) practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved;

d) updated and production of installation records as identified in 4.2."

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6.0 Appendices

Table 6-1: List of people and competences for Crosswind project

Name:	Initials:	Background/competences:	Allowable role:
Rasmus Simonsen	RBS	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering) Graduated in 2020 Experience 2023-present Ballard power system lead ATEX engineer on stationary products. Responsible for EX design and approval on various containerized solutions for land based and marine applications. EX consultant for various customers and internal projects. 2020-2023 Fuel cell development project manager. Lead engineer and owner of documentation for storage and testing facilities involving liquid and gas installations. Courses -ATEX course at Teknologisk Institut -Zone classification 60079-10 course at TML safety engineering -Internal Ballard H2 fuel cell course	Responsible person, Operatives/technician and designer

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Table 6-1: List of people and competences for Crosswind project			
Karin Hesselholt	KHE	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering) Graduated in 1987 Experience: 1987 to 2006 (Maersk Line). Worked as Marine Engineer -Chief Engineer onboard LPG/C vessels Performing maintenance work on cargo equipment as well as performing Approval Scheme on behalf of Lloyds Register. 2013 to 2017 (Svanehøj Pumps) Senior Project Manager on delivery of Cargo Pumps for Statoil Floating Storage Vessels. Preforming ATEX certification of the Cargo Pumps (capacity 500m^3 crude Oil/hour) for installation in Zone 1. Notified Body DTI (Teknologisk Institut) 2020 – present (Ballard Power Systems) Senior Application Engineer/Marine Specialist. Working with development of the Fcwave module and the Type Approval of the modules with Class Societies DNV, LR and ABS. Participating in HAZID approvals for marine installation of FCwave modules in Vessels. Courses -ATEX course at Teknologisk Institut -Internal Ballard H2 fuel cell course	Project Manager/Technician and designer

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Table 6-1: List of people and competences for Crosswind project			
Peter Blach	PBL	Qualification -Automation Engineer Graduated in 2012 Experience 2017 – present (Ballard Power Systems) Working with development of the FCwave module and the Type Approval of the modules with Class Societies DNV Courses -Internal Ballard H2 fuel cell course	Operatives/technician and designer
Peter Blok	PBH	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering)	Operatives/technician
Andreas Simony	ASM	Qualification -BSc - Motorsport Technology Graduated in 2016 -MSc - Racing Engine Design Graduated in 2017 Experience NA Courses -Internal Ballard H2 fuel cell course	Operatives/technician

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Table 6-1: List of people and competences for Crosswind project			
Rasmus Knudsen	RKL	Qualification -BSc - Motorsport Technology Graduated in 2016 -MSc - Racing Engine Design Graduated in 2017 Experience NA Courses -Internal Ballard H2 fuel cell course	Operatives/technician
Morten Fog	MFO	Qualification -Marine engineer (Bachelor in Technology Management and Marine Engineering) Graduated in 2008	Operatives/technician and designer

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Table 6-2: *Qualifications Rasmus Simonsen*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	x		
understanding and ability to read and assess engineering drawings	x		
practical understanding of explosion protection principles and techniques	x		
working knowledge and understanding of relevant standards in explosion protection	x		
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration	x		
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	x		
understanding of the general principles of types of protection and marking	x		
understanding of those aspects of equipment design which affect the protection concept	x		
understanding of content of certificates and relevant parts of this standard	x		
general understanding of inspection and maintenance requirements of IEC 60079-17	x		
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard	x		
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	x		
use of documentation in 4.2	x		
production of reports, e.g. inspection reports, to the user as identified in 4.2	x		
practical skills necessary for the preparation and installation of relevant concepts of protection	x		
use and production of installation records as identified in 4.2.	x		
Designer qualification			

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Table 6-2: *Qualifications Rasmus Simonsen*			
detailed knowledge of the general principles of explosion protection	x		
detailed knowledge of the general principles of types of protection and marking	x		
detailed knowledge of those aspects of equipment design which affect the protection concept	x		
detailed knowledge of content of certificates and relevant parts of this standard	x		
understanding of practical skills for the preparation and installation of relevant concepts of protection	x		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	x		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard	x		
general understanding of inspection and maintenance requirements of IEC 60079-17	x		
production of documentation specified in 4.2	x		
production of designers certificates to the user as identified in 4.2	x		
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved	x		
updated and production of installation records as identified in 4.2	x		

Table 6-3: *Qualifications Peter Blach*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques	X		

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Table 6-3: *Qualifications Peter Blach*			
working knowledge and understanding of relevant standards in explosion protection	X		
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		x	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking	X		
understanding of those aspects of equipment design which affect the protection concept	X		
understanding of content of certificates and relevant parts of this standard	X		Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		To an electrical point of view
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		To an electrical point of view
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		
practical skills necessary for the preparation and installation of relevant concepts of protection	X		Primarily to an electrical point of view
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection	X		
detailed knowledge of the general principles of types of protection and marking	X		

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Table 6-3: *Qualifications Peter Blach*			
detailed knowledge of those aspects of equipment design which affect the protection concept	X		To an electrical point of view
detailed knowledge of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
production of documentation specified in 4.2	X		
production of designers certificates to the user as identified in 4.2	X		
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved	X		
updated and production of installation records as identified in 4.2	X		

Table 6-4: *Qualifications Peter Blok*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques	X		

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Table 6-4: *Qualifications Peter Blok*			
working knowledge and understanding of relevant standards in explosion protection		X	
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking	X		
understanding of those aspects of equipment design which affect the protection concept	X		
understanding of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	Familiar with what is specified by designer
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		
practical skills necessary for the preparation and installation of relevant concepts of protection	X		
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection		X	
detailed knowledge of the general principles of types of protection and marking		X	

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Table 6-4: *Qualifications Peter Blok*			
detailed knowledge of those aspects of equipment design which affect the protection concept		X	
detailed knowledge of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection		X	
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	
general understanding of inspection and maintenance requirements of IEC 60079-17		X	Only what is instructed in manuals written by qualified personnel
production of documentation specified in 4.2		X	
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved		X	
updated and production of installation records as identified in 4.2		x	

Table 6-5: *Qualifications Andreas Simony*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering		X	
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques		X	

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Table 6-5: *Qualifications Andreas Simony*			
working knowledge and understanding of relevant standards in explosion protection		X	
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking		X	Informed on the relevant information I reference to our system
understanding of those aspects of equipment design which affect the protection concept		X	Informed on the relevant information I reference to our system
understanding of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	On instruction by qualified personnel
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2		X	Instructed in the relevant reports for Ballard use
practical skills necessary for the preparation and installation of relevant concepts of protection	X		
use and production of installation records as identified in 4.2.		X	Instructed in the relevant reports for Ballard use
Designer qualification			

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Table 6-5: *Qualifications Andreas Simony*			
detailed knowledge of the general principles of explosion protection		X	
detailed knowledge of the general principles of types of protection and marking		X	
detailed knowledge of those aspects of equipment design which affect the protection concept		X	
detailed knowledge of content of certificates and relevant parts of this standard		X	
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Will be informed in refence to the Ballard procedure of documenting inspection and maintenance
production of documentation specified in 4.2		X	Capable of creating mechanical documentation according to standard
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved		X	
updated and production of installation records as identified in 4.2		X	

Table 6-6: *Qualifications Rasmus Knudsen*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			

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Table 6-6: *Qualifications Rasmus Knudsen*			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques		X	
working knowledge and understanding of relevant standards in explosion protection		X	
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking		X	Informed on the relevant information I reference to our system
understanding of those aspects of equipment design which affect the protection concept		X	Informed on the relevant information I reference to our system
understanding of content of certificates and relevant parts of this standard		X	Understanding of the certificate part, but concrete content of the standard may be limited
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Only what is instructed in manuals written by qualified personnel
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	On instruction by qualified personnel
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		

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Table 6-6: *Qualifications Rasmus Knudsen*			
practical skills necessary for the preparation and installation of relevant concepts of protection	X		
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection		X	
detailed knowledge of the general principles of types of protection and marking		X	
detailed knowledge of those aspects of equipment design which affect the protection concept		X	
detailed knowledge of content of certificates and relevant parts of this standard		X	
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard		X	
general understanding of inspection and maintenance requirements of IEC 60079-17	x		Will be informed in refence to the Ballard procedure of documenting inspection and maintenance
production of documentation specified in 4.2		X	
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved		X	
updated and production of installation records as identified in 4.2		x	

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Table 6-7: *Qualifications Morten Fog*			
Qualification	Fulfil	Not fulfil	Note:
Responsible person qualifications			
general understanding of relevant electrical engineering	X		
understanding and ability to read and assess engineering drawings	X		
practical understanding of explosion protection principles and techniques	X		
working knowledge and understanding of relevant standards in explosion protection	X		
basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration		X	
Operatives/technicians qualifications			
understanding of the general principles of explosion protection	X		
understanding of the general principles of types of protection and marking	X		
understanding of those aspects of equipment design which affect the protection concept	X		
understanding of content of certificates and relevant parts of this standard	X		
general understanding of inspection and maintenance requirements of IEC 60079-17	X		Will be informed in refence to the Ballard procedure of documenting inspection and maintenance
familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		To the use for Ballard applications
understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
use of documentation in 4.2	X		
production of reports, e.g. inspection reports, to the user as identified in 4.2	X		
practical skills necessary for the preparation and installation of relevant concepts of protection	X		

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Table 6-7: *Qualifications Morten Fog*			
use and production of installation records as identified in 4.2.	X		
Designer qualification			
detailed knowledge of the general principles of explosion protection	X		
detailed knowledge of the general principles of types of protection and marking	X		
detailed knowledge of those aspects of equipment design which affect the protection concept	X		
detailed knowledge of content of certificates and relevant parts of this standard	X		
understanding of practical skills for the preparation and installation of relevant concepts of protection	X		
detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection	X		
detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard	X		
general understanding of inspection and maintenance requirements of IEC 60079-17	X		
production of documentation specified in 4.2	X		
production of designers certificates to the user as identified in 4.2		X	
practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved	X		
updated and production of installation records as identified in 4.2	X		

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Sub Section K03

Performance Test Results (FAT)

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	17/09/2024	First Issue

Document Title:	**BLPH Project - Performance Test Results (FAT)**
Document Number:	K559-2254-CWIWP4202202-K03-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K03-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Ballard Power Systems Europe A/S
Majsmarken 1
DK-9500 Hobro
K559-2254-CWIWP4202202-J08-002

Confirmation of Satisfactory FAT

Part No.	601456B-7002362 Incl. sub-assemblies: 601456B-7002973 601456B-7003716
Product name	FC PowerGen 1000kW
Serial No.	601456B

Ballard Power Systems Europe A/S confirms that the above-listed equipment has satisfactorily with comments undergone and passed the Factory Acceptance Test (FAT) according to

BLPH Project – Acceptance Test Procedure (FAT) [K559-2254-CWIWP4202202-J08-001]

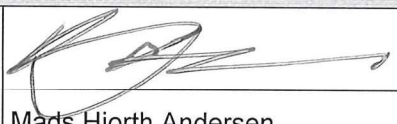
BLPH Project - Test Matrix for FAT and SAT [K559-2254-CWIWP4202202-J99-002]

601456B Crosswind BLPH FAT punch list [K559-2254-CWIWP4202202-J08-003]

prior to the shipment.

CrossWind C.V. acknowledges that the Factory Acceptance Test (FAT) for the above-listed equipment was witnessed and confirms that the test was performed satisfactorily with comments, and all agreed-upon specifications have been met.

Signatures

Ballard Power Systems Europe A/S			
Signature:			
Name:	Mads Hjorth Andersen		
Title:	Project Manager	Date:	04-09-2024
CrossWind C.V.			
Signature:			
Name:	Martin Taylor		
Title:	Crosswind Commissioning Manager	Date:	04-09-2024
Inspector			
Signature:			
Name:	Luigi Pignatelli		
Title:	Inspector for Crosswind	Date:	04-09-2024

Note: This document serves as formal confirmation that the FAT has been successfully completed and witnessed, with both parties in agreement on the satisfactory results. It should be signed by authorized representatives of both parties.

Short Title	Megablock Witnessed Factory Acceptance Test - CrossWind
Full Title	Megablock Witnessed Factory Acceptance Test - CrossWind
Abstract	*A selection of the Factory Acceptance Tests of the CrossWind Megablock system with witnesses from the CrossWind, Shell, Rosetti Marino and a surveyor from Fulkrum (CrossWind).*

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Revision Record

Rev #	Description	Revised By	Date (dd-mm-yyyy)
-	Initial Release	RKN	27-02-2024
1	General updates	RKN	17-06-2024
1a	Updated with results	TAN	20/8-2024
2	Updated leak test procedure	TAN	30-08-2024
2a	Updated with results	TAN	30-08-2024
2b	Updated with leakage rates	MHA	02-09-2024

Luigi Signarelli
ON BEHALF OF CrossWind
DATE 4/9/2024 WR

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1.0 Executive Summary

This document outlines the tests to be included in the witnessed Factory Acceptance Test. These tests aim to show the overall functionality of the fuel cell-based power plant. The verification should show the capability of delivering the expected AC power and that the product is ready to be delivered and installed on site.

When the delegations from CrossWind, Shell, Rosetti Marino and the surveyor from Fulkrum (CrossWind) were at Ballard Europe, Hobro to witness the selection of Factory Acceptance Tests 4/12 tests were performed and passed. The remaining eight tests are to be performed later are the following:

- F18 H2 leakage test
- O01 System Start/stop
- O09 Load Test – Step response 0 to 35%
- O10 Load Test – step response 35% to 70%
- O11 Load Test – Step response 65 to 100%
- O12 Load Test – 100% stability test – 3 hours
- O13 Load Test – Step response 100% to 50%
- O14 Load Test – step response 50% to 0%

2.0 References

- PWR008 Ballard commissioning document
- EN 60204-1
- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure
- SPC ID 0104 H2 Leak Test Procedure

3.0 Definitions and Acronyms

FC	FCwave™
H2	Hydrogen
FAT	Factory Acceptance Test
HT1	High temperature 1050kW cooling system
HT2	High temperature 1050kW cooling system
LT	Low temperature cooling system

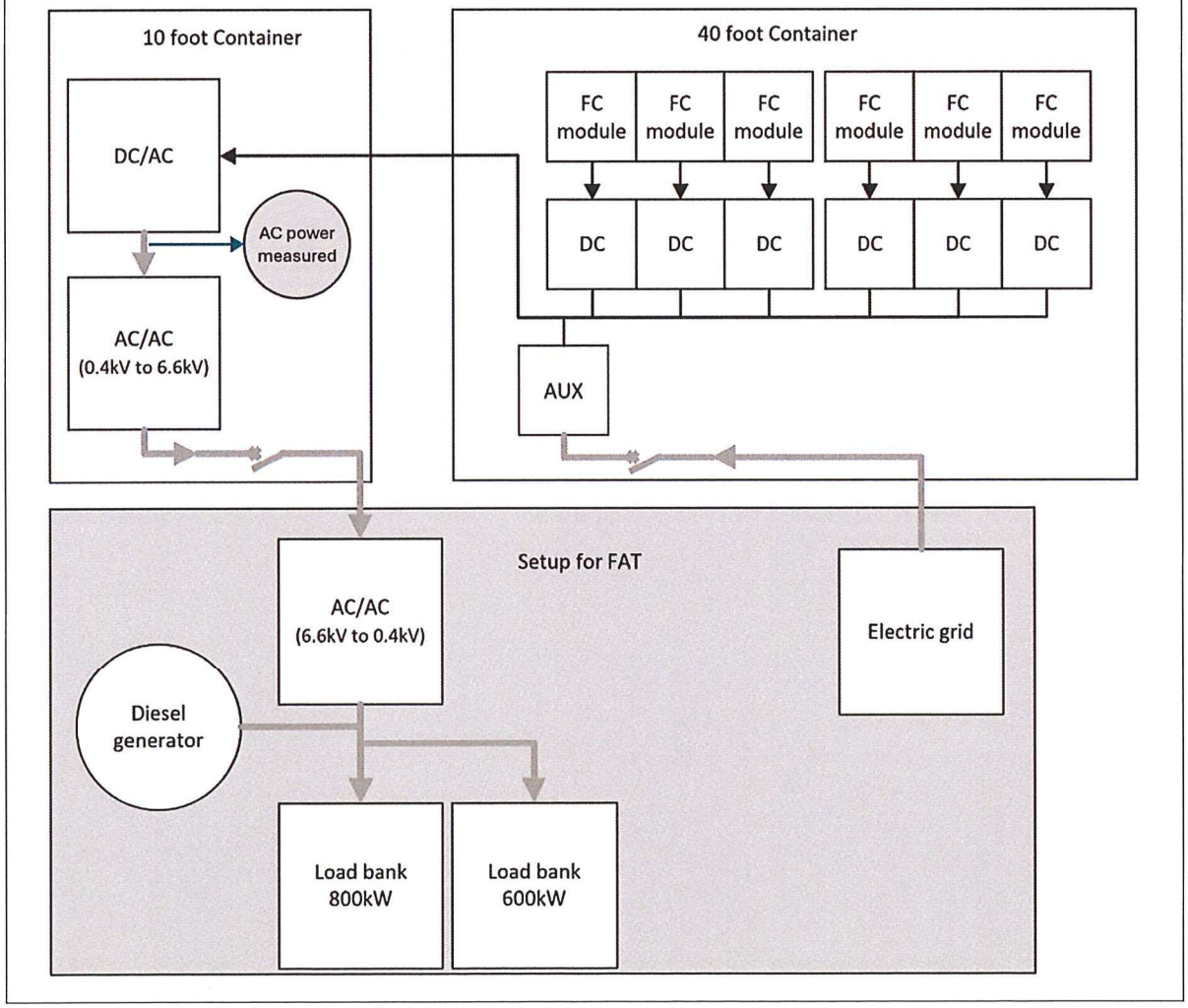
4.0 Objectives and Background

This document describes the witnessed Factory Acceptance Tests. The tests do not include the internal testing that has been done to secure product maturity, mechanical and electrical connections have been done correctly.

The scope of testing is:

- Go through the Megablock with the customer to find defects that needs to be corrected
- Safety systems are functioning correctly in a complete Megablock with coolers.
- Megablock produces AC current, and the tests shall verify the capability to produce AC current following the demand.

Figure 1: Megablock System test overview



5.0 Functional tests

5.1 F02 Visual inspection

5.1.1 Test

The test involves an examination of the paint job through visual inspection, assessing the overall build quality, and checking for any dents. The focus is also on evaluating the assembly quality to ensure compliance with weather resistance.

5.1.2 Relevant Standard / document

- No reference

5.1.3 Brief Test Plan

- Visual inspection with customer of full system meaning inside and outside container solution.
- Take comprehensive pictures of the full system and test setup, including close-ups of vital components, with timestamps for reference.

5.1.4 Pass/Fail criteria.

- Visual inspect with customer to review quality of full system.

5.1.5 Test Result

Table 1: Visual inspection – Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Inspection of paint	Accepted	Pass	See item list for further elaboration
13/8-2024	Assessing build quality	Accepted	Pass	See item list for further elaboration
13/8-2024	Check for dents	Accepted	Pass	See item list for further elaboration

5.2 F07 Electrical safety test – 10-foot container

5.2.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

5.2.2 Relevant Standard / document

- EN 60204-1

5.2.3 Brief Test Plan

- According to EN 60204-1

5.2.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

5.2.5 Test Result

Table 2: Electrical safety test - Test results

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Grounding Continuity	Accepted	Pass	-
13/8-2024	High Potential	Accepted	Pass	-

Table 3: Electrical safety test - calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
Metrel CE-Multitester	086-003	19/1-2025	Grounding Continuity and High Potential

5.3 F08 Electrical safety test – 40-foot container

5.3.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

5.3.2 Relevant Standard / document

- EN 60204-1

5.3.3 Brief Test Plan

- According to EN 60204-1

5.3.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

5.3.5 Test Result

Table 4: Electrical safety test - Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Grounding Continuity	Accepted	Pass	-
13/8-2024	High Potential	Accepted	Pass	-

Table 5: Electrical safety test - Calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
Metrel CE-Multitester	086-003	19/1-2025	Grounding Continuity and High Potential

5.4 F10 Safety

5.4.1 Test

Conduct tests of safety inputs and outputs, including emergency stop buttons, smoke detectors, gas detectors and external connections.

5.4.2 Relevant Standard / document

- Safety input checklist according to EN/ISO 13849-2 procedure

5.4.3 Brief Test Plan

- Trigger each safety input according to checklist.
  - Emergency pushbuttons
  - Smoke detectors test
  - H2 sensor test
  - External safety switches
  - External feedback

5.4.4 Pass/Fail criteria.

- Verified according to checklist.
- Each item triggers the correct alarm

5.4.5 Test Result

Table 6: Safety - Test Result

Date tested	Item	Result	Pass/Fail	Notes
13/8-2024	Emergency pushbuttons	OK	Pass	-
13/8-2024	Smoke detectors	OK	Pass	3 sensors in 40ft container and 1 sensor in 10 ft container
13/8-2024	H2 sensors	OK	Pass	3 sensors in 40ft container
13/8-2024	External safety switches	OK	Pass	-
13/8-2024	External feedback	OK	Pass	-

Table 7: Safety - Calibration Equipment

Unit	Equipment number	Calibration due date	Equipment used for
Dräger calibration gas, 2% Hydrogen	Cylinder No: 955-657732	Valid until 10/1-2029	H2 sensors

5.5 F18 H_2 Leakage test

5.5.1 Test procedure

All pipework and H2 instrumentation subassemblies must be inspected, recorded, verified and pass in accordance with the procedure in section 5.4 in *SPC ID 0104 H2 Leak Test Procedure Rev 002* prior to full system FAT.

System H2 leakage test is done system pressure decay test, according to section 5.5 in *SPC ID 0104 H2 Leak Test Procedure Rev 002.*

5.5.2 Pass/Fail criteria.

Pressure decay test with a maximum leakage no greater than specified in test procedure.

Result details are documented in the template *SPC ID 0204 System pressure decay test template*

Parameter	Value	Description
L_A [Nm^3/h]	**2,72 – 3,58 x10^{-3}**	**Maximum allowed pressure decay to pass pressure decay test, where L_A = L_S + L_Mu**
L_S [Nm^3/h]	0	Summarized expected leak rates of all components in the system (per design leak rate).
L_Mu [Nm^3/h]	2,72 – 3,58 x10^{-3}	Calculated accuracy of the measuring system, used to perform the test.
L_C [Nm^3/h]	2,7x10^{-5}	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

5.5.3 Test Result

Table 8: H2 leakage - Test Result

Date tested	Item	Leakage rate L_1 [Nm^3/h]	Pass/Fail	Notes
3/9-2024	H2 line 1	4.03E-05	Pass	-
3/9-2024	H2 line 2	8.06E-05	Pass	-
3/9-2024	H2 line 3	0.00E+00	Pass	-
3/9-2024	H2 line 4	1.60E-04	Pass	-
3/9-2024	H2 line 5	7.27E-05	Pass	-
3/9-2024	H2 line 6	-8.16E-05	Pass	-

6.0 Operational tests

Operations are done using operator HMI or remote HMI in normal operating mode.

6.1 O01 System Start/Stop - Normal low load operation.

6.1.1 Test

Fuel Cell system can start, deliver minimum power and perform controlled stop without faults. This test is based on DC power.

6.1.2 Relevant Standard / document

- No reference

6.1.3 Brief Test Plan

- All FC in standby
- Request 100kW DC
- Delay 120 seconds
- Request zero power
- Repeat with new preferred FC until all tested.

6.1.4 Pass/Fail criteria.

- Fuel Cell Package starts without faults.
- No persistent system alarms.
- Correct available power signal.
- DC Power output within +/-5% and stable in less than 60 seconds
- Fuel Cell Package stops without faults.
- FC in stand-by in less than 30 seconds.

6.1.5 Test Result

Table 9: System Start/Stop – Normal low load operation - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	FCwave 1	All pass criterias passed except time to standby	Pass with note	Shut down to standby longer than 30 seconds
3/9-2024	FCwave 2	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 58 seconds. Power output dipped to 82 kW during the test.
3/9-2024	FCwave 3	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 55 seconds.
3/9-2024	FCwave 4	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 59 seconds.
3/9-2024	FCwave 5	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 57 seconds.
3/9-2024	FCwave 6	All pass criterias passed except time to standby	Pass with note	Shut down to standby took 1 minute 3 seconds.

6.2 O09 Load Test – step response 0 to 35%

6.2.1 Test

Test step response by adding 35% load in one step from no load while measuring AC power quality.

6.2.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.2.3 Brief Test Plan

- All FC in stand-by.
- Apply set point by requesting 350kW AC

6.2.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.2.5 Test Result

Table 10: Load Test - step response 0 to 35% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 0-35%	45 seconds for start-up 0-350kW AC. Slight overshoot on 30 kW AC	Pass	With reference to document C08 it is estimated that a ramp time to 500 kW is 75 seconds.
3/9-2024	AC power quality	2,8-2,9% VAC THD 2-50 No alarms	Pass	

6.3 O10 Load Test – step response 35% to 70%

6.3.1 Test

Test step response by adding 35% load in one step to reach 70% load while measuring AC power quality.

6.3.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.3.3 Brief Test Plan

- 3 FC running delivering 350kW AC steady state.
- 2 FC in stand-by
- Apply set point by requesting 700kW AC power.

6.3.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC
- AC power quality within SPC ID 107
- No persistent system alarms.

6.3.5 Test Result

Table 11: Load Test - step response 35% to 70% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 35%-70%	All 3 started up. 23 seconds startup time	Pass	With reference to document C08 it is estimated that a ramp time from 250 kW to 750 kW is 45 seconds.
3/9-2024	AC power quality	2,8-3,0 % VAC THD 2-50 No alarms	Pass	

6.4 O11 Load Test – step response 65% to 100%

6.4.1 Test

Test step response by adding 35% load in one step to reach full load while measuring AC power quality.

6.4.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.4.3 Brief Test Plan

- 6 FC running delivering 650kW AC steady state.
- Apply set point by requesting 1000kW AC power.

6.4.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Startup time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.4.5 Test Result

Table 12: Load Test - step response 65% to 100% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 65%-100%	18 seconds startup time	Pass	With reference to document C08 it is estimated that a ramp time from 250 kW to 750 kW is 45 seconds.
3/9-2024	AC power quality	3,0-3,1 % VAC THD 2-50 No alarms	Pass	

6.5 O12 Load Test – 100% stability test - 3 hours.

6.5.1 Test

Test steady state at 100% load for 3 hours while measuring power quality.

6.5.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.5.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.

6.5.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.5.5 Test Result

Table 13: Load Test – Steady state 100% load - Test Result

Date tested	Item	Result	Pass/Fail	Notes
04-09-24	Full load test	1000 kW for 3 hours	Pass	See below
04-09-24	AC power quality	2.3-3.6 % VAC THD 2-50 No alarms	Pass	

- Following added to document 05/09/2024
- In agreement with customer, after half elapsed time of the test, BOP load was increased to maximum by the following:
  - All HT fans forced to 100%
  - HT Coolant pumps forced to 70%
  - Ventilation (40ft+10ft) increased to 100%
- No impact on power delivery was observed.

6.6 O13 Load Test – step response 100% to 50%

6.6.1 Test

Test step response by removing 50% load in one step at full load while measuring power quality.

6.6.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.6.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.
- Request 500kW AC.

6.6.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.6.5 Test Result

Table 14: Load Test - step response 100% to 50% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3/9-2024	Step response 100%-50%	Ramp down in 15 seconds	Pass	Wit reference to document C08 it is estimated that a ramp down time from 800 kW to 200 kW is 15 seconds.
3/9-2024	AC power quality	3,0-2,6 % VAC THD 2-50 No alarms	Pass	

6.7 O14 Load Test – step response 50% to 0%

6.7.1 Test

Test step response by removing 50% load in one step to no load while measuring AC power quality.

6.7.2 Relevant Standard / document

- SPC ID 0107 Power Quality Measurement Test Procedure

6.7.3 Brief Test Plan

- 3 FC running delivering 500kW AC.
- Request 0% and apply set point.

6.7.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- FC: Shutdown time < curve+5 seconds at any FC.
- AC power quality within SPC ID 107
- No persistent system alarms.

6.7.5 Test Result

Table 15: Load Test - step response 50% to 0% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
03-09-2024	Step response 50%-0%		Pass	Test is executed with 6 FC instead of 3 as the plan describes
—	AC power quality	NA	NA	Not applicable due to the unit not producing power

ON BEHALF OF Ballard
DATE 6/9/2024 WR

SPC ID 0203 Pipework inspection and leakage test check sheet

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on allowable leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 heater, String 1	1-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 1	1-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 3	3-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 5	5-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater string 1,2,3 Inlet

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





H2 Heater string 4,5,6 Inlet



H2 Heater string 1,2,3,4,5,6 Shut-off Valve & Pipes

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





SPC ID 0203 Pipework inspection and leakage test check sheet

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on expected leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 Heater+Container, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 1	1-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 3	3-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container string 1,2,3,4,5,6



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

H2 Container pipe to FCwave



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

SPC ID 0204 System Pressure Decay Test Template

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-08-2024
2	Updated	TAN	09-09-2024

Purpose	Pressure decay test template for recording tightness and evaluating system pipework integrity
Reference procedure	SPC ID 0104 rev 002 H2 Leak Test Procedure

Checked by	MHA	Date: 09/09-2024
Approved by	MHA	Date: 09/09-2024

Title	System Pressure Decay, Complete Assembly, Crosswind
Project	601456B Crosswind BLPH
Test date	03-09-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓ see Sheet "P&ID"

Test volume	String 1 HA01+DA02-QM01 to YV_H30 solenoid valve in FCwave 1. Similar valves for string 2-6.
Test fluid/gas	Hydrogen
Test location	Crosswind Container, Majsmarken 1, 9500 Hobro Denmark
Test performed by	TAN
Results approved by	MHA
Filing date	09-09-2024

L_S - Expected leak rate for pipework system							
Ferrule fittings tightness tolerance	< 0		bar				
Bonded seal tightness tolerance	< 0		bar				
L_S total*	= 0		bar				
L_S total	=	0	NM3/h				
L_Mu - Measuring system uncertainty							
pressure gauge uncertainty							
transmitter FS (full scale)	=	16	barg				
Linearity	<	0.2	% of FS	=	<	32	mbar
Non-repeatability	<	0.1	% of FS	=	<	16	mbar
Analogue input	±	10	microA	=		10	mbar/10 minutes
Accuracy ±0.25% actual reading	±	32.5	microA		=	32.5	mbar
Temperature uncertainty (3 Kelvin)				=	±	82	mbar/10 minutes
L_Mu total					=	172.5	mbar

*=All joints and valves are considered to be classified "enhanced tightness". Hence zero allowable leak rate

Calculation of L_Mu, measuring system uncertainty

	V	T0	T1	T2	P0	P1	P2	Pa1	Pa2	t	L_Mu
	M3	°C	°C	°C	kPa	barg	barg	kPa	kPa	minutes	NM3/h
String 1	3.46E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.53E-03
String 2	3.05E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.12E-03

String 3	2.67E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	2.72E-03
String 4	2.74E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	2.80E-03
String 5	3.12E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.19E-03
String 6	3.50E-03	15	15	15	101.325	7.150	6.978	101.325	101.325	10	3.58E-03

Calculation of L_A, max evaluated leak rate for pipework system acceptance

	L_S	L_Mu		L_A
	NM3/h	NM3/h		NM3/h
String 1	0	3.53E-03	=	3.53E-03
String 2	0	3.12E-03	=	3.12E-03
String 3	0	2.72E-03	=	2.72E-03
String 4	0	2.80E-03	=	2.80E-03
String 5	0	3.19E-03	=	3.19E-03
String 6	0	3.58E-03	=	3.58E-03

Procedure

Fill in design pressure =	6.5	barg
The Test Pressure is 1.1 times design pressure or above =	7.15	barg
If the system previosly has been leakage tested with formier gas, this test can also use the used gas for operation		
To perform the test follow "Sequence" paragraph 5.5.3 in SPC 0104 H2 Leak Test Procedure		

Calculation of L1, actual leak rate

	V	T0	T1	T2	P0	P1	P2	Pa1	Pa2	t	L1 (gas leakage rate)
	M3	°C	°C	°C	kPa	barg	barg	kPa	kPa	minutes	NM3/h
String 1	0.003458573	15	19.7	19.7	101.325	7.494	7.492	1015	1015	10	4.03E-05
String 2	0.003458573	15	19.7	19.7	101.325	7.578	7.574	1015	1015	10	8.06E-05
String 3	0.002666793	15	19.7	19.7	101.325	7.95	7.95	1015	1015	10	0.00E+00
String 4	0.002741607	15	19.7	19.7	101.325	7.552	7.542	1015	1015	10	1.60E-04
String 5	0.003120525	15	19.7	19.7	101.325	7.452	7.448	1015	1015	10	7.27E-05
String 6	0.003500483	15	19.7	19.7	101.325	7.28	7.284	1015	1015	10	-8.16E-05

Sensor	Sensor placement
Temperature sensor T1 & T2	BT01 Sensor in H2 heater
Pressure sensor P1 & P2	FCwave pressure inlet sensor
Atmospheric pressure Pa1 & Pa2	Data from https://www.dmi.dk/maalinger/show/DK/2620167/Hobro/

Result of test

	L1	<	L_A	Pass (Below acceptance criteria L_A)
	NM3/h		NM3/h	Pass/Fail
String 1	4.03E-05	<	3.53E-03	Pass
String 2	8.06E-05	<	3.12E-03	Pass
String 3	0.00E+00	<	2.72E-03	Pass
String 4	1.60E-04	<	2.80E-03	Pass
String 5	7.27E-05	<	3.19E-03	Pass
String 6	-8.16E-05	<	3.58E-03	Pass

Title: System Pressure Decay, Complete Assembly, CrossWind
P&ID of Hydrogen Supply system

SPC ID: 0204
Revision: 2

Printed on: 09-09-2024

Hydrogen Supply System - Fuel Cells 1-6

=RE01
Fuel Cell System 1

+GB01
FCwave 1

-XM01
20mm
H2 Supply Inlet

-WP_H2927
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB02
FCwave 2

-XM01
20mm
H2 Supply Inlet

-WP_H2926
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB03
FCwave 3

-XM01
20mm
H2 Supply Inlet

-WP_H2925
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

=RE02
Fuel Cell System 2

+GB04
FCwave 4

-XM01
20mm
H2 Supply Inlet

-WP_H2924
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB05
FCwave 5

-XM01
20mm
H2 Supply Inlet

-WP_H2923
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

+GB06
FCwave 6

-XM01
20mm
H2 Supply Inlet

-WP_H2922
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

=HA01+DA02
Hydrogen Supply System, Container #1 Outside

-XT01
Wall pass-through

-WP_H2917
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT02
Wall pass-through

-WP_H2916
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT03
Wall pass-through

-WP_H2915
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT04
Wall pass-through

-WP_H2914
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT05
Wall pass-through

-WP_H2913
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-XT06
Wall pass-through

-WP_H2912
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

Y V
QM21

=HA01+DA02-QM21
DN20
Shut-off valve

Y V
QM22

=HA01+DA02-QM22
DN20
Shut-off valve

Y V
QM23

=HA01+DA02-QM23
DN20
Shut-off valve

Y V
QM24

=HA01+DA02-QM24
DN20
Shut-off valve

Y V
QM25

=HA01+DA02-QM25
DN20
Shut-off valve

Y V
QM26

=HA01+DA02-QM26
DN20
Shut-off valve

-WP_H2907
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2906
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2905
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2904
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2903
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2902
Hydrogen
3.5-4.5 barg
-5.4 - 80°C
<4.9 g/s

Y V
QM11

=HA01+DA02-QM11
DN20
Shut-off Valve

Y V
QM12

=HA01+DA02-QM12
DN20
Shut-off Valve

Y V
QM13

=HA01+DA02-QM13
DN20
Shut-off Valve

Y V
QM14

=HA01+DA02-QM14
DN20
Shut-off Valve

Y V
QM15

=HA01+DA02-QM15
DN20
Shut-off Valve

Y V
QM16

=HA01+DA02-QM16
DN20
Shut-off Valve

-BL01
SI = 11 mm
Ex Point Liquid Detection

BT01
PT1000 -40...150 °C
Liquid Temperature Sensor

-CM01
SS316, Volume 146L
Hydrogen Heater Vessel

-WP01
DN25, 3000m
Tube Coil

-WP02
DN25, 3000m
Tube Coil

-WP03
DN25, 3000m
Tube Coil

-WP04
DN25, 3000m
Tube Coil

-WP05
DN25, 3000m
Tube Coil

-WP06
DN25, 3000m
Tube Coil

-EA01
3x400V, 9kW, Ex
Heating Element 1

-EA02
3x400V, 9kW, Ex
Heating Element 2

-WP_H2947
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2946
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2945
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2944
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2943
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

-WP_H2942
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
<4.9 g/s

H

=HA01+DA02-QM01
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM02
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM03
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM04
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM05
DN25
Isolation Valve, Lockable

H

=HA01+DA02-QM06
DN25
Isolation Valve, Lockable

=HKN70
Baseload Power Hub, Hydrogen Supply

0.5 - 25.4 g/s
-5.4 - 80°C
3.5 - 4.5 barg
Hydrogen

=HA01+DA02-XM01
DN32 ASME B16.5
H2 Supply Connection

P T
BT01

=HA01+DA02-BP01
0...10 barg
Hydrogen Inlet
Pressure Transmitter

-WP_H2900
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
0.5 - 25.4 g/s

H

=HA01+DA02-QM00
DN32
Manual shutoff valve
Lockable

-WP_H2901
Hydrogen
3.5 - 4.5 barg
-5.4 - 80°C
0.5 - 25.4 g/s

Reference Item Number	Ballard Part # TBD
EPLAN Project Name	6014568 - Shell Baseload Power Hub
EPLAN Revision	-.P13
EPLAN Project Pages	319
=	+ + + & 802

REVISION INFORMATION	
DESCRIPTION	
DATE	08-Mar-24

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THIS DOCUMENT'S APPROVAL IS MANAGED BY E-SIGNATURE ON FILE IN BALLARD POWER SYSTEMS' PLM SYSTEM

DRAWING	6014568 C03 Process and Instrumentation Diagram
REVISION	-.P13
DRAWING TITLE	Crosswind/Shell Baseload Power Hub, Fuel Cell Container 1MW, no BESS
SHEET TYPE/DESC	Hydrogen Supply System
ALL SHEETS ARE THE SAME REVISION STATUS	SIZE A1
LANGUAGE EN	SHEET/TOTAL 4 / 14

FRMS110653/08

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	13-08-2024
Test location	Crosswind Containers, Majsmarken 1, 9500 Hobro, Denmark
Test performed by	PBL & TAN

Grounding continuity

EN 60204-1:2018 - Section 18.2.2 - Test 1

Test performed with a test current of 10A

Main location	Location	Measurement	Unit
40ft container	Busbar to busbar	0.024	Ohm
	Module 1	0.018	Ohm
	DC/DC cabinet 1	0.023	Ohm
	Module 2	0.024	Ohm
	DC/DC cabinet 2	0.019	Ohm
	Module 3	0.026	Ohm
	DC/DC cabinet 3	0.016	Ohm
	Module 4	0.026	Ohm
	DC/DC cabinet 4	0.016	Ohm
	Module 5	0.024	Ohm
	DC/DC cabinet 5	0.017	Ohm
	Module 6	0.029	Ohm
	DC/DC cabinet 6	0.015	Ohm
	Control cabinet	0.021	Ohm
	Control cabinet right door	0.032	Ohm
	Lifting crane track, dolly	0.028	Ohm
	LT piping	0.031	Ohm
	Isolation transformer cover	0.039	Ohm
	Cable tray	0.019	Ohm

Main location	Location	Measurement	Unit
10ft container	Busbar to busbar	0.019	Ohm
	Main DC/Acpoint 1	0.032	Ohm
	Main DC/Acpoint 2	0.024	Ohm
	Main DC/Acpoint 3	0.027	Ohm
	DC/AC conduncter point 1	0.037	Ohm
	DC/AC conduncter point 2	0.022	Ohm
	DC/AC conduncter point 3	0.023	Ohm
	LT coolant pipe	0.024	Ohm
	Cable tray	0.02	Ohm
	Main transforer grounding bolt	0.023	Ohm
	Main transformer chassis	0.02	Ohm
	Cable tray	0.022	Ohm

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	13-08-2024
Test location	Crosswind Containers, Majsmarken 1, 9500
Test performed by	PBL & TAN

Isolation resistance
EN 60204-1:2018 - Section 18.3
Test performed with a test voltage of 1000V

Main location	Location	Measurement	Unit
40 ft container	L1-PE	> 999.9	MOhm
	Cooling skid L1	10.01	Mohm
	Colling skid L2	6.252	Mohm
	Cooling skid L3	12.81	Mohm
	AUX supply L1	251	Mohm
	AUX supply L2	337	MOhm
	AUX supply L3	237	Mohm

Main location	Location	Measurement	Unit
10ft container	L1+L2+L3-PE on AC circuit	592	Mohm

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	13-08-2024
Test location	Crosswind Containers, Majsmarken 1, 9500
Test performed by	PBL & TAN

Isolation resistance

EN 60204-1:2018 - Section 18.4

Test performed with a test voltage of 2500VAC

Main location	Location	Measurement	Unit	Notes
40ft container	PE and L1	0	mA	The surge arrestor has been bypassed to allow the test to be conducted
	PE and L2	0	mA	
	PE and L3	0	mA	

Main location	Location	Measurement	Unit	Notes
10 FT container	PE and L1	7.1	mA	
	PE and L2	7.1	mA	
	PE and L3	7	mA	

Date: 2024-09-11

Author: PBL, TAN

Ballard Power Systems Europe

Summary:

Thermographic report from Crosswind FAT2, 2024-09-04.

System is operating at 100% (1MW) and have been at full power for >1 hour with the cooling and ventilation system operating at 100%.

Test start at 8:55

The first few images are the system from a distance.

First half of the report shows thermal images from inside the 40ft container, with focus on DC power cables, pumps and fans and process exhaust pipes.

Second half of the report shows the system test equipment and outside the system.

There are no items of concern.

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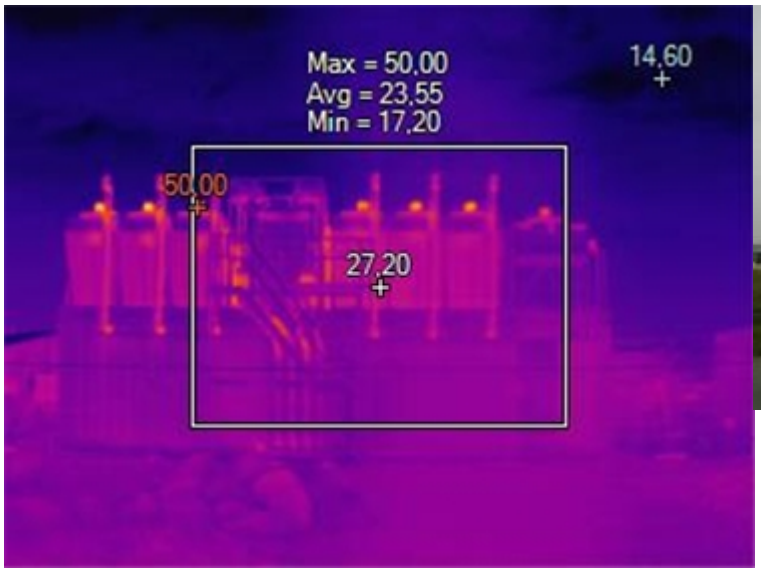




Image Info

Name	IR_00252.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	14,60 °C to 50,00 °C
Image Time	04/09/2024 11:45:17 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27,2 °C	27,2 °C	27,2 °C	0,95	22,0 °C	0,00	
Centerbox	50,0 °C	17,2 °C	23,6 °C	0,95	22,0 °C	2,67	
Hot	50,0 °C	50,0 °C	50,0 °C	0,95	22,0 °C	0,00	
Cold	14,6 °C	14,6 °C	14,6 °C	0,95	22,0 °C	0,00	

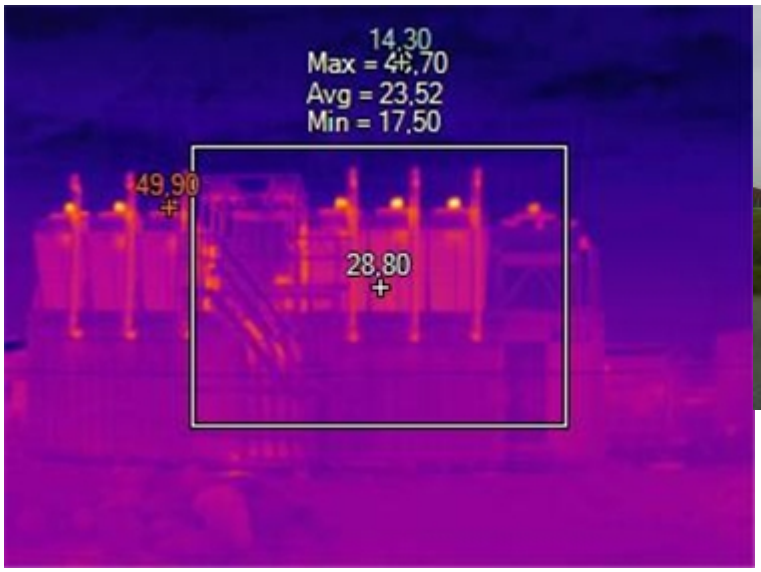


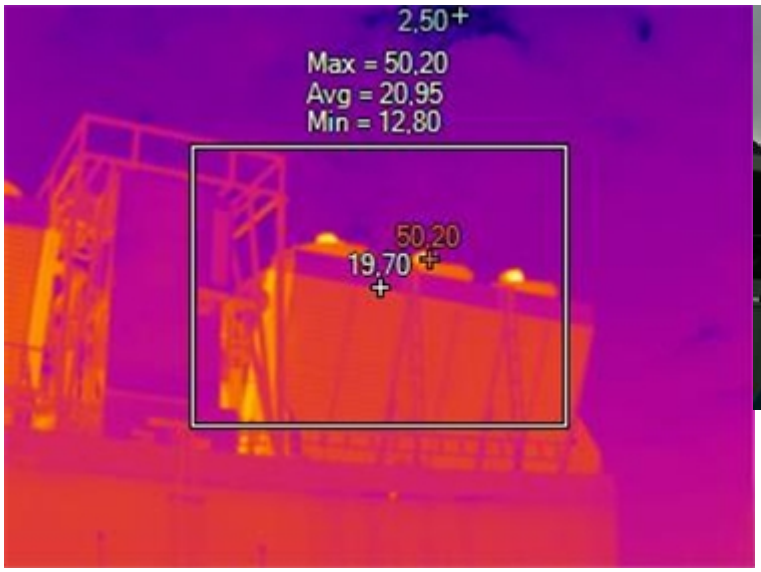


Image Info

Name	IR_00251.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	14,30 °C to 49,90 °C
Image Time	04/09/2024 11:45:00 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,8 °C	28,8 °C	28,8 °C	0,95	22,0 °C	0,00	
Centerbox	49,7 °C	17,5 °C	23,5 °C	0,95	22,0 °C	3,28	
Hot	49,9 °C	49,9 °C	49,9 °C	0,95	22,0 °C	0,00	
Cold	14,3 °C	14,3 °C	14,3 °C	0,95	22,0 °C	0,00	



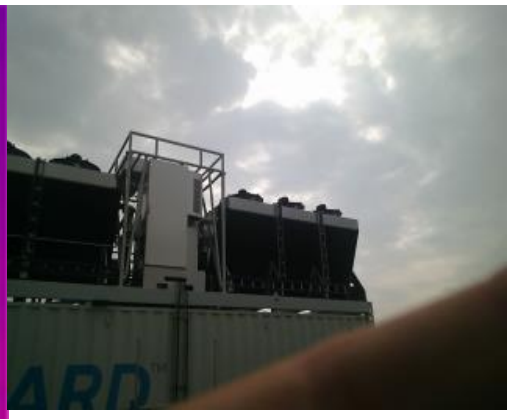


Image Info

Name	IR_00250.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	2,50 °C to 50,20 °C
Image Time	04/09/2024 11:43:56 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	19,7 °C	19,7 °C	19,7 °C	0,95	22,0 °C	0,00	
Centerbox	50,2 °C	12,8 °C	20,9 °C	0,95	22,0 °C	5,34	
Hot	50,2 °C	50,2 °C	50,2 °C	0,95	22,0 °C	0,00	
Cold	2,5 °C	2,5 °C	2,5 °C	0,95	22,0 °C	0,00	

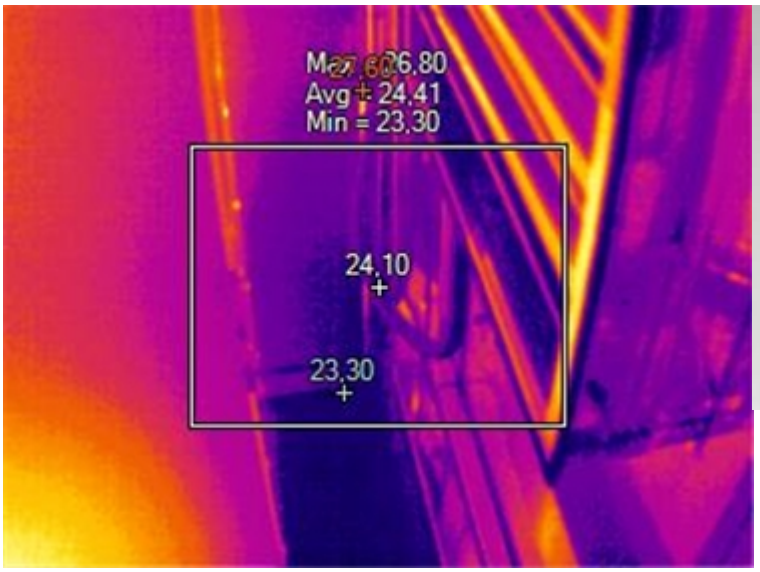




Image Info

Name	IR_00248.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,30 °C to 27,60 °C
Image Time	04/09/2024 11:31:07 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24,1 °C	24,1 °C	24,1 °C	0,95	22,0 °C	0,00	
Centerbox	26,8 °C	23,3 °C	24,4 °C	0,95	22,0 °C	0,56	
Hot	27,6 °C	27,6 °C	27,6 °C	0,95	22,0 °C	0,00	
Cold	23,3 °C	23,3 °C	23,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00247.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	23.10 °C to 28.60 °C
Image Time	04/09/2024 11:31:00 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	28.6 °C	23.2 °C	23.9 °C	0.95	22.0 °C	0.55	
Hot	28.6 °C	28.6 °C	28.6 °C	0.95	22.0 °C	0.00	
Cold	23.1 °C	23.1 °C	23.1 °C	0.95	22.0 °C	0.00	

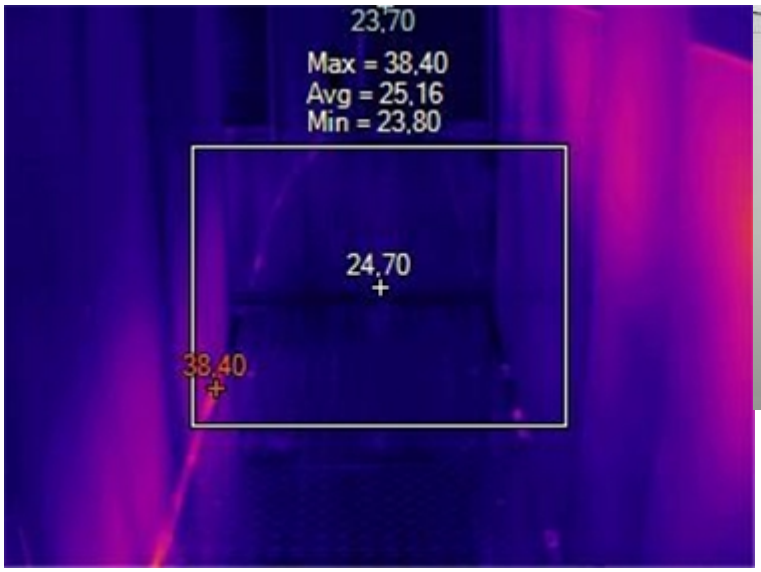




Image Info

Name	IR_00246.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,70 °C to 38,40 °C
Image Time	04/09/2024 11:30:47 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24,7 °C	24,7 °C	24,7 °C	0,95	22,0 °C	0,00	
Centerbox	38,4 °C	23,8 °C	25,2 °C	0,95	22,0 °C	0,71	
Hot	38,4 °C	38,4 °C	38,4 °C	0,95	22,0 °C	0,00	
Cold	23,7 °C	23,7 °C	23,7 °C	0,95	22,0 °C	0,00	

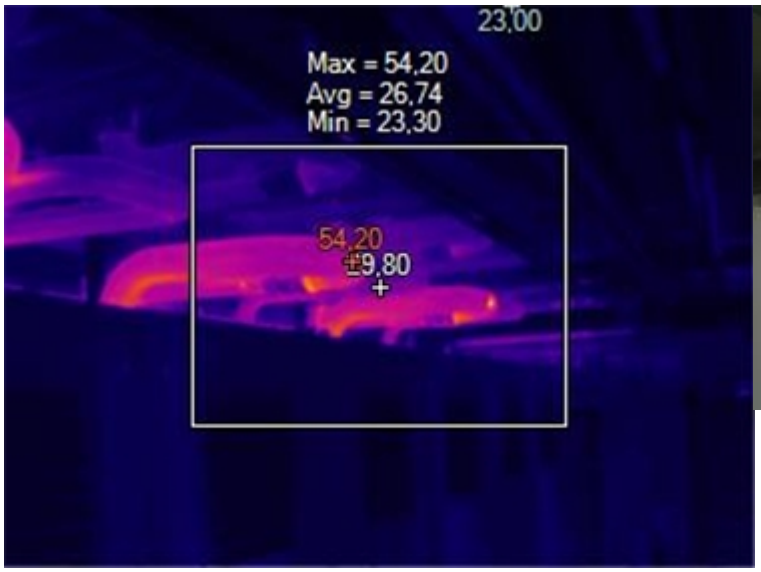




Image Info

Name	IR_00245.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,00 °C to 54,20 °C
Image Time	04/09/2024 11:30:41 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,8 °C	29,8 °C	29,8 °C	0,95	22,0 °C	0,00	
Centerbox	54,2 °C	23,3 °C	26,7 °C	0,95	22,0 °C	3,47	
Hot	54,2 °C	54,2 °C	54,2 °C	0,95	22,0 °C	0,00	
Cold	23,0 °C	23,0 °C	23,0 °C	0,95	22,0 °C	0,00	

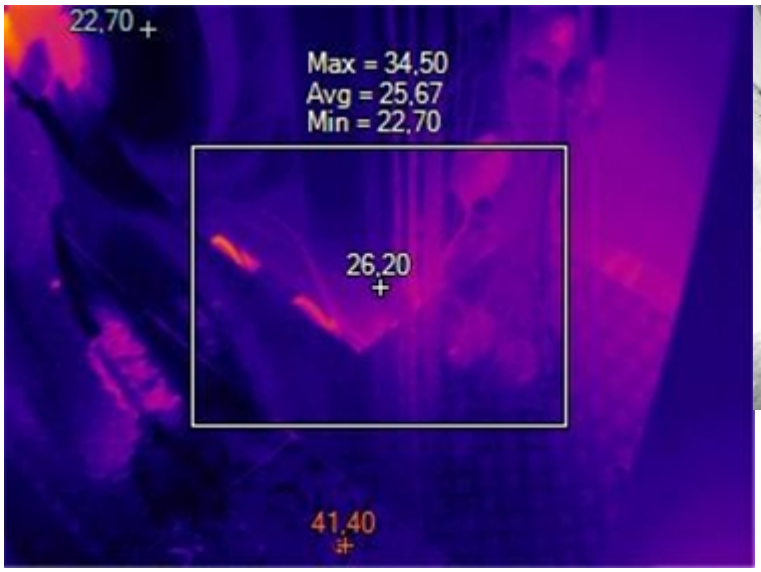




Image Info

Name	IR_00244.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,70 °C to 41,40 °C
Image Time	04/09/2024 11:30:33 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	26,2 °C	26,2 °C	26,2 °C	0,95	22,0 °C	0,00	
Centerbox	34,5 °C	22,7 °C	25,7 °C	0,95	22,0 °C	1,26	
Hot	41,4 °C	41,4 °C	41,4 °C	0,95	22,0 °C	0,00	
Cold	22,7 °C	22,7 °C	22,7 °C	0,95	22,0 °C	0,00	

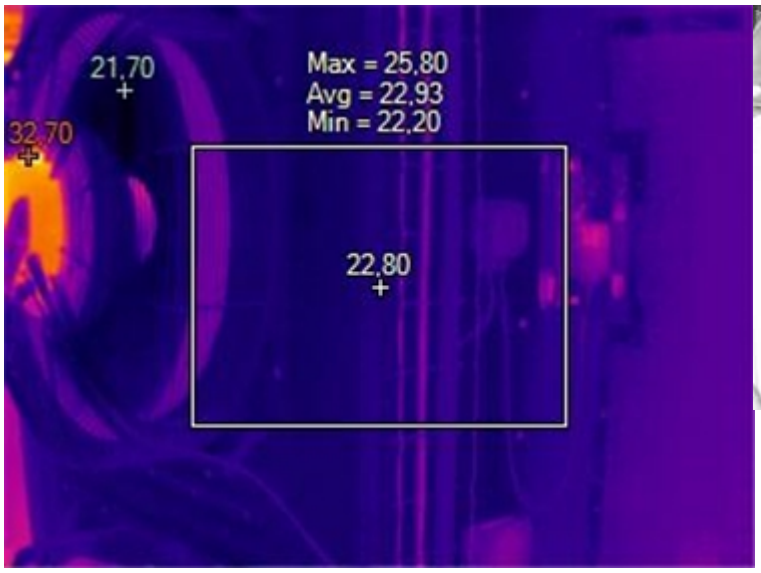




Image Info

Name	IR_00243.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,70 °C to 32,70 °C
Image Time	04/09/2024 11:30:27 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22,8 °C	22,8 °C	22,8 °C	0,95	22,0 °C	0,00	
Centerbox	25,8 °C	22,2 °C	22,9 °C	0,95	22,0 °C	0,44	
Hot	32,7 °C	32,7 °C	32,7 °C	0,95	22,0 °C	0,00	
Cold	21,7 °C	21,7 °C	21,7 °C	0,95	22,0 °C	0,00	

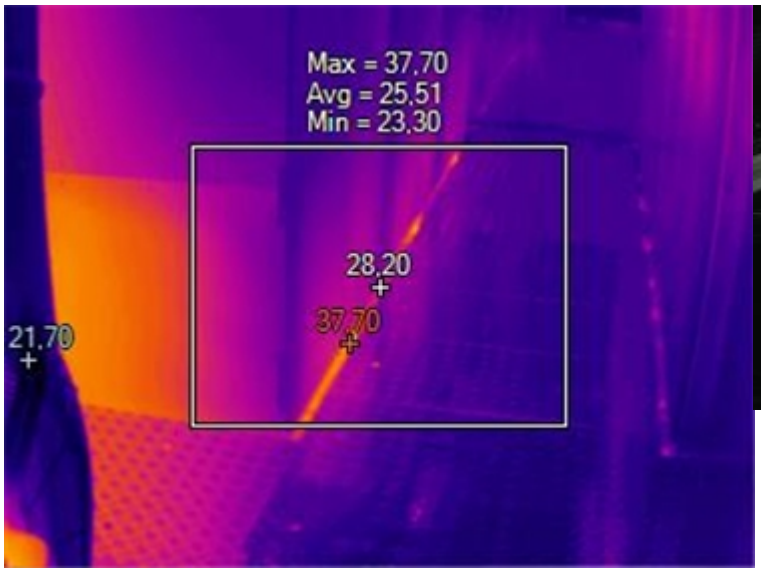




Image Info

Name	IR_00242.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,70 °C to 37,70 °C
Image Time	04/09/2024 11:30:17 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,2 °C	28,2 °C	28,2 °C	0,95	22,0 °C	0,00	
Centerbox	37,7 °C	23,3 °C	25,5 °C	0,95	22,0 °C	1,49	
Hot	37,7 °C	37,7 °C	37,7 °C	0,95	22,0 °C	0,00	
Cold	21,7 °C	21,7 °C	21,7 °C	0,95	22,0 °C	0,00	

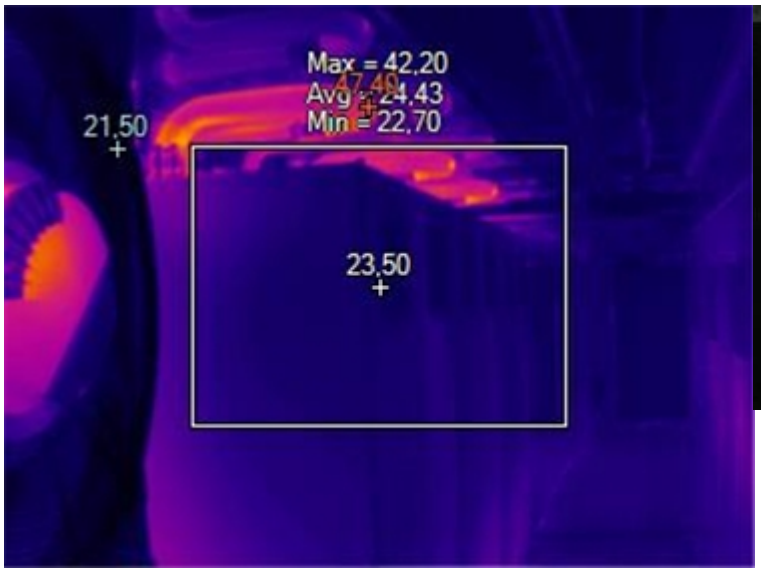




Image Info

Name	IR_00241.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,50 °C to 47,40 °C
Image Time	04/09/2024 11:30:12 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,5 °C	23,5 °C	23,5 °C	0,95	22,0 °C	0,00	
Centerbox	42,2 °C	22,7 °C	24,4 °C	0,95	22,0 °C	1,92	
Hot	47,4 °C	47,4 °C	47,4 °C	0,95	22,0 °C	0,00	
Cold	21,5 °C	21,5 °C	21,5 °C	0,95	22,0 °C	0,00	

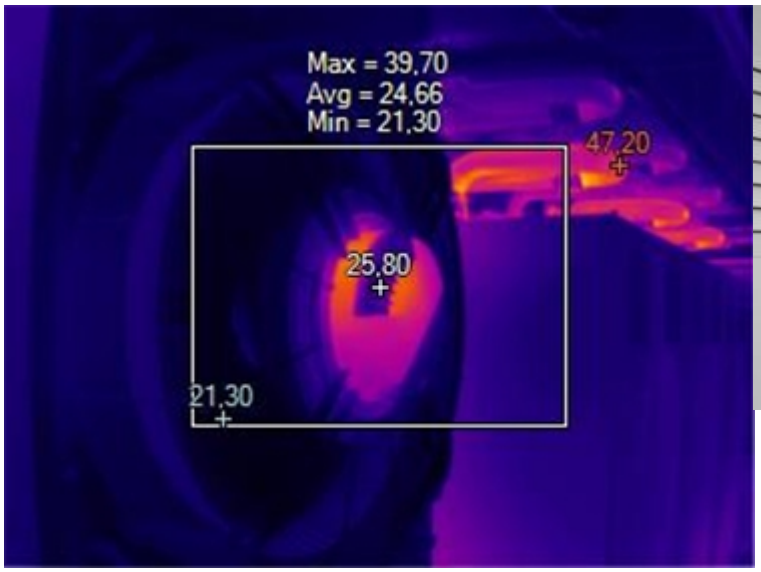




Image Info

Name	IR_00240.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,30 °C to 47,20 °C
Image Time	04/09/2024 11:29:44 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	
Centerbox	39,7 °C	21,3 °C	24,7 °C	0,95	22,0 °C	3,44	
Hot	47,2 °C	47,2 °C	47,2 °C	0,95	22,0 °C	0,00	
Cold	21,3 °C	21,3 °C	21,3 °C	0,95	22,0 °C	0,00	

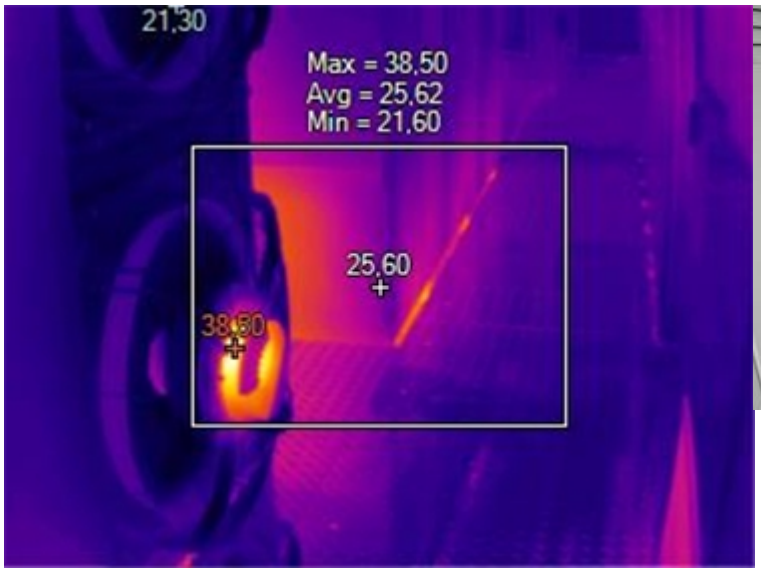




Image Info

Name	IR_00239.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,30 °C to 38,50 °C
Image Time	04/09/2024 11:29:27 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,6 °C	25,6 °C	25,6 °C	0,95	22,0 °C	0,00	
Centerbox	38,5 °C	21,6 °C	25,6 °C	0,95	22,0 °C	2,50	
Hot	38,5 °C	38,5 °C	38,5 °C	0,95	22,0 °C	0,00	
Cold	21,3 °C	21,3 °C	21,3 °C	0,95	22,0 °C	0,00	

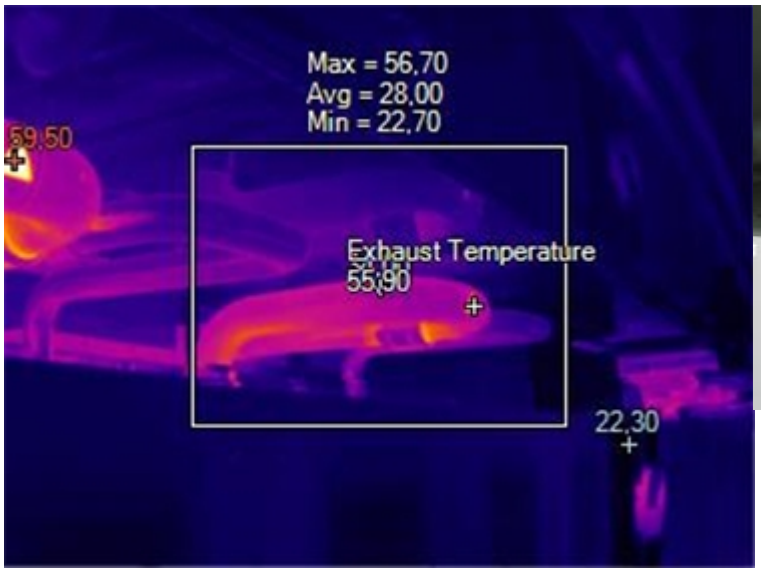




Image Info

Name	IR_00238.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,30 °C to 59,50 °C
Image Time	04/09/2024 11:29:09 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	34,0 °C	34,0 °C	34,0 °C	0,95	22,0 °C	0,00	
Centerbox	56,7 °C	22,7 °C	28,0 °C	0,95	22,0 °C	4,18	
Hot	59,5 °C	59,5 °C	59,5 °C	0,95	22,0 °C	0,00	
Cold	22,3 °C	22,3 °C	22,3 °C	0,95	22,0 °C	0,00	
Exhaust Temperature	55,9 °C	55,9 °C	55,9 °C	0,95	22,0 °C	0,00	

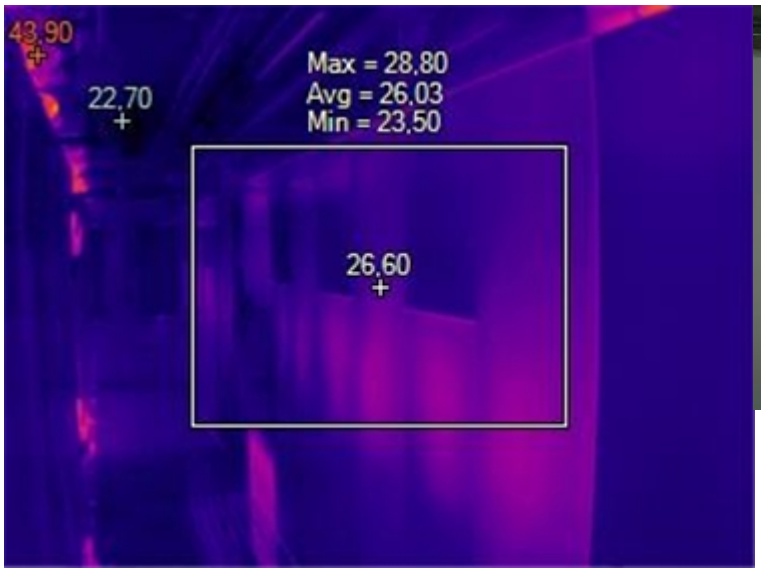




Image Info

Name	IR_00237.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,70 °C to 43,90 °C
Image Time	04/09/2024 11:29:01 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	26,6 °C	26,6 °C	26,6 °C	0,95	22,0 °C	0,00	
Centerbox	28,8 °C	23,5 °C	26,0 °C	0,95	22,0 °C	1,08	
Hot	43,9 °C	43,9 °C	43,9 °C	0,95	22,0 °C	0,00	
Cold	22,7 °C	22,7 °C	22,7 °C	0,95	22,0 °C	0,00	

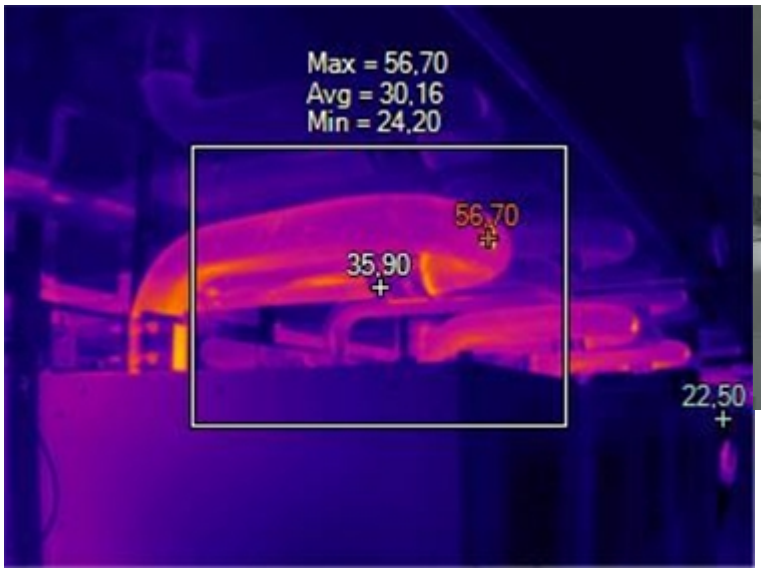




Image Info

Name	IR_00236.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,50 °C to 56,70 °C
Image Time	04/09/2024 11:28:50 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	35,9 °C	35,9 °C	35,9 °C	0,95	22,0 °C	0,00	
Centerbox	56,7 °C	24,2 °C	30,2 °C	0,95	22,0 °C	4,12	
Hot	56,7 °C	56,7 °C	56,7 °C	0,95	22,0 °C	0,00	
Cold	22,5 °C	22,5 °C	22,5 °C	0,95	22,0 °C	0,00	

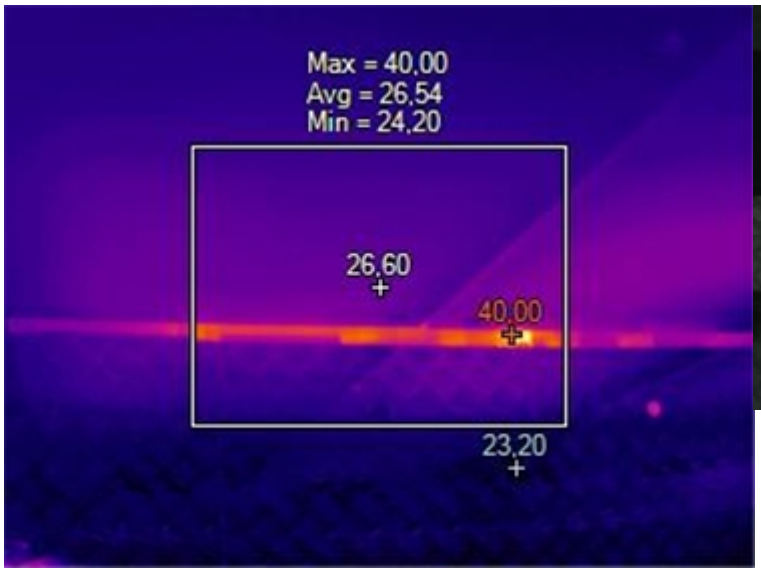




Image Info

Name	IR_00235.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	23,20 °C to 40,00 °C
Image Time	04/09/2024 11:28:41 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	26,6 °C	26,6 °C	26,6 °C	0,95	22,0 °C	0,00	
Centerbox	40,0 °C	24,2 °C	26,5 °C	0,95	22,0 °C	1,49	
Hot	40,0 °C	40,0 °C	40,0 °C	0,95	22,0 °C	0,00	
Cold	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	

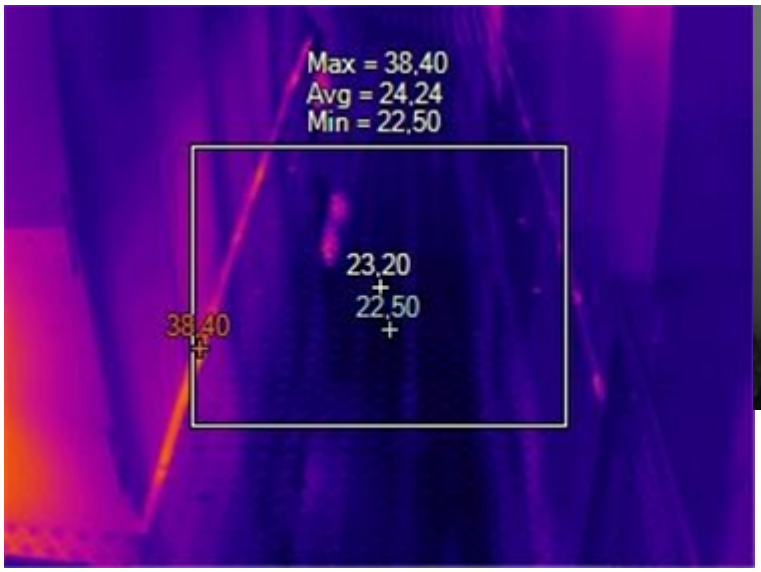




Image Info

Name	IR_00234.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,50 °C to 38,40 °C
Image Time	04/09/2024 11:28:29 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	
Centerbox	38,4 °C	22,5 °C	24,2 °C	0,95	22,0 °C	1,21	
Hot	38,4 °C	38,4 °C	38,4 °C	0,95	22,0 °C	0,00	
Cold	22,5 °C	22,5 °C	22,5 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00233.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	21,10 °C to 30,70 °C
Image Time	04/09/2024 11:28:14 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,8 °C	23,8 °C	23,8 °C	0,95	22,0 °C	0,00	
Centerbox	30,7 °C	23,2 °C	25,4 °C	0,95	22,0 °C	1,64	
Hot	30,7 °C	30,7 °C	30,7 °C	0,95	22,0 °C	0,00	
Cold	21,1 °C	21,1 °C	21,1 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00232.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	22,20 °C to 37,00 °C
Image Time	04/09/2024 11:28:09 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	
Centerbox	34,0 °C	22,8 °C	24,6 °C	0,95	22,0 °C	1,91	
Hot	37,0 °C	37,0 °C	37,0 °C	0,95	22,0 °C	0,00	
Cold	22,2 °C	22,2 °C	22,2 °C	0,95	22,0 °C	0,00	

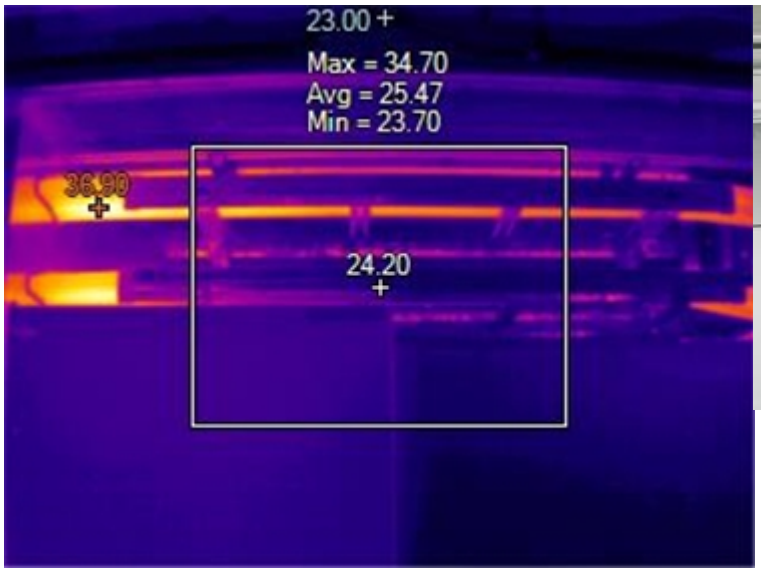




Image Info

Name	IR_00231.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	23.00 °C to 36.90 °C
Image Time	04/09/2024 11:27:56 AM
Asset Name	UC50 Aux AC Cabinet

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.2 °C	24.2 °C	24.2 °C	0.95	22.0 °C	0.00	
Centerbox	34.7 °C	23.7 °C	25.5 °C	0.95	22.0 °C	1.52	
Hot	36.9 °C	36.9 °C	36.9 °C	0.95	22.0 °C	0.00	
Cold	23.0 °C	23.0 °C	23.0 °C	0.95	22.0 °C	0.00	

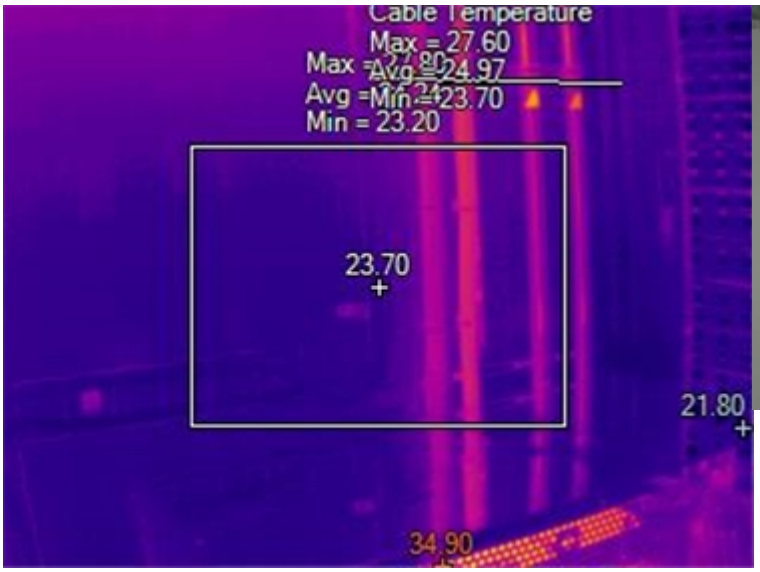




Image Info

Name	IR_00230.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	21.80 °C to 34.90 °C
Image Time	04/09/2024 11:27:50 AM
Asset Name	UC50 Aux AC Cabinet

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	27.8 °C	23.2 °C	24.2 °C	0.95	22.0 °C	0.90	
Hot	34.9 °C	34.9 °C	34.9 °C	0.95	22.0 °C	0.00	
Cold	21.8 °C	21.8 °C	21.8 °C	0.95	22.0 °C	0.00	
Cable Temperature	27.6 °C	23.7 °C	25.0 °C	0.95	22.0 °C	0.94	

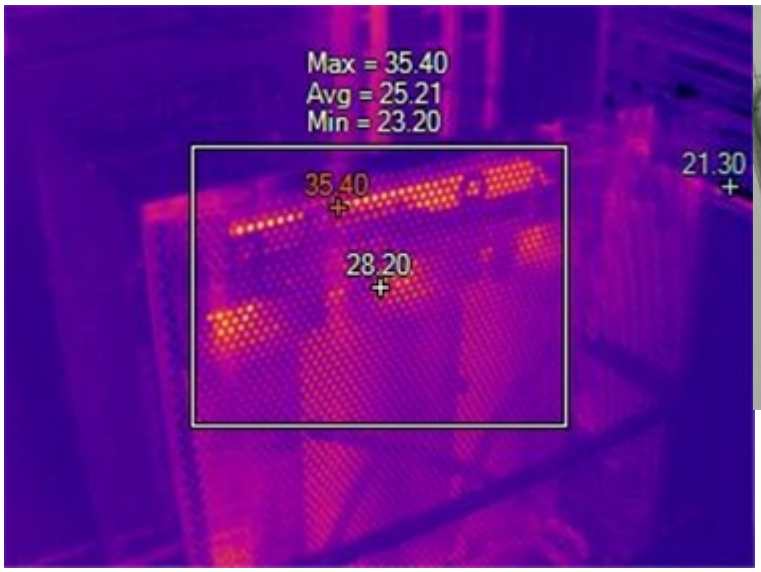




Image Info

Name	IR_00229.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	21.30 °C to 35.40 °C
Image Time	04/09/2024 11:27:38 AM
Asset Name	UC50 Aux AC Cabinet

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.2 °C	28.2 °C	28.2 °C	0.95	22.0 °C	0.00	
Centerbox	35.4 °C	23.2 °C	25.2 °C	0.95	22.0 °C	1.37	
Hot	35.4 °C	35.4 °C	35.4 °C	0.95	22.0 °C	0.00	
Cold	21.3 °C	21.3 °C	21.3 °C	0.95	22.0 °C	0.00	

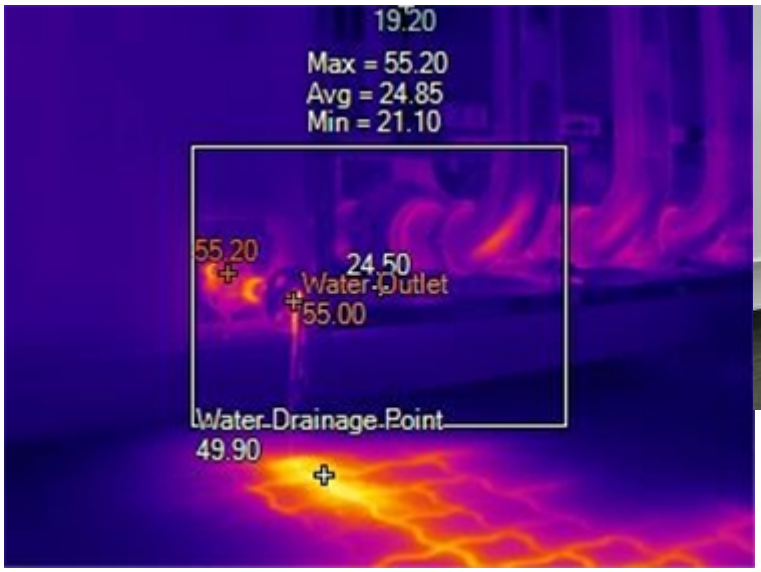




Image Info

Name	IR_00228.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	19.20 °C to 55.20 °C
Image Time	04/09/2024 11:26:59 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.5 °C	24.5 °C	24.5 °C	0.95	22.0 °C	0.00	
Centerbox	55.2 °C	21.1 °C	24.8 °C	0.95	22.0 °C	3.00	
Hot	55.2 °C	55.2 °C	55.2 °C	0.95	22.0 °C	0.00	
Cold	19.2 °C	19.2 °C	19.2 °C	0.95	22.0 °C	0.00	
Water Outlet	55.0 °C	55.0 °C	55.0 °C	0.95	22.0 °C	0.00	
Water Drainage Point	49.9 °C	49.9 °C	49.9 °C	0.95	22.0 °C	0.00	

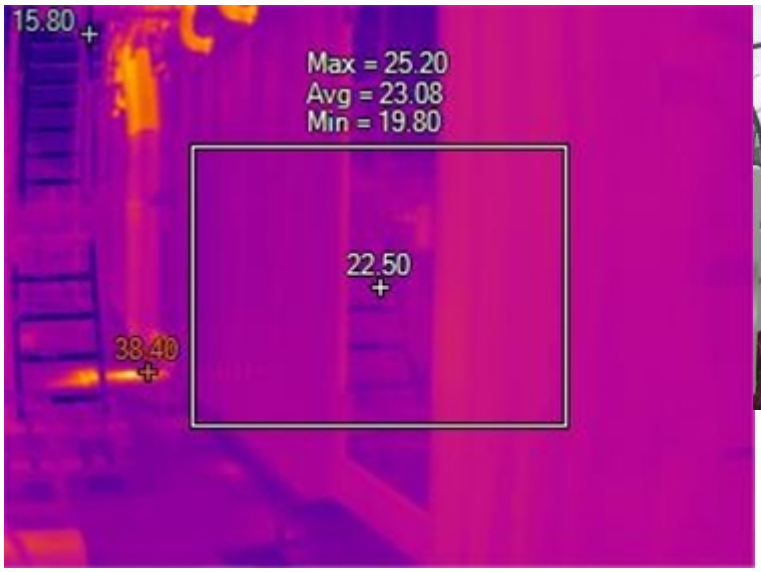




Image Info

Name	IR_00227.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	15.80 °C to 38.40 °C
Image Time	04/09/2024 11:26:38 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22.5 °C	22.5 °C	22.5 °C	0.95	22.0 °C	0.00	
Centerbox	25.2 °C	19.8 °C	23.1 °C	0.95	22.0 °C	1.06	
Hot	38.4 °C	38.4 °C	38.4 °C	0.95	22.0 °C	0.00	
Cold	15.8 °C	15.8 °C	15.8 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00226.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	18,20 °C to 54,70 °C
Image Time	04/09/2024 11:25:55 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	37,9 °C	37,9 °C	37,9 °C	0,95	22,0 °C	0,00	
Centerbox	50,7 °C	21,1 °C	26,1 °C	0,95	22,0 °C	5,37	
Hot	54,7 °C	54,7 °C	54,7 °C	0,95	22,0 °C	0,00	
Cold	18,2 °C	18,2 °C	18,2 °C	0,95	22,0 °C	0,00	

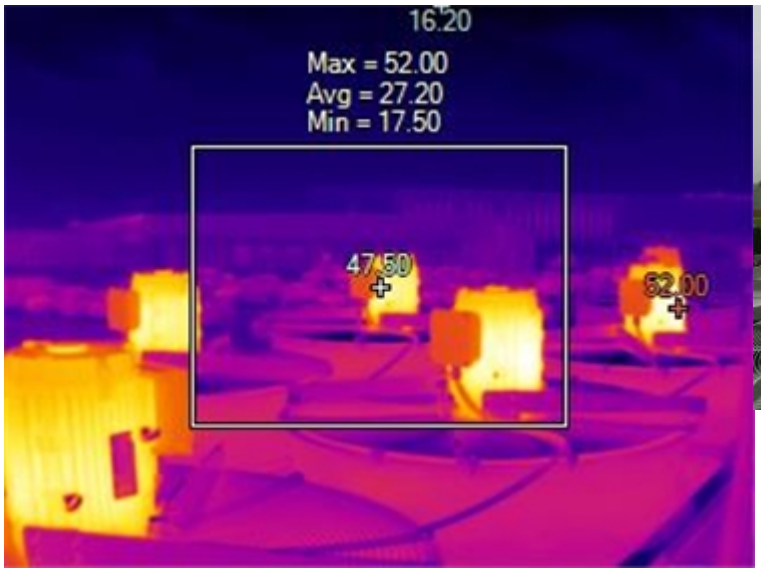




Image Info

Name	IR_00225.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.20 °C to 52.00 °C
Image Time	04/09/2024 11:25:34 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	47.5 °C	47.5 °C	47.5 °C	0.95	22.0 °C	0.00	
Centerbox	52.0 °C	17.5 °C	27.2 °C	0.95	22.0 °C	7.80	
Hot	52.0 °C	52.0 °C	52.0 °C	0.95	22.0 °C	0.00	
Cold	16.2 °C	16.2 °C	16.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00224.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	20.70 °C to 39.50 °C
Image Time	04/09/2024 11:24:49 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.5 °C	28.5 °C	28.5 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	22.5 °C	30.9 °C	0.95	22.0 °C	4.68	
Hot	39.5 °C	39.5 °C	39.5 °C	0.95	22.0 °C	0.00	
Cold	20.7 °C	20.7 °C	20.7 °C	0.95	22.0 °C	0.00	

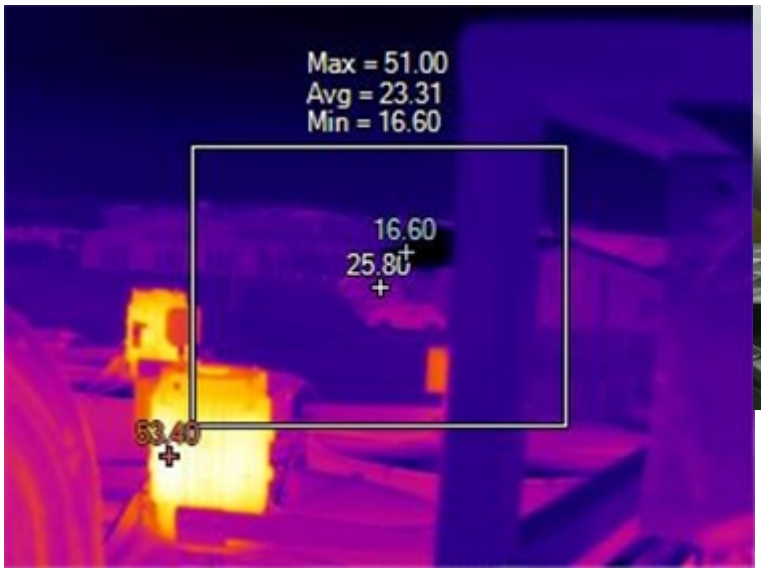




Image Info

Name	IR_00222.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.60 °C to 53.40 °C
Image Time	04/09/2024 11:23:50 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25.8 °C	25.8 °C	25.8 °C	0.95	22.0 °C	0.00	
Centerbox	51.0 °C	16.6 °C	23.3 °C	0.95	22.0 °C	5.36	
Hot	53.4 °C	53.4 °C	53.4 °C	0.95	22.0 °C	0.00	
Cold	16.6 °C	16.6 °C	16.6 °C	0.95	22.0 °C	0.00	

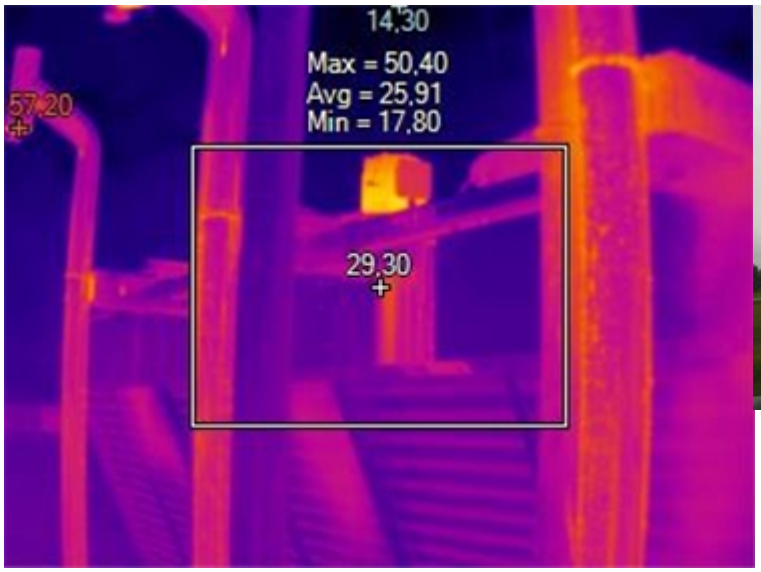




Image Info

Name	IR_00221.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	14,30 °C to 57,20 °C
Image Time	04/09/2024 11:23:38 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,3 °C	29,3 °C	29,3 °C	0,95	22,0 °C	0,00	
Centerbox	50,4 °C	17,8 °C	25,9 °C	0,95	22,0 °C	5,31	
Hot	57,2 °C	57,2 °C	57,2 °C	0,95	22,0 °C	0,00	
Cold	14,3 °C	14,3 °C	14,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00220.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	13,10 °C to 36,20 °C
Image Time	04/09/2024 11:22:30 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27,1 °C	27,1 °C	27,1 °C	0,95	22,0 °C	0,00	
Centerbox	34,2 °C	18,2 °C	25,2 °C	0,95	22,0 °C	2,26	
Hot	36,2 °C	36,2 °C	36,2 °C	0,95	22,0 °C	0,00	
Cold	13,1 °C	13,1 °C	13,1 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00219.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	14.30 °C to 39.70 °C
Image Time	04/09/2024 11:22:14 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.5 °C	28.5 °C	28.5 °C	0.95	22.0 °C	0.00	
Centerbox	32.7 °C	15.3 °C	22.2 °C	0.95	22.0 °C	2.54	
Hot	39.7 °C	39.7 °C	39.7 °C	0.95	22.0 °C	0.00	
Cold	14.3 °C	14.3 °C	14.3 °C	0.95	22.0 °C	0.00	

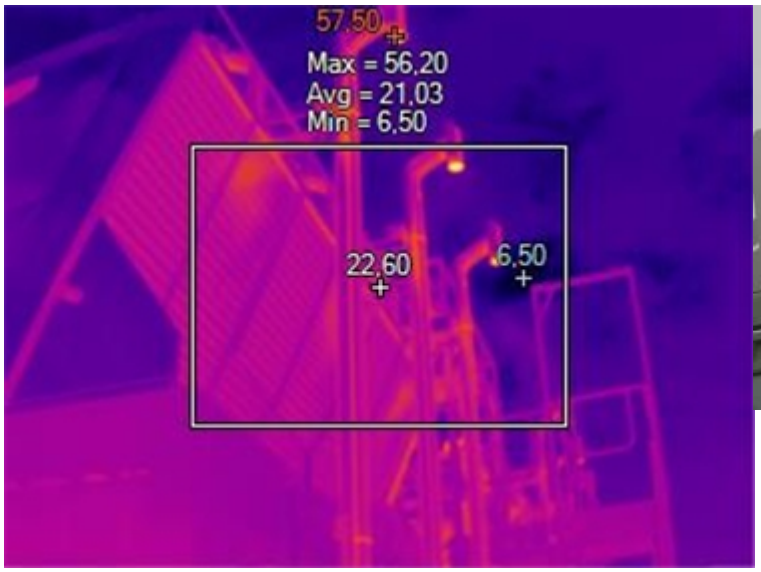




Image Info

Name	IR_00218.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	6,50 °C to 57,50 °C
Image Time	04/09/2024 11:21:25 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22,6 °C	22,6 °C	22,6 °C	0,95	22,0 °C	0,00	
Centerbox	56,2 °C	6,5 °C	21,0 °C	0,95	22,0 °C	5,14	
Hot	57,5 °C	57,5 °C	57,5 °C	0,95	22,0 °C	0,00	
Cold	6,5 °C	6,5 °C	6,5 °C	0,95	22,0 °C	0,00	

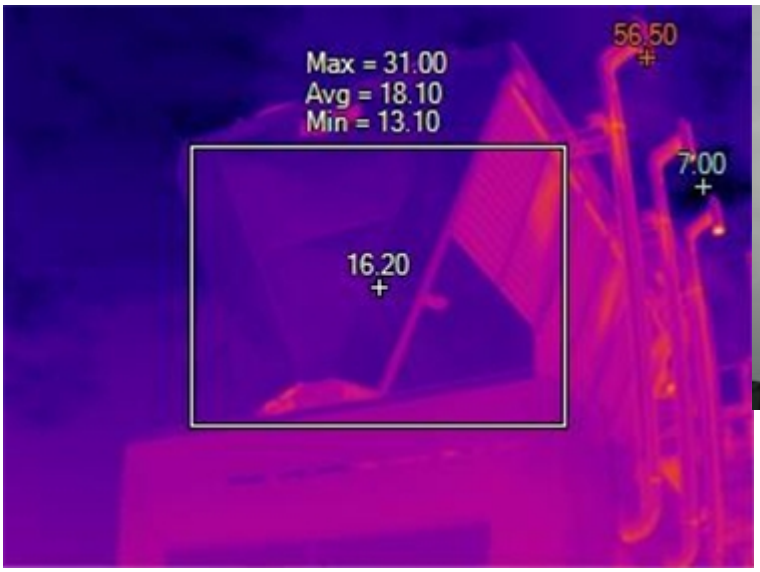




Image Info

Name	IR_00217.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	7.00 °C to 56.50 °C
Image Time	04/09/2024 11:21:15 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	16.2 °C	16.2 °C	16.2 °C	0.95	22.0 °C	0.00	
Centerbox	31.0 °C	13.1 °C	18.1 °C	0.95	22.0 °C	3.33	
Hot	56.5 °C	56.5 °C	56.5 °C	0.95	22.0 °C	0.00	
Cold	7.0 °C	7.0 °C	7.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00216.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	18.20 °C to 144.30 °C
Image Time	04/09/2024 11:20:35 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	21.2 °C	21.2 °C	21.2 °C	0.95	22.0 °C	0.00	
Centerbox	23.7 °C	18.6 °C	21.9 °C	0.95	22.0 °C	0.96	
Hot	144.3 °C	144.3 °C	144.3 °C	0.95	22.0 °C	0.00	
Cold	18.2 °C	18.2 °C	18.2 °C	0.95	22.0 °C	0.00	

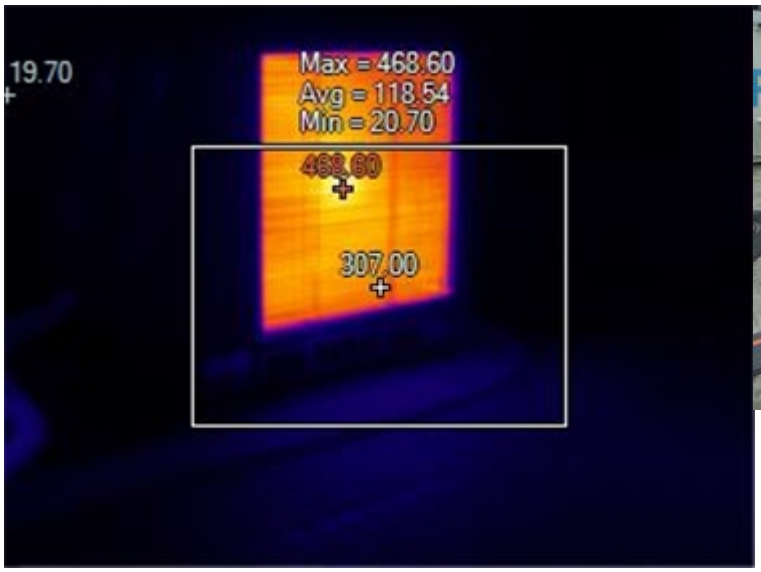




Image Info

Name	IR_00215.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	19.70 °C to 468.60 °C
Image Time	04/09/2024 11:19:20 AM
Asset Name	Test Equipemnt

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	307.0 °C	307.0 °C	307.0 °C	0.95	22.0 °C	0.00	
Centerbox	468.6 °C	20.7 °C	118.5 °C	0.95	22.0 °C	129.65	
Hot	468.6 °C	468.6 °C	468.6 °C	0.95	22.0 °C	0.00	
Cold	19.7 °C	19.7 °C	19.7 °C	0.95	22.0 °C	0.00	

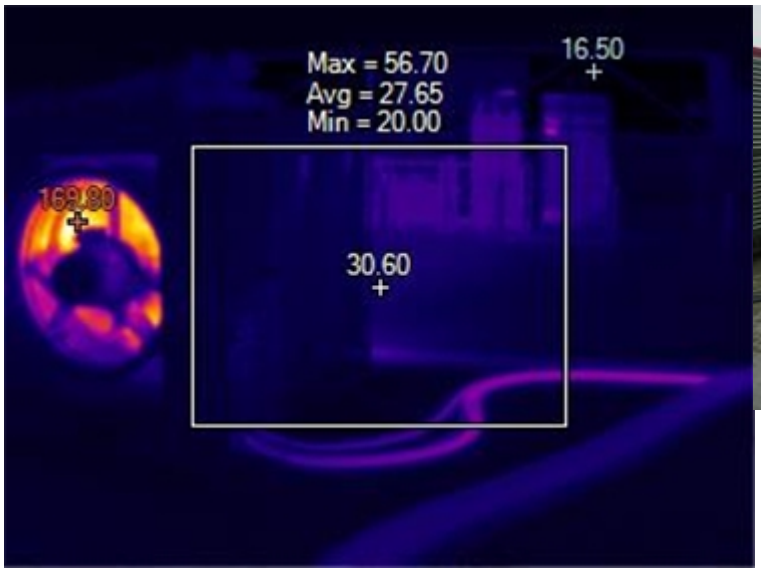




Image Info

Name	IR_00214.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.50 °C to 169.80 °C
Image Time	04/09/2024 11:18:48 AM
Asset Name	Test Equipemnt

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.6 °C	30.6 °C	30.6 °C	0.95	22.0 °C	0.00	
Centerbox	56.7 °C	20.0 °C	27.6 °C	0.95	22.0 °C	6.06	
Hot	169.8 °C	169.8 °C	169.8 °C	0.95	22.0 °C	0.00	
Cold	16.5 °C	16.5 °C	16.5 °C	0.95	22.0 °C	0.00	

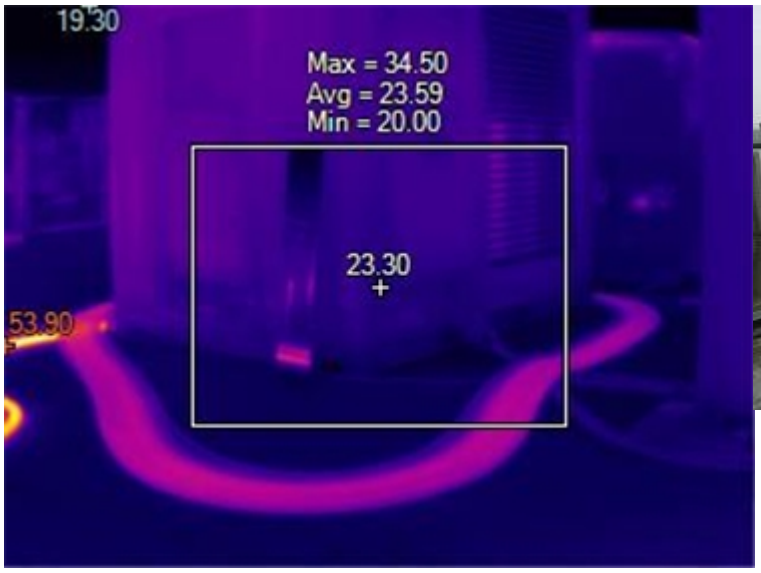




Image Info

Name	IR_00213.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	19.30 °C to 53.90 °C
Image Time	04/09/2024 11:18:26 AM
Asset Name	Test Equipemnt

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.3 °C	23.3 °C	23.3 °C	0.95	22.0 °C	0.00	
Centerbox	34.5 °C	20.0 °C	23.6 °C	0.95	22.0 °C	1.81	
Hot	53.9 °C	53.9 °C	53.9 °C	0.95	22.0 °C	0.00	
Cold	19.3 °C	19.3 °C	19.3 °C	0.95	22.0 °C	0.00	

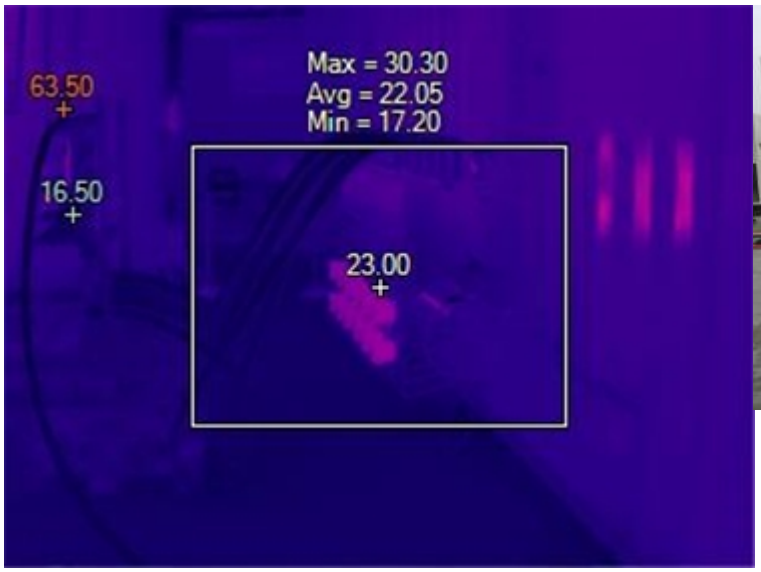




Image Info

Name	IR_00212.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.50 °C to 63.50 °C
Image Time	04/09/2024 11:18:08 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.0 °C	23.0 °C	23.0 °C	0.95	22.0 °C	0.00	
Centerbox	30.3 °C	17.2 °C	22.1 °C	0.95	22.0 °C	1.74	
Hot	63.5 °C	63.5 °C	63.5 °C	0.95	22.0 °C	0.00	
Cold	16.5 °C	16.5 °C	16.5 °C	0.95	22.0 °C	0.00	

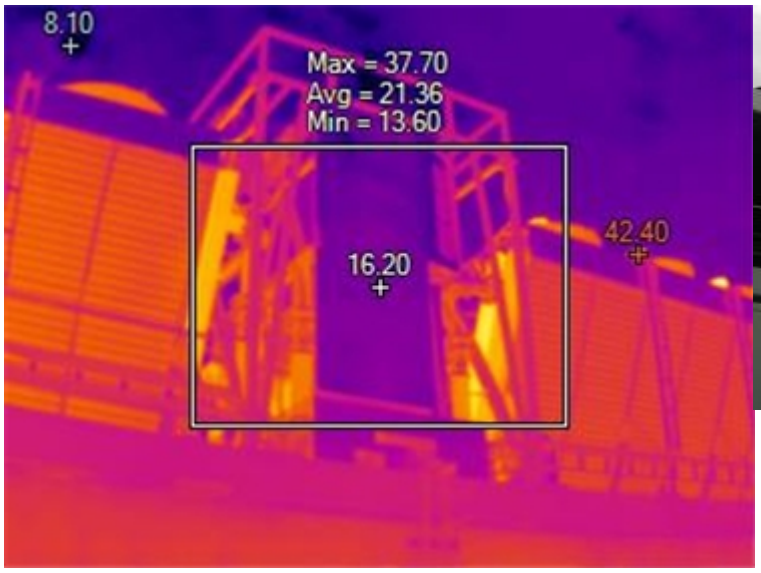




Image Info

Name	IR_00209.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	8.10 °C to 42.40 °C
Image Time	04/09/2024 11:17:23 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	16.2 °C	16.2 °C	16.2 °C	0.95	22.0 °C	0.00	
Centerbox	37.7 °C	13.6 °C	21.4 °C	0.95	22.0 °C	5.11	
Hot	42.4 °C	42.4 °C	42.4 °C	0.95	22.0 °C	0.00	
Cold	8.1 °C	8.1 °C	8.1 °C	0.95	22.0 °C	0.00	

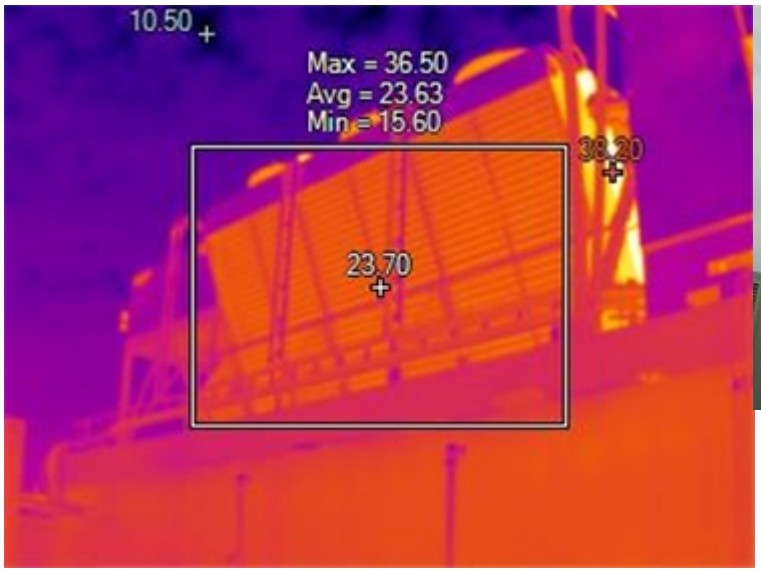




Image Info

Name	IR_00208.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	10.50 °C to 38.20 °C
Image Time	04/09/2024 11:16:35 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	36.5 °C	15.6 °C	23.6 °C	0.95	22.0 °C	2.30	
Hot	38.2 °C	38.2 °C	38.2 °C	0.95	22.0 °C	0.00	
Cold	10.5 °C	10.5 °C	10.5 °C	0.95	22.0 °C	0.00	

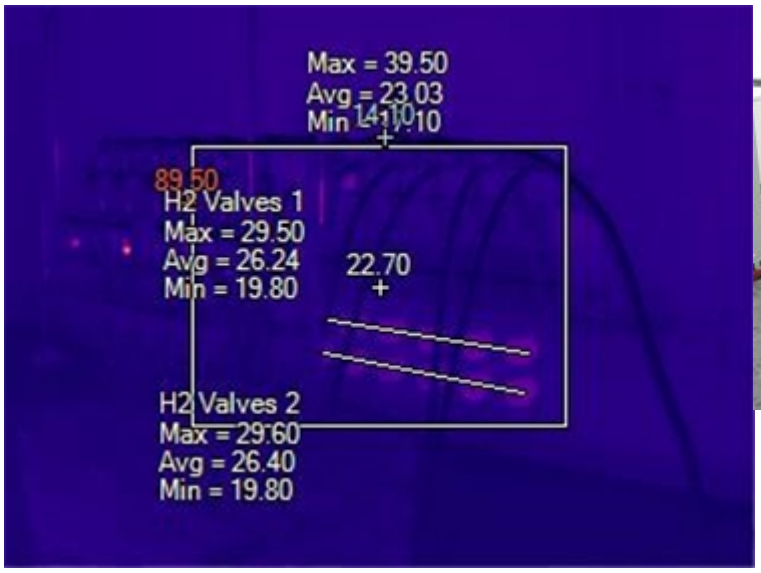




Image Info

Name	IR_00207.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	14.10 °C to 89.50 °C
Image Time	04/09/2024 11:16:21 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22.7 °C	22.7 °C	22.7 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	17.1 °C	23.0 °C	0.95	22.0 °C	1.82	
Hot	89.5 °C	89.5 °C	89.5 °C	0.95	22.0 °C	0.00	
Cold	14.1 °C	14.1 °C	14.1 °C	0.95	22.0 °C	0.00	
H2 Valves 1	29.5 °C	19.8 °C	26.2 °C	0.95	22.0 °C	2.45	
H2 Valves 2	29.6 °C	19.8 °C	26.4 °C	0.95	22.0 °C	2.53	

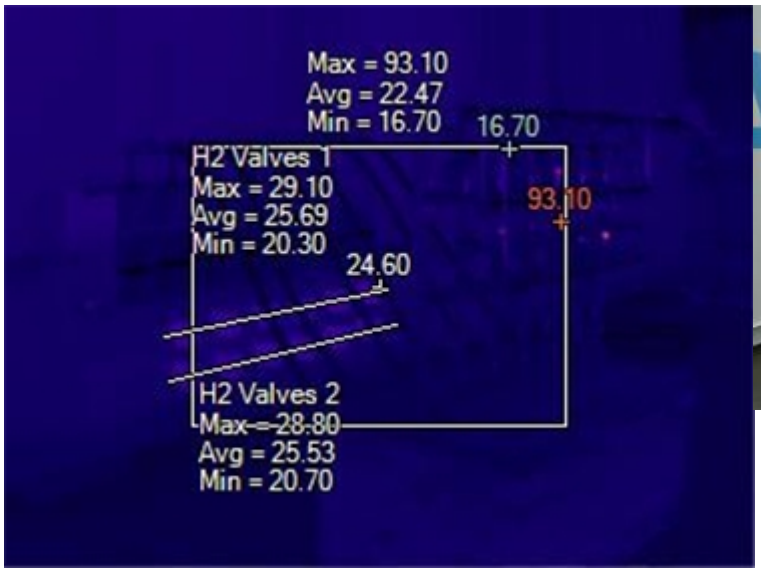




Image Info

Name	IR_00206.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	16.70 °C to 93.10 °C
Image Time	04/09/2024 11:16:09 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.6 °C	24.6 °C	24.6 °C	0.95	22.0 °C	0.00	
Centerbox	93.1 °C	16.7 °C	22.5 °C	0.95	22.0 °C	1.81	
Hot	93.1 °C	93.1 °C	93.1 °C	0.95	22.0 °C	0.00	
Cold	16.7 °C	16.7 °C	16.7 °C	0.95	22.0 °C	0.00	
H2 Valves 1	29.1 °C	20.3 °C	25.7 °C	0.95	22.0 °C	2.39	
H2 Valves 2	28.8 °C	20.7 °C	25.5 °C	0.95	22.0 °C	2.28	

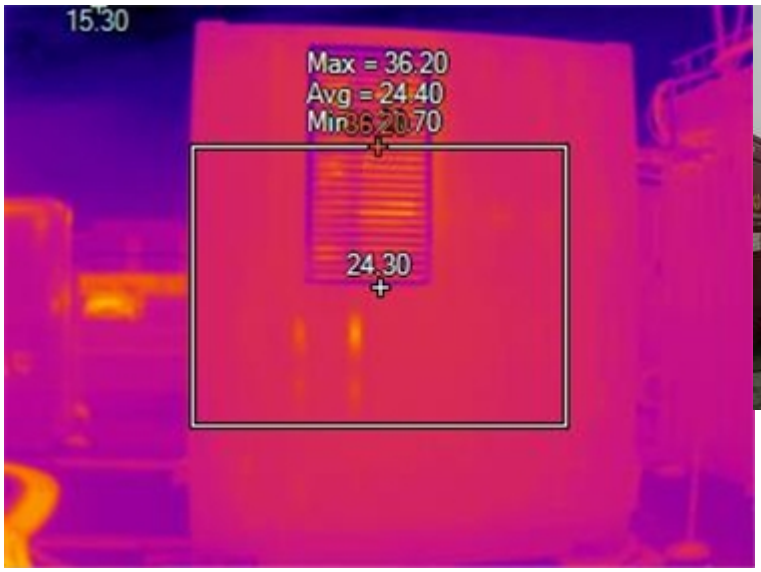




Image Info

Name	IR_00205.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	15.30 °C to 36.20 °C
Image Time	04/09/2024 11:15:41 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	24.3 °C	24.3 °C	24.3 °C	0.95	22.0 °C	0.00	
Centerbox	36.2 °C	20.7 °C	24.4 °C	0.95	22.0 °C	0.71	
Hot	36.2 °C	36.2 °C	36.2 °C	0.95	22.0 °C	0.00	
Cold	15.3 °C	15.3 °C	15.3 °C	0.95	22.0 °C	0.00	

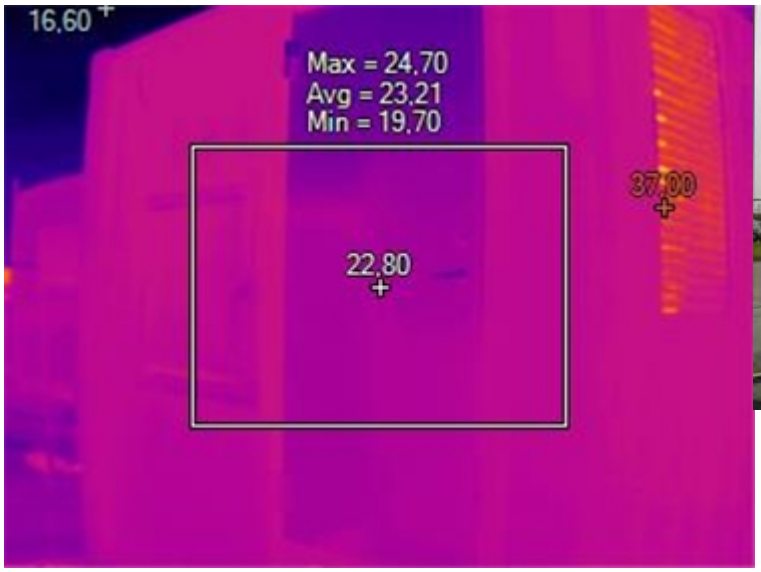




Image Info

Name	IR_00204.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	16,60 °C to 37,00 °C
Image Time	04/09/2024 11:15:27 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22,8 °C	22,8 °C	22,8 °C	0,95	22,0 °C	0,00	
Centerbox	24,7 °C	19,7 °C	23,2 °C	0,95	22,0 °C	0,67	
Hot	37,0 °C	37,0 °C	37,0 °C	0,95	22,0 °C	0,00	
Cold	16,6 °C	16,6 °C	16,6 °C	0,95	22,0 °C	0,00	

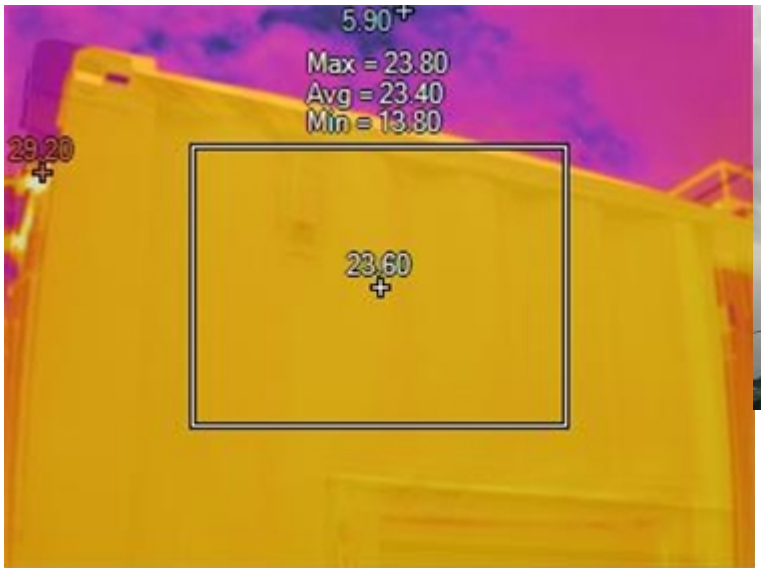




Image Info

Name	IR_00203.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	5.90 °C to 29.20 °C
Image Time	04/09/2024 11:15:10 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.6 °C	23.6 °C	23.6 °C	0.95	22.0 °C	0.00	
Centerbox	23.8 °C	13.8 °C	23.4 °C	0.95	22.0 °C	0.74	
Hot	29.2 °C	29.2 °C	29.2 °C	0.95	22.0 °C	0.00	
Cold	5.9 °C	5.9 °C	5.9 °C	0.95	22.0 °C	0.00	

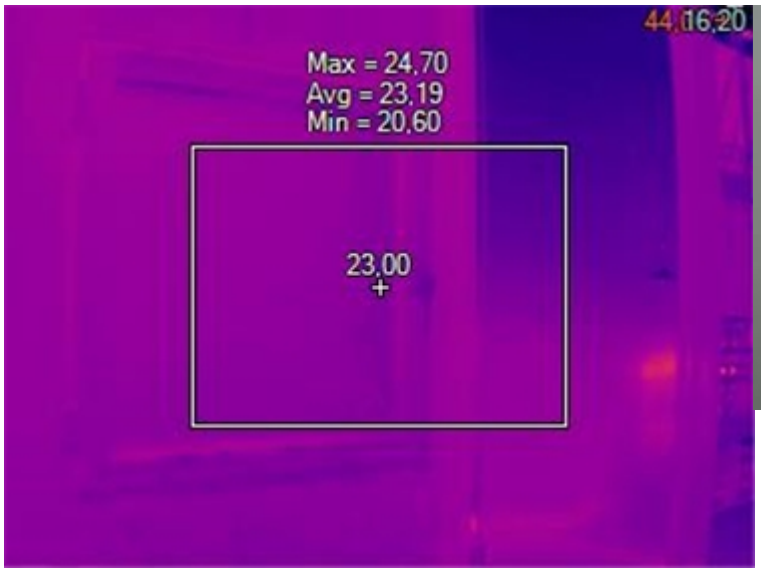




Image Info

Name	IR_00202.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	16,20 °C to 44,00 °C
Image Time	04/09/2024 11:15:01 AM
Asset Name	10ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,0 °C	23,0 °C	23,0 °C	0,95	22,0 °C	0,00	
Centerbox	24,7 °C	20,6 °C	23,2 °C	0,95	22,0 °C	0,73	
Hot	44,0 °C	44,0 °C	44,0 °C	0,95	22,0 °C	0,00	
Cold	16,2 °C	16,2 °C	16,2 °C	0,95	22,0 °C	0,00	

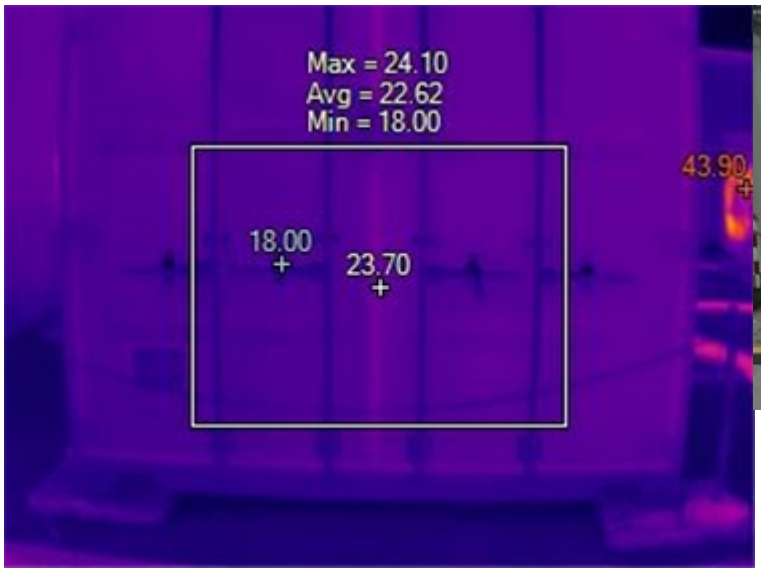




Image Info

Name	IR_00201.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	18.00 °C to 43.90 °C
Image Time	04/09/2024 11:14:23 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23.7 °C	23.7 °C	23.7 °C	0.95	22.0 °C	0.00	
Centerbox	24.1 °C	18.0 °C	22.6 °C	0.95	22.0 °C	0.46	
Hot	43.9 °C	43.9 °C	43.9 °C	0.95	22.0 °C	0.00	
Cold	18.0 °C	18.0 °C	18.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00200.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	9.80 °C to 35.70 °C
Image Time	04/09/2024 11:14:05 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32.9 °C	32.9 °C	32.9 °C	0.95	22.0 °C	0.00	
Centerbox	35.7 °C	13.3 °C	21.7 °C	0.95	22.0 °C	5.19	
Hot	35.7 °C	35.7 °C	35.7 °C	0.95	22.0 °C	0.00	
Cold	9.8 °C	9.8 °C	9.8 °C	0.95	22.0 °C	0.00	

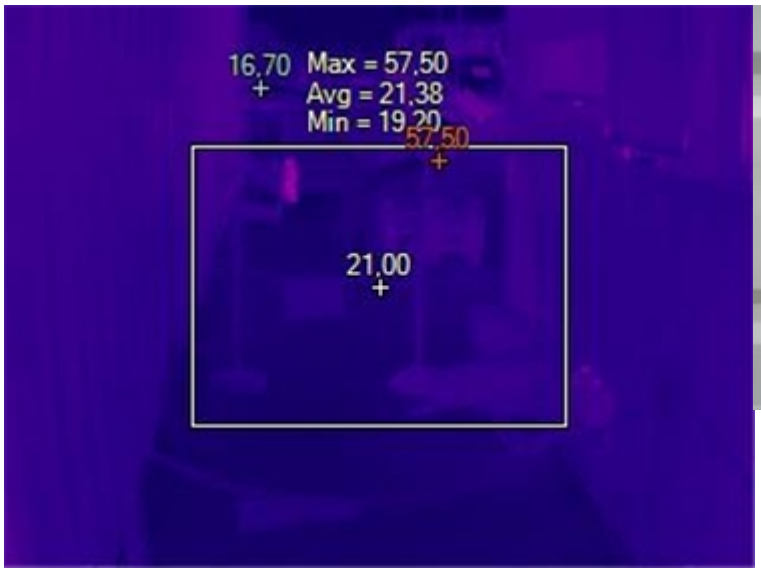




Image Info

Name	IR_00199.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	16,70 °C to 57,50 °C
Image Time	04/09/2024 11:13:51 AM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	21,0 °C	21,0 °C	21,0 °C	0,95	22,0 °C	0,00	
Centerbox	57,5 °C	19,2 °C	21,4 °C	0,95	22,0 °C	1,03	
Hot	57,5 °C	57,5 °C	57,5 °C	0,95	22,0 °C	0,00	
Cold	16,7 °C	16,7 °C	16,7 °C	0,95	22,0 °C	0,00	

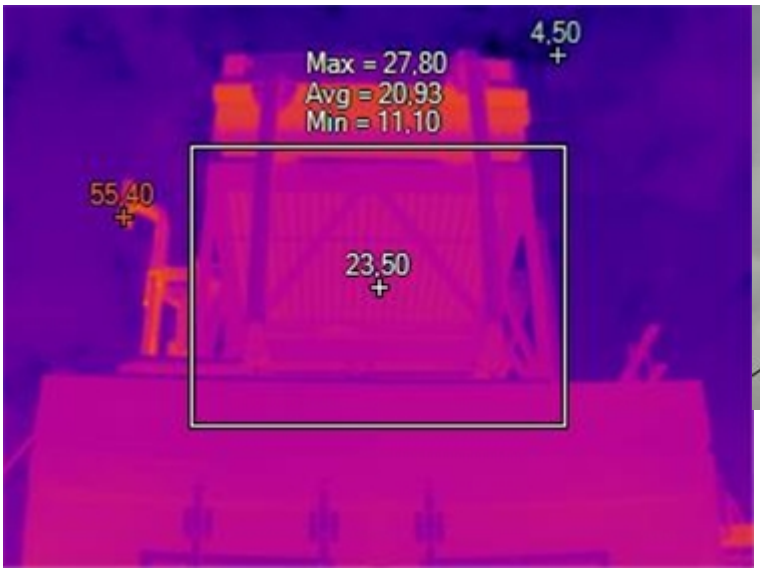




Image Info

Name	IR_00198.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Calibration Range	-10,00 °C to 550,00 °C
Image Range	4,50 °C to 55,40 °C
Image Time	04/09/2024 11:13:37 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	23,5 °C	23,5 °C	23,5 °C	0,95	22,0 °C	0,00	
Centerbox	27,8 °C	11,1 °C	20,9 °C	0,95	22,0 °C	2,73	
Hot	55,4 °C	55,4 °C	55,4 °C	0,95	22,0 °C	0,00	
Cold	4,5 °C	4,5 °C	4,5 °C	0,95	22,0 °C	0,00	

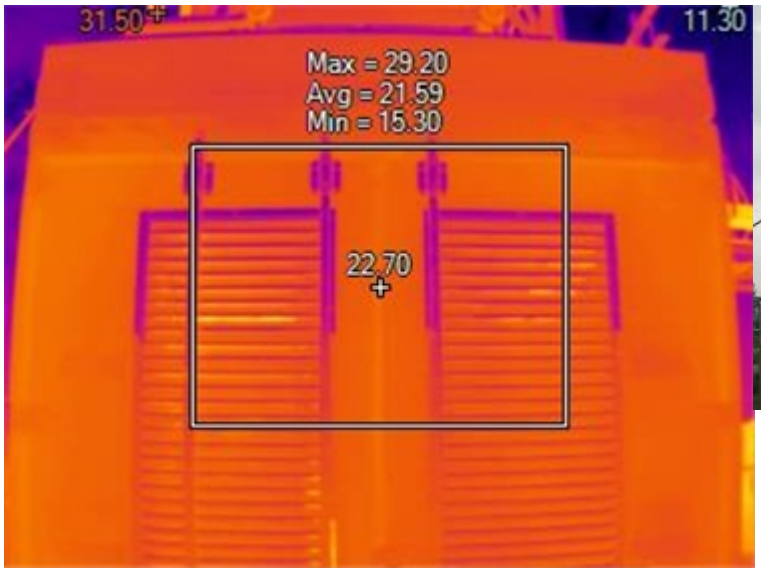




Image Info

Name	IR_00197.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Calibration Range	-10.00 °C to 550.00 °C
Image Range	11.30 °C to 31.50 °C
Image Time	04/09/2024 11:13:10 AM
Asset Name	40ft Container Exterior

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	22.7 °C	22.7 °C	22.7 °C	0.95	22.0 °C	0.00	
Centerbox	29.2 °C	15.3 °C	21.6 °C	0.95	22.0 °C	1.48	
Hot	31.5 °C	31.5 °C	31.5 °C	0.95	22.0 °C	0.00	
Cold	11.3 °C	11.3 °C	11.3 °C	0.95	22.0 °C	0.00	

Summary:

Date: 09/08/2024

Author: PBL

Ballard Power Systems Europe

Summary:

Thermograhic test of the Crosswind BLPH 1MW system

Entire power train included, from Fuel DCDC converters to AC output transformer.

Hottest item found is DC fuses at 70-75 degrees, which is within expected range.

No items found with elevated temperatures

Some images of test setup is included, but not inside Crosswind scope.

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Image Info

Name	IR_00190.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	14.50 °C to 53.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:39:16 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	36.0 °C	36.0 °C	36.0 °C	0.95	22.0 °C	0.00	
Centerbox	53.5 °C	19.5 °C	31.1 °C	0.95	22.0 °C	4.48	
Hot	53.5 °C	53.5 °C	53.5 °C	0.95	22.0 °C	0.00	
Cold	14.5 °C	14.5 °C	14.5 °C	0.95	22.0 °C	0.00	

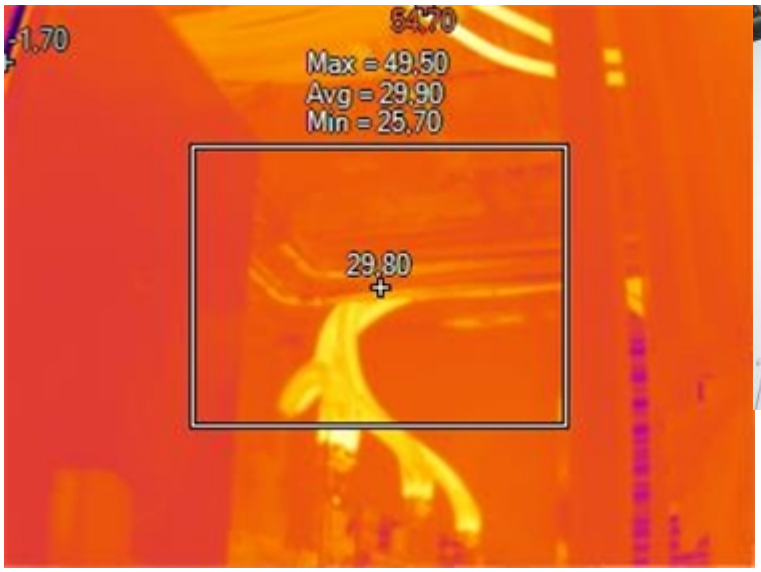




Image Info

Name	IR_00189.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	-1,70 °C to 54,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:39:07 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,8 °C	29,8 °C	29,8 °C	0,95	22,0 °C	0,00	
Centerbox	49,5 °C	25,7 °C	29,9 °C	0,95	22,0 °C	4,28	
Hot	54,7 °C	54,7 °C	54,7 °C	0,95	22,0 °C	0,00	
Cold	-1,7 °C	-1,7 °C	-1,7 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00188.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	17,50 °C to 53,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:39:01 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	52,5 °C	52,5 °C	52,5 °C	0,95	22,0 °C	0,00	
Centerbox	53,0 °C	20,0 °C	30,7 °C	0,95	22,0 °C	5,37	
Hot	53,0 °C	53,0 °C	53,0 °C	0,95	22,0 °C	0,00	
Cold	17,5 °C	17,5 °C	17,5 °C	0,95	22,0 °C	0,00	

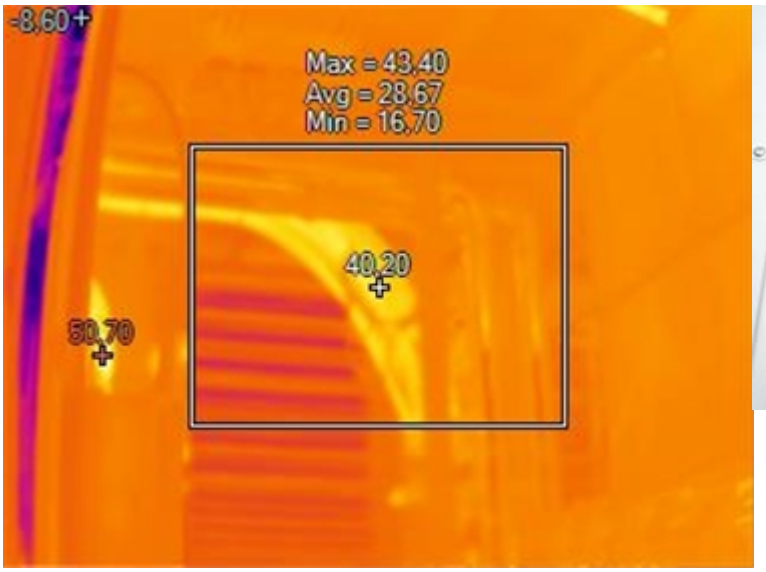




Image Info

Name	IR_00187.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	-8,60 °C to 50,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:43 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	40,2 °C	40,2 °C	40,2 °C	0,95	22,0 °C	0,00	
Centerbox	43,4 °C	16,7 °C	28,7 °C	0,95	22,0 °C	5,00	
Hot	50,7 °C	50,7 °C	50,7 °C	0,95	22,0 °C	0,00	
Cold	-8,6 °C	-8,6 °C	-8,6 °C	0,95	22,0 °C	0,00	

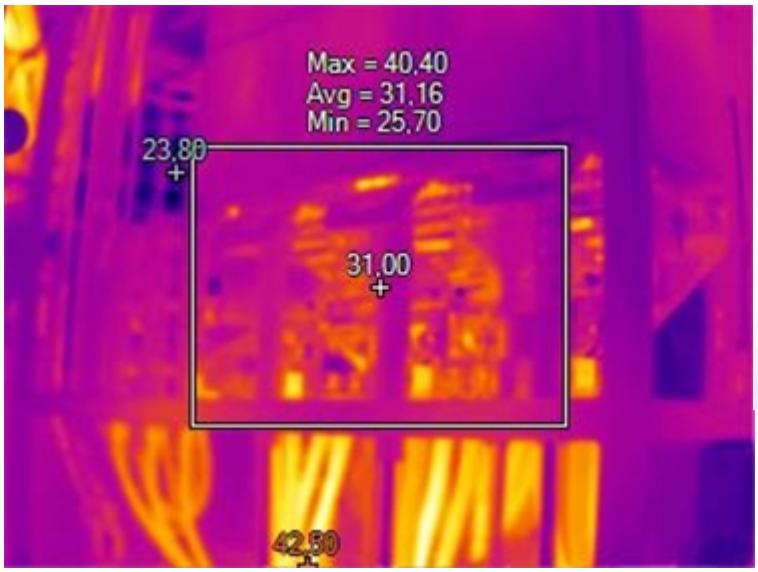




Image Info

Name	IR_00186.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	23,80 °C to 42,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:30 PM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,0 °C	31,0 °C	31,0 °C	0,95	22,0 °C	0,00	
Centerbox	40,4 °C	25,7 °C	31,2 °C	0,95	22,0 °C	1,78	
Hot	42,5 °C	42,5 °C	42,5 °C	0,95	22,0 °C	0,00	
Cold	23,8 °C	23,8 °C	23,8 °C	0,95	22,0 °C	0,00	

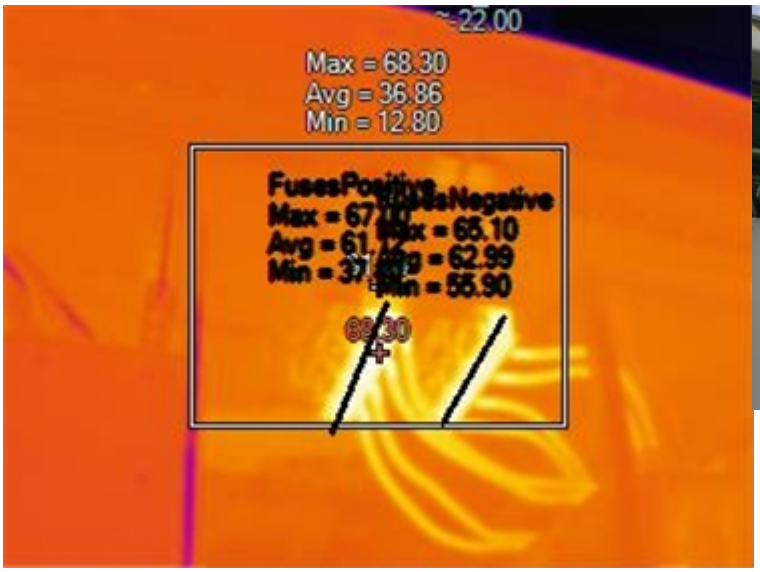




Image Info

Name	IR_00185.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	~-22.00 °C to 68.30 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:21 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.0 °C	31.0 °C	31.0 °C	0.95	22.0 °C	0.00	
Centerbox	68.3 °C	12.8 °C	36.9 °C	0.95	22.0 °C	9.49	
Hot	68.3 °C	68.3 °C	68.3 °C	0.95	22.0 °C	0.00	
Cold	-22.0 °C	-22.0 °C	-22.0 °C	0.95	22.0 °C	0.00	
FusesPositive	67.0 °C	37.4 °C	61.1 °C	0.95	22.0 °C	8.12	
FusesNegative	65.1 °C	55.9 °C	63.0 °C	0.95	22.0 °C	1.76	

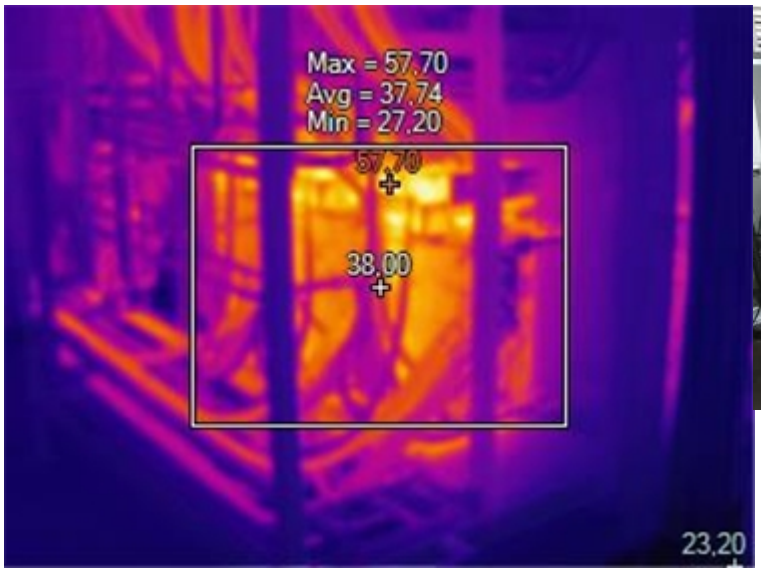




Image Info

Name	IR_00184.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	23,20 °C to 57,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:38:12 PM
Asset Name	PowerTrain
Asset Group	PowerTrain > DA03 10ft Container > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Centerbox	57,7 °C	27,2 °C	37,7 °C	0,95	22,0 °C	6,38	
Hot	57,7 °C	57,7 °C	57,7 °C	0,95	22,0 °C	0,00	
Cold	23,2 °C	23,2 °C	23,2 °C	0,95	22,0 °C	0,00	

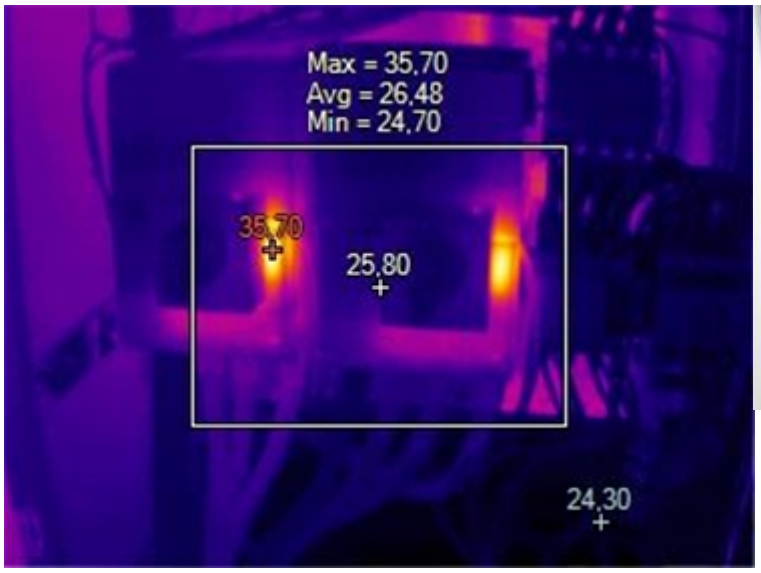




Image Info

Name	IR_00183.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	24,30 °C to 35,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:24 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	
Centerbox	35,7 °C	24,7 °C	26,5 °C	0,95	22,0 °C	1,52	
Hot	35,7 °C	35,7 °C	35,7 °C	0,95	22,0 °C	0,00	
Cold	24,3 °C	24,3 °C	24,3 °C	0,95	22,0 °C	0,00	

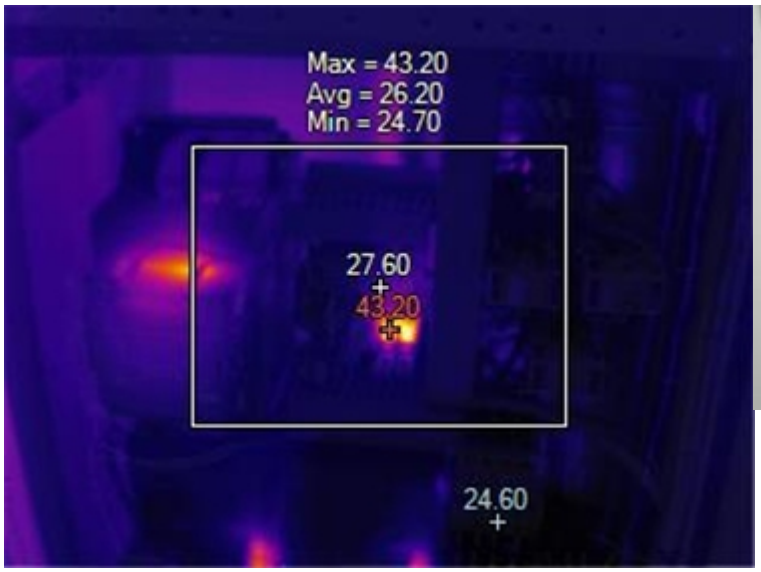




Image Info

Name	IR_00182.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.60 °C to 43.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:15 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27.6 °C	27.6 °C	27.6 °C	0.95	22.0 °C	0.00	
Centerbox	43.2 °C	24.7 °C	26.2 °C	0.95	22.0 °C	1.57	
Hot	43.2 °C	43.2 °C	43.2 °C	0.95	22.0 °C	0.00	
Cold	24.6 °C	24.6 °C	24.6 °C	0.95	22.0 °C	0.00	

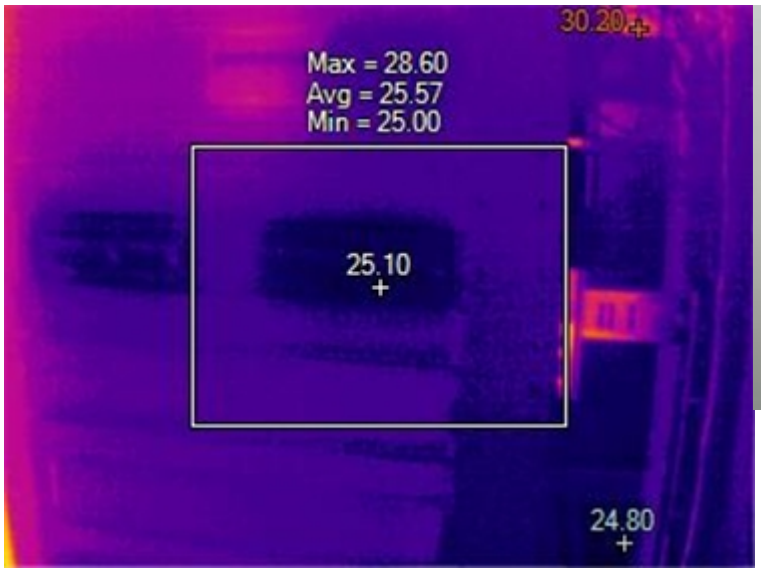




Image Info

Name	IR_00181.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.80 °C to 30.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:10 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25.1 °C	25.1 °C	25.1 °C	0.95	22.0 °C	0.00	
Centerbox	28.6 °C	25.0 °C	25.6 °C	0.95	22.0 °C	0.27	
Hot	30.2 °C	30.2 °C	30.2 °C	0.95	22.0 °C	0.00	
Cold	24.8 °C	24.8 °C	24.8 °C	0.95	22.0 °C	0.00	

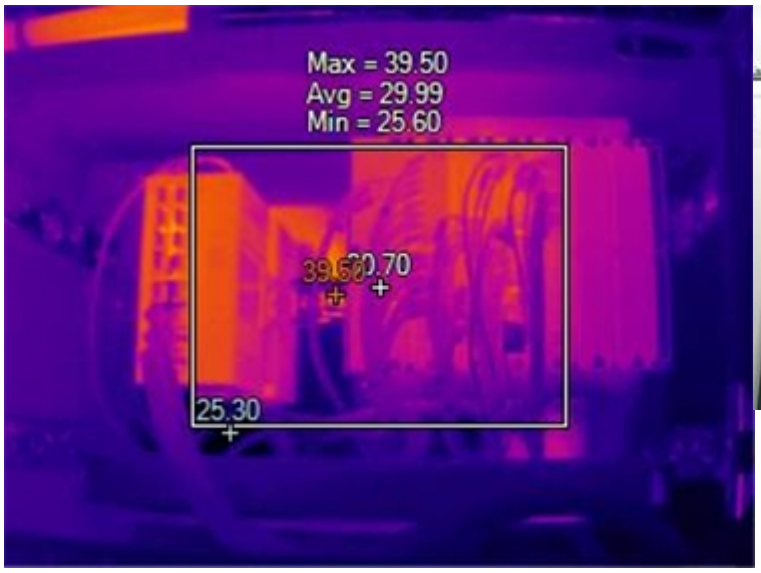




Image Info

Name	IR_00180.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.30 °C to 39.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:36:04 PM
Asset Name	UC50 Aux AC Cabinet
Asset Group	UC50 Aux AC Cabinet > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.7 °C	30.7 °C	30.7 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	25.6 °C	30.0 °C	0.95	22.0 °C	1.76	
Hot	39.5 °C	39.5 °C	39.5 °C	0.95	22.0 °C	0.00	
Cold	25.3 °C	25.3 °C	25.3 °C	0.95	22.0 °C	0.00	

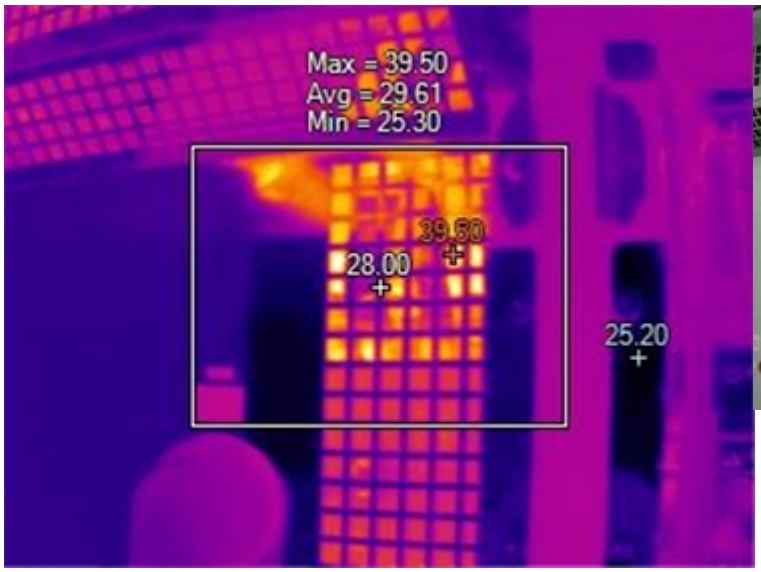


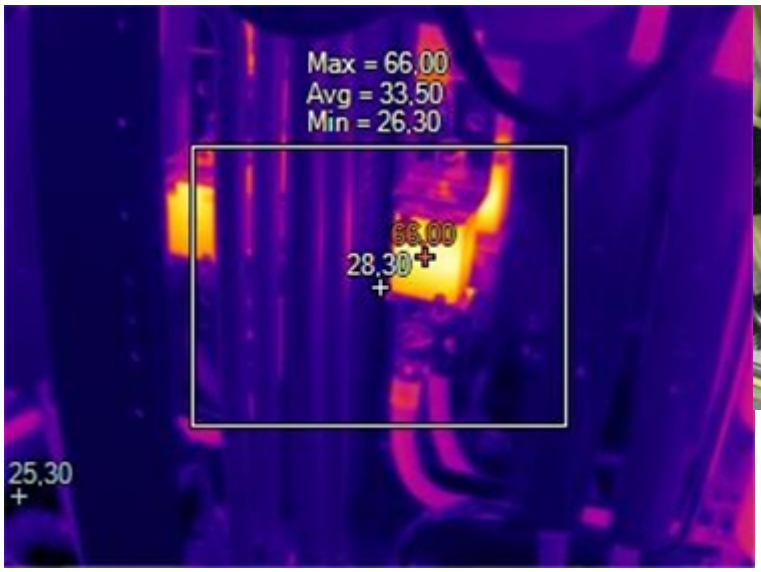


Image Info

Name	IR_00179.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 39.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:35:14 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.0 °C	28.0 °C	28.0 °C	0.95	22.0 °C	0.00	
Centerbox	39.5 °C	25.3 °C	29.6 °C	0.95	22.0 °C	2.95	
Hot	39.5 °C	39.5 °C	39.5 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	



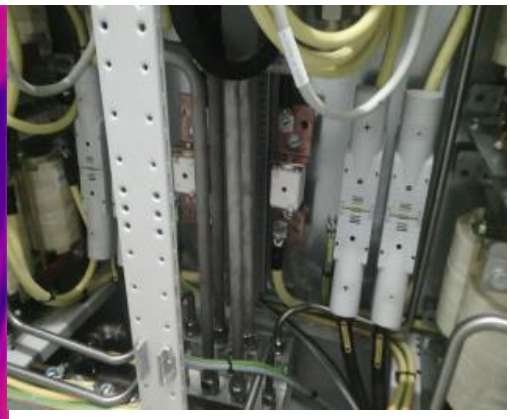
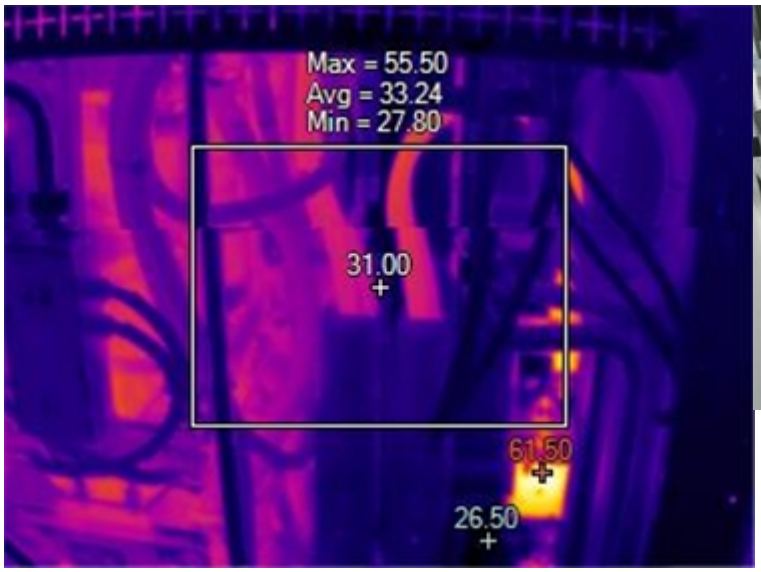


Image Info

Name	IR_00178.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 66,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:35:07 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,3 °C	28,3 °C	28,3 °C	0,95	22,0 °C	0,00	
Centerbox	66,0 °C	26,3 °C	33,5 °C	0,95	22,0 °C	8,35	
Hot	66,0 °C	66,0 °C	66,0 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	



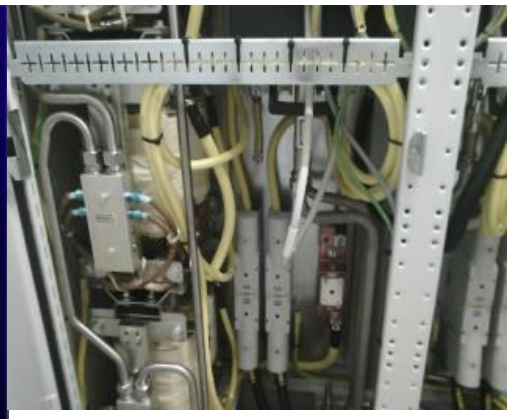


Image Info

Name	IR_00177.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.50 °C to 61.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:35:01 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.0 °C	31.0 °C	31.0 °C	0.95	22.0 °C	0.00	
Centerbox	55.5 °C	27.8 °C	33.2 °C	0.95	22.0 °C	4.10	
Hot	61.5 °C	61.5 °C	61.5 °C	0.95	22.0 °C	0.00	
Cold	26.5 °C	26.5 °C	26.5 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00176.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	26,20 °C to 44,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:34:54 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	34,5 °C	34,5 °C	34,5 °C	0,95	22,0 °C	0,00	
Centerbox	44,0 °C	27,1 °C	34,3 °C	0,95	22,0 °C	3,56	
Hot	44,0 °C	44,0 °C	44,0 °C	0,95	22,0 °C	0,00	
Cold	26,2 °C	26,2 °C	26,2 °C	0,95	22,0 °C	0,00	

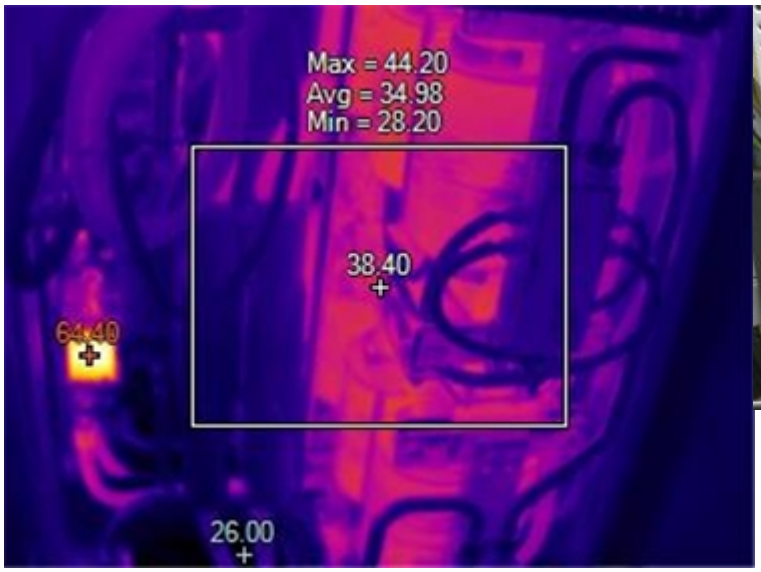




Image Info

Name	IR_00175.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.00 °C to 64.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:34:45 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	38.4 °C	38.4 °C	38.4 °C	0.95	22.0 °C	0.00	
Centerbox	44.2 °C	28.2 °C	35.0 °C	0.95	22.0 °C	4.79	
Hot	64.4 °C	64.4 °C	64.4 °C	0.95	22.0 °C	0.00	
Cold	26.0 °C	26.0 °C	26.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00174.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	27.50 °C to 43.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:34:39 PM
Asset Name	DCDC Converter 6
Asset Group	DCDC Converter 6 > UC06 DCDC Cabinet #6 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32.0 °C	32.0 °C	32.0 °C	0.95	22.0 °C	0.00	
Centerbox	43.5 °C	27.7 °C	34.0 °C	0.95	22.0 °C	3.99	
Hot	43.5 °C	43.5 °C	43.5 °C	0.95	22.0 °C	0.00	
Cold	27.5 °C	27.5 °C	27.5 °C	0.95	22.0 °C	0.00	

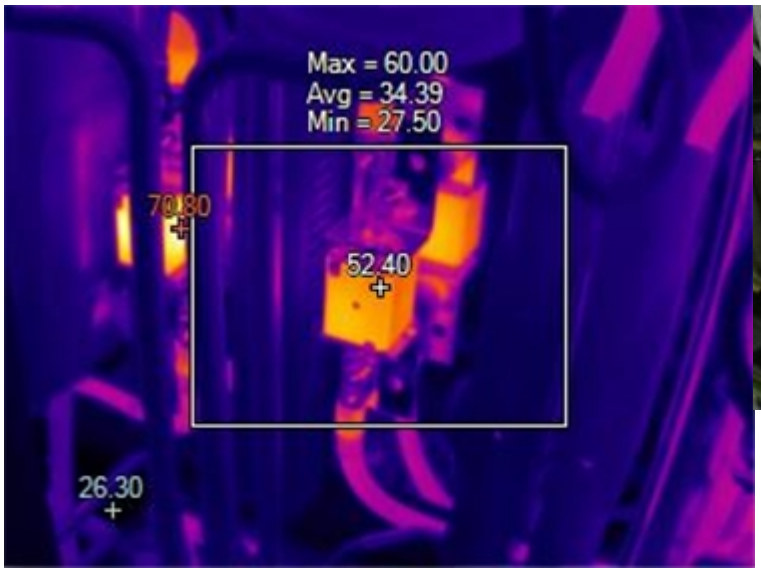


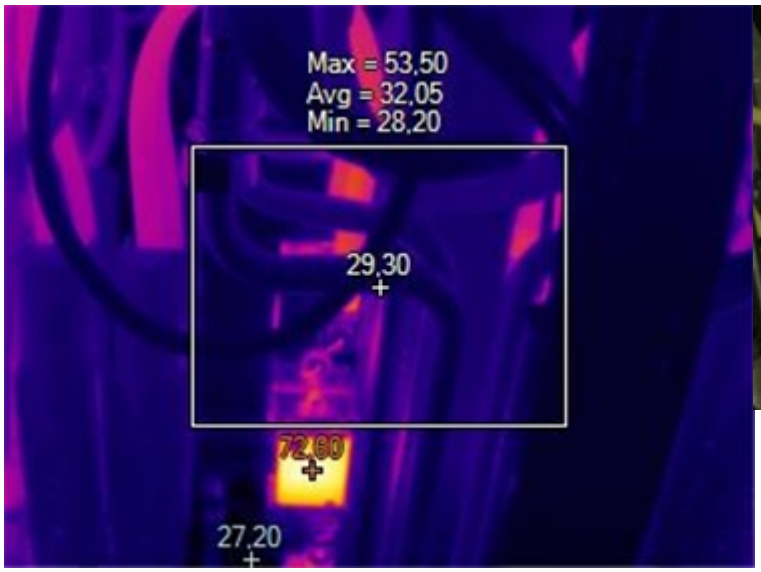


Image Info

Name	IR_00173.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.30 °C to 70.80 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:43 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	52.4 °C	52.4 °C	52.4 °C	0.95	22.0 °C	0.00	
Centerbox	60.0 °C	27.5 °C	34.4 °C	0.95	22.0 °C	7.82	
Hot	70.8 °C	70.8 °C	70.8 °C	0.95	22.0 °C	0.00	
Cold	26.3 °C	26.3 °C	26.3 °C	0.95	22.0 °C	0.00	



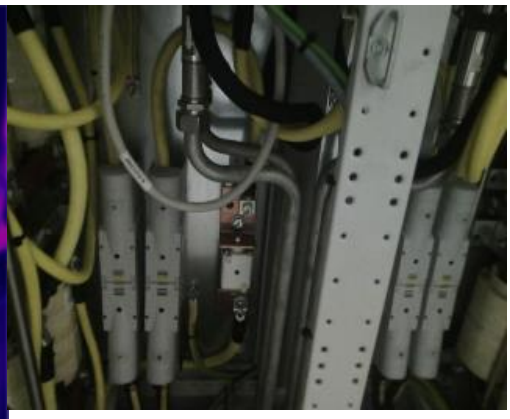


Image Info

Name	IR_00172.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	27,20 °C to 72,60 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:34 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,3 °C	29,3 °C	29,3 °C	0,95	22,0 °C	0,00	
Centerbox	53,5 °C	28,2 °C	32,0 °C	0,95	22,0 °C	3,91	
Hot	72,6 °C	72,6 °C	72,6 °C	0,95	22,0 °C	0,00	
Cold	27,2 °C	27,2 °C	27,2 °C	0,95	22,0 °C	0,00	



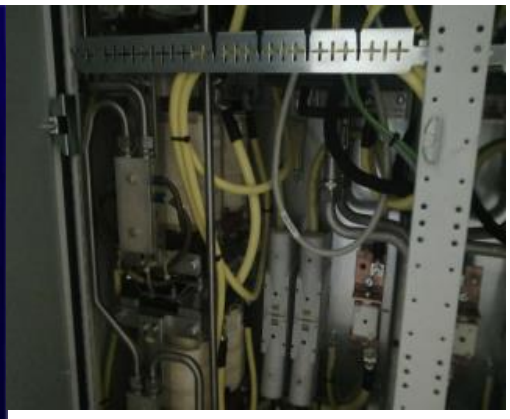


Image Info

Name	IR_00171.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.30 °C to 71.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:25 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	34.5 °C	34.5 °C	34.5 °C	0.95	22.0 °C	0.00	
Centerbox	44.2 °C	27.7 °C	34.6 °C	0.95	22.0 °C	3.91	
Hot	71.5 °C	71.5 °C	71.5 °C	0.95	22.0 °C	0.00	
Cold	26.3 °C	26.3 °C	26.3 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00170.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,80 °C to 44,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:18 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32,0 °C	32,0 °C	32,0 °C	0,95	22,0 °C	0,00	
Centerbox	44,2 °C	28,3 °C	33,5 °C	0,95	22,0 °C	3,59	
Hot	44,7 °C	44,7 °C	44,7 °C	0,95	22,0 °C	0,00	
Cold	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	

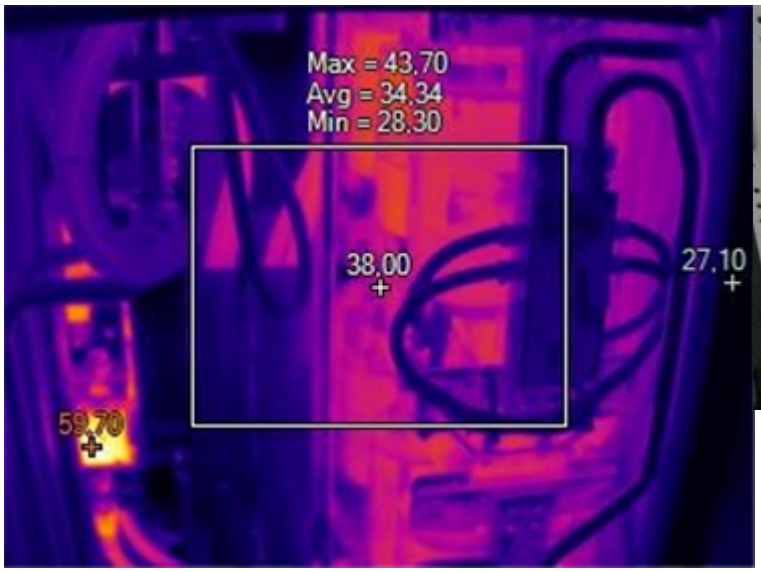




Image Info

Name	IR_00169.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	27,10 °C to 59,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:13 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Centerbox	43,7 °C	28,3 °C	34,3 °C	0,95	22,0 °C	4,34	
Hot	59,7 °C	59,7 °C	59,7 °C	0,95	22,0 °C	0,00	
Cold	27,1 °C	27,1 °C	27,1 °C	0,95	22,0 °C	0,00	

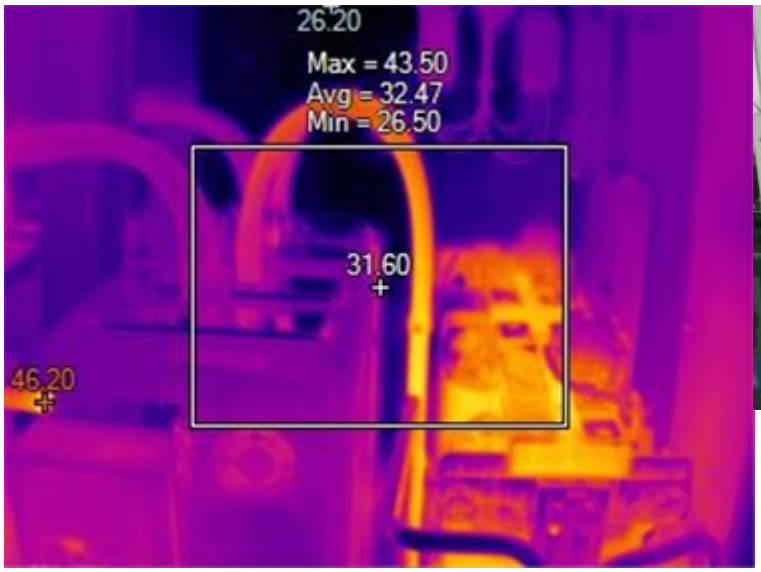




Image Info

Name	IR_00168.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.20 °C to 46.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:33:07 PM
Asset Name	DCDC Converter 5
Asset Group	DCDC Converter 5 > UC05 DCDC Cabinet #5 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.6 °C	31.6 °C	31.6 °C	0.95	22.0 °C	0.00	
Centerbox	43.5 °C	26.5 °C	32.5 °C	0.95	22.0 °C	4.14	
Hot	46.2 °C	46.2 °C	46.2 °C	0.95	22.0 °C	0.00	
Cold	26.2 °C	26.2 °C	26.2 °C	0.95	22.0 °C	0.00	

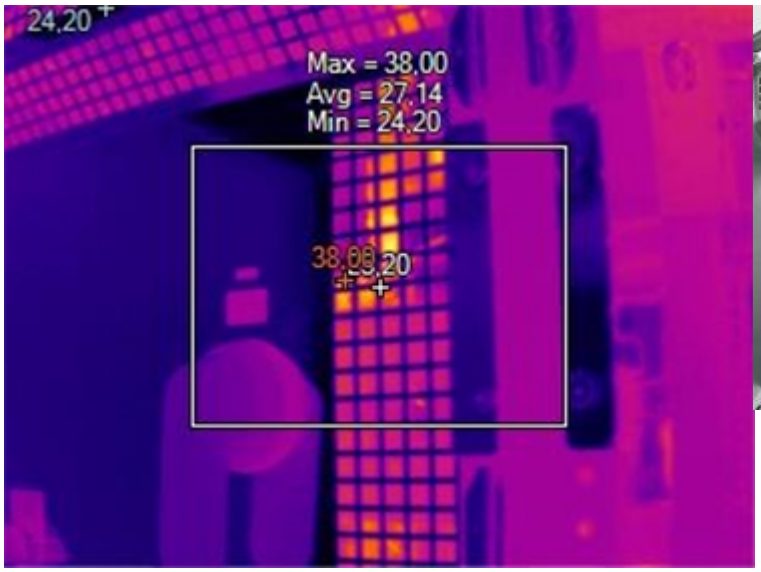




Image Info

Name	IR_00167.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	24,20 °C to 38,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:32:09 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	25,2 °C	25,2 °C	25,2 °C	0,95	22,0 °C	0,00	
Centerbox	38,0 °C	24,2 °C	27,1 °C	0,95	22,0 °C	1,86	
Hot	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Cold	24,2 °C	24,2 °C	24,2 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00166.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.70 °C to 42.90 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:32:01 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32.7 °C	32.7 °C	32.7 °C	0.95	22.0 °C	0.00	
Centerbox	42.9 °C	25.7 °C	32.0 °C	0.95	22.0 °C	3.97	
Hot	42.9 °C	42.9 °C	42.9 °C	0.95	22.0 °C	0.00	
Cold	25.7 °C	25.7 °C	25.7 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00165.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.50 °C to 43.70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:31:56 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.7 °C	30.7 °C	30.7 °C	0.95	22.0 °C	0.00	
Centerbox	43.7 °C	27.2 °C	32.8 °C	0.95	22.0 °C	3.63	
Hot	43.7 °C	43.7 °C	43.7 °C	0.95	22.0 °C	0.00	
Cold	24.5 °C	24.5 °C	24.5 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00164.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	26,20 °C to 43,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:31:49 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30,3 °C	30,3 °C	30,3 °C	0,95	22,0 °C	0,00	
Centerbox	43,5 °C	26,7 °C	32,6 °C	0,95	22,0 °C	4,36	
Hot	43,5 °C	43,5 °C	43,5 °C	0,95	22,0 °C	0,00	
Cold	26,2 °C	26,2 °C	26,2 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00163.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 43,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:31:43 PM
Asset Name	DCDC Converter 4
Asset Group	DCDC Converter 4 > UC04 DCDC Cabinet #4 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	32,5 °C	32,5 °C	32,5 °C	0,95	22,0 °C	0,00	
Centerbox	43,0 °C	25,7 °C	32,2 °C	0,95	22,0 °C	3,73	
Hot	43,0 °C	43,0 °C	43,0 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	

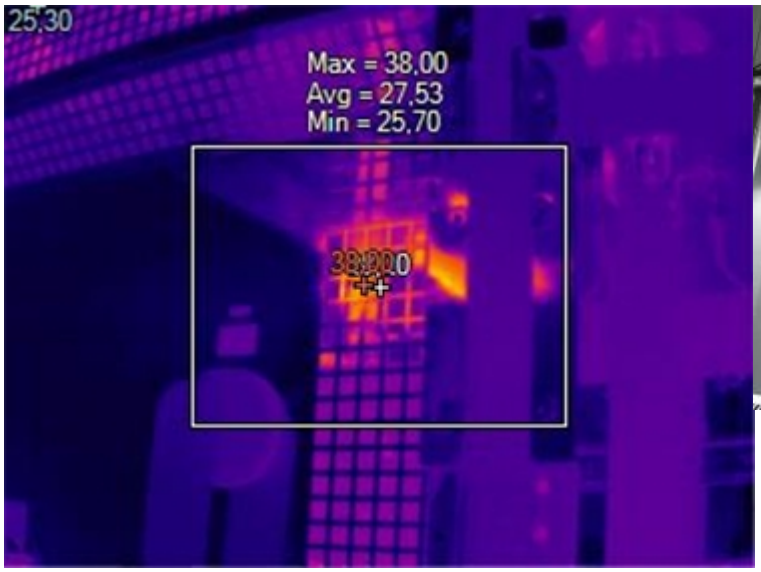




Image Info

Name	IR_00162.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 38,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:34 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28,2 °C	28,2 °C	28,2 °C	0,95	22,0 °C	0,00	
Centerbox	38,0 °C	25,7 °C	27,5 °C	0,95	22,0 °C	1,61	
Hot	38,0 °C	38,0 °C	38,0 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	

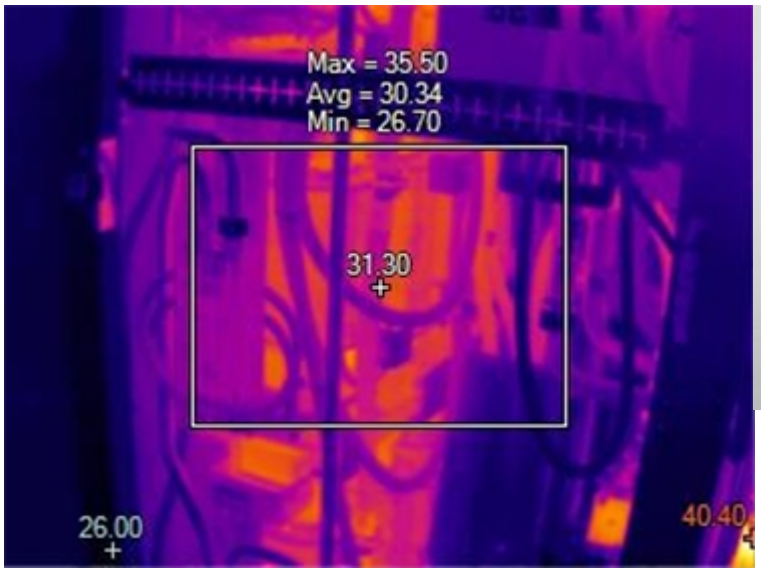




Image Info

Name	IR_00161.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	26.00 °C to 40.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:22 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.3 °C	31.3 °C	31.3 °C	0.95	22.0 °C	0.00	
Centerbox	35.5 °C	26.7 °C	30.3 °C	0.95	22.0 °C	1.65	
Hot	40.4 °C	40.4 °C	40.4 °C	0.95	22.0 °C	0.00	
Cold	26.0 °C	26.0 °C	26.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00160.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.60 °C to 36.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:16 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.5 °C	28.5 °C	28.5 °C	0.95	22.0 °C	0.00	
Centerbox	36.5 °C	26.7 °C	29.9 °C	0.95	22.0 °C	1.97	
Hot	36.5 °C	36.5 °C	36.5 °C	0.95	22.0 °C	0.00	
Cold	25.6 °C	25.6 °C	25.6 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00159.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 41.00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:07 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27.7 °C	27.7 °C	27.7 °C	0.95	22.0 °C	0.00	
Centerbox	41.0 °C	25.8 °C	29.5 °C	0.95	22.0 °C	2.41	
Hot	41.0 °C	41.0 °C	41.0 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00158.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,10 °C to 34,40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:30:02 PM
Asset Name	DCDC Converter 3
Asset Group	DCDC Converter 3 > UC03 DCDC Cabinet #3 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,7 °C	31,7 °C	31,7 °C	0,95	22,0 °C	0,00	
Centerbox	34,4 °C	26,2 °C	30,1 °C	0,95	22,0 °C	1,63	
Hot	34,4 °C	34,4 °C	34,4 °C	0,95	22,0 °C	0,00	
Cold	25,1 °C	25,1 °C	25,1 °C	0,95	22,0 °C	0,00	

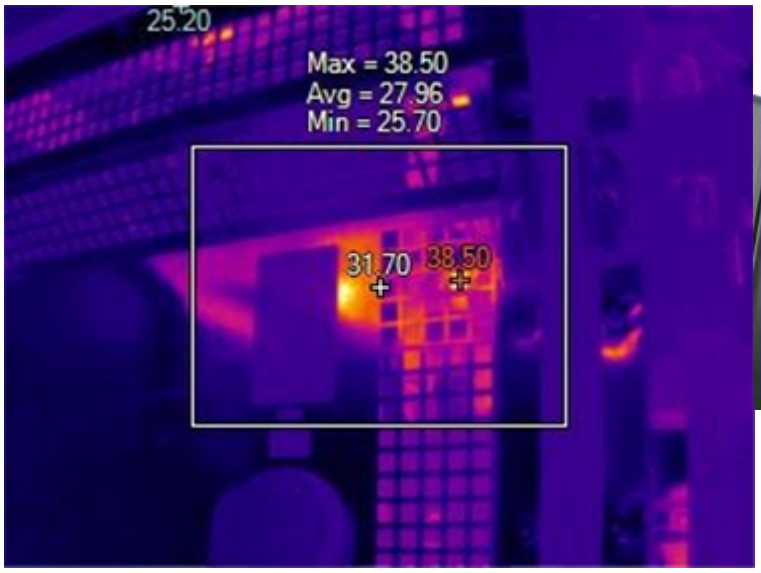




Image Info

Name	IR_00157.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 38.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:25 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.7 °C	31.7 °C	31.7 °C	0.95	22.0 °C	0.00	
Centerbox	38.5 °C	25.7 °C	28.0 °C	0.95	22.0 °C	1.71	
Hot	38.5 °C	38.5 °C	38.5 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00156.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,80 °C to 35,70 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:13 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,7 °C	31,7 °C	31,7 °C	0,95	22,0 °C	0,00	
Centerbox	34,0 °C	27,1 °C	29,9 °C	0,95	22,0 °C	1,34	
Hot	35,7 °C	35,7 °C	35,7 °C	0,95	22,0 °C	0,00	
Cold	25,8 °C	25,8 °C	25,8 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00155.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 35,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:08 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,8 °C	29,8 °C	29,8 °C	0,95	22,0 °C	0,00	
Centerbox	35,5 °C	27,2 °C	29,7 °C	0,95	22,0 °C	1,43	
Hot	35,5 °C	35,5 °C	35,5 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00154.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.70 °C to 34.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:28:00 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31.0 °C	31.0 °C	31.0 °C	0.95	22.0 °C	0.00	
Centerbox	34.4 °C	25.8 °C	29.5 °C	0.95	22.0 °C	1.64	
Hot	34.4 °C	34.4 °C	34.4 °C	0.95	22.0 °C	0.00	
Cold	24.7 °C	24.7 °C	24.7 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00153.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.20 °C to 34.40 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:27:54 PM
Asset Name	DCDC Converter 2
Asset Group	DCDC Converter 2 > UC02 DCDC Cabinet #2 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	30.3 °C	30.3 °C	30.3 °C	0.95	22.0 °C	0.00	
Centerbox	33.5 °C	26.5 °C	29.6 °C	0.95	22.0 °C	1.38	
Hot	34.4 °C	34.4 °C	34.4 °C	0.95	22.0 °C	0.00	
Cold	25.2 °C	25.2 °C	25.2 °C	0.95	22.0 °C	0.00	

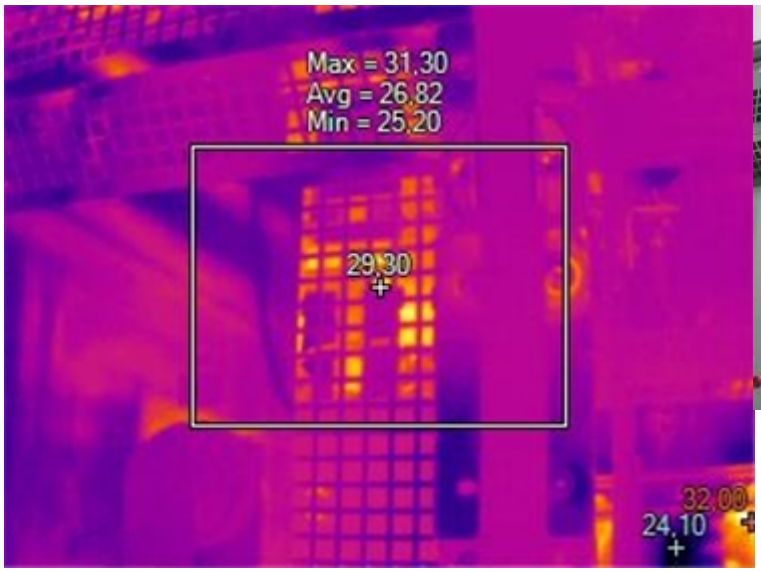




Image Info

Name	IR_00152.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	24,10 °C to 32,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:45 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,3 °C	29,3 °C	29,3 °C	0,95	22,0 °C	0,00	
Centerbox	31,3 °C	25,2 °C	26,8 °C	0,95	22,0 °C	0,81	
Hot	32,0 °C	32,0 °C	32,0 °C	0,95	22,0 °C	0,00	
Cold	24,1 °C	24,1 °C	24,1 °C	0,95	22,0 °C	0,00	

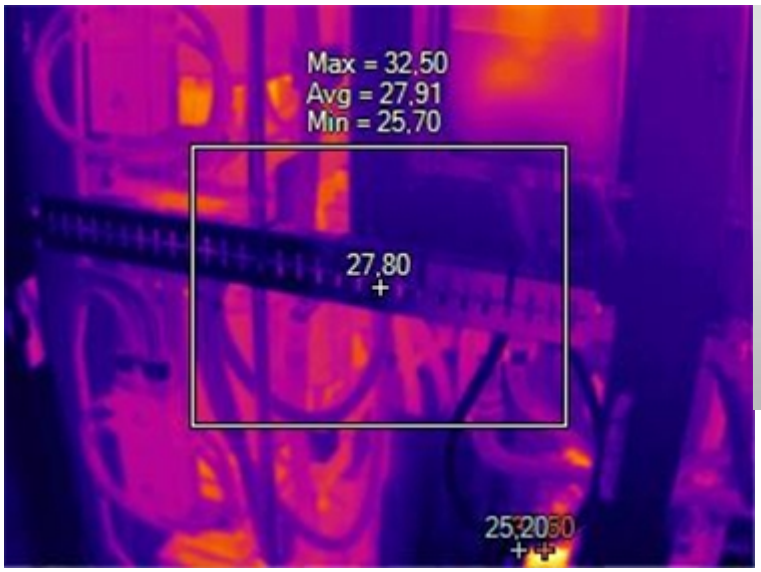




Image Info

Name	IR_00151.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,20 °C to 37,50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:31 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27,8 °C	27,8 °C	27,8 °C	0,95	22,0 °C	0,00	
Centerbox	32,5 °C	25,7 °C	27,9 °C	0,95	22,0 °C	1,36	
Hot	37,5 °C	37,5 °C	37,5 °C	0,95	22,0 °C	0,00	
Cold	25,2 °C	25,2 °C	25,2 °C	0,95	22,0 °C	0,00	

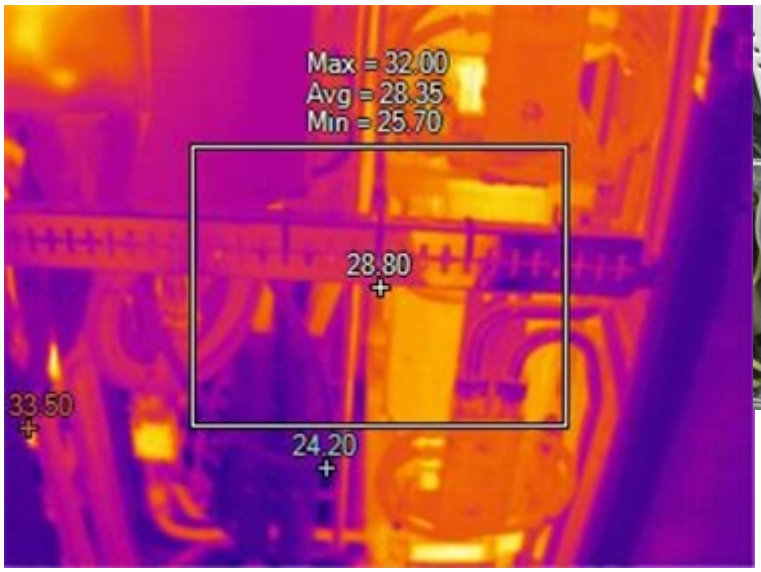




Image Info

Name	IR_00150.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	24.20 °C to 33.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:26 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	28.8 °C	28.8 °C	28.8 °C	0.95	22.0 °C	0.00	
Centerbox	32.0 °C	25.7 °C	28.3 °C	0.95	22.0 °C	1.47	
Hot	33.5 °C	33.5 °C	33.5 °C	0.95	22.0 °C	0.00	
Cold	24.2 °C	24.2 °C	24.2 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00149.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	25,30 °C to 34,20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:21 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	29,1 °C	29,1 °C	29,1 °C	0,95	22,0 °C	0,00	
Centerbox	34,2 °C	26,3 °C	28,3 °C	0,95	22,0 °C	1,49	
Hot	34,2 °C	34,2 °C	34,2 °C	0,95	22,0 °C	0,00	
Cold	25,3 °C	25,3 °C	25,3 °C	0,95	22,0 °C	0,00	





Image Info

Name	IR_00148.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	25.00 °C to 33.50 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:26:16 PM
Asset Name	DCDC Converter
Asset Group	DCDC Converter > UC01 DCDC Cabinet #1 > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	27.1 °C	27.1 °C	27.1 °C	0.95	22.0 °C	0.00	
Centerbox	33.0 °C	26.0 °C	28.5 °C	0.95	22.0 °C	1.51	
Hot	33.5 °C	33.5 °C	33.5 °C	0.95	22.0 °C	0.00	
Cold	25.0 °C	25.0 °C	25.0 °C	0.95	22.0 °C	0.00	





Image Info

Name	IR_00147.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	20.60 °C to 448.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:24:21 PM
Asset Name	Test Equipemnt
Asset Group	Test Equipemnt > Test Equipment > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	52.2 °C	52.2 °C	52.2 °C	0.95	22.0 °C	0.00	
Centerbox	356.8 °C	24.7 °C	49.4 °C	0.95	22.0 °C	37.85	
Hot	448.2 °C	448.2 °C	448.2 °C	0.95	22.0 °C	0.00	
Cold	20.6 °C	20.6 °C	20.6 °C	0.95	22.0 °C	0.00	

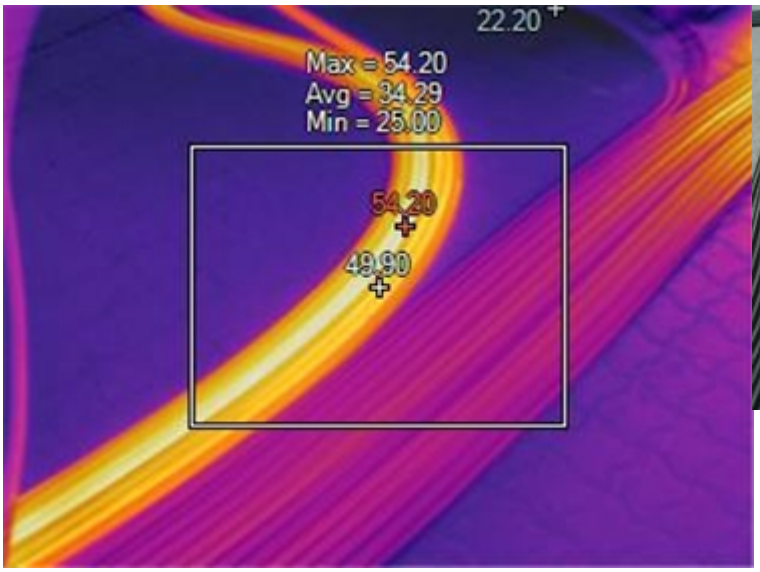




Image Info

Name	IR_00146.IS2
Emissivity	0.95
Background Temperature	22.00 °C
Image Range	22.20 °C to 54.20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:24:03 PM
Asset Name	Test Equipemnt
Asset Group	Test Equipemnt > Test Equipment > Crosswind BLPH

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	49.9 °C	49.9 °C	49.9 °C	0.95	22.0 °C	0.00	
Centerbox	54.2 °C	25.0 °C	34.3 °C	0.95	22.0 °C	8.06	
Hot	54.2 °C	54.2 °C	54.2 °C	0.95	22.0 °C	0.00	
Cold	22.2 °C	22.2 °C	22.2 °C	0.95	22.0 °C	0.00	

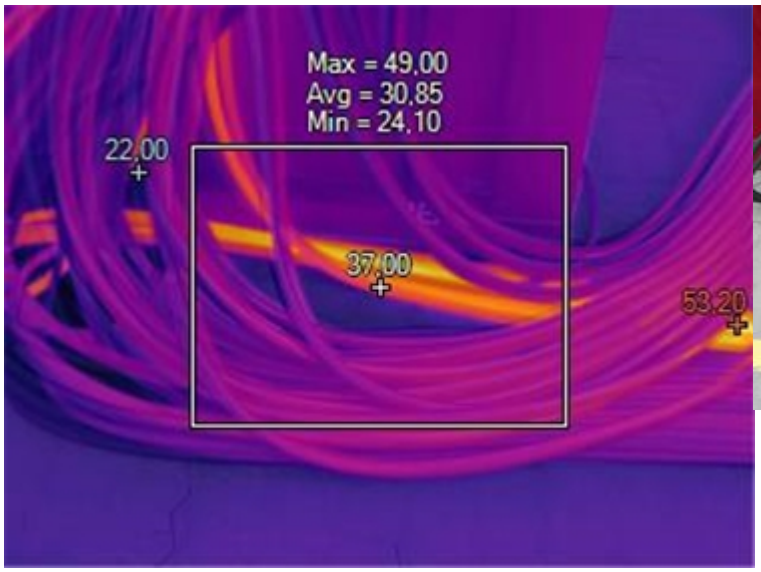




Image Info

Name	IR_00145.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	22,00 °C to 53,20 °C
Camera Serial Number	TiS75+-23080231
Image Time	08/08/2024 16:23:52 PM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	37,0 °C	37,0 °C	37,0 °C	0,95	22,0 °C	0,00	
Centerbox	49,0 °C	24,1 °C	30,9 °C	0,95	22,0 °C	4,13	
Hot	53,2 °C	53,2 °C	53,2 °C	0,95	22,0 °C	0,00	
Cold	22,0 °C	22,0 °C	22,0 °C	0,95	22,0 °C	0,00	

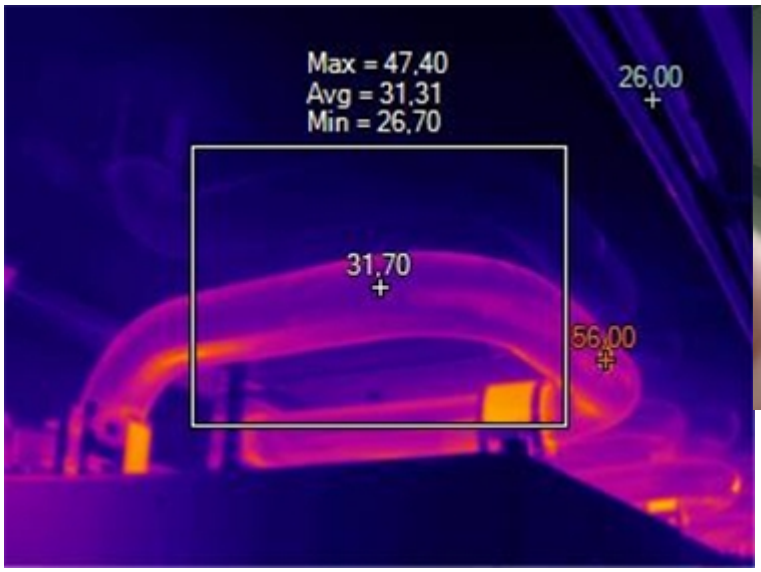




Image Info

Name	IR_00143.IS2
Emissivity	0,95
Background Temperature	22,00 °C
Image Range	26,00 °C to 56,00 °C
Camera Serial Number	TiS75+-23080231
Image Time	11/07/2024 12:56:17 PM

Marker Info

Marker Name	Maximum	Minimum	Average	Emissivity	BG Temp	Std.Dev	Delta-T
Centerpoint	31,7 °C	31,7 °C	31,7 °C	0,95	22,0 °C	0,00	
Centerbox	47,4 °C	26,7 °C	31,3 °C	0,95	22,0 °C	3,73	
Hot	56,0 °C	56,0 °C	56,0 °C	0,95	22,0 °C	0,00	
Cold	26,0 °C	26,0 °C	26,0 °C	0,95	22,0 °C	0,00	

Summary:

Sub Section K12

Type Approval Certificates

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	11/08/2023	First Issue
002	01/05/2025	Updated and ABS certificate added

Document Title:	**BLPH Project - Type Approval Certificates**
Document Number:	K559-2254-CWIWP4202202-K12-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-K12-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	K12
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

TYPE APPROVAL CERTIFICATE

Certificate No:
TAE00004GG
Revision No:
2

This is to certify:

That the Fuel Cell

with type designation(s)
FCwave

Issued to
Ballard Power Systems Europe A/S
Hobro, Nordjylland, Denmark

is found to comply with
DNV rules for classification – Ships

Application :

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV.

Issued at **Hamburg** on **2023-07-14**
This Certificate is valid until **2027-05-31**.
DNV local unit: **Denmark CMC**

Approval Engineer: **Sven Lellesch**

for **DNV**

Olaf Drews
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.

Product description

FCwave™ is a PEM fuel cell power module with rated power of 200 kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinet. The system, lower and upper cabinet, each have individual serial numbers and can be replaced during the service lifetime of the product.

The fuel for the system is pressurized gaseous hydrogen. The hydrogen storage system is not part of Ballard Power Systems Europe scope and therefore not part of the type approval. Oxidant for the reaction is drawn from ambient air and compressed in the internal compressors to feed the fuel cell stacks.
From the stacks, the module will deliver up to 720V direct current to the output of the system. It acts as a load follower electrically. The system needs power from external power source such as the vessels power system to start up, but when running it self-powers the internal Balance of Plant components. The controller and safety system require 24 VDC continuously from the vessels power system to function.
The system requires external water cooling to remove excess heat from the exothermic reaction in the fuel cells. The heat transfer is done with the integrated heat exchanger. The heat can be used in shipboard systems or disposed of as the customer desires. The fuel cells used in the system are Low Temperature PEM fuel cells. Temperatures in the system are below 100°C. The Fuel cell system is built into a cabinet. The cabinet has an ingress protection of IP44. The system is designed to be installed inside a fuel cell installation room. FCwave™ follows the gas safe machinery space concept as per IGF Code.

System Data

Control System Hardware and Software Version

Software	2.X.X	Dated 01/06 2023
Firmware	4.0.4.0	Dated 24/11 2021 (Deif AS)

Safety System Hardware and Software Version

Software	1.1.0	Dated 01/06 2023
Firmware	4.4	01/27 2022 (Siemens)

Independent Safety triggered by

Hydrogen concentration measurement inside fuel cell
External E Stop
Heat Detection inside fuel cell
Smoke Detection inside fuel cell
Ventilation Air Flow inside fuel cell

Interfaces to vessel

Are to be coordinated for each installation
Fuel Cell installation Room and Room requirements
Vessel control system
24VDC safety power supply
24VDC power supply
DC input/output
H2 supply
Low temperature cooling supply
High temperature cooling supply
H2 Enclosure ventilation outlet
Process exhaust outlet
H2 Enclosure ventilation Inlet
Process air inlet
Water drain

Application/Limitation

Fuel cell of type FCwave™ is approved for application as per DNV-RU-SHIP Pt.6 Ch.2 Sec.3.

Installation room
The fuel cell space (H2 enclosure as part of the FCwave™ cabinet) is not equipped with A60 insulation and is not equipped with a fire extinguishing system as indicated in MSC.1/Circ.1647 para 3.1.2 and 3.3.1. Additional installation room requirements shall be defined in the detailed design phase for the vessel.

The installation room is regarded as non-hazardous space.
The free volume of the installation room shall not be less than 10m³.
Gas detection is recommended for the fuel cell installation room and in the ventilation exhaust.

The FCwave™ does not provide an emergency stop button. Adequate and accessible emergency stop buttons shall be provided and integrated to the FCwave™ emergency stop circuit.
Access to the installation room during operation shall be limited to trained service technicians and crew that have received Ballard fuel cell training. Unrestricted access to the installation room can be permitted when all fuel cell modules are powered off and otherwise deemed permissible.

Hydrogen supply
Supply piping to each cabinet shall be carried out as double walled piping following the IGF Code principles.
Each FCwave™ cabinet shall be provided with a shut-off valve with a closing time of less than 2 seconds.
The hydrogen mass flow to each FCwave™ must be restricted by suitable means in all operation scenarios to 4.9g/s.
The dimension (diameter and length) of the hydrogen supply piping from shut-off valve to module interface plate shall not exceed 5000 cm³ as per Integration Manual.

Ventilation
The fuel cell space (H2 enclosure as part of the FCwave™ cabinet) is designed with area classification according to IEC 60079-10:2020, at least suitable for zone 2 installation.
In all cases process air and ventilation exhaust must remain separated, combination of multiple systems exhaust of the same type only. If process and/or ventilation exhausts are combined from multiple systems, they must be equipped with separate isolation dampers, which must close if the module are not operating.
The integration to the vessel shall ensure the exhaust from FC modules (ventilation air) is led to a safe location free of any spark or ignition source.

Approval Conditions
For each delivery to DNV class the following documentation of the fuel cell power installation is to be submitted for approval:

Fuel cell power installation
- Reference to this type approval certificate
- Documents according to DNV RU-SHIP, Pt. 6 Ch. 2 Sec. 3, table 3 for Fuel cell power installation
- G060 Structural fire protection drawing
- G200 Fixed fire protection drawing
- MAN002 Integration Manual

The Type Approval covers hardware and software listed under product description.

When the type approved software is revised (affecting all future deliveries) DNV is to be informed by forwarding updated software version documentation. If the changes are judged to affect functionality for which rule requirements apply a new functional type test may be required and the certificate may have to be renewed to identify the new software version.

Product certificate
Each delivery of the application system is to be certified according to Pt.6, Ch.2, Sec. 3. The certification test is to be performed at the manufacturer of the application system before the system is shipped to the yard. After certification, the clause for application software control will be put into force

Application software control
All changes in software are to be recorded as long as the system is in use on board. Documentation of major changes are to be forwarded to DNV for evaluation and approval before implemented on board

Type Approval documentation

Tests carried out

Marking of product
The components shall be marked for traceability to the Type Approval.

Periodical assessment
For retention of the Type Approval, a periodical assessment as per DNV-CP-0338 Sec.4 shall be performed by a DNV Surveyor in order to verify that the conditions for the Type Approval are complied with.
To check the validity of this certificate, please look it up in https://approvalfinder.dnv.com.

Certificate No: LR23327644TA
Issue Date: 27/07/2023
Expiry Date: 26/07/2028

Type Approval Certificate

This is to certify that the undernoted product(s) has/have been tested with satisfactory results in accordance with the relevant requirements of the Lloyd's Register Type Approval System.

Manufacturer	**Ballard Power Systems Europe A/S**
Address	Majsmarken 1, Hobro, 9500, Denmark
Type	Fuel Cell Module
Description	FCwave™ is a PEM fuel cell power module with rated power of 200 kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinet. The system, lower and upper cabinet, each have individual serial numbers and can be replaced during the service lifetime of the product. The fuel for the system is pressurized gaseous hydrogen. The hydrogen storage system is not part of Ballard Power Systems Europe scope and therefore not part of the type approval. Oxidant for the reaction is drawn from ambient air and compressed in the internal compressors to feed the fuel cell stacks. From the stacks, the module will deliver up to 720V DC to the output of the system. It acts as a load follower electrically. The system needs power from external power source such as the vessels power system to start up, but when running it self-powers the internal Balance of Plant components. The controller and safety system require 24V DC continuously from the vessels power system to function. The system requires external water cooling to remove excess heat from the exothermic reaction in the fuel cells. The heat transfer is done with the integrated heat exchanger. The heat can be used in shipboard systems or disposed of as the customer desires. The fuel cells used in the system are Low Temperature PEM fuel cells. Temperatures in the system are below 100°C. The Fuel cell system is built into a cabinet. The cabinet has an ingress protection of IP 44. The system is designed to be installed inside a fuel cell installation room.

Jin Meng

Electrical & Control - Senior Specialist to
Lloyd's Register EMEA
A member of the Lloyd's Register group

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Type Approval Certificate

FCwave™ follows the gas safe machinery space concept as per IGF Code.

Trade Name

FCwave™

Application

Marine, Offshore and Industrial applications for use in environmental categories ENV1, as defined in Lloyd's Register Type Approval System, Test Specification Number 7, Fuel Cell Modules, January 2023.

Specified Standard

-Manufacturer's specification
-IACS UR E10 Rev. 8 / 2021 as applicable

Ratings

-Maximum rated output power: 200kW
-Operating voltage: 350 – 720V DC
-Rated current: 2 x 300A or 1 x 550A

Other Conditions

The Fuel Cell Module is approved subject to the following conditions:

- A risk assessment specific to fuel cell power installations is to be carried out for each installation on board.The risk assessment is to evaluate risks related to the safe operation of the ship and as such is to address the safety of the fuel cell power installation itself and, where the fuel cell installation provides power for propulsion of the ship or other essential services, the dependability of the fuel cell power installation.
- The Fuel Cell Module shall only be used in accordance with the manufacturer's instructions and recommendations.
- The Fuel Cell Module shall be installed and maintained in accordance with the applicable rules, regulations, and standards for marine applications.
- The Fuel Cell Module shall be operated and monitored in accordance with the relevant safety requirements.
- The Fuel Cell Module shall be subject to periodic inspections and maintenance, in accordance with the manufacturer's recommendations and applicable rules and regulations.

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Type Approval Certificate

Type Approval does not eliminate the need for normal inspection and survey procedures required by the Rules and Regulations.
If the specified standards are amended during the validity of this certificate, the product is to be re-approved prior to it being supplied to vessels to which the amended standards apply.

This certificate is not valid for equipment, the design, ratings or operating parameters of which have been varied from the specimen tested. The manufacturer should notify Lloyd's Register EMEA of any modification or changes to the equipment in order to obtain a valid Certificate.

The Design Appraisal Document HPC2262032/JM/PH and its supplementary Type Approval Terms and Conditions form part of this Certificate.

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Confirmation of Product Type Approval

Company Name: BALLARD POWER SYSTEMS EUROPE A/S

Address: MAJSMARKEN 19500 HOBRO Denmark

Product: Fuel Cell

Model(s): FCwave

Endorsements:

Certificate Type	Certificate Number	Issue Date	Expiry Date
Product Design Assessment (PDA)	24-2503176-PDA	01-JUL-2024	30-JUN-2029
Manufacturing Assessment (MA)	24-6556075	26-AUG-2024	25-AUG-2029
Product Quality Assurance (PQA)	NA	NA	NA

Tier
5 - Unit Certification Required

Intended Service
Main & Auxiliary Power Generation for Marine and Offshore Applications

Description
FCwave is a low temperature PEM fuel cell power system with rated power output of 200kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinets, each has individual serial numbers and can be replaced during the service lifetime of the product, as necessary.

Ratings
Power output: 200 KW

H2 Inlet Supply Pressure: 3.5 - 6.5 barg

H2 Design Temperature of operation: 0 - 80°C

Fuel Cell Hydrogen Operating Pressure: 0.2 - 1.0 barg

H2 Flowrate to Valve Block: 4.9 g/s

Ingress Protection of Cabinet: IP44

Operating Ambient Temperature: 0 -45 degree

Service Restrictions
Unit Certification is required for this product as indicated in the 4-9-3/Table 2 and 4-9-9/15.7 of the ABS Rules for Building and Classing Marine Vessels (2024).

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If the manufacturer or purchaser request an ABS Certificate for compliance with a specification or standard, the specification or standard, including inspection standards and tolerances, must be clearly defined.

Comments

1. The Manufacturer has provided a declaration about the control of, or the lack of Asbestos in this product.

2. During final installation the attending Surveyor is to verify that redundant gas detectors able to detect H2 are installed in the appropriate locations and operate properly. Any accumulation of gas to 20% LFL should trigger gas detector alarm and accumulation to 40% LFL should trigger the ESD.

3. During final installation the attending Surveyor is to verify that the FCwave is equipped with anchor mechanisms or other suitable attachments to the base structure or the hull.

4. Upon installation, the Surveyor is to verify that the door air intakes/inlets are clear to minimize the risk of complete blockage.

5. Upon installation, the Surveyor is to verify that the Chassis is properly grounded.

6. After assembled to a complete assembly unit or subassembly unit, each production unit of equipment used in control, monitoring and safety systems is to be tested at the manufacturer’s shop in the presence of the ABS Surveyor according to 4-9-9/15.7 TABLE 2 as follows:

i) Visual inspection

ii) Performance test

iii) External Power supply failure

7. FCwave system has been assigned with a Category II system classification per 4-9-3/Table 1 of the Marine Vessels Rules. Accordingly, the following tests are to be performed and are to be witnessed by the Surveyor at the Factory in accordance with 4-9-3/Table 2 of the Marine Vessels Rules (MVR).

i) 3.6: Fault Simulation.

ii) 3.7: Factory Acceptance Tests.

8. The design applies the Hazardous Zone Classification method of IEC 60079-10. The fuel cell installation room is considered as a Non-Hazardous Zone or Zone 2 with negligible extent in accordance with IEC 60079-10-1/Table D.1, with all hydrogen fuel piping entering the space and leading to or from the non-structural fuel cell space enclosure to be provided with a double-wall containment system appropriate to the fuel used by the piping.

9. Structural fire protection shall apply to the fuel cell installation room boundaries, not the fuel cell space enclosure; fire detection and fire extinguishing system requirements shall apply to the fuel cell installation room, not within the fuel cell space enclosure as per Section 3 of Fuel Cell Power Systems Requirements.

10. For each installation, safety concepts including the hazardous zone of the fuel cell installation room and multiple installation of the fuel cell units are to be declared to the flag administration for further consideration and evaluated during the risk assessment.

Notes, Drawings and Documentation

Drawing No. 120-26421-1, FCE003-4.5 EMC test report, Revision: A, Pages: 1

Drawing No. 28859 O60X2 Stainless steel pipe Cert. no. 40144, Double Wall H2 pipe, Revision: A, Pages: 1

Drawing No. 28914 O20X2 Stainless steel pipe Cert no. 466220, Double Wall H2 pipe, Revision: A, Pages: 2

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Drawing No. 4006956 Datasheet, Fire Wire, Revision: A, Pages: 1

Drawing No. 7000090 - Double Wall pipe drawing, Double Wall H2 pipe, Revision: A, Pages: 3

Drawing No. CMS001, Control and safety system description, Revision: A, Pages: 1

Drawing No. CMS003, Control systems diagrams, Revision: A, Pages: 1

Drawing No. CMS004, Power supply arrangement - Schematics, Revision: A, Pages: 1

Drawing No. CMS004-A, Power supply arrangement, Revision: A, Pages: 1

Drawing No. CMS004-B, High voltage supply arrangement , Revision: A, Pages: 1

Drawing No. CMS004-C, Sensor Single Line Diagram, Revision: A, Pages: 1

Drawing No. CMS004-E, FCWave Circuit Diagrams, Revision: A, Pages: 1

Drawing No. CMS005_SEL005, Instrument Cables and equipment list, Revision: A, Pages: 1

Drawing No. CMS006_SEL004, Electrical Datasheet, Revision: A, Pages: 1

Drawing No. CMS007_SAX001, Control Software Specification, Revision: A, Pages: 1

Drawing No. CMS008, Field Instruments periodic test plan, Revision: A, Pages: 1

Drawing No. CMS008-A, Field Instrument List, Revision: A, Pages: 1

Drawing No. CMS009, Software Quality Plan, Revision: A, Pages: 1

Drawing No. CMS010, Schematic description of input and output circuits, Revision: A, Pages: 1

Drawing No. CMS012, Control Monitoring and Safety Test Procedure, Revision: A, Pages: 1

Drawing No. CMS012-A CMS012 Test Report 4, CMS012-A CMS012 Test Report 4, Revision: -, Pages: -

Drawing No. CMS013, CAN matrix, Revision: A, Pages: 1

Drawing No. CMS014, Control System Alarm List, Revision: A, Pages: 1

Drawing No. CMS015, Safety System Documentation, Revision: A, Pages: 1

Drawing No. Correspondence, PDA Preliminary Comment Responses, Revision: 0, Pages: 26

Drawing No. Correspondence, PDA Application New PDA Fuel Cell Power System, Revision: -, Pages: -

Drawing No. FAT001, System FAT, Revision: A, Pages: 1

Drawing No. FAT002, FAT with surveyor, Revision: A, Pages: 1

Drawing No. FCE003, Test programme, Revision: A, Pages: 1

Drawing No. FCE003-2, Safety Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-3, Performance Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.1, Inclination Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.2, Vibration Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.3, Environmental Climate Chamber Test Programme, Revision: A, Pages: 1

Drawing No. FCE003-4.4, Power Supply Test Programme, Revision: A, Pages: 1

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Drawing No. FCE003-4.5, EMC Test Programme, Revision: A, Pages: 1

Drawing No. H2E Purge Valve Datasheet, H2E Purge Valve, Revision: A, Pages: 6

Drawing No. INT001 Explosion Analysis Report 1, INT001 Explosion Analysis Report 1, Revision: -, Pages: -

Drawing No. MAN001_SEL003, Service Manual, Revision: A, Pages: 1

Drawing No. MAN002, Integration Manual, Revision: A, Pages: 1

Drawing No. N1424AY6-A1013702, FCE003-4-4 Power supply failure test report, Revision: A, Pages: 1

Drawing No. N1427ES7-A1110380, FCE003-2 2.2 Temperature Test, Revision: A, Pages: 1

Drawing No. N1427X8Y-A1121839-rev01, FCE003-2 2.5 Safety System Test, Revision: A, Pages: 1

Drawing No. N14284B8-A1125744, FCE003-3 DV29 Nameplate power performance test, Revision: A, Pages: 1

Drawing No. N14284YU-A1127125-rev01, FCE003-2 2.3 Back Pressure Test, Revision: A, Pages: 1

Drawing No. N1428BMZ-A1133039, FCE003-2 2.6 Electric Safety Test, Revision: A, Pages: 1

Drawing No. N1428NN3-A1141771, FCE003-3 DV32_33 Response time/start-stop test, Revision: A, Pages: 1

Drawing No. N1428NN4-A1141772, FCE003-2 2.1 Safety Pressure Test, Revision: A, Pages: 1

Drawing No. N1429D4U-A1156670, FCE003-4.1 Inclination test, Revision: A, Pages: 1

Drawing No. N1429EKW-A1157845, FCE003-2 2.4 Block Airways Test, Revision: A, Pages: 1

Drawing No. PRC001…005, Design criteria for pressure containing components, Revision: A, Pages: 1

Drawing No. PWR001, Arrangement Plan, Revision: A, Pages: 1

Drawing No. PWR002, PPHA FCWave, Revision: A, Pages: 1

Drawing No. PWR003, Hazardous Area classification plan, Revision: A, Pages: 1

Drawing No. PWR004, Piping diagram, Revision: A, Pages: 1

Drawing No. PWR005, P&ID, Revision: A, Pages: 1

Drawing No. PWR005, P&ID, Revision: , Pages: 1

Drawing No. PWR006, Functional description, Revision: A, Pages: 1

Drawing No. PWR007_PWR002, Safety description (Risk asessment), Revision: A, Pages: 1

Drawing No. PWR008-C, Commissioning checklist, Revision: A, Pages: 1

Drawing No. PWR008_TES001, Commissioning procedure, Revision: A, Pages: 1

Drawing No. PWR009, Safety concept, Revision: A, Pages: 1

Drawing No. Pipes 106039 1 DOC, Double Wall H2 pipe, Revision: A, Pages: 4

Drawing No. SVE001…003, Ventilation diagram, Revision: A, Pages: 1

Drawing No. Silicon Hose Datasheet, Silicone Hose, Revision: A, Pages: 3

Drawing No. Silicone Hose 7000046 - Fuel outlet manifold, Silicone Hose, Revision: A, Pages: 2

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Drawing No. Silicone Hose 7000047 - Fuel inlet manifold, Silicone Hose, Revision: A, Pages: 3

Drawing No. TAC 44860/B2 BV, BV_Hy-Lok_Tube_Fittings_2022, Revision: -, Pages: -

Drawing No. Tube fittings catalogue, HY-LOK 7000778, Revision: -, Pages: -

Term of Validity
This Product Design Assessment (PDA) Certificate remains valid until 30/Jun/2029 or until the Rules and/or Standards used in the assessment are revised or until there is a design modification warranting design reassessment (whichever occurs first).

Acceptance of product is limited to the "Intended Service" details prescribed in the certificate and as per applicable Rules and Standards.

This Certificate is valid for installation of the listed product on ABS units which exist or are under contract for construction on or previous to the effective date of the ABS Rules and standards applied at the time of PDA issuance. Use of the Product for non-ABS units is subject to agreement between the manufacturer and intended client.

ABS Rules
Rules for Conditions of Classification, Part 1 - 2024 Marine Vessel Rules 1-1-4/7.7, 1-1-A3, 1-1-A4, Which covers the following:

Marine Vessel Rules (MVR) 2024 :4-9-3/Table 1, 4-9-3/Table 2, 4-9-9/15.7, 5C-13-7/3, 5C-13-16/1.1

Requirements for Fuel Cell Power Systems for Marine and Offshore Applications 2023

International Standards
IEC 60079-10: Classification of Area – Explosive Gas Atmosphere

IEC 62282-2-100:2020, Fuel cell technologies - Part 2-100: Fuel cell modules – Safety

IEC 62282-3-100:2019, Fuel cell technologies - Part 3-100: Stationary fuel cell power systems - Safety

EU-MED Standards
NA

National Standards
NA

Government Standards
NA

Other Standards
NA





Corporate ABS Programs
American Bureau of Shipping

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Print Date and Time: 30-Aug-2024 2:49

ABS has used due diligence in the preparation of this certificate, and it represents the information on the product in the ABS Records as of the date and time the certificate is printed.

If the Rules and/or standards used in the PDA evaluation are revised or if there is a design modification (whichever occurs first), a PDA revalidation may be necessary.

The continued validity of the MA is dependent on completion of satisfactory audits as required by the ABS Rules. The validity of both PDA and MA entitles the product to receive a **Confirmation of Product Type Approval**.

Acceptance of product is limited to the “Intended Service” details prescribed in the certificate and as per applicable Rules and Standards.

This Certificate is valid for installation of the listed product on ABS units which exist or are under contract for construction on or prior to the effective date of the ABS Rules and standards applied at the time of PDA issuance. ABS makes no representations regarding Type Approval of the Product for use on vessels, MODUs or facilities built after the date of the ABS Rules used for this evaluation.

Type Approval requires Drawing Assessment, Prototype Testing and assessment of the manufacturer's quality assurance and quality control arrangements. The manufacturer is responsible to maintain compliance with all specifications applicable to the product design assessment. Unless specifically indicated in the description of the product, certification under type approval does not waive requirements for witnessed inspection or additional survey for product use on a vessel, MODU or facility intended to be ABS classed or that is presently in class with ABS.

Due to wide variety of specifications used in the products ABS has evaluated for Type Approval, it is part of our contract that; whether the standard is an ABS Rule or a non-ABS Rule, the Client has full responsibility for continued compliance with the standard.

Questions regarding the validity of ABS Rules or the need for supplemental testing or inspection of such products should, in all cases, be addressed to ABS.

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Section Q

Quality Documentation

Sub Section Q99

ATEX inspections during manufacturing

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	01/05/2025	First Issue
002	13/05/2025	Document number corrected

Document Title:	**BLPH Project - ATEX Inspections during Manufacturing**
Document Number:	BPSE-INN-BPH-ITP-00005
Legacy Number:	K559-2254-CWIWP4202202-Q99-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-Q99-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	Q99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

SPC ID 0203 Pipework inspection and leakage test check sheet

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on expected leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 Heater+Container, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 1	1-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 3	3-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container string 1,2,3,4,5,6



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

H2 Container pipe to FCwave



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

SPC ID 0203 Pipework inspection and leakage test check sheet

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on allowable leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 heater, String 1	1-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 1	1-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 3	3-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 5	5-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater string 1,2,3 Inlet

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





H2 Heater string 4,5,6 Inlet



H2 Heater string 1,2,3,4,5,6 Shut-off Valve & Pipes

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





Short Title	**ATEX Inspection Checklist**
Full Title	**ATEX Inspection Checklist, 601456B Crosswind Hydrogen Manifold**
Abstract	-

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Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	RBS	2. September 2024

Checked by: RBS	Date: Sept 2024
Approved by: PBL	Date: Sept 2024

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• Purpose and Scope

The purpose of this document is to provide a checklist for the Crosswind ATEX area containing the hydrogen manifold.

• References

Document	Name	Author
IEC 60079-17	Explosive atmospheres - Part 17: Electrical installations inspection and maintenance	IEC
JEVI 1953 861 100	Datasheet "Ex D-8640 Immersion Heater, 9kW 3x400VAC"	Sinus JEVI
	Datasheet "ASCO Solenoid Valves 210 series"	Emerson
	Datasheet "ASCO Solenoid NF series"	Emerson
	Datasheet "IFM LMT01A"	IFM
	Datasheet "HUBA 520 pressure sensor"	HUBA
	Datasheet "IFM TT1050-01"	IFM
	Datasheet "PR electronic 9202	PR electronic
	Datasheet "PR electronic 9113"	PR electronic
	Datasheet "PR electronic 9106"	PR electronic

- **Checklist:**

1.1 Hydrogen heater element

1.1.1 Test

The test is done accordingly to the test schematics in IEC 60079-17 Tabel C.1 following descriptions of the test will be below if applicable.

1.1.2 Relevant Standard / document

- IEC 60079-17
- JEVI datasheet 1953 861 100

1.1.3 Brief Test Plan

- Inspection will be done in respect to the datasheet, standards and Visual inspection prior to startup.

1.1.4 Pass/Fail criteria.

- The pass/fail criteria is specified for each inspection element is shown in Table 1.

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Table 1: Heater Inspection – Test Result

Item	Criteria	Result	Pass/Fail	Notes
Equipment is appropriate to the EPL/Zone requirement of the location	Gc or better	GB	✓	
Equipment group is correct	IIC	IIC	✓	
Equipment temperature class is correct	T1	T4	✓	
Degree of protection (IP grade) of the equipment is appropriate for the level of protection/group/conductivity	>IP55	IP66	✓	
Equipment circuit identification is correct	Present	✓	✓	
Equipment circuit identification is available	Yes	✓	✓	
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	NA	—	—	—
There is no damage or unauthorized modifications	None	none	✓	
There is no evidence of unauthorized modification	None	none	✓	
Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight	Yes		✓	
Threaded covers on enclosures are of the correct type, are tight and secured	Yes		✓	
Joint surfaces are clean and undamaged and gaskets, if any, are satisfactory and positioned correctly	Yes		✓	
Condition of enclosure gaskets is satisfactory	Yes		✓	
There is no evidence of ingress of water or dust in the enclosure in accordance with the IP rating	No		✓	

Dimensions of flanged joint gaps are: – within the limits in accordance with the manufacturer's documentation or – within maximum values permitted by the relevant construction standard at time of installation or – within maximum values permitted by site documentation	—	—	—	—
Electrical connections are tight	Yes		✓	
Unused terminals are tightened	Yes		✓	
Type of cable is appropriate	Voltage and Environmental		✓	
There is no obvious damage to cables	No		✓	
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	Not relevant	Not relevant	Not relevant	Not relevant
Stopping boxes and cable boxes are correctly filled	Yes		N/A	N/A
Integrity of conduit system and interface with mixed system maintained	No leaks			
Earthing connections, including any supplementary earthing bonding connections are satisfactory (for example connections are tight and conductors are of sufficient cross-section)	Inspection		✓	Gnd connected inside housing
Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	<100mOhm	32mΩ	✓	
Automatic electrical protective devices are set correctly (auto-reset not possible)	Not present	Not present	Not present	Not present
Automatic electrical protective devices operate within permitted limits	Not present	Not present	Not present	Not present
Specific conditions of use (if applicable) are complied with	None	none	N/A	

Cables not in use are correctly terminated	Yes		✓	
Obstructions adjacent to flameproof flanged joints are in accordance with IEC 60079-14	Not present		N/A	
Variable voltage/frequency installation complies with documentation	Not present	Not present	Not present	Not present
Temperature sensors function according to manufacturer's documents	Not present	Not present	Not present	Not present
Safety cut off devices function according to manufacturer's documents	Inspected		✓	
The setting of the safety cut off is sealed	Yes		✓	
Reset of a heating system safety cut off possible with tool only	Yes		✓	
Auto-reset is not possible	Yes		✓	
Reset of a safety cut off under fault conditions is prevented	Yes		✓	
Safety cut off independent from control system	Yes		✓	
Level switch is installed and correctly set, if required	Yes (External to heater)		✓	
Flow switch is installed and correctly set, if required	NA		N/A	
Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	Yes = X in product number	IP66 SS ect	✓	
No undue accumulation of dust and dirt	No		✓	

1.2 H2 Shut Off Valve

1.2.1 Test

The test is done accordingly to the test schematics in IEC 60079-17 Tabel C.1 following descriptions of the test will be below if applicable.

1.2.2 Relevant Standard / document

- IEC 60079-17
- Datasheet "ASCO solenoid valves 210 series"
- Datasheet "ASCO Solenoid NF series"

1.2.3 Brief Test Plan

- Inspection will be done in respect to the datasheet, standards and Visual inspection prior to startup.

1.2.4 Pass/Fail criteria.

- The pass/fail criteria are specified for each inspection element is shown in Table 2.

Table 2: Hydrogen Valve Inspection – Test Result

Item	Criteria	Result	Pass/Fail	Notes
Equipment is appropriate to the EPL/Zone requirement of the location	Gc or better	Gb	✓	
Equipment group is correct	IIC	IIc	✓	
Equipment temperature class is correct	T1	T4	✓	
Degree of protection (IP grade) of the equipment is appropriate for the level of protection/group/conductivity	>IP55	IP67	✓	
Equipment circuit identification is correct	Present		✓	
Equipment circuit identification is available	Present		✓	
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	Not applicable	Not applicable	Not applicable	Not applicable
There is no damage or unauthorized modifications	None		✓	
There is no evidence of unauthorized modification	None		✓	
Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight	Yes		✓	
Threaded covers on enclosures are of the correct type, are tight and secured	No threaded cover	No threaded cover	No threaded cover	No threaded cover
Joint surfaces are clean and undamaged and gaskets, if any, are satisfactory and positioned correctly	Yes		✓	
Condition of enclosure gaskets is satisfactory	Yes		✓	
There is no evidence of ingress of water or dust in the enclosure in accordance with the IP rating	No		✓	

Dimensions of flanged joint gaps are: – within the limits in accordance with the manufacturer's documentation or – within maximum values permitted by the relevant construction standard at time of installation or – within maximum values permitted by site documentation	Tightened to 85 Nm on bonded seal connection	85 Nm	✓	
Electrical connections are tight	Yes		✓	
Unused terminals are tightened	Yes		NA	
Type of cable is appropriate	Voltage and Environmental		✓	
There is no obvious damage to cables	None		✓	
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	Tightness – refer to leakage test		Leakage Passed ✓	
Stopping boxes and cable boxes are correctly filled	Not applicable	Not applicable	Not applicable	Not applicable
Integrity of conduit system and interface with mixed system maintained	Not applicable	Not applicable	Not applicable	Not applicable
Earthing connections, including any supplementary earthing bonding connections are satisfactory (for example connections are tight and conductors are of sufficient cross-section)	Inspection		✓	Gnd connected inside
Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	<100mOhm	<40mΩ	✓	
Automatic electrical protective devices are set correctly (auto-reset not possible)	Not present	Not present	Not present	Not present
Automatic electrical protective devices operate within permitted limits	Not present	Not present	Not present	Not present
Specific conditions of use (if applicable) are complied with	X= stainless steel	Ok	✓	

Cables not in use are correctly terminated	Pass		✓	no loose cables
Obstructions adjacent to flameproof flanged joints are in accordance with IEC 60079-14	Not present	Not present	Not present	Not present
Variable voltage/frequency installation complies with documentation	Not present	Not present	Not present	Not present
Temperature sensors function according to manufacturer's documents	Not present	Not present	Not present	Not present
Safety cut off devices function according to manufacturer's documents	Not present	Not present	Not present	Not present
The setting of the safety cut off is sealed	Not relevant	Not relevant	Not relevant	Not relevant
Reset of a heating system safety cut off possible with tool only	Not relevant	Not relevant	Not relevant	Not relevant
Auto-reset is not possible	Not relevant	Not relevant	Not relevant	Not relevant
Reset of a safety cut off under fault conditions is prevented	Not relevant	Not relevant	Not relevant	Not relevant
Safety cut off independent from control system	Not relevant	Not relevant	Not relevant	Not relevant
Level switch is installed and correctly set, if required	Not relevant	Not relevant	Not relevant	Not relevant
Flow switch is installed and correctly set, if required	Not relevant	Not relevant	Not relevant	Not relevant
Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	Yes = X in product number	Yes	✓	
No undue accumulation of dust and dirt	No		✓	

1.3 Sensing elements

1.3.1 Test

The test is done accordingly to the test schematics in IEC 60079-17 Tabel C.2 following descriptions of the test will be below if applicable.

1.3.2 Relevant Standard / document

- IEC 60079-17
- Datasheet "IFM LMT01A"
- Datasheet "HUBA 520 pressure sensor"
- Datasheet "IFM TT1050-01"
- Datasheet "PR electronic 9202"
- Datasheet "PR electronic 9113"
- Datasheet "PR electronic 9106"

1.3.3 Brief Test Plan

- Inspection will be done in respect to the datasheet, standards and Visual inspection prior to startup.

1.3.4 Pass/Fail criteria.

- The pass/fail criteria are specified for each inspection element is shown in Table 3.

Table 3: Sensing Elements – Test Result

Item	Criteria	Result	Pass/Fail	Notes
Circuit and/or equipment documentation is appropriate to the EPL/zone	Gc or better	Ga + Gb	✓	
Equipment installed is that specified in the documentation	Yes		✓	
Circuit and/or equipment category and group correct	Yes		✓	
IP rating of equipment is appropriate to the Group III material present	>IP55	IP67 IP66	✓	
Equipment temperature class is correct	T1	T4, T4	✓	
Ambient temperature range of the apparatus is correct for the installation	-10°C to +25°C		✓	
Service temperature range of the apparatus is correct for the installation	0°C to 40°C		✓	
Installation is clearly labelled	Yes			needs label on PT+LT
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	Not applicable	Not applicable	Not applicable	Not applicable
Cable glands and blanking elements are the correct type, complete and tight	Yes		✓	
There are no unauthorized modifications	None		✓	
There is no evidence of unauthorized modifications	None		✓	
Diode safety barriers, galvanic isolators, relays and other energy limiting devices are of the approved type, installed in accordance with the certification requirements and securely earthed where required	Yes		✓	

Condition of enclosure gaskets is satisfactory	Yes; if applicable	N/A	✓	
Electrical connections are tight	Yes		✓	
Printed circuit boards are clean and undamaged	Yes	N/A	N/A	N/A
The maximum voltage Um of the associated apparatus is not exceeded	Yes		✓	
Cables are installed in accordance with the documentation	Yes		✓	
Cable screens are earthed in accordance with the documentation	Yes		✓	
There is no obvious damage to cables	None		✓	
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	Yes		N/A	
Point-to-point connections are all correct	Yes		✓	
Earth continuity is satisfactory (e.g. connections are tight, conductors are of sufficient cross-section) for non-galvanically isolated circuits	<100mOhm	<35mΩ	✓	
Earth connections maintain the integrity of the type of protection	Yes		✓	
Intrinsically safe circuit earthing is satisfactory	Yes		✓	
Insulation resistance is satisfactory	Yes		✓	
Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common distribution boxes or relay cubicles	Yes			Partly
Short-circuit protection of the power supply is in accordance with the documentation	Yes		✓	

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Specific conditions of use (if applicable) are complied with			N/A	
Cables not in use are correctly terminated	Yes		✓	
Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	Yes		✓	
No undue external accumulation of dust and dirt	Yes		✓	

Inspection performed by: RBS

Ballard Power Systems Product Solution

Date:

03/09-2024

Executed

30/08-2024

Section N

Spares and Maintenance Data

Sub Section N01-001

Integration Manual

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	8/15/2024	First Issue
002	9/11/2025	Updated, as build

Document Title:	**BLPH Project - Integration Manual**
Document Number:	K559-2254-CWIWP4202202-N01-001
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	N01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

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Rev	**CO**	**Description**	Date
0B	CJA	Reacting on "0A Integration Manual CRS - Code 2" + included revision number of all references Updated part number and naming to match nameplate (Megablock → PowerGen, Grid Interface Container → Converter Container). Changed header to match CRW document naming Continuous reaction on CRS – Code 2	06/12/2024
002	RBS	Code 2 updates according to CRS	09/02/2025

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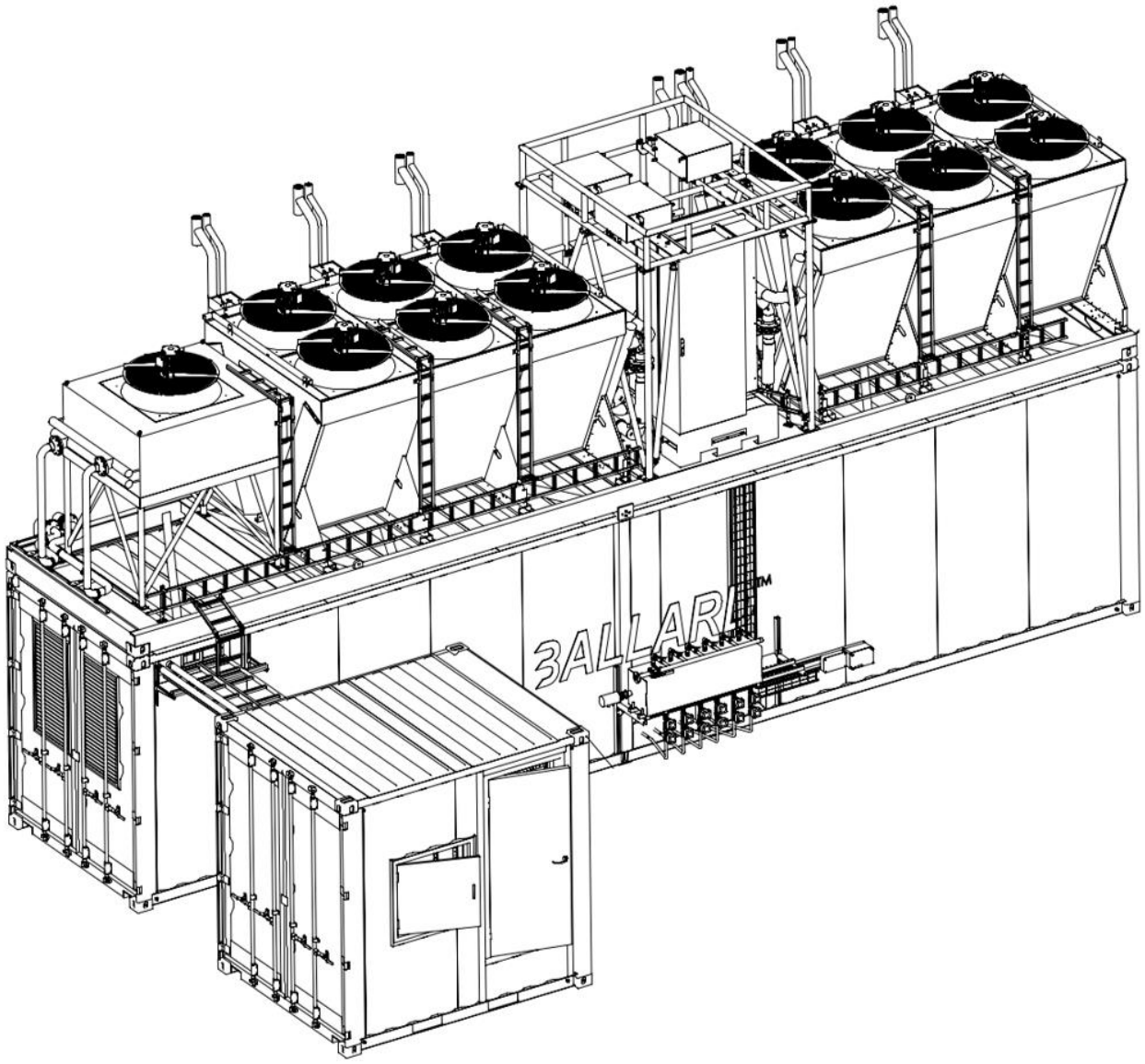
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FC PowerGen 1000kW

Part no.: 601456B-7002362

Configuration: 40ft Fuel Cell Container w. 6 FCwave™
10ft Converter Container, 6,6 kVAC

Integration Manual



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There are inherent risks in the operation of a fuel cell module that can result in death or bodily injury or loss or damage to property. It is therefore necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device. Persons who install, operate, and service the device are required to be technically qualified and experienced in working with electrical equipment, compressed gases, and H2.

This manual includes certain safety guidelines and recommendations; however, this manual is not intended to cover all situations. The customer is responsible for determining the suitability of the customer's particular design or application, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. Ballard Power Systems Europe A/S ("BPSE") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the operating recommendations in the manual. The customer is responsible for being aware of, and complying with, all applicable laws and regulations. BPSE has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

Procedures described in any part of the manual can only be attempted once the customer has read this entire manual. Failure to follow any instruction or recommendation could result in death or bodily injury or loss or damage to property.

BPSE intends for the device to be installed, operated, and serviced only by approved technically qualified and experienced people who understand the principles of fuel cell technology, are aware of the safe operating limits of fuel cells, and are familiar with the risks posed by operating a fuel cell module. BPSE relies on customers to use their own knowledge and experience when installing, operating, and servicing the device. BPSE also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual.

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2.0 General Information

2.1 System introduction

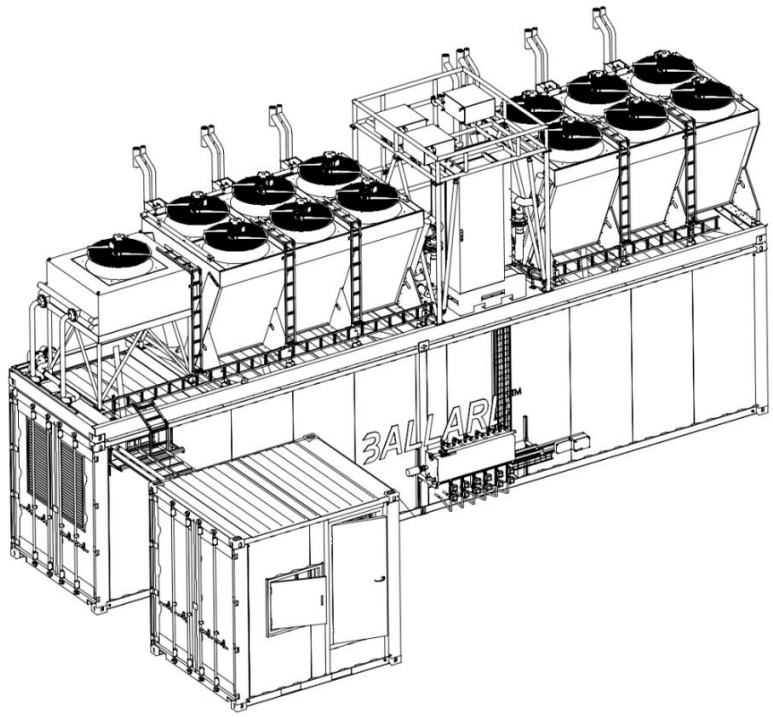
The Ballard FC PowerGen is a modularized power generator, comparable to a diesel-generator. It is a stationary, megawatt-scale hydrogen PEM fuel cell solution, utilizing the FCwave™ from Ballard.

The solution contains all needed elements to produce 1MW AC from hydrogen, when supplied with an auxiliary power supply, a local hydrogen supply, and an electrical grid that is controlled by a Power Management System (PMS), communicating with the use of Modbus.

Integration between the FC PowerGen and the local PMS enables the integrator to create a coherent and automatic system that reacts on the power-demand on the grid, within the given dynamic and capability limits of the solution.

The FCwave and the internals of the containers are designed in such a way that no explosive hazard zones are created inside the solution.

Figure 1: System overview



Indicative illustration layout of system.

2.2 Manual purpose and scope

This Integration Manual offers instructions, procedures, technical information, and best practice to assist integrators in designing a compatible designated site and subsystems that integrate seamlessly with it, in preparation for installation of the system.

It covers topics such as:

- Integration safety
- System descriptions
- Mechanical/electrical interfaces and control details.
- Required In- and Outputs

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Before commencing integration and installation of the system, personnel must read and understand the Operator Manual and this Integration Manual.

2.3 Intended audience

The intended user of this manual is qualified Integrators partaking in designing the designated site and subsystems for the FC PowerGen, within the intended use and limits of the system.

Aspects of this manual require the integrator to have read and understood the Transport and Handling Manual, Operator Manual and Service and Maintenance Manual. Furthermore, a general knowledge of the fuel cell processes, and how to set up control and communications using Modbus TCP/IP are required.

2.4 Manual series

The Manual Series provides manuals covering different life-phases of the system, as defined in Table 2-1:

Table 2-1: Manual series contents

Document no.	Title	Brief purpose description	Intended user(s)
Ballard: 7003672 CW: K559-2254-CWIWP4202202-R01-002	Transportation and Handling Manual	Enables safe, land-based, transport and handling from manufacturer to designated site.	Personnel qualified in preparation of, handling, and transport of freight.
Ballard: 7003718 CW: K559-2254-CWIWP4202202-N01-001	Integration Manual	As described in section 2.2	As described in section 2.3
Ballard: 7003717 CW: K559-2254-CWIWP4202202-N01-002	Operator Manual	Provides information to personnel for safe operation of the solution, instructions for operator-based maintenance, safety rules and recommendations	Operators, Integrators, Installers, Service and Maintenance personnel, personnel working in or near the system, and persons instructing visitors.
Ballard: 7003719 CW: K559-2254-CWIWP4202202-N01-003	Service and Maintenance Manual	Provide information regarding Service and Maintenance schedules and related safety.	Service and Maintenance personnel.

Ballard Power Systems Europe may update the provided manuals on an ongoing basis.

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2.5 Hazard Symbols

Hazard symbols throughout the manual indicate objectives or potentially dangerous situations.

Table 2-2: Hazard symbols

	**MANDATORY ACTIONS**: are marked with blue action-points. This indicates actions that must be performed. Ignoring may result in an accident, which could cause damage to equipment or other property, and could cause bodily injury if not promptly detected and remedied.
	**PROHIBITIONS**: are marked with red prohibition-signs. This indicates a forbidden action. Ignoring may result in immediate bodily injury or loss of life or could cause damage to equipment or other property
	**WARNINGS**: are marked with yellow triangles and/or square warning. Indicates hazards that may result in an accident, which could cause immediate bodily injury or loss of life or could cause damage to equipment or other property.
	**CAUTION:** indicates actions that may result in an accident, which could cause damage to equipment or other property, and which could cause bodily injury if not promptly detected and remedied.
	**ELECRICAL HAZARD** Obey ALL warnings, cautions, and safety instruction related to electricity. Failure to do so may result in electrical shock leading to personal injury or death.

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2.6 References

Throughout the manual are referrals to separate documents. These references documents are available on the BPSE after sales Service Portal.

Should a document not be available, contact BPSE.

Table 2-3: Reference documents

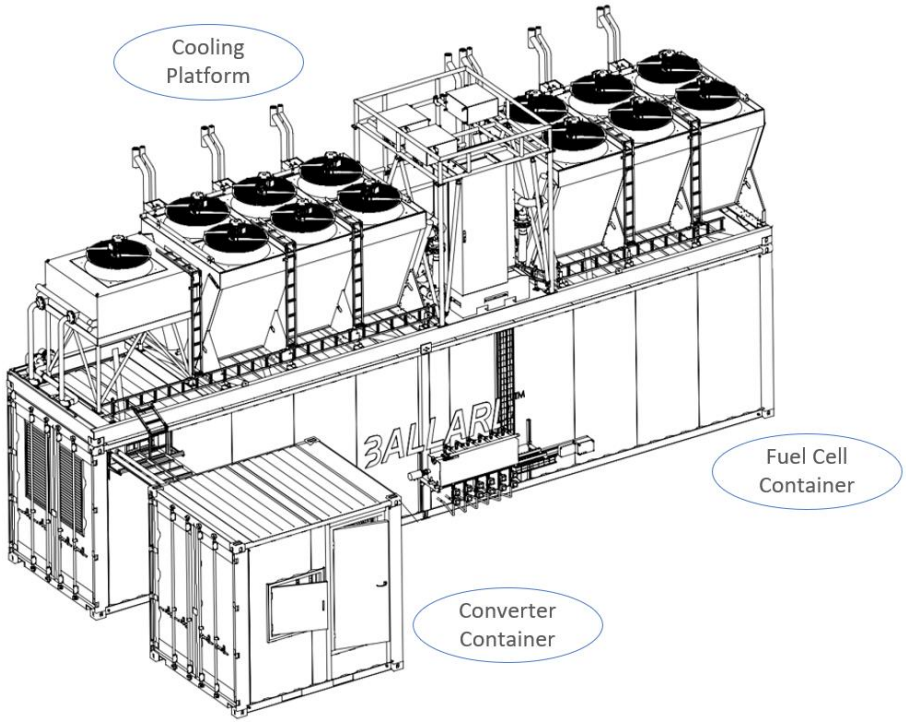
Document no.:	Document name:
K559-2254-CWIWP4202202-D03-001Rev002	Technical Datasheet
K559-2254-CWIWP4202202-C08-001Rev004	Control philosophy and Logic block diagrams
K559-2254-CWIWP4202202-D05-001Rev001	Material Safety Data Sheets
K559-2254-CWIWP4202202-C99-001Rev002	Hydrogen Safety Concept
K559-2254-CWIWP4202202-K02-001Rev002	Equipment hazardous area certificate and schedule
K559-2254-CWIWP4202202-B01-001Rev010	General Arrangement
K559-2254-CWIWP4202202-E99-004Rev002	Grounding Layout
K559-2254-CWIWP4202202-E01-001Rev001	Interconnection Diagram
K559-2254-CWIWP4202202-E99-003Rev001	Cable Transit Schedule
K559-2254-CWIWP4202202-E03-008Rev001	Electrical Interface Documentation
K559-2254-CWIWP4202202-E99-005Rev001	Secure Remote Access
K559-2254-CWIWP4202202-C03-001Rev006	P&IDs
K559-2254-CWIWP4202202-J08-001Rev003	Factory Acceptance Test
K559-2254-CWIWP4202202-C08-002Rev005	FC package Modbus Map
K559-2254-CWIWP4202202-C08-003Rev003	Alarm list
K559-2254-CWIWP4202202-N01-005Rev001	Lockout Tagout
K559-2254-CWIWP4202202-N01-006Rev002	Fuel Cell Module Integration Manual

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3.0 System Description

The system is a modularized power generator based on a number of FCwave™ Fuel cell units.
The FC PowerGen consists of the following main components:

Figure 2: Major components overview



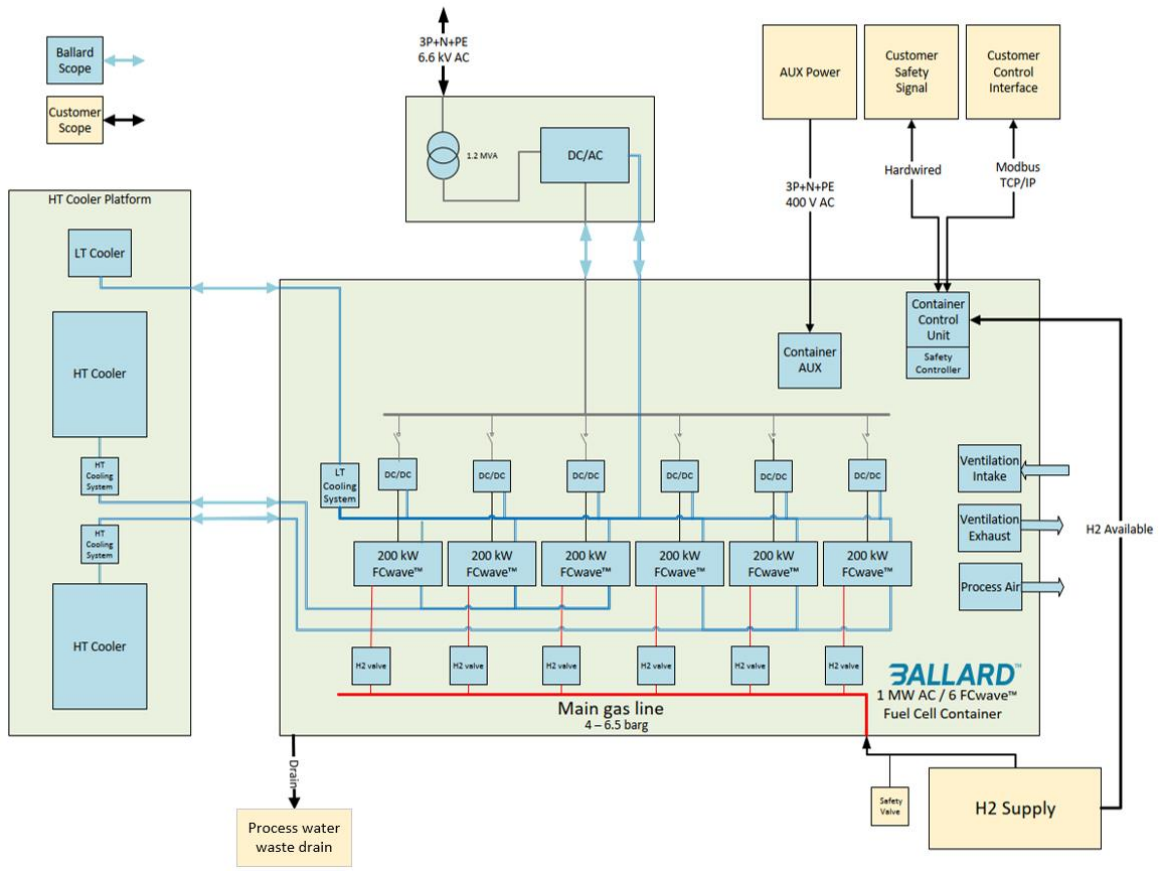
Short descriptions of major components can be found in Table 3-1

Table 3-1: Major components of the machine (See Figure 2)

Component	Short Description
Fuel Cell Container	Based on a 40ft HC container, modified to a machine housing with access, ventilation, light safety etc. The container holds 6 FCwave modules with installation, internal 400VAC power supply for complete Balance of Plant components, main controller, LT pump system and DC/DC converters.
Cooling Platform	40ft Cooling Platform with service platform. 2 individual HT radiators dimensioned to the specific solution 2 individual HT pump-systems 1 LT radiator
Converter Container	Based on a 10ft HC container, modified to a machine housing with access, ventilation, light, safety etc. Holds DC to AC grid-forming power electronics, Isolation transformer, and Grid Main Breaker.

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Figure 3: Scope block diagram



Block Diagram showing the scope of main components and connections of the system.

3.1 Intended use

The system acts as a grid following power generator, providing up to 1MW electrical power from H2 at 6.6kVAC 50Hz. This system is designed and is intended to be used for offshore stationery application (fixed installed system). Hydrogen supply to the system is in the customer scope and the details about the hydrogen standards, quality etc. are mentioned in the integration and other manuals that will be provided to the customers. The customer local Power Management System (PMS) requests the amount of power to be generated within the given dynamic and capacity limits of the system, which are communicated in real-time on the Modbus TCP/IP. The Modbus data is transported between the system and the PMS.

The system has multiple operating data available on the same Modbus, including alarms.

The system is placed in operation by request from PMS via Modbus, and similarly can be stopped, if necessary, which will stop power supplying the to the grid. The system can be stopped remotely on request. During normal operation, a power request of 0 is accepted by the system.

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3.2 General Operating states

Table 3-2: General Operating mode descriptions

Operating Mode	Brief description
Off	Container fully depowered.
Sleep	Container minimum operational level. Control and safety system are operating, but no high-power systems (>20kW) are operating. Hydrogen supply and fuel cells are inactive.
Standby	Waiting state for "Run" command from high level control system. Hydrogen supply and MV link disabled.
Running	Operational state for the container, where the fuel cell modules are consuming hydrogen to produce electrical energy. Cooling and ventilation systems are operating to support fuel cell modules.
Shutdown	The cooling and ventilation systems shuts down. Container returns to standby.
Fault	Internal fault state. Hydrogen supply and fuel cells are inactive.

For more details, refer to section 7.1

3.3 General System description

3.3.1 Fuel Cell Container

The Fuel Cell Container houses 4-6 FCwave™ units. Each FCwave™ is a separate unit with full hydrogen safety and a double wall barrier to ventilate any possible hydrogen leakages, internal to the FCwave™, directly to the outside.

The fuel cell container is equipped with a ventilation system, which will ensure that filtered process air is available for the FCwave™. The ventilation system will also create an air flow through the container, for cooling and ventilation the room.

Process piping installation is generally below the raised floor. Access to this area below the floor is for service only and requires tools. For moving heavy service components inside the container, it is equipped with a crane rail for a manual trolley.

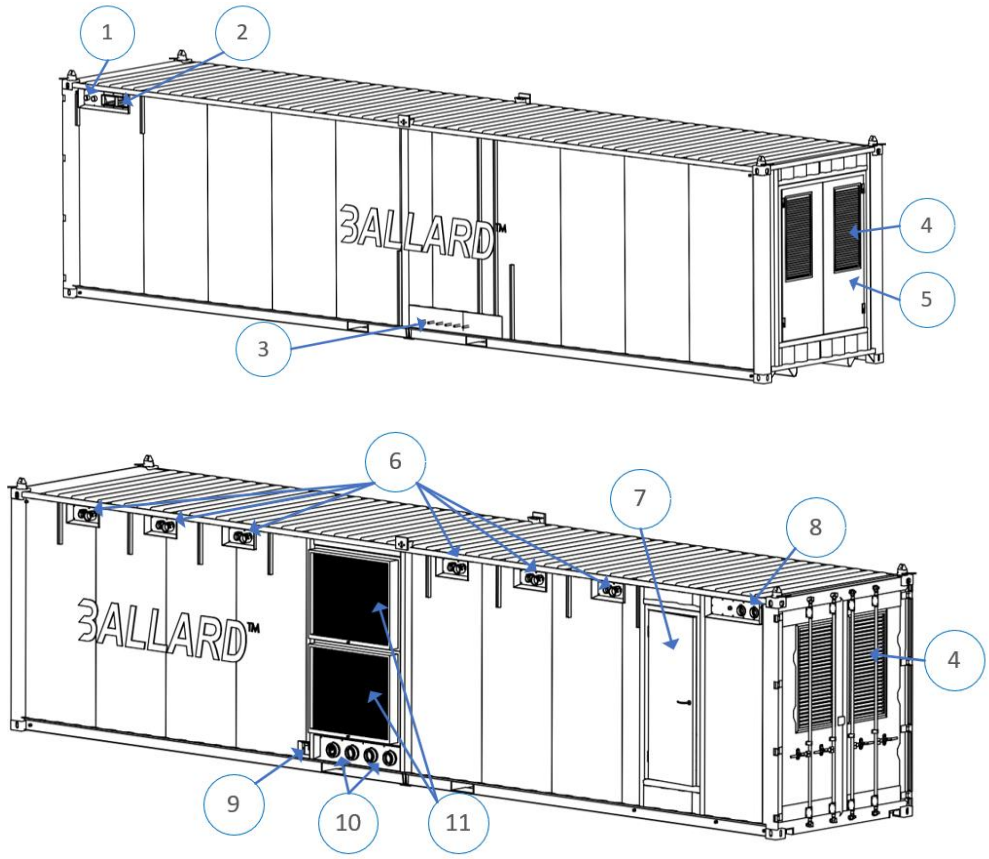
The DCDC panels for fuel cell power output connects each FCwave™ to a common DC link busbar, which feeds the outgoing connection of the Fuel Cell Container. Each DCDC panel for fuel cell output can be isolated electrically, to allow for maintenance on the specific cabinet or related FC wave.

The system controller is a centralized unit that monitors and operates the entire system and includes a separate safety controller to prevent any critical failure or emergency situations to escalate.

The power for auxiliary units such as water pumps, container ventilation and basic power is fed from a 400V AUX power panel which again is supplied from the DC link or from an external power supply, in case of shutdown of the solution.

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Figure 4: Fuel Cell Container overview



Indicative overview of Fuel Cell Container with numbered ballons (see Table 3-3)

Table 3-3: Fuel cell Container overview descriptions (See Figure 4)

1	LT Cooling interface (Converter Container)
2	Wall passthrough for Control Signals, auxiliary power, and DC power cables to Converter Container
3	Gaseous hydrogen piping wall passthrough
4	Ventilation exhaust
5	Service doors
6	Process air and hydrogen enclosure ventilation exhausts
7	Main access door
8	LT Cooling interface (Heat dissipation and Header tank)
9	Process water drain
10	HT Cooling system interface
11	Ambient air intake: Container ventilations and process air

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3.3.2 Cooling Platform

The Cooling platform is a steel structure with the footprint of a 40ft container. The purpose of the cooling platform is to dissipate the heat generated by the High Temperature (HT) cooling system that cools the Fuel Cell Modules, and heat generated by the Low Temperature (LT) cooling system that cools the power electronics of the solution. The standard installation method of the platform is to mount it on top of the fuel cell container, using standard container locks.

The sizing of the coolant fans and radiators are dependent on the ambient temperatures of the designated site and operating conditions of the system.

If utilization of the generated heat produced by the fuel cells during operating for heating of building etc., a heat exchanger can be fitted to allow heat recovery.

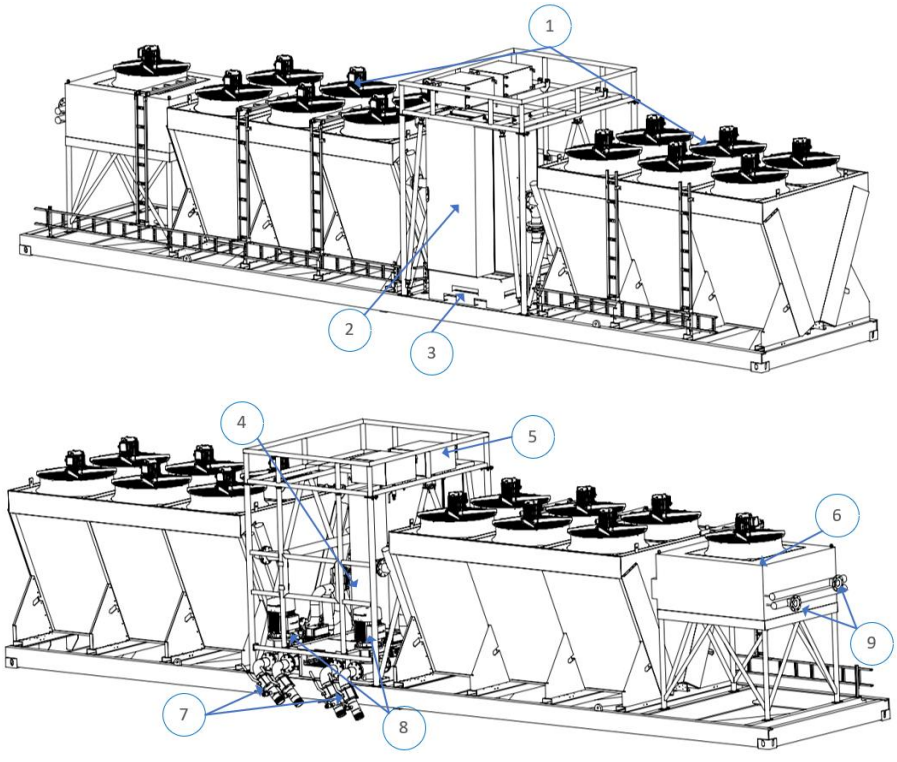
The cooling systems are open unpressurized circuits, cooling with the media Ethylene glycol. Each system has an open header tank for volume changes due to temperature.

The highest temperature of the HT and LT cooling systems are approximately 60 and 48 °C.

The pumps and pump control for the HT Cooling system is placed between the two big radiators (HT Coolers) on the cooling platform. Access is to this area is for service only and requires a ladder.

The pump for the LT Cooling system is located inside the Fuel Cell Container. The control is located in the same cabinet as the HT cooling.

Figure 5: HT cooling platform overview



Indicative overview of HT Cooling Platform with numbered ballons (see Table 3-4)

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Table 3-4: HT Cooling platform overview descriptions (See Figure 5)	
1	HT Cooler with fans
2	Controller panel (backside)
3	Control signals in- and out
4	Service platform
5	Header tank
6	LT Cooler with fan
7	HT Coolant in- and outlet
8	HT Coolant pump
9	LT Coolant in- and outlet

3.3.3 Converter Container

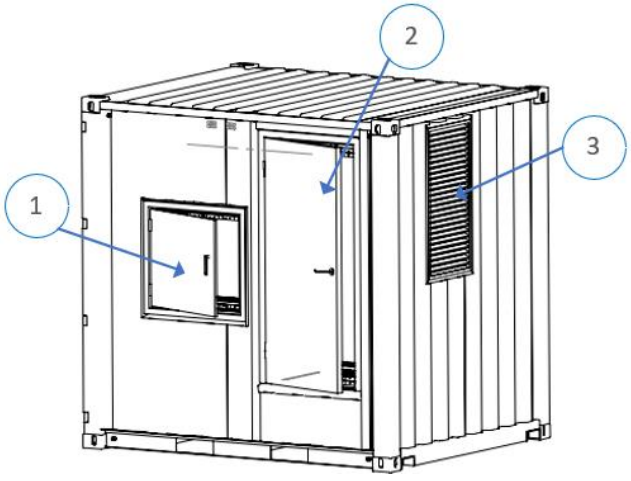
The Converter Container is structurally a 10ft high-cube double-door container, modified to the specific need. It is designed as an electrical cabinet, housing DC/AC converters and a transformer that converts the energy to the desired voltage (6,6kV). Access to the inside is through the normal container doors which are, because of electrical safety, mechanically prevented from opening during operation. These are also equipped with safety sensors, which will immediately bring the entire solution to "Failure state" if opened.

Access is restricted to instructed and trained personnel, and only after a safety procedure is followed, which will deenergize the container to a safe mode.

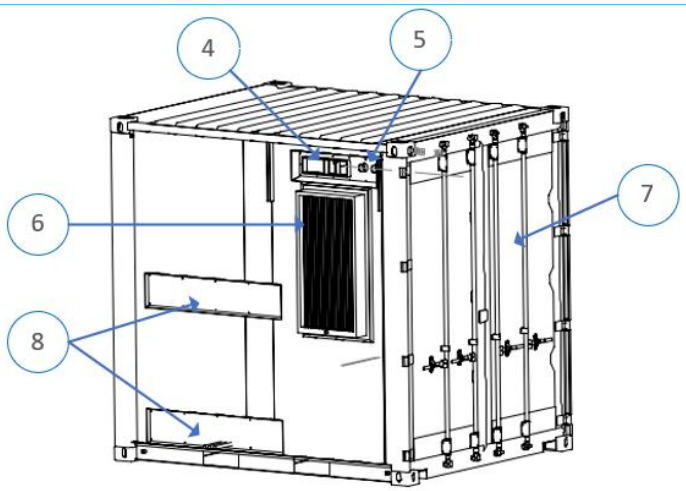
The control panel and grid breaker front of the Converter Container is accessible from the outside, behind an additional locked door which will not shut down the solution if opened.

Customers connection of the grid is through the container side.

Figure 6: Converter Container overview



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Indicative overview of Converter Container with numbered ballons (see Table 3-5)

Table 3-5: Converter Container overview descriptions (See Figure 6)	
1	Control panel access door
2	Main output breaker access door
3	Ventilation exhaust
4	Wall passthrough for Control Signals and DC power cables from Fuel Cell Container
5	LT Cooling interface
6	Ventilation air intake
7	Service doors
8	Output interface (1MW AC)

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4.0 Safety

The system is to be installed in cooperation with Ballard personnel. While working on the system there should always be more than one person present.



The reader of this manual must read the operator manual mentioned in section 2.4 as a complement to this integration manual regarding general function and safety.

4.1 Designated site Access and Security

It is recommended that the designated site is fenced off to prevent unauthorized access, and access within the fenced area should be limited.

The site responsible shall ensure that access to the site is limited to qualified personnel who are familiar with the site safety requirements. Appropriate Personal Protection Equipment (PPE) must be worn per site guidelines and warning signage must be adhered to.

4.2 Machine Access

At no time is unauthorized personnel permitted inside the containers or on the Cooling Platform of the solution.

To access the containers and the Cooling Platform through the designated doors, it may be required by local legislation that permanent stairs and use of temporary scaffolding or lifts are installed/available. Stairs could be as indicated in Figure 7.

Ballard can assist in creating such additional component to the system if agreed upon.

Figure 7: Example access stairs



Indicative example of solution to access the Main Access Door on the Fuel Cell Container

The exterior container doors must always remain locked except during active installation, integration, service, or maintenance. The locks should be inspected regularly by site personnel to ensure that only authorized personnel have access to the insides.

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It is recommended to keep a communications device on your person when being inside.

During operation, it is not recommended to be inside the Fuel Cell Container and access the Cooling Platforms.

The Converter Container is designed with safety-interlock on the access door, preventing access during operation. Opening the container doors of the Converter Container triggers a safety-switch which acts as an emergency stop, immediately shutting down the system.

4.3 Site safety for Personnel

As soon as practical the site responsible shall provide Ballard with a written set of site safety requirements and safety protocols that will conform with local regulations and industry norms.

The site responsible may amend the site safety requirements to conform to local regulations and such industry norms, by providing written notice of changes to Ballard reasonably in advance of their effective date.

The site responsible must require that all contractors and visitors comply with these site safety requirements. Ballard will comply with site safety requirements provided and be allowed access to the site to perform necessary tasks throughout the life of the system.

Site safety requirements given by Ballard are minimum requirements, as they may be a result of a mitigation measure from the risk assessment.

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4.4 Hazardous materials

The complete list of coolants and lubricants used in the 1MW Fuel Cell Container is shown below.

Table 4-1: Hazardous materials

Type	Name	Description / Use	Sub-assembly
Coolant	Glysantin® FC G20®	Used in the internal cooling loop of the fuel cell modules, where a low electrical conductivity is required. Pre-mixed 50/50 ethylene glycol-based coolant specifically developed to support the requirements in fuel cell technologies. It maintains a low and stable electrical conductivity, while at the same time providing protection against corrosion, frost and overheating.	Fuel Cell Modules
Coolant	Proviflow® Neo	Used in both HT and LT cooling loops. Pre-mixed 50/50 ethylene glycol-based coolant with OAT (Organic Acid Technology) inhibitors and designed to offer freeze point suppression as well as protection against corrosion, hard water scaling and bacterial growth.	Container Solution
Lubricant	Ceramic Grease PV.20.01	High-grade assembly paste and high temperature lubricant grease without metal particles used for lubrication of bolts.	Container Solution
Lubricant	Krytox™ GPL 205	Chemically inert, PTFE thickened grease based on perfluoropolyether (PFPE) oils that is safe for use around hazardous chemicals, these lubricants are non-flammable and safe for use in oxygen service. They can be used in extreme conditions, such as continuous high temperatures of up to 204 °C (400 °F) and will survive short-term peak temperatures of up to 220 °C (429 °F).	Fuel Cell Modules
Lubricant	Krytox™ GPL 206	Chemically inert, PTFE thickened grease based on perfluoropolyether (PFPE) oils that is safe for use around hazardous chemicals, these lubricants are non-flammable and safe for use in oxygen service. They can be used in extreme conditions, such as continuous high temperatures of up to 260 °C (500 °F) and will survive short-term peak temperatures of up to 270 °C (518 °F).	

More details can be found in the document Material Safety Data Sheets.

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4.5 Energy Lock-out-tag-out (LOTO)

Energy sources provided to the system, as well as the Grid connection, must be provided with means for lockout (de-energization), and a written procedure detailing the equipment, and steps required.

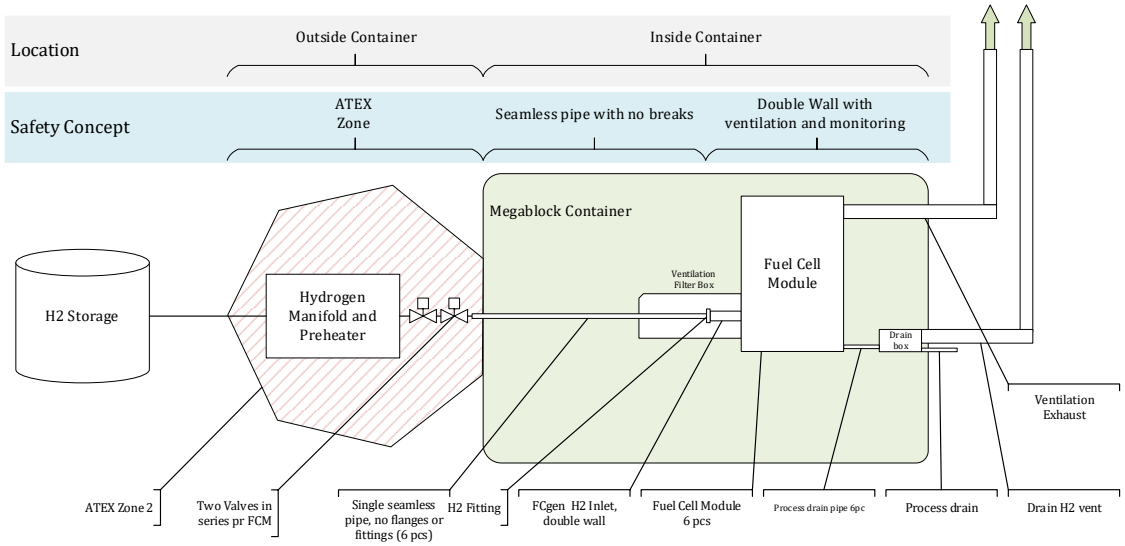
Use proper work-etiquette regarding LOTO when working on energy-suppling components.

Refer to Lockout Tagout document for details.

4.6 Explosion safety

The hydrogen safety philosophy has several safety concepts, as indicated in Figure 8.

Figure 8: Hydrogen flow overview



Illustrative overview of hydrogen flow. See Hydrogen Safety Concept for more details.

Hydrogen is delivered to the hydrogen interface from a local hydrogen storage (refer to section 6.3 for specifications).

The area in which the interface, the hydrogen-manifold and -preheater, and hydrogen safety valves resides, is classified as an ATEX Zone 2. A hazardous mixture will not likely be present in normal operating conditions, and if so, only for a short period at a time. Electrical equipment in this zone is and shall conform to regulations and have the "EX" marking or similar. Detailed drawing of the hazard zone can be found in the General Arrangement. For more information regarding equipment installed in the zone, refer to the Equipment hazardous area certificate and schedule

Respect the zone indicated, do not introduce any source of ignition.

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There is no risk of hydrogen leakages inside the general space of the FC PowerGen Fuel Cell Container that can create an explosive atmosphere, due to the design of the feed pipes being seamless, one-piece-bends from outside of the container, routed through the container space, and connected the applicable Fuel Cell module.

The connection to a Fuel Cell Module (The H2 Fitting) is encapsulated within an extension of the Fuel Cell Modules Hydrogen Enclosure called the "Ventilation filter box", thus utilizing dilution and removal of any potential hydrogen with mechanical ventilation. Should leakages from this connection occur, the hydrogen detectors within the Fuel Cell Module will detect it and trigger a safe shutdown of that module and hydrogen supply.

The Ventilation system of the Fuel Cell Container creates a slight over-pressure to counteract ingress from particles and gas. As an additional precaution in case of hydrogen entering, the general space inside is equipped with hydrogen sensors. The position of these will detect any hydrogen entering or exiting the container through the ventilation system.

All safety-related triggers of the solution will shut off the hydrogen supply of either the affected system or the entire system.

4.6.1 Trace amount of H2

The process exhaust contains all biproducts from the fuel-cell stacks within the Fuel Cell Modules. The exhaust is a mixture of high-humidity, low-oxygen process air with trace amounts of hydrogen. The concentration of hydrogen will always be below 1%v, i.e. 25% of Lower Explosive Level (LEL), leading to a non-hazardous zone according to Fuel Cell Module Integration Manual.

The source of the media in the Process Water Drain stems from the process exhaust. Thereby are also here found trace amount hydrogen which also are under 25% of LEL, leading to a non-hazardous zone. A hydrogen separator is fitted upstream to the process water drain and the trace amount of hydrogen are led through an exhaust to above the containers.

4.7 Fire safety

The Fuel Cell Modules have internal fire detection in the form om smoke detectors and linear heat detectors. If a Fuel Cell module detects to high temperature, it will automatically perform a safe shutdown of itself and indicate an alarm.

If Smoke is detected inside the general space of the Fuel Cell Container, the entire system will perform a safe shutdown and indicate an alarm.

Should a fire occur, exit through the provided emergency exits.

The system is not delivered with fire-extinguishers.

4.8 Craneage and lifts

During installation onto the designated site, and installation of general hardware i.e. exhausts and interconnections between the major components of the solution, tools such as cranes and lifts are to be used. These tasks can only be done by instructed personnel.

Scaffolding, lifts, and cranes must be made available, unless otherwise agreed upon with Ballard.

A lifting study for craneage is recommended to be conducted by the site responsible, referring to the respective transport and handling manual of the solution's major components and description of positioning and assembly in section 5.1.

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4.9 Electrical safety

Installation of electrical connections between the major components of the solution is the responsibility of Ballard if not agreed upon otherwise. Electrical connections to the Interfaces described in section 6.0 is the responsibility of the interface-connecting party.



The electrical system of the solution is designed in accordance with electrical and fuel cell codes to minimize electrical hazards. Electrical hazards will occur when the design is significantly compromised, typically through alteration, improper maintenance, or wear.

Dimensioning of cables and safety-equipment on the supplying and receiving end of electrical connections outside the solution must be done according to local legislation.

Select cabling and safety-equipment to the system that appropriately suits the application. Ensure to meet specifications of voltage, current, environmental temperature limits, chemical and mechanical resistance, and flexure requirements of the application. Avoid hazardous and unsafe situations that could result from condition such as, but not limited to:

- Improper grounding
- Handling electrical leads or devices with wet hands or on wet ground
- Frayed electrical leads
- Incorrect or improper connection of the terminal leads
- Short circuits
- Back-feed from energized normal and emergency power sources

Shutting down the solution during active installation and integration may be necessary. Voltages may remain in the solution for a length of time. No activities are to be performed during this time as it presents a shock hazard.

Certain circumstances can lead to voltage persisting on the electrical systems. Always check for residual voltage before any activities. In some cases, it may require removal of hydrogen in the FCwave.

4.9.1 High DC Voltage Isolation Failures

Under normal circumstances, all high DC voltages are isolated from ground and the resistance is monitored. If isolation is lost on one high-voltage pole, a person working on the electrical system can sustain a fatal current-flow by touching the other voltage-pole and ground.

If two simultaneous faults occur and isolation is lost on both voltage-poles, a high voltage short circuit can occur resulting in extremely high currents/flash arcs. High currents can generate a large amount of heat which can subsequently damage electrical equipment and cause bodily harm.

Components inside the solution affects the resistance to ground, resulting in lower resistance over time.

Above-mentioned hazards are mitigated by the safety system of the solution. It actively monitors the resistance, warning if anything is to be reacted on, or shutting down the entire system in case of sustained resistance-drop or fault.

⚠ ELECTRICAL HAZARD	
	**If an isolation failure is detected and located in the MODULE, do not operate the fuel cell module until the root cause is determined and remedied.**

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4.9.2 Batteries



Inside the solution reside several Lead-acid batteries for UPS systems. Prior to transportation of the solution, the State of Charge (SoC) have been lowered to >30% and connections have been disconnected.

Ballard personnel will re-connect these according to respective manuals and the SoC is raised to normal operation conditions during commissioning.

4.9.3 Converter Container access



The internals of the Converter Container are designed as an electrical cabinet (IP00), meaning that current-carrying conductors and terminals are exposed.

⚠ ELECTRICAL HAZARD	
	**HIGH VOLTAGE – 6.6 kV** **Danger of electrocution** **Authorized personnel only** **Keep clear and follow safety protocols** **Proper PPE required** **Failure to comply may result in serious injury or death**

Access is prohibited during operation. Opening the doors, except the control panel door on the side, activates the safety system, triggering emergency stop of the entire system. Residual voltages remain in certain components.

Entering this container requires prober de-energization and lockout tagout. Wait at least 10 minutes after de-energization before entering, and measure for residual voltages (<20VDC is safe)



Disconnection of the 6.6 kV connection must be done by trained personnel.

The disconnection must have lock-out-tag-out performed (Keyed interlock system) by the work-responsible. Please referee to Lockout Tagout procedure



4.9.4 Earthing

Provided Earthing-connection by the site is crucial for electrical safety. Refer to Grounding Layout for details.

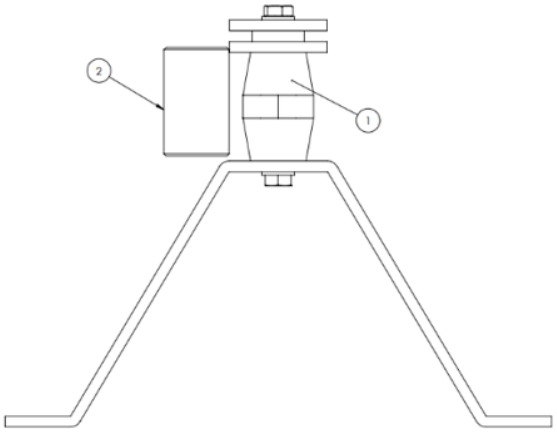
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4.9.5 Transportation Spacer

Prior to Transportation of the solution, an electrical isolator has been swapped with a transportation tube made of steel, ensuring stability of the MV transformer, located in the Converter Container.

This must be swapped back to the isolator prior to any commissioning activities.

Figure 9: Transportation Spacer



Indicative illustration of the Isolator (1) that are swapped with the transportation tube (2)

4.10 Personal Protective Equipment (PPE)

Personnel must bring and use appropriate PPE.

In general:

- Safety shoes are mandatory.
- Hearing protection must be available and used when the system is operational.
- Fire inhibited clothes must be used when working on the electrical system.
- Helmets must be used when working with internal crane.
- Helmets and Fall arrest equipment must be used when working in heights.
- Suitable gloves and eye protection must be used for working with coolant.
- Suitable gloves must be used for where risk of cuts is present.
- Suitable tools for working on live voltages – marked with double triangle as per EN 60900.

During installation is it further recommended that personnel around the activities wear fluorescent jackets for visibility.

Working atop the containers (outside of the service platform) creates a risk of falling from almost 3m - Harnesses are required.

Do not work in these areas during extreme raining, windy, or snowy conditions.

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4.11 Environmental conditions

Activities during rainy/snowy conditions should be avoided. If activities are performed during these conditions, the technician is responsible for ensuring that rain etc. does not enter the containers and electrical cabinets.



Process exhaust contains water. During freezing conditions, snow and icicles may form.

Wear safety helmets under these conditions.

4.12 Installation planning



It is recommended to create a realistic timeline for an installation-plan, mitigating the risk of stressful situations, potentially leading to injuries.

4.13 Control safety

The solution provides several control signals and information through the Modbus TCP/IP Connection. Follow the instructions in section 7.0 to ensure safe operation.

4.14 Testing safety

The solution is tested at the manufactures site according to the Factory Acceptance Test (FAT).

During commissioning of the solution, a similar Site Acceptance Test (SAT) will be conducted.

Only authorized personnel are allowed in the vicinity of the solution during testing.

During full-load testing (all FCwave™ running), no personnel are allowed on the Cooling platform.

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5.0 Positioning and Assembly

Activities during positioning and assembly of the solution at the designated site is according to agreements with Ballard. Customer must provide the specified requirements in section 5.2 as well as a cranage plan on site, prior to Ballard engagement in these activities.

NOTE: Some interface connections described in section 6.0 could be beneficial to have ready prior to Positioning and Assembly.

5.1 General Positioning and Assembly process

The following procedure describes the general process of positioning and assembly onto the designated site, not necessarily in chronological order. Refer to General Arrangement for details on site-specific details.

The major units of the system are to be handled as described in the respective Transport and Handling Manual (See section 2.4).

- The Fuel Cell Container is positioned onto the designated site for permanent installation, anchored to the ground.
- Twist-locks are placed in the upper ISO corners of the Fuel Cell Container, as well as middle-support for Cooling Platform.
- The Cooling platform is lifted and placed on top of the twist-locks and the middle-support, ensuring that it is properly supported.
- Twist-locks are locked, permanently fixating the Cooling platform to Fuel Cell Container.
- The Converter Container is positioned onto the designated site for permanent installation, anchored to the ground.
- Electrical and mechanical assembly between the units are carried out by Ballard personnel.
- Electrical and mechanical connection to the system is carried out by suppliers.
- Applicable tests after assembly are performed.

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5.2 Designated site Requirements

The following sections describe requirements for Positioning and Assembly of the system.

5.2.1 Environmental Operation Conditions

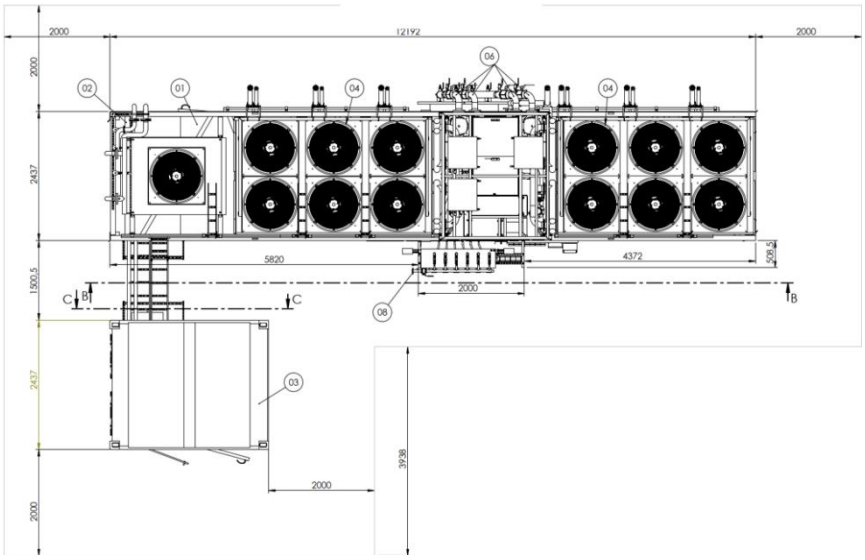
The system is intended to be installed outside, exposed to weather conditions.

Table 5-1: Operating conditions	
Altitude	< 100 m
Minimum ambient temperature, operating	-8,4 °C
Maximum ambient temperature, operating	+25 °C
Humidity	5-95% RH
Wind velocity	31 m/s
Extreme wind velocity for 1-Year recurrence	33,1 m/s
Extreme wind velocity	41 m/s
Weather	Designed for all year operation in temperate offshore areas, including wind driven rain and snow
Salt mist and Sea salt protection	Yes
Flooding	Approx 10cm above ground level
Earthquake	Not earthquake safe but designed to withstand customer-defined accelerations.

5.2.2 Space claim

The system has a space claim that enables access to the system required for future service and maintenance. To ensure proper function of the coolers, any buildings taller than 6.6 meters should be located at least 5 meters away.

Figure 10: Indicative illustration of space claim



Actual space claim can be found in General Arrangement

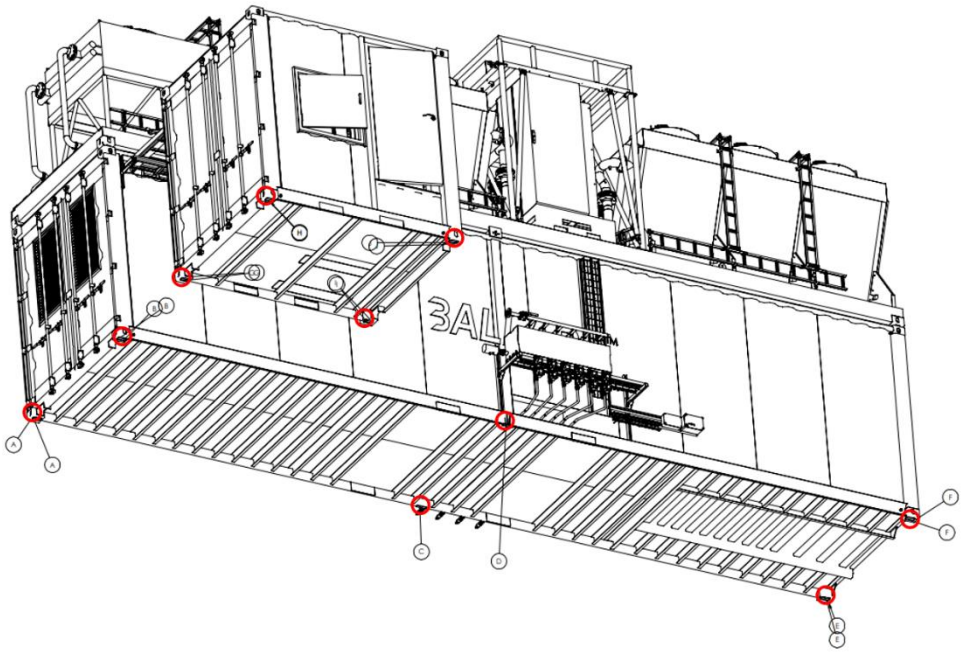
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5.2.3 Floor/foundation characteristics

Requirements of the foundation is a level surface, and it need to be able to carry the final weight of the assembled system on the designated load-points.

Refer to General Arrangement for details.

Figure 11: Indicative illustration of load-points



Specific Loads can be found in General Arrangement

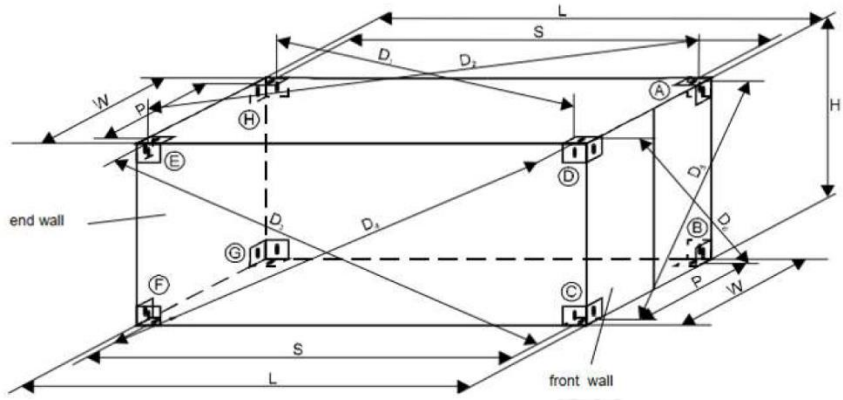
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5.2.4 Anchoring

The containers must be anchored to the ground using container tie-downs or ground-plate twist-locks. Ensure physical support of designated load-points as described in section 5.2.3.

If anchoring is done using the bottom-side of the ISO corners (B, C, F, G in Figure 12), e.g. ground-plate twist-locks, verify the corner-distances of the containers prior to design of site.

Figure 12: ISO Container corners distances (see Table 5-2)



Source: Polski Rejestr Statków – Rules for the construction of containers – July 2014

Table 5-2: Distance between container corners for anchoring (See Figure 12)

Item	P	S
Fuel Cell Container	2260 (+3) (-5) mm.	11989 (+3) (-10) mm.
Converter Container		2787 (+3) (-10) mm.

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5.3 Temporary requirements

For commissioning of the system, the following temporary requirements are applicable, depending on the agreements with Ballard.

5.3.1 Trucking and crane workspace

The designated site for the system shall provide space for the trucks delivering the major system components, as well as for crane lifting and handling as defined in the respective Transportation and Handling Manual (see section 2.4).

5.3.2 Load bank

If the designated grid for the system is not ready to provide the needed load for testing procedures defined in the SAT, an electrical load bank may be necessary during commissioning. The load bank can be provided by Ballard if agreed upon.

A load bank needs to be installed temporarily, and the site must provide space and power for this unit.

Space claim and power requirements for the Load bank provided by Ballard may vary.

Ballard-provided load bank will be removed after functional testing of the system.

5.3.3 Hydrogen Battery and manifold

For testing purposes during commissioning, a Hydrogen Battery and manifold may be needed if the local supply is not ready. For guidance on the hydrogen battery and manifold please contact your Ballard representative.

The hydrogen battery needs to be installed temporarily, and the site must provide space and power for the unit, keeping in mind safety precautions.

Space claim for the Hydrogen Battery and manifold may vary. Contact your Ballard representative for more information.

Ballard-provided Hydrogen and manifold battery will be removed after functional testing of the system.

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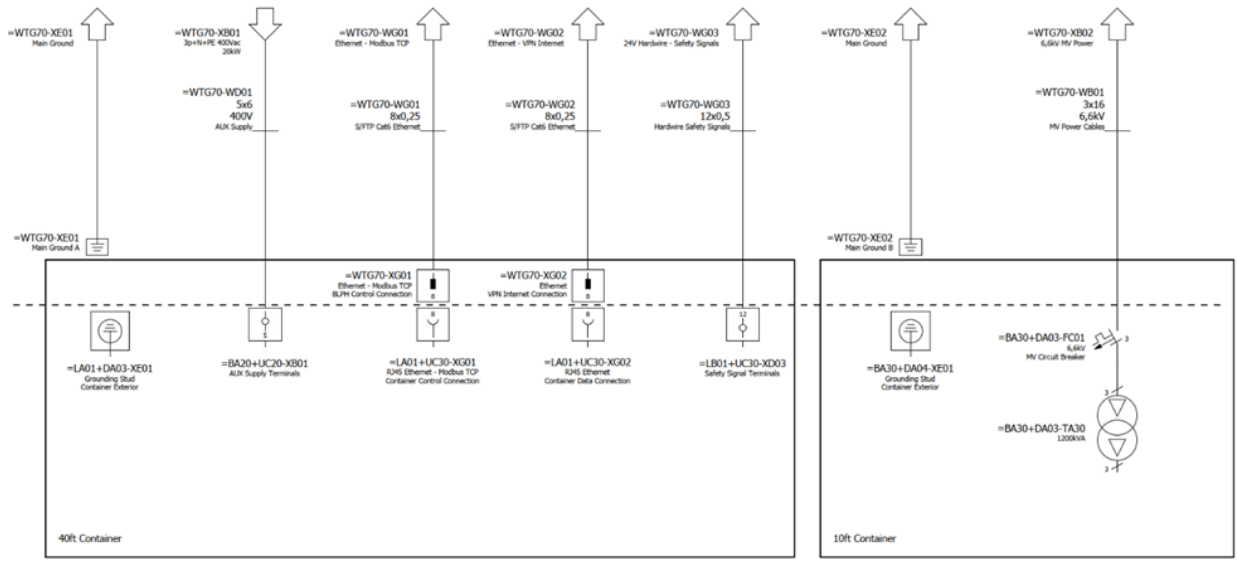
6.0 Interface descriptions and requirements

All delivered energy sources to the interfaces must have an applicable LOTO-procedure for Ballard personnel to use when installing. All interfacing flanges/connections must be fully supported and compensated for loads and moments.

6.1 Cable connections

Drawing of cable connections can be seen below in Figure 13.

Figure 13: Cable Interconnection Diagram



See Interconnection Diagram for detailed version.

Table 6-1: Electrical, network and safety-signals connections

Connection	Description	Physical connection
MV Interface	Main power delivery interface – 3 phase 6,6kV AC 50Hz 100A connection	3 pcs single Conductor Cables
Auxiliary supply	Container auxiliary supply – 3p+N+PE 400V 50Hz 32A supply	5G6 Cable (optionally 5G10)
Network Connection	Network cable carrying Modbus TCP control signals and SCADA data to local Power Management System.	Copper ethernet ($4x2x0,5mm^2$) OR Fiber optic cable (addon, depends on agreed upon solution)
Service Connection	Network cable carrying service and troubleshooting information to Ballard. Encrypted. See section 6.2 for details.	
Safety Signals	Multiconductor signal cable carrying hardwired safety signals between FC package and local PMS.	Multiconductor cable ($6x2x0,75mm^2$)

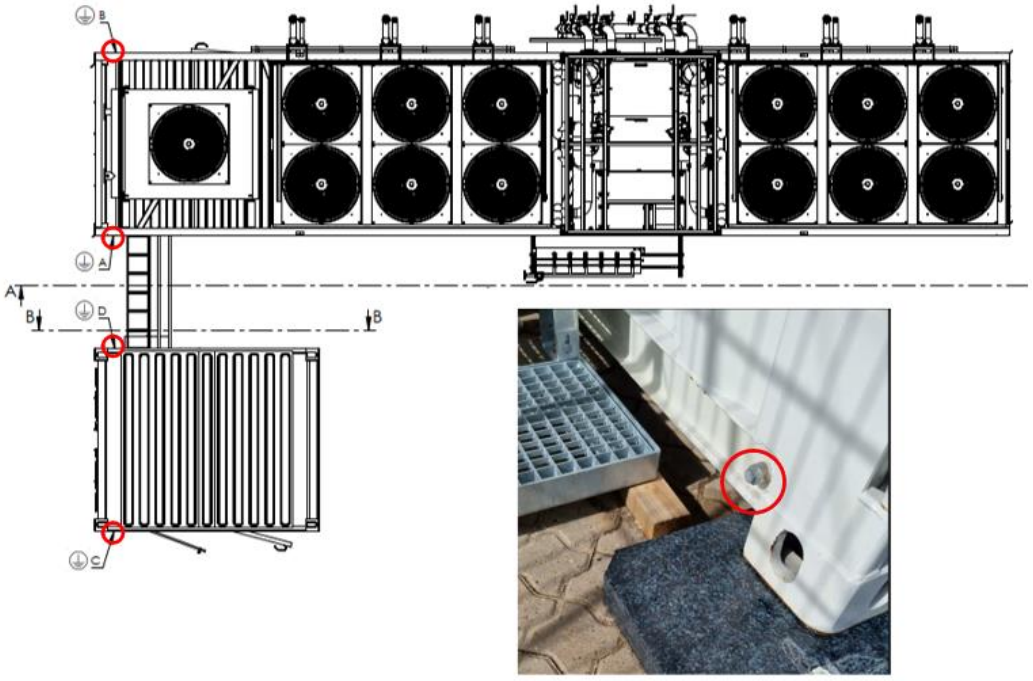
Details of connections in Table 6-1 can be found in the Cable Transit Schedule and the Electrical Interface Documentation.

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6.1.1 Earthing

The solution provides 2 earthing studs on each container. Each stud needs an earthing connection with low enough resistance to ground as defined by local legislation.

Figure 14: Location of interfaces for Earthing



The earthing points are located at each corner of each container – refer to Grounding Layout

Table 6-2: Earthing point specifications

Point	Bolt size
A	M12x1.5
B	M12x1.5
C	M12x1.5
D	M12x1.5

6.2 Service connection

The service connection enables Ballard service technicians to use a secure and encrypted VPN connection to gain remote access to the control system for monitoring and service. During installation, it is Ballard preference to deliver with a Secure Remote Access gateway installed including a 4G wireless antenna, which allows the service connection, data collection and remote access.

This wireless function will be removed if the final architecture enables a wired secure access tunnel through the local infrastructure to the internet. This access tunnel should be completely separated from the local PMS in order to maintain the best possible separation between the Operational Technology and data going to the internet.

Refer to Secure Remote Access document for more details.

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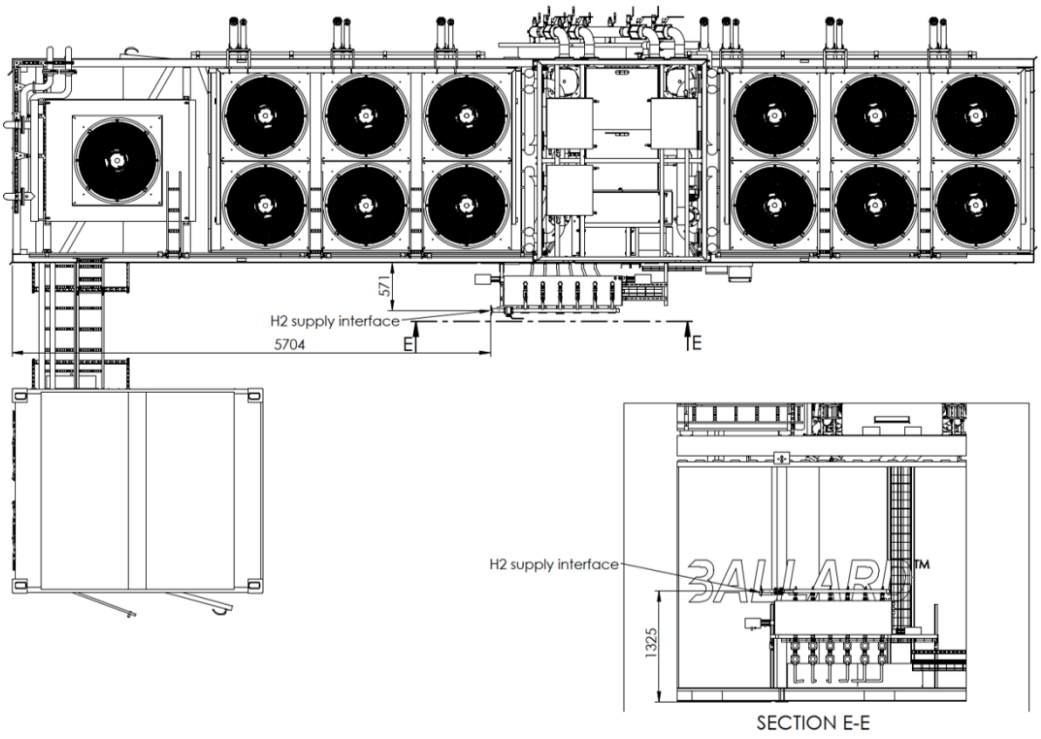
6.3 Upstream Hydrogen supply

For each FCwave™ installed in the Fuel Cell Container, a hydrogen supply pipe is routed inside the Fuel Cell Container to the outside. Each pipe it is connected to an outlet on the Hydrogen heater, that increases the temperature of the supplied hydrogen if needed.

The upstream hydrogen supply is to be connected to the interfaces on the hydrogen heater, located as indicated in Figure 15.

The upstream hydrogen supply provided may be compressed gas storage, vaporization of liquid hydrogen or reforming of other fuels, if requirements listed in Table 6-3 are met.

Figure 15: Location of Upstream hydrogen supply interface



Indicative figure of Upstream hydrogen supply interface. Refer to General Arrangement for specific location.

Table 6-3: Upstream hydrogen supply requirements

Item	Requirements
Fuel type	Gaseous hydrogen
Hydrogen grade	As per SAE spec. J2719 OR ISO 14687:2019 Type I, Type II – Grade D
Hydrogen supply Pressure	4 – 6.5 bar(g)
Hydrogen temperature	-8,4 - 80 °C
Hydrogen Consumption Rate, BOL	0,9-29,4 g/s

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Table 6-3: Upstream hydrogen supply requirements	
Physical interface	Standard flange DN32 (EN1759-1) Flange face RF Allowable nozzle load: 50 N*
Upstream particulate filter	40µm
Upstream isolation valve	Manual and lockable isolation valve as close interface as possible (Access for service personnel)

Refer to P&IDs for more details.

* All interfacing flanges/connections must be fully supported and compensated for loads and moments.



The pipe connection must be protected against accidental damage.



Purging the internal H2 system through the hydrogen supply is prohibited. Special procedures apply for purging of the FCwave, and training is required.

6.3.1 Pressure relief valve

With the required pressure of the system stated in Table 6-3, the integrator must install a pressure relief valve for the hydrogen supply set for 10 bar(g). The solution closes the hydrogen supply safety valve(s) applicable if pressure exceeds the maximum.

Handling of released hydrogen must be done in a safe manner, not creating a potential explosion zone near the equipment.

6.4 Process Water drainage

The fuel cell process produces DI water, which are routed from each FCwave™ to a common drainpipe using gravity. The common drainpipe has a hydrogen separation box to make sure no traces of hydrogen will be in the process drain. The potential H2 is routed in a pressure loose chimney to a safe area. Due to this separation box, only pure process water will exit at the drain connection.

The process water drain piping downstream must be constructed of materials resistant to corrosion since DI water is present. Contact Ballard with questions regarding material selection.

The solution provides a heat-trace cable that is pushed into the drainpipe downstream from the interface so that it does not freeze and/or block the flow of liquid. If the process water is unable to flow, the system will indicate with an error.

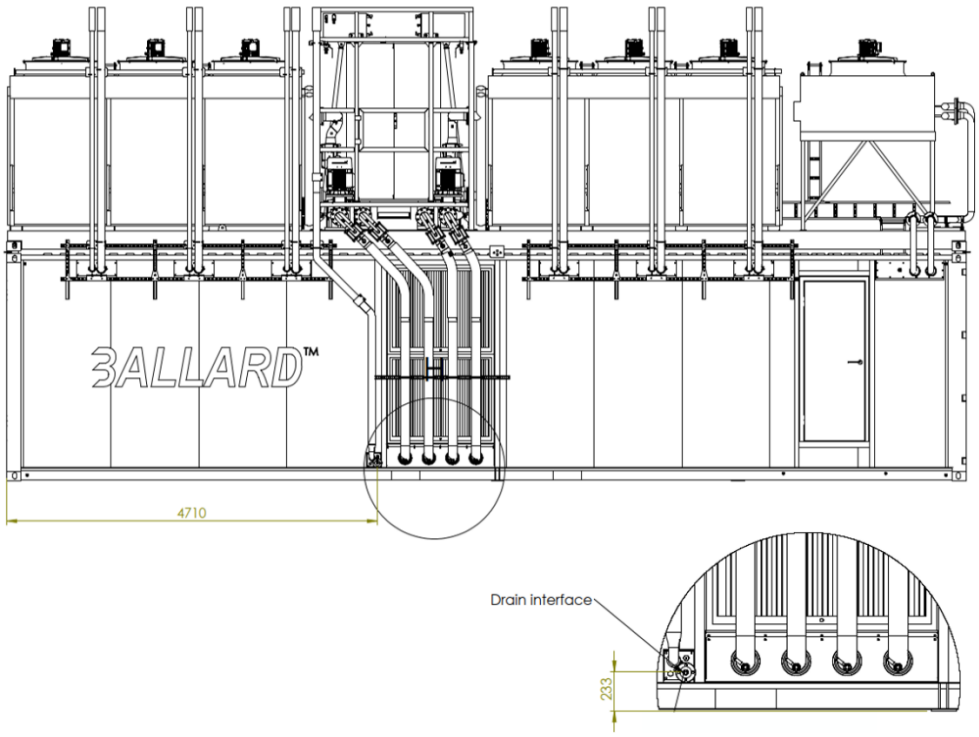
Disposal of the media should be done according to local legislation.

Table 6-4: Process Water Drainage connection requirements	
Item	**Value**
Media	De-Ionized Water
Temperature	10-50 °C
Volume	0 – 13,2 L/min

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Table 6-4: Process Water Drainage connection requirements	
Drinking water	no
Physical connection	1’’ ASME B 16.5 flange

Figure 16: Location of Process Water Drain interface



Refer to General Arrangement – Drain Interface

6.5 Lightning protection

The site responsible must follow EN62305 or other applicable local legislation regarding lightning protection.

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7.0 Control of the system

The solution is designed for the Integrators local PMS to control the system through a wired Ethernet Modbus TCP/IP Connection.

The solution is made as simple as possible for the Integrator, with few control signals, and a high amount of system information signals available.

7.1 Operating States

The solution operates in the modes described in Table 7-1 and illustrated in Figure 17.

Table 7-1: Operating mode descriptions

Operating Mode	Brief description	Preconditions
Off	Container fully depowered.	No power supplied to container; UPS batteries depleted
Initialization	Functions to establish baseline container status, with connections to external power and communications.	After bootup. 400Vac Auxiliary power supplied to Container.
Sleep	Container minimum operational level. Control and safety system are operating, but no high-power systems (>20kW) are operating. Hydrogen supply and fuel cells are inactive.	400Vac Supplied to Container. Communications heartbeat from PMS
Wakeup	Container enables 24V supply to fuel cell modules and starts container ventilation system.	400Vac Supplied to Container. Signal from PMS (Standby).
Standby	Waiting state for "Run" command from high level control system. Hydrogen supply and MV link disabled.	400Vac Supplied to Container Signal from PMS (Standby)
Startup	Transitional phase when PMS signals container to initiate operation. The significant part of this phase is that the container will draw a significant amount of power during startup, to energize fuel cell modules and cooling fans/pumps. After startup is complete on the fuel cells, the container transitions to "Running". All systems operational. Hydrogen system active.	400Vac from internal microgrid. Signal from PMS (Run). MV link active (10-150kW power draw, depending on # of FCwave starts concurrent). Hydrogen-supply active.
Running	Operational state for the container, where the fuel cell modules are consuming hydrogen to produce electrical energy. Cooling and ventilation systems are operating to support fuel cell modules.	Signal from PMS (Run). Signal from PMS (Power request). MV link active (up to 1050kW power produced) Hydrogen-supply active.

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Table 7-1: Operating mode descriptions		
Rampdown	When signaled from PMS that operation is done, the container stops power production and performs fuel cell module shutdown procedures. Fuel cell modules shutting down. Hydrogen system transitions from active to inactive. After shutdown is complete, container proceeds to aftercooling.	Signal from PMS (Standby) MV link active (~10kW power draw) Hydrogen-supply active.
Aftercooling	After fuel cell system has shut down, container performs aftercooling from the cooling system and ventilation from the container ventilation	400Vac Supplied to Container MV link active (~5kW power draw)
Shutdown	The cooling and ventilation systems shuts down. Container returns to standby.	400Vac Supplied to Container. MV link transitions from active to Inactive.
Fault	Internal fault state. Hydrogen supply and fuel cells are inactive.	400Vac Supplied to Container. Fault indication to PMS.

For more details, refer to Control philosophy and Logic block diagrams.

The primary state machine is shown below in Figure 17.

For states with a fixed duration, the current best estimate is shown.

For states with no duration listed, the transition depends on external signals.

In all states, the solution can transition to a fault state and the corresponding alarm will appear on the HMI and Modbus, where measures must be remedied prior to re-engagement/reset.

Figure 17: State machine diagram

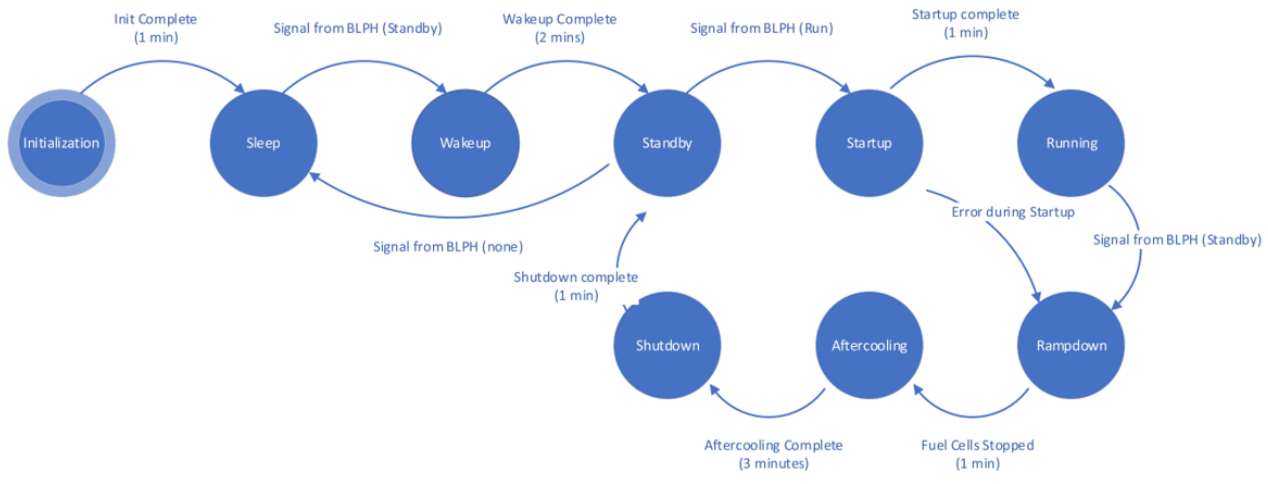


Diagram for the main state machine for the FC PowerGen.

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7.2 Control

This section outlines guidelines for the Power Request from the BLPH, which should be known by the integrator.

- The startup duration for a fuel cell module is approx. 30 seconds.
- A running fuel cell module can ramp from minimum power to rated power in 10 seconds.
- Start-up and significant step-up in power request will be limited by the startup duration, followed by the ramp-up time.
- Ramp-down is not limited by startup duration.
- The power request should be set to the desired value, instead of incrementally increased as fuel cells come online.
    - If the power request is incrementally increased, the FC package controller may not start all required fuel cell modules, and the power output will be limited by multiple sequential startup delays.
- Ballard expects that a Battery Energy Storage System (BESS) or similar power-spike capable system is used for short term spikes and dips in load and the FC package is responsible for long term power delivery with minimum short-term changes in requested power.
- The fuel cell package restart limits are as follows:
    - Restart less than 6 times in an hour.
    - Restart less than 20 times in a 24-hour period.

7.3 Disconnecting the MV bus

This section describes the consequences of disconnecting the MV bus from the FC package.

7.3.1 Disconnecting when not in operation

When the package is not in operation (State "Sleep" or "Cold Standby"), the MV bus can freely be disconnected.

7.3.2 Disconnecting while operating

The MV bus cannot be disconnected while the FC package is operating.

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7.4 Modbus TCP/IP

Control of the system is through the use of ethernet Modbus TCP/IP.

Provided Modbus table can be found in the FC package Modbus Map.

The Modbus Map presents the available read and write signals, using the function codes in Table 7-2.

The following descriptions presents the main signals that are available for the Integrator.

Table 7-2: Allowable Function Codes	
Discrete coils	
Function code 01	Read single coil
Function code 05	Write single coil
Function code 15	Write multiple coils
Discrete inputs	
Function code 02	Read single discrete input
Holding register	
Function code 03	Read single Holding register
Function code 06	Write single Holding register
Function code 16	Write multiple Holding register
Input register	
Function code 04	Read single Input register

7.4.1 Discrete coils

Read and write access.

A limited amount, if any at all, of discrete coils may be available.

7.4.2 Discrete Inputs

Read only access.

Here the status of components such as the Main Low Voltage Breaker, Local/remote control status, and statuses of internal subsystem are available.

7.4.3 Holding register

Read and write access.

7.4.3.1 Export Power Setpoint

The purpose of this signal is for the integrators PMS to signal the amount of delivered power desired at any given time.

Function: Export Power Setpoint

Tag: POWER_SP

Address 1000

Datatype: INT16

Scaling: 0.1 [kW]

Range: 55.0 to 1000.0 kW *(.0 is necessary)*

If 0<POWER_SP<55.0, the delivered power is 55.0 kW.

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The nature of Fuel Cell technology limits the speed of which it can rise and lower the delivered power. With this, the integrator can expect a defined maximum ramp-up and Ramp-down. The system will automatically follow these ramps, regardless of the export power setpoint.

7.4.3.2 Control word

The control word is the signal that enables the external signal to initiate the state changes described in section 7.1.

Function: Control word

Address 1001

Datatype: BOOL

Bit 0: wakeup/go to standby

Bit 1: go to sleep

Bit 2: Start/run

(In running mode, exported power is controlled as defined in section 7.4.1)

Bit 3: Stop

Bit 4: <Spare>

Bit 5: Reset

7.5 Input Register

Read only access.

An extensive list of live information, such as statuses and error codes. Refer to the FC package Modbus Map.

7.6 Alarm list

Refer to Alarm list for details.

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8.0 Testing

During installation and integration of the system, subsystems and interface connections, test procedures are conducted. These procedures verify the functionality and safety of specific parts of the system and integrated subsystems.

The tests are performed by/in collaboration with Ballard personnel and sub-suppliers.

The Site Acceptance Test (SAT) is similar to the Factory Acceptance Test document.

Tests could include, but are not limited to:

- Functionality tests
  - Visual inspection
  - Coolant circuit leakage tests
  - Electrical interconnection test
  - Electrical safety test
  - Initial Power up
  - Safety system
  - Auxiliary power and Balance of Plant (BOP) validation
  - UPS
  - Internal Load test
  - Hydrogen leakage test
- Pre-operations tests
  - Fuel Cell Commissioning
  - Emergency stop, no load, low load, full load
  - Hydrogen storage interface
  - Cooling circuits
  - Ventilation
  - Noise level
  - Thermographic
- Operations test
  - System start/stop – normal low load
  - Error simulation
  - Change FCwave to "service state"
  - Steady state operation
  - Power quality tests
  - Load test
    - ramp up, ramp down
    - step response
    - Load test – full load
    - Load test – no load
  - Full operation test cycle

8.1 Testing of hydrogen supply

For initial testing of the system itself, a temporary hydrogen supply in the form of a Hydrogen Battery and manifold (See requirements of this in section 5.3.3) may be used. This is to verify the functionality of the delivered system, prior to integration of the hydrogen supply delivery system of the designated site.

Integration and testing of the hydrogen supply on the designated site is a collaborative test.

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8.2 Load testing

Initial load-testing of the solution may be performed with the use of a temporary load bank that is mounted to the grid interface.

Testing with the designated grid and signals to/from the integrators PMS is done in collaboration with the responsible.

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Sub Section N01-002

Operator Manual

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003	3/13/2025	Corrected according to comments sheet
004	9/3/2025	Comment section/area visible in pdf file removed

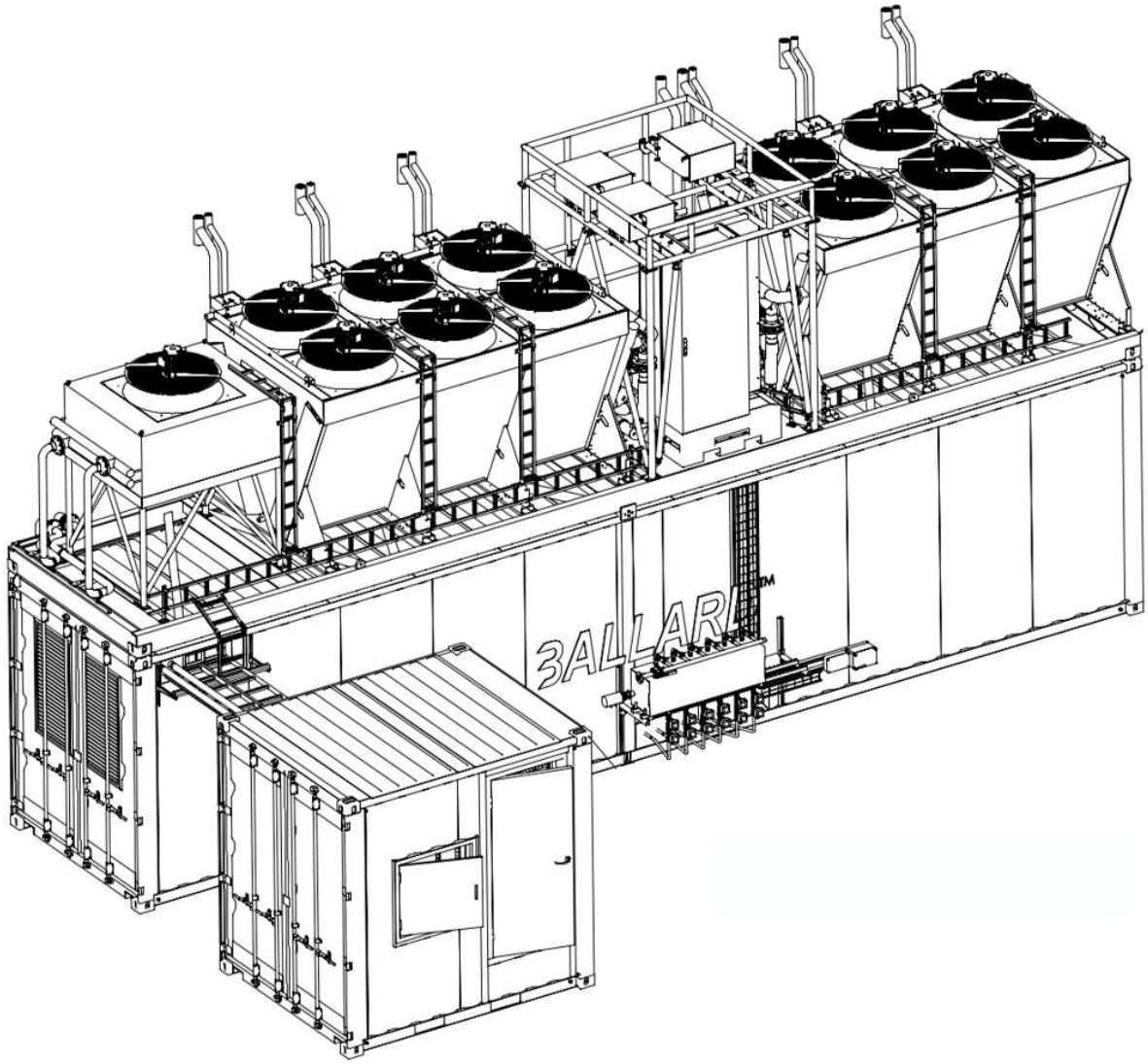
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FC PowerGen 1000kW

Part no.: 601456B-7002362

Configuration: 40ft Fuel Cell Container w. 6 FCwave™
10ft Converter Container, 6.6 kVAC

Operator Manual



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1.0 Disclaimer

NOTE: READ THIS BEFORE ATTEMPTING ANY PROCEDURES DESCRIBED IN THIS MANUAL

There are inherent risks in the operation of a fuel cell module that can result in death or bodily injury or loss or damage to property. It is therefore necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device. Persons who install, operate, and service the device are required to be technically qualified and experienced in working with electrical equipment, compressed gases, and H2.

This manual includes certain safety guidelines and recommendations; however, this manual is not intended to cover all situations. The customer is responsible for determining the suitability of the customer's particular design or application, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. Ballard Power Systems Europe A/S ("BPSE") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the operating recommendations in the manual. The customer is responsible for being aware of, and complying with, all applicable laws and regulations. BPSE has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

Procedures described in any part of the manual can only be attempted once the customer has read this entire manual. Failure to follow any instruction or recommendation could result in death or bodily injury or loss or damage to property.

BPSE intends for the device to be installed, operated, and serviced only by approved technically qualified and experienced people who understand the principles of fuel cell technology, are aware of the safe operating limits of fuel cells, and are familiar with the risks posed by operating a fuel cell module. BPSE relies on customers to use their own knowledge and experience when installing, operating, and servicing the device. BPSE also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual.

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2.0 General Information

This manual is mandatory reading for personnel working in or near the system, and persons instructing visitors prior to access to the system.

2.1 System introduction

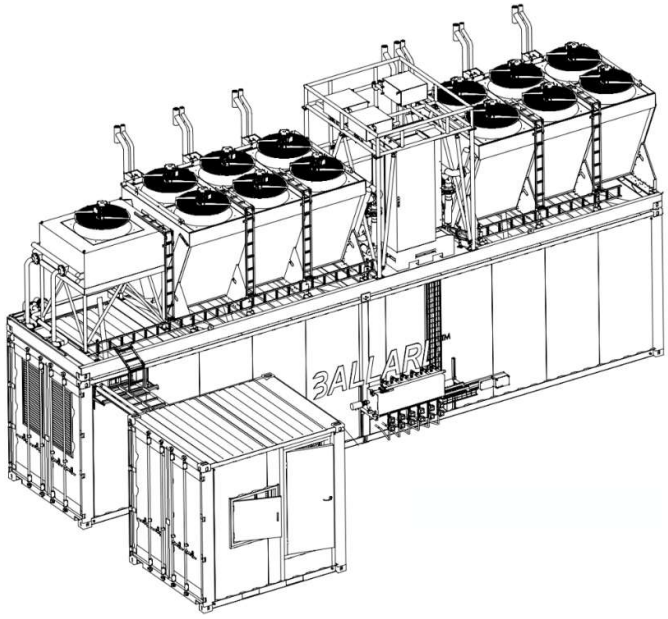
The Ballard FC PowerGen is a modularized power generator, comparable to a diesel-generator. It is a stationary, megawatt-scale hydrogen PEM fuel cell solution, utilizing the Ballard FCwave™.

The solution contains all needed elements to produce 1MW AC, when supplied with an auxiliary power supply, a local hydrogen supply, and an electrical grid that is controlled by a Power Management System (PMS), communicating with the use of Modbus.

Integration between the FC PowerGen and the local PMS enables the integrator to create a coherent and automatic system that reacts on the power-demand on the grid, within the given dynamic and capability limits of the solution.

The FCwave and the internals of the containers are designed in such a way that no explosive hazard zones are created in or around the system.

Figure 1: System overview



Indicative illustration of entire system

2.2 Manual purpose and scope

This operator Manual offers instructions for operating the system, instructions for operator-based maintenance, safety rules and recommendations.

It does not cover the operating instructions through the Modbus connection, refer to the Integration manual.

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2.3 Intended audience

The intended user of this Operator Manual is Operators, integrators, Installers, Service and Maintenance personnel, customer personnel working in or near the system, and persons instructing visitors prior to access to the system.



Before interacting directly or indirectly with the system, personnel must read and apply this manual.

2.4 Manual series

The Manual Series provides manuals covering different life-phases of the plant, as defined in Table 2-1:

Table 2-1: Manual series contents

Document no.	Title	Brief purpose description	Intended user(s)
Ballard: 7003672 CW: K559-2254-CWIWP4202202-R01-002	Transportation and Handling Manual	Enables safe, land-based, transport and handling from manufacturer to designated site.	Personnel qualified in preparation of, handling, and transport of freight.
Ballard: 7003718 CW: K559-2254-CWIWP4202202-N01-001	Integration Manual	Enables integrators to design designated site and subsystems required within the intended use and limits of the system.	Integrators partaking in designing the designated site and subsystems, and commissioning.
Ballard: 7003717 CW: K559-2254-CWIWP4202202-N01-002	Operator Manual	As described in section 2.2	As described in section 2.3
Ballard: 7003719 CW: K559-2254-CWIWP4202202-N01-003	Service and Maintenance Manual	Provide information regarding Service and Maintenance schedules and related safety.	Service and Maintenance personnel.

Ballard Power Systems Europe (BPSE) may update the provided manuals on an ongoing basis.

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2.5 Hazards Symbols

Hazard symbols throughout the manual indicate objectives or potentially dangerous situations.

Table 2-2: Hazard symbols

	**MANDATORY ACTIONS**: are marked with blue action-points. This indicates actions that must be performed. Ignoring may result in an accident, which could cause damage to equipment or other property, and could cause bodily injury if not promptly detected and remedied.
	**PROHIBITIONS**: are marked with red prohibition-signs. This indicates a forbidden action. Ignoring may result in immediate bodily injury or loss of life or could cause damage to equipment or other property
	**WARNINGS**: are marked with yellow triangles and/or square warning. Indicates hazards that may result in an accident, which could cause immediate bodily injury or loss of life or could cause damage to equipment or other property.
	**CAUTION** in this manual indicates actions that may result in an accident, which could cause damage to equipment or other property, and which could cause bodily injury if not promptly detected and remedied.
	**ELECRICAL HAZARD** Obey ALL warnings, cautions, and safety instruction related to electricity. Failure to do so may result in electrical shock leading to personal injury or death.

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2.6 References

Throughout the manual are referrals to separate documents. These references documents are available on the BSPE after sales Service Portal.

Should a document not be available, contact BSPE.

Table 2-3: Reference documents

Document no.:	Document name:
K559-2254-CWIWP4202202-B01-001Rev009	General Arrangement
K559-2254-CWIWP4202202-D05-001Rev001	Material Safety Data Sheets
K559-2254-CWIWP4202202-C08-001Rev004	Control philosophy and Logic block diagrams
K559-2254-CWIWP4202202-C99-001Rev002	Hydrogen Safety Concept

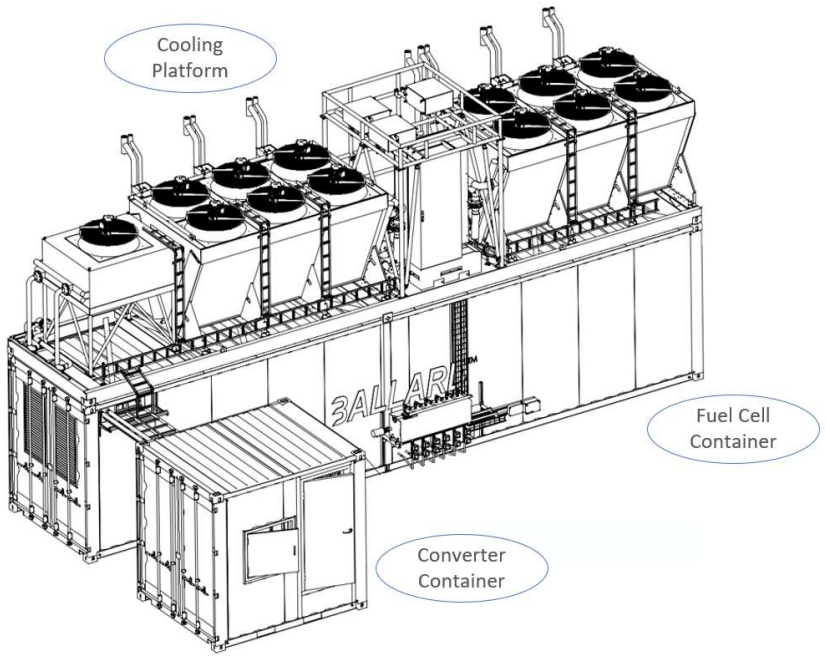
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3.0 FC PowerGen Description

3.1 Major components

The system is a modularized power generator based on a number of FCwave™ Fuel cell units.
The FC PowerGen consists of the following main components:

Figure 2: Major components overview



Short descriptions of major components can be found in Table 3-1

Table 3-1: Major components of the machine (See Figure 2)

Component	Short Description
Fuel Cell Container	Based on a 40ft HC container, modified to a machine housing with access, ventilation, light safety etc. The container holds 6 FCwave modules with installation, internal 400VAC power supply for complete Balance of Plant components, main controller, LT pump system and DC/DC converters.
Cooling Platform	40ft Cooling Platform with service platform. 2 individual HT radiators dimensioned to the specific solution 2 individual HT pump-systems 1 LT radiator
Converter Container	Based on a 10ft HC container, modified to a machine housing with access, ventilation, light, safety etc. Holds DC to AC grid-forming power electronics, Isolation transformer, and Grid Main Breaker.

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3.2 General Functional Description

The FC PowerGen is designed for fully autonomous and remote operation with no operator interface, except for service purposes. It is activated and operated remotely by the PMS of the integrators designated microgrid, for the solution to deliver power to.

While there is no fault internally on the fuel cell system or externally signaled, the solution will start and stop fuel cells as needed, to maintain delivery of requested power and keep operational health.

The solution accepts a power-request of zero. In this case it will be running in a stand-by mode, powered by either the auxiliary power supply, the power produced by itself, or a combination.

If any single input to the safety controller is outside acceptable parameters, e.g. hydrogen detection, E-stop activation, or external trip, the safety-system will trip and activate emergency shutdown. Depending on the severity of a potential fault, it will either:

- Initiate controlled shutdown on affected system(s) or the entire solution, or
- Instantaneously shutdown and isolate energy on affected system(s) or the entire solution.

Loss of hydrogen supply will stop operation and be handled as a failure.

3.3 Local HMI

Inside the Fuel Cell Container is located an HMI in the form of a touchscreen. This is available for service purposes of the machine. An overview of the system can be seen, and parameter changes can be made when unlocked with the use of a password (for authorized personnel only).

Instructions of use and/or creation of an HMI/SCADA for the PMS of local grid is not within the scope of the FC PowerGen, but a responsibility of the local integrator with the use of the Integration Manual.

3.4 Alarms

The following alarms are externally to the FC PowerGen triggered and should be handled by the site operator. For other alarms than mentioned, contact Ballard.

3.4.1 No hydrogen

The solution provides a signal to show that hydrogen is not available at the proper requirements. In case of "no hydrogen" alarm, please investigate hydrogen-supply upstream.

3.4.2 Remote Emergency Hydrogen Supply

The system has received a remote stop signal from upstream hydrogen supply, please investigate upstream.

3.4.3 Remote Emergency Site

The system has received a remote stop signal from PMS, please investigate downstream.

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3.5 General Operating States

The solution is designed for the Integrators local PMS to control the system through a wired Ethernet Modbus TCP/IP Connection.

The solution operates in the modes described in Table 3-2.

Table 3-2: General Operating mode descriptions

Operating Mode	Brief description	Preconditions
Off	Container fully depowered.	No power supplied to container; UPS batteries depleted
Initialization	Functions to establish baseline container status, with connections to external power and communications.	After bootup. 400Vac Supplied to Container.
Sleep	Container minimum operational level. Control and safety system are operating, but no high-power systems (>20kW) are operating. Hydrogen supply and fuel cells are inactive.	400Vac Supplied to Container. Communications heartbeat from PMS
Wakeup	Container enables 24V supply to fuel cell modules and starts container ventilation system.	400Vac Supplied to Container. Signal from PMS (Standby).
Standby	Waiting state for "Run" command from high level control system. Hydrogen supply and MV link disabled.	400Vac Supplied to Container Signal from PMS (Standby)
Startup	Transitional phase when PMS signals container to initiate operation. The significant part of this phase is that the container will draw a significant amount of power during startup, to energize fuel cell modules and cooling fans/pumps. After startup is complete on the fuel cells, the container transitions to "Running". All systems operational. Hydrogen system active.	400Vac from internal microgrid. Signal from PMS (Run). MV link active (10-150kW power draw, depending on # of FCwave starts concurrent). Hydrogen-supply active.
Running	Operational state for the container, where the fuel cell modules are consuming hydrogen to produce electrical energy. Cooling and ventilation systems are operating to support fuel cell modules.	Signal from PMS (Run). Signal from PMS (Power request). MV link active (up to 1050kW power produced) Hydrogen-supply active.
Rampdown	When signaled from PMS that operation is done, the container stops power production and performs fuel cell module shutdown procedures. Fuel cell modules shutting down. Hydrogen system transitions from active to inactive. After shutdown is complete, container proceeds to aftercooling.	Signal from PMS (Standby) MV link active (~10kW power draw) Hydrogen-supply active.

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Table 3-2: General Operating mode descriptions		
Aftercooling	After fuel cell system has shut down, container performs aftercooling from the cooling system and ventilation from the container ventilation	400Vac Supplied to Container MV link active (~5kW power draw)
Shutdown	The cooling and ventilation systems shuts down. Container returns to standby.	400Vac Supplied to Container. MV link transitions from active to Inactive.
Fault	Internal fault state. Hydrogen supply and fuel cells are inactive.	400Vac Supplied to Container. Fault indication to PMS.

For more details, refer to Control philosophy and Logic block diagrams.

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4.0 General Safety

⚠ CAUTION	
	**The FC PowerGen is intended to be remotely controlled.** **Automated start up may occur at any time if not prevented with applicable procedures.**

4.1 Machine access

At no time is access permitted inside the machine containers for unauthorized personnel, especially the Converter Container.

The exterior container doors must always remain locked except during active installation, integration, service, or maintenance.

⚠ WARNING	
	**Access to the internals of Converter Container is strictly prohibited except when applicable procedures are done by trained personnel, approved by the manufacturer.**

4.2 Hazardous materials

4.2.1 Coolant



The solution utilizes two types of coolant. The LT and HT cooling circuit uses the Glycol-based coolant Proviflow®, and the internal closed coolant loop of the FCwave™ uses GLYSANTIN® FC G20.

For more details, refer to the document "Material Safety Data Sheets".

During normal operation there should be no leakage of coolant. If a leakage is noted, Manufacturer must be informed.

General rules are:

- Avoid contact with eyes and skin.
- Use protective gloves and tightly sealed googles.
- Avoid ingestion and inhalation of vapors.
- Spillage – do not allow to enter sewers/surface or ground water, absorb with a liquid–binding material, dilute with water.
- Disposal must be made according to official regulations.

4.2.2 Lubricant

General for container solution: Ceramic Grease PV.20.01, used as assembly paste and high temperature lubricant grease without metal particles for lubrication of bolts.

Fuel Cell Modules: Krytox™ GPL 205 & 206: Grease safe for use around hazardous chemicals, non-flammable. For extreme temperatures.

General rules are:

- Avoid contact with eyes and skin
- Avoid ingestion and inhalation of vapors.
- Use protective gloves, safety glasses, and suitable protective clothing.
- Spillage – do not allow to enter sewers/surface or ground water, absorb with a liquid-binding material, dilute with water.
- Disposal must be made according to official regulations.

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4.2.3 Process water

The fuel cell process produces De-Ionized Water, which is routed from each FCwave™ to a H2 separator. The trace amount of H2 is led to the process-drain exhaust, and the process water is led to a drainpipe, connected to the outside drain system.

De-Ionized Water is not suitable for drinking water.

4.2.4 Hydrogen

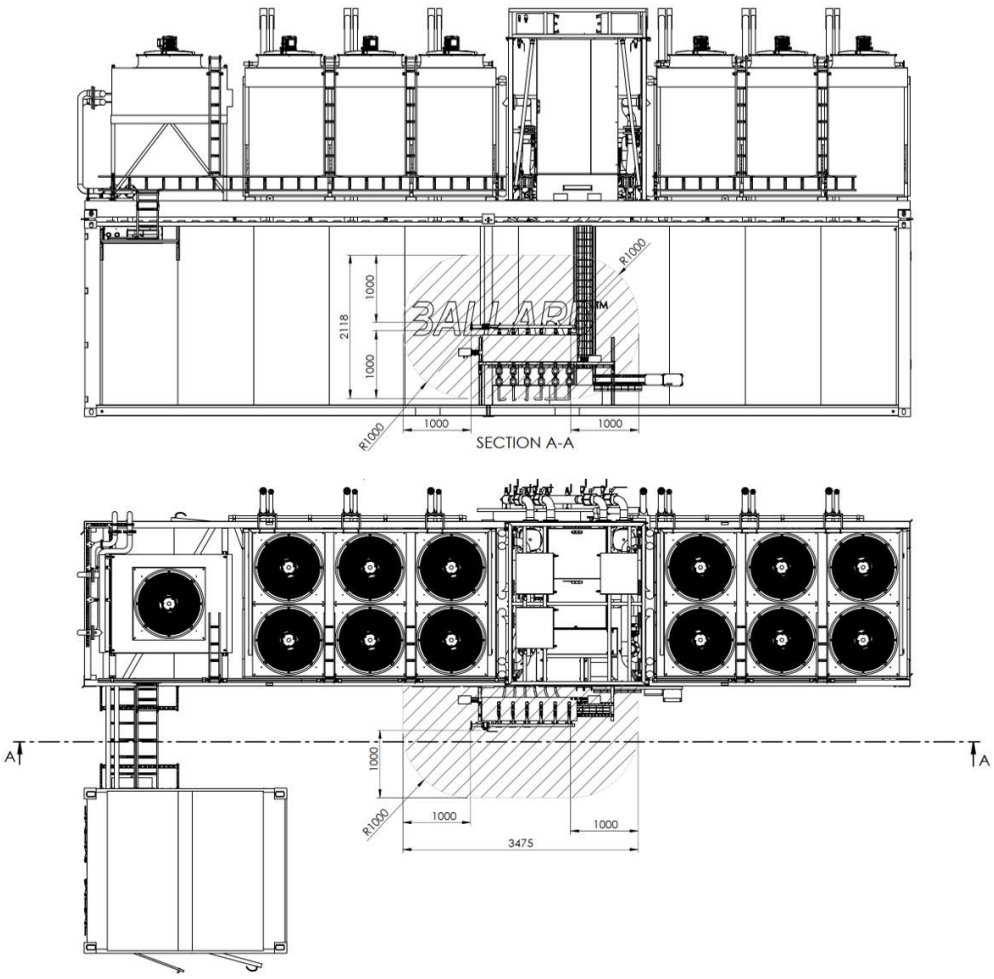
Risks of hydrogen leakages is highly unlikely.

Areas within the solution are classified as non-hazardous since areas with the slightest risk of leakage are monitored by the safety system and excessively ventilated to dilute and remove the hydrogen, thereby removing any explosion hazard inside the system.



The area around the External hydrogen handling unit is classified as an EX-Zone 2 with a max 1 meter extend. Here, an explosive gas atmosphere is not likely to occur in normal operation, but, if it does occur, will exist for a short period only.

Figure 3: EX Zone – External hydrogen handling unit



EX-zone marked around the External hydrogen handling unit.

Refer to Hydrogen Safety Concept for more details about the EX-zone.

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Minimize all activities in the EX-zone
Activities must be done by trained personnel
Do not introduce any ignition source into the EX-zone



4.3 Site safety for Personnel

4.3.1 Personal Protection Equipment (PPE)

Appropriate PPE should always be worn while interacting with the system directly and/or indirectly. Wear a safety helmet, protective glasses, gloves, and other protective equipment, as required by the designated site.

4.3.2 Noise

During normal operation the noise-level emitted varies depending on the operating conditions. The noise-level in the surrounding area may reach up to 80dB, the highest being in front of the air-intakes.



Hearing protection should be available and used when in the surrounding area.

4.3.3 Emergency doors

The fuel cell container is equipped with two emergency exit doors, see Figure 4.

Do not store material or in other way block the emergency doors.

4.3.4 Freezing conditions

The process exhaust contains water. This water will freeze and turn into snow and ice. Care must be taken when outside temperatures are at or below 0 °C.

- It is possible that icicles are formed on the exterior of the containers, creating a risk of falling objects.
- It is possible that surrounding surfaces have icing, creating a risk of slipping.
- Avoid or restrict access to the area if needed

4.3.5 Medical devices

During some operating modes, the system will create a magnetic field which may influence medical devices. Such devices shall not enter the system.

4.3.6 Fire

The Fuel Cell Modules have internal fire detection in the form of smoke detectors and linear heat detectors. If a Fuel Cell module detects fire, it will automatically perform a safe shutdown of itself and indicate an alarm.

If Smoke is detected inside the general space of the Fuel Cell Container, the entire system will perform a safe shutdown and indicate an alarm.

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Should a fire occur, exit through the provided emergency exits.

4.3.7 Explosion Safety

The solution introduces an area with explosion hazard around the hydrogen interface. This zone is classified as a Zone 2, meaning that a hazardous mixture of hydrogen in the area will not likely be present under normal operating conditions, and if so, only for a short period at a time. Detailed drawing of the hazard zone can be found in the General Arrangement.

	**Respect the zone indicated, do not introduce any source of ignition.**

4.3.8 Hot surfaces

	**During operation, hot surfaces are present. Respect the nature of the machine and avoid touching surfaces marked.**

4.3.9 Service and maintenance

	**When service and maintenance are conducted, personnel in the area must follow the instructions from the responsible service technician.**

4.4 Cleaning

The area around the system should be kept clean and with unrestricted access, e.g. during winter snow.

Cleaning of the major components of the system must be done according to the service instruction. Do not wash down exterior without consulting the service manual.

4.5 Settings

No settings for the FC PowerGen are available for the general operator. Settings are restricted to Integrators and Service and Maintenance Personnel through the use of Modbus communication and the HMI inside the Fuel Cell Container.

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4.6 Safety labels on the machine

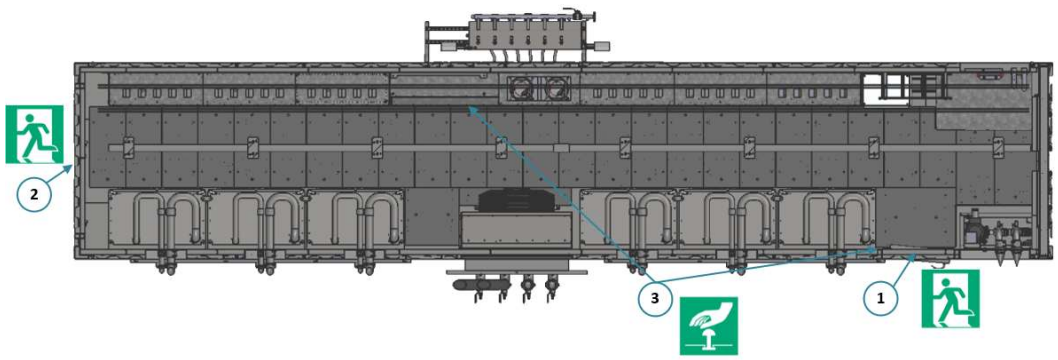
Table 4-1: Safety labels on the machine			
	Emergency exit		Use hearing protection
	Authorized personnel only		Wear safety footwear
	No smoking		Read manual
	No open flame		Risk of electric shock
	No access for active implanted cardiac devices or others alike		Hot surface
	Not lifting point		Automatic startup
	Lifting point		Crush of hands

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5.0 Safety inside Fuel Cell Container

When the entirety of this manual has been consulted, it is safe to enter the Fuel Cell Container during operation. The Fuel Cell Container is designed to meet minimum IP20 for all equipment installed.

Figure 4: Safety equipment in Fuel Cell Container



Emergency doors, emergency buttons

5.1 General rules

The interior of the Fuel Cell Container is to be kept as clean as possible:

- Remove any litter or debris.
- Keep the doors closed to allow for ventilation air to be filtered.
- The Fuel Cell Container is a machine, respect the rules and signs. Do NOT open equipment without proper instruction and safety measures as described in relevant service work instruction.
- It is recommended to keep a communications device on your person when being inside.

The interior light can be switched on and off next to the main entrance door.

If any abnormal condition is noted on entry, avoid entering and contact Ballard service.

5.2 Emergency exit

The main entry door (Figure 4, 1) is on the side of the container. The door is equipped with an emergency Push bar on the inside.

There is an additional service access door (Figure 4, 2) at the end of the container. This door is intended for use only during specific service activities and emergency exit.

5.3 Emergency Stop button

The Emergency Stop buttons (Figure 4, 3) are placed next to the main access door, and on the MCU panel. Activating one will immediately shut down the entire system and disengage the main output connection to the grid.

The emergency stop button may not be used as a general stop button of the machine.

It is important to note that not all energy sources are disconnected from the machine when the emergency button is activated. Systems such as UPS batteries for the control-systems and the Auxiliary power supply etc., supplies energy to the system during emergency stop.

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5.4 Emergency lighting

Part of the internal lighting of the container is supplied with power from the UPS during an emergency.

5.5 Fire safety

The Fuel Cell Container is equipped with a fire detection system using multiple detectors. The activating of a detector may lead to partial shutdown of the affected unit or a complete shutdown of the system.

- Smoke detectors are mounted in the ceiling of the container, monitoring the inlet and outlet of the ventilation air.
- Each FCwave module contains an internal smoke detector and linear heat detector.

5.6 Hydrogen safety

The Fuel Cell Container is designed to prevent leakages of hydrogen inside the container, and there are no hydrogen-flammable or -explosive conditions inside the system.

As an additional precaution, in case of hydrogen entering the container, the container is equipped with three hydrogen sensors in the general space of the container. One at the ventilation intake and one at each of the ventilation exhausts, which will detect incoming and exiting hydrogen.

If one of these hydrogen detector is triggered, the safety system shuts off all the hydrogen supply valves and trigger emergency shutdown of the fuel cell modules and power converters.

Refer to Hydrogen Safety Concept for more details.

5.7 Electrical safety

The electrical cabinets are only to be opened by instructed electricians and require a tool.

⚠ ELECTRICAL HAZARD	
	**Special attention is required to the DC cabinets.** **The voltage on the DC busbars is 750V, and special procedures must be followed to disconnect and discharge the system prior to opening.** **Refer to Service and Maintenance Manual.**

5.8 Auxiliary power supply

The system requires a permanently mounted auxiliary power supply. Auxiliary power supply is used during operating modes where power from the fuel cells is not available.

The auxiliary power is present at all times, also when the main grid breaker is open, unless disconnected remotely.

5.9 Noise

During operation the sound level may reach up to 94dB inside the container. Hearing protection must be used when inside the container.

If the fuel cell system is shut down for service and starting are prevented by applicable lock-out, hearing protection is not mandatory.

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Hearing protection must be worn during operation.

5.10 Hot surfaces

The components and piping of the LT cooling rack may reach a temperature of 45°C.

The components and piping of the HT cooling that are placed below the raised technical floor may reach a temperature of 65°C. The floor should only be opened in consultation with the instructions in the service manual.

The Process exhaust piping above the fuel cells may reach a temperature of 70°C during fuel cell operation. Avoid touching.



The HT Coolant pipes reach temperatures up to 65°C during normal operation.

The process exhausts reach temperatures above 70°C during operation.

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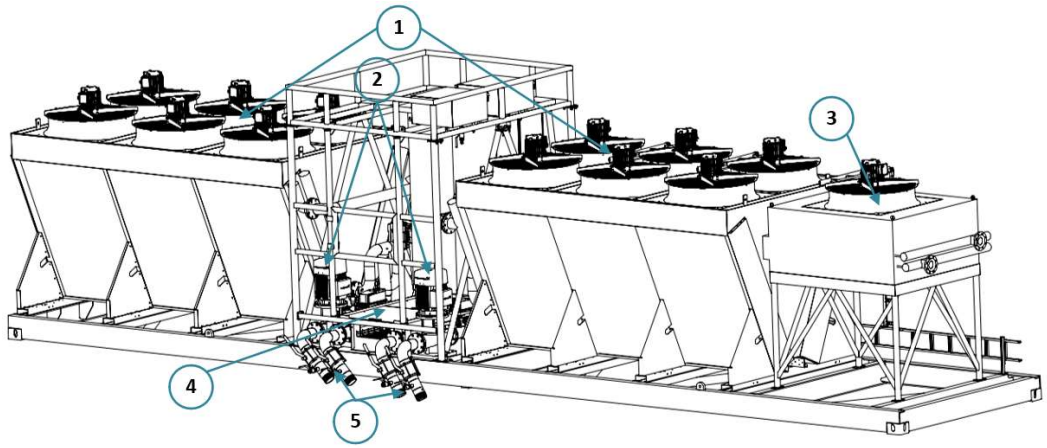
6.0 Cooling Platform

The Cooling platform is a steel structure with the footprint of a 40ft container. The purpose of the cooling platform is to dissipate the excess heat generated. The cooling systems are open unpressurized systems with open header tanks to accommodate for volume changes due to temperature. The cooling media is Ethylene glycol, and the highest temperature is approximately 65 °C.

The exhausts from each FCwave™ is fastened to the HT cooling platform.

- Process air, oxygen reduced air from the electrochemical process saturated with water.
- Hydrogen ventilation air

Figure 5: Cooling platform overview



Indicative overview of HT Cooling Platform with numbered ballons (see Table 6-1)

Table 6-1: HT Cooling platform overview descriptions (See Figure 5)

1	HT Coolers with fans
2	HT Coolant pumps
3	LT Cooler with fan
4	Platform Service area
5	HT Coolant in- and outlet

6.1 Platform Service area

The Service Area of the Cooling Platform is located between the HT coolers. The Cooling Platform is placed on top of the Fuel Cell Container, approximately 3 meters above ground level. This makes the Service Area inaccessible for unauthorized personnel.

Access for authorized personnel is with a designated ladder which is hooked on to the service area extension, or from a scaffold or similar, if service work requires.

The Service Area has a surrounding fencing. This prevents service engineers from falling from height. Special care must be taken in extreme weather conditions, consider using PPE equipment (harness).

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Prior to accessing the Service Area of the Cooling Platform, the Service and Maintenance Manual must be consulted.

6.2 Hydrogen safety

There is no Hydrogen present at the service area.

6.3 Electrical safety

The electrical cabinets are only to be opened by instructed electricians and require a tool.

6.4 Noise

During operation the sound level may reach up to 80dB in the Service Area, main source being the cooling fans on top of the coolers.

Use hearing protection when in operation.

6.5 Hot surfaces

The components and piping of the HT cooling may reach a temperature of 65°C during operation.

Mounted to the HT Cooling Platform are the Process exhaust from the Fuel Cell Modules that resides inside the Fuel Cell Container. These may reach temperatures up to 70°C.

Avoid touching.

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7.0 Converter Container

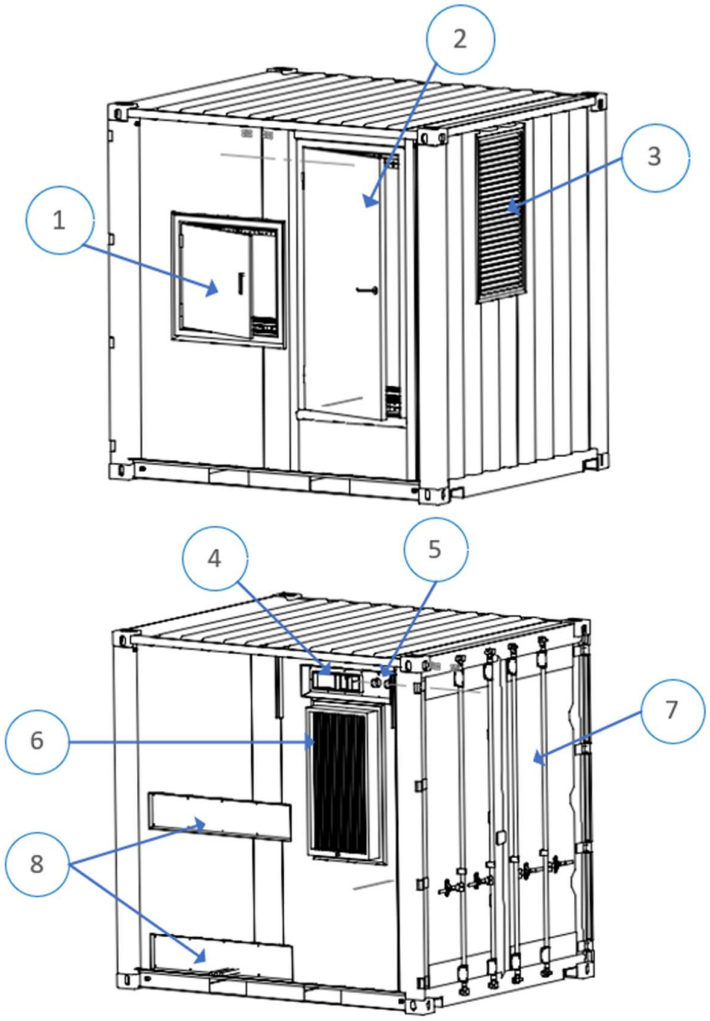
The Converter Container is structurally a 10ft high-cube double-door container, modified to the specific need. It is designed as an electrical cabinet, housing DC/AC converters and a transformer that converts the energy to the desired voltage (6.6 kV).

Access to the inside is through the normal container doors which are, because of electrical safety, mechanically prevented from opening during operation. These are also equipped with safety sensors, which will immediately bring the entire solution to "Failure state" if opened.

Access is restricted to instructed and trained personnel, and only after a safety procedure is followed, which will deenergize the container to a safe mode.

The control panel and grid breaker front of the Converter Container is accessible from the outside, behind an additional locked door which will not shut down the solution if opened.

Figure 6: Converter Container overview



Indicative overview of 10ft Converter Container with numbered ballons (see Table 7-1)

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Table 7-1: Converter Container overview descriptions (See Figure 6)	
1	Control panel access door
2	Main output breaker access door
3	Ventilation exhaust
4	Wall passthrough for Control Signals and DC power cables from Fuel Cell Container
5	LT Cooling interface
6	Ventilation air intake
7	Service doors
8	Converter (1MW AC output)

7.1 Electrical safety

⚠ ELECTRICAL HAZARD	
	**HIGH VOLTAGE – 6.6 kV** **Danger of electrocution** **Authorized personnel only** **Keep clear and follow safety protocols** **Proper PPE required** **Failure to comply may result in serious injury or death**

7.2 Access

There is no access to the insides of the Converter Container for unauthorized personnel, as some aspects inside are IP00.

Access is only granted with proper de-energization procedures found in the Service and Maintenance Manual.

Opening any of the access doors triggers a safeguard, immediately de-energizing the entire FC PowerGen and requires a resetting procedure.

It is recommended to keep a communications device on your person when being inside.

⚠ WARNING	
	**Access to the internals of Converter Container is strictly prohibited except when applicable procedures are done by trained personnel, approved by the manufacturer.**

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Sub Section N01-003

Service and Maintenance Manual

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Revision history		
Rev.	**Date.**	**Description**
001	8/15/2024	First Issue
002		
003	2/28/2025	Corrected as per CrossWind comments
004	11/4/2025	Front page added as per CW comment

Document Title:	**BLPH Project - Service and Maintenance Manual**
Document Number:	K559-2254-CWIWP4202202-N01-003
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	N01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Revision Record			
Rev	**CO**	**Description**	Date
0B	CJA	Updated part number and naming to match nameplate (Megablock → PowerGen, Grid Interface Container → Converter Container). Reacting to CRS. Incorporated content from N01-004. Added section 6.1 regarding top-swap tool Added section 10 troubleshooting, with Cause and Effects chart as source.	2024-12-17
0C	KHE	Corrected in accordance with comments from CrossWind	2025-02-27

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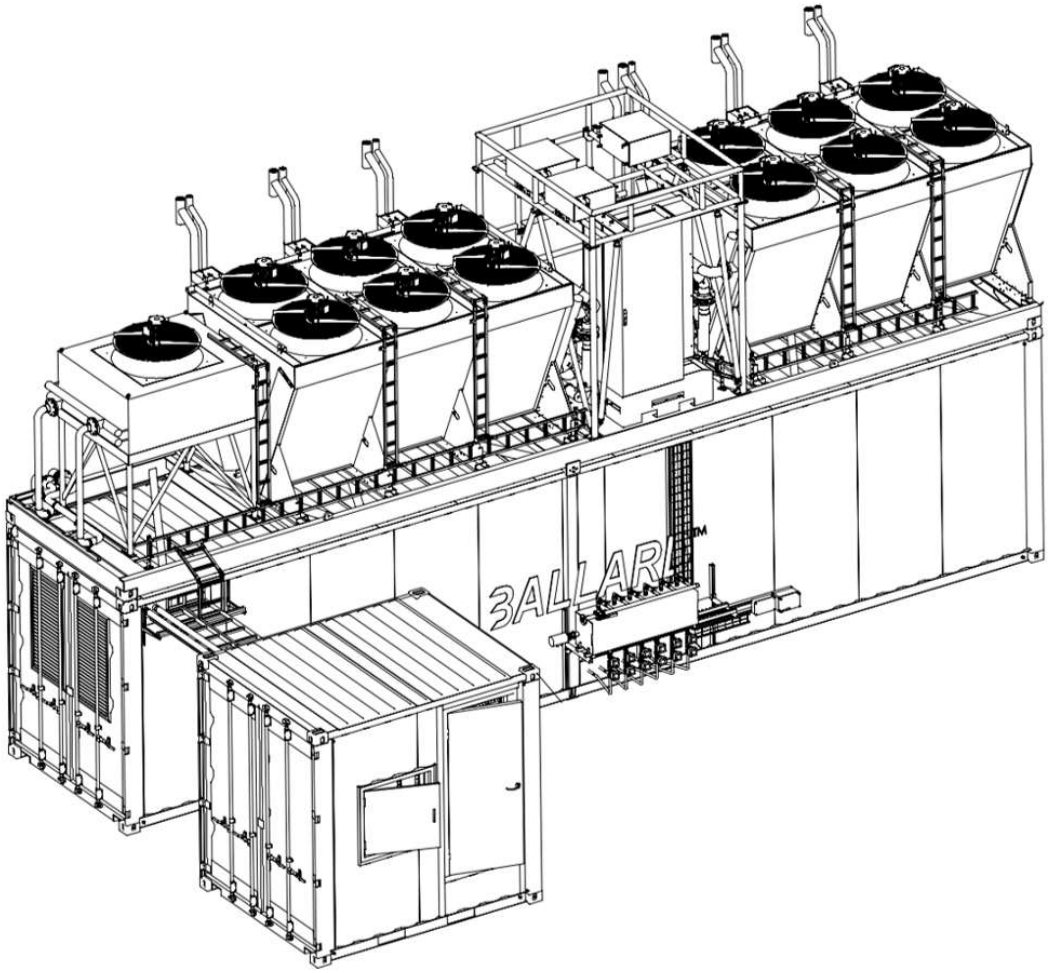
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FC PowerGen 1000kW

Part no.: 601456B-7002362

Configuration: 40ft Fuel Cell Container w. 6 FCwave's
10ft Converter Container, 6,6 kVAC

Service and Maintenance Manual



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1.0 Disclaimer

NOTE: READ THIS BEFORE ATTEMPTING ANY PROCEDURES DESCRIBED IN THIS MANUAL

There are inherent risks in the operation of a fuel cell module that can result in death or bodily injury or loss or damage to property. It is therefore necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device. Persons who install, operate, and service the device are required to be technically qualified and experienced in working with electrical equipment, compressed gases, and H2.

This manual includes certain safety guidelines and recommendations; however, this manual is not intended to cover all situations. The customer is responsible for determining the suitability of the customer's particular design or application, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. Ballard Power Systems Europe A/S ("BPSE") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the operating recommendations in the manual. The customer is responsible for being aware of, and complying with, all applicable laws and regulations. BPSE has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

Procedures described in any part of the manual can only be attempted once the customer has read this entire manual. Failure to follow any instruction or recommendation could result in death or bodily injury or loss or damage to property.

BPSE intends for the device to be installed, operated, and serviced only by approved technically qualified and experienced people who understand the principles of fuel cell technology, are aware of the safe operating limits of fuel cells, and are familiar with the risks posed by operating a fuel cell module. BPSE relies on customers to use their own knowledge and experience when installing, operating, and servicing the device. BPSE also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual.

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2.0 General Information



Service and Maintenance personnel must read and understand the Operator Manual mentioned in section 2.4 prior to activities covered by this manual.

2.1 Manual Purpose and scope

This Service and Maintenance Manual for the FC PowerGen provides guidance and instructions for routine inspections, testing, and maintenance tasks necessary for the safe and reliable operation of the system throughout its operational lifetime.

It covers topics such as:

- Safety protocols
- System Description
- Preventative Maintenance

Excluded from this manual are specific Service-, Maintenance-, and Repair- instructions. These are separate documents, reserved for trained and authorized personnel.

2.2 Intended audience

The intended audience for this manual is persons involved in service and maintenance of the FC PowerGen system.

Technicians and maintenance personnel who are responsible for servicing and maintaining the system must be authorized and trained by Ballard to perform service and maintenance according to this Manual, referred documentation, and instructions.



Technicians and Maintenance personnel must read and adhere to this manual when performing service and maintenance on the system.

Audience Key characteristics:

- **Technical proficiency**: The intended audience possesses a strong technical background and expertise in Fuel cells and electrical systems.
- **Authorized personnel**: Technicians and maintenance personnel are authorized by the manufacturer to access and use the Service and Maintenance Manual.
- **Training requirement**: The service responsible must use technicians who have undergone specific training programs provided by the manufacturer to ensure proficiency in servicing and maintaining the system safely.
- **Responsibility**: The service responsible must ensure the execution of routine inspections, testing, components change, and other maintenance tasks necessary for the safe functionality of the system.

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2.3 Training Level Certification

2.3.1 System service

Service on the system, excluding the FCwave, may only be performed by Ballard authorized personnel listed in the service authorization list and only according to the service tasks for which they are approved.

2.3.2 Fuel cell service

Personnel performing service on FCwave must be trained according to Ballard training levels:

Tier 1 – Service technicians and fuelers

Tier 2 – Service technicians and mechanics

Tier 3 – Senior Service technicians and Engineers

Details of roles and responsibilities are reinforced by Ballard's standard Service Level Agreement. Contact Ballard for details regarding training.

2.4 Manual series

The Manual Series provides manuals covering different life-phases of the system, as defined in Table 2-1:

Table 2-1: Manual series contents

Document no.	Title	Brief purpose description	Intended user(s)
Ballard: 7003672 CW: K559-2254-CWIWP4202202-R01-002	Transportation and Handling Manual	Enables safe, land-based, transport and handling from manufacturer to designated site.	Personnel qualified in preparation of, handling, and transport of freight.
Ballard: 7003718 CW: K559-2254-CWIWP4202202-N01-001	Integration Manual	Enables integrators to design a designated site and subsystems required within the intended use and limits of the system.	Integrators partaking in designing the designated site and subsystems, and commissioning.
Ballard: 7003717 CW: K559-2254-CWIWP4202202-N01-002	Operator Manual	Provides information to personnel for safe operation of the solution, instructions for operator-based maintenance, safety rules and recommendations	Operators, Integrators, Installers, Service and Maintenance personnel, personnel working in or near the system, and persons instructing visitors.
Ballard: 7003719 CW: K559-2254-CWIWP4202202-N01-003	Service and Maintenance Manual	As described in section 2.1	As described in section 2.2

Ballard Power Systems Europe (BPSE) may update the provided manuals on an ongoing basis.

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2.5 Ballard Aftersales Service

Contact information on Ballard Aftersales Service can be found at:
https://www.ballard.com/support/

2.6 Hazard Symbols

Hazard symbols throughout the manual indicate objectives or potentially dangerous situations.

Table 2-2: Hazard symbols

	**MANDATORY ACTIONS**: are marked with blue action-points. This indicates actions that must be performed. Ignoring may result in an accident, which could cause damage to equipment or other property, and could cause bodily injury if not promptly detected and remedied.
	**PROHIBITIONS**: are marked with red prohibition-signs. This indicates a forbidden action. Ignoring may result in immediate bodily injury or loss of life or could cause damage to equipment or other property
	**WARNINGS**: are marked with yellow triangles and/or square warning. Indicates hazards that may result in an accident, which could cause immediate bodily injury or loss of life or could cause damage to equipment or other property.
	**CAUTION** in this manual indicates actions that may result in an accident, which could cause damage to equipment or other property, and which could cause bodily injury if not promptly detected and remedied.
	**ELECRICAL HAZARD** Obey ALL warnings, cautions, and safety instruction related to electricity. Failure to do so may result in electrical shock leading to personal injury or death.

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2.7 References

Throughout the manual are referrals to separate documents. These references documents are available on the BPSE after sales Service Portal.

Should a document not be available, contact BPSE.

Table 2-3: Reference documents

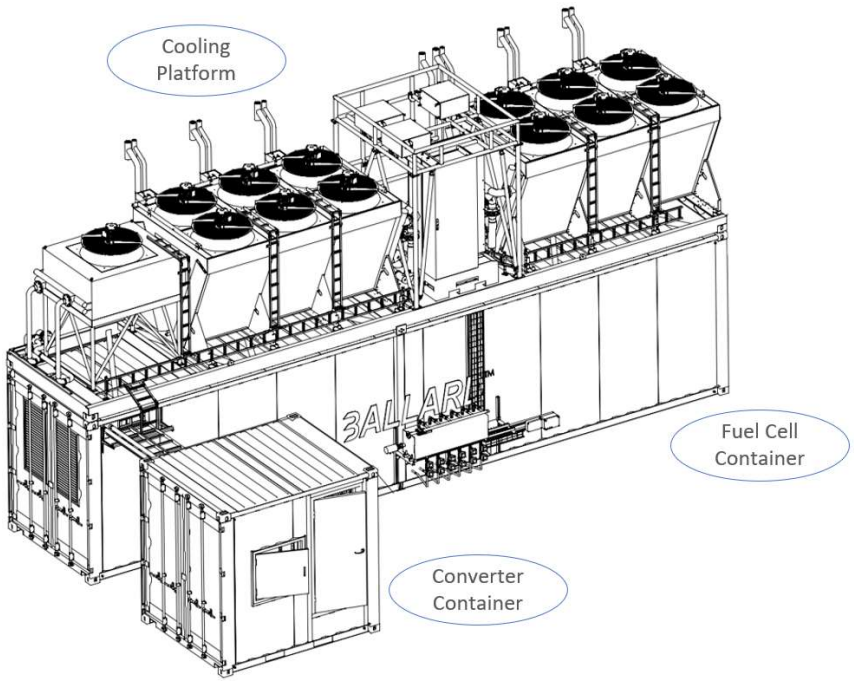
Document no.:	Document name:
7003724 (attached)	Maintenance Plan
K559-2254-CWIWP4202202-D05-001Rev001	Material Safety Data Sheets
K559-2254-CWIWP4202202-C99-001Rev002	Hydrogen Safety Concept
K559-2254-CWIWP4202202-K02-001Rev002	Equipment hazardous area certificate and schedule
K559-2254-CWIWP4202202-B99-003Rev001	Structural calculations - false floor
K559-2254-CWIWP4202202-B01-001Rev009	General Arrangement
K559-2254-CWIWP4202202-C03-001Rev006	P&IDs
K559-2254-CWIWP4202202-C06-001Rev007	Electrical Single Line Diagram
K559-2254-CWIWP4202202-E03	Electrical Cabinet Documentation
K559-2254-CWIWP4202202-N01-005Rev001	Lockout Tagout
N99 - MAN001Rev1.1.1	FCwave – Service and Maintenance Manual
K559-2254-CWIWP4202202-C07-001Rev002	Cause and Effects Chart

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3.0 General System Description

The system is a modularized power generator based on a number of FCwave™ Fuel cell units.
The FC PowerGen consists of the following main components:

Figure 1: Major components overview



Short descriptions of major components can be found in Table 3-1

Table 3-1: Major components of the machine (See Figure 1)

Component	Short Description
Fuel Cell Container	Based on a 40ft HC container, modified to a machine housing with access, ventilation, light safety etc. The container holds 6 FCwave modules with installation, internal 400VAC power supply for complete Balance of Plant components, main controller, LT pump system and DC/DC converters.
Cooling Platform	40ft Cooling Platform with service platform. 2 individual HT radiators dimensioned to the specific solution 2 individual HT pump-systems 1 LT radiator
Converter Container	Based on a 10ft HC container, modified to a machine housing with access, ventilation, light, safety etc. Holds DC to AC grid-supplying power electronics, Isolation transformer, and Grid Main Breaker.

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4.0 Safety

4.1 General safety



The reader of this manual shall read the operator manual mentioned in section 2.4 for additional information on general function and safety, as a supplement to the manual.

The applicable service procedure must always be consulted before any service activity is performed.

Any safety related information herein must be followed.



All service technicians must understand and comply with good workmanship and safety procedures generally associated with machinery service, even if these procedures are not specifically stated in this document.

While working on the system, there should always be more than one person present on-site.

4.2 Personal Protective Equipment

The service technician must bring and use appropriate PPE.

In general:

- Safety shoes are mandatory.
- Hearing protection must be available and used when the system is operational.
- Fire inhibited clothes must be used when working on the electrical system.
- Helmets must be used when hoisting equipment inside the Fuel Cell Container.
- Helmets and Fall arrest equipment must be used when working at heights.
- Suitable gloves and eye protection must be used for working with coolant.
- Suitable gloves must be used for where risk of cuts is present, i.e. under the raised floor because of sharp edges.
- Suitable tools for working on live voltages – as per EN 60900.

Procedures may specify additional PPE.

4.3 Corrective maintenance

In situations where errors arise because of defective or worn-out parts, contact Ballard for support. Corrective maintenance must be done by authorized personnel.

4.4 Retrofitting and modifications

Retrofitting and modifications of the system shall be in collaboration with Ballard. Contant Ballard for support. Ballard will not take responsibility for any non-approved items applied; it is the responsibility of the applying entity. Unapproved modification may affect the warranty on the entire system.

4.5 Spare and wear parts and consumables

Using spare parts and consumables from third party manufacturers can cause risk. Only use original parts or parts approved by the manufacturer.

The manufacturer takes no responsibility for damage as a result of using parts not released by, or approved by, the manufacturer.

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4.6 Coolant



The solution utilizes two types of coolant. The LT and HT cooling circuit uses the Glycol-based coolant Proviflow®, and the internal closed coolant loop of the FCwave™ uses GLYSANTIN® FC G20.

For more details, refer to the document "Material Safety Data Sheets".

During normal operation there should be no leakage of coolant. If a leakage is noted, Manufacturer must be informed.

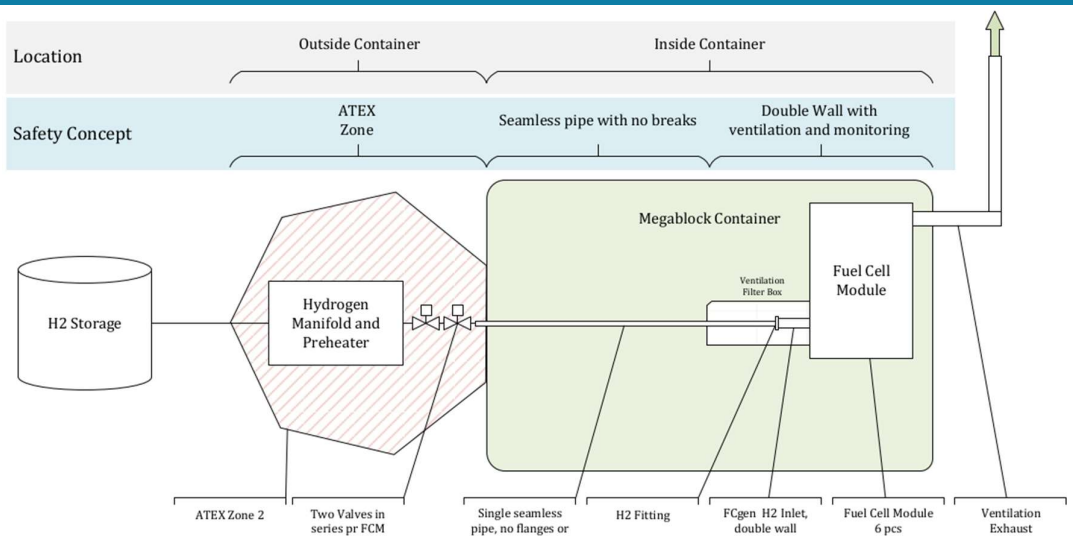
General rules are:

- Avoid contact with eyes and skin.
- Use protective gloves and tightly sealed googles.
- Avoid ingestion and inhalation of vapors.
- Spillage – do not allow to enter sewers/surface or ground water, absorb with a liquid–binding material, dilute with water.
- Disposal must be made according to official regulations.

4.7 Explosion safety

The hydrogen safety philosophy has several safety concepts, as indicated in Figure 2.

Figure 2: Hydrogen flow overview



Illustrative overview of hydrogen flow. See Hydrogen Safety Concept for more details.

Hydrogen is delivered to the hydrogen interface from a local hydrogen storage.

The area in which the interface, the hydrogen-manifold and -preheater, and hydrogen safety valves resides, is classified as an ATEX Zone 2. A hazardous mixture will not likely be present in normal operating conditions, and if so, only for a short period at a time. Electrical equipment in this zone is and shall conform to regulations and have the "EX" marking or similar. Detailed drawing of the hazard zone can be found in the General Arrangement. For more information regarding equipment installed in the zone, refer to the Equipment hazardous area certificate and schedule

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Respect the zone indicated, do not introduce any source of ignition.

There is no risk of hydrogen leakages inside the general space of the FC PowerGen Fuel Cell Container that can create an explosive atmosphere, due to the design of the feed pipes being seamless, one-piece-bends from outside of the container, routed through the container space, and connected the applicable Fuel Cell module.

The connection to a Fuel Cell Module (The H2 Fitting) is encapsulated within an extension of the Fuel Cell Modules Hydrogen Enclosure called the "Ventilation filter box", thus utilizing dilution and removal of any potential hydrogen with mechanical ventilation. Should leakages from this connection occur, the hydrogen detectors within the Fuel Cell Module will detect it and trigger a safe shutdown of that module and hydrogen supply.

The Ventilation system of the Fuel Cell Container creates a slight over-pressure to counteract ingress from particles and gas. As an additional precaution in case of hydrogen entering, the general space inside is equipped with hydrogen sensors. The position of these will detect any hydrogen entering or exiting the container through the ventilation system.

All safety-related triggers of the solution will shut off the hydrogen supply of either the affected system or the entire system.

4.7.1 Trace amount of H2

The process exhaust contains all biproducts from the fuel-cell stacks within the Fuel Cell Modules. The exhaust is a mixture of high-humidity, low-oxygen process air with trace amounts of hydrogen. The concentration of hydrogen will always be below 1%v, i.e. 25% of Lower Explosive Level (LEL), leading to a non-hazardous zone.

The source of the media in the Process Water Drain stems from the process exhaust. Thereby are also here found trace amount hydrogen which also are under 25% of LEL, leading to a non-hazardous zone. A hydrogen separator is fitted upstream to the process water drain and the trace amount of hydrogen are led through an exhaust to above the containers.

4.7.2 Working in the EX Zone

Personnel working in the EX-zone needs knowledge and skills as required by IEC 60079-14 and be approved as Operatives or Technicians on the EX-installation.



The defined EX zone is classified as Zone 2.

Only approved personnel are allowed to work in the ATEX Zone.



When working on systems containing hydrogen, refer to the correct procedures for Lock-out-tag-out. See Lockout Tagout document.

4.8 Fire safety

The Fuel Cell Modules have internal fire detection in the form of smoke detectors and linear heat detectors. If a Fuel Cell module detects fire, it will automatically perform a safe shutdown of itself and indicate an alarm.

If Smoke is detected inside the general space of the Fuel Cell Container or Converter Container, the entire system will perform a safe shutdown and indicate an alarm.

Should a fire occur, exit through the provided emergency exits.

There is no fire fighting equipment provided with the system.

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4.9 Electrical safety



The electrical system of the solution is designed in accordance with electrical and fuel cell codes to minimize electrical hazards. Electrical hazards may occur when the design is significantly compromised, typically through alteration, improper maintenance, or wear.

Dimensioning of cables and safety-equipment on the supplying and receiving end of electrical connections outside the solution must be done according to local legislation.

Select cabling and safety-equipment to the system that appropriately suits the application. Ensure to meet specifications of voltage, current, environmental temperature limits, chemical and mechanical resistance, and flexure requirements of the application. Avoid hazardous and unsafe situations that could result from condition such as, but not limited to:

- Improper grounding
- Handling electrical leads or devices with wet hands or on wet ground
- Frayed electrical leads
- Incorrect or improper connection of the terminal leads
- Short circuits
- Back-feed from energized normal and emergency power sources

Shutting down the solution during active Service and Maintenance may be necessary. Voltages may remain in the solution for a length of time. No activities are to be performed during this time as it presents a shock hazard.

Certain circumstances can lead to voltage persisting on the electrical systems. Always check for residual voltage before any activities. In some cases, it may require removal of hydrogen in the FCwave.

4.9.1 High DC Voltage Isolation Failures

Under normal circumstances, all high DC voltages are isolated from ground and the resistance is monitored. If isolation is lost on one high-voltage pole, a person working on the electrical system can sustain a fatal current-flow by touching the other voltage-pole and ground.

If two simultaneous faults occur and isolation is lost on both voltage-poles, a high voltage short circuit can occur resulting in extremely high currents/flash arcs. High currents can generate a large amount of heat which can subsequently damage electrical equipment and cause bodily harm.

Components inside the solution affects the resistance to ground, resulting in lower resistance over time.

Above-mentioned hazards are mitigated by the safety system of the solution. It actively monitors the resistance, warning if anything is to be reacted on, or shutting down the entire system in case of sustained resistance-drop or fault. Maintenance on the resistance-lowering-over-time-, and the monitoring-device(s) are crucial for the electrical safety of the system.

⚠ ELECTRICAL HAZARD	
	**If an isolation failure is detected and located in the MODULE, do not operate the fuel cell module until the root cause is determined and remedied.**

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4.9.2 Batteries

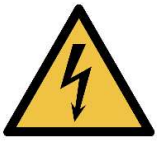


Batteries resides inside the system. Use applicable LOTO when working on system to avoid electrical hazards.

4.9.3 Converter Container access



The internals of the Converter Container are designed as an electrical cabinet (IP00), meaning that current-carrying conductors and terminals are exposed.

⚠ ELECTRICAL HAZARD	
	**HIGH VOLTAGE – 6.6 kV** **Danger of electrocution** **Authorized personnel only** **Keep clear and follow safety protocols** **Proper PPE required** **Failure to comply may result in serious injury or death**

Access is prohibited during operation. Opening the container doors activates the safety system, triggering emergency stop of the entire system. Residual voltages remain in certain components.

Entering this container requires prober de-energization and lockout tagout. Wait at least 10 minutes after de-energization before entering, and measure for residual voltages (<20VDC is safe).

4.10 Lock-out-tag-out (LOTO)

Ensure to use proper work-etiquette regarding LOTO on energy-containing systems, such as electrical supply, hydrogen, and batteries, when working on the system.

See Lockout Tagout document for procedures.

4.11 Heavy equipment

Some service and maintenance procedures require lifting of heavy equipment, such as an air-intake fan, top-module of an FCwave™, or an HT coolant pump motor.

Use of the monorail inside the fuel cell container, chain hoists, or forklifts are required, and safety precautions regarding these apply.

The Working Load Limit (WLL) of the monorail inside the Fuel Cell Container is 750kg.

4.12 Environmental conditions

Activities during rainy/snowy conditions should be avoided. If activities are performed during these conditions, the technician is responsible for ensuring that rain etc. does not enter the containers and electrical cabinets.

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Process exhaust contains water. During freezing conditions, snow and icicles may form.

Wear safety helmets under these conditions.

5.0 HMI - Service Interface

The system has a password-protected Service Interface, only accessible for authorized technicians.

The Service Interface can be accessed in three different ways:

1. Locally through the HMI touch screen located inside the Fuel Cell Container,
2. Locally with the use of a PC and a wired ethernet connection, to the secure internal network of the system, or
3. Remote access through the Secure Remote Access gateway.



Only trained and authorized personnel may access and use the Service Interface



Unauthorized accessing and usage of the Service Interface without proper training may result in serious injury

A default display showing main operating status is displayed when not in use as service interface.

6.0 Preparation for Maintenance

Technicians must examine the need for de-energization through means which is not within the scope of the system. Processes for de-energization of these shall be provided by whomever responsible.
Examples:

- Grid-connection switch-disconnector at customer end.
- Safety and/or isolation valve for Hydrogen supply.

Each service and maintenance tasks within the system may require varying de-energization of different sub-systems. User proper LOTO procedures as defined in the Lockout Tagout document.

An FCwave™ is placed in a "service state" prior to any de-energization of the hydrogen supply.

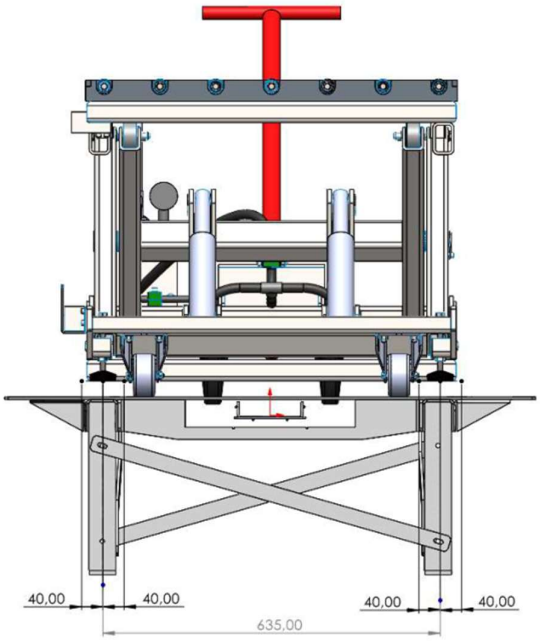
Service technicians must refer to the documents P&IDs, Electrical Single Line Diagram, and Electrical Cabinet Documentation for technical details of the system.

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6.1 FCwave™ Top-swap service tool

In order to perform a top-swap on an FCwave™, the service technician must use the applicable Service Cart Tool and follow the limits-of-use described below.

Figure 3: Placement of FCwave™ Service Cart Tool



Applicable service tool part number: 7000512

The flooring is designed only to temporarily carry the weight of the cart and top-module in a static state, transferring the weight to the legs of the floor through the leveling foots.

Ensure that the placement is correct (±40mm) – failing to do so will deform the flooring and may create a potential hazard for personnel.

The Service Cart Tool it is NOT intended to be moved on the wheels while carrying the top part of an FCwave™

To move a top-module of an FCwave™ inside the container, use an applicable hoist, mounted in the monorail.

For more details on the flooring, refer to the document Structural calculations - false floor.

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7.0 Preventative Maintenance - Fuel Cell Container

Figure 4: Fuel Cell Container – External overview



1: Main access door	4: HT drain valves
2: Service door	5: Hydrogen Heater
3: Air intakes	6: Hydrogen Interface

7.1 General External

7.1.1 Cleaning

The outside of the container may be cleaned using water and a nonabrasive cleaning agent.

Do not use high pressure cleaning.

During cleaning of Air intakes, the corresponding damper must manually be placed in closed position and disconnected. Reset to automatic after cleaning. The dampers can be actuated from the service interface.

7.1.2 Air dampers

The ventilation dampers must be able to operate unobstructed. Any material block or damage to damper blades must be corrected without unnecessary delay.

7.1.3 HT coolant drains

The HT coolant-drain valves at the bottom of the HT main pipes connecting the HT loop of the container to the HT cooling platform must be closed.

In case of leakage, immediately correct and check level of coolant.

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7.1.4 Access areas

The areas in front of the main door, the service door, and the cooling platform service area should be kept clean and free from obstacles.

7.1.5 Process water drain

The process water drain is directed to a designated drainage system of the local site.

It should be checked at every maintenance period that the drain is unobstructed.

The process drain is equipped with an exhaust and a heat trace that protects the drain against freezing. Inspection is performed according to the Maintenance Plan.

Process water is DI water and is not suitable as drinking water.

7.1.6 Process-, ventilation, and drain exhausts.

Each FCwave unit has a set of exhausts: process air and ventilation.

The drain has an exhaust.

It should be checked at every maintenance period that the exhausts are unobstructed.

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7.2 EX-zone

De-energization of electrical components for maintenance must be done, ensuring that no ignition source ever exists in the EX-zone.

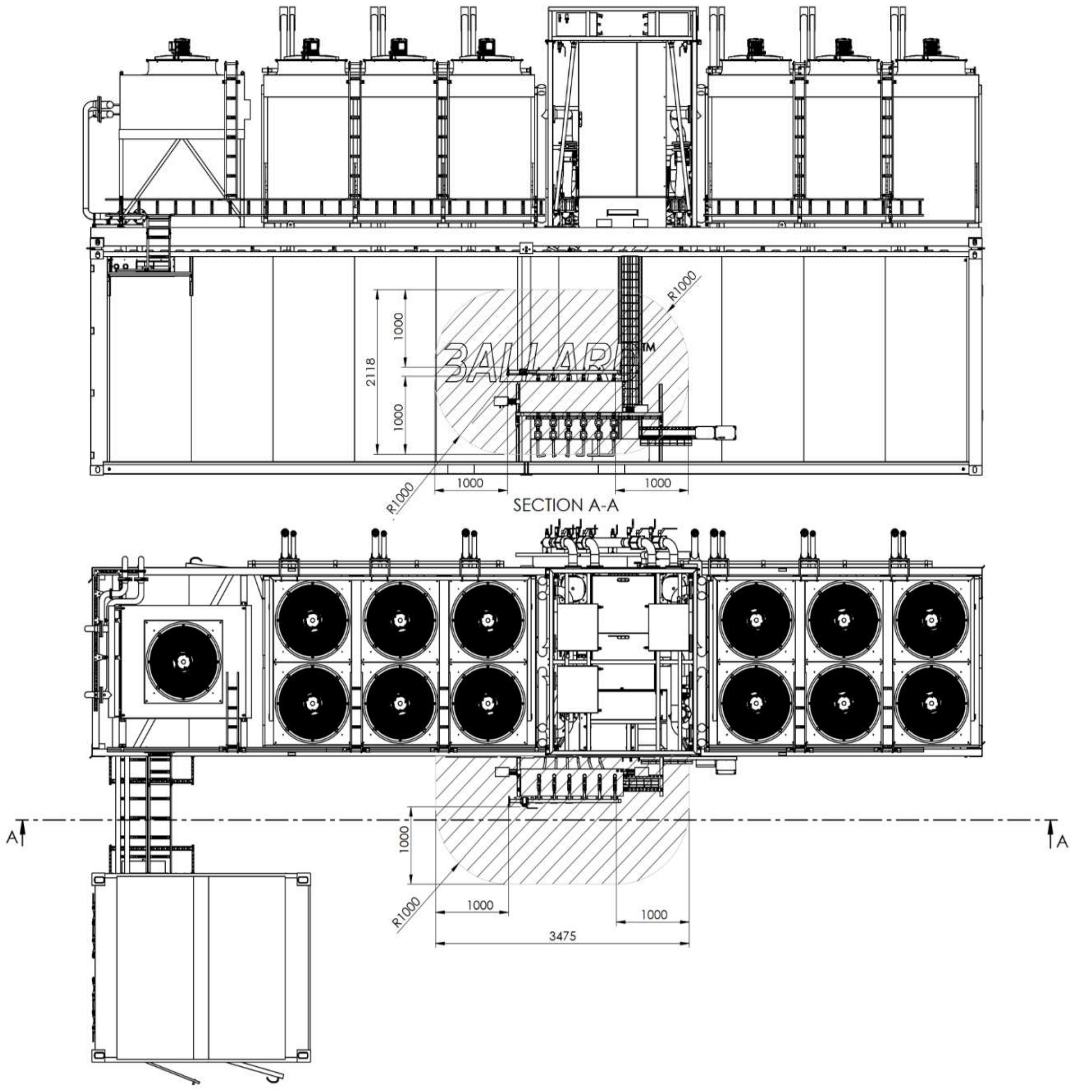


The defined EX zone is classified as Zone 2.

Only approved personnel are allowed to work in the ATEX Zone.



Figure 5: EZ-zone illustration



For detailed version, refer to the General Arrangement

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7.2.1 Hydrogen heater

During low ambient temperature, the hydrogen is heated to the hydrogen heater. The heater is filled with coolant and are heated using electrical heating elements.

The surface of the heater may reach up to 45°C.



If the Hydrogen Heater has run recently, wait for it to cool down before touching it and components mounted.

The following components of the Hydrogen Heater have no defined service/maintenance tasks defined by their documentation.

- Pressure sensor
- Temperature sensor
- Cables to sensors
- Cables to heating elements
- Cable glands on JEVI D-8640 heating elements
- Cable glands on Solenoid Shut-off valve (H2)
- Sensor EX barrier
- General Hy-lok fittings

  It is recommended that visual inspection on above-mentioned components is done.

7.2.1.1 Hydrogen Heater cooling media

The coolant level is monitored. In case of low level, it must be topped up.

The Hydrogen heater must have the coolant freeze-protection checked with the use of a refractometer regularly and changed as needed.

Coolant is 50/50% mixture of demineralized water and Proviflow Neo, which is an Ethylene-glycol based. Can be purchased as pre-mixed.

Criteria: minimum freezing point of -30°C

7.2.1.2 Level sensor – IFM LMT01A

Refer to Manufacturers (IFM) Operating Instructions – section 9.

- De-energize supply
- Check sensor tip for deposits and damage. Clean if badly soiled. In case of damage, replace the unit – the unit cannot be repaired.
- When reinstalling, carefully clean the probe neck and the installation slot, especially the sealing surface, with appropriate methods to ensure that the unit is resistant to ingress and without dead space.
- Re-energize supply.

7.2.1.3 Heating element - JEVI D-8640

Refer to Manufacturer's (JEVI) Installation, Operation and maintenance instructions, section 4.0

Maintenance free, however after 1 year of operation:

- De-energize supply (=LA01+UC30-FC41…42)
- Check the thermostat for damage

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- Check connections inside junction box
- verify correct connections and re-assemble
- Re-energize supply

If no heating is done when needed, check and press the manual reset button.

7.2.2 H2 Solenoid Shut-off valve – Emerson ACSO

Check for excessive wear – leakage tests

- Externally

  Potential leakage areas: Pipe connections (Hy-lok) and valve stem.

  Hy-lok connections have low probability of leakage. If leakage occur, refer to components manual for replacement.

  If leakage from valve stem, rebuild with manufacturer kit or replace component.
- Inline

  If inline leakage occurs, rebuild with manufacturer kit or replace component.

Leakage test:

- Close valve(s) on designated H2 line
- Lower pressure downstream
- Monitor pressure downstream for a set period
- Search for external leakages with applicable outdoor-use leakage detector.

7.2.3 Manual isolation valve – Hy-lok 110 Ball Valve

Refer to Manufacturers (Hy-lok) Instruction manual for maintenance.

Leakage test – Stem:

In case of stem leakage, tighten the Flange Nut. If the leakage remains after tightening, check damage to the stem, outer package and inner package. Replace parts or component(s) as needed,

Leakage test – Inline:

If the leakage happens inside the valve, ensure whether the valve is in fully closed condition. If the reason of leakage is seat damage, replace the seat or the component.

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7.3 Access



Access is restricted to authorized personnel only

7.3.1 Main access door

The door on the container side is the main entrance to the interior of the Fuel Cell Container. The door is locked and should only be unlocked by authorized personnel during service.

It is possible to unlock the door and enter the container while it is in full or partial operation.

In this case the door may not be kept open for a longer period, as this will affect the internal ventilation system. **Note**: The ventilation creates a slight overpressure inside the container.

Generally, the door should be closed to keep a clean environment inside the container.

7.3.2 Service door

The service door at the end of the container is intended for special service cases and should otherwise be kept closed.

The door can in any case be opened from inside and functions as an emergency exit.



Service personnel must unlock this service door when any activities are performed inside the container, to enable any first responders to gain access if needed.

7.3.3 Container doors

The standard container doors are not intended for use and should always be locked.

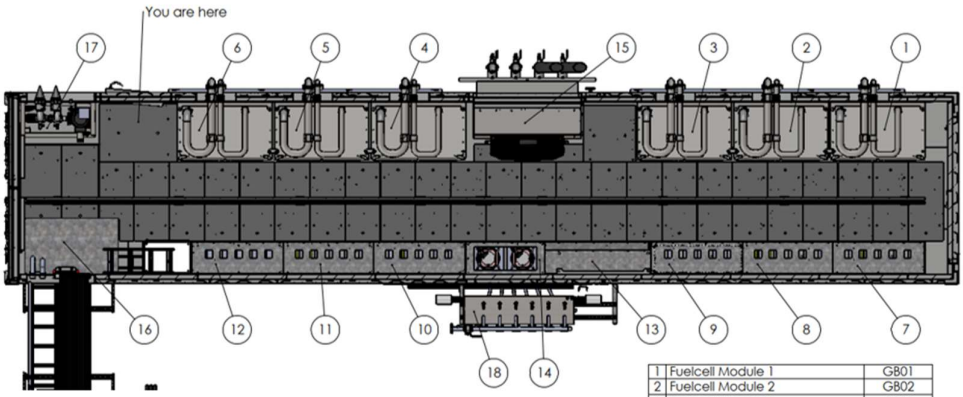


Before leaving the site check that all doors are safely locked.

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7.4 Internal

Figure 6: Fuel Cell Container - Internal overview



1	Fuelcell Module 1	GB01
2	Fuelcell Module 2	GB02
3	Fuelcell Module 3	GB03
4	Fuelcell Module 4	GB04
5	Fuelcell Module 5	GB05
6	Fuelcell Module 6	GB06
7	Fuelcell DC/DC Cabinet 1	UC01
8	Fuelcell DC/DC Cabinet 2	UC02
9	Fuelcell DC/DC Cabinet 3	UC03
10	Fuelcell DC/DC Cabinet 4	UC04
11	Fuelcell DC/DC Cabinet 5	UC05
12	Fuelcell DC/DC Cabinet 6	UC06
13	Controle Cabinet	UC20
14	Internal Container Ventilation	UC07
15	Container Ventilation	
16	AUX Transformer	TA03
17	LT Pump Rack	GP11
18	H2 Heater	EB01

Indicative illustration of the internals of the Fuel Cell Container

7.4.1 General

The interior should be kept clean and walking space unobstructed.

The floor plates are secured by screws and should always be secured unless service is in progress.

When working in the area below the floor, it is recommended to use gloves.



When the system is in operation use hearing protection.

If the system is locked to prevent starting, having hearing protection available is only recommended.



When working in the container, make sure that there is free access to an emergency exit door, and unlock the doors to allow for rescue personnel to enter the container through the emergency doors.



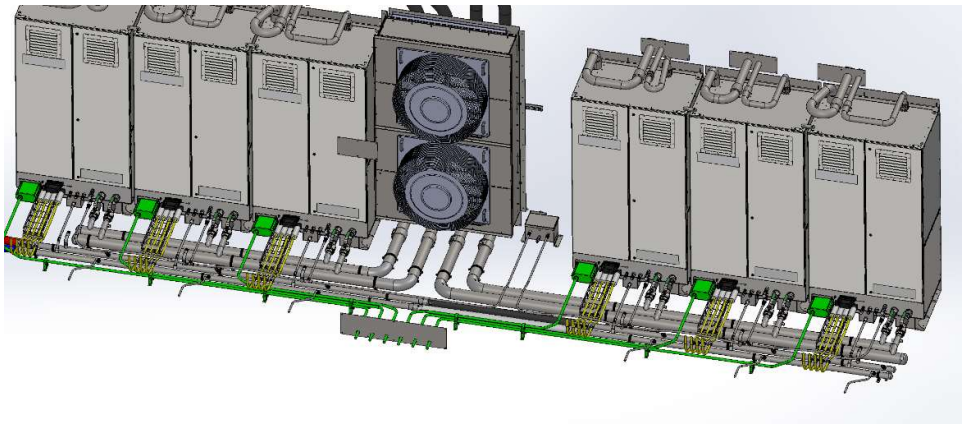
The container interior is equipped with overhead light sources. Use additional light where appropriate to avoid errors.

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7.4.2 Hydrogen piping

The hydrogen-piping runs as seamless feed pipes from the outside of the container and into Ventilation Filter Box where it is connected to the Fuel cell module.

Figure 7: Hydrogen piping



The interior hydrogen supply system is located below the floor.

Refer to P&IDs document for more details.

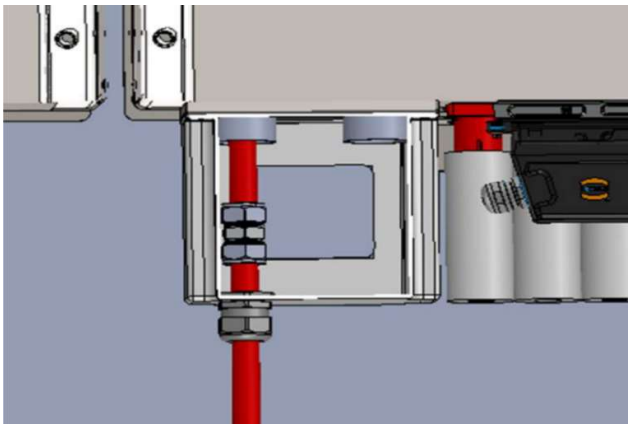
Special procedure must be followed to purge hydrogen in the piping downstream from isolation valve

7.4.3 Fuel cell hydrogen connection (ventilation filter box)

The ventilation filter box ensures that the supply-connection is well ventilated during normal operation, ensuring dilution and removal of any, highly unlikely, hydrogen leakage.

These connections must be checked with a hydrogen sniffer, and the filter of the ventilation filter box changed as defined by the Maintenance Plan.

Figure 8: Ventilation filter box



Top-view cut-off illustration of ventilation filter box. The filter is fitted to the bottom opening.

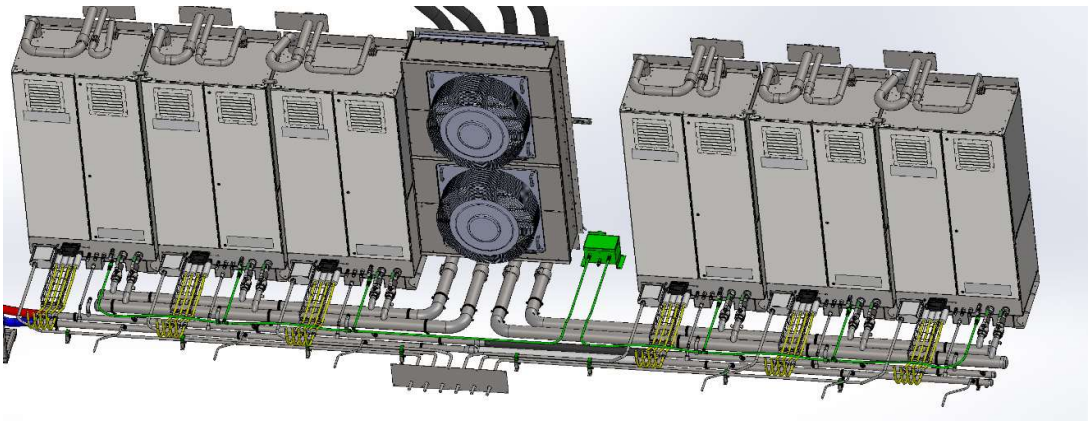
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7.4.4 Fuel cell process water drain

The fuel cell process water drain system collects process water from the Fuel Cell Modules (DI-water from the chemical reaction). This is led to a separator tank where gaseous matter is separated from the media. The gaseous matter is led to an exhaust, and the liquid matter are led to the exterior drain described in section 7.1.5.

Refer to P&IDs document for more details.

Figure 9: Process water drain system



Indicative illustration of piping and tank – layout/design my vary.

The separator tank is placed below the floor next to the main air-intake.

A heater wire is mounted to the exhaust and drain interface, ensuring that the water does not freeze. Inspect this system as defined by the Maintenance Plan.

7.4.5 Fuel cells

The service scheme for the FCwave is not covered in this document. Prior to service activity on the FCwave, the person must complete Ballard training relevant for the service planned. Service and safety instructions will be made available as part of the training.

Access to the interior of the FCwave units is only permitted for authorized personnel - see 2.3.2

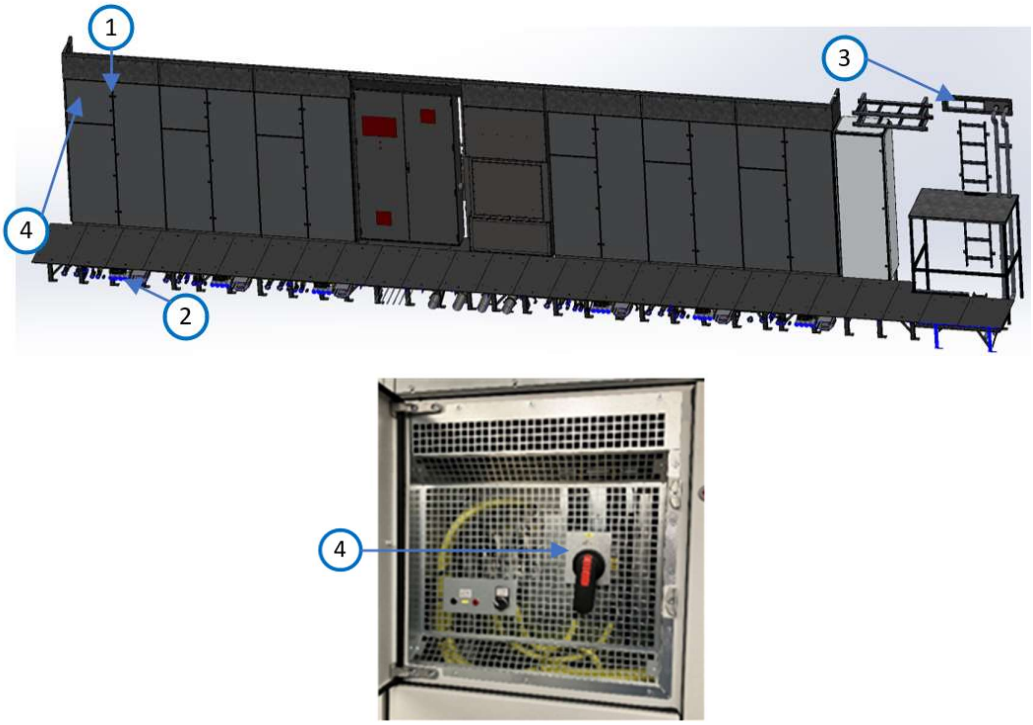
For details on service and maintenance tasks, refer to FCwave – Service and Maintenance Manual and the attached Maintenance plan for the FCwave.

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7.4.6 Electrical DC system

The power system is based on 750 VDC.
Special safety procedures must be followed when working on the system.
Do not open DC cabinets without following proper procedure

Figure 10: DC system



1: DC cabinet (1 of 6)
2: DC fuel cell cable
3: DC out to Converter Container
4: DC cabinet breaker

Each DC cabinet is equipped with a breaker behind the top left door. The breaker is used to isolate the cabinet and corresponding Fuel Cell Module from the DC link.

Proper procedure must be followed when dis- and re-connecting a DC cabinet, failure to do so may result in damage or injury.

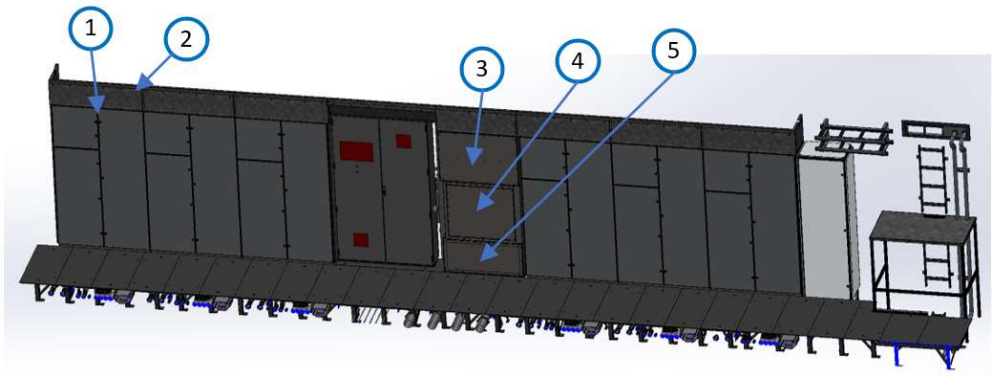
A yearly inspection of each DC cabinet must be done, including checking for leakages of coolant and a thermographic inspection of electrical components and connections.

Any time access to DC areas is made, ensure cleanliness.

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7.4.7 Internal ventilation

Figure 11: Internal ventilation



1: DC/DC cabinet 2: Ventilation/DC-cable duct	3: Ventilation fan box 4: Heating element box 5: Ventilation outlet

The internal ventilation system is removing heat from the power electronics and adding room heating in case of low temperature.

The circulation fan is placed in the central unit (3) together with a heater (4). It pulls air from below the floor, through the DC cabinets (1). Heated air exits at the outlet by the floor (5).

Each of the cabinets that the air is pulled through has a manual air-restrictor in the top, which is mounted in a fixed position, equalizing the flow through all ventilated cabinets. The settings of these are not to be changed.

There are no filters in the system.

Refer to P&IDs document for more details.



Do not open the ventilation duct unless the entire system is shut down and deenergized.

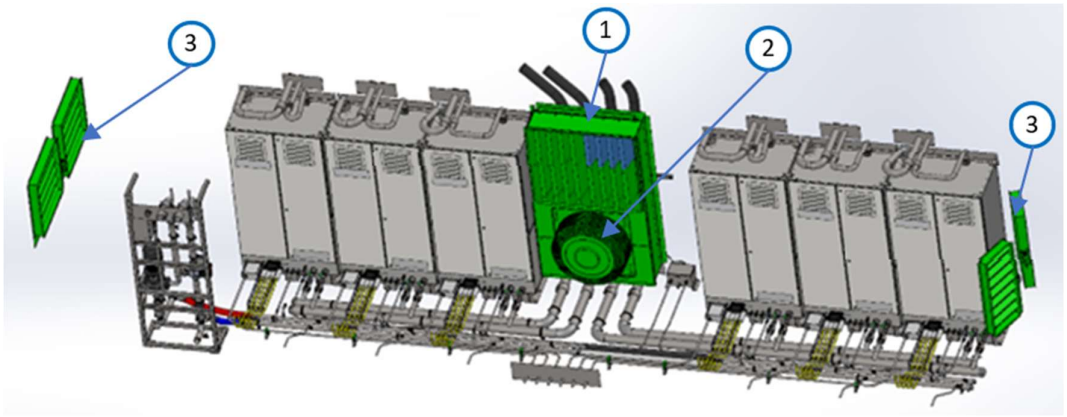
The DC cables are inside the conduit and there is access to the DC cabinets from the duct.

The heating element box must be cleaned and undergo a thermographic inspection of electrical power connections.

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7.4.8 External ventilation

Figure 12: Indicative illustration of external ventilation



1: Inlet filters
2: Main intake fans
3: Ventilation outlet with damper
Layout may vary

The external ventilation system is dual functioning, using external air to remove heat from the inside and providing air for the fuel cell process. Air flow is based on multiple parameters and controlled by fan speed and damper position.

The external ventilation is made to ensure a clean environment inside the container by filtering all incoming air and maintaining a slight overpressure inside the container.

Refer to P&IDs for more details.

Opening the doors of the container disturbs the air balance in the container. When doors are open, the fans will run in a locked base, unregulated setting – do not leave doors open unnecessarily.

The pressure-drop across the main filters is monitored to ensure proper function. The main filters replacement schedule is defined by the Maintenance Plan.

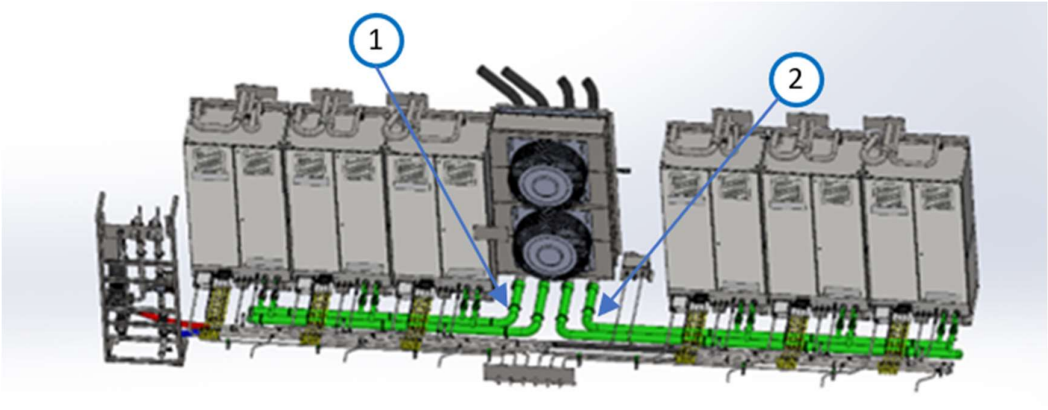
The service schedule for the fans of the intake is defined by the Maintenance Plan.

The dampers should be able to operate unobstructed. Any material block or damage to damper blades must be corrected without delay.

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7.4.9 HT Cooling systems

Figure 13: Indicative illustration of HT cooling system



1: HT cooling manifold FC 4, 5 & 6
2: HT cooling manifold FC 1, 2 & 3
Layout may vary

The 2 HT cooling systems are cooling the fuel cell stacks for FC1,2,3 and FC4,5,6 respectively, at approximately 60°C.

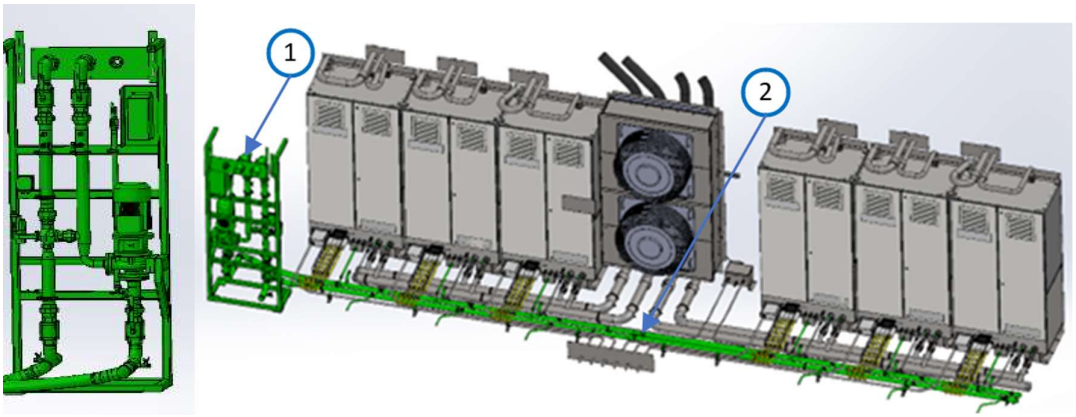
Details of the cooling media can be found in the document Material Safety Data Sheets.

There are no serviceable parts of the HT cooling system inside the container, but a visual inspection for leakages must be conducted.

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7.4.10 LT Cooling systems

Figure 14: Indicative illustration of LT cooling system



1: LT cooling pump rack
2: LT cooling manifold
Layout may vary

The LT cooling systems provides cooling for power electronics at approximately 45°C.
Refer to P&IDs and document for more details.
Details of the cooling media can be found in the document Material Safety Data Sheets.
The LT pump must be serviced as defined by the Maintenance Plan.
The LT Coolant strainer must be inspected and cleaned as defined by the Maintenance Plan.
Testing of the quality of the freeze-protection in the coolant.

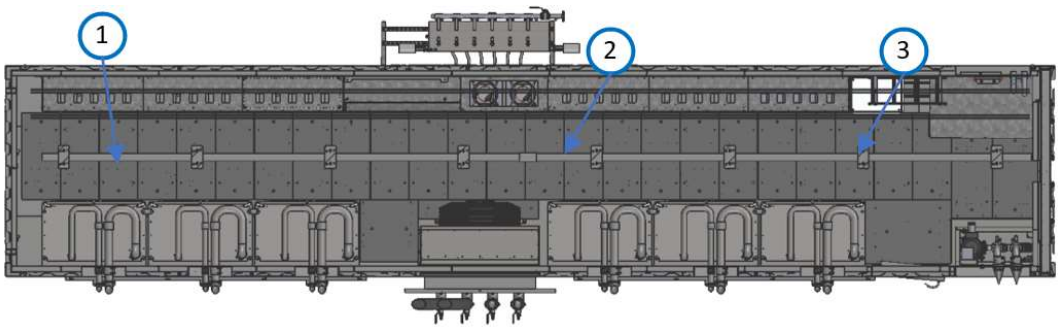
7.4.11 UPS

The container houses several 24VDC UPS modules. These are located under the floor.
The functionality of these, and the battery health must be checked.

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7.4.12 Container safety system

Figure 15: Safety sensors location



1, 2 and 3: H2 sensor & smoke detector

The container interior is equipped with 3 sets of safety sensors, each consisting of an H2 sensor and a smoke detector.

The sensors are integrated in the container safety system together with the FCwave safety signals, emergency stop, and electrical safety.

Figure 16: Safety sensors



H2 detection and smoke detection

The function of the sensors is tested as defined by the Maintenance Plan.

The H2 sensor must be calibrated as defined and change of sensor must be done because of degradation.

Functionality test on the emergency stops internally and externally to the system must be conducted.

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8.0 Preventative Maintenance – Converter Container

Figure 17: Converter Container – external overview



1: Access door	4: Air exhaust
2: Main breaker access door	5: Grid Interface
3: Control cabinet access door	6: Air Intake

The Converter Container has the main output power electronics and transformer inside. The interior is not a workplace, and it should only be accessed as needed for specific services.

8.1 External

8.1.1 Cleaning

The outside of the container may be cleaned using water and a nonabrasive cleaning agent.

Do not use high pressure cleaning.

During cleaning of Air intakes, the corresponding damper must manually be places in closed position and disconnected. Reset to automatic after cleaning. The dampers can be actuated from the service interface.

8.1.2 Air dampers

The ventilation dampers must be able to operate unobstructed. Any material block or damage to damper blades must be corrected without unnecessary delay.

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8.2 Access

The service door at the end of the container is intended for special service cases and should otherwise be kept closed.



Access to the internals is for authorized personnel only.
Never force entry.



Proper procedures for lock-out-tag-out must be performed, prior to entering.
See Lockout Tagout document.



Before leaving the site check that all doors are safely locked.

8.3 Internal

8.3.1 General

The interior should be kept clean and walking space unobstructed.



The UPS actively supply power to the control cabinet when the AC supply is disconnected.



Never work inside the container without a colleague.

Only firefighters should open the doors in case of fire.

8.4 Ventilation

The ventilation is made to ensure proper temperature and a clean environment inside the container by filtering all incoming air and maintaining a slight overpressure inside the container.

The pressure-drop across the main filters is monitored to ensure proper function. The main filters replacement schedule is defined by the Maintenance Plan.

The service schedule for the fans of the intake is defined by the Maintenance Plan.

The dampers should be able to operate unobstructed. Any material block or damage to damper blades must be corrected without delay.

The heating elements of the container heater must be inspected and cleaned.

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8.5 Power components

The internal DC bus is supplied by the incoming DC from the Fuel Cell Container.

The power from the Fuel Cell Container is converted to 400 V AC and connects to the Main breaker (grid connection). Components include DCAC converter with filter, transformer 400VAC to 6,6 kVAC, main breaker and connecting busbars.

Thermographic inspection of power electronics, connections, and applicable cabinets must be performed.

8.6 LT Cooling

The LT cooling system provides cooling of power electronics at approximately 45°C.

Refer to P&IDs and Material Safety Data Sheets document for more details.

The connections of the LT cooling system must be inspected for leakages.

8.7 UPS

The container houses several 24VDC UPS modules. The functionality of these, and the battery health must be checked.

8.8 Container safety sensors

Figure 18: Sensors



Smoke detector & temperature sensor

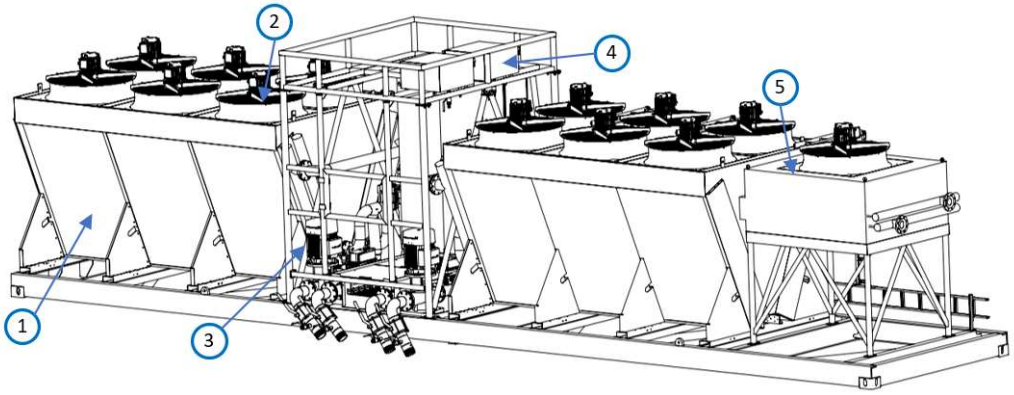
The container interior is monitored for smoke, has a safe-lock and door safety switches, one on each container door pair.

The sensors are integrated in the container safety system.

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9.0 Preventative Maintenance - Cooling Platform

Figure 19: Cooling platform - Overview



1: HT Cooler 2: Cooler fan 3: HT pump	4: Header Tank 5: LT Cooler

The Cooler platform has 2 individual HT cooling systems and the cooler for the LT Cooling system.

The HT Cooling systems are identical, each with a dry cooler, header tank, pump, valves, and sensors.

Each of the three cooling system is designed to allow for operation up to external temperature of 45°C. The systems are without active cooling, and it is therefore important that the coolers are kept in good operating condition.

There must be regular inspection of coolers at each service visit. The coolers must be kept clean and free from material blocking the airflow.

There is minimum a yearly cleaning and inspection of the coolers.

Cleaning of coolers, access to fans etc. may require using a ladder, lift, scaffolding or similar - Availability is customer responsibility, or as agreed upon.

Rules for working in height and fall arrest equipment applies.

Pumps, sensors, and valves can generally be serviced from the work platform. The platform is designed to be reachable by ladder and has a safety cave. Working inside the cave with the gate closed can be done without fall arrest equipment.

The HT pumps must be visually checked for leakages and serviced as defined by the Maintenance Plan.

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The cooling system contains Glycol.
See Material Safety Data Sheets for details.
Avoid spillage, use gloves and eye protection.

The coolant levels are monitored by level switches in the header tanks. In case of low coolant level, it must be topped up. The function of the level switches must be verified, defined by the Maintenance Plan.

The coolant must be checked yearly to secure proper freezing protection.

If for service or other reasons one of the cooling systems must be emptied and refilled, procedure must be followed, ensuring that the system is de-aeriated.

The Control Cabinet of the Cooling platform contains a UPS that must be tested as defined by the Maintenance Plan.

Fans on the coolers must be visually inspected and cleaned.

HT Fan Drive Cabinet Chiller shall have checked/cleaned/replaced the air-intake filter, cleaned the condensate drain trap and recharged refrigerant as needed.

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10.0 Troubleshooting

The system allows for remote monitoring where warnings and alarms are available. The following troubleshooting processes should be done by trained personnel. Refer to Cause and Effects Chart.

10.1 Safety system

Safety trip on an FCwave, Hydrogen safety valve override, Power converter Safe Torque Off (STO) or motor drive STO:

- Check internal and integrator-provided emergency stop buttons
- Check for hydrogen detection
- Check for fire detection

10.2 Hydrogen

If the hydrogen valves by the hydrogen heater are unexpectedly closed:

- Check internal emergency stop buttons
- Check for hydrogen detection
- Check for fire detection
- Check for DCAC Converter trip
- Check for LT Cooling system loss
- Check for ventilation failure
- Check the process water drain for blockage
- Check for communication failure to integrator
- Check for hydrogen supply and signal

10.3 FCwave

Single module has stopped:

- Check for FCwave internal alarm
- Check for applicable DCDC's trip

Multiple modules have stopped:

- Check for HT Cooling system loss

All modules have stopped:

- Check for DCAC converter trip
- Check for LT Cooling system loss
- Check for ventilation failure
- Check the process water drain for blockage
- Check for communication failure to integrator
- Check for hydrogen supply and signal

Single module Derate:

- Check for FCwave internal warnings

Multiple modules Derate:

- Check for HT cooling system loss

All modules Derate:

- Check for LT Cooling system loss
- Check for Ventilation Derate

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10.4 Power converters

Power converter derates:

- Check LT Cooling system Derate
- Check ventilation derate (Some power converters are air-cooled)

Power converter stop:

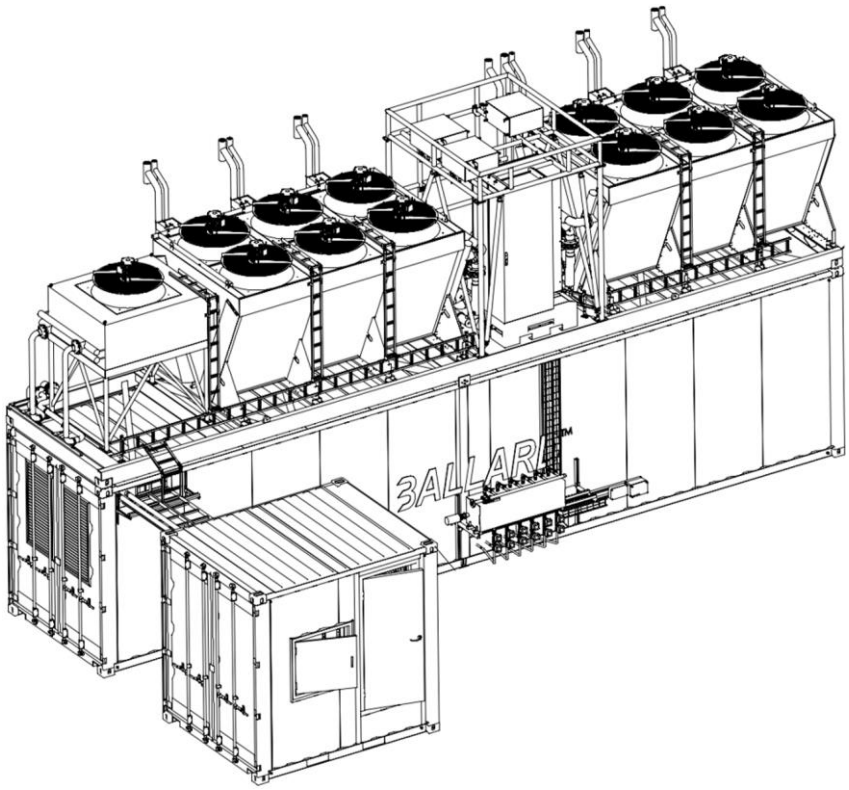
- Check DCDC converter trip
- Check DCAC converter trip
- Check for LT Cooling system loss
- Check ventilation derate (Some power converters are air-cooled)
- Check for communication failure to integrator

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FC PowerGen 1000kW

Part no.:	601456B-7002362
Configuration:	40ft Fuel Cell Container w. 6 FCwave's 10ft Converter Container, 6,6 kVAC

Maintenance Plan



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1.0 Fuel Cell Container

Table 1-1: Fuel Cell Container – Preventive Maintenance schedule

Task	Usage-based[1] Hours	Time-based Months/years	Comment
General			
Cleaning	Each visit	6 mths	Ensure that the container is clean and that the walk-area inside and outside is clear of obstacles
Hydrogen			
Check Hydrogen piping		1 yr	Sniffer-test for leakages (FCM interface, hydrogen Interface, hydrogen heater)
Check Hydrogen Heater coolant level and level sensor		6 mths	Functionally test of level senor, check coolant level, add if necessary
Test Hydrogen Heater coolant quality		1 yr	Check Freeze protection quality with refractometer
Check Hydrogen Heater heating elements		1 yr	Functionality check of Hydrogen heater
Leakage test – H2 Solenoid shut-off valve		1 yr	External/inline testing.
Leakage test – Manual isolation valve		1 yr	External/inline testing.
Process Drain			
Check Process drain heat trace		6 mths	Check functionality with thermography
Check Process drain catch-tank level switch		1 yr	Functionality check of Level switch
Cooling			
Check HT cooling system		6 mths	Visual check for leakages
Check LT cooling system		6 mths	Visual check for leakages
Check LT coolant strainer		6 mths	Visual check for cleanliness. Clean if dirty
LT Coolant pump and motor		6 mths	Visual check for leakages. Clean if dirty.
Test LT Coolant quality		1 yr	Check Freeze protection quality with refractometer
Ventilation			
Check ventilation dampers (Louvres)	Each visit	6 mths	Functionality check. Obstruction and/or damage must be corrected. Clean if dirty
Check container heater cleanliness		1 yr	Clean if dirty
Check container Air-intake-fan		6 mths	Visual inspection for damage, dust, and grime
Change container Air-intake filter		6 mths	Replace
Change Ventilation Filter Box (Fuel Cell Module)		6 mths	Replace
Electrical			

[1] Service interval, whichever comes first

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Table 1-1: Fuel Cell Container – Preventive Maintenance schedule			
Thermography inspection		1 yr	Of power electronics, cabinets, and heating
Check UPS		1 yr	Functionality test and battery health
Clean DC/DC cabinets		1 yr	Clean if dirty
Safety system			
Check smoke detectors		1 yr	Functionality test
Calibrate Hydrogen sensor		1 yr	Use test-gas
Life-check Hydrogen sensor		6 mths	Check sensor vitality
Change Hydrogen sensor		TBD[2]	Replace Hydrogen sensor due to degradation
Emergency stop (internals and externals)		1 yr	Functionality test
Test RCD's		6 mths	Functionality test with applicable multimeter

[2] Depends on environmental conditions, and are a result of the sensor vitality test

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2.0 Converter Container

Table 2-1: Converter Container – Preventive Maintenance schedule

Task	Usage-based[1] Hours	Time-based Months/years	Comment
General			
Cleaning	Each visit	6 mths	Ensure that the container exterior and interior are clean, and that the walk-area inside and outside is clear of obstacles
Cooling			
Check LT cooling system		6 mths	Check for leakages
Ventilation			
Check ventilation dampers (Louvres)	Each visit	6 mths	Functionality check. Obstruction and/or damage must be corrected. Clean if dirty
Check container heater cleanliness		1 yr	Inspect. Clean if dirty
Check container Air-intake-fan		1 yr	Visual inspection for damage, dust, and grime
Change container Air-intake filter		6 mths	Replace
Electrical			
Thermographic inspection		1 yr	Of power electronics, cabinets, and heating
Check UPS		1 yr	Functionality test and battery health
Safety system			
Check smoke detectors		1 yr	Functionality test
Check Safety-lock		1 yr	Functionality test
Check Door safety switches		1 yr	Functionality test
Test RCD's		6 mths	Functionality test with applicable multimeter

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3.0 Cooling Platform

Table 3-1: Cooling Platform – Preventive Maintenance schedule

Task	Usage-based[1] Hours	Time-based Months/years	Comment
Cooling			
Check cooler cleanliness	Each visit	6 mths	Clean if dirty (Pressure wash as per cooler manual)
Check HT coolant level		6 mths	Add if necessary. If excessive amount missing, search for leakages.
Test HT Coolant quality		1 yr	Check Freeze protection quality with refractometer
Check LT coolant level		6 mths	Add if necessary. If excessive amount missing, search for leakages.
Check Header-tank(s) level switch		1 yr	Functionality check of Level switch
Check cooler fan(s)		1 yr	Visual inspection for damage, dust, and grime
Check HT coolant pump(s)		6 mths	Visual check for leakages. Clean if dirty.
Main inspection HT Coolant pump(s)	16000h	2 yr	Inspect bearing temperature, noise, cracks, alignment, bolt/screws tightness, electrical connections, winding isolation resistance, bearing condition
Check HT Fan Drive Cabinet Chiller air-intake filter		1 yr[3]	Clean with warm water from exhaust side to intake side and let et dry or replace.
Check HT Fan Drive Cabinet Chiller condensate drain trap			Clean by pouring soapy water into the face of evaporator coil. Alternatively, locate drain and blow compressed air.
Fan Drive Cabinet Chiller refrigerant recharging			Standard Discharge/recharge procedure for R134A
Electrical			
Check UPS		Yearly	Functionality test and battery health
Test RCD's		6 mths	Functionality test with applicable multimeter

[3] Depends on environmental conditions

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5.1.4 Maintenance Plan – MAN001-C

It is required to follow maintenance plan to ensure trouble-free operation during the lifetime of FCwave module.

The maintenance tasks for the FCwave module are listed in the Table 5-1. Refer to the Customer Portal (see section 1.1) for the latest revision.

Make sure that all electrical connections are disconnected before performing any maintenance activity on the FCwave module.

Maintenance Plan, FCwave 200kW	Document ID: MAN001-C			Revision: 0
	*Interval			
Task	Hours	Month(s)	References	Comments
Check coolant level indicator	250	1	Refer to section 5.4.4	Inspect the level between minimum and maximum
Check ventilation inlet flow switch	1000	3	Refer to section 5.5.4	Check if ventilation stops to function at set level alarm.
Check differential pressure safety switch	1000	3	Refer to section 5.5.6	The safety shut down system must activate in absence of negative pressure in H_2 enclosure.
Check fuel cell module BOP components	N/A	3	Refer to section 5.6.1	Coordinate this while performing other inspections or service is performed
Check external harnesses and electrical components	N/A	3	Refer to section 5.6.2	Check all external harnesses and electrical components for signs of damage or corrosion
Check for coolant leaks	1500	3	Refer to section 5.4.1	Check external coolant hoses and module for signs of coolant leaks
Check stack coolant conductivity	1500	3	Refer to section 5.4.2	Replace DI filter (resin cartridge) if conductivity exceeds specification of <5mS/cm.

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Maintenance Plan, FCwave 200kW	Document ID: MAN001-C			Revision: 0
	*Interval			
Task	Hours	Month(s)	References	Comments
		Note: Depending on the integration layout, more frequent servicing may be required. All integrators must include a working ground fault monitoring system as a part of integration, and shutdown the system if grounding resistance is too low.		
Check smoke detector functionality	1000	3	Refer to section 5.5.7	This is a mandatory service activity
Check ground fault monitor functionality	N/A	3	Refer to section 5.6.3	If used, this is a mandatory service activity
Check calibration of hydrogen sensor	1000	3	Refer to section 5.5.2	This is a mandatory service activity, record sensor readings. Replace if necessary
Check module ventilation air intake filter and fans	1000	3	Refer to section 5.7.1 and section 5.5.9	Check module ventilation air intake filter condition and fan functionality, replace if necessary
Check coolant particulate filter (Wedge wire screen)	6000	Every 1 year	Refer to section 5.4.3	Check filter (wedge wire screen) and gasket at the main module inlet. Clean and install if needed. Replace if necessary.
Check Linear heat detector functionality	N/A	6	Refer to section 5.5.1	-
Check LV Electronic circuit breaker	N/A	N/A	Refer to section 5.6.13	In case of failure or misreading in the system, it is recommended to replace
Replace Purge valve	N/A	Every 5 years	Refer to section 5.2.1	Check for durability issues and quality, replace if necessary
Replace HRB	5000	Every 1 year	Refer to section 5.2.2	Check for leak issues on shaft sealing, replace if necessary

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Maintenance Plan, FCwave 200kW	Document ID: MAN001-C			Revision: 0
	*Interval			
Task	Hours	Month(s)	References	Comments
Replace HRB spider coupling	10000	Every 2 years	Refer to section 5.2.2	Inspect for wear, replace if necessary
Replace HRB Motor bearings	20000	Every 5 years	Refer to section 5.2.2	Check for vibration levels depending on RPM of the motor
Replace Hydrogen Valve block	N/A	Every 5 years	Refer to section 5.2.3	Check for durability issues and quality, replace if necessary
Check of Safety valve in Valve block	N/A	Every 5 years	Refer to section 5.2.3	*Under construction*
Replace process air filter/mass flow meter	10000	Every 2 years	Refer to section 5.3.1	Check for durability issues and quality, replace if necessary
Replace process air valves	N/A	Every 5 years	Refer to section 5.3.2	Check for durability issues and quality, replace if necessary
Replace Humidifier (x3) unit	7000	Every 2 years	Refer to section 5.3.3	Check for durability issues membrane quality, replace if necessary
Replace Aftercooler assembly	N/A	Every 2 years	Refer to section 5.3.4	Check for durability issues and quality, replace if necessary
Replace Air compressors	N/A	Every 5 years	Refer to section 5.3.5	Check for durability issues and quality, replace if necessary
Replace coolant and DI filter replacement	20000	Every 2 years	Refer to section 5.4.3	Ethylene Glycol 50/50
Replace coolant tank level switch	N/A	Every 2 years	Refer to section 5.4.5	Check for durability issues and quality, replace if necessary
Replace coolant flow control valves	N/A	Every 2 years	Refer to section 5.4.6	Check for durability issues and quality, replace if necessary

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Maintenance Plan, FCwave 200kW	Document ID: MAN001-C			Revision: 0
	*Interval			
Task	Hours	Month(s)	References	Comments
Replace coolant pump motor bearings	20000	Every 5 years	Refer to section 5.4.7	Check for vibration levels depending on RPM of the motor
Replace coolant pump wear parts and shaft seals	20000	Every 5 years	Refer to section 5.4.7	Check for pump performance and seal leakages, replace if necessary
Replace DI filter	1500	3	Refer to section 5.4.8	Replace if conductivity is too high
Replace H2 sensor	6000	Every 1 year	Refer to section 5.5.3	Check for durability issues and quality, replace if necessary
Replace Smoke detector	6000	Every 1 year	Refer to section 5.5.8	Check for durability issues and quality, replace if necessary
Replace Ventilation fans	N/A	Every 5 years	Refer to section 5.5.9	Check for durability issues and quality, replace if necessary
Replace H2 enclosure water ingress sensor	N/A	Every 2 years	Refer to section 5.5.5	Check for durability issues and quality, replace if necessary
Replace fuel cell stack assembly	34000	Every 5 years	Refer to section 5.5.10	Check for operating conditions, polarizations, and leaks in the module.
Replace ventilation air intake filter	3000	6	Refer to section 5.7.1	Service interval to be validated for each customer / application. Validation should occur no later than initial 1000 hours.
Replace cabinet water ingress sensor	N/A	Every 2 years	Refer to section 5.7.2	Check for durability issues and quality, replace if necessary
Replace HRB and Coolant motor controllers	N/A	N/A	Refer to section 5.6.4	In case of failure or misreading in the system, it is recommended to replace

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	*Interval			
Task	Hours	Month(s)	References	Comments
Replace Air compressor controllers	N/A	N/A	Refer to section 5.6.5	In case of failure or misreading in the system, it is recommended to replace
Replace Current Transducers	N/A	N/A	Refer to section 5.6.6	In case of failure or misreading in the system, it is recommended to replace
Replace Voltage Contactors	N/A	N/A	Refer to section 5.6.7	In case of failure or misreading in the system, it is recommended to replace
Replace Voltage Transducers	N/A	N/A	Refer to section 5.6.8	In case of failure or misreading in the system, it is recommended to replace
Replace Fuses	N/A	N/A	Refer to section 5.6.9	In case of failure or misreading in the system, it is recommended to replace
Replace Bleed down and Precharge resistors	N/A	N/A	Refer to section 5.6.10	In case of failure or misreading in the system, it is recommended to replace
Replace Diodes	N/A	N/A	Refer to section 5.6.11	In case of failure or misreading in the system, it is recommended to replace
Replace Electric panel ventilation fans	N/A	N/A	Refer to section 5.6.12	In case of failure or misreading in the system, it is recommended to replace
Replace High Voltage Panel	N/A	N/A	Refer to section 5.6.14	In case of failure or misreading in the system, it is

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Maintenance Plan, FCwave 200kW	Document ID: MAN001-C			Revision: 0
	*Interval			
Task	Hours	Month(s)	References	Comments
				recommended to replace
Replace Low Voltage Panel	N/A	N/A	Refer to section 5.6.15	In case of failure or misreading in the system, it is recommended to replace
Replace MCU	N/A	N/A	Refer to section 5.6.16	In case of failure or misreading in the system, it is recommended to replace
Replace Temperature sensors	N/A	N/A	Refer to section 5.8	In case of failure or misreading in the system, it is recommended to replace
Replace Pressure sensors	N/A	N/A	Refer to section 5.9	In case of failure or misreading in the system, it is recommended to replace
* Whichever comes first.				

Table 5-1: Maintenance Plan – MAN001-C

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Sub Section N01-004

ATEX Zone Components Maintenance

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Revision history		
Rev.	**Date.**	**Description**
001	29/10/2024	First Issue
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ATEX Zone components maintenance



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1.0 Disclaimer

NOTE: READ THIS BEFORE ATTEMPTING ANY PROCEDURES DESCRIBED IN THIS MANUAL

There are inherent risks in the operation of a fuel cell module that can result in death or bodily injury or loss or damage to property. It is therefore necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device. Persons who install, operate, and service the device are required to be technically qualified and experienced in working with electrical equipment, compressed gases, and H2.

This manual includes certain safety guidelines and recommendations; however, this manual is not intended to cover all situations. The customer is responsible for determining the suitability of the customer's particular design or application, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. Ballard Power Systems Europe A/S ("BPSE") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the operating recommendations in the manual. The customer is responsible for being aware of, and complying with, all applicable laws and regulations. BPSE has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

Procedures described in any part of the manual can only be attempted once the customer has read this entire manual. Failure to follow any instruction or recommendation could result in death or bodily injury or loss or damage to property.

BPSE intends for the device to be installed, operated, and serviced only by approved technically qualified and experienced people who understand the principles of fuel cell technology, are aware of the safe operating limits of fuel cells, and are familiar with the risks posed by operating a fuel cell module. BPSE relies on customers to use their own knowledge and experience when installing, operating, and servicing the device. BPSE also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual.

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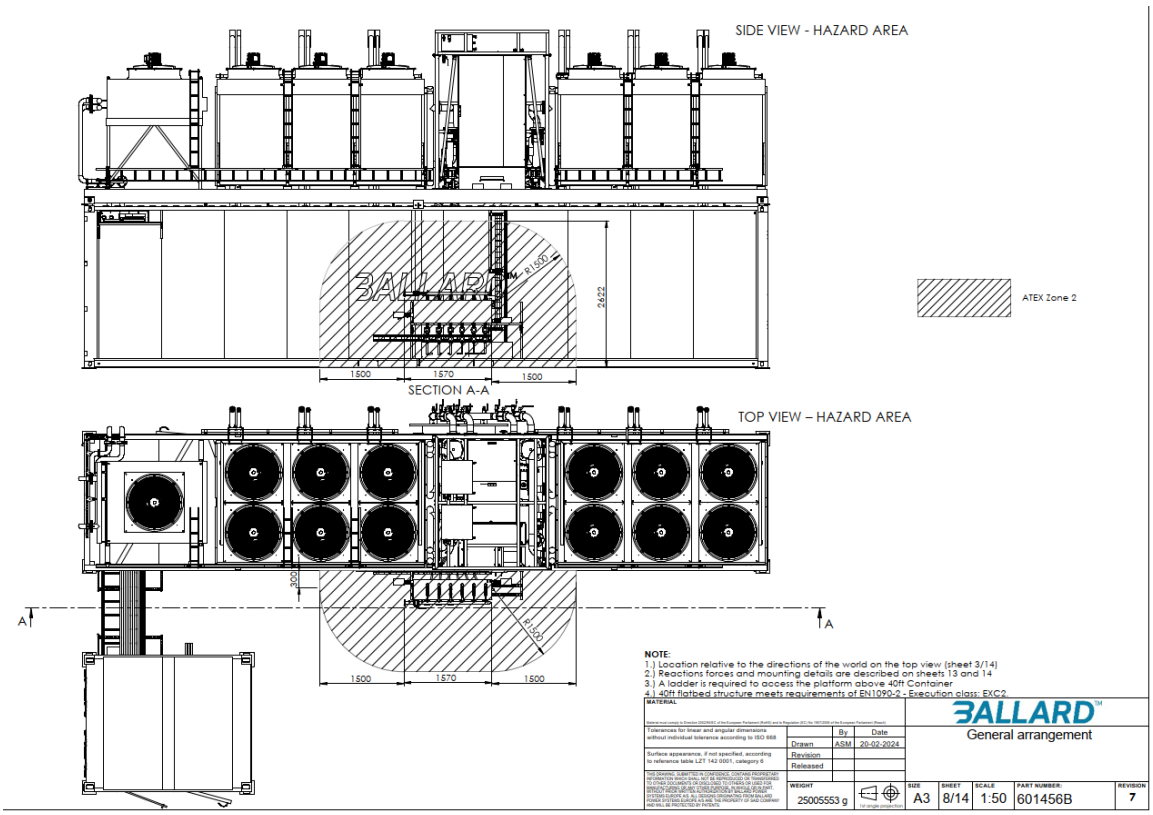
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2.0 General information

2.1 Introduction

This document serves to supply information regarding the needed maintenance on components that exists inside the ATEX zone.

Figure 1: ATEX zone



Source document: General arrangement - K559-2254-CWIWP4202202-B01-001Rev008

2.2 ATEX Zone maintenance safety



The defined EX zone is classified as Zone 2.

Only approved personnel are allowed to work in the ATEX Zone.



2.3 Coolant media

Coolant is Proviflow Neo. Refer to Material Safety Data Sheets - K559-2254-CWIWP4202202-D05-001.

2.4 De-energization

De-energization of electrical components for maintenance must be done, ensuring that no ignition source ever exists in the EX-zone.

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2.5 Components relevant to the ATEX zone

Table 2-1: List of components relevant to ATEX zone

Component	Device full tag	Manufacturer	Device/model/type	Service/ maintenance section
Hydrogen Heater	=HA01+DA02-CM01	Ballard	7003635	3.1
Level sensor – Hydrogen heater	=HA01+DA02-BL01	IFM	LMT01A - LMACE-A12E-QSKG-1/US/3D/3G	3.1.2
Connection wire – Level sensor	=HA01+DA02-BL01-WG01	IFM	ADOGH040MSS0010K04	N/A
Pressure Sensor – Hydrogen heater	=HA01+DA02-BP01	HUBA Control AG	Pressure Transducer 520 Series	N/A
Connection wire – Pressure sensor	=HA01+DA02-BP01-WG01	IFM	ADOGH040MSS0010K04	N/A
Temperature sensor – Hydrogen heater	=HA01+DA02-BT01	IFM	TT1050	N/A
Connection wire – Temperature sensor	=HA01+DA02-BT01-WG01	IFM	ADOGH040MSS0010K04	N/A
Heater element 1&2 - Hydrogen heater	=HA01+DA02-CM01-EA01...EA02	JEVI A/S	D-8640	3.1.3
Connection wires – Heater element 1&2	=HA01+DA02-EA01-WD01	Miltronic AB /Lapp Group	ÖLFLEX® CLASSIC 135 CH	N/A
	=HA01+DA02-EA02-WD01			
Cable glands – Heater element 1&2	=HA01+DA02-EA01	HAWKE	ICG 653 UNIV Os M20	N/A
	=HA01+DA02-EA02			
Solenoid Shut-off Valve, NC	=HA01+DA02-QM1.1...1.6	Emerson ASCO	NF X E210C488E 24/DC	3.2
	=HA01+DA02-QM2.1...2.6			
Solenoid Shut-off Valve cable gland	=HA01+DA02-QM1.1....16	HAWKE	501/421/O M20 421OM20	N/A
	=HA01+DA02-QM2.1...2.6			
H2 pipe wall passthrough	=HA01+DA02-XT01…06	Roxtec	EXRSB050000212	N/A
Sensor Ex Barrier*	=LA01+UC42-TF01	PR Electronics AS	9113B-U9	N/A
Container wall pass-through cable gland	=HA01+DA02-XT07…11	HAWKE	501/421/O M20 421OM20	N/A

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Table 2-1: List of components relevant to ATEX zone				
Fuel Cell string Manual isolation valve	=HA01+DA02-QM01…06	Hy-lok	Hy-lok 110 Ball Valve	3.3
Main H2 manual isolation valve	=HA01+DA02-QM00	Armatec	DVC Type 1311, 131150032	N/A
H2 pipe wall passthrough	=HA01+DA02-XT01…06	Roxtec	EXRSB0500002121	N/A

*Not installed inside ATEX zone

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3.0 Maintenance tasks on components in ATEX zone

3.1 Hydrogen Heater



If the Hydrogen Heater has run recently, wait for it to cool down before touching it and components mounted.

The following components of the Hydrogen Heater have no defined service/maintenance tasks defined by their documentation.

- Pressure sensor
- Temperature sensor
- Cables to sensors
- Cables to heating elements
- Cable glands on JEVI D-8640 heating elements
- Cable glands on Solenoid Shut-off valve (H2)
- Sensor EX barrier
- General Hy-lok fittings

It is recommended that visual inspection on above-mentioned components is done.

3.1.1 Hydrogen Heater cooling media

The Hydrogen heater must have the coolant freeze-protection checked with the use of a refractometer regularly and changed as needed.

Coolant is 50/50% mixture of demineralized water and Proviflow Neo, which is an Ethylene-glycol based.

Criteria: minimum freezing point of -30°C

3.1.2 Level sensor – IFM LMT01A

Refer to Manufacturers (IFM) Operating Instructions – section 9.

- De-energize supply
- Check sensor tip for deposits and damage. Clean if badly soiled. In case of damage, replace the unit – the unit cannot be repaired.
- When reinstalling, carefully clean the probe neck and the installation slot, especially the sealing surface, with appropriate methods to ensure that the unit is resistant to ingress and without dead space.
- Re-energize supply.

3.1.3 Heating element - JEVI D-8640

Refer to Manufacturer's (JEVI) Installation, Operation and maintenance instructions, section 4.0

Maintenance free, however after 1 year of operation:

- De-energize supply (=LA01+UC30-FC41…42)
- Check the thermostat for damage

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- Check connections inside junction box
- Re-assemble and verify correct connections
- Re-energize supply

If no heating is done when needed, check and press the manual reset button.

3.2 H2 Solenoid Shut-off valve – Emerson ACSO

Check for excessive wear – leakage tests

- Externally

  Potential leakage areas: Pipe connections (Hy-lok) and valve stem.

  Hy-lok connections have low probability of leakage. If leakage occur, refer to components manual for replacement.

  If leakage from valve stem, rebuild with manufacturer kit or replace component.
- Inline

  If inline leakage occurs, rebuild with manufacturer kit or replace component.

Leakage test:

- Close valve(s) on designated H2 line
- Lower pressure downstream
- Monitor pressure downstream for a set period
- Search for external leakages with applicable outdoor-use leakage detector.

3.3 Manual isolation valve – Hy-lok 110 Ball Valve

Refer to Manufacturers (Hy-lok) Instruction manual for maintenance.

Leakage test – Stem:

In case of stem leakage, tighten the Flange Nut. If the leakage remains after tightening, check damage to the stem, outer package and inner package. Replace parts or component(s) as needed,

Leakage test – Inline:

If the leakage happens inside the valve, ensure whether the valve is in fully closed condition. If the reason of leakage is seat damage, replace the seat or the component.

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Sub Section N01-005

Lockout Tagout

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FC

Part no.: 601456B-7002362
Document ID: K559-2254-CWIWP4202202-N01-005
Configuration: 40ft Fuel Cell Container w. 6 FCwave™
10ft Converter Container, 6,6 kVAC

PowerGen 1000kW

Lockout Tagout (LOTO)



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1.0 General information

1.1 Lock-out-tag-out

Always open/disconnect applicable connections and perform lock-out-tag-out, using relevant locking-methods and tagging-signage to reduce the risk of accidents.

Figure 1: ABB SA1



Example log-out-tag-out kit for MCB's and others



Always measure for voltages



Emergency buttons are NOT for Lock-out-tag-out.

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2.0 Site Requirements and Permission to work systems

2.1 Site Requirements

When the FC system is installed on a customer or other site, rules governing the applicable site may be in place, which must be complied with. These rules may concern hot work, live work, work at heights or other activities.

If Ballard personnel observe any unsafe activity, by Ballard personnel or other workers, they are required to report this to site supervisor and Ballard management.

2.2 Permission to Work management

When the FC system is installed on a customer or other site, it is expected that there exists a system governing permission to work, covering scopes such as area, activities, time slot and responsible person.

Ballard personnel is required to participate and comply with relevant policies and procedures for Permission to Work management.

3.0 Fuel Cell Container

3.1 Interface connections (Externals)

3.1.1 Auxiliary power supply (=HKN70-XB01)

 The auxiliary power supply is outside Ballard scope. Responsible entity must either provide a procedure for their end (Upstream) or perform the procedure when needed.

If work on the supply-side of the switch disconnector is to be done, follow that procedure.

 When disconnecting the Auxiliary Power supply, the UPS inside may engage.

3.1.2 Hydrogen supply (=HKN70)

 The Hydrogen Supply is outside Ballard scope. Responsible entity must provide a procedure for their end (Upstream) or perform the procedure when needed.

If work on the supply side of the interface is to be done, follow that procedure.

LOTO from the interface and downstream on is normally in correlation with service tasks on an FCwave™ (see section electrical LOTO in section 3.2.3)

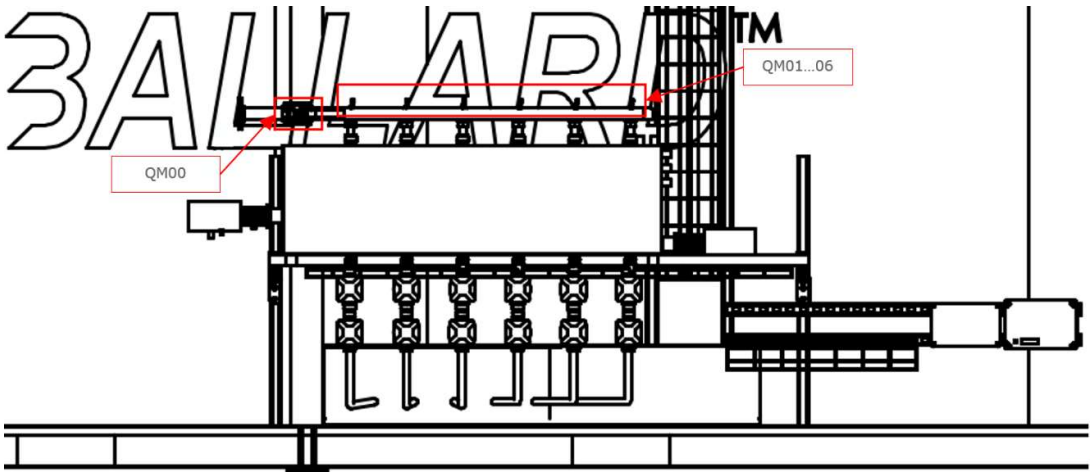
Typical hydrogen supply LOTO:

- Locate applicable manual isolation valve by the hydrogen heater (=HA01+DA02-QM01…06)
  alternatively, supply to all FCwave's can be done with the main shutoff valve (HA01+DA02-QM00)
- Turn off
- Lock-out-tag-out with padlock and sign

 Hydrogen remains in the piping from the manual isolation valve, downstream to the hydrogen supply interface of the FCwave. Refer to section 3.2.3 for bleeding.

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Figure 2: Manual H2 isolation valves



All valves are lockable, enabling LOTO

3.2 Internals

3.2.1 Auxiliary power supply (-SG01)

LOTO of auxiliary power supply to the internal of the container

Auxiliary power supply may be live

1. Locate +UC50
2. Open +UC50 (The bigger cabinet door on the left)
3. Open switch disconnector (-SG01)
4. Lock-out-tag-out with padlock and sign
5. Verify absence of voltage with applicable voltmeter

When disconnecting the Auxiliary Power supply, the UPS may engage.

Re-connect

1. Ensure that work is finished, and that cabinet is clean
2. Ensure that fuses downstream of auxiliary supply switch disconnector is off
3. Re-engage switch disconnector
4. Re-engage fuses downstream one at a time
5. Remove tag-out

3.2.2 DCDC cabinet (+UC01…06)

LOTO and De-energization

1. Shut down the FCwave applicable to the DCDC cabinet through the HMI/ModBus.
   e.g.: Fuel Cell Module 1 (+GB01) if working on DCDC Cabinet #1 (+UC01)
2. Open the top-left door of the applicable DCDC cabinet with Double-bit key no. 5 cabinet key.

Do not open any other doors of the DCDC cabinet yet.

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Figure 3: Top-left door on DCDC cabinet (left)



Cabinet door marked with "Switch disconnector inside"

3. Open the switch disconnector
4. Lock-out-tag-out switch disconnector with padlock and sign

RESIDUAL POWER – In DCDC's - Wait at least 5 minutes

5. Open cabinet doors

DC-link is most likely LIVE

6. Remove pre-charge fuses (4pcs - right top)
   This ensures that accidental activation of pre-charge turn-knop next to the switch disconnector handle does not introduce electrical hazard.
7. Optional: Unplug the 4 DC-connections in the bottom of the FCwave (beneath the floor).
8. Verify absence of voltage with applicable voltmeter (between top of DCDC's B+ and B-)

Re-connect

1. Ensure that work is finished, and that cabinet is clean
2. Re-apply pre-charge fuses
3. Close the two cabinet doors without the switch disconnector and turn-knop for pre-charge behind
4. Pre-charge the components of the cabinet using the turn-knop
5. Verify voltage by measuring with voltmeter in the two available plugs (530-750VDC)
6. Re-engage switch disconnector and close cabinet door.
7. Remove tag-out

3.2.3 FCwave™ (+GB01…06)

LOTO and De-energization (External to the FCwave™)

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Electrical power

1. Set FCwave state to "Prepare for service" in HMI/ModBus and wait for it to transition.
2. Electrical supply LOTO:
    a. Open the top-left door of the applicable DCDC cabinet.

    Do not open any other doors of the DCDC cabinet yet.

    b. Open switch disconnector
    c. Lock-out-tag-out switch disconnector with padlock and sign

    RESIDUAL POWER – In DCDC's - Wait at least 5 minutes

    d. Open cabinet doors

    DC-link is most likely LIVE

    e. Remove pre-charge fuses (4pcs - right top)
    This ensures that accidental activation of pre-charge turn-knop next to the switch disconnector handle does not introduce electrical hazard.
    f. Verify absence of voltage with applicable voltmeter (between top of DCDC's B+ and B-)
    g. Optional: Unplug the 4 DC-connections in the bottom of the FCwave (beneath the floor).

Re-connect

1. Ensure that work is finished, and that areas are clean
2. Close the doors on the FCwave™
3. Re-apply pre-charge fuses in DCDC cabinet
4. Close the two cabinet doors in the DCDC cabinet without the switch disconnector and turn-knop for pre-charge behind
5. Pre-charge the components of the cabinet using the turn-knop
6. Verify voltage by measuring with voltmeter in the two available plugs (530-750VDC)
7. Re-engage switch disconnector and close cabinet door.
8. Remove tag-out
9. Take FCwave™ out of service state through HMI/ModBus

Gas

1. Typically, as described in section 3.1.1

Hydrogen remains in the piping from the manual isolation valve, downstream to the hydrogen supply interface of the FCwave

2. Continue de-energization of FCwave internals as described it's in manual

Re-connect

Typically reverse

24VDC Supply and control

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1. Disconnect plug from the bottom of the FCwave (beneath the floor)
2. Verify absence of voltage with applicable voltmeter

Re-connect

1. Ensure that work is finished, and that areas are clean
2. Reconnect

3.2.4 MCU cabinet (+UC20)

 MCU cabinet contains foreign control voltages – e.g. safety signals from customer

 UPS batteries supply energy to the MCU cabinet. These are located under floor by door (24VDC) and disconnected as described in section 3.2.5

The MCU cabinet is powered from +UC50

1. Ensure low-to-no power consumption in the MCU cabinet by opening fuses inside
2. Locate +UC50
3. Open +UC50 Right-lower door with Double-bit key no. 5 cabinet key
4. Open -FC04
5. Lock-out-tag-out -FC04 with ABB SA1, padlock and sign
6. Verify absence of voltage with applicable voltmeter

Alternative:

1. Ensure low-to-no power consumption in the MCU cabinet by opening fuses inside
2. Locate switch disconnector on the right side of the cabinet (-QB01)
3. Open -QB01

 The power supply (upstream from switch disconnector) remains live

4. Lock-out-tag out -QB01with padlock and sign
5. Verify absence of voltage with applicable voltmeter

Re-connect

1. Ensure that work is finished, and that cabinets are clean
2. Re-engage chosen switch disconnector
3. Re-engage fuses inside MCU cabinet
4. Remove LOTO

3.2.5 UPS

Access the UPS(s) by removing the floor-panel marked “Batteries”.

Power source:

1. Locate and turn off applicable fuse in +UC20
2. Lock-out-tag-out applicable fuse with ABB SA1, padlock and sign
3. Verify absence of voltage on UPS interface with applicable voltmeter

 Energy in UPS batteries remain

Outgoing power:

1. Ensure no power is drawn from UPS
2. Remove the 2x spade-fuses on applicable UPS unit(s)

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3. Tag-out
4. Verify absence of voltage with applicable voltmeter

Re-connect

1. Ensure that work is finished, and that area is clean
2. Ensure no energy-draw from the UPS when reconnecting the spade-fuses by opening the applicable fuses
3. Reconnect spade connectors
4. Close the earlier opened fuses

3.2.6 LT pump drive

1. Locate and turn off the fuse in the MCU cabinet (+UC20)
2. Lock-out-tag-out of fuse with ABB SA1, padlock and sign

 RESIDUAL POWER – In Frequency Converter - Wait at least 5 minutes

3. Verify absence of voltage with applicable voltmeter

 The 24VDC control and supply remains active

Re-connect

1. Ensure that work is finished, and that area is clean
2. Reconnect in reverse order

3.2.7 Intake fans

1. Locate and turn off the fuse in the MCU cabinet (+UC20)
2. Lock-out-tag-out fuse(s) with ABB SA1, padlock and sign
3. Turn lock-function of plug on the fan and remove by pulling

Re-connect

1. Ensure that work is finished, and that area is clean
2. Reconnect plug on fan
3. Close fuse(s)

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4.0 Converter Container

	**The internals of the Converter Container are not accessible when the system is running.**
	**Internals are IP00 area**
	**Never force entry, never de-activate safeguards.**

Entering the 10ft Converter Container

1. Remove the on the padlock on the container door with applicable key
2. Open the container door
3. Mount the padlock to the locking handle (like in Figure 4), ensuring that the container doors cannot be closed and locked by anyone with no knowledge of the work being done.

Figure 4: Mounted padlock on open container door



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4.1 Interface connections

4.1.1 Grid connection (=HKN70-XB02)

 – The Grid connection is outside Ballard scope. The responsible entity must provide a procedure for their end of the cable(s). If work downstream of the 1250KVA Transformer (-TA30) is to be done, follow that procedure.

4.1.2 DC bus (DC1)

 The DC bus in the Converter Container may be supplied both from the DC interconnection from the Fuel Cell Container and the grid connection.

If work is to be done inside the Converter Container, the DC bus must be fully de-energized.

4.1.3 AC Power Supply (BP2)

AC is supplied from the Fuel Cell Container to the Control Cabinet (+UC31) in the Converter Container. It can be shut-off locally or externally (locally – refer to section 4.2.1)

 UPS batteries supply energy to the Control cabinet. – refer to section 4.2.5.

Externally to Power Converter Container:

1. Locate +UC50 in the Fuel Cell Container
2. Open door with Double-bit key no. 5 cabinet key
3. Open switch disconnector -FC05
4. Lock-out-tag-out with padlock and sign

 RESIDUAL POWER – In converters - Wait at least 5 minutes

5. Verify absence of voltage with applicable Voltmeter

4.2 Internals

4.2.1 AC Power Supply (-QB01)

AC is supplied from the Fuel Cell Container to the Control Cabinet in the Power Converter Container. It can be shut-off locally or externally (Externally - refer to section 4.1.3).

Locally:

1. Access the Control Cabinet (+UC31) on the Converter Container by opening the door on the backside of the container (Key needed).
2. Open the control cabinet (+UC31) with a Double-bit key no. 5 cabinet key.
3. Turn off the fused switch disconnector (-QB01) in the cabinet (+UC31)

 The power-supply remains active upstream from -QB01. If work is to be done upstream, follow the procedure in section 4.1.3.

 RESIDUAL POWER – In converters - Wait at least 5 minutes before proceeding

4. Verify absence of voltage with applicable voltmeter

 When disconnecting the Auxiliary Power supply, the UPS may engage.

4.2.2 Grid connection (-FC30)

Actuating/ Lock-out-tag-out is performed as defined by the manual for ABB SACE Emax 2.

 – Live parts may be present

Description of Disconnection of the Customer-end of the connected cable(s) is provided by customer

4.2.3 Transformer

Voltage to the Transformer is removed by the safety-system, when opening a door.

Make sure that the grid connection, described in section 4.2.2, is disconnected.

4.2.4 Capacitors

Voltage to the capacitors is removed by the safety system, when opening a door.

Make sure that the grid connection, described in section 4.2.2, is disconnected.

 RESIDUAL POWER – In capacitors - Wait at least 5 minutes

4.2.5 UPS

The UPS(s) is located in +UC31 which is accessed by opening the container doors that face away the Fuel Cell Container.

Power source:

1. Locate and turn off applicable fuse in +UC31
2. Lock-out-tag-out applicable fuse with ABB SA1, padlock and sign
3. Verify absence of voltage on UPS interface with applicable voltmeter

 Energy in UPS batteries remain present

Outgoing power of UPS:

4. Stop machine through HMI/ModBus
5. Locate the container doors that face away from the Fuel Cell Container.
6. Open the door with applicable key
7. Access the UPS that is located inside +UC41
8. Ensure no power is drawn from UPS
9. Remove the 2x spade-fuses on applicable UPS unit(s)
10. Tag-out
11. Verify absence of voltage with applicable voltmeter

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Re-connect

1. Ensure that work is finished, and that area is clean
2. Ensure no energy-draw from the UPS when reconnecting the spade-fuses by opening the applicable fuses
3. Reconnect spade connectors
4. Close the earlier opened fuses

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5.0 HT Cooling Platform

5.1.1 Control cabinet (+UC30)

The power supply of the HT Cooling Platform can be shut off locally on the Control Cabinet, or in +UC50 inside the Fuel Cell Container.



A 24VDC UPS is in the cabinet.

Converters: DCDC for the UPS and Frequency converters for the pumps.

Foreign control signals.

Locally:

1. Turn off switch disconnector on the cabinet (-QB01)

 RESIDUAL POWER – In converters - Wait at least 5 minutes

2. Verify absence of voltage with applicable voltmeter

 The power-supply remains active upstream from -QB01. If work is to be done upstream, follow the procedure below.

Externally to HT Cooling Platform:

1. Locate +UC50 in the Fuel Cell Container
2. Open +UC50 with a Double-bit key no. 5 cabinet key.
3. Open switch disconnector -FC04
4. Lock-out-tag-out with padlock and sign

 RESIDUAL POWER – In converters - Wait at least 5 minutes

5. Access the Control Cabinet (+UC30) on the HT Cooling Platform with a Double-bit key no. 5 cabinet key.
6. Verify absence of voltage with applicable voltmeter

5.1.2 UPS

The UPS is in the Control Cabinet.

Using MCCB:

1. Locate applicable fuse (MCCB) in +UC30
2. Open the fuse
3. Lock-out-tag-out fuse with ABB SA1, padlock and sign
4. Verify absence of voltage on UPS interface with applicable voltmeter

 Energy in UPS batteries remain present

Using fuses on UPS:

1. Ensure no power is drawn from UPS by opening applicable fuses
2. Remove the 2x spade-fuses on UPS unit

 Energy in UPS batteries remain present

3. Tag-out with sign
4. Verify absence of voltage with applicable voltmeter

Re-connect

1. Ensure that work is finished, and that the cabinet is clean
2. Open the applicable fuses to ensure no energy-draw from the UPS when reconnecting the spade connectors
3. Reconnect spade connectors or turn on fuse
4. Close the earlier opened fuses

5.1.3 HT Coolant pump

1. Locate and turn off the applicable fuse in the Control cabinet (+UC30)
2. Lock-out-tag-out fuse with ABB SA1, padlock and sign

 RESIDUAL POWER – In Frequency Converter - Wait at least 5 minutes

3. Verify absence of voltage with applicable voltmeter

Re-connect

1. Ensure that work is finished, and that area is clean
2. Close fuse

5.1.4 Cooling fan / VFD

This section applies to the cooling fans -GQ11…16, -GQ21…16, and -QG31, as well as their applicable Variable Frequency Drive (VFD)

 Foreign control signals

1. Locate and turn off the applicable fuse in the Control cabinet (+UC30)

 RESIDUAL POWER – In Frequency Converter - Wait at least 5 minutes

2. Lock-out-tag-out fuse with ABB SA1, padlock and sign
3. Turn lock-function of plug on the fan and remove by pulling

Re-connect

1. Ensure that work is finished, and that area is clean
2. Reconnect any disconnected plugs on fan
3. Close fuse

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5.1.5 VFD Cabinet chiller

1. Locate and turn off -FC40 in the Control cabinet (+UC30)
2. Lock-out-tag-out fuse with ABB SA1, padlock and sign

Re-connect

1. Ensure that work is finished, and that area is clean
2. Close fuse

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Sub Section N01-006

Fuel Cell Module Integration Manual

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200kW Marine Fuel Cell Integration Manual



1. Disclaimer

NOTE: READ THIS BEFORE ATTEMPTING ANY PROCEDURE DESCRIBED IN THIS MANUAL

This manual includes certain safety guidelines and recommendations. However, this manual is not intended to cover all situations.

This manual attempt to specify the requirements for most applications, but for applications which may require operation outside of the stated specifications, please contact Ballard Power Systems Europe.

The integrator is responsible for being aware of, and complying with, all applicable laws and regulations.

The integrator is responsible for determining the suitability of the FCwave™ for the particular application and ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated.

Ballard Power Systems Europe, Inc. ("Ballard") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the intended use according to this manual.

Ballard has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

Procedures described in any part of the manual can only be attempted once the customer has read this entire manual.

There are inherent risks in the operation of a fuel cell module that can result in death or bodily injury or loss or damage to property.

- It is necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device.
- Persons who install, operate, and service the device are required to be technically qualified and experienced in working with electrical equipment, hot and/or pressurized fluids, and hydrogen.

Ballard relies on customers to use their own knowledge and experience when installing, operating, and servicing the device.

Ballard also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual. See abbreviation list.

Ballard reserves the right to make updates or other changes to this manual and/or to the products described in this manual, at any time without notice.

Updates and other changes to the manual may be posted on the Ballard website and may be accessed through the customer portal.

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4. Abbreviations

Acronym	Definition
BOL	Beginning of Life
BOP	Balance of Plant
BPSE	Ballard Power Systems Europe
CAN	Controller Area Network
DI	Deionized
EOL	End Of Life
FC	Fuel Cell
FCM	Fuel Cell Module
FCwave	Product name 200kW Marine Fuel Cell module
H2	Hydrogen (Gaseous)
H2E	Hydrogen Enclosure
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
IP	Ingress Protection Rating
LEL	Lower Explosive Limit (18% vol mix with atmospheric air)
LFL	Lower Flammability Limit (4% vol mix with atmospheric air)
LVC	Low Voltage Connector
MCU	Module Control Unit
PEM	Proton Exchange Membrane (Fuel Cell Technology)
RDU	Remote Data Unit
SVN	Subversion, internal source code repository
UPS	Uninterruptable Power Supply
VCS	Vessel Control System

Table 1 – List of Abbreviations

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5. Reference Documents

Document	Title
7001000-01	FCwave™ 200kW Arrangement Plan
CMS010	Schematic description of Input and Output Circuits
CMS013	Customer CAN Matrix
CMS014	Control System Alarm List
CMS006	Electrical Datasheet

Table 2 – List of Reference Documents

6. General Information

6.1. Scope of Manual

This Integration Manual provides the necessary system requirements for integrating and operating the FCwave™ 200 kW Marine Fuel Cell Module (hereafter referred to as the "module").

It covers topics such as

Expected product performance,
Required system inputs/outputs,
Mechanical/electrical interfaces and control details.

7. FCwave™ Fuel Cell Module Datasheet

Too see the latest revision of the electrical datasheet (CMS006), go to Customer Portal, or contact Ballard Power Systems Europe.

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7.1. Fuel cell module

The major components and features of the module sub-systems are listed below:

- Liquid cooled PEM (Proton Exchange Membrane) fuel cell stacks.
- Built-in control system, control power supplies and control power distribution.
- Independent Safety Controller with separate power supply and safety instrumentation.
- Sensors for voltage, current, pressure and temperature measurements.
- Safety devices, including ventilation system (fans and ventilation exhaust line), fuel pressure relief device, fire detection and hydrogen sensors.
- High voltage contactors for electrically isolating the fuel cell stack from the high voltage output terminals.
- High voltage system pre-charging and reverse current protection during start-up.

Hydrogen (Anode) Sub-system

- Complete hydrogen subsystem, which delivers and conditions the fuel supply to the fuel cell stacks.
- Valve block with integrated hydrogen shutoff, pressure regulation and safety pressure relief device.
- Hydrogen recirculation with purge.

Air (Cathode) Sub-system

- Air compressors and inverter assemblies for supplying process air to the fuel cell module.
- Air mass flow sensor for air flow rate measurement and control.
- Intercooler and humidifier for conditioning the incoming air stream.

Coolant Sub-system

- Internal high-temperature coolant loop, with coolant pump and controller assembly for supplying coolant to the fuel cell stacks.
- Liquid to liquid stainless-steel heat exchanger between internal high-temperature coolant loop and customer coolant loop, able to handle a wide range of coolant media (fresh water, water-glycol mix).
- Electronically actuated control valves used for stack coolant inlet temperature control.
- Separate low-temperature coolant loop to cool motors and motor controllers.

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8. Safety

8.1. Hazard Symbols



WARNING *in this manual indicates actions that may result in an accident, which could cause immediate bodily injury or loss of life or could cause damage to equipment or other property.*



CAUTION *in this manual indicates actions that may result in an accident, which could cause damage to equipment or other property, and which could cause bodily injury if not promptly detected and remedied.*



ELECTRICAL HAZARD*- Obey ALL warnings, cautions, and safety instruction related to electricity. Failure to do so may result in electrical shock leading to personal injury or death.*

8.2. General Safety



The modules are to be installed in a dedicated fuel cell installation room.

The system integrator is responsible for providing means to lockout energy sources on the system prior to any service activity being performed, and a written procedure to Ballard service personnel detailing the equipment and steps required to sufficiently lock out all necessary energy sources.

- Keep module doors and electrical enclosures closed when the system is operating.
- The module and its auxiliary systems are intended to be serviced only by personnel technically qualified and experienced in handling electrical equipment and compressed/flammable gases
- Remove jewelry, watches, rings, and metal objects on clothing that can potentially cause short circuits when working on the fuel cell module.

8.3. High Temperature Safety



Integrator shall ensure that process exhaust piping is leak tight and touch proof.

- Surfaces on coolant interfaces and the process exhaust can reach up to 80 °C during normal operation.
- Components within the fuel cell module can reach temperatures up to 120 °C during normal operation.

8.4. High-Pressure Safety



The module uses pressurized gases which can be hazardous.

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- Use caution and ensure circuits are de-pressurized before opening any lines or fittings.
- Some sub-systems may remain pressurized even when the fuel cell module is powered off.

8.5. High Voltage Safety



Ballard recommends that the electrical integration of the fuel cell module must be designed under the supervision of a qualified professional electrical engineer.

It is the integrator's responsibility to design the integration of the fuel cell module such that the integration complies with all applicable legislation and requirements.

After shutdown, high voltages may remain on the fuel cell stacks for a duration of time. No maintenance activities are to be performed during this time as the stacks present a shock hazard. Also, residual reactants (oxygen and hydrogen) within the fuel cell module can cause the fuel cell output voltage to rise unexpectedly.

Allow the fuel cell voltage to drop to below 30 VDC prior to servicing the fuel cell module. Certain circumstances can lead to voltage persisting on the fuel cell stack indefinitely.

Always check for residual voltage before any service activity.

Operate the fuel cell module high voltage as a "floating electrical system". Ensure that neither the fuel cell high voltage positive terminal nor the fuel cell high voltage negative terminal is connected to the application ground, earth or chassis.

Before working on the fuel cell module and its auxiliary systems in a floating DC system, it's important to make sure the system is de-energized. This involves checking for near-zero volts in three key areas: between the fuel cell's high voltage positive and negative terminals, between the high voltage positive terminal and the chassis, and between the high voltage negative terminal and the chassis.

Measurements are to be made on both AC volts and DC volts scales.

The monitoring of the isolation resistance of the overall high voltage system shall be done with a device capable of detecting both single and double pole isolation failures.

The system integrator is responsible for ensuring that a suitable ground fault monitoring system is installed and functioning during operation of the fuel cell power system. If the level of electrical isolation is ever deemed unsafe according to regulatory standards, the integrator must provide means for the fuel cell power system to be shut down in case of a ground fault.

Select fuel cell module power output cables that appropriately suit the application.

Ensure that cable specifications meet voltage, current, environmental temperature limits, chemical and mechanical resistance and flexure requirements of the application.

Avoid hazardous and unsafe situations that could result from conditions such as, but not limited to, the following:

Improper grounding
Handling electrical leads or devices with wet hands or on wet ground
Frayed electrical leads

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Incorrect or improper connection of the terminal leads
Short circuits
Back-feed from energized normal and emergency power sources

8.6. High Voltage Isolation Failures



Under normal circumstances both high voltage output terminals (positive and negative) are isolated from the fuel cell module enclosure and low voltage system.

If isolation is lost on one high voltage pole, a person working on the module could sustain a fatal current flow by touching the other high voltage pole and ground.

If two simultaneous faults occur and isolation is lost on both high voltage poles, a high voltage short circuit can occur resulting in extremely high currents. High currents can generate a large amount of heat which will subsequently damage electrical and fuel cell systems and cause bodily harm.

It is the responsibility of the system integrator to ensure that the electrical isolation between the high voltage and low voltage systems (Ground) is accurately and continuously measured and that appropriate action is taken before a hazardous condition develops.

Normal System

Under normal operation, the fuel cell system will operate as shown in Figure 1 where both high voltage poles are isolated from ground.

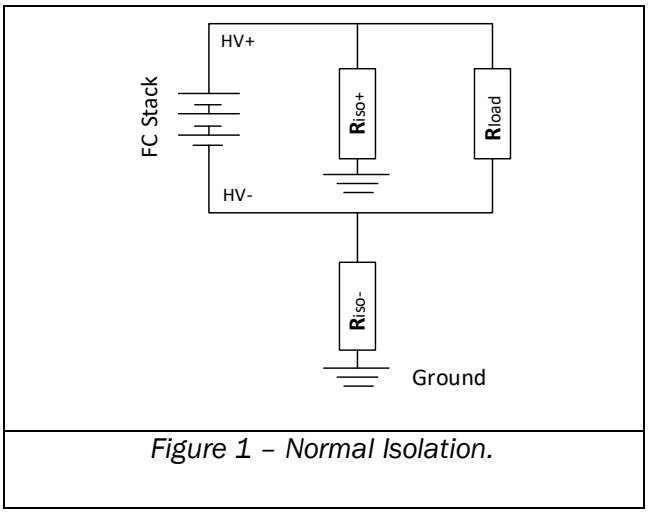


Figure 1 – Normal Isolation.

Single Pole Isolation Failure

In a single pole isolation failure, one point on the high voltage circuit is no longer isolated from ground as shown in Figure 2. An isolation resistance measurement or ground fault detection system can typically detect this failure if utilized. A single pole isolation failure will not cause a short-circuit, nor will

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it prevent fuel cell operation, however, it significantly increases the risk of electrical shock for personnel working on or around the fuel cell system.

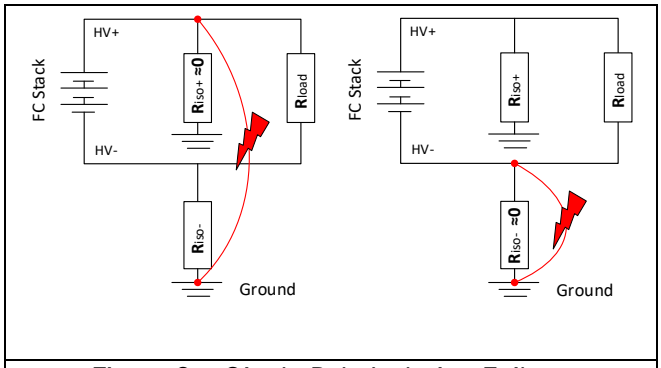


Figure 2 – Single Pole Isolation Failure.

Double Pole Isolation Failure

A double pole isolation failure, where the high voltage system is no longer isolated from ground in two different locations, may result in a high voltage short-circuit as shown in Figure 3. An isolation resistance measurement or ground fault detection system can typically detect this failure if utilized.

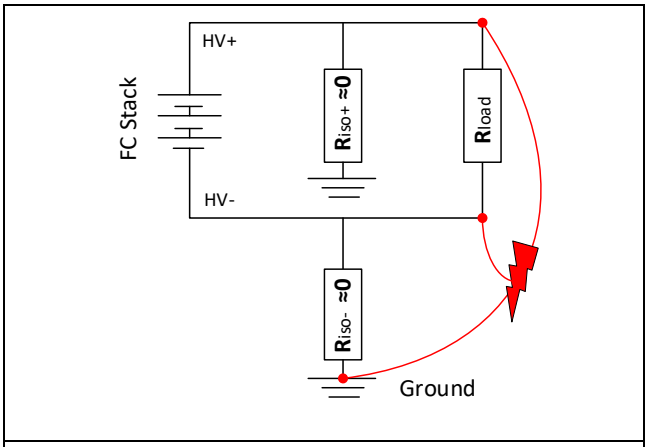


Figure 3 – Double Pole Isolation Failure.



If an isolation failure is detected and found to be located in the module, do not operate the fuel cell module until the root cause is determined and remedied.

Distributed Capacitance and Effects on HV Safety

The Distributed capacitance is the total amount of capacitance that exists between each pole of an isolated high voltage system and the chassis (fuel cell enclosure). This capacitance is a concern as it can hold charge which can be discharged into a person that simultaneously touches the high voltage system and chassis.

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In normal operation, this is not an issue as all high voltage conductors are covered and insulated but could be a concern if a system is being serviced.

HV safety due to residual reactants

Within the module, the fuel cell stack will also maintain voltage if hydrogen and air are present within the system. Voltage could also be generated when a fuel or air source is introduced, and reactants are moved to an active point in the fuel cell stack. This voltage will normally bleed down to safe levels within minutes, but this should always be verified using the RDU interface first, and then testing with digital multi-meter prior to accessing the module.

Confirm that the voltage is zero

Between pole to pole (positive to negative)
Between each pole to chassis before service.

Built in service procedures involve running the air compressors and hydrogen recirculation blower to inert the fuel cell prior to servicing the system Is necessary.

Refer to section “31.2 State: Prepare for Service” for pre-maintenance procedures. Untrained service personnel should not perform maintenance procedures on fuel cell modules.

One other effect of the distributed capacitance will be a delay in the ground fault detection system measurement.

8.7. Hydrogen Safety

⚠WARNING

Install and handle the hydrogen in accordance with applicable regulations and the gas supplier’s recommendations.

- Hydrogen is a colorless, odorless, and highly flammable gas so there will be no warning signals before unconsciousness results.
- Hydrogen is lighter than air and will escape upwards. This also allows it to diffuse through many materials considered airtight.
- Hydrogen is non-toxic, but it can cause asphyxiation by displacing the oxygen in the air, so do not operate the module in enclosed or non-ventilated areas.

Furthermore, hydrogen’s small molecular size results in high buoyancy and diffusivity, so any leaked hydrogen will be diluted readily by the surrounding air.

Present potential leakage or permeation sites

- Fuel lines,
- Non-welded connections,
- Non-metal seals such as gaskets, O-rings,
- Pipe thread compounds and packings

Hydrogen leaks which develop within the fuel cell module will be detected by a hydrogen sensor located inside the fuel cell module hydrogen enclosure ventilation duct. Detection of a high hydrogen concentration will trigger an alarm causing the closing of the fuel cell module hydrogen supply valve

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(integrator's scope) before an unsafe condition can exist. For more information see section "14.5 Module H2 Supply Valve and H2_ENABLE"

It is possible for a hydrogen sensor to degrade to the point where it will no longer trigger an alarm if the hydrogen content exceeds safety limits. For this reason, the H2 sensor is part of the maintenance plan.

Exposure to Volatile Organic Compounds (VOC's) is known to cause hydrogen sensor degradation, care should be taken to avoid exposure whenever possible. High levels of VOCs are often encountered during vessel painting and solvent degreasing; therefore, it is recommended that the module or hydrogen sensors to be removed during these processes. Efforts have been made to isolate the sensor from contamination; however, degradation can still occur.

Some failure modes can result in hydrogen gas being present in the cooling system header tank. The risk can be mitigated by following the design considerations, maintenance procedures and filling instructions specified in Section 18.8.

The hydrogen supply to the module will remain pressurized when the module is shut down. Verify that there is no pressure in this line prior to disconnecting the hydrogen supply.

The hydrogen lines inside the module may contain hydrogen, even after the module has been removed from the system. Safely vent the remaining hydrogen pressure prior to removing the fuel cell module.

The responsibility for leak detection external of the fuel cell module rests with the system integrator.

It is strongly recommended that the integrator implement hydrogen detection in any enclosure where the fuel cell module is installed, including the fuel cell room, or similar enclosed space. Interlock the hydrogen detection system with a hydrogen supply valve installed directly upstream of the fuel cell module.

If an excessive hydrogen leak is detected, cease operation of the FCM and do not restart the FCM until safe operation conditions are reestablished.

⚠WARNING **The module hydrogen sensor may degrade if exposed to various contaminants and become less sensitive when degraded. Scheduled checks, as per the module service schedule, ensure that the sensors have sufficient sensitivity for safe operation. Failure to perform scheduled hydrogen sensor checks can result in unsafe operation of the module, as the module may not shut down in the presence of ventilation outlet emissions if the hydrogen sensor is severely degraded.**

8.8. Chemical Hazards

The fuel cell HT coolant loop contains ethylene glycol.

Ethylene glycol is toxic if ingested or if its vapors are inhaled.

All personnel handling ethylene glycol or working on the fuel cell stack HT coolant loop are required to adhere to the precautionary measures identified in the Safety Data Sheet of the specific coolant being used.

Such precautionary measures include Personal Protective Equipment (PPE), for instance wearing safety glasses and chemically protective gloves.

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Dispose ethylene glycol in accordance with applicable local regulations.

8.9. Acoustical Noise

The acoustical noise of the FCwave™ during standby has an A-weighted equivalent Sound Pressure Level (SPL) of 69 dB(A) $L_{Aeq,2min}$ 1 meter from module front. During normal operation (steady at 200kW) the A-weighted equivalent SPL is 88 dB(A) $L_{Aeq,2min}$ at the same location. During ramping up, the maximum noise level reaches 92 dB(A) $L_{Aeq,1sec}$ (1m from module front).

To reduce the likelihood of hearing impairment, all personnel are advised to wear hearing protection devices entering the fuel cell engine room while FCwave(s) are operational.

8.10. FCwave™ hazard mitigation approach

The potential hazards related to the FCwave, posing the highest risks are:

- Unacceptable hydrogen concentrations (in the ventilation or process air exhaust) leading to fuel-fed combustion.
- Electrical short-circuits and possible shock hazards caused by reduced electrical isolation of the high voltage system.

The control system is coupled with sensors (Such as Pressure, temperature, H2 concentration et.al.) intended to identify conditions (which can lead to a hazardous situation) and shut down the operation of the FCwave™ and related functions, before an unsafe condition develops. The safety control functions are managed in a dedicated controller unit.

9. FCwave™ Performance

The performance and lifetime of the FCwave™ module is, among others, depending on good quality reactants (fuel = hydrogen, oxidant = air). Make sure the quality of the reactants meets or exceeds requirements outlined in this document.

The FCwave™ can be configured in either Single or Dual Output modes. The preferred configuration has to be planned before commissioning.

Table 3 shows the module output to the DC/DC or DC/AC converter (in general connected to a DC/DC).

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Power	Configuration	Voltage	Current
50 – 200kW	Dual Output	350 – 720 VDC	(2x) 50 - 300A
50 – 195kW	Single Output	350 – 720 VDC	(1x) 100 - 550A

Table 3 – Module power, voltage, and current limits

Figure 4, Figure 5, Figure 6 and Figure 7 show the expected performance envelope of the FCwave™ module. The net power output represents the output to the module DC/DC converter and accounts for the power generated by the fuel cell stacks and the power draw of the BOP components. The net power output is the total power available to the vessel.

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9.1. System Output Voltage and Current

The voltage from the module is dependent on the load drawn from the system, the correlation between power and voltage is shown in Figure 4. Output current in relation to system output power is shown in Figure 5.

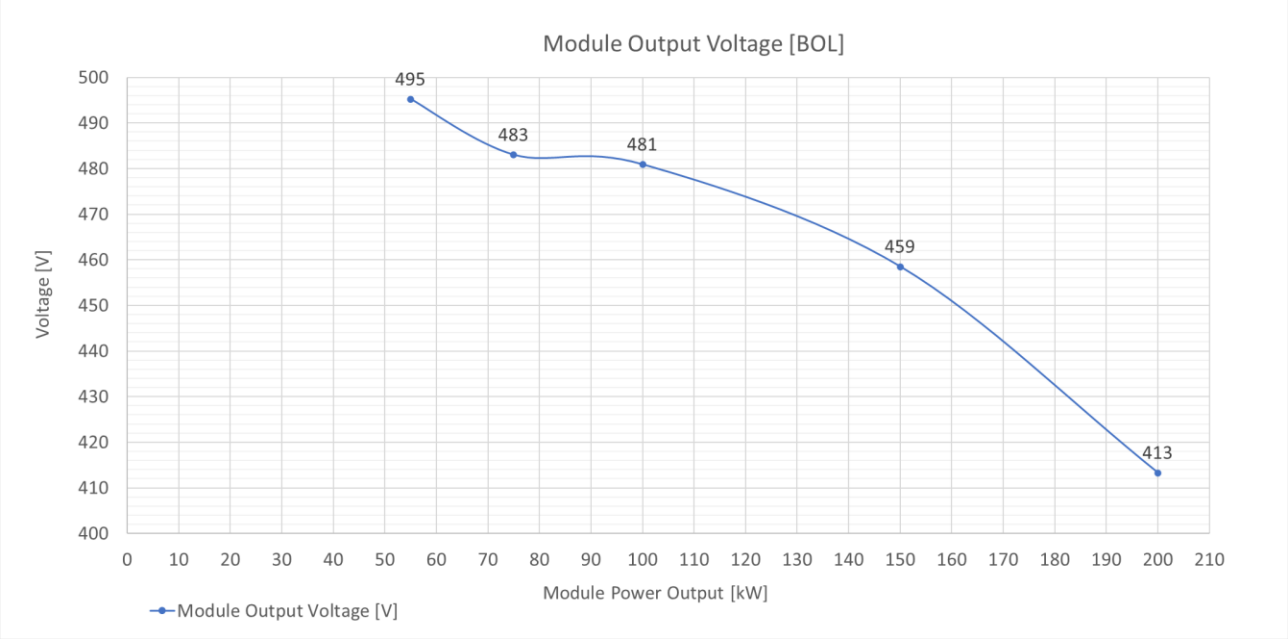


Figure 4 – Module output Voltage at Beginning of Life.

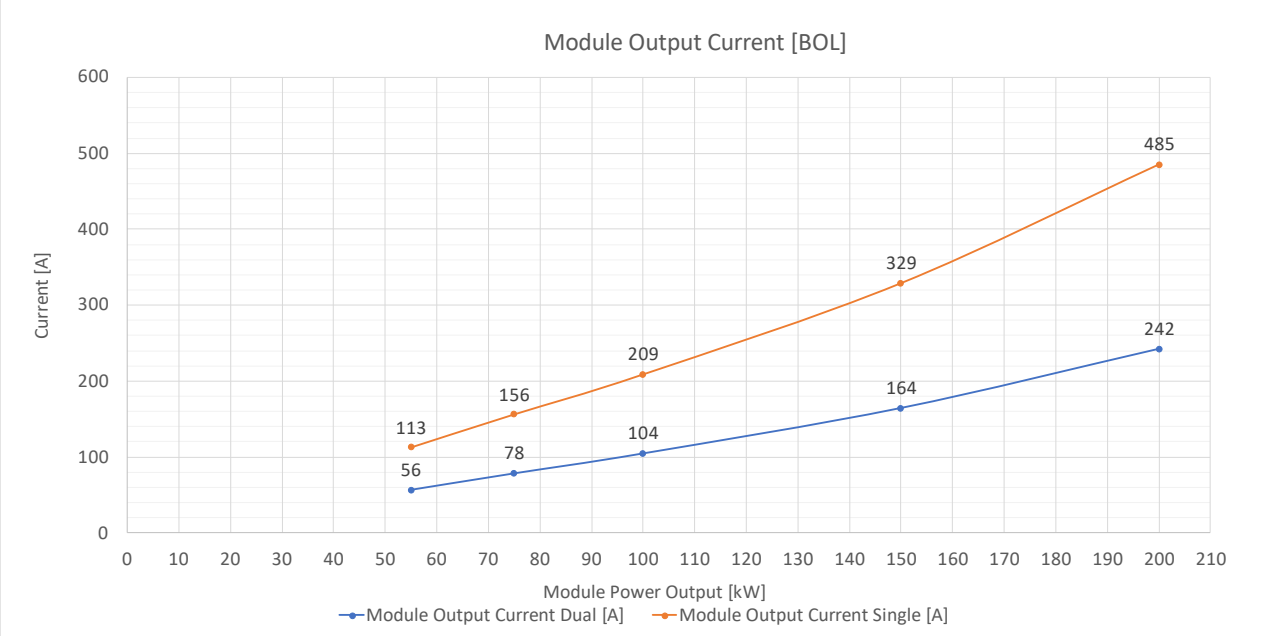


Figure 5 – Module Output Current at BOL.

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9.2. System Efficiency

The module electrical net efficiency in Figure 6 is defined as the fraction of electrical energy produced.

The lower heating value of hydrogen used for the calculation is 119,91 MJ/kg (ISO 6976:1995).

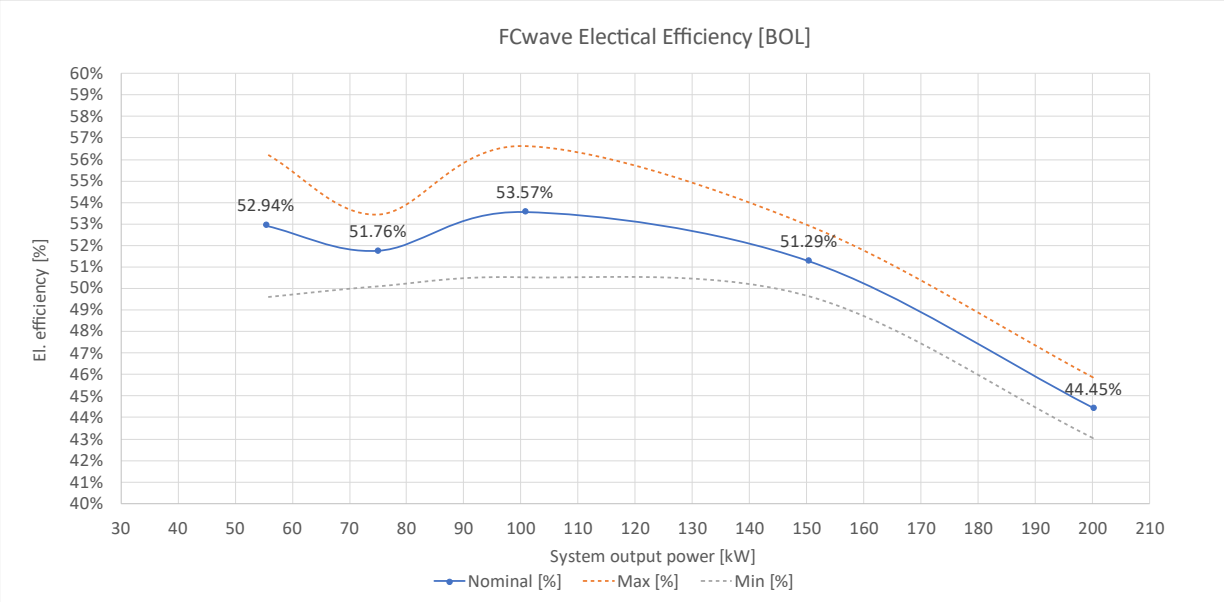


Figure 6 – Module Net Efficiency BOL.
(Test done according to IEC62282-3-200:2016 using 95 confidence interval)

9.3. System Hydrogen mass flow

The hydrogen consumed by the module at different load points are shown in Figure 7 – Hydrogen mass flow.

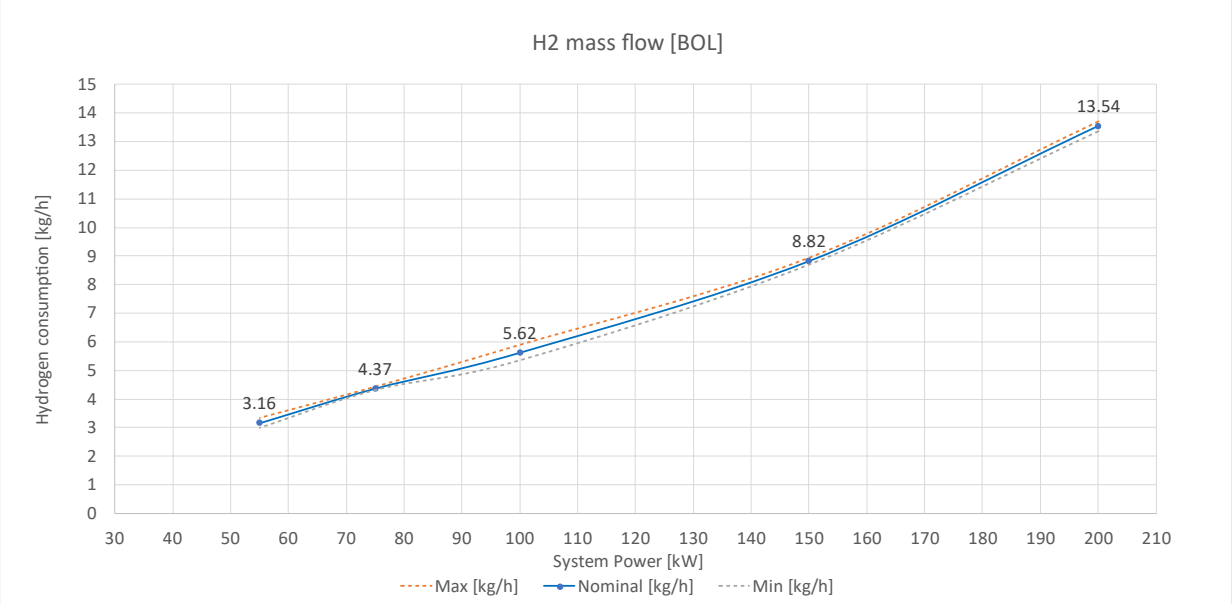


Figure 7 – Hydrogen mass flow BOL.
(Test done according to IEC62282-3-200:2016 using 95 confidence interval)

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10. Mechanical Integration

Measurements and figures in this section are for reference only and should not be used for design purposes. Ballard can supply 3D models and integration drawings upon request.

10.1. Reference Drawings

For a list of the mechanical reference drawings contained in the **7001000-01**, refer to Table 4 – Mechanical Reference Drawings.

Mechanical Reference Drawings	
Drawing Number	Drawing Title
7001000-01, Sheet 1	General Arrangement Plan
7001000-01, Sheet 2	Interface Panel Connection Locations
7001000-01, Sheet 3	Process Exhaust and H2E Ventilation Locations

Table 4 – Mechanical Reference Drawings contained in 7001000-01.

10.2. Module Installation

This section describes the major physical properties of the FCwave™ fuel cell module.

Modules require front access, refer to section 10.4 “Space Claim for Service Access”. Modules do not require side or rear access and can be placed side by side, back-to-back or a combination thereof.

Refer to the isometric view of the module in Figure 8, below.

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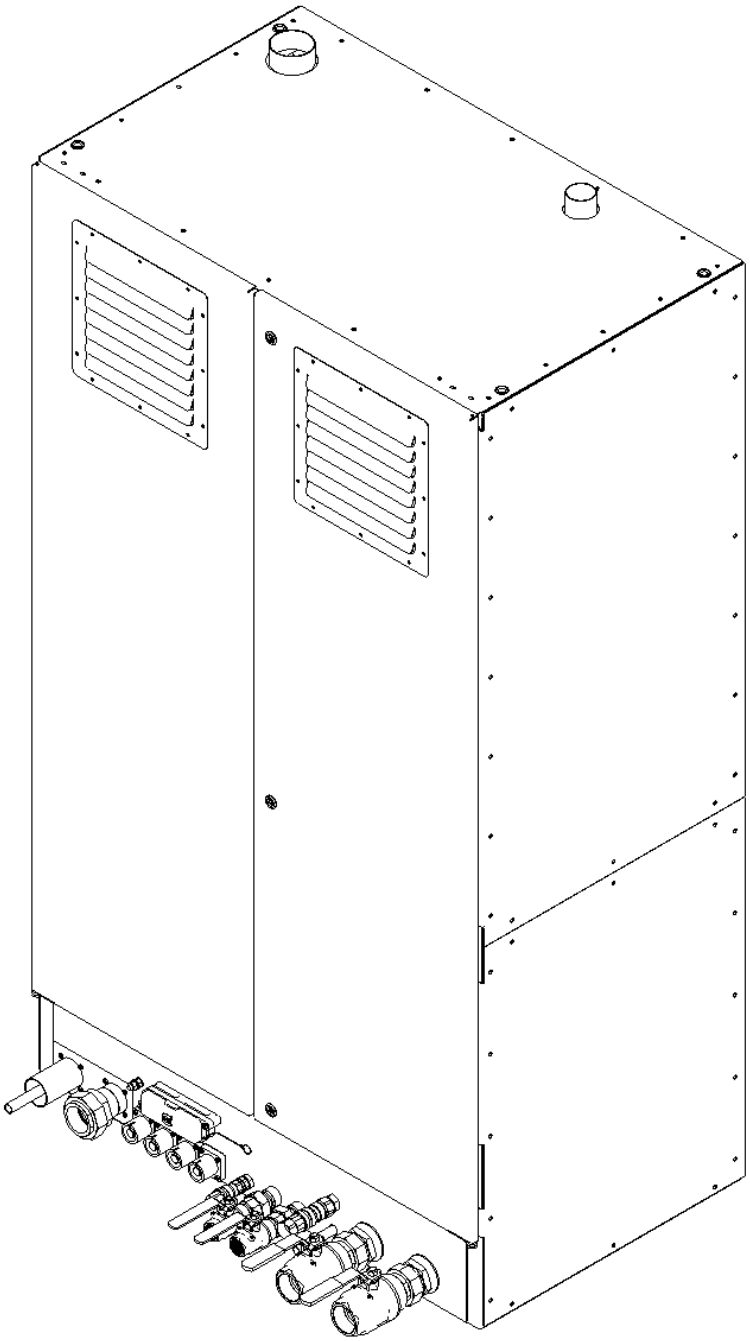


Figure 8 – Isometric view of FCwave™ module.

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10.3. False Floor

The module is designed to be installed in a Fuel Cell Installation Room, with a false floor.

As shown in Figure 9 and Figure 10, the module is designed to mount on a solid floor, with the false floor installed 200mm above (the false floor is not included, it is responsibility of the integrator). The

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200mm space is used to connect process and electrical connections to the module. The false floor will serve as protection for these connections.

The false floor panels should be removable for service access.

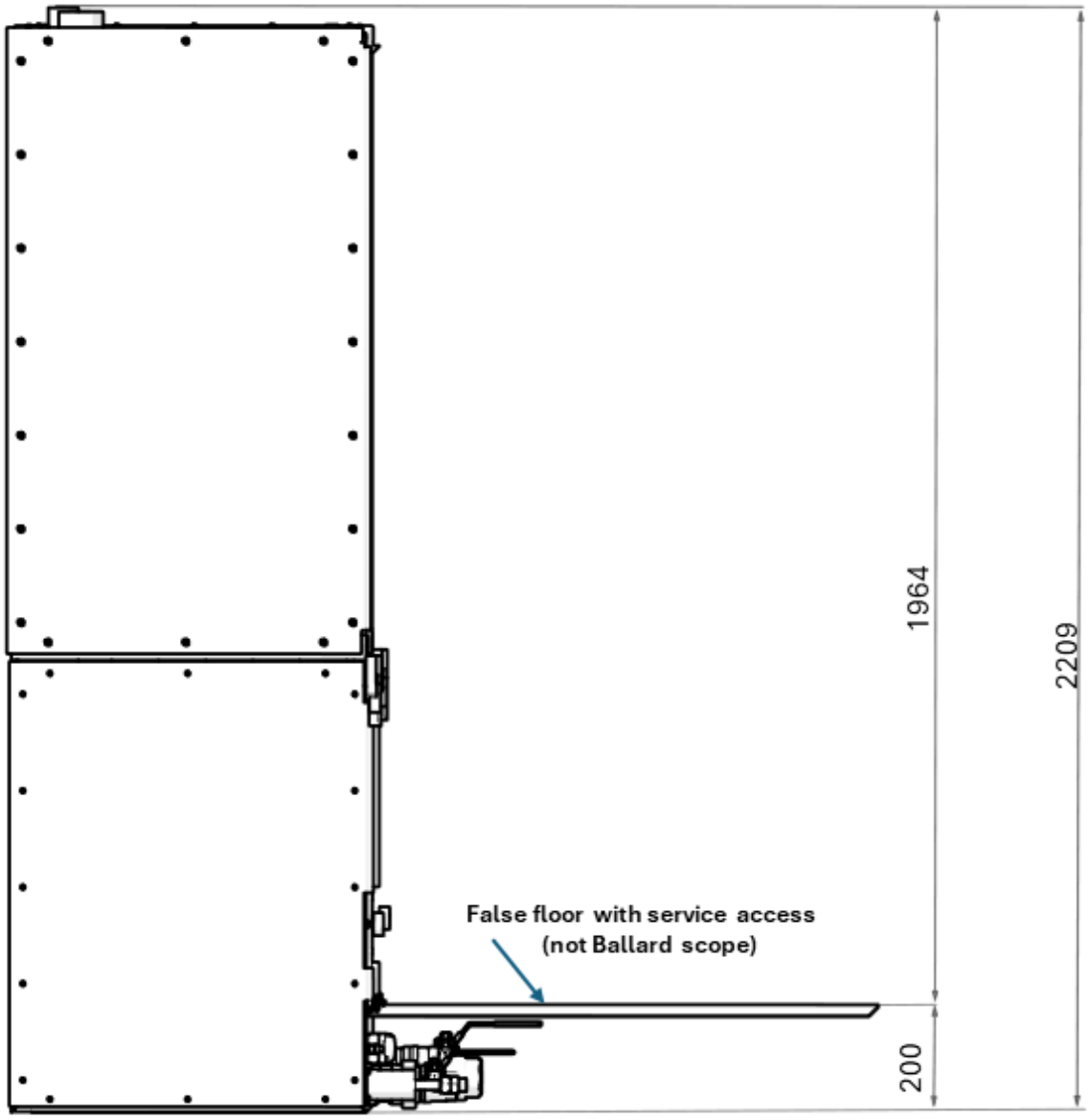


Figure 9 – Module Side View, showing details of False Floor with service access.

[Dimensions in mm]

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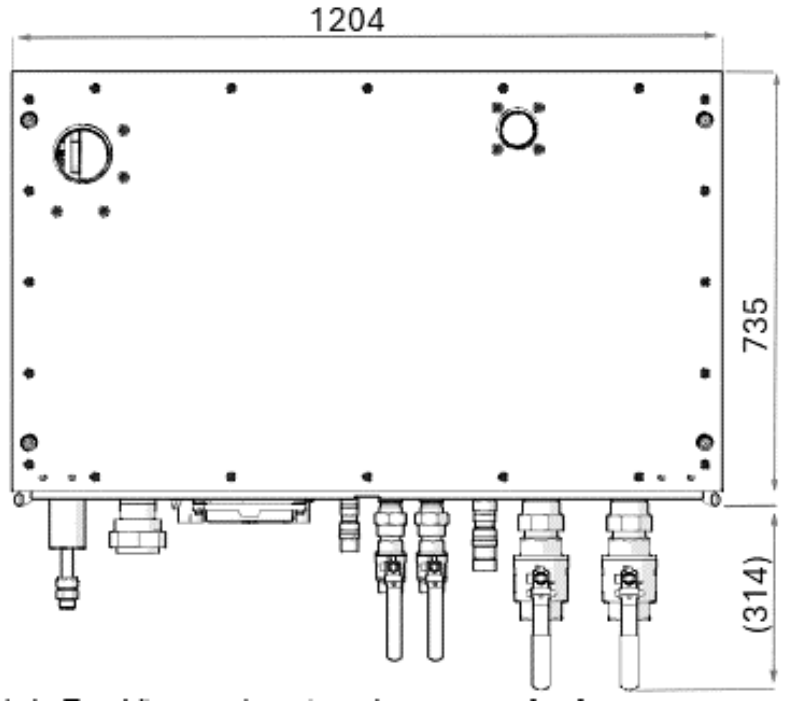


Figure 10 – Module Top View, showing clearances for front process and electrical connectors. [Dimensions in mm].

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10.4. Space Claim for Service Access

The space in front of the module shall be available for service activities. See Table 5 and Figure 11.

Cabinet doors can be wide-opened to 120°. If necessary, demount the cabinet doors for additional service access during maintenance procedures.

The false floor must be designed to carry the weight during service and component replacements, see Table 5.

Specification	
Width	1500 mm
Depth	1100 mm
Height	2300 mm
False floor load capacity	>845 kg

Table 5 – Space Claim for Service Access

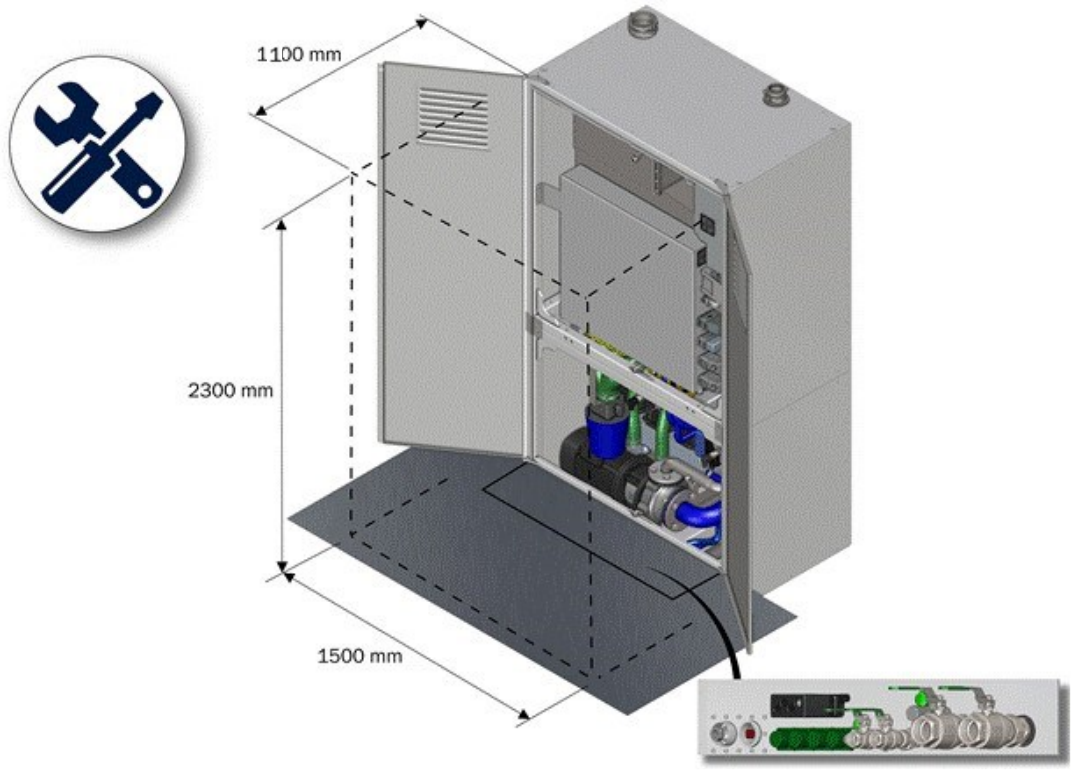


Figure 11 – Space Claim for service access to module.

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10.5. Mounting points and Center of Gravity

Please refer to Ballard document 7001000-01. This document specifies mounting points and center of gravity for a complete FCwave™ module.

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10.6. Module Lifting

When lifting the FCwave™ module during shipping and installation, only use a suitable lifting beam, or equipment design to connect to all four lifting points on the top. Lifting beam and eyebolts are not provided by Ballard.

WARNING **Local regulation for lifting and handling the equipment have to be followed, failure to follow guidelines can cause lifting accident, which leads to personnel injury and damage to equipment.**



Figure 12 – FCwave™ cabinet with lifting beam and eyebolts.

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10.7. Module Split Cabinet

The FCwave™ module can be split in two halves (top and bottom). This separation in halves eases the installation of the module in the Fuel Cell Room (if necessary) and also makes a “top swap” of the Fuel Cell section possible, see Figure 13. This procedure is only to be undertaken by Ballard personnel or people trained by Ballard.

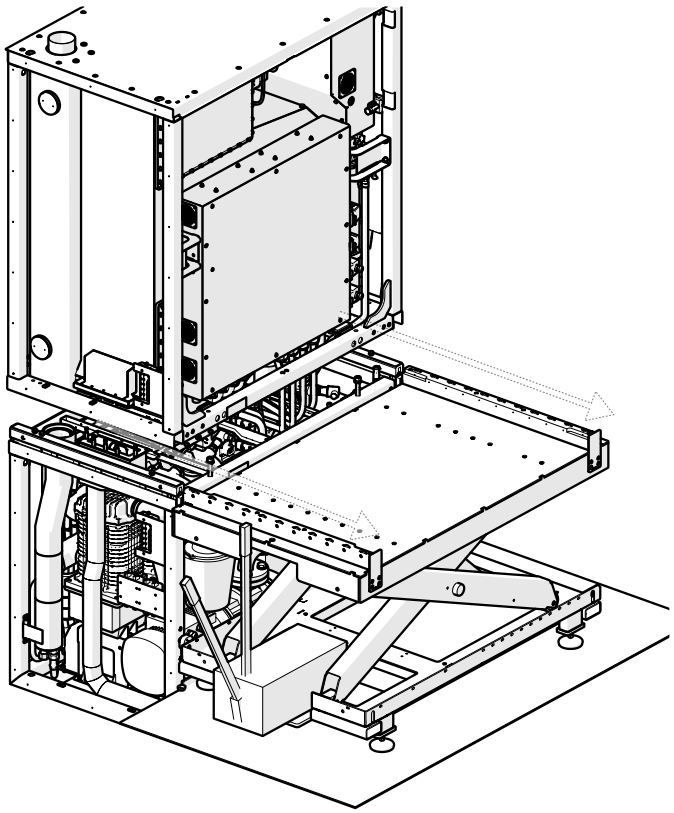


Figure 13 – The module cabinet split into upper and lower sections with lifting cart.

10.8. Lifting on sight

On sight, it is recommended to have a crane in front of the module that can lift the top part of the module and the cart, in case of top module swap. The crane has to be able to go from the module to the exit of the installation room. An example of this crane can be seen in Figure 14.

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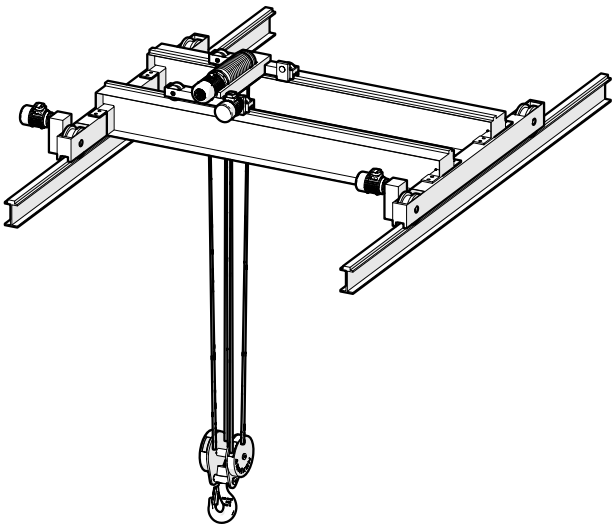


Figure 14 Crane used to move the Top module and the cart.

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11. Fuel Cell Installation Room Requirements

For type approved FCwave™ modules it is required that the fuel cell is installed within a Fuel Cell Installation Room, which must fulfill all requirements from the classification society and IMO.

The compartment in which the fuel cell modules are to be installed are termed the “Fuel Cell Installation Room”, and requirements are presented below in the following sections.

11.1. Structural Requirements for the Installation

This section describes the structural requirements for the Fuel Cell Installation Room, where one or more fuel cell modules are installed. The FCwave™ module shall always be installed in a shelter to protect against weather conditions such as but not limited to, heavy rain, direct sun, extreme heat & cold, dust etc.

1. The FCwave™ must be securely fastened at bottom, back and top.
2. The FCwave™ is designed to be accommodated in a Fuel Cell Installation Room with a false floor, with the hydrogen and electrical supply placed below the floor.
3. Requirements for service access in front of the FCwave™ must be followed, see Figure 11.
4. The Fuel Cell Installation Room free volume should not be less than 10m^3.

11.2. Hydrogen connection

The hydrogen supply connection to the module must fulfill the following requirements:

1. A hydrogen supply shutoff valve with a reaction time less than 2 seconds is required to be installed for each module.
2. The hydrogen flow must be restricted by suitable means such that hydrogen mass flowrate shall not exceed 4.9 g/s.
3. The amount of hydrogen in the fuel cell module must be minimized when not in operation. The physical volume of the pipe between hydrogen shutoff valve and module interface plate is not to exceed 5 liters.
4. For maritime installations, it is a requirement that the pipe between the hydrogen shutoff valve and module interface plate is double-walled, with detection measures for the annular space.

11.3. Process exhaust connection

This section describes the options for process exhaust connections from a FCwave™ module in a Fuel Cell Installation Room:

In all cases, the following apply:

1. Process exhaust must be let to the outside.
2. FCwave™ process exhaust can be fully water saturated and with negligible hydrogen (below <2% of the LFL) content.

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3. The process exhaust must have provision for a drain at the lowest point of the connection, as there will be condensation inside the process piping.[1]

11.4. Module Ventilation exhaust connection

Module ventilation exhaust should be led to a safe exterior location free of any spark or ignition source. The integrator must prevent ingress of water droplets or other debris running backwards into the system through the ventilation exhaust.

The material of the exhaust systems shall withstand the environment, and not be of risk of corrosion clogging due to sediments in the exhaust system. Recommended material is EN 1.4301 / AISI 304 or EN 1.4401 / AISI 316 stainless steel. It is important that no debris or lose sediments enter the FCwave™ .

The exhaust and the ventilation is two separate systems, and should not be joined.

The integrator's side of the ventilation exhaust connection should be done of 1.4404/AISI 316L or 1.401/AISI 304 stainless steel, to minimize the amount of corrosion and other particles accumulating in their walls and the possibility of them falling into the FCwave™.

11.5. Installation Room ventilation

The air handling system in the fuel cell installation room must be sufficient to supply the FCwave™ process air (as specified in section 11.1). Addition ventilation of the fuel cell installation room to be determined by Classification Society or Vessel Integrator.

Ballard recommends performing a calculation according to IEC 60079-10 to establish the required ventilation rate for the fuel cell installation room. In normal operation, all probable leakage scenarios internal to the FCwave™ are managed inside the module.

11.6. Drain connections

It is required that integrator implements backflow prevention from module to module and/or from external source to module(s).

11.7. Safety system

The vessel control and safety system must include visual and audible signaling to crew in appropriate locations.

Recommendation is to clearly indicate which FC module is in operation inside the fuel cell room.

The FCwave™ does not provide an emergency stop button, only an input for one. It is the responsibility of the integrator to install adequate and accessible safety stop buttons or similar, as well as ensure the integration of FCwave™ in the emergency stop circuit (Figure 36).

An uninterruptible power supply must provide a 24VDC output with a maximum voltage deviation of ±10% (applicable to both normal and safety supply) for a duration exceeding 10 minutes, as indicated in Table 25.

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[1] Draining the process exhaust though the FCwave™ module process water drain is not permissible.

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11.8. Fuel Cell Installation Room Access

Access to the fuel cell installation room during operation shall be limited to trained service technicians and personnel that have received Ballard fuel cell training.

Unrestricted access to the fuel cell installation room can be permitted by the vessel authorities when all fuel cell modules are powered off and otherwise deemed permissible.

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12. Process Connections

Process connections for the module are located on the lower part of the front panel, as shown in Figure 15. Annotation references are shown in Table 6.

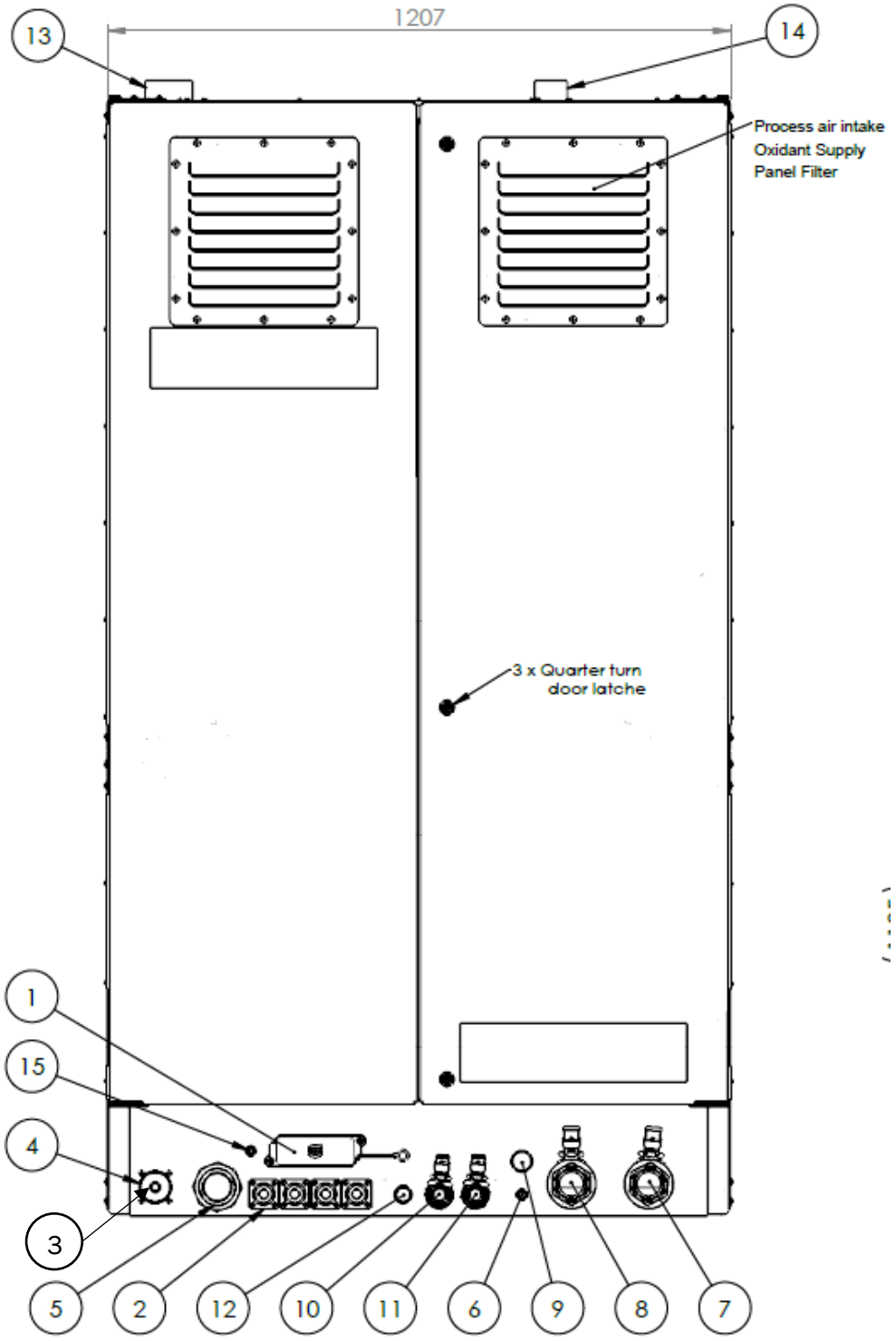


Figure 15 – Detail View of module process connections.

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Process Connections					
Position	Description	Connection	Media	Temperature	Pressure
1	Control and Communication Connector	Harting Male 24HPR	24V DC, Hardwired, CAN bus, Ethernet	n/a	n/a
2	High Voltage Connectors	Amphe-Phase, SLS Panel Source	330-720 VDC, 2*300A or 1*550A	n/a	n/a
3	H2 Supply – Primary Barrier	Ø20 x 1,8mm	Gaseous H2, <4,9 g/s	0 – 80 °C	3,5 – 6,5 barg
4	H2 Supply – Secondary Barrier	Ø60,3 x 2mm	n/a	n/a	n/a
5	H2 Enclosure Ventilation Inlet	DN50 – ISO7/1 R2”	Air, Salt-filtered	<45 °C	Ambient
6	Process Water Drain	Ø18 mm	DI Water	10-70 °C	n/a
7	High Temperature Coolant Out	DN50 – ISO7/1 Rp 2”	Coolant, see section 18.5	dT = 25 °C max 65°C	dP < 0,3 bar
8	High Temperature Coolant In	DN50 – ISO7/1 Rp 2”	Coolant, see section 18.5	5 – 45 °C	<30 barg
9	High Temperature Coolant Fill/Drain	Non-drip coupling G3/4” DN14	Internal Coolant fluid, see section 18.3	10 – 70 °C	<100 mbarg
10	Low Temperature Coolant In/Out	DN25 – ISO7/1 – Rp1”	LT Coolant, see section 19	5 – 50 °C	< 1,5 barg
11	Low Temperature Coolant In/Out	DN25 – ISO7/1 – Rp1”	LT Coolant, see section 19	5 – 50 °C	< 1,5 barg
12	Low Temperature Coolant Fill/Drain	Non-drip coupling G1/2” DN9	LT Coolant, see section 19	5 – 50 °C	< 1,5 barg
13	Process Exhaust	Ø88,9 x 2,0mm	Oxygen-depleted air, DI water droplets. See section 16.5	50 – 80 °C	Backpressure <15mbar @ 12700 lpm
14	H2 Enclosure Ventilation Exhaust	Ø60,3 x 2,0 mm	Air, trace H2 amounts	< 55 °C	Backpressure < 200 Pa @ 750 lpm
15	Grounding stud	M10 Zinc coated copper stud	Grounding point	n/A	n/a

Table 6 – Process Connections, refer to Figure 15.

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12.1. Process Air

The installation section describes the intake and exhaust for process air.

Process air intake is through the air filters on the module door panels, as shown on Figure 8. Integrator shall supply conditioned air to the Fuel Cell Installation Room as described in section 16.2 - Process Air Intake Quality.

The module air exhaust should be connected to an outlet with a drain downstream of the process air outlet to capture liquid that will condensate in the pipe.

Note that the pressure-drop presented by the exhaust piping and any installed equipment must be considered. See section 16.4 and 16.5 for more details.

12.2. Ventilation Air

The module is equipped with active ventilation of the hydrogen carrying sections of the module (Hydrogen Enclosure / “H2E”). The air intake for the ventilation is in the cabinet base of the module, incorporating the hydrogen pipe.

The ventilation fans inside the module are only designed to ventilate the module itself. The fans are not designed to ventilate any double-wall piping arrangement outside the module. The annular space around the primary fuel pipe is welded closed at the interface panel

The integration shall ensure the exhaust from FC modules (ventilation air) is led to a safe location free of any spark or ignition source.

The ventilation inlet and outlet must be equipped with automated fire dampers. The dampers must be closed in case of fire, and before releasing a fire extinguishing system.

12.3. Hydrogen Fuel

The gaseous hydrogen fuel process interface connections are a double wall design, detailed in Figure 16:

Primary Barrier:
Ø20 x 1,8 mm
Welded connection
Secondary Barrier:
Ø60,3mm
Welded connection surrounding the primary barrier.

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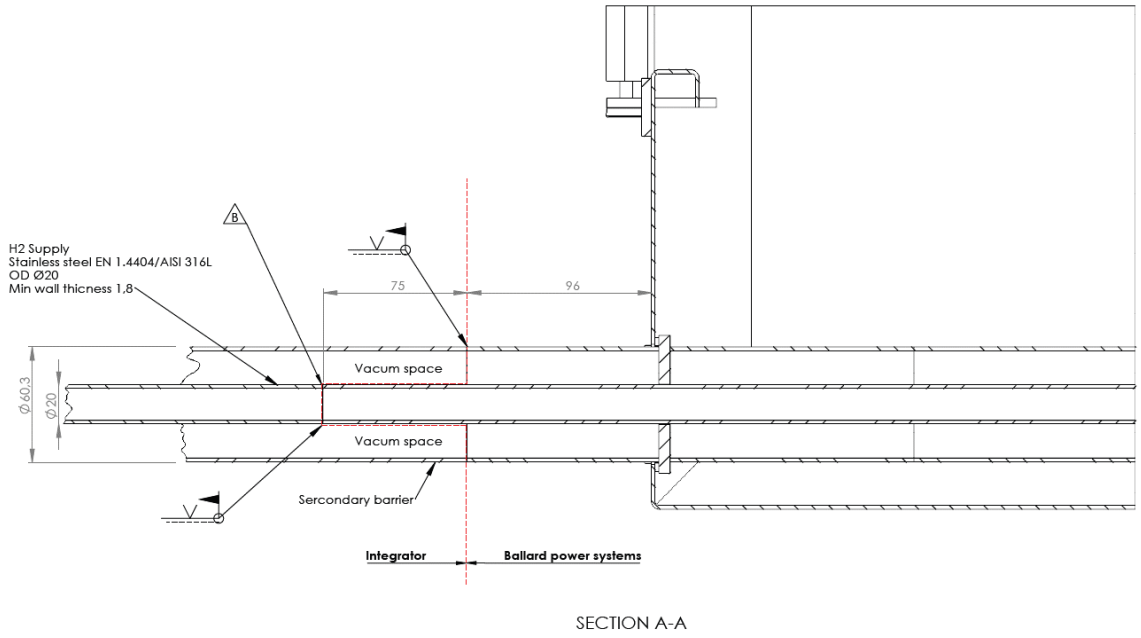


Figure 16 – H2 Supply Connection Detail View.

The space between primary and secondary barrier inside the FC module carries the H2E ventilation air. The space between inner and outer tubes must be ventilated by the integrator in a marine application. For stationary applications no ventilation is needed.

12.4. Welding of Hydrogen pipe

In marine applications, the welding of the double walled pipe has to be performed in accordance with requirements from Classification Societies and Vessel Integrator.

After welding the Hydrogen pipe in on the interface of the FCwave™ system, the welding shall go through a cleaning and pressure test.

Contact Ballard support for details

Cleaning recommendations

When welding of the double walled pipe is completed and approved, cleaning of the hydrogen pipe is required, due to removal of any impurities in the pipe. Cleaning can be performed by blowing with air or Nitrogen.

⚠ CAUTION Contact Ballard service for details regarding this procedure or check the service documentation

Pressure testing recommendations

After cleaning of H2 supply pipe, a pressure test must be carried out.

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CAUTION *Contact Ballard service for details regarding this procedure or check the service documentation*

12.5. Coolant

The integrator is to supply module coolant to both the High Temperature and Low Temperature coolant loop inside the module.

High Temperature Coolant Loop:
Transfers the excess heat produced by the reaction inside the fuel cells to the integrator. See section 18 - High temperature Coolant Subsystem.

Low Temperature Coolant Loop:
Transfers the excess heat produced by the liquid cooled balance of plant components inside the module to the integrator. See 19 - Low Temperature Cooling .

12.6. Process Drain

The integrator is to connect a drain to the Process water drain. This drain separates and leads away the liquid water produced in the reaction and not carried away in the process exhaust.

12.7. Electrical connections

Locate the fuel cell module such that there is enough clearance to access:

The Low Voltage Connector, which provides 24V power to the Control and Safety systems alongside hardwired and bus data connections.
High Voltage DC output connectors, which provide the electrical power produced by the system.

13. Environmental Protection

The module is constructed with the ingress protection rating IP44 for the module (excluding connectors) and IP67 for front panel electrical connectors only.

~~Do not use a direct high pressure water spray on the FC module.~~

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14. Anode Subsystem

This section contains information about the anode (hydrogen) system inside the FCwave™ (Ballard scope) and the upstream hydrogen delivery system (customer scope).

The purpose of the internal hydrogen system is providing hydrogen for the fuel cell stacks. A simplified hydrogen system is shown in Figure 17 – Simplified Hydrogen System.

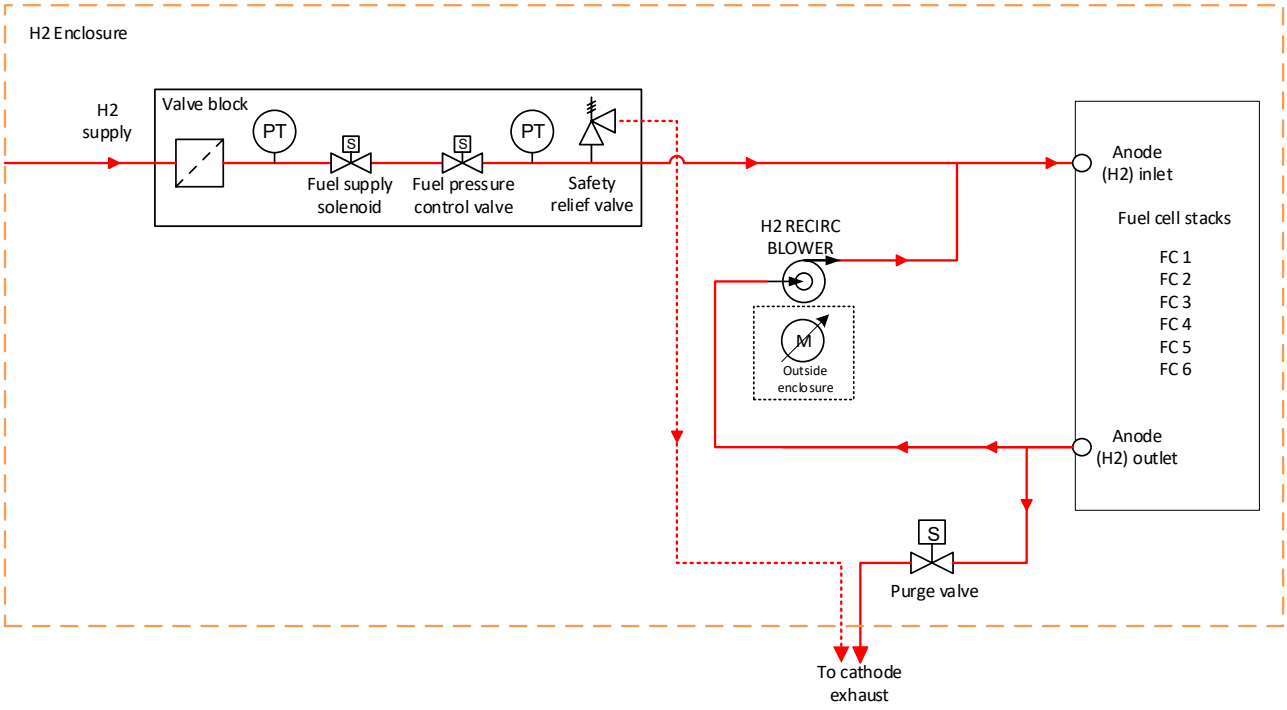


Figure 17 – Simplified Hydrogen System.

14.1. Requirements for upstream H2 delivery system

This section describes the requirements that the integrator must fulfill in the H2 supply system before the module boundary.

Integrator must provide sufficient hydrogen of a quality, pressure and temperature as specified in:

Table 7 – Hydrogen Supply Quality Specification.
Table 8 – Hydrogen Supply Temperature and Pressure Specification.
Table 9 – Hydrogen Supply Flow Rate Specification.

The source of hydrogen may be compressed gas storage, vaporization of liquid hydrogen or reforming of other fuels, if quality, pressure and temperature requirements are met.

Integrator must in accordance with classification society fulfill the requirement of H2 supply pipe leading to module.

Integrator must provide a block and bleed capability upstream of the module. A schematic of this can be seen in Figure 18.

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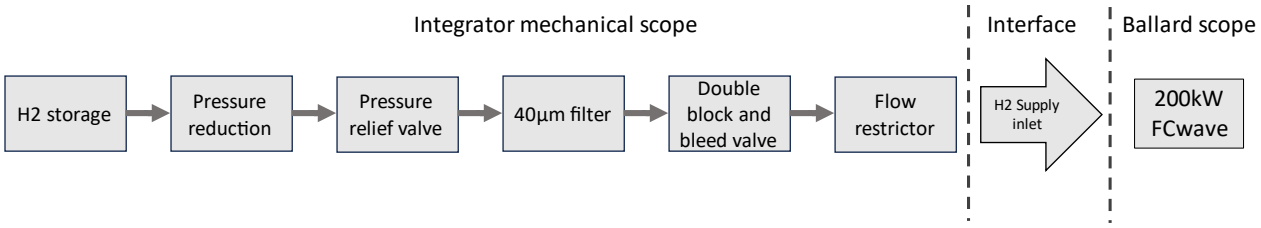


Figure 18-- Installation diagram of the H2 system with integrator and Ballard's parts differentiated.

14.2. Anode System Overview

The fuel cell module anode system is primarily comprised of an internal fuel supply shutoff valve and devices for regulating and conditioning the fuel pressure and water content. A Hydrogen Recirculation Blower (HRB) circulates the hydrogen inside the fuel loop.

A small amount of gas in the hydrogen circuit is purged to maintain acceptable hydrogen concentrations at the stack and remove N2 and water. This purged gas is directed to the process exhaust where it is diluted to a safe concentration by mixing with the process exhaust.

In the unlikely event that the hydrogen loop is over-pressurized, a mechanical pressure relief valve installed on the fuel valve block is in place to safely relieve the pressure (see section 14.3).

Perform a leak check after any service work is done to hydrogen supply fittings and associated piping

Follow the hydrogen supply quality requirements specified in Table 7 – Hydrogen Supply Quality Specification. Both hydrogen quality specifications are acceptable.

Specification	
Hydrogen Quality	SAE J2719:MAR2020
OR	
Hydrogen Quality	ISO 14687:2019 Type I, Type II – Grade D

Table 7 – Hydrogen Supply Quality Specification.

Hydrogen can be sourced from compressed gaseous storage or vaporization of liquid hydrogen if quality and temperature requirements are met.

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Before commissioning and after service on the hydrogen supply system (external to module), a sequence of fill and drain cycles will be needed to ensure the correct hydrogen purity.

For the vessel tank system several fill and drain cycles (especially with new hydrogen storage tanks) will be required as they often come pre-filled with nitrogen or air. Contact the tank manufacturer for the recommended purge procedure.

If the resultant hydrogen purity is questionable, then it is recommended that a sample of the gas be analyzed by a laboratory for its composition. If these purity levels are not achieved, then there can be adverse effects to the performance of the fuel cell stack.

A 40µm filter should be installed directly upstream of the fuel cell module fuel supply inlet to ensure the particulate size requirement is met.

Note: Incomplete purging of the vessels hydrogen tank is often a source of impurity. Ensuring that hydrogen tanks are purged as per the manufacturer's specification is crucial to remove residual inert gases. After purging, it is recommended to have a gas sample analyzed ensure all inert gases are removed from the hydrogen storage system

⚠ CAUTION **Improper purging can often result in conditions leading to irreversible fuel cell damage and may have warranty implications.**

14.3. Hydrogen Supply Temperature and Pressure

When selecting a pressure regulator to install upstream of the fuel cell module, regulator droop[2] and hysteresis should be considered to ensure that the supply pressure is always within the range specified in Table 8.

Specification	
Nominal Inlet Pressure	4,5 barg
Minimum Inlet Pressure	3,5 barg
Maximum Inlet Pressure	6,5 barg
Maximum Inlet Temperature	80 °C
Minimum Inlet Temperature	0 °C

Table 8 – Hydrogen Supply Temperature and Pressure Specification.

Locating a pressure transducer and/or pressure gauge immediately upstream of the fuel cell module can be a valuable tool for troubleshooting hydrogen supply issues.

NOTE: A low pressure relief valve (internal to the module) is vented into the cathode exhaust. Implement overpressure protection in case of a fuel delivery system regulator malfunction. It is recommended that the integrator provide two levels of protection:

Electronic: If a regulating device from a storage is installed upstream ensure following:

Allow for electrical disabling of the fuel delivery system (e.g., remove power from the normally closed solenoid valves using a pressure switch) if the regulator outlet pressure exceeds 10 barg. Set up the system such that the hydrogen

[2] Sometimes referred to as the 'Proportional Band' or 'Offset', droop is an inherent characteristic in all self-operated and pilot-operated regulators. Droop is a decrease in outlet pressure from the set value due to an increase in media flow rate.

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supply will not be switched on automatically when the downstream pressure drops.

Mechanical: Install a pressure relief valve, sized to maintain the pressure less than **10 barg** at maximum flow.

WARNING **Fuel supply overpressure can result in an unsafe situation since it can cause the fuel cell module hydrogen components to fail. It is very important that these components are adequately protected in the event of a hydrogen supply pressure regulator malfunction or failure which results in an overpressure.**

14.4. Hydrogen Supply Flow Rate

Always provide enough hydrogen flow to the fuel cell module. The maximum expected hydrogen flow rates are specified in Table 9.

At this maximum flow rate, the hydrogen supply pressure should remain within the range specified in Table 8.

Integrator **shall** install an orifice restriction such that hydrogen mass flowrate shall not exceed 4,9 g/s.

Specification	
Max H2 Flow (Design)	4,9 g/s
Minimum Flow Operational Flow Full Load [BOL]	3,76 g/s

Table 9 – Hydrogen Supply Flow Rate Specification.

14.5. Module H2 Supply Valve and H2_ENABLE

The integrator is required to install a fuel shutoff solenoid valve directly upstream of the fuel cell module. This valve should be situated as close as possible to the fuel cell module fuel supply inlet to minimize the volume of hydrogen which will remain in the supply line during a shutdown.
The fuel cell module has a hydrogen supply shutoff valve inside the fuel cell module. This valve is meant to stop the flow of fuel into the fuel cell when the fuel cell module transitions from Running to Standby state. It is not designed to be a fuel system isolation/shutoff valve and does not replace the integrator's main fuel shutoff valve.

WARNING **The integrator is to ensure the H2 Supply valve is not used a shutoff method or that this valve is not closed during operation or though the shutdown sequence (see section "25 Control System – State Machine"). Failure to abide by this may result in stack fuel starvation or an alarm condition that will allow the high voltage contactors to open under load.**

WARNING **When shutdown, pressurized hydrogen is trapped in the supply line connected to the fuel cell module. The integrator must provide a means to isolate the supply line and vent any hydrogen remaining in the supply line prior to disconnecting the fuel cell module from the system for service**

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The module provides an output to the integrator (H2_ENABLE), which signals to the vessel that the module requests opening of the H2 Supply Valve. H2_ENABLE is switched to the negative of the 24V supply when active, see Figure 19.
Please note that the H2 Supply Valve is separate from the internal shut-off valve inside the module.

This low-side output switching arrangement allows both module and integrator to control the open/close status of the H2 supply valve for the module.

The integrators H2 supply valve must be of the Normally Closed type.

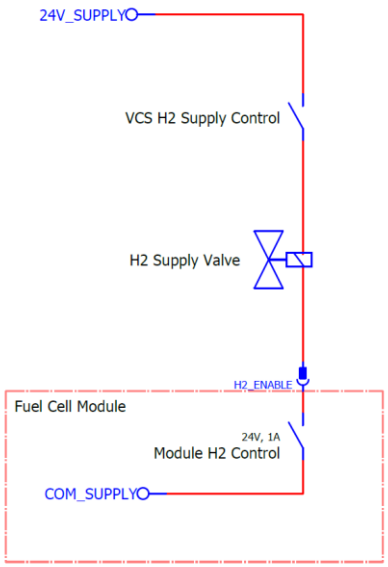


Figure 19 – H_2 Supply Valve Control.

15. Hydrogen Enclosure Ventilation

The module is equipped with active ventilation of the hydrogen carrying sections of the module (Hydrogen Enclosure / “H2E”).

> Integrator is responsible for salt and water droplet filtration from H2E Ventilation air.
> This includes prevention of water droplets running backwards into the system through the ventilation exhaust.

The air intake for the ventilation is in the cabinet base of the module. The ventilation air is in customer scope. Module ventilation shown in Figure 20 – Simplified P&ID for the Module Ventilation system.

The maximum allowable fuel cell module and auxiliary systems ambient temperature is specified in Table 10.

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Specification	
Maximum Fuel Cell Module Ambient Temperature	45°C
Minimum Fuel Cell Module Ambient Temperature	>0°C

Table 10 – Ambient Temperature Specification.

Specification	
Module Ventilation Air Salt Content maximum allowable content	< 20µg/m³

Table 11 – Ventilation Air Salt Content Specification.

The ventilation duct acts as the secondary barrier in the double barrier protection principle.

Two ventilation fans are installed in the ventilation exhaust. The ventilation fans draw air from the inlet through the H2 Enclosure to the ventilation exhaust outlet.

The ventilation air is exhausted out of the upper-most part of the module, and shall be routed to a zone, with no ignition sources within a safe distance.
There is an option for rear facing ventilation exhaust, see section **Error! Reference source not found.**.

Note that the pressure-drop presented by the ventilation exhaust piping and any installed equipment must be considered. See Table 12.

Specification	
Ventilation Exhaust Backpressure (Maximum allowable pressure-drop between at Ventilation air outlet port and atmosphere)	≤2 mBar at 750 lpm
Ventilation inlet pressure drop (Maximum allowable pressure-drop between atmosphere and Ventilation air inlet port)	≤2 mBar at 750 lpm

Table 12 – Air Ventilation Exhaust Backpressure Specification.

The ventilation system is a key safety component, and is under close surveillance, with multiple monitored functions:

Redundancy of fans,
Fan rotation monitoring
Flow monitoring in inlet duct.
Pressure monitoring in hydrogen enclosure
Redundancy on Hydrogen sensors, which will detect any unacceptable levels of hydrogen in the outlet.

NOTE: The hydrogen sensors will need to be accessed periodically as part of preventive maintenance activities.

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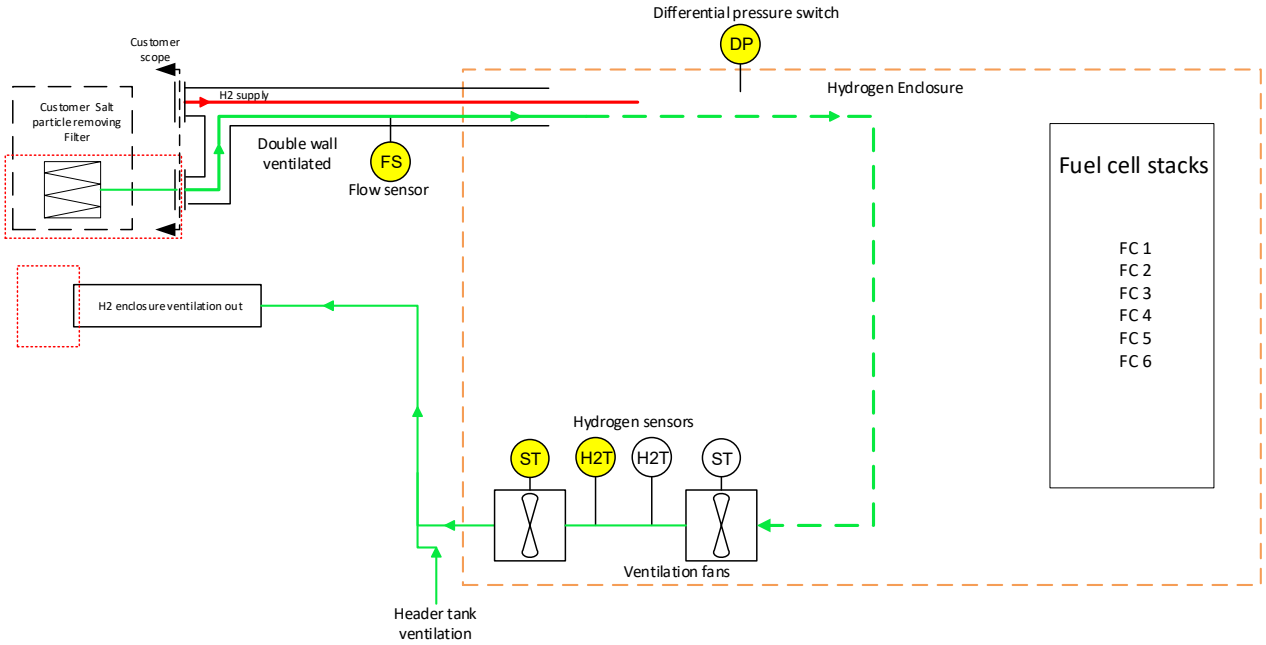


Figure 20 – Simplified P&ID for the Module Ventilation system.

16. Cathode Subsystem

The purpose of the cathode subsystem is to provide oxygen from atmospheric air to the fuel cell stacks. Process air is taken from the fuel cell installation room. It is the integrators responsibility to ensure sufficient air supply to the fuel cell modules as well as the required air quality.

Table 13 Ambient air characteristics necessary for the cathode subsystem.

Specification.	
Air inlet minimum temperature	0°C
Air inlet maximum temperature	+45°C
Maximum allowable salt concentration	< 20µg/m³
Process air pr FCwave™ module[3]	12.700 l/min

16.1. Process Air Subsystem Overview

The process air delivery system will automatically supply the necessary air to the fuel cell module. The amount of process air will depend on the current being drawn from the fuel cell.

[3] Minimum amount of air available at all times while the FC module is running

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The process air delivery subsystem is primarily composed of an intake filter, twin compressors, and air conditioning elements (humidifiers) before air enters the stacks. After the stacks, air exits from the module through the process air exhaust. A simplified process air system is shown in Figure 21.

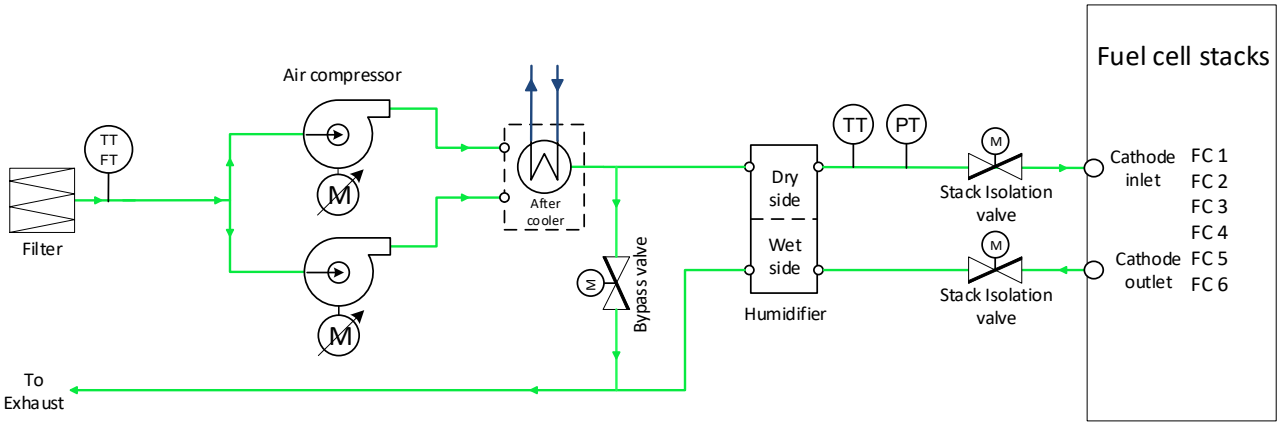


Figure 21 – Simplified Process Air System.

16.2. Process Air Intake Quality

The air filter in the cabinet doors of the module will ensure the purity of the air delivered to the fuel cell stack meets acceptable levels. To increase filter life and improve their performance, the fuel cell room shall be treated to minimize quantity of salts, SOx, NOx and ammonia, as they are quite harmful to the FCwave™ module. The air filter is a service item and part of the preventative maintenance schedule.

Consult Ballard during the integration design for feedback on this topic.

16.3. Process Air Intake

The process air intake is in the top of the two cabinet doors in the module. The air intake must have enough clearance and not be restricted . See Figure 8 – Isometric view of FCwave™ module. The air in the fuel cell room shall be of good quality (as explained above) and come from a non-hazardous zone. There shall be enough free space around the module to ensure sufficient air intake (as explained in section 11.1).

16.4. Process Air Exhaust Backpressure

The process air flow rate capacity of the air delivery system is sensitive to the backpressure exerted at the process air exhaust of the fuel cell module. In vessel integration, the integrator should work to minimize the pressure drop through the exhaust piping and any additional components such as a water separator in the exhaust. The backpressure at this exhaust should not exceed the value in Table 14

Specification	
Item	Value
Process air Exhaust Backpressure (Maximum allowable pressure-drop between the process air outlet port and atmosphere)	≤15 mbar
Average exhaust flow	12.700 lpm

Table 14 – Air Exhaust Backpressure Specification.

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Consult Ballard during the integration design for feedback on this topic.

16.5. Process Air Exhaust Composition

Specification	
Item	Value
Temperature	50-80 °C
Mass flow	100 – 260 g/s (dry basis)
Nitrogen	78 – 92% (dry vol)
Oxygen	7 – 21% (dry vol)
Relative Humidity	~100% RH
Liquid Water	Stack current and coolant temperature specific
Hydrogen	Startup: <1 % (dry vol) Operation: <1 % (dry vol)

Table 15 – Air Exhaust Composition Specification.

The expected composition of the process air exhaust stream is detailed in Table 15.

The process air exhaust will contain oxygen-depleted air, water in liquid and vapor form, and a small amount of hydrogen. The hydrogen component in the process air exhaust is the result of purged gas from the hydrogen circuit.

WARNING Special note should be taken of the reduced oxygen content in the exhaust stream. Personnel is not permitted inside exhaust ducting or other spaces containing fuel cell exhaust with fuel cell operating. All such spaces shall be thoroughly ventilated before personnel is permitted to enter.

16.6. Process Air Exhaust Integrator Requirements

This section describes the requirements to the integrator when designing the process air exhaust from the fuel cell module.

The exhaust piping must be suitable for the temperatures and composition as outlined in Table 15. Note that the air stream contains significant amounts of de-ionized water droplets and vapor. The surface temperatures of the exhaust can be up to 80 °C hot.

The liquid water from the exhaust must be handled by the integrator. As the condensed water will collect in the lowest sections of the exhaust piping, experience has shown that this settlement of liquid could lead to corrosion, freezing during periods of non-operation and intermittent spraying of liquid water out the exhaust pipe. It is recommended that the integrator incorporate a water drain on low sections of the piping.

Note: The drain in the FCwave™ is not intended for draining customer part of the exhaust system.

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17. Process Water Drain

The fuel cell reaction produces DI water, which must be drained from the module from the Process Water Drain.

Refer to section 12 “Process Connections”, in Figure 15, the Process Water Drain is number “6”.

The process water drain piping must be constructed of materials resistant to DI water. Contact Ballard if there are questions regarding material selection.

The Integrator shall ensure the drain does not freeze and block the flow of liquid.

The produced water at 200 kW is ≤ 3 L/min. This is mostly water vapor mixed with the process exhaust.

Only a small percentage of this water will come out the process water drain as liquid.

Specification	
Item	**Value**
Media	De-Ionized Water
Temperature	20 – 70°C
Volume	0 – 3 L/min
Potable Water	No

Table 16 – Process Water Properties and Composition.

18. High temperature Coolant Subsystem

As part of the fuel cell stack operation, heat is developed. The liquid cooled stacks reject heat proportional to the power output. The amount of rejected heat is increased in proportion to stack aging/degradation and load. A simplified coolant circuit is shown in Figure 22 – Simplified HT Coolant Circuit.

18.1. HT Coolant System Overview

The FCwave™ module coolant delivery subsystem contains a coolant pump and motor set with a liquid cooled controller which delivers the required coolant flow to the fuel cell module. The coolant inside the module passes through an internal heat exchanger, where heat is transferred to the external coolant loop, provided by the integrator.

Coolant loop and composition:

Internal Coolant
Allowed cooling medium: High-purity De-ionized water / ethylene glycol 50/50 mix (further options see Table 17 and Table 59)

External Coolant (High Temperature loop) – **Integrator supply**
De-ionized water, fresh water, or glycol mixture. Integrator is responsible for cooling medium and pump.

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A pair of electronically controlled valves are regulating the stack coolant inlet temperature. The valves either throttles the flow of coolant to the heat exchanger or bypass the heat exchanger.

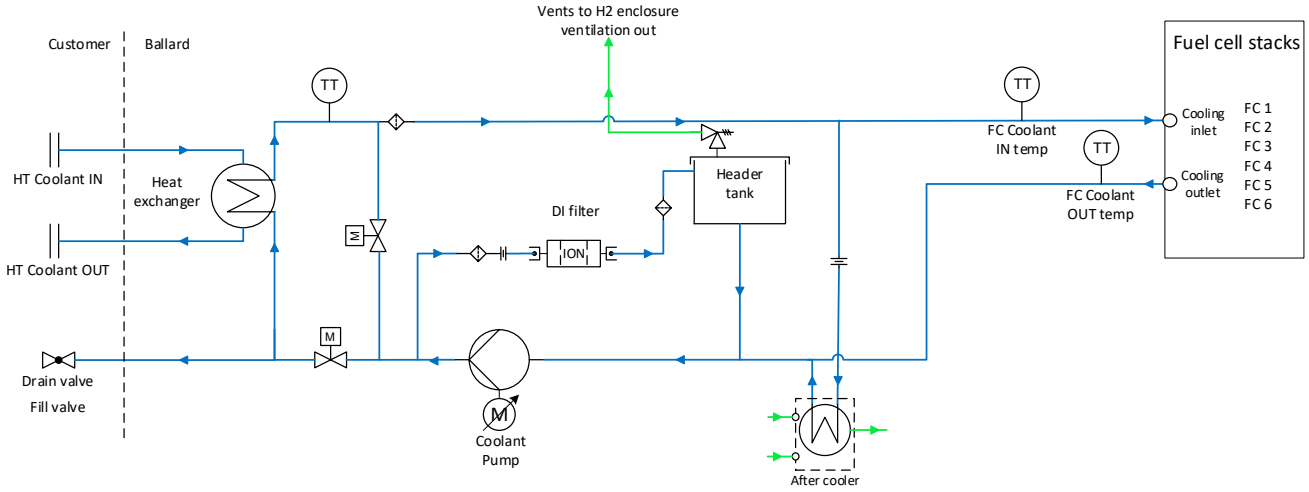


Figure 22 – Simplified HT Coolant Circuit.

During start-up, the coolant valves is positioned to bypass the heat exchanger, allowing coolant to recirculate though the stack, reducing the warm-up time. The internal cooling system also contains a particulate filter to remove any particulate matter present.

18.2. Coolant Chemical Hazard

⚠ CAUTION

The fuel cell coolant loop will contain ethylene glycol. For safety see chapter 8.8

18.3. Internal Coolant Specification

Follow the requirements specified in Table 17 – Module Coolant Specification, ensure that:

- The cooling system can maintain the conductivity below the maximum specified value.
- Adequate clean maintenance practices are in place.
- Any material used in the cooling system is compatible with the coolant type.

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Specification	
Item	Value
Conductivity	≤ 5µS/cm @ 25 °C
Ethylene Glycol Concentration	≤ 50% volume Balance DI Water or 60% volume Balance DI Water[4]
Particulate Size	<100 µm
Chloride Concentration	≤2 ppm
Iron Concentration	≤2 ppm

Table 17 – Module Coolant Specification.

NOTE: High coolant conductivity will result in loss of electrical isolation between the fuel cell high voltage and the system chassis since the coolant circuit can provide a conductive path. The coolant conductivity specified in Table 17 should be suitable for most applications; however, the conductivity required for a specific application may need to be lower to achieve an overall system isolation which satisfies regulatory standards. The integrator should ensure that the conductivity limit chosen is suitable for their application.

To maintain the stack coolant conductivity below the maximum level, a DI filter is installed in the coolant circuit. Part of the overall coolant flow is diverted to the DI filter to continuously remove ions in the water.

Table 18 lists the recommended suppliers for fuel cell grade ethylene glycol mixture. Pure ethylene glycol mixed with deionized water is acceptable (providing the conductivity is <5µs) and deionized water (under **non-freezing** operation). Do not use other coolant types. Pure deionized water (<5µS conductivity) is permissible if the module is used for laboratory operation and is kept above freezing temperatures.

Specification		
Supplier	**Part Number**	**Notes**
BASF	Glysantin J21725	50/50 Ethylene Glycol / DI Water Pre-mixed
BASF / Valvoline	Glysantin FC G 20-00/50	50/50 Ethylene Glycol / DI Water Pre-mixed
Merck	100949	Ethylene Glycol Extra Pure
Univar	610583	50/50 Ethylene Glycol / DI Water Pre-mixed
Univar	1126085	Pure Ethylene Glycol
Univar UK	4338	Pure Monoethylene Glycol
Dynalene	LC-EG	Ethylene Glycol / DI Water Pre-mixed

Table 18 – Coolant Suppliers. Some of these coolants come pre-mixed others need to be diluted. The maximum 50% Ethylene Glycol concentration as mentioned in the specification must be followed.

[4] If the storage temperature after operation is expected to be <-37°C then use 60/40 glycol/DI water mix. The module is pre-flushed with 60/40 glycol/DI before shipping.

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NOTE: It is not recommended to store modules filled with deionized water for more than 7 days, due to its reactivity. Stagnant deionized water has shown an ability to create a corrosion reaction in some components of the module. For extended storage it is recommended to flush the coolant circuit with a water/ethylene glycol mix. Use only coolants shown in Table 18 or consult Ballard Power Systems.

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18.4. Internal Coolant Volume

The coolant volume of the fuel cell module and coolant delivery system is specified in Table 19.

Specification	
Item	Value
Internal coolant system volume	45 L

Table 19 – Module Coolant Volume Specification.

For filling and draining the internal coolant system, see section "18.8 Filling and Draining the Internal Coolant Loop"

The coolant header tank contains no more than 10 liters of volume.

CAUTION **Overpressure of the coolant circuit during filling can cause permanent damage to the fuel cell.**

18.5. External Coolant Specification

The list of permitted coolant compositions for the external primary coolant loop is listed in Table 20.

Specification	
Item	Value
Coolant Medium	DI Water, Water/Glycol mixture
Maximum particulate size	1,2 mm
Maximum pressure	30 barg
Maximum inlet temperature	45 °C

Table 20 – Module External Coolant Specification.

18.6. Coolant Inlet Temperature and Heat Rejection

Maintain the temperature specified in Table 21 for a nominal fuel cell module coolant inlet temperature.

Some comments and considerations for coolant heat rejection and inlet temperature control:

The expected module coolant heat rejection and flow rates at End Of Life (EOL) are specified in Table 21 – HT coolant loop specifications. These values can be used as a guideline for sizing the coolant radiator.

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Specification		
Parameter	**Value**	**Unit**
Coolant inlet temperature nominal	40	°C
Coolant inlet temperature minimum	5	°C
Coolant outlet temperature maximum	65	°C
Coolant loop ΔT	25	°C
Maximum heat dissipation full load EOL	350	kW
Expected mass flowrate cold side [@40°C inlet]	14.015	kg/h
Connections	DN50, 2" ISO7/1	
Pressure drop, Heat exchanger customer side [@ 11.000 kg/h]	< 100	mbar

Table 21 – HT coolant loop specifications.

The expected module coolant heat rejection and flow rates at End Of Life.

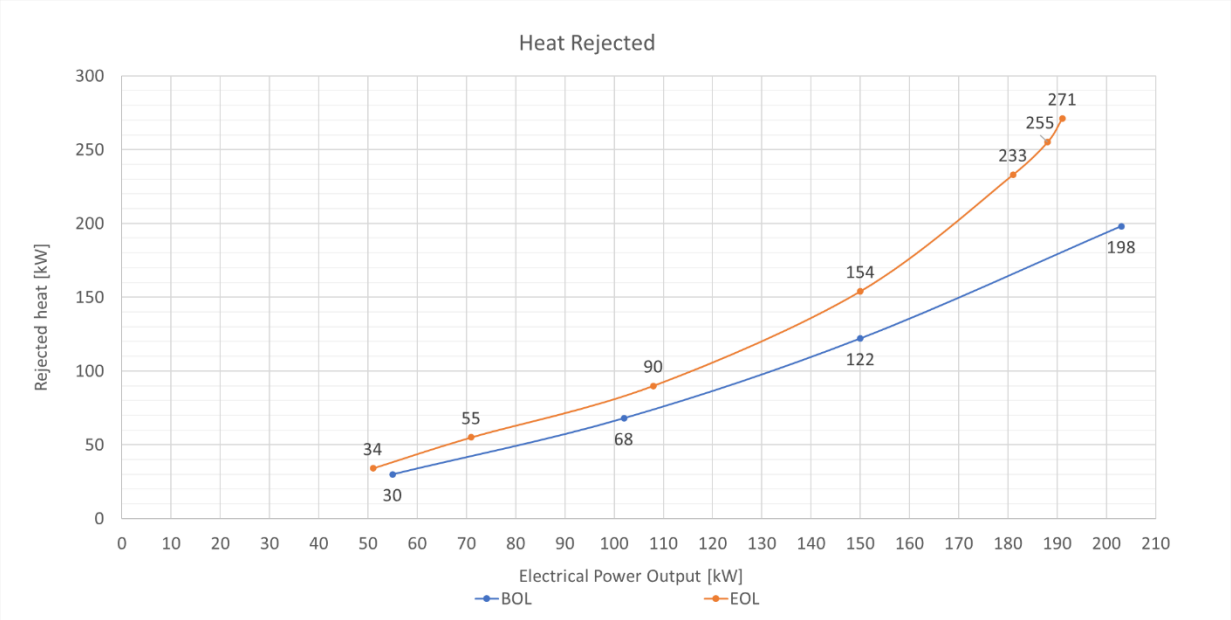


Figure 23 - System Heat Rejection through the heat exchanger vs. Power.

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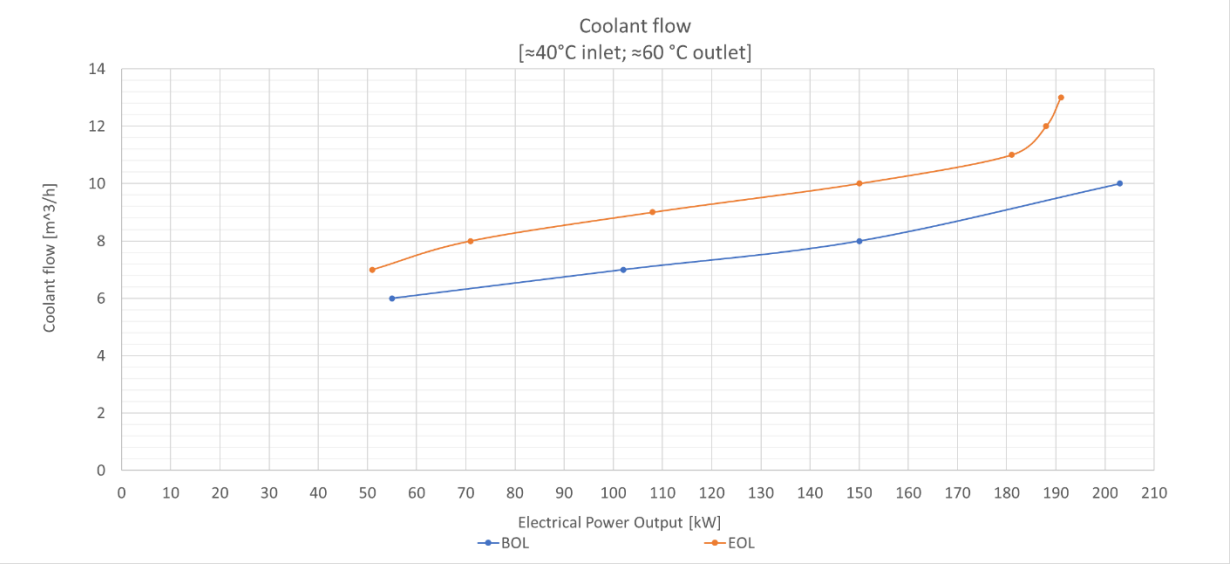


Figure 24 - System Coolant Flow vs. Power (HT customer coolant flow)

18.7. Header Tank of the Coolant System, Air Bleed and Pump Make Up

The module contains an internal header tank for the HT coolant loop, which provides a reservoir of coolant and accommodates thermal expansion of the coolant. There is a low level switch in the header tank to provide warning for low coolant levels.

When filling or draining the module's HT coolant loop, use the makeup connector outlined in Table 6 position 9. Connect an external pump to the connector and use the pump to fill the module with coolant.

When handling coolant, wear personal protective equipment in accordance with the Safety Data Sheet and local regulations. Hydrogen gas may accumulate in the coolant tank. Purge the header tank of said hydrogen prior to servicing. Always wear safety eyewear and eliminate sources of ignition (flames, sparks, electrical tools, etc.) when servicing the header tank.

18.8. Filling and Draining the Internal Coolant Loop

The Internal Coolant loop can be filled and drained by a fill/drain connection on the interface plate of the module. An external pump is connected to this port and used to fill or drain the module.

During filling operations, **do not** overfill the coolant header tank, but continually observe the reading in the sight glass on the header tank. Flowrates and pressure during filling are specified in Table 22.

To perform a filling and draining of the system Service Tier 1 training completion is required.

Specification	
Make-up pressure	Between 200 mbarg and 1 Barg

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Make-up flowrate	< 10 lpm

Table 22 – Module Coolant make up pressure and flowrate.

When changing the coolant inside the module, use the provided fill/drain port (see Figure 15).

It is strongly recommended that the coolant is pumped into the lowest part of the circuit with the use of a small off-board coolant fill pump. When filling the internal coolant circuit, keep an eye on the sight glass on the header tank, where the coolant level is visible.

Care should be taken as to not overpressure the coolant circuit during filling. This can occur if the flow of the coolant being pumped in exceeds the capacity of the header tank vent to relieve the displaced air. It is recommended to install a mechanical pressure relief device at the outlet of the coolant fill pump cart that is set to 1.0 Barg.

19. Low Temperature Cooling System

The fuel cell module also contains a low temperature cooling system. The low temperature cooling system is an independent system used for cooling of:

- Inverter for Cooling Pump motor
- Inverter for Hydrogen Recirculation Blower electrical motor
- Air compressors (2 pcs)
- Inverters for air compressors

The low temperature cooling system is considered as an auxiliary coolant circuit internal to the fuel cell module. Unlike the main cooling system, there is no coolant pump in the auxiliary circuit. The coolant and flow for this system is supplied by the integrator and should comply to the data given in Table 23. Integrator connection to the low temperature cooling system is in the base of the cabinet.

Diagram over the low temperature coolant circuit is shown in Figure 25. Interface connectors are shown in Figure 15.

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Specification		
Parameter	**Value**	**Unit**
Maximum inlet temperature	50	°C
Minimum inlet temperature	5	°C
Maximum inlet pressure	1,5	barg
Maximum heat dissipation	5	kW
Pressure drop	1	barg
Typical flow *[@Δt 10°C; inlet 40°C & outlet 50°C]*	8	L/min
Coolant mix	50/50 Water Glycol mix.[5]	
Connections	DN25 – ISO7/1 – Rp1”	

Table 23 – LT coolant loop specifications.

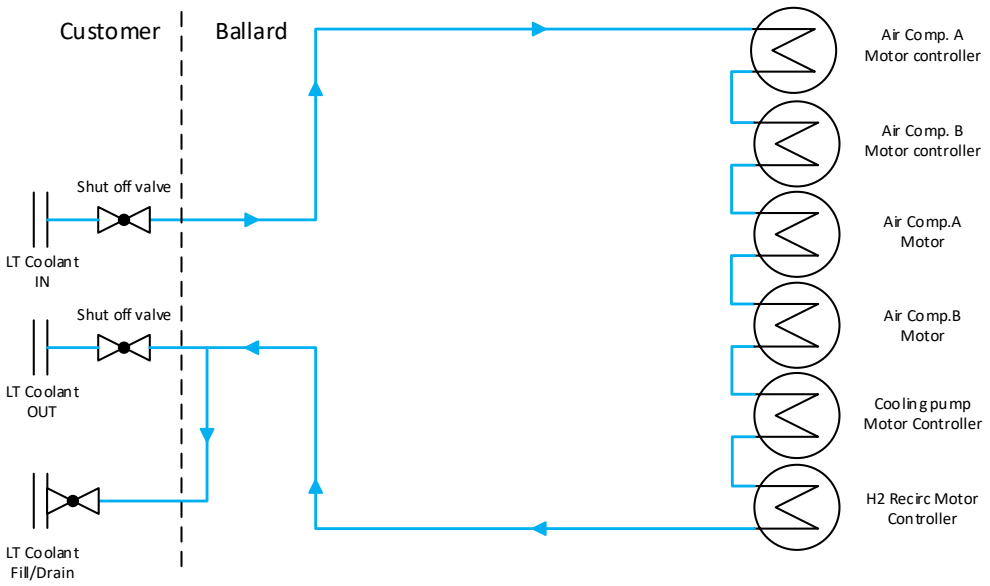


Figure 25 – Low Temperature cooling loop (LT Cooling).

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[5] DI water is not permitted as coolant medium

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20. Gas Freeing and Inerting Procedures

Before performing service on the FCwave™ module, the following must be verified:

- Hydrogen supply line has been depleted
- No dangerous voltages are present in the system

The FCwave™ system includes an automated procedure that must be executed before beginning maintenance procedures, which depletes hydrogen from the supply line and system.

WARNING **Before accessing High Voltage Panel or components inside the Hydrogen Enclosure, all procedures must be followed**

20.1. Inerting procedure – Prepare for Service

This automatic procedure is carried out by request of the Vessel Control System, which activates an automatic subroutine in the FCwave™ fuel cell module which performs the inerting procedure. The function “Prepare for Service” uses the module blowers and compressors to ensure the module is ready for maintenance.

There is no requirement for the integrator to supply inert gas such as Nitrogen.

After completion of the automated procedure, manual verification of voltage must be performed before any maintenance actions.

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21. Control and Electrical Introduction

The purpose of this section is to provide the integrator a high-level overview of the control and electrical systems that comprises the FCwave™ module.

The fuel cell module contains four main control and electrical systems:

- Low voltage electrical (24 VDC)
  - Responsible for supplying all process instrumentation and controllers with power. Contains internal EMC filters and fuses
- High voltage electrical (350-720 VDC)
  - Responsible for supplying power from the fuel cell stacks to the integrator and balance of plant components. Power to start the system is provided by the integrator during the start-up sequence.
- Control System
  - Responsible for monitoring and controlling the processes inside the fuel cell module, communicating with the integrator, datalogging and service functionality
- Safety System
  - Responsible for monitoring the safety and integrity of the fuel cell module. This includes hydrogen concentration measurements, ventilation air flow verification and fire detection.

The following overview includes references to the different aspects of the operation of the FCwave™ module and the sections where they are described. Use Ctrl+Click to jump to the references.

Control System
- Supply
7 FCwave™ Fuel Cell Module Datasheet
22.1 Low Voltage Supply
- Functionality
25 Control System – State Machine
30 Start-up sequence for the FCwave™ module
32 Normal Operation Example
- CAN bus
37.3 CAN Communication
37.4 CAN Customization Key
35.5 Low Voltage Connector Pin Assignment
- Physical connections
34.2 Digital Supply and Signal Definitions
35 Low Voltage Connector Construction
35.5 Low Voltage Connector Pin Assignment
Safety System
- Supply
22.1 Low Voltage Supply
- Functionality
38 Safety System – Functional description
- Physical connections
34.2 Digital Supply and Signal Definitions
35 Low Voltage Connector Construction

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35.5 Low Voltage Connector Pin Assignment
Operating the module
- Establishing communications
37.3 CAN Communication
37.4 CAN Customization Key
37.5 Controller Heartbeat
- Error codes
37.1 Fault Severities
37.2 Resetting a fault
- DCDC Converters
27 Integration with external DCDC Converters
28 DCDC Control Indicators
29 Important limits during operation
30 Start-up sequence for the FCwave™ module
- Operational Sequence
30 Start-up sequence for the FCwave™ module
31 Special Operating States
32 Normal Operation Example
- Precharge
30.3 Pre-charge
- Startup sequence
32.1 Startup Sequence
- Module running
29 Important limits during operation
- Shutdown and after-run process
30.7 Shutdown procedure of the DCDCs
32.4 Shutdown sequence
32.5 Pressure Decay self-test
33 Overnight storage of FCwave

CAUTION **Before operating the FCwave™ module, carefully read through all above points and refer any questions to your Ballard representative. Improper use and handling of the fuel cell may lead to dangerous situations and permanent or temporary damage and performance degradation of the fuel cell module.**

22. Low Voltage Electrical Overview

The control system of the FCwave™ is powered by two 24V DC supply voltages, as specified in CMS006.

The normal 24V supply powers the module controller, module sensors and control voltage for the motor controllers.

The safety 24V supply powers the safety system, safety controller and safety sensors.

The 24V supply voltages are passed through EMI filters before being separated out to the different sub-systems in the module.

The module controllers are powered from the 24V supply and runs continuously while 24V is supplied to the module. Ventilation fans, internal to the module, are also running while 24V is supplied.

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The 24V system is internally fused with resettable electronic circuit breakers.

22.1. Low Voltage Supply

The system is supplied by 24V DC. Please note the voltage tolerance on the 24V supply is narrower than normal 24V marine supply. The Low voltage supply shall be equipped with a UPS system with at least 10 minutes of backup duration. When the UPS system is active, Ballard strongly recommends that the module is brought to a controlled **shutdown** without delay.

Specification	
Control and Safety system supply voltage	24 V DC
Maximum Allowable voltage deviation	±10%

*Table 24 – **Control and Safety system** supply specification.*

Specification	
Control and Safety system supply backup	Uninterruptible Power Supply required
Backup duration	10 minutes

Table 25 – Control and Safety system UPS specification.

22.2. Design Standard and Exceptions

The module control system is designed to comply with EN-60204-1:2018.

The system does not have a bonding between 0 Vdc and chassis/ground.

23. High Voltage Electrical Overview

The FCwave™ module PEM fuel cell stacks are a DC current source, with an output voltage which varies depending on the current drawn from the system. This relationship is shown in Figure 4 – Module output Voltage and Figure 5 – Module Output Current.

The HV DC system must be operated as a floating electrical system, see section 40.1.

During operation, the stacks supply power to the BOP components, internal to the module, making it self-sufficient. As described in section 27.2, external high voltage DC power must be provided during startup. During operation, the fuel cell stacks convert chemical energy from hydrogen to electrical and thermal energy, the rate of which is dependent on the load imposed on the fuel cell module by the external DCDC converters. The fuel cell operates as a load follower, such that the managing of the load is the responsibility of the integrator. To assist in this, the module communicates its operational limits to the integrator over the CAN bus.

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23.1. Pre-charge of the Electrical HV system

The input stages of the motor inverters in the module contain capacitors, which may lead to surges in current draw if directly connected to a high voltage supply without current limiting measures in place.

The FCwave™ module contain equipment and control sequences for gradually charging the internal capacitances such that current surges are avoided.

The pre-charge sequence is detailed in section “30.3 Pre-charge”

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24. Control and Safety System Overview

The control and safety system of the Module is comprised of the following, illustrated in Figure 26:

- **Module Control Unit**
  - Responsible for control of the fuel cell and balance of plant components.
  - Monitors and controls the state of reactants and power flowing to and from the module.
  - Monitors and reacts to system conditions, including hydrogen concentration measurements.
  - Transfers data logs to Ballard when able to establish communication with the Internet (via encrypted connection)
- **Safety Control Unit**
  - Responsible for monitoring safety of the module via independent sensors and inputs. Provides hardwire signals to and from the vessel.
  - Independent from Module Control Unit, triggers emergency shutdown of module when it detects an emergency.

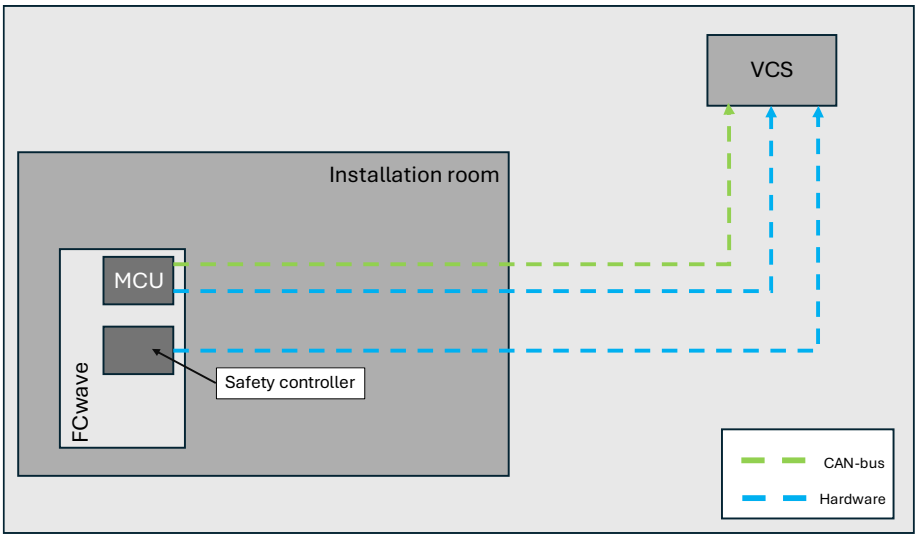


Figure 26 – Control System Architecture.

25. Control System – State Machine

The module control is based on a state machine, in which states correspond to the operating mode of the fuel cell. These states are communicated to the integrator over the CAN bus.

25.1. Introduction

In normal operation, inputs from the integrator causes the state machine to transition from the initial "Locked" state towards the "Running" state, in which the fuel cell is in operation.

The states are enumerated in Table 26. Please note that some states contain internal sub-states.

The normal high-level sequence of states for the fuel cell module, as well as the customer signals, required to initiate the various state changes, is shown in Figure 27 – High Level State Sequence.

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Estimates of power flow, to and from the fuel cell, during the state sequence and the approximate timing of **Startup** and **Shutdown** sequences, are also shown.

The integrator should follow the diagram for the control signal sequence to ensure safe operation of the module.

State	Description
Locked	The module controller is active, after receiving the **SAFE_IN** signal (see Table 41) but will remain in **Locked** state until the correct CAN customization key is received.
Unlocked	Correct CAN customization key received from the drive system (see Section 37.4). High Voltage circuits are depowered.
Pre-charge	The module pre-charge internal HV circuit. When pre-charge is complete, module enters **Standby.**
Standby	The module is waiting for the **MODULE_RUN** CAN signal to start the fuel cell. Module HV bus is connected to Vessel. Stack contactors are open.
Prepare for maintenance	This state provides a function for depleting the module of hydrogen to prepare for maintenance.
Startup	A sequence of steps that power up the fuel cell stacks and prepare the module to provide power. Air and hydrogen start flowing to the fuel cell module. Fuel cell stack voltage will rise. High voltage output contactors are closed. Note: This state contains sub-states internally.
Running	The module will set I_ALLOW > 0 Amps and current can be drawn from the fuel cell (see Section 32.1).
Shutdown	Water is purged from the reactant gas circuits and a controlled bleed down of voltage from the stack is performed. Module state will return to Unlocked. Note: This state contains sub-states internally.

Table 26 – System Operating States and Descriptions.

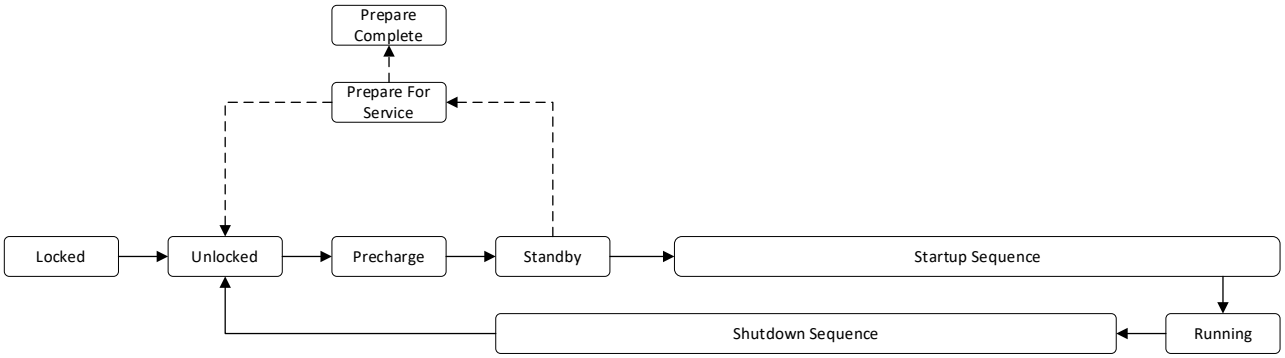


Figure 27 – High Level State Sequence for FCwave.

A more detailed overview of the module state machine is available in section 28 " DCDC Control Indicators", Figure 29 – FCwave™ State machine with DCDC Indicators.

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26. Ballard Master Control Unit

The module can be operated from a Vessel Control System directly, or if several FCwave™ modules are present, they can be controlled from a Ballard Master Control Unit.

For questions regarding the master control unit, contact Ballard.

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27. Integration with external DCDC Converters

The fuel cell module is a DC power source and operates as a load follower, with the external DCDC operating as load controller. This makes it extremely important to have the right understanding of the fuel cell module operation when designing the DCDC control.

27.1. Requirements for external DCDC converters

This section describes the functional requirements for the DCDC converters connected to the high voltage DC outputs.

These requirements are valid for bi-directional DCDC converters, which can provide power to the module during startup. For other configurations, please contact Ballard Europe.

For control specification for the DCDC converter(s), see section 30.6 “Startup procedure of DCDCs” and section 30.7 “Shutdown procedure of the DCDCs”.

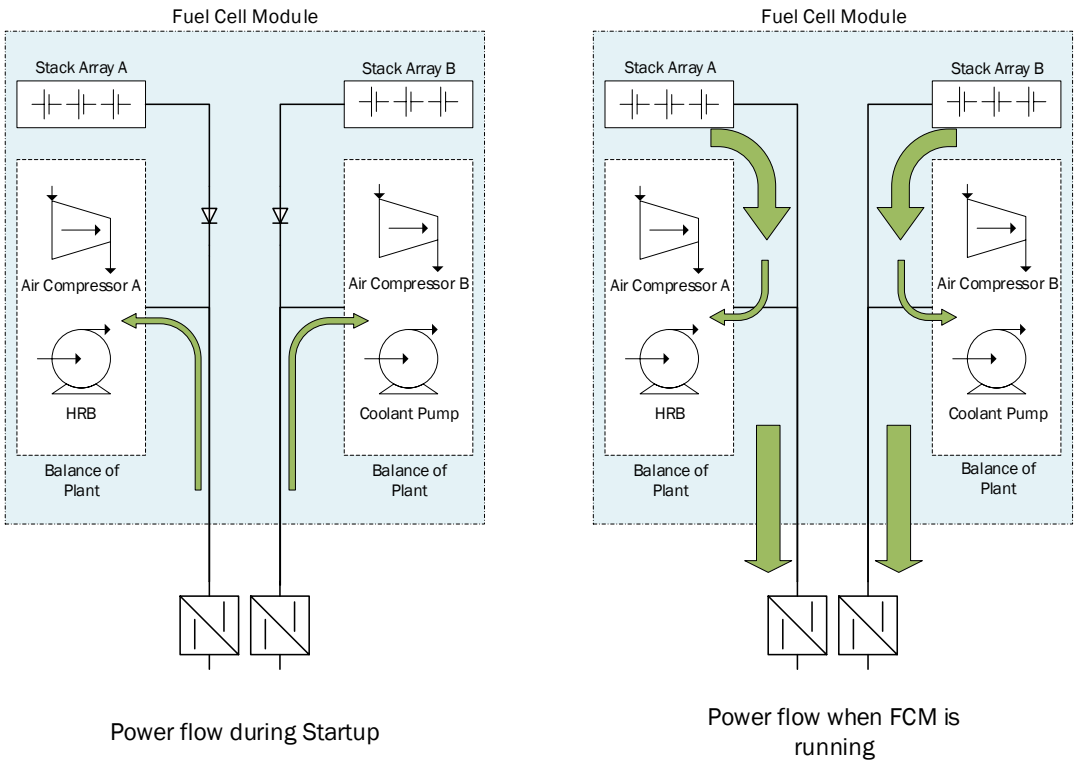


Figure 28 – Power flow to and from FCM during startup and run mode.

Dual Output configuration shown.

27.2. Role of the DCDC converters

The role of the DCDC converters is twofold:

During module startup, DCDC(s) must source power to the Balance of Plant (BOP) components of the module. After startup, the BOP components are powered by the stacks, directly.

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During normal operation, regulate the current drawn from the module, within the specified limits of I_Allow and the vessel operator.

Proper integration between the DCDC and the module is essential, as the module is a load-follower with dynamic and static limitations that the module cannot enforce by itself.

These limitations are communicated to the integrator via CAN bus (see section 37.2), and the integrator is responsible for respecting them when supplying power to the vessel.

27.3. Functional Requirements

Two converters are to be connected to the module for the dual output configuration.
Single converter is to be connected to the module for the single output configuration.
Converters must be able to handle voltages and currents as specified in CMS006 “FCwave™ Fuel Cell Module Datasheet”.
When the converter is drawing power from module to the vessel DC bus (power supplied from module to vessel):
The converter must be able to operate in constant-current (CC) mode, or a functionally identical mode. The setpoint must be on the input side.
The converter must have input side high and low voltage limits.
Stack voltage measurement is provided by the module controller and provided to integrator over CAN bus.
Output voltage and current limits are solely the responsibility of the integrator.
When the converter is drawing power form the vessel DC bus and supplying to the module (sourcing from vessel to module):
The converter must be able to operate in constant-voltage (CV) mode. The setpoint must be set on the input side.
The setpoint for the CV operation is received over CAN bus from the module and will in the range from 300 to 500 VDC.
During CV operation, the voltage must be within ±5% of setpoint. Below 2% deviation is preferred.
The CV operational mode shall implement a current-limiting function on the input side, which ensures the safety of the system.
The current draw from the module will start high and fall to 0 as BOP load transitions from external DCDCs to the internal stacks. The DCDC must allow the voltage to increase above the setpoint without exporting power from the module. Power needs during startup is detailed in section 32.2 “Startup Energy Consumption”.
Voltage ripple during operation shall not exceed 5% nominal voltage during the full range of operation. Voltage ripple of less than 2% is preferred.

27.4. DCDC Converters during start up

When the customer wishes to operate the fuel cell module, external power must be supplied.
As the stacks require both oxygen and hydrogen, the air compressor and hydrogen recirculation system must operate before the stacks can supply power.

To operate the module successfully, the DCDC must adhere to the procedures, described below and illustrated in Figure 28:

During module startup, DCDC(s) must source power to the Balance of Plant (BOP) components of the module. After startup, the BOP components are powered by the stacks, directly.

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During normal operation, regulate the current drawn from the module, within the specified limits of I_Allow and the vessel operator.
See the section 28 “DCDC Control Indicators” which describe when the DCDC converters are to operate in which direction and mode.

The voltage and current requirements are detailed in section 30.6 “Startup procedure of DCDCs”.

27.5. DCDC Converters during operation

During the “Running” state of the module, the DCDC converters are required to operate in constant current mode, with the setpoint set at the input side (towards module).

27.6. Definitions

- All voltages and currents are Direct Current.
- Power flow **from** Fuel Cell Module **to** rest of vessel is defined as positive direction.
  - Current flowing from module is denoted I > 0.
  - Current flowing from vessel to module (e.g., during startup) is I < 0.
- Input of the DCDC converter is defined to be towards the fuel cell module.
- Output of the DCDC converter is defined to be towards the vessel drivetrain.
- In dual output configuration, the DCDC converter connected to stack string A is referred to as “Converter A” or “CNV A” in abbreviated terms. “Converter B” or “CNV B” is similarly connected to stack string B.
- $I_{OutputA}$ is the current flowing from module to Converter A
- $I_{OutputB}$ is the current flowing from module to Converter B

27.7. DCDC Technical Requirements

This section describes the validated specifications for the external DCDC converters.

Product validation and EMC testing has been performed with DCDC converter switching frequency of 4kHz and 5kHz. If the integrator wishes to use switching frequencies outside the validated range, contact Ballard. If there are questions about using bigger DCDC converters, ask Ballard.

Specification		
External DCDC Converter switching frequency	Minimum	4 kHz
	Maximum	5 kHz
Voltage Ripple	Maximum	5% peak-peak
	Preferred	2% peak-peak
Maximum DCDC size	< 400kW	

Table 27 – DCDC Converter requirements.

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28. DCDC Control Indicators

This section describes the function of several indicator bits, transmitted over the CAN bus to the integrator. These bits indicate the desired operating mode of the connect DCDC converters.

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The bits are transmitted in the CAN Message "FCM_REQUEST_1" and are defined as follows:

- **DCDC_STOP**
  - This bit, if active, signals that the Fuel Cell does not require the DCDC converter to be active and it should not be actively modulating.
- **DCDC_IMPORT**
  - This bit, if active, signals that the Fuel Cell requests that the DCDC converter is active and operates in constant voltage mode towards the fuel cell module. Desired voltage setpoints and current limits are transmitted in the "FCM_REQUEST_2" CAN message.
- **DCDC_EXPORT**
  - This bit, if active, signals that the Fuel Cell is ready to provide power to the vessel and the DCDC converter should be active and operating in constant current mode towards the vessel. Current limitations are described in the following sections:
    - Section 29 - Important limits during operation.
    - Section 29.5 - Ramp rates

The DCDC Control Indicators are illustrated in Figure 29 – FCwave™ State machine with DCDC Indicators.

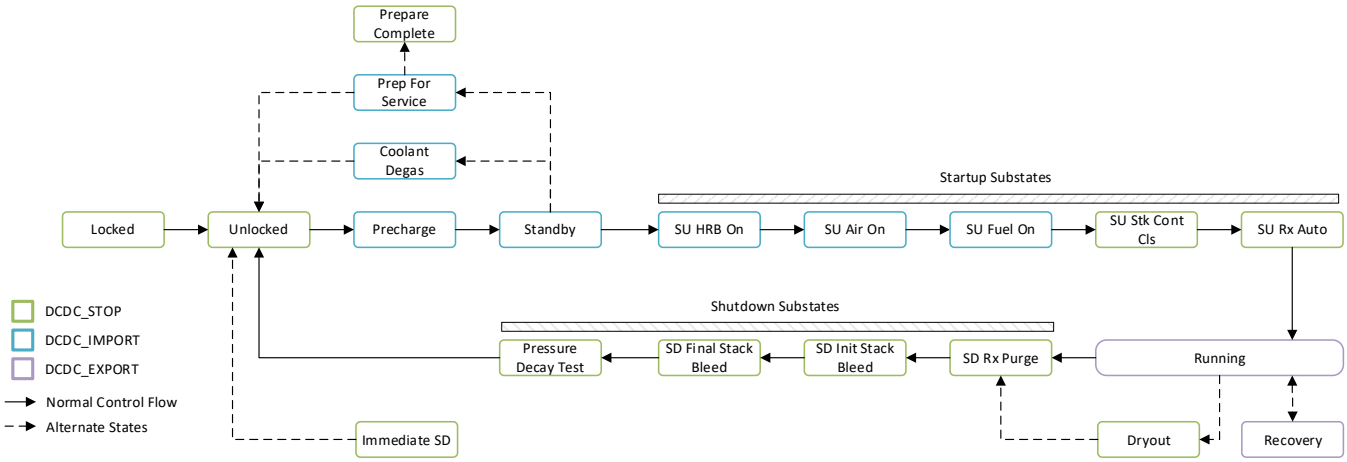


Figure 29 – FCwave™ State machine with DCDC Indicators.

28.1. DCDC_STOP Control Indicator

In case the DCDC_STOP control indicator is active, the module requests no action from the connected DCDC converters. They can be in standby mode, but no active modulation.

The DCDC_STOP control indicator is active during the following states:

- When the module is in Locked and Unlocked states
- When the module is in the shutdown sequence after operating
- When the module is in the later part of the **Startup** sequence
- When the module is in the **Dry-out** or **Prepare for Service Complete** state (see section 31 "Special Operating States")

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28.2. DCDC_IMPORT Control Indicator

In case the DCDC_IMPORT control indicator is active, the module requests that the connected DCDC converter is active, operating in Constant Voltage mode with constant voltage towards the fuel cell module.

The DCDC_IMPORT Control Indicator is active during the following states:

When the module is in **Pre-charge** and **Standby** states.
When the module is in the early part of the **Startup** sequence
Please note that the module becomes self-powering after the SU Fuel On state, as both hydrogen and oxygen is present in the stacks, therefore the DCDC is stopped until the module reaches Running state
When the module is in the **Coolant Degas** or **Prepare for Service** state (see section 31 “Special Operating States”)

28.3. DCDC_EXPORT Control Indicator

In case the DCDC_EXPORT control indicator is active, the module requests that the connected DCDC converter is active, operating in Constant Current mode, exporting power from the fuel cell module to the DC-bus.

Current limitations are described in the following sections:

- Section 29 - Important limits during operation
- Section 29.5 - Ramp rates

The DCDC_EXPORT Control Indicator is active during the following states:

When the module is in the Running state
When the module is in the Recovery state (see section 31 “Special Operating States”)

29. Important limits during operation

29.1. Minimum and Startup Current Draw

The fuel cell module has a minimum current draw of 50A for each stack string at BOL (Equivalent to approx. 55 kW) from the module. Operating at a power level below this, for an extended period, will reduce stack lifetime. If the customer current draw is below the minimum level, for more than 10-20 seconds, the module will shut down in a controlled fashion and report an error code to the operator. For a single output module, the value is doubled (100A minimum current draw)

During startup, it is recommended that the initial current is 10A (20A for single output configuration), (see Table 28 – Initial Current Draw Specification) and then ramped to minimum current draw with the ramp rate specified in section 29.5 “Ramp rates”

Specification	
Single Output Configuration – Initial Current Draw	20 A
Dual Output Configuration – Initial Current Draw	10 A

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Table 28 – Initial Current Draw Specification.

29.2. I_Allow and I_Offset

The fuel cell controller will report a maximum allowable instantaneous current draw for the stacks (*I_Allow*) as part of the CAN message transmitted by the Fuel Cell – the message is transmitted with a 100 ms interval.

The Module Control Unit will also report a desired offset between the stack strings, which serves to balance load between components and extend lifetime of the stacks. This parameter is not used in single output systems

- Single Output Configuration:
  - The I_Allow parameter is the maximum allowable current draw from the system. Current draw is never to exceed this value
  - The I_Offset parameter is disregarded.

- Dual Output Configuration:
  - The I_Allow parameter is the maximum allowable current that can be drawn from each string. Current draw for each string is never to exceed this value.
  - The module transmits the I_Offset parameter, which should be added to the current draw from string A and subtracted to the current draw from string B
  - The I_Offset parameter is signed, and a positive value indicates that a higher current should be drawn from string A than string B
  - I_Offset is capped at ±7,5A.

$$I_{OutputA} < I_{Allow}$$

$$I_{OutputB} < I_{Allow}$$

$$I_{OutputA} = I_{Output} + I_{Offset}$$

$$I_{OutputB} = I_{Output} - I_{Offset}$$

Where:

I_{Output} is the current as desired by the customer
$I_{OutputA}$ is the current setpoint for the DCDC converter attached to Output A
$I_{OutputB}$ is the current setpoint for the DCDC converter attached to Output B
I_{Allow} is the maximum instantaneous current draw, transmitted from the Module Control Unit via CAN bus
I_{Offset} is the desired offset between $I_{OutputA}$ and $I_{OutputB}$.

Example:

- Dual Output Configuration

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- I_{Output} is 200A
- I_{Allow} is 250A
- I_{Offset} is +2A
- In this example, the current draw from the DCDC converters ($I_{OutputA}$ and $I_{OutputB}$) must be below 250A and $I_{OutputA}$ should be 202A and $I_{OutputB}$ should be 198A.

29.3. Origin of the I_Allow parameter

The default current limit is set based on maintaining a minimum air stoichiometric ratio, with a maximum allowable current. Computations are then made to determine whether any other factors should be limiting the stack current below its default value. If any of these computations lead to a lower maximum allowable current than the default, module output is de-rated.

Exceeding I_Allow for more than 3 sec will result in an immediate shutdown procedure, to protect the module.

In order to obtain best long-term performance from the module, it is recommended to follow the current-ramp, described in section 29.5.

29.4. Reverse current protection during start-up operation

During startup, the following precautions are taken to prevent reverse polarization of the stacks:

HV system is isolated from stacks via diodes.
HV system is pre-charged gradually, to prevent sudden voltage and current spikes.
The permissible voltage range is transmitted to the integrator over CAN bus.
Voltage is measured inside the module and compared to the acceptable range.
Current limitations are transmitted to integrator over CAN bus. Integrator is responsible for ensuring that the DCDC(s) operate within this range.

If any parameters deviate from allowed ranges, start-up is aborted, and module returns to the 'unlocked' state. Module may open HV contactors to isolate itself if parameters are outside acceptable range. This is done in all alarm severity 3 and safety severity 4 situations.

⚠WARNING Reverse polarization of the stacks must be prevented. This occurs when a voltage, higher than the stack voltage, is applied to the system. A direct consequence of this is rapid heating, hydrogen development and irreversible damage to the stacks.

In worst-case, rapid heating and hydrogen development can lead to detonation or deflagration of present or developed hydrogen, inside the module.

29.5. Ramp rates

As described in section 29 "Important limits", the ability of the fuel cell module to respond to dynamic changes in current draw is bounded.

For longevity of the stacks and balance of plant components, it is recommended to avoid rapid cycling of the current draw, as this will lead to excessive wear on stacks and BOP components.

Ballard recommends that current draw, during normal operation, follows the current vs. time graph shown in Figure 30 – Current/Time ramp for operation of external DCDCs.

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Specification	
Single Output Configuration - Maximum increase/decrease in current draw	40 A/s
Dual Output Configuration - Maximum increase/decrease in current draw (each output)	20 A/s

Table 29 – Current Draw Delta Specification.

Please note that in some shutdown conditions, the I_Allow parameter will decrease more rapidly than specified in Table 29.

Current draw must never exceed I_Allow, which may decrease (or become 0) more rapidly than specified ramp rates. In this case, converter current draw must be immediately reduced to I_Allow or less.

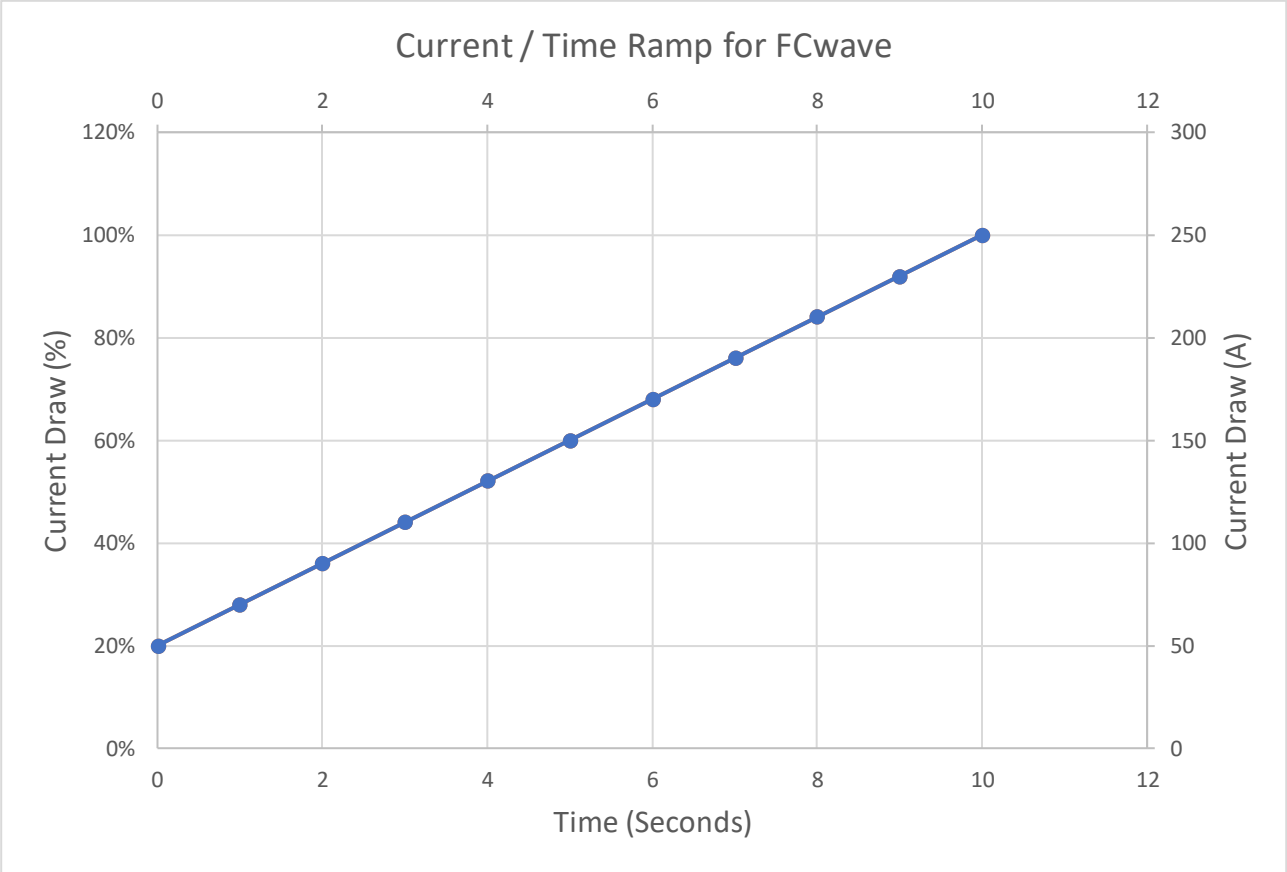


Figure 30 – Current/Time ramp for operation of external DCDCs. Dual Output Configuration shown.

The integrator must always ensure that the current draw remains below the I_Allow parameter, as transmitted over the CAN bus.

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30. Start-up sequence for the FCwave™ module

This section describes the sequence to start operation of the FCwave™ module.

30.1. Standby to Running Cycles

Lifetime of the system is based on the maximum number of **Standby** to **Running** cycles specified in Table 30. This is to preserve the performance of the fuel cell stack and BOP for the entire life cycle of the module. Ballard recommends this is not exceeded in daily use.

Recommendation	
Average Standby to Running Cycles	4 cycles per day (based on 18-hour days)

Table 30 – Maximum Standby-Running Cycles Recommended.

30.2. Vessel Requirements

When integrator desires to operate the Fuel Cell Module (FCM), the integrator must first ensure the following systems are ready to perform as outlined in the datasheet:

- H_2 supply system is ready to provide hydrogen.
- Coolant system is ready to transport heat away from module.
- DCDC converters are ready to operate.
- FCM is in the **Unlocked** state.

The integrator sets the “MD_Enable” hardwire connection to the FCM. This causes the module to enter the **Precharge** state.

30.3. Pre-charge

The module can enter the **Precharge** state from the Unlocked state. In the pre-charge state, the module connects the internal HVDC bus to the external HVDC supply and gradually charges the internal capacitors.

In Pre-charge state, the module awaits HVDC from Integrator. The module will send a severity 1 warning if HV is not measured after 5 seconds. It will stay in Pre-charge indefinitely until either HV is present and pre-charge process is complete or MD_Enable is not active.

- The module low side DC bus is directly coupled to the external DC bus.
- The module high side DC bus is coupled to the external DC bus over a pair of 500Ω resistors.
- This limits the current to 1A or less.
- Internally the voltage is measured:

When the voltage has exceeded a minimum level **AND**
Rate of change on the internal voltage is below a threshold.

- The module high side DC bus is coupled directly to the external DC bus.
- The resistors are decoupled.
- **Precharge** is complete.

When pre-charge is complete, module transitions to the **Standby** state.

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30.4. Standby state

From the **Standby** state, the module provides power to the motor controllers and prepares for operation. H_2 supply valves are closed.

When the integrator transmits the "MD_Run" signal over the CAN bus, the module will transition to the **Startup** state.

The DCDCs must provide a constant voltage to the HV system.

The module can be kept in **Standby** state indefinitely. High voltage DC power is present, but consumption is very low in **Standby** state, unless maintenance is being performed.

30.5. Startup sequence

In the **Startup** state, which comprises several sub-states, the module readies all systems for operation, requests H_2 valves open from the Integrator, and performs the stack power-up sequence.

In this mode, the constant voltage provided by the DCDCs must be kept operating, in order to provide power for the **Startup** sequence, see section 28.

> The air compressors are brought to minimum power levels and start providing oxidizer to the stacks.
> When the HRB is running, the module will flush the H_2 loop, to quickly fill the fuel cells with hydrogen.
> As oxygen and hydrogen are circulated in the stacks, the voltage increases, and rises above the voltage provided by the DCDCs. BOP supply is transitioned from external supply to the stacks.

Integrator shall stop providing a constant voltage when module state (as reported in the FCM_STATUS_1 CAN telegram, see **CMS013 CAN Matrix**) is "**Startup Stk Cont Cls**" or **Startup RX Auto**

The MCU signals the DCDCs to stop and air compressors are spooled up and the module will be able to provide power as the MCU transitions to Running state

During startup, the power supplied from the DCDCs to the module is below 4kW.

30.6. Startup procedure of DCDCs

When controlling the DCDC converters, attention must be paid to the CAN messages from the module, which describe when to provide or draw power.

The DCDC(s) must react according to the following CAN-messages, see **CMS013 - CAN Matrix**:

From message "FCM_STATUS_1"

- DCDC_STOP
- DCDC_IMPORT
- DCDC_EXPORT

From message "FCM_REQUEST_2"

- String A Maximum Import Current (I_BOP_A)
- String B Maximum Import Current (I_BOP_B)
- String A Minimum Voltage (UFC_MIN_A)

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- String B Minimum Voltage (UFC_MIN_B)

The module must not receive nor draw any current through the DCDCs in states *Locked* and *Unlocked*. (DCDC disabled or in stopped state). In these states the contactors are open and the module is disconnected from the DCDC.

In the states **Precharge** until[6] **Startup *Stk Cont Close***, the DCDCs must keep a voltage above the minimum voltages, by supplying adequate current. Preferred voltages are 350 to 450 V, and maximum voltages are 550 V. This is signaled by the flag "DCDC_IMPORT" being true.

There must never be supplied more current than the Maximum Import Current, even if the voltage would drop to less than the minimum voltage.

Going from the beginning of the **Startup** sequence to **Startup Stk Cont Close** takes 30 seconds typically.

In the state **Startup Stk Cont Close**, the DCDC shall stop providing constant voltage (Flag DCDC_STOP is true).

In the state **Running** the DCDC converter shall be in voltage-following constant current mode. In this state I_ALLOW will be ramped up to above the minimum current, described in section 29, within 1 second. The DCDC then has 10 seconds to increase the current draw to above the minimum current.

If the DCDC fails to draw more than the minimum current, the module will first provide a warning over the CAN bus, and if the current draw still does not exceed minimum levels, will signal a fault and perform a controlled shutdown.

30.7. Shutdown procedure of the DCDCs

Before a shutdown, it is required to reduce the current draw to the minimum current, described in section 32.4 "Shutdown sequence".

When a shutdown is initiated, the module will enter the state *Shutdown Rx Purge.* The maximum current the DCDCs must draw is now 0 A. I_ALLOW will within 1 second fall to below 10 A. This state will last between 10 and 60 seconds.

After reducing DCDC power to 0A and module has transitioned to *Shutdown Rx Purge*, the DCDC converters are not needed until next restart of the module and can be switched to standby.

The module will then deplete internal reactant remains and perform a pressure decay test to verify the tightness of the hydrogen system (see section 32.5). After this test is complete the module transitions to unlocked state. If MD_Enable is still present, the module will again enter the **Precharge** state.

[6] Following the normal startup procedure. The states are *Standby, Startup HRB on, Startup Air On, and Startup Fuel On*

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31. Special Operating States

This section describes the special operating states that the system can operate in when requested.

These states are not a part of normal operating sequence but are necessary for maintenance activities and pre-storage preparations.

31.1. State: Coolant Degas

The purpose of this state is to remove air bubbles from the Internal HT coolant loop. This state is typically used after coolant fill/drain cycles, or maintenance involving the HT coolant loop

Parameter:	Value:	Comment:
Preceding state	Standby	
HV Supply	Yes, <3kW	Power to operate coolant pump
Customer HT Coolant	No	
Customer LT Coolant	Yes	Coolant for inverter, expected <500W
H2 Supply	No	
Exit condition	Manual	Returns to Unlocked state

Table 31 – Coolant Degas State.

To use this state, bring module to **Standby** and activate the DEGAS_REQ bit. When completed, disable the bit. This state takes typically 5-10 minutes to degas the coolant loop after a complete drain/fill cycle.

In this state, the coolant pump circulates the coolant while the internal valves actuate in order to flush all air bubbles in the internal coolant loop.

The state is active as long as requested by customer/maintenance personnel.

This state does not affect the external HT coolant supply.

31.2. State: Prepare for Service

The purpose of this state is to remove all residual hydrogen from the fuel circuit, such that maintenance activities can be performed in a safe manner. The hydrogen is reacted with oxygen from the air and either used by the motor inverters or dissipated in the bleed resistors.

This is achieved by circulating the contents in the fuel system by operating the HRB and supplying oxygen by operating the compressors at low speed.

Parameter:	Value:	Comment:
Preceding state	Standby	
HV Supply	Yes, <4kW	Power to operate HRB, Air compressors
Customer HT Coolant	No	
Customer LT Coolant	Yes	Coolant for inverters, expected <500W
H2 Supply	No	
Exit condition	When finished	Next state: “Prepare Complete”

Table 32 – Prepare for Service State.

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When **Prepare for Service** is complete, all hydrogen in the fuel system is exhausted and the stack voltage is reduced to below 10V. The system transitions to **Prepare Complete**.

31.3. State: Prepare Complete

The purpose of this state is to indicate for maintenance personnel that the system has completed the procedures to exhaust available hydrogen and stack voltage is below dangerous levels.

This state has no exit condition, and a power cycle is required to exit it.

Parameter:	Value:	Comment:
Preceding state	Prepare for Service	
HV Supply	No	
Customer HT Coolant	No	
LT Coolant	No	
H2 Supply	No	
Exit condition	None	Requires power cycle to exit state.

Table 33 – Prepare Complete State.

Please note that the prepare for maintenance procedure it not intended for daily use, as excessive use of this functionality may degrade stack performance.

31.4. State: Dry-out

The purpose of this state is to remove liquid water from the module, such that stacks are in a “dry” condition after completing this procedure. This is intended to be the final part of the last operation cycle before long term storage or transportation of the module, where temperatures may reach freezing conditions.

Parameter:	Value:	Comment:
Preceding state	Running	I_Allow ramps to 0A, then disconnects HV system.
HV Supply	Disconnected	
Customer HT Coolant	Yes	Reduced cooling requirements
LT Coolant	Yes	
H2 Supply	Yes	
Exit condition	Timed, Conditional	Exits to module shutdown. Duration 6 min or less

Table 34 – Dry-out State.

Initiating Dry-out

The prerequisites for the dry-out sequence are as follows:

- The module must be in the “Running” state.
- No alarms

To start the dry-out sequence, enable the “DRYOUT REQUEST” bit from over the CAN bus.

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Dry-out Sequence

When requested to begin a dry-out, the module ramps I_Allow to 0A. When the customer current is reduced to <5A, the module begins the dry-out process.

The integrator will observe that the fuel cell module opens its HV connectors and disconnects from the vessel HV system. When disconnected, the module ramps up temperature and airflow to accomplish the dry-out process. During this state, the air compressors are operating at high power levels.

Dry-out Completion

When the module has completed the dry-out process or 6 minutes has elapsed, the module will perform a controlled shutdown process, identical to a normal operational shutdown. After the shutdown, the module is prepared for long term storage.

Restarting module after Dry-out and Storage

When the module is to be operated again after the dry-out procedure, integrator must operate the module in a low power regime (50-75kW) for at least 20 minutes before increasing power. This allows the stack to return to proper humidification conditions.

Expect that performance is impacted until stacks are re-humidified. This is temporary and can be helped by performing a conditioning cycle, contact Ballard for details.

31.5. State: Recovery

The Recovery state is intended to recover temporary performance degradations.

Please consult with Ballard before utilizing the recovery functionality.

Parameter:	Value:	Comment:
Preceding state	Running	Certain conditions apply.
HV Supply	Operating	
HT Coolant	Yes	
LT Coolant	Yes	
H2 Supply	Yes	
Exit condition	Manual	Returns to Running.

Table 35 – Recovery State.

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32. Normal Operation Example

During normal operation, the stack converts hydrogen to power, dependent on the current drawn and at a voltage primarily dependent on the stack operating point. The voltage vs. current relationship is described by the system polarization curve.

Operation Example					
Sequence	**Description**	**Module State or Transition**	**DCDC Indicators**		**Typical duration**
1	Integrator enables 24V supplies to module and SAFE_IN safety input. Integrator sends Module key over CAN bus	Module transitions from Off to Locked to Unlocked	STOP	False	1-2 minute
			IMPORT	False	
			EXPORT	False	
	Module is in Unlocked state	Module state is Unlocked	STOP	True	Can stay in Unlocked indefinitely.
			IMPORT	False	
			EXPORT	False	
2	Integrator enables MD_Enable input	Module transitions from Unlocked to Precharge	STOP	True	<1 second
			IMPORT	False	
			EXPORT	False	
	Module pre-charges HV Circuit	Module transitions from Precharge to Standby	STOP	False	2 seconds
			IMPORT	True	
			EXPORT	False	
	Module is in Standby	Module State is Standby	STOP	False	Can stay in Standby indefinitely
			IMPORT	True	
			EXPORT	False	
3	Integrator wishes to operate FCwave™ module and sends MD_Run over CAN bus	Module transitions from Standby to Startup sequence	STOP	False	<1 second
			IMPORT	True	
			EXPORT	False	
4	Module has begun drawing power on HV bus to spin compressors, module requests H2 valves open. Hydrogen flows to stacks	Startup sequence	STOP	False	30 seconds
			IMPORT	True	
			EXPORT	False	
5	Module is self-powered from stacks, start-up sequence continues	Startup sequence	STOP	True	<15 seconds
			IMPORT	False	
			EXPORT	False	

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6	Module completes the startup sequence and enters Running. Module transmits I_Allow > 0 on CAN bus and begins producing power	Running	STOP	False	<5 seconds
			IMPORT	False	
			EXPORT	True	
7	Module is in Running state and produces power to vessel. Integrator follows current ramp and does not exceed I_Allow	Running	STOP	False	Module can operate indefinitely
			IMPORT	False	
			EXPORT	True	
8	Integrator wishes to stop operating the module. Ramp current draw to <10A as described in section 32.4 and stop sending MD_Run	Running	STOP	False	<10 seconds
			IMPORT	False	
			EXPORT	True	
9	Module begins shutdown sequence	Module transitions from Running to Shutdown	STOP	True	<1 second
			IMPORT	False	
			EXPORT	False	
10	Module executes shutdown sequence. After complete shutdown sequence module transitions to Unlocked	Shutdown to Pressure Decay	STOP	True	30 seconds
			IMPORT	False	
			EXPORT	False	
11	Module performs pressure decay self-test of hydrogen system.	Pressure Decay to Unlocked	STOP	True	30 seconds
			IMPORT	False	
			EXPORT	False	
12	After 15 minutes inactivity, it is permissible to power off module	Unlocked to Off			15 mins

Table 36 – Operation Example Events. See Figure 31.

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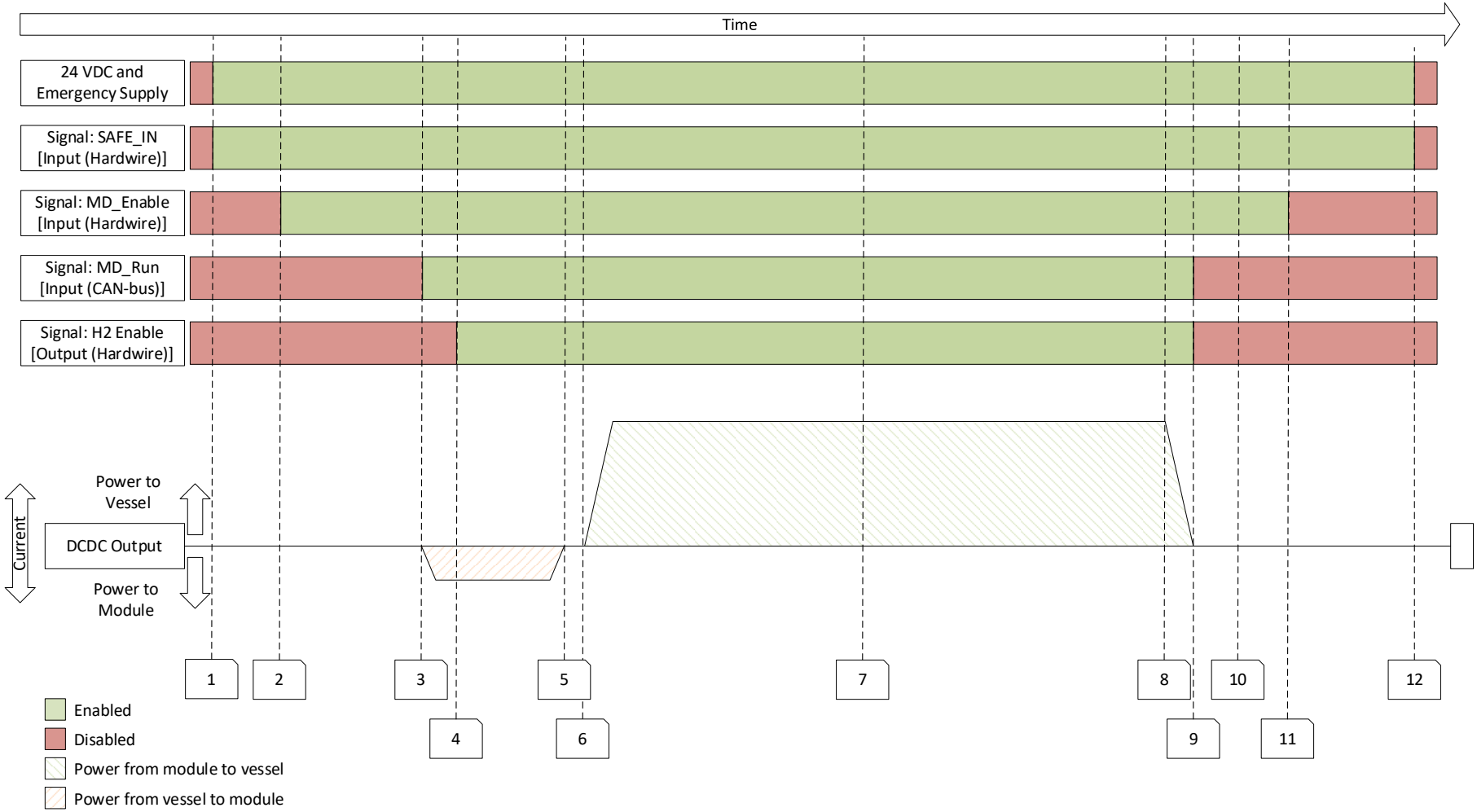


Figure 31 – Control Sequence during startup and operation of FCwave. See Table 36.

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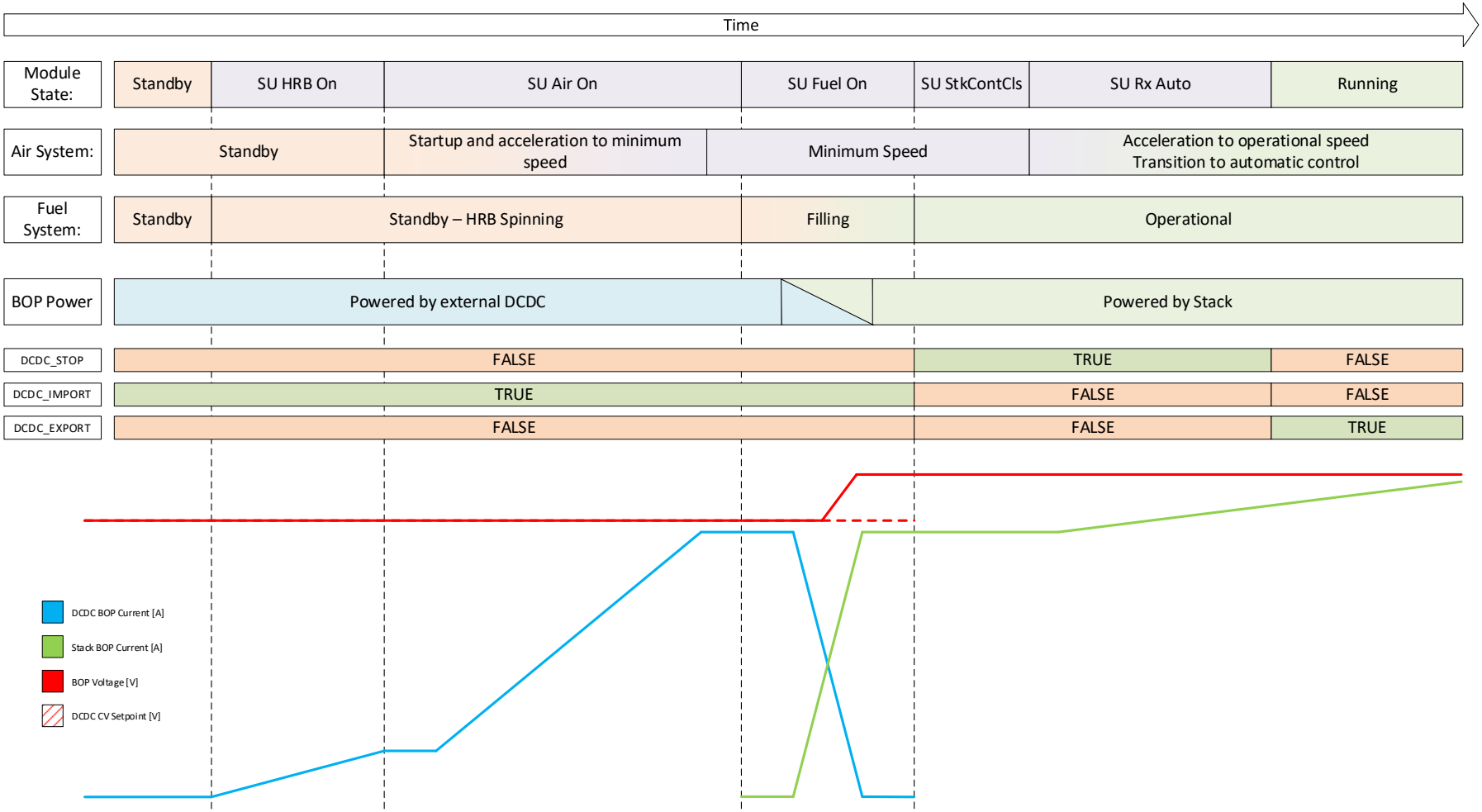


Figure 32 – FCwave™ Startup Sequence and DCDC Integration.

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32.1. Startup Sequence

The detailed **Startup** sequence for the FCwave™ module is outlined in Table 37 and shown in Figure 32.

FCwave™ Module Startup - Detailed			
Module State	**Description**	**Module State or Transition**	**Typical duration**
Standby	Module has completed pre-charge. DCDC is providing constant voltage to BOP components. Current draw is ~0	Standby	Indefinite
Standby	Integrator transmits MD_RUN over CAN bus	Transition to SU HRB On	n/a
SU HRB On	HRB Motor spins up. DCDC maintains voltage, current draw increases.	SU HRB On	~5 sec
	HRB is at speed	Transition to SU Air On	n/a
SU Air On	Air compressors initialize and spin to startup speed. DCDC load increases as compressors draw power.	SU Air On	~10 sec
SU Air On	Air compressors stable at startup speed. DCDC load stable.	Transition to SU Fuel On	n/a
SU Fuel On	Fuel subsystem opens valves and flood stacks with hydrogen. Stack voltage increase to ~600V. Load on DCDCs fall to nearly 0, as BOP is powered by stacks through diodes.	SU HRB On	~15 sec
SU Fuel On	Fuel pressure is stable at nominal levels	Transition to SU StkContCls	n/a
SU StkContCls	Main stack contactors close, bypassing startup diodes.	Transition to SU Rx Auto	<1 sec
SU Rx Auto	BOP Components switch from minimum setpoints to operational control	SU Rx Auto	~5 sec
SU Rx Auto	BOP Components are stable at operational control	Transition to Running	n/a
Running	Module is ready to provide power	Running	n/a

Table 37 – Detailed Startup sequence, See Figure 32.

32.2. Startup Energy Consumption

The energy consumption during **Startup** is detailed in Table 38.

Type	Duration	Amount	Total Energy
24VDC auxiliary power input	Continuously	352W	10 kJ
HV DC	0-27s	4000W	52
Hydrogen	4-6s	0,11 g/s	66 kJ
Combined	-	-	128 kJ

Table 38 – Startup energy consumption.

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32.3. Running state

Transition from start-up to running state

When module transitions from **Startup** to **Running** state, "I_ALLOW" will rise above 0 Amps and the integrator can begin drawing current from the module.

The interval between the transition to **Running** mode and for the integrator to begin drawing current should not exceed 5 seconds, under normal operating conditions.

If the integrator does not draw more than the minimum current, the module will first signal a severity 1 warning. If the current draw remains below minimum level for more than 20 seconds, the module will perform a controlled shutdown and signal a severity 2 alarm.

Running state limitations

In the running state, the system is providing electrical power, and acting as a load follower for the DCDCs. The system has limited dynamic capabilities and will signal its ability to provide current as described in section 29.

Note: During operation, the integrator must respect the limits imposed by "I_ALLOW".

Note: During operation, the integrator shall not reduce current draw below minimum levels (50A), except during shutdown. Brief (<5 seconds) reductions below 50A can be permitted but should be avoided.

Note: The recommended current ramp is specified in section 29.5

32.4. Shutdown sequence

When the integrator wishes to stop operating the FCM, the proper procedure is as follows:

1. Reduce current draw from DCDCs to 10A.
2. Reduce to 0 A, within 5 seconds disable the MD_Run CAN signal.
3. The module preforms the shutdown sequence. Expected duration is 45 seconds.
4. During the shutdown, the module performs a pressure decay self-test, see section 32.5.
5. After shutdown is complete, module returns to Unlocked state.
6. Integrator decides if module is expected to operate soon:
    a. If module is not expected to operate in < 1h, disable MD_Enable and module transitions to **Unlocked** state.
    b. If module is expected to operate in < 1h, maintain MD_Enable and module will return to **Standby** state
    In order to return to Standby, external HVDC supply must be active as described in section "30.3 Pre-charge"
7. When the module switches to **Standby** state, integrator can re-enable MD_Run to restart module or disable MD_Enable if an imminent restart is not expected.
8. If integrator disables MD_Enable, module switches to **Unlocked** state

Module may be powered off 15 minutes after entering **Unlocked** state[7]. The module will during this time consume the remaining hydrogen in the supply system, as it may not be turned off with excess

[7] Duration to be revised after system testing, in order to verify the duration it takes to dissipate H2 inside the module

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hydrogen in the supply line. It is recommended to turn off the 24V supply if the module is not used for the next several hours.

During this time, the module will also upload log files to Ballard if internet is available.

32.5. Pressure Decay self-test

This section describes the pressure decay self-test performed by the module as a part of the shutdown sequence.

Conditions for performing the self-test is as follows:

- Shutdown is caused by customer disabling MD_Run CAN signal
- No alarms active

During the test, the module uses hydrogen to partially pressurize the internal hydrogen loop and then close supply valve. Then the pressure decay over time is monitored and evaluated. The pressure decay self-test typically lasts 30 seconds.

Failed Pressure Decay self-test

If the module fails the pressure decay self-test, it will signal a severity 2 alarm and require a specific acknowledgement of the alarm before allowing restart. The causes of a failed self-test can be:

- Unable to pressurize internal hydrogen loop.
  - Internal pressure does not reach setpoint within time limit. Ensure module has available hydrogen to perform self-test
- Pressure decays too rapidly
  - This indicates a leakage inside the hydrogen loop. Contact Ballard service
- Pressure test aborted
  - The test is aborted if MD_Enable becomes high or any alarms are active.

If a pressure decay test failure occurs, it is required to perform an investigation into the cause of the failure. This investigation should include all relevant data, including ventilation exhaust hydrogen content and inlet pressure. When the cause has been identified and the system is deemed safe, the pressure decay failure can be reset by setting the “Pressure Decay Failure Reset” bit in the VCS_REQUEST CAN message. For further instruction on pressure decay testing follow the maintenance instructions.

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33. Overnight storage of FCwave

This section describes the options for an installed FCwave™ module during overnight (unattended) options on the vessel.

33.1. Environmental Concerns

If the module is left overnight or for longer periods, for example weekend and holidays, the environment surrounding the module must stay within the environmental specifications as listed in Table 10 – Ambient Temperature Specification.

NOTE: Do not permit the hydrogen enclosure ventilation intake to circulate air <0°C into the module

33.2. Power off

When finished with the daily operation of the module, allow the module to remain 15 minutes in non-operating state (Unlocked or Standby), such that H2E ventilation may continue to operate and allow the module to cool down.

After the 15 minutes has elapsed, shut off 24V power to the FCwave™ module.

In the unpowered state, no part of the control or safety system is operational and there is no activity inside the module.

It is not possible to turn off the control system only, as one of the ventilation fans operate off the control system supply.

33.3. Unlocked

If it is desired to maintain the hydrogen enclosure ventilation and monitoring system of the module, allow the module to remain in the “Unlocked” state, where the alarm system is operational, and the hydrogen enclosure is continually ventilated by the fans.

In this state, the module draws 350W continuously, which must be provided by the vessel.

NOTE: Do not permit the hydrogen enclosure ventilation intake to circulate air <0°C into the module

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34. Low Voltage Electrical Connections

This section describes in detail the connections between the FCwave™ module and the vessel. For the recommended wiring diagram, refer to document CMS010 “Schematic description of Input and Output Circuits”, with focus on appendix CMS101-A.

34.1. Switching types

Figure 33, Figure 34 and Figure 35 illustrate the different types of inputs and outputs from the module.

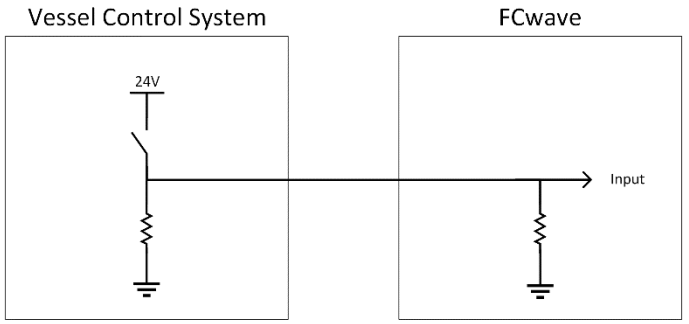


Figure 33 – High-Side Switching Input.

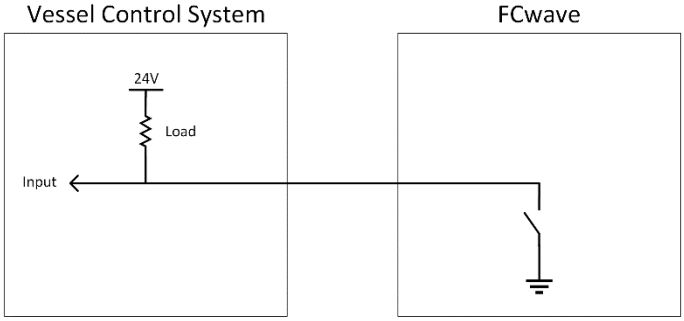


Figure 34 – Low-Side Switching Output.

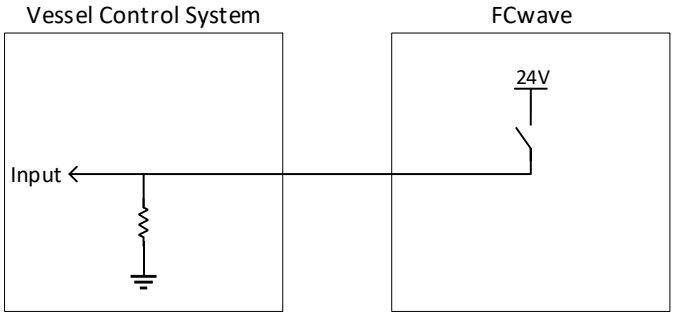


Figure 35 – High-Side Switching Output.

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34.2. Digital Supply and Signal Definitions

Hardwired inputs and outputs between the drive system and module are defined in Table 39, Table 40, and Table 41. These include the type of signal and a description of their purpose.

Module Supply Definitions

Interface Specification				
Interface name long	**Interface name**	**Interface type**	**Input / Output**	**Description**
24V DC supply	24V_SUPPLY	Supply	Input	Max 750W power draw
DC common	COM_SUPPLY	Supply	Input	DC Common. Not connected to GND.
Module grounding stud	GND_01	Grounding stud	Grounding	Grounding of module frame

Table 39 – Connection Definitions for Module Control Supply.

Fuel Cell Controller Signal Definitions

Signals in this category are referenced to 24V_SUPPPLY. CAN bus communications are specified in **CMS013 CAN Matrix**.

Interface Specification						
Interface name long	**Interface name**	**Interface type**	**Input / output**	**Switching type**	**Description**	**Active High/Low**
Module enable	MD_Enable	24V Hardline	Input	High side input	Signal to transition module from **Unlocked** to **Standby** state – Used prior to module activation	Active High
H2 enable	H2_ENABLE	24V Hardline	Output	Low side output	Signal to hydrogen supply system to open upstream H2 valves and provide hydrogen for module activation. Switched to COM_SUPPLY when active. See section 14.5.	Switched to COM_SUPPLY when active.
FUEL CELL MODULE STATUS OK	FCM_OK	24V Hardline	Output	High side output	Signal to customer if module is operational (I.e., has no fault of severity 2 or 3). (*Please note that this is separate from a Safety system emergency).*	Active low. High = FCM OK Low = FCM Error
Customer CAN bus	CAN_02	CAN bus	Bidirectional	n/a	Customer interface to fuel cell module.	n/a
Ethernet	ETH_01	Ethernet	Bidirectional	n/a	Service and Datalogging interface.	n/a

Table 40 – Signal Definitions for Module Controller and Display Panel.

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Safety System Supply and Signal Definitions

Signals in this category are referenced to 24V_SAFE.

Interface Specification						
Interface name long	**Interface name**	**Interface type**	**Input / output**	**Switching type**	**Description**	**Active High/Low**
24V DC supply safety	24V_SAFE	Supply	Input	n/a	Max 250W power draw, Ship Emergency Supply	n/a
DC common safety	COM_SAFE	Supply	Input	n/a	DC Emergency Supply Common. Not connected to GND.	n/a
Main safety in	SAFE_IN	24V Hardline	Input	High side input	Safety input from Vessel control system. Disable this signal to trip emergency system externally.	Active High
Main safety out	SAFE_MAIN	24V Hardline	Output	High side output	Main output from safety control system. This output will, together with the following sub-system specific output signal give the condition of the emergency system.	Active High
Safety – fire detection	SAFE_FIRE	24V Hardline	Output	High side output	Output indicating the status of the fire detection system.	Active High
Safety – hydrogen concentration	SAFE_H2CONC	24V Hardline	Output	High side output	Output indicating the status of the hydrogen concentration in the H2 enclosure being too high.	Active High
Safety – ventilation status	SAFE_VENT	24V Hardline	Output	High side output	Output indicating the status of the ventilation system.	Active High
Safety - watchdog	SAFE_WD	24V Hardline	Output	High side output	Output indicating the status of the safety system internal monitoring.	Active High
Estop – wire 1	ESTOP_W1	24V Hardline	Input	High side Input	Input to safety system from external 2-wire ESTOP button, Integrator responsibility.	Active High
Estop – wire 2	ESTOP_W2	24V Hardline	Input	High side Input	Input to safety system from external 2-wire ESTOP button, Integrator responsibility.	Active High
Estop – out 1	ESTOP_OUT1	24V Hardline	Output	n/a	ESTOP output for external 2-wire ESTOP button. Connected internally to “24V-SAFE”.	n/a
Estop – out 2	ESTOP_OUT2	24V Hardline	Output	n/a	ESTOP output for external 2-wire ESTOP button. Connected internally to “24V-SAFE”.	n/a
Safety – External ESTOP	SAFE_EXTERN	24V Hardline	Output	High side output	Output indicating the status of the external safety inputs	Active High

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Safety – Fire Detection System Malfunction	SAFE_FIREMALF	24V Hardline	Output	High side output	Output indicating the status of the fire detection apparatus. When inactive, indicates a malfunction in the fire detection system	Active High

Table 41 – Signal Definitions for Safety System.

34.3. ESTOP Connections and wiring

The ESTOP connections on the FCwave™ module, as detailed in Table 41 should be wired according to applicable standards and rules for the application.

Ballard recommends the ESTOP connection and button connected to the FCwave™ should fulfill the following requirements:

Construction compliant to EN/ISO 13850
Contacts should be of the type "Positive forced opening normally closed contact", two contact sets
Wiring performed in accordance with diagram CMS010-A and section 35 2133586288.429.

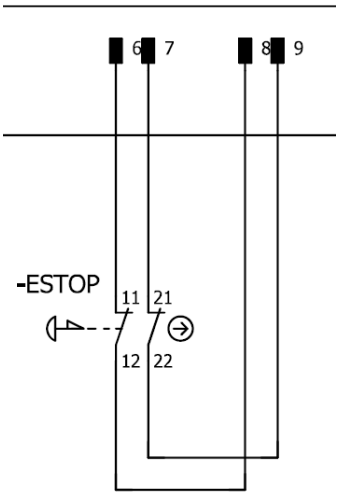


Figure 36 – ESTOP Wiring diagram, reproduced from CMS010-A.

35. Low Voltage Connector Construction

The Low Voltage Connector ("LVC") is constructed with a housing and a frame containing six modular elements, each with a distinct function and connection pattern.

35.1. Signal Wiring

Ballard strongly suggests shielded wiring for low voltage power, bus and signals. Shielding is absolutely required for CAN bus communications (Slot D).

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35.2. Connector Elements

The Ballard scope of the Low Voltage Connector (LVC) is constructed by the following elements:

Component	Tag	Manufacturer	MFG Part name	MFG Part #
Housing	X_E01	Harting	Han 24HPR Base Panel Screw locking	09 40 024 0311
Frame	X_E01	Harting	Han hinged frame plus, for 6 modules a-f	09 14 024 0371
Slot A	X_E01-A	Harting	Han 40A axial module, female 2,5-8 mm²	09 14 002 2701
Slot B	X_E01-B	Harting	Han DD Quick-Lock module, female	09 14 012 2732
Slot C	X_E01-C	Harting	Han Gigabit Module, Female	09 14 008 3111
Slot D	X_E01-D	Harting	Han D-Sub module, crimp female	09 14 009 3101
Slot E	X_E01-E	Harting	Han 40A axial module, female 2,5-8 mm²	09 14 002 2701
Slot F	X_E01-F	Harting	Han DD Quick-Lock module, female	09 14 012 2732

Table 42 – Low Voltage Connector Construction.

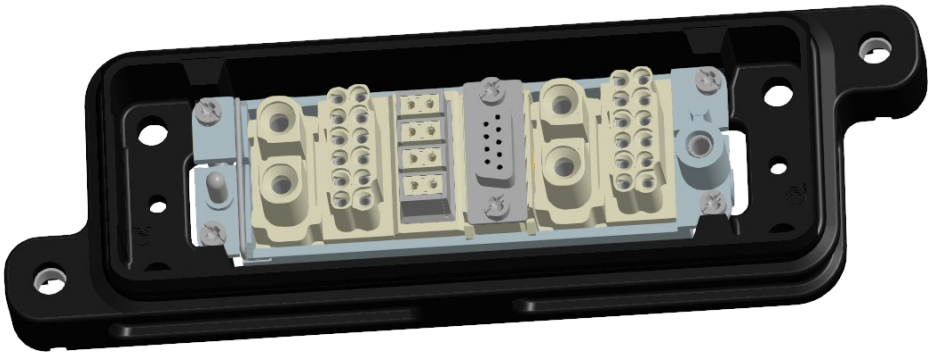


Figure 37 – Rendering of Low Voltage Connector. Slots A to F are shown from left to right.

As shown in Figure 37, the LVC is comprised of the frame with the 6 modules slotted into the frame. The Modules are designated A to F, viewing the image from left to right.

35.3. Protection of the Low Voltage Connector

When the Control and Communication Connector is not mated to a suitable plug, it should be protected against ingress of dust, grime and fluids by an appropriate protective cover.

Ballard will provide a screw locking cover for the connector during shipping and handling. If this cover is lost, replacement can be purchased from Ballard or Harting, quoting Harting Stock # 9400245411.

When mated to a suitable connector or protective cover, the Ingress Protection rating of the connector is IP65 and IP68 in both cases.

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35.4. Low Voltage Connector kit

Ballard can supply a kit containing a suitable set of parts to construct a connector. Contact Ballard Europe and request “7500168 Integrator LVDC Connector Kit”.

35.5. Low Voltage Connector Pin Assignment

This section describes the pin assignment for the low voltage connector.

Slot A

This slot in the connector is the connection point for the module 24VDC supply. Voltages and tolerances are described in CMS006.

Pin	Tag	Function	Interface name
1	=X_E01-A:1	+24VDC	24V_SUPPLY
2	=X_E01-A:2	0VDC	COM_SUPPLY

Table 43 – Slot A Signal Definitions and Assignments.

Slot B

This slot in the connector is the connection point for the fuel cell controller signals. These signals are referenced to the potentials in Slot A

Pin	Tag	Function	Interface name
1	=X_E01-B:1	Digital Out	FCM_OK
2	=X_E01-B:2	Digital Out	H2_ENABLE
3	=X_E01-B:3	Digital In	MD_Enable
4-12	Various	Not Connected	Not Applicable

Table 44 – Slot B Signal Definitions and Assignments.

Slot C

This slot in the connector is the connection point for the Module Control Unit Ethernet Interface.

The module is wired according to TIA **T568B**.

Pin	Color	Function	Interface name
1	Orange / White	Ethernet	MCU Network
2	Orange	Ethernet	
3	Green / White	Ethernet	
4	Blue	Ethernet	
5	Blue / White	Ethernet	
6	Green	Ethernet	
7	Brown / White	Ethernet	
8	Brown	Ethernet	

Table 45 – Slot C Signal Definitions and Assignments.

See section 37.6 “Module Default IP and CAN Address” for details on the ethernet connection.

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Slot D

This slot in the connector is the connection point for the Module Control Unit CAN bus module control interface. The connector accepts a standard D-SUB 9 pin plug, male.

For functional details, please refer to **CMS013 CAN Matrix.**

Pin	Tag	Function	Interface name
2	=X_E01-D:2	CAN LOW	CAN02, Low
7	=X_E01-D:7	CAN HIGH	CAN02, High
3	=X_E01-D:3	CAN GND	CAN02, Ground
SH	=X_E01-D:SH	CAN Shield	CAN02, Shield
<others>	Various	Not Connected	Not Applicable

Table 46 – Slot D Signal Definitions and Assignments.

Slot E

This slot in the connector is the connection point for the module 24VDC supply for the Safety System. Voltages, Power Draw and tolerances are described in CMS006.

This should be connected to the Vessel Emergency Supply.

Pin	Tag	Function	Interface name
1	=X_E01-E:1	+24VDC	24V_SAFE
2	=X_E01-E:2	0VDC	COM_SAFE

Table 47 – Slot E Signal Definitions and Assignments.

Slot F

This slot in the connector is the connection point for the safety system signals. These signals are referenced to the potentials in Slot E.

Please refer to Table 41 – Signal Definitions for Safety System for functional description.

Pin	Tag	Function	Interface name
1	=X_E01-F:1	Digital Out	SAFE_MAIN
2	=X_E01-F:2	Digital Out	SAFE_FIRE
3	=X_E01-F:3	Digital Out	SAFE_H2CONC
4	=X_E01-F:4	Digital Out	SAFE_VENT
5	=X_E01-F:5	Digital Out	SAFE_WD
6	=X_E01-F:6	+24VDC, Max 0,25A	ESTOP_OUT1
7	=X_E01-F:7	+24VDC, Max 0,25A	ESTOP_OUT2
8	=X_E01-F:8	Digital In	ESTOP_IN1
9	=X_E01-F:9	Digital In	ESTOP_IN2
10	=X_E01-F:10	Digital In	SAFE_IN
11	=X_E01-F:11	Digital Out	SAFE_FIREMALF
12	=X_E01-F:12	Digital Out	SAFE_EXTERN

Table 48 – Slot F Signal Definitions and Assignments.

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36. High Voltage Connections

The purpose of this section is to describe the HVDC connectors on the front plate of the module.

The module has 4 connection points from the stack strings, two from each.

36.1. Connector - HVDC

The HVDC connectors are produced by Amphenol Industrial, within the product line Amphe-Power.



Figure 38 – Amphe-Power panel mount connector – Module connectors are red or black.

The four front panel mount connectors are color coded and keyed to prevent connection errors.

TAG	Electrical Connection	MFG	MFG#	Ballard Part #	Color	Keying
X_HV01	String A Positive	Amphenol Industrial	APSPS-1-R-T5	7000819	Red	1
X_HV02	String B Positive	Amphenol Industrial	APSPS-2-R-T5	7000820	Red	2
X_HV03	String A Negative	Amphenol Industrial	APSPS-1-BK-T5	7000821	Black	1
X_HV04	String B Negative	Amphenol Industrial	APSPS-2-BK-T5	7000822	Black	2

Table 49 – HVDC Connector Tags.

Amphe-Power Range – Key Specification	
No of Contacts	1
Maximum Continuous Current Rating	Up to 800A
Surge Current	75kA
Short Circuit Rating	Up to 35.5kA
Cables Cross Sectional Area C.S.A	24mm2 to 300mm2
Contact Termination	Screw or Crimp
Mating Method	Bayonet Lock
Operating Voltage	1000VAC
Max Rated Voltage to Earth	2kV AC/ 3kV DC

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Minimum Flashover	9.5kV DC or AC Peak
Insulation Resistance	>5M ohms @ 500V DC
Ingress Protection	IP67
Protection against Electrical Shock	IP2X
Flammability	UL94-V0
Mating Cycles	>500
Shell Material	High Temperature Thermoplastic
Contact Plating	Silver

Table 50 Amphe-Power key specifications

36.2. Mating Part - HVDC

This section describes the recommended mating Parts to be used with the power connectors.

TAG	Electrical Connection	MFG	MFG#	Ballard Part #	Color	Keying
Customer Scope	String A Positive	Amphenol Industrial	APSLD-1-R-S120-M40S	7000823	Red	1
Customer Scope	String B Positive	Amphenol Industrial	APSLD-2-R-S120-M40S	7000825	Red	2
Customer Scope	String A Negative	Amphenol Industrial	APSLD-1-BK-S120-M40S	7000824	Black	1
Customer Scope	String B Negative	Amphenol Industrial	APSLD-2-BK-S120-M40S	7000826	Black	2

Table 51 – HVDC Connector Mating parts.

Ballard Europe can supply a set of matching connectors suitable for 120mm2 cables. Contact Ballard Europe and request “7500169 Integrator HVDC Connector Kit”.

36.3. Protection of the High Voltage Connector

When the High Voltage Connectors are not mated to a suitable plug, they should be protected against ingress of dust, grime and fluids by an appropriate protective cover.

When mated to a suitable connector or protective cover, the Ingress Protection rating of the connectors is IP67.

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37. Control System – Fault Severities and Reporting

This section details the reporting of severities and fault handling by the module. A sample alarm is listed, but the full list of possible alarms is too long to present here. Integrators are referred to **CMS014 Control System Alarm List**.

The module has 1 level of informational message and 3 levels of warnings and alarms of increasing severity, internal to the control system.
A further level is handled separately by the safety control system and is included for completeness.

37.1. Fault Severities

Table 52 – Module Fault Severities and Descriptions lists the five types of module fault severities.

> Severity 0 through 3 is handled by the control system and does not involve the independent safety system.
> Severity 4 is handled by the safety system and overrides the module control system.

There are several ways the module can notify the Vessel Control System of a fault condition. The module provides a hardwired output (**FCM_OK**) to indicate when it has entered an alarm state. The module also broadcasts its Operating State via CAN, along with the fault codes detailed in the CAN Matrix Customer Specification (**CMS013 CAN Matrix**) document. The list of fault codes, their description and details are available in document **CMS014 Control System Alarm List**.

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Alarm Severities	
Severity	**Description**
0: information	No fault reporting to drive system. May derate **I_ALLOW**, otherwise for information only. Severity 0 events are logged by the modules on-board data acquisition system.
1: Warning	A system parameter has deviated from normal range. The fault category is reported to the drive system over CAN, along with its severity. The hardwired **FCM_OK** output remains unchanged. The module should be inspected and/or process data reviewed. Does not result in a shutdown.
2: Alarm	A system parameter has exceeded acceptable operating range, and the fuel cell module will undergo a **controlled shutdown**. The fault is reported to the drive system over CAN and the hardwired signal **FCM_OK** output will go to **0V.** **I_ALLOW** will be set to 0A. Do not exceed **I_ALLOW**. After a severity 2 fault, **do not** attempt a restart until action has been taken to identify and resolve the cause of the fault. To clear this fault, cycle the hardwired **MD_EN** signal.
3: Severe Alarm	• A system parameter has exceeded a safe operating range, and the fuel cell module will undergo an **immediate shut down**. • The fault is reported to the drive system over CAN and the hardwired signal **FCM_OK** output will go **0V**. • **I_ALLOW** will be set to 0A **immediately**. Cease current draw from the fuel cell module immediately. This severity will cause the high voltage contactors to open under load. • After a severity 3 fault, the fuel cell module must not be restarted until the cause of the fault has been determined and resolved. In addition, the module should be inspected for safe operation and Ballard must be consulted before a restart is performed.
4: Safety System Activation	• The module safety system has tripped and disabled all outputs from the module controller. This causes contactors to open under load and closes all hydrogen valves. The module performs an **immediate uncontrolled shutdown.** • The type of emergency is reported over the safety hardline connections (see section Safety System Supply and Signal Definitions2133586288.429). The hardwired signal **FCM_OK** output will go **0V**. • **I_ALLOW** will be set to 0A **immediately**. Cease current draw from the fuel cell module immediately. This severity will cause the high voltage contactors to open under load. • After a severity 4 fault, the fuel cell module must not be restarted until the cause of the fault has been determined and resolved. In addition, the module should be inspected for safe operation and Ballard must be consulted before any further actions are taken.

Table 52 – Module Fault Severities and Descriptions.

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37.2. Resetting a fault

To reset an alarm from the module, after remedying the fault and verifying that the underlying cause cannot reoccur, the integrator can toggle the **MD_Enable** signal.

The module controller clears alarms on the rising edge of **MD_Enable**, refer to section 2133586288.429 “Fuel Cell Controller Signal Definitions”.

Alternatively, the integrator can attempt to reset faults over the CAN bus. This can be done in the “Unlocked” state by sending the “Alarm Acknowledge” bit in the **VCS_REQUEST** can message.

37.3. CAN Communication

The individual CAN messages to and from the fuel cell module are detailed in the CAN Matrix Customer Specification **CMS013**. Contact Ballard Power Systems for the latest version of the customer-specific CAN matrix. The CAN network operates at a fixed baud rate of 250 kbps and a watchdog is in place to verify CAN activity.

As CAN networks are susceptible to noise, it is strongly recommended to follow best practice and use shielded cables for all CAN wiring. Special care should be taken for the placement of the two terminating resistors on the CAN bus.

Include a 120Ω terminating resistor on the module CAN interface. It is the responsibility of the integrator to add the terminating resistors on the customer interface harness. The module contains one 120 Ω resistor at the MCU CAN bus connection point. After complete assembly, the measured resistance between CAN high and Low should be 60±5 Ω.

Note: The module will shut down (Severity 2) if CAN communication is lost during operation. It is strongly recommended to have a proper wiring, shield each CAN cable and to be EMI proof.

37.4. CAN Customization Key

Ballard will supply each integrator with a unique customization key, which can be found on the CAN Matrix Customer Specification (**CMS013**) document. Send this specific CAN message to allow the module to exit **Locked** state (refer to Figure 27 – High Level State Sequence). It is also used to ensure the correct software is in place for the integrator.

37.5. Controller Heartbeat

The module controller sends a heartbeat over CAN, for the integrator to use as an input for their watchdog. This heartbeat should be synchronized with the drive side watchdog as a method to ensure the module controller is powered up and active. The CAN message **FCM_REQUEST_1** transmits as soon as low voltage power is provided, and the controller is booted-up. As per the CAN matrix (**CMS013**), it is an 8-bit counter that increments every 100 milliseconds and will wrap around after 25.5 seconds (255 heartbeats).

37.6. Module Default IP and CAN Address

Modules are delivered, unless explicitly requested otherwise by customer/Integrator, according to a default IP and CAN address schedule provided in Table 54 – Single Module IP and CAN address. For multiple modules in a deployment, the range of IP, CAN source addresses and CAN destination addresses (called “PDU Specific”) are given in Table 55 – Multiple Module IP and CAN .

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37.7. Single Module and Vessel CAN Address

For deployments of a single module, default IP and CAN addresses are as follows:

Vessel Name	IP Address	CAN bus Source Address
<no fixed name>	<no fixed address>	0x27

Table 53 – Vessel Control System CAN address.

Module Name	IP Address	CAN bus Source Address
“Vesselname 1”	10.10.10.10	0x12

Table 54 – Single Module IP and CAN address.

37.8. Multiple modules

There is a practical limit to how many modules can co-exist on a single CAN bus. This limit is currently unconfirmed but is expected to be around 8 modules without exceeding CAN bus traffic recommendations. This pre supposes no other traffic on the CAN bus.

For deployments of multiple modules, the default IP and CAN addresses are as Table 55. The vessel control system CAN source address is unchanged.

Module Name	MCU IP Address	MCU CAN bus Source Address	VCS CAN bus PDU Specific Offset
“Vesselname 1”	10.10.10.10	0x12	0x00
“Vesselname 2”	10.10.10.11	0x13	0x01
“Vesselname 3”	10.10.10.12	0x14	0x02
“Vesselname 4”	10.10.10.13	0x15	0x03
“Vesselname 5”	10.10.10.14	0x16	0x04
“Vesselname 6”	10.10.10.15	0x17	0x05
“Vesselname 7”	10.10.10.16	0x18	0x06
“Vesselname 8”	10.10.10.17	0x19	0x07
<etc>	<etc>	<etc>	<etc>

Table 55 – Multiple Module IP and CAN addresses.

The FCwave™ CAN matrix is designed with inspiration from SAE standard J1939, thus the FCwave™ CAN Matrix specifies a PDU Specific for all CAN messages from Vessel to Module controller. The CAN bus PDU Specific Offset must be added to the value specified in that document, in effect modifying the message ID of the relevant CAN messages.

Example

Table 56 below shows how the IP and CAN addresses should be set up for a vessel named “Ballard” with four FCwave™ modules installed.

Module Name	MCU IP Address	VCS_REQUEST Msg ID	VCS_STATUS Msg ID	VCS_REQUEST_FAST Msg ID	MCU CAN Source Address
“Ballard 1”	10.10.10.10	0x10FF0027	0x18FF0027	0x00FFA027	0x12
“Ballard 2”	10.10.10.11	0x10FF0127	0x18FF0127	0x00FFA127	0x13
“Ballard 3”	10.10.10.12	0x10FF0227	0x18FF0227	0x00FFA227	0x14

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"Ballard 4"	10.10.10.13	0x10FF0327	0x18FF0327	0x00FFA327	0x15

Table 56 - IP and CAN address example for deployment of four FCwave™ modules.

37.9. EMC / EMI

The system integrator is responsible for ensuring EMC/EMI conformity to regulatory standards for the integration with DCDC equipment and vessel communication system.

Steps can be taken when routing the high voltage output cables in order to minimize emissions from a switching load during operation. The positive and negative conductor going to each individual load should be bundled closely and routed together. If possible, the conductors should be shielded as well.

37.10. Hydrogen Alarm Lockout

The module is equipped with two hydrogen sensors to monitor the hydrogen concentration in the hydrogen enclosure outlet ventilation.
The sensor associated with the control alarms are discussed below.

Alarm: A2_ AZT_J50_H

In an event where the ventilation air hydrogen sensor trips, a severity 2 alarm ***A2_AZT_J50_H*** will shut the module down and **FCM_OK** signal will be set to 0V. This alarm will trigger an additional alarm called ***A2_ AZT_J50_HLOCK*** (high lock) which will lock the module and prevent further attempts of restarting until the Hydrogen level is below the acceptable limit. Once the H2 is no longer in alarm, ***A2_ AZT_J50_H*** may be cleared by cycling ***MD_Enable*** but ***A2_ AZT_J50_HLOCK*** will remain latched.

A2_ AZT_J50_HLOCK

To *clear* ***AZT_J50_HLOCK, AZT_J50_HLOCK_RESET*** must be enabled from the Service Interface or over customer CAN link. Only trained personnel should perform the reset function after it is deemed safe to do so.

Note: if an attempt is made to set the *RESET* flag without a hydrogen lockout present, another severity 2 alarm ***A2_ AZT_J50_RESETERR*** will be set to ensure the system is not forced to run in an unsafe condition. To reset the reset error the reset flag needs to be cleared followed by cycling ***MD_Enable***. For details, please refer to the CAN Matrix Customer Specification (CMS013) document.

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38. Safety System – Functional description

The Safety Controllers purpose in the module is to ensure that all foreseable dangerous situations are detected, signaled to the vessel, and that the module is brought to a safe state.

The safety controller takes input from the following safety subsystems:

- Hydrogen detection
- Ventilation monitoring
- Fire detection
- External emergency notification
- Controller Watchdog

38.1. Warning and Alarm notification

It is the responsibility of the integrator to display an audible and a visual alarm if the emergency system notifies the vessel control system. The module does not include audible or visual indicators for the alarms.

38.2. Hydrogen detection

The safety controller takes input from a hydrogen volumetric concentration sensor, which gives an alarm at 40% LFL. Activation of this alarm leads to immediate shutdown of the module and signals to the vessel that an H_2 alarm has been tripped, this signaling is done over the SAFE_H2 hardwire connection, see 2133586288.429 “Safety System Supply and Signal Definitions”.

Failure of the sensor is treated as a high-level detection.

Detection of H_2 above 40% LFL or failure of the sensor causes a Severity 4 Safety System Activation.

38.3. Ventilation monitoring

The safety controller takes input from the devices and sensors ensuring the flow of ventilation air though the H_2 enclosure. If any of these fails, the safety system triggers an immediate shutdown and signals the vessel that a ventilation failure has occurred.

The ventilation subsystem monitors the following parameters:

- Ventilation intake airflow speed.
- H2 enclosure differential pressure monitoring.
- Fan and secondary fan rotational speed (Tacho).

Failure of any sensor is treated as a failure of the ventilation monitoring and causes a Severity 4 Safety System Activation.

Restriction of the ventilation airflow

If the air flow through the module ventilation is restricted, due to accident or buildup of debris, the airflow flow switch will trip. Ensure that the ventilation intake and outlet are routed correctly, and no debris may collect in the ventilation intake.

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38.4. Fire detection

The safety system has fire detection via a linear heat detection cable. This cable passes over the electric motors, motor controllers, high voltage panel and fuel cell stacks, where heat from a fire would be detected if present.

In case of a fire, the heat will melt the insulation on the internal conductors in the fire wire cable and cause a change in ohmic resistance of the fire wire. The monitoring system detects this change and triggers a Severity 4 Alarm (Safety System Activation). The signal will be sent to vessel firefighting system.

The system also contains a smoke detector, which will trigger the Safety System activation if it detects smoke inside the module.

The monitoring system can discriminate between a fire detection and the cable failing open circuit. The open circuit triggers a shutdown and lockout of the controller, until certified personnel can perform trouble shooting and maintenance. No signal will be sent to vessel firefighting system.

38.5. External emergency

The safety controller has two external inputs to the module.

- Vessel Safety Status
- Emergency Pushbutton (two-wire)

The vessel safety status is an input from the vessel control system to the module, where the vessel signals to the module that the vessel is in a safe state. If an emergency, external to the module, occurs (from the Vessel control system, such as flooding, fire in other compartments, hydrogen detection, etc.), this input allows the vessel control system to trigger an emergency shutdown of the module.

The emergency pushbutton input is connected to a two-wire emergency “mushroom-style” pushbutton, placed in the fuel cell room **Note: Integrator scope**. This allows personnel in the fuel cell room to trigger an emergency shutdown.

38.6. Reset of the Safety Controller

A reset of the Safety Controller requires a full power cycle of the 24V power supply to the module.

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39. Datalogging function

The MCU stores operational date from the module. This information is then transmitted to Ballard over a secure connection via the vessel internet connection when the connection is enabled by bridge control.

This data allows Ballard personnel to troubleshoot and diagnose issues with the module and is essential to rapid response and resolving issues.

Before requesting assistance from Ballard, allow remote data unit to upload data to Ballard.

39.1. Remote connection details

Network Communication Specification	
Parameter	**Value**
Network Access	Ethernet/IP 100/1000 Mbit/s
WAN	Dynamic, private, internet routable IP address.
Availability	When possible, required at least once each 24-hr. period.
Internet Connection Throughput	>256 Kbps upload.
Data Logging Rate	10 MB/Hr/Module
Internet connection details	Provided during commissioning of module. Dedicated IP address and gateway needs to be aligned with integrator

Table 23 - Datalogging Connection Requirements.

39.2. Location of Stored Data

Data is stored on the module control unit (MCU) locally before being transmitted securely to Ballard.

39.3. Maintenance access

During commissioning and service, Ballard service personnel will require a wired ethernet connection which is routable to the module ethernet interface.

Service access is also possible via a service interface on the low voltage panel.

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40. High Voltage Electrical

This section describes the High Voltage interface between the FCwave™ and the DC/DC converters on the integrator's side. It also covers electrical safety both for the service personnel and the module.

40.1. High Voltage Interface

Operate the fuel cell module as a "floating electrical system" by ensuring that neither the fuel cell high voltage positive terminal nor the fuel cell high voltage negative terminal is connected to the application ground, earth or chassis.

The peak total current output at the fuel cell module high voltage connections is not to exceed 300 amps, but higher currents are possible if the limit is exceeded by the vessel system. Note that the module is **unfused**. Load cables must be sized properly for the maximum load that the vessel is expected to draw.

WARNING **To ensure a floating DC system is de-energized prior to servicing the fuel cell module, it is critical to measure zero volts between the fuel cell high voltage positive and high voltage negative terminals, between the fuel cell high voltage positive terminal and chassis, and between the fuel cell high voltage negative terminal and chassis. Measurements need to be made on both AC volts and DC volts scales.**

The system integrator is responsible for providing a means to lockout all necessary energy sources on the system prior to any service activity being performed. Furthermore, the integrator must provide a written procedure to Ballard personnel, detailing the equipment and steps required to sufficiently lock out all energy sources, such as a high voltage or high-power electrical sources.

40.2. Voltage Measurement

The fuel cell module has on-board measurements of the fuel cell stack DC voltages. While these measurements are sent by the module over CAN, it is strongly recommended that integrators do not only rely on the internal module voltage measurement.

40.3. High Voltage Disconnection

The module is disconnected from the Vessel by decoupling the HV DC connectors on the interface panel. See item #2 on Figure 15 – Detail View of module process connections.

40.4. Bonding

A stud is provided on the module for bonding. The bonding point is located left of the Control and Communication Connector (item #1 in Figure 15). The integrator must ensure that the bonding points are bonded to the vessel chassis or earth ground by a cable rated for the full current output of the fuel cell module, see (CMS006). The required maximum resistance between the fuel cell module bonding stud and chassis or earth ground is shown in Table 57.

Specification	
Maximum Resistance to Chassis	0.005Ω

Table 57 – Bonding Resistance Specification

Template 210818-1 Rev. A

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40.5. Ground Fault Monitor

The system integrator must ensure that a suitable ground fault monitoring system is installed and is functional. For a DC dual-output floating electrical system, the ground fault monitoring system must monitor all High-voltage DC outputs. Refer to section 8.6 for safety related issues to ground faults.

40.6. Electrical Isolation

Following the directives in DS/EN 60204-1-2018, two isolating devices are required.

1. For each **incoming** supply to a machine
2. For each **onboard** power supply

The isolation of the **incoming** supply is the customer's responsibility.

For the **onboard** power supply, the precautions taken are:

- The Ampherol plugs have retaining means to prevent accidental disconnection.
- There is a clear warning notice stating "Do not disconnect under load".

Use the isolation resistance in Table 58 as a reference. The isolation resistance of the FCwave will depend on the filter used. The filter each module have will depend on whether the module was produced before or after the 2nd of August of 2024.

Typical Resistance (HV) to Chassis:	
Modules from before 02/07/2024	240kΩ
Modules from after 02/07/2024	400kΩ

Table 58 – Module Electrical Isolation.

40.7. High Voltage Power During Maintenance

During service by Ballard certified personnel, the module may request HV power to perform diagnostic tasks.

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41. Multiple Module Installation

The purpose of this section is to describe the requirements and additional action points needed for an installation of multiple FCwave™ modules in a single installation onboard a vessel or installation room.

The compartment in which the fuel cell modules are to be installed is termed the “Fuel Cell Installation Room”, and requirements are presented below in the following sections.

41.1. Structural Requirements for the Installation

Follow instructions from section 11 Fuel Cell Installation Room Requirements.

41.2. Hydrogen connection

The hydrogen supply connection to the module must fulfill the following requirements:

5. A hydrogen supply shutoff valve with a reaction time less than 2 seconds is required to be installed for each module.
6. The hydrogen flow must be restricted by suitable means such that hydrogen mass flowrate shall not exceed 4.9 g/s.
7. The amount of hydrogen in the fuel cell module must be minimized when not in operation. The physical volume of the pipe between hydrogen shutoff valve and module interface plate is not to exceed 5 liters.
8. It is a requirement that the pipe between the hydrogen shutoff valve and module interface plate is double-walled, with detection measures for the annular space.

41.3. Process exhaust connection

This section describes the options for process exhaust connections from multiple FCwave™ modules in a Fuel Cell Installation Room:

Permitted options are:

1. Individual process exhausts from each module led to the outside without combining them
   1.1. The process exhaust should not exceed the backpressure specifications in Table 14
2. Combined process exhaust from multiple modules led to the outside
   2.1. This requires a separate isolation damper for each module, which will close when modules are not operating to prevent backflow from running modules to non-running modules.
   2.2. The combined process exhaust should not exceed the backpressure specifications in Table 14 in any operational scenario
   2.3. The design of the combined process exhaust should in all operational cases prevent backflow from modules running at differing output levels (e.g. full power and partial power)

Option 1 and 2 are illustrated in Figure 39.

In all cases, the following apply:

- Process exhaust must be let to the outside.
- FCwave™ process exhaust is fully water saturated and with negligible hydrogen content.

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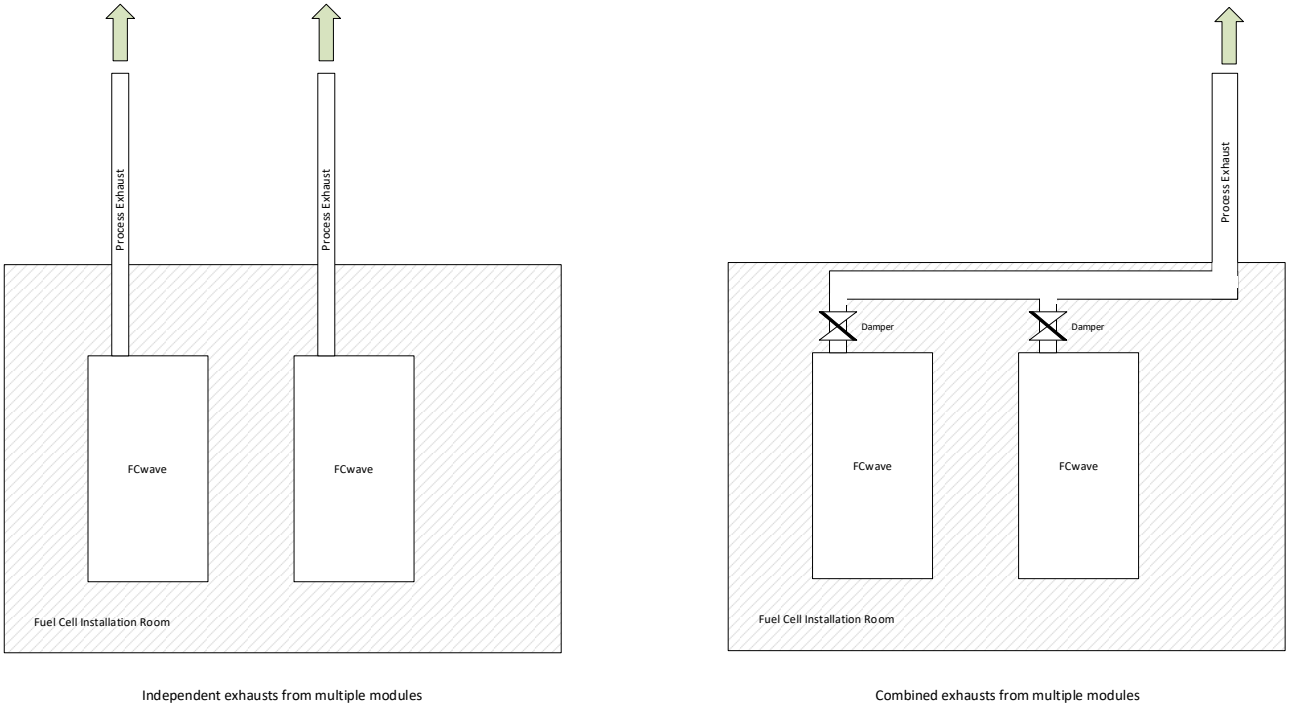


Figure 39 – Options for process exhaust of multiple FCwave™ modules.

41.4. Module Ventilation exhaust connection

If ventilation exhausts are combined from multiple systems, they must be equipped with separate isolation dampers, which must close if the module are not operating.

H2 Enclosure ventilation must be let to the outside.

The integration to the vessel shall ensure the exhaust from FC modules (ventilation air) is led to a safe location free of any spark or ignition source.

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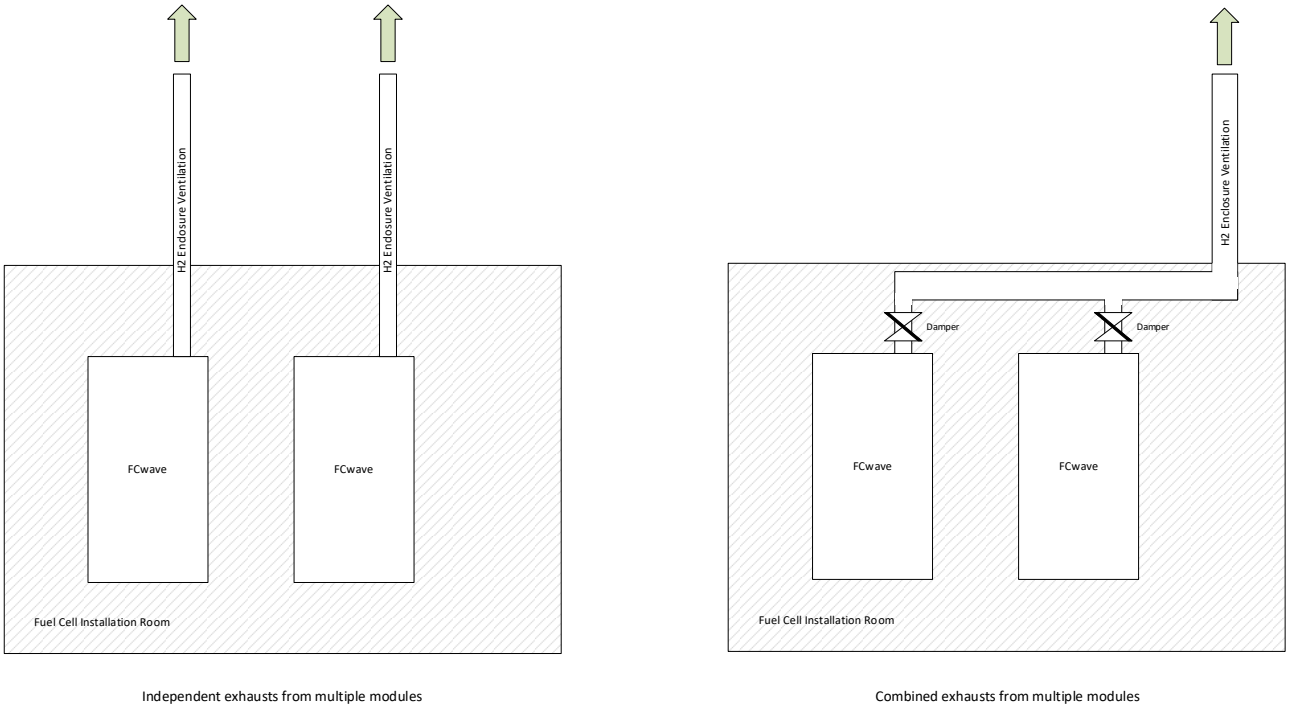


Figure 40 – Options for ventilation exhaust of multiple FCwave™ modules.

41.5. Installation Room ventilation

The air handling system in the fuel cell installation room must be sufficient to supply the FCwave™ process air. Addition ventilation of the fuel cell installation room to be determined by Classification Society or Vessel Integrator.

Ballard recommends performing a calculation according to IEC 60079-10 to establish the required ventilation rate for the fuel cell installation room. In normal operation, all probable leakage scenarios internal to the FCwave™ are managed inside the module.

41.6. Drain connections

The process water drain connection from multiple modules may be combined. It is required that integrator implements backflow prevention from module to module or from external source to module(s). The maximum allowed pressure is 25mbar.

41.7. Coolant connections

The coolant circuits from multiple modules may be combined. The integrator should consider the following:

- Each module must be provided sufficient coolant during operation.
- If individual models are in different states of operation (running / not-running), consider shutting off the cooling flow to the not-running modules.

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41.8. Safety system

The vessel control and safety system must include visual and audible signaling to crew in appropriate locations.

Recommendation is to clearly indicate which FC module is in operation inside the fuel cell room.

The FCwave™ does not provide an emergency stop button. It is the responsibility of the integrator to install adequate and accessible safety stop buttons or similar, as well as ensure the integration of FCwave™ in the emergency stop circuit.

41.9. Fuel Cell Installation Room Access

Access to the fuel cell installation room during operation shall be limited to trained service technicians and crew that have received Ballard fuel cell training

Unrestricted access to the fuel cell installation room can be permitted by the vessel authorities when all fuel cell modules are powered off and otherwise deemed permissible.

42. Maintenance

The fuel cell module requires periodic maintenance for safe operation throughout the service lifetime of the module. Contact Ballard Customer Care for training.

It is the responsibility of the customer to carry out the maintenance tasks according to the maintenance schedule. Additionally, the customer must keep maintenance records listing each task, along with dates, fuel cell module serial number, operating hours, replaced parts, and any measurement values. The records must be provided to Ballard upon request.

43. Module Shipping and Storage

The FCwave™ module is designed to be installed in a dedicated fuel cell room fulfilling the relevant fire protection and ventilation requirements as per SOLAS and Classification Society. Generally, all the electrical components are stored in a dry room. Always place the equipment indoors for safety reasons.

Minimum requirements of warehouse/dry room storage:

Temperature between -40 °C to +60 °C
0-95% relative humidity
No condensing
Corrosion-proof atmosphere
No dripping water

For sub-zero storage after integration, consult Ballard and ensure proper precautions have been taken. Refer to Table 59 for a specified and exhaustive list.

Modules operated with deionized water are required to be flushed, according to Table 59.

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CAUTION **Ensure the low temperature coolant loop (detailed in section 19) is supplied with the appropriate coolant temperature range for the intended storage temperature.**

System	Coolant	Indoor storage conditions	Need to do this preparation
HT Loop	50/50 DI water-Ethylene Glycol	-40° to 60°C	Drain and flush with 50/50 Ethylene Glycol /DI water
LT Loop	50/50 Water-Glycol	-40° to 60°C	Drain and flush with 50/50 Glycol/water

Table 59 – Module Storage Preparations.

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44. Appendix

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Process Exhaust Hydrogen Content

Full Title: Process Exhaust Hydrogen Concentration

Abstract: The process exhaust hydrogen concentration is analyzed. The result is that in all situations the ventilation/airflow, release rate, and release type lead to a non-hazardous zone according to IEC 60079-10-1.

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1.0 Background

This document is intended to provide information on the potential hydrogen concentrations that can be present in the FCwave process exhaust and the resulting zone at the exhaust point. It is not covering the Hydrogen Enclosure Ventilation.

2.0 FCwave Operation

The FCwave is designed based on a dilution principle where air is used to dilute any hydrogen present down to a safe level. The gas present in the process exhaust is a mix of oxygen depleted air (product from the electrochemical reaction), air (from stack bypassing), and hydrogen (from purging).

The target is to dilute the hydrogen content to below 25% of LFL (1%v of H2). The safety systems in the FCwave, collectively provide assurance, that if an error occurs, safety features are in place to shut down hydrogen supply and maintain a high dilution.

2.1 Steady State Operation

During steady state operation of the FCwave the source of hydrogen is from purging. This purging happens following an internal algorithm adjusting the purge cycle based on current drawn from the fuel cell stack. At minimum load the air flow required for the electrochemical reaction is not enough to ensure high dilution. Therefore, an air bypass valve is incorporated to allow for increased air flow in these situations, resulting in high dilutions.

With this dilution principle the measured hydrogen concentration of the exhaust is as listed in Table 2-1.

Table 2-1: *Hydrogen Concentration in Exhaust*	
55 kW	<1%v H2 (dry volume)
200 kW	<1%v H2 (dry volume)
Startup	<1%v H2 (dry volume)

The ventilation/airflow, release rate, and release type lead to a non-hazardous zone according to IEC 60079-10-1[1].

During ramping the concentration is not different from steady state operation.

2.2 Startup

During startup it is ensured that air flow is initiated, and sufficient ventilation is present before any hydrogen is entering the system. This ensures that ventilation is always available, and the needed dilution is achieved.

The purge cycle in startup is adjusted to remove water and nitrogen from the anode side of the stack.

With this dilution principle the calculated hydrogen concentration of the exhaust is as listed in Table 2-1.

The ventilation/airflow, release rate, and release type lead to a non-hazardous zone according to IEC 60079-10-1.

[1] Based on IEC 60079-10-1, Table D.1, Figure F.3, and Figure F.4.

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2.3 Shutdown

During shutdown purging is stopped before air flow. Any residual hydrogen will be consumed by the electrochemical reaction. Thus, there are no sources of release and hence a non-hazardous zone.

2.4 Abnormal operation

During abnormal operation any release will be stopped immediately and there will be no persistent hydrogen present. The air flow is maintained to secure high dilution.

The ventilation/airflow, release rate, and release type lead to a non-hazardous zone according to IEC 60079-10-1.

3.0 Definitions and Acronyms

Table 3-1: Definitions and Acronyms	
LFL	Lower Flammability Level

4.0 Reference documents

Table 4-1: Reference documents	
IEC 60079-10-1	Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres
MAN002	FCwave Integration Manual

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Sub Section N01-007

Fuel cell Maintenance manual

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0B	CO42074	1. Organization: The overall structure and organization of the manual have been redefined in this version. The sections have been renumbered and rearranged, potentially for better clarity and ease of use. 2. Section Titles: The titles of some sections have been modified to streamline and better categorize the content. 3. Content Refinement: Some content has been rephrased or rearranged for better readability and understanding. For instance: • Safety information and hazard sections have been refined. • The maintenance and replacement procedures have been grouped differently. • The maintenance plan has been removed from the service manual and it is considered an independent document. • Information that´s not related to the service manual scope is removed. 4. Addition and Omission of Sections: Some sections have been added or omitted entirely in revision 0B compared to revision 0A.	2024-06-06

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Fuel Cell Module Service Manual, FCwave™ 200kW



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1.0 Disclaimer

NOTE: READ THIS BEFORE ATTEMPTING ANY PROCEDURES DESCRIBED IN THIS MANUAL

There are inherent risks in the operation of a fuel cell module that can result in death or bodily injury or loss or damage to property. It is therefore necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device. Persons who install, operate, and service the device are required to be technically qualified and experienced in working with electrical equipment, compressed gases, and H_2.

This manual includes certain safety guidelines and recommendations; however, this manual is not intended to cover all situations. The customer is responsible for determining the suitability of the customer's particular design or application, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. Ballard Power Systems Europe A/S ("BPSE") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the operating recommendations in the manual. The customer is responsible for being aware of, and complying with, all applicable laws and regulations. BPSE has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

Procedures described in any part of the manual can only be attempted once the customer has read this entire manual. Failure to follow any instruction or recommendation could result in death or bodily injury or loss or damage to property.

BPSE intends for the device to be installed, operated, and serviced only by approved technically qualified and experienced people who understand the principles of fuel cell technology, are aware of the safe operating limits of fuel cells, and are familiar with the risks posed by operating a fuel cell module. BPSE relies on customers to use their own knowledge and experience when installing, operating, and servicing the device. BPSE also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual.

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2.0 Abbreviations

Table 2-1: List of abbreviations

Acronym	Definition	Acronym	Definition
AC	Alternating Current	**HV**	High Voltage
BOL	Beginning of Life	**HVAC**	Heating, Ventilation and Air Conditioning
BOP	Balance of Plant	**HVP**	High Voltage Panel
BPSE	Ballard Power Systems Europe	**I/O**	Input / Output
CAN	Controller Area Network	**IMO**	International Maritime Organization
CNV	Converter	**IP**	Internet Protocol
CUS	Customer	**LED**	Light Emitting Diode
CE	Conformité Européene (European Conformity)	**LEL**	Lower Explosive Limit (18% vol mix with atmospheric air)
DC	Direct Current	**LFL**	Lower Flammability Limit (4% vol mix with atmospheric air)
DI	Deionized	**LT**	Low Temperature
EOL	End of Life	**LV**	Low Voltage
ESD	Electrostatic Discharge	**LVP**	Low Voltage Panel
FC	Fuel Cell	**MCU**	Module Control Unit
FCM	Fuel Cell Module	**PEM**	Proton Exchange Membrane (Fuel Cell Technology)
FCwave®	Product name Fuel Cell module	**RDU**	Remote Data Unit
FRU	Field Replacement Unit	**TBC/TBD**	To Be Controlled/Determined
-XD	Hydrogen Power Management	**UPS**	Uninterruptable Power Supply
H2	Hydrogen (Gaseous)	**VAC**	Volts Alternating Current
H2E	Hydrogen Enclosure	**VCS**	Vessel Control System
HT	High Temperature	**WEG**	Water Ethylene Glycol

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3.0 Symbols

Table 3-1: List of Symbols

Term	Description		Term	Description
°	degree		**kg**	kilograms
µS	microsiemens		**kW**	kilowatt
Ω	ohm		**kΩ**	kiloohm
%	percent		**lbs**	pound
A	ampere		**MHz**	megahertz
bard	bar differential		**mm**	millimeter
Bar(g)	bar gauge pressure		**mVpp**	milli volts peak to peak
bin	binary (true or false)		**PCV**	pressure control valve
°C	Celsius		**PN**	part number
cm	centimeter		**rpm**	revolutions per minute
dBA	decibel		**s**	second
°F	Fahrenheit		**SEV**	severity (of a fault)
g	gram		**TETRA**	TErrestrial Trunked RAdio
H2	Hydrogen (Gaseous)		**v**	Volt
IP Rating	Ingress Protection Rating		**Vdc**	volts direct current

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4.0 General information

4.1 Introduction

The FCwave™ 200kW Marine Fuel Cell Module documentation package provides a general system description, operation, installation, maintenance requirements, and safety information with the specific needs of user in mind.

This Service Manual describes the requirements and information necessary for the operation and maintenance of the FCwave™ 200kW Marine Fuel Cell Module. Proper installation and integration is described in the Integration Manual.

This manual is applicable to systems with the following name plates:

FCwave™ 200kW Marine Fuel Cell Module.

For any other additional technical information, which is not specified in this manual, please contact BPSE.

Please refer to http://ballard.com/support/global-support for updated support contact information, call +45 88435500 or contact technicalcare@ballardeurope.com.

Download Service Documentation

Customers can log on to BPSE After Sales Service Portal to download the latest product-related documents:

Go to http://www.ballard.com/, click on "Support/Global Product Support" option at the top of webpage, then go to BPSE After Sales Portal by clicking on "customer portal here."

OR

Use the direct link: https://www.ballard.com/support/customer-portal-(beta)

At the Login screen, use your Username and Password[1] to enter the portal, where you can download the latest product documentation.

Remember to read and acknowledge the terms of use in the Customer Care Portal by ensuring the box is ticked off beside the declaration:

"I have read and accept the terms and conditions as outlined by Ballard Power Systems."

[1] If you do not have a Username and Password, click on the "register here" link to get an account.

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4.2 Product information

The FCwave™ 200kW Marine Fuel Cell Module operating on hydrogen fuel is an efficient, environment-friendly, zero-emission, direct-current (DC) Power source used for mobility applications in the marine industries. The only emissions from a fuel cell are water vapor and heat. The principle is well-described, proven performance and thoroughly tested with type approvals. The system is modular in design and scalable to meet variable power requirements.

Benefits of fuel cell technology (FCwave™ module) in the marine industries are:

Longer range	–	H2 has a much higher energy density than batteries.
Fast, flexible refueling	–	onboard storage tanks which allow convenient refueling at dock.
Modular design	–	deployed in parallel and dispatchable with vessel space constraints.
Reliable power	–	proven performance, less maintenance and costs, longer service life.

Multiple 200kW modules, electrically configured in parallel to provide efficient power, for any other ranges and design requirements contact Ballard.

4.3 FCwave Marine Fuel cell Module Overview

Power	:	55 – 200 kW
Operating voltage	:	350 – 720 VDC
Input voltage	:	24 VDC
Current	:	(2x) 50 – 300 A, for dual output configuration (1x) 100 - 550 A, for single output configuration
Cooling Output Temperature	:	65°C
Humidity	:	5 – 95 %RH

The major components and features of the module systems are listed below:

- Liquid cooled PEM (Proton Exchange Membrane) fuel cell stacks.
- Built-in control system, control power supplies and control power distribution.
- Independent Safety Controller with separate power supply and safety instrumentation.
- Sensors for voltage, current, pressure and temperature measurements.
- Safety devices, including ventilation fans, fuel pressure relief device, fire detection and hydrogen sensors.
- High voltage contactors for electrically isolating the fuel cell stack from the high voltage output terminals.
- High voltage system pre-charging and reverse current protection during start-up.

4.3.1 Hydrogen Fuel sub-system (Anode)

- Complete hydrogen subsystem, which delivers and conditions the fuel supply to fuel cell stacks.
- Integrated valve block with hydrogen shutoff, pressure regulation and safety pressure relief device.
- Hydrogen recirculation with purge.

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4.3.2 Process Air sub-system (Cathode)

- Built in air compressors, motors, and inverter assemblies for supplying process air to the fuel cell module.
- Air mass flow sensor for air flow rate measurement and control.
- Intercooler and humidifier for conditioning the incoming air stream.

4.3.3 Coolant sub-system

- Internal high-temperature coolant loop, with coolant pump, motor, and controller assembly for supplying coolant to the fuel cell stacks.
- Liquid to liquid stainless-steel heat exchanger between internal high-temperature coolant loop and customer coolant loop, able to handle a wide range of coolant media (fresh water, water-glycol mix).
- Electronically actuated control valves used for stack coolant inlet temperature control.
- Separate low-temperature coolant loop to cool motors and motor controllers.

4.4 Reference Documents

The documents below are available in the online customer portal. In case you would like to request one of the documents below, please feel free to contact the Customer Care department of Ballard Power Systems Europe.

Document	Title
MAN002 2.2.0	200kW Marine Fuel Cell Integration Manual
FRM5104414	Leak Test Report Form, FCwave™ 200kW
SER5104300	FRU List
MAN5100654	Portable leak test box instruction (25-5000 sccm)
CMS006	FCwave Fuel Cell Module Datasheet

Table 4-1: List of Reference Documents

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5.0 Technical datasheet

Too see the latest revision of the electrical datasheet, go to the Customer Portal, or contact Ballard Power System Europe (see section 4.1).

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6.0 Safety, hazards, warnings, and provisos

It is the responsibility of the operator to read and understand this service manual and other information provided, and to use the correct operating procedures.

The product should only be operated by qualified (trained) personnel. Failure to do so can result in personal injury or equipment damage.

Read the entire manual before the initial start-up of the product. It is important to know the correct operating procedures for the product and all safety precautions to prevent the possibility of property damage and/or personal injury.

This section contains general safety-related information. It describes the potential hazards and associated warnings for the system and the precautions that must be taken to minimize these hazards.



Figure 6-1: General safety precautions

6.1 Hazard symbols



WARNING in this manual indicates actions that may result in an accident, which could cause immediate bodily injury or loss of life or could cause damage to equipment or other property.



CAUTION in this manual indicates actions that may result in an accident, which could cause damage to equipment or other property, and which could cause bodily injury if not promptly detected and remedied.



ELECTRICAL HAZARD Obey ALL warnings, cautions, and safety instruction related to electricity. Failure to do so may result in electrical shock leading to personal injury or death.

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6.2 Safety labels

The following standard ISO labels are used in the FCwave™ System:



The Hazardous Voltage symbol indicates that hazardous voltages exist inside the equipment.





The Earth Ground symbol (green is an older version which might occur) indicates the grounding point on the system where an Earth ground connection is required for proper system grounding.



The Auto Start symbol indicates that there are components that may start on without warning. Proper Shutdown and then disconnection of the system will prevent equipment from starting while work is being performed.

6.3 General safety

WARNING

The module is to be installed in a dedicated fuel cell installation room.

The system integrator is responsible for providing means to lockout energy sources on the system prior to any service activity being performed, and a written procedure to Ballard personnel detailing the equipment and steps required to sufficiently lockout all necessary energy sources.

- Keep cabinet doors and electrical enclosures closed when the system is operating.
- Only personnel who are technically qualified and experienced in handling electrical equipment and compressed/flammable gases are permitted to service the fuel cell module and its auxiliary system.
- Remove jewelry, watches, rings, and metal objects on clothing that can potentially cause short circuits when working on the fuel cell system.

6.4 High temperature and high-pressure safety

WARNING

Integrator shall ensure that cathode exhaust piping is leak tight and touch proof.

- Coolant interfaces and the process exhaust can reach up to 80°C during normal operation.
- Components within the fuel cell module can reach temperatures up to 120°C during normal operation.

The module uses pressurized gases which can be hazardous.

- Use caution and ensure circuits are de-pressurized before opening any lines or fittings.
- Some sub-systems may remain pressurized even when the fuel cell module is powered off.

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6.5 High voltage safety



Ballard recommends that the electrical integration of the fuel cell module must be designed under strict supervision of a qualified professional electrical engineer.

It is the integrator's responsibility to design the fuel cell system such that it complies with all applicable codes and standards.

After shutdown, high voltages may remain on the fuel cell stacks for a period of time. No maintenance activities are to be performed during this time as the stacks present a shock hazard. Also, residual reactants (oxygen and hydrogen) within the fuel cell module can cause the fuel cell output voltage to rise unexpectedly.

Allow the fuel cell voltage to drop to below 30 VDC prior to servicing the fuel cell module. Certain circumstances can lead to voltage persisting on the fuel cell stack indefinitely.

- Always check for residual voltage before any service activity.

Operate the fuel cell module high voltage as a "floating electrical system". Ensure that neither the fuel cell high voltage positive terminal nor the fuel cell high voltage negative terminal is connected to the application ground, earth, or chassis.

To ensure a floating DC system is de-energized prior to servicing the fuel cell module and its auxiliary systems, it is critical to measure near zero volts between

- the fuel cell high voltage positive and high voltage negative terminals
- between the fuel cell high voltage positive terminal and chassis
- between the fuel cell high voltage negative terminal and chassis

Measurements are to be made on both AC volts and DC volts scales.

Monitor the isolation resistance of the overall high voltage system with a device capable of detecting both single and double pole isolation failures.

The system integrator is responsible for ensuring that a suitable ground fault monitoring system is installed and functioning during operation. If the level of electrical isolation is ever deemed unsafe according to regulatory standards, the system integrator is required to completely shut down the fuel cell module.

Select fuel cell module power output cables that appropriately suit the application.

Ensure that cable specifications meet voltage, current, environmental temperature limits, chemical and mechanical resistance, and flexure requirements of the application.

Avoid hazardous and unsafe situations that could result from conditions such as, but not limited to, the following:

- Improper grounding
- Handling electrical leads or devices with wet hands or on wet ground
- Frayed electrical leads
- Incorrect or improper connection of the terminal leads
- Short circuits
- Back-feed from energized normal and emergency power sources

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6.5.1 High Voltage safety check before module maintenance

Before servicing the module, Ballard strongly recommends that a high voltage safety check is performed by a trained technician.

Tools needed for procedure	10mm socket screwdriver, door key, 4mm hex key, multimeter

Table 6-1: Tools needed for High Voltage safety check

1. The first step is to request system into 'Prepare for service'. Ensure module reaches 'Prepare complete' (refer to section 7.2.7 for more details) as shown below.

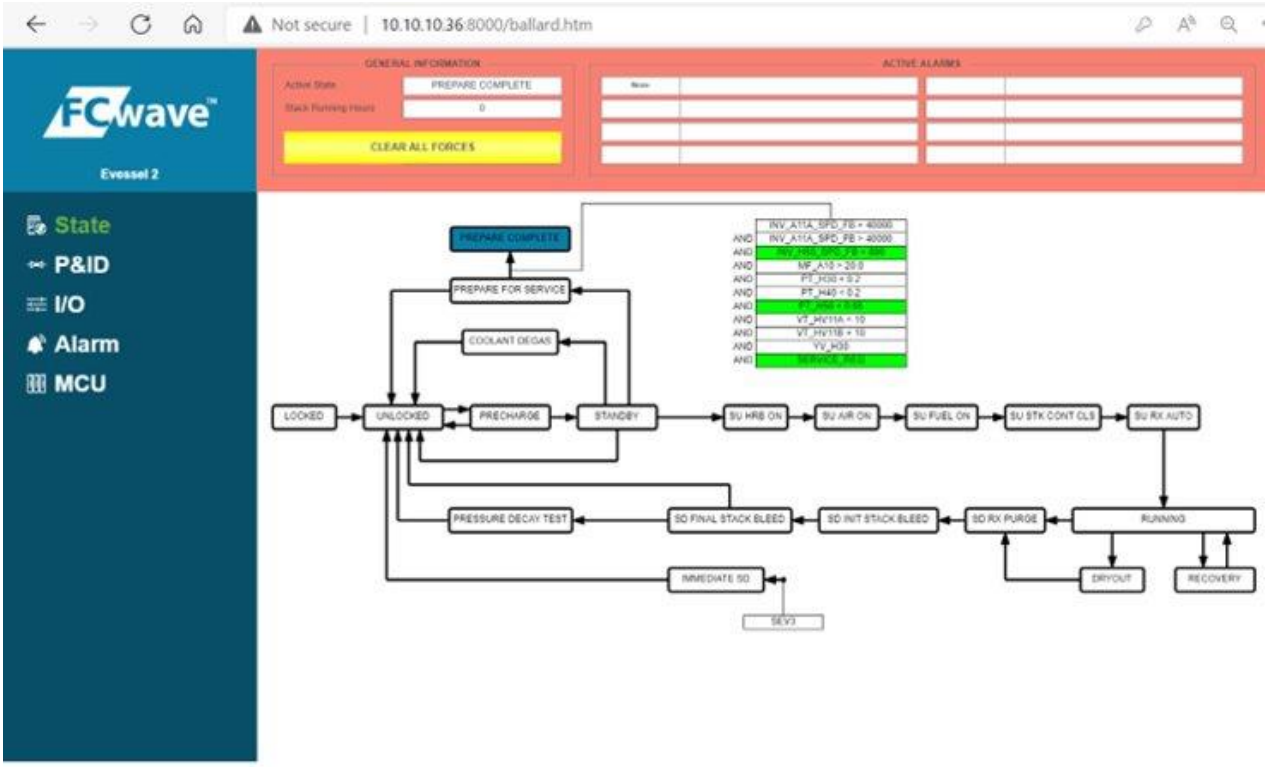


Figure 6-2: Request system to Prepare for Service

2. Confirm the module is ready for power down and maintenance by checking the integrator side. Remember to follow local lockout and tagout procedures.
3. Open system doors.

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4. Loosen 2 pcs. M6 bolts to disconnect the low voltage electrical connection (X_E01) with attached cables from the module.

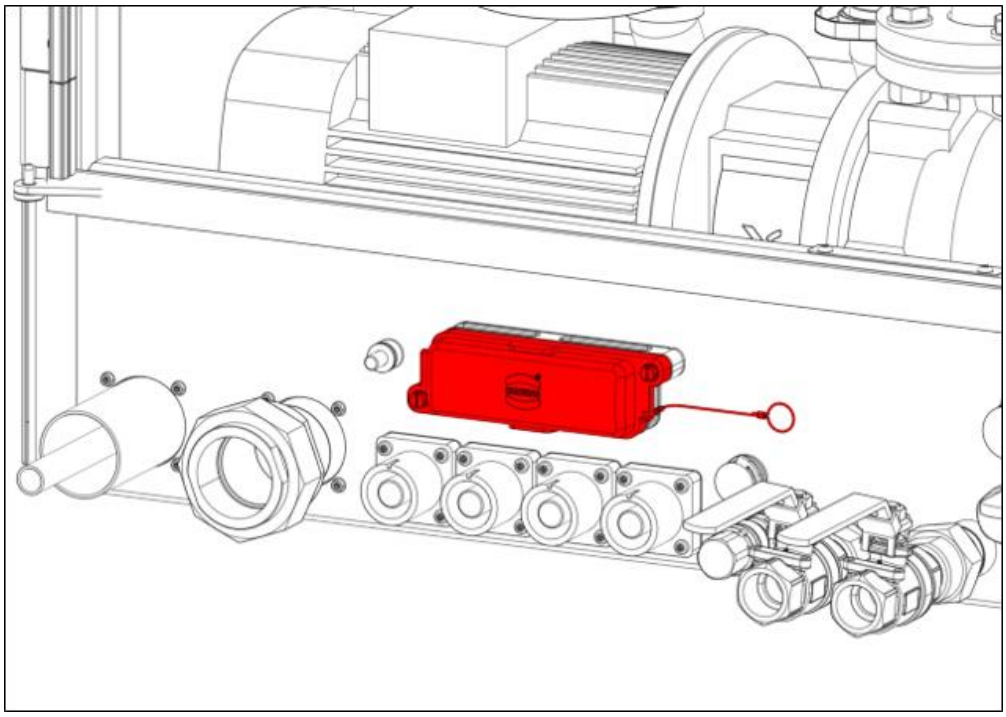


Figure 6-3: Removed low voltage electrical connection from module (shown in disconnected condition)

5. Press lock pin and turn counterclockwise to disconnect the high voltage electrical plugs from the front of the module.

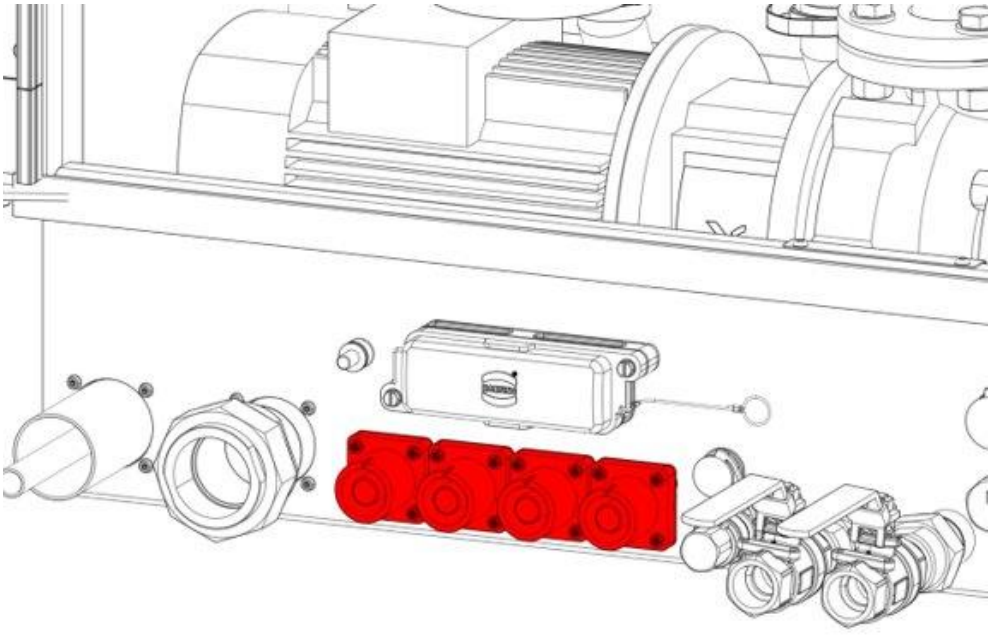


Figure 6-4: Removed high voltage electrical connection from module (shown in disconnected condition)

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6. Uninstall 12 pcs. M5x10 hex head bolts and remove the high voltage panel cover.

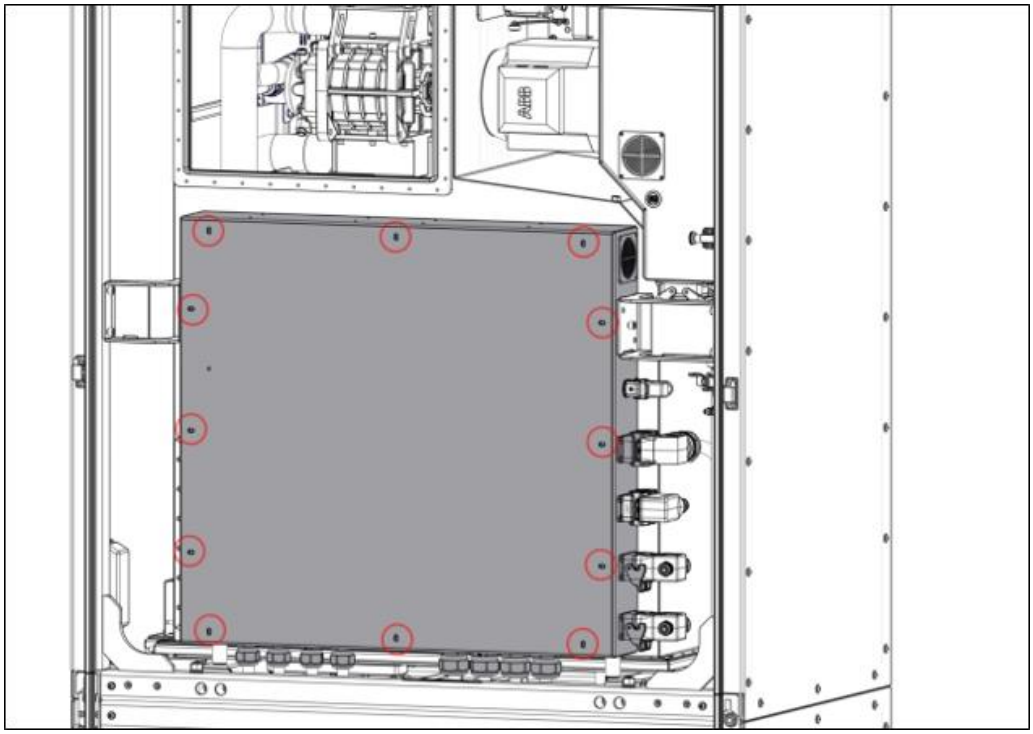


Figure 6-5: Remove high voltage panel cover

7. Measure the terminals to verify that no DC voltage is present in the HV panel.

   Use a multimeter to measure following terminals (shown in Figure 6-6) to verify that the voltage is lower than 10 VDC.:

   - negative (_XDA-2)
   - positive (_XDA+1, F_VTHV11A, F_VTHV12A, F_VTHV13A, and F_VTHV40A)

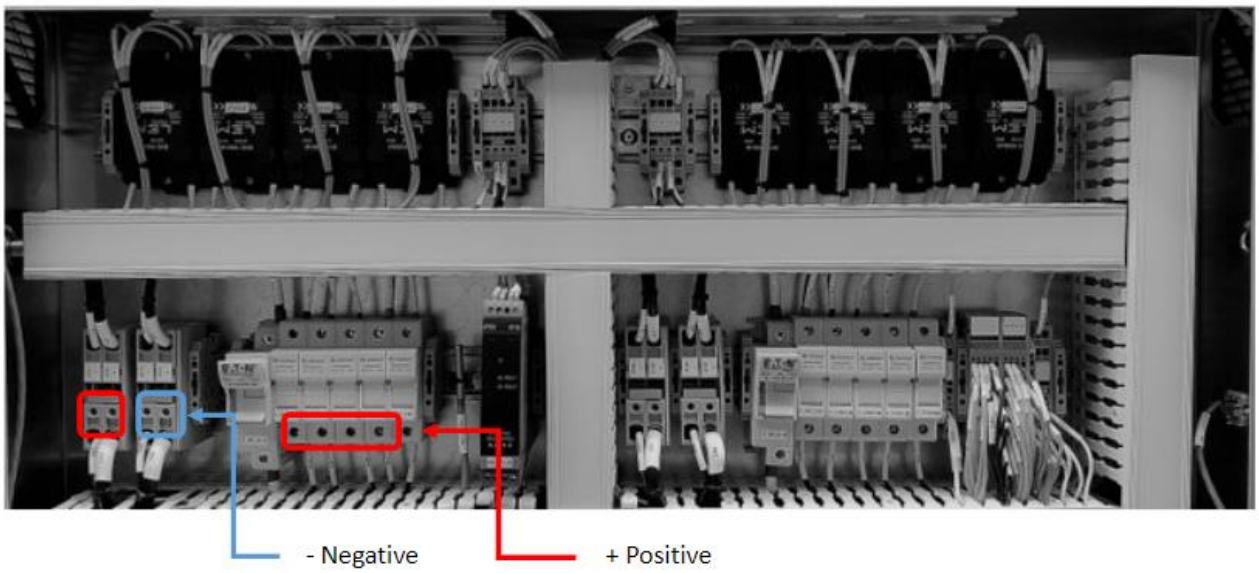


Figure 6-6: Left-hand side terminals

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8. After measurement of left-hand terminals, proceed to do the same for the following right-hand terminals (shown in Figure 6-7):
   - negative (_XDB-2)
   - positive (_XDB+1, F_VTHV11B, F_VTHV12B. F_VTHV13B. F_VTHV40B)

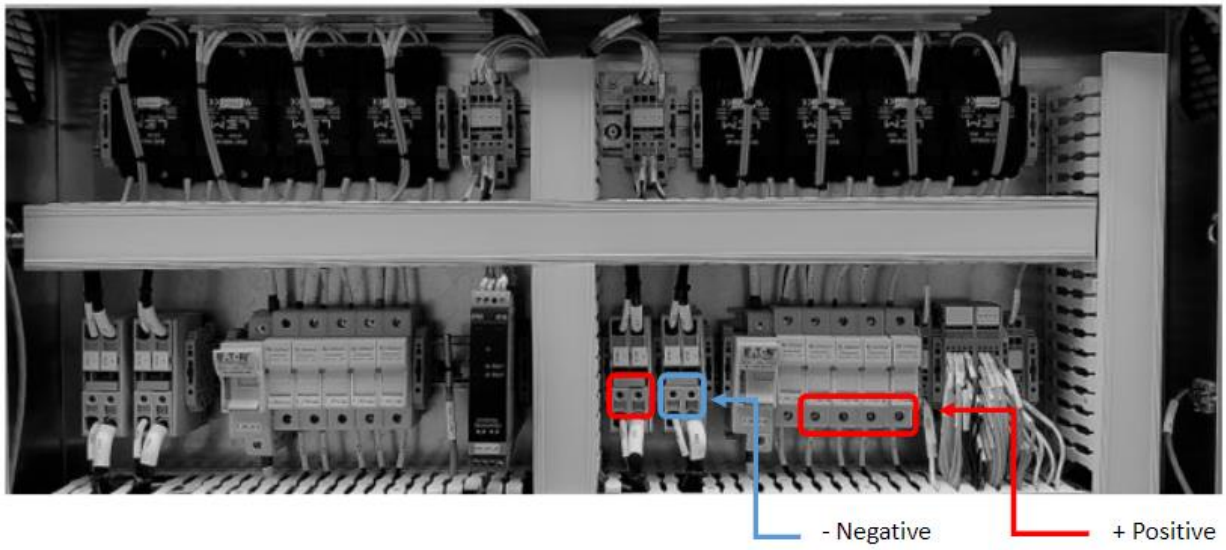


Figure 6-7: Right-hand side terminals

9. The module is now safe for maintenance and/or service.

6.6 High Voltage Isolation Failures



Under normal circumstances both high voltage output terminals (positive and negative) are isolated from the fuel cell module enclosure and low voltage system.

If isolation is lost on one high voltage pole, a person working on the module could sustain a fatal current flow by touching the other high voltage pole and ground.

If two simultaneous faults occur and isolation is lost on both high voltage poles, a high voltage short circuit can occur resulting in extremely high currents. High currents can generate a large amount of heat which will subsequently damage electrical and fuel cell systems and cause bodily harm.

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6.6.1 Normal system

In normal operation, the FCwave module will operate as shown below where both high voltage poles are isolated from ground.

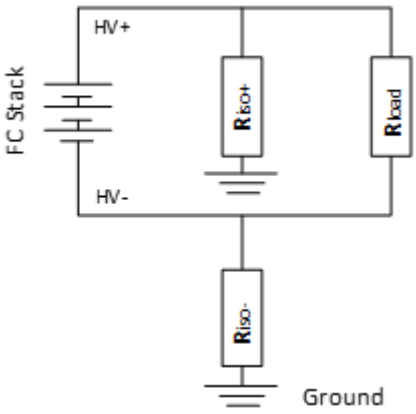


Figure 6-8: Normal isolation

6.6.2 Single Pole Isolation Failure

In a single pole isolation failure, one point on the high voltage circuit is no longer isolated from ground as shown in below figure.

An isolation resistance measurement or ground fault detection system can typically detect this failure on utilization.

A single pole isolation failure cannot cause a short-circuit nor prevent fuel cell operation, but it importantly increases the risk of electrical shock and causes injury to personnel while working on the FCwave module.

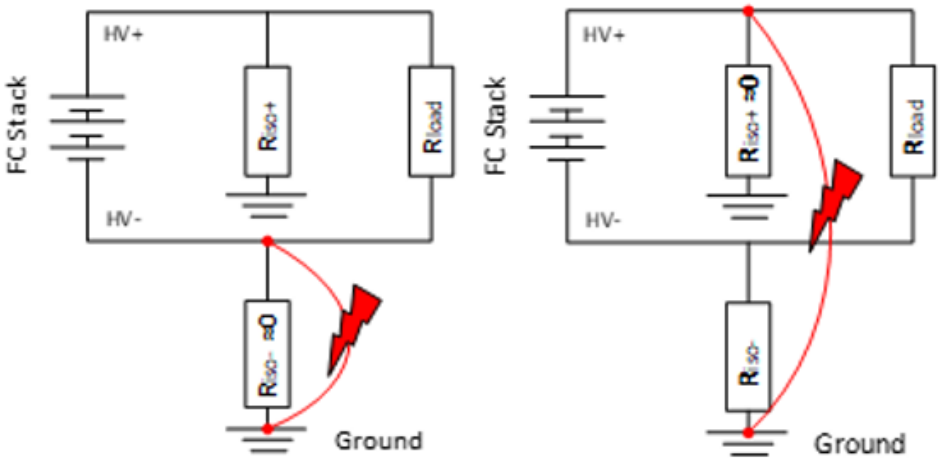


Figure 6-9: Single Pole Isolation Failure

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6.6.3 Double Pole Isolation Failure

A double pole isolation failure, where the high voltage system is no longer isolated from ground in two different locations, can result in a high voltage short-circuit as shown in figure below.

An isolation resistance measurement or ground fault detection system can typically detect this failure on utilization.

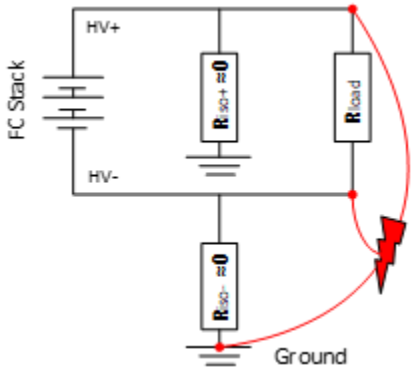


Figure 6-10: Double Pole Isolation Failure



If an isolation failure is detected and indicated in the FCwave module, do not operate the fuel cell module until the malfunction is determined and corrected.

6.6.4 Distributed Capacitance and Effects on HV Safety



The Distributed capacitance is the total amount of capacitance that exists between each pole of an isolated high voltage system and the chassis. This capacitance is a concern as it can hold charge which can be discharged into a person that simultaneously touches the high voltage system and chassis.

In normal operation, this is not an issue as all high voltage conductors are covered and insulated but it could be a concern if a system is being serviced. The fuel cell module has sources of capacitance that should be considered before servicing the high voltage system.

Within the module, the fuel cell stack will also maintain voltage if hydrogen and air are present within the system. Voltage could also be generated when a fuel or air source is introduced, and reactants are moved to an active point in the fuel cell stack. This voltage will normally bleed down to safe levels within minutes, but this should always be verified using the RDU interface first, and then testing with digital multi-meter prior to accessing the module.

Confirm that the voltage is zero

- Between pole to pole (positive to negative)
- Between each pole to chassis before service

Built in "Prepare for service" procedure involves running the air compressors and hydrogen recirculation blower to ensure the fuel cell reaches "STATE- PREPARE COMPLETE" prior to servicing the system.

One other effect of the distributed capacitance will be a delay in the ground fault detection system measurement. Some versions of the ground fault detectors are only suitable for distributed capacitance values of 1uF, and others are suitable for values up to 20uF.

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6.7 Hydrogen safety



Hydrogen is a colorless, odorless, and highly flammable gas. Hydrogen is non-poisonous, but it can cause breathing problems when mixed with oxygen in the air.

1. There are no warning symptoms before unconsciousness occurs.
2. Do not operate the module in a closed space or in non-ventilated areas.
3. Install and handle the hydrogen in accordance with applicable regulations and the gas supplier's recommendations.
4. Hydrogen is lighter than air and will deflate upwards.
5. Leaked hydrogen can readily mix with the adjacent air, as its small molecular size has higher buoyancy and diffusivity.

Handle with care as hydrogen can diffuse through materials even though considered gastight. Fuel lines and non-metal seals such as gaskets, O-rings, pipe thread compounds and packings can cause potential leakages.



The FCwave module hydrogen sensors can degrade if they are exposed to various contaminants and thus become less sensitive.

The FCwave module hydrogen enclosure is equipped with primary and secondary sensors to detect leakages in the system:

- A high hydrogen concentration indication report as
  - Severity 1 Warning at 0.8% vol H_2 (20% LFL)
  - Severity 2 Alarm at 1.2% vol H_2 (30% LFL)
  - Severity 4 Safety system activation at 1.6% vol H_2 (40% LFL)
- These hydrogen sensors send signal to ship control system, which triggers alarm to the integrator (refer to Table 6-3).
- Interconnect hydrogen detection system with a hydrogen supply shutoff valve installed directly upstream of the FCwave module.
- If an excessive hydrogen concentration leak is detected, STOP the FCwave module operation.
- Perform leak tests.

As part of preventive maintenance, check the hydrogen sensor in the module regularly. Refer to the sensor's service maintenance plan (section 8.1.4).

Exposure to Volatile Organic Compounds (VOC's) causes hydrogen sensor degradation and thus precautions must be taken to avoid exposure whenever possible. The system is installed with high grade technology sensors with longer service life and increased tolerance to VOC's. High levels of VOC's are frequently experienced during vessel painting and solvent degreasing. Therefore, it is recommended that the module or hydrogen sensors are removed during these processes.

The degraded hydrogen sensor effects are:

- Makes sensor less sensitive.
- Output will have a lower indication for a given hydrogen concentration.
- A degraded sensor in operation will no longer send any alarm, even when the concentration of hydrogen exceeds the threshold limits.

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A failure mode can occur if there is hydrogen present in the cooling system header tank. Follow the precautions that follow the design considerations and maintenance procedures.

- The hydrogen supply to the module can stay pressurized even after the module is shut down.
- Make sure there is no pressure in the line before disconnecting the hydrogen supply pipes
- The hydrogen lines inside the module can contain hydrogen, even after the module is removed from the system
- Safely vent the hydrogen pressure before removal of the fuel cell module

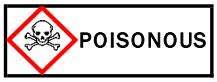
6.7.1 H_2 Sensor Alarm and Warning Limits

Control system warnings and alarms are communicated via CAN-bus. Alarm time is sensor response time plus debounce time, estimated to be 5 seconds.

H2 Alarm Limits				
Hydrogen level (vol%)	Lower Flammability Level for %vol H2	Module Action	Severity	Sensor
0.8	20%	Warning – Operation continues	1	Primary
1.2	30%	Alarm – Controlled Shutdown	2	Primary
1.6	40%	Alarm – Emergency Shutdown	4	Primary and Secondary

Table 6-2: H_2 Alarm Limits

6.8 Chemical hazards



Ethylene-glycol is poisonous, when swallowed get medical aid immediately.

The fuel cell coolant loop contains ethylene glycol.

- Ethylene glycol is toxic if ingested or if its vapors are inhaled.
- All personnel handling ethylene glycol or working on the fuel cell stack coolant loop are required to adhere to the precautionary measures identified in the safety data sheet of the specific coolant being used.
- Such precautionary measures include wearing safety glasses and chemically protective gloves.
- Dispose ethylene glycol in accordance with applicable local regulations.

6.9 FCwave module Hazard mitigation approach

The highest risk potential hazards posed by the module are unacceptable hydrogen concentrations (in the ventilation or process air exhaust) leading to fuel-fed combustion, electrical short-circuits, and possible shock hazards caused by reduced electrical isolation of the high voltage system.

The control system is coupled with various measurement devices that are designed to identify conditions (which can lead to hazards) and will terminate module operation before unsafe conditions develop.

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6.9.1 Module Alarm and Shutdown Types

This section describes the types of alarm activation and subsequent control system shutdowns. The system has two controllers:

- Fuel cell module controller unit (MCU)
- Separate safety controller which handles safety related sensors

Alarm type	Description	Action	Consequence
Severity 0 – Information	No fault reporting to drive system. May derate 'I_ALLOW', otherwise for information only. Severity 0 events are logged by the module's on-board data acquisition system.	Messages of this level are only for information to the vessel, and no time constraint is placed on reaction from the vessel or integrator.	No timer
Severity 1 – Warning	A system parameter has deviated from normal range. The fault category is reported to the drive system over CAN, along with its severity. The hardwired 'FCM_OK' output remains unchanged. This level of severity is used for a functional or internal parameter, which is at the limits of normal operation. The current value of the parameter does not harm personnel or material.	Bring the warning limit back within optimal range.	If the deviation from normal operating range continues to increase, a severity 2 alarm is activated.
Severity 2 - Alarm	A system parameter has exceeded acceptable operating range, and the fuel cell module will undergo a controlled shutdown. The fault is reported to the drive system over CAN and the hardwired signal 'FCM_OK' output will go to 0V. 'I_ALLOW' will be set to 0A.	Do not exceed 'I_ALLOW' when the severity 2 fault is active. After a severity 2 fault, do not attempt a restart until action has been taken to identify and resolve the cause of the fault. To clear this fault, cycle the hardwired 'MD_EN' signal.	System performs a shutdown. ≤ 30 sec for the controlled shutdown.
Severity 3 – Severe alarm /immediate shutdown	A system parameter has exceeded a safe operating range, and the fuel cell module will undergo an immediate shut down. The fault is reported to the drive system over CAN and the hardwired signal 'FCM_OK' output will go to 0V. 'I_ALLOW' will be set to 0A immediately. Cease current draw from the fuel cell module immediately, since this severity will cause the high voltage contactors to open under load.	After a severity 3 fault, the fuel cell module must not be restarted until the cause of the fault has been determined and resolved. In addition, inspect the module for safe operation and consult Ballard before a restart is performed.	≤ 1 sec hard shut down.
Severity 4 – Safety System Activation (SIS)	The module safety system has tripped and disabled all outputs from the module controller. This causes contactors to open under load and close all hydrogen valves. The module performs an immediate shutdown. This type of emergency is reported over the safety hardline connections. The hardwired signal 'FCM_OK' output will go to 0V. 'I_ALLOW' will be set to 0A immediately. Severity 4 is handled by the safety and overrides the module control system	Cease current draw from the fuel cell module immediately, since this severity will cause the high voltage contactors to open under load. After a severity 4 fault, the fuel cell module must not be restarted until the cause of the fault has been determined and resolved. In addition, inspect the module for safe operation and consult Ballard before any further actions are taken.	≤ 1 sec emergency shut down.

Table 6-3: Module Alarm and Shutdown Types

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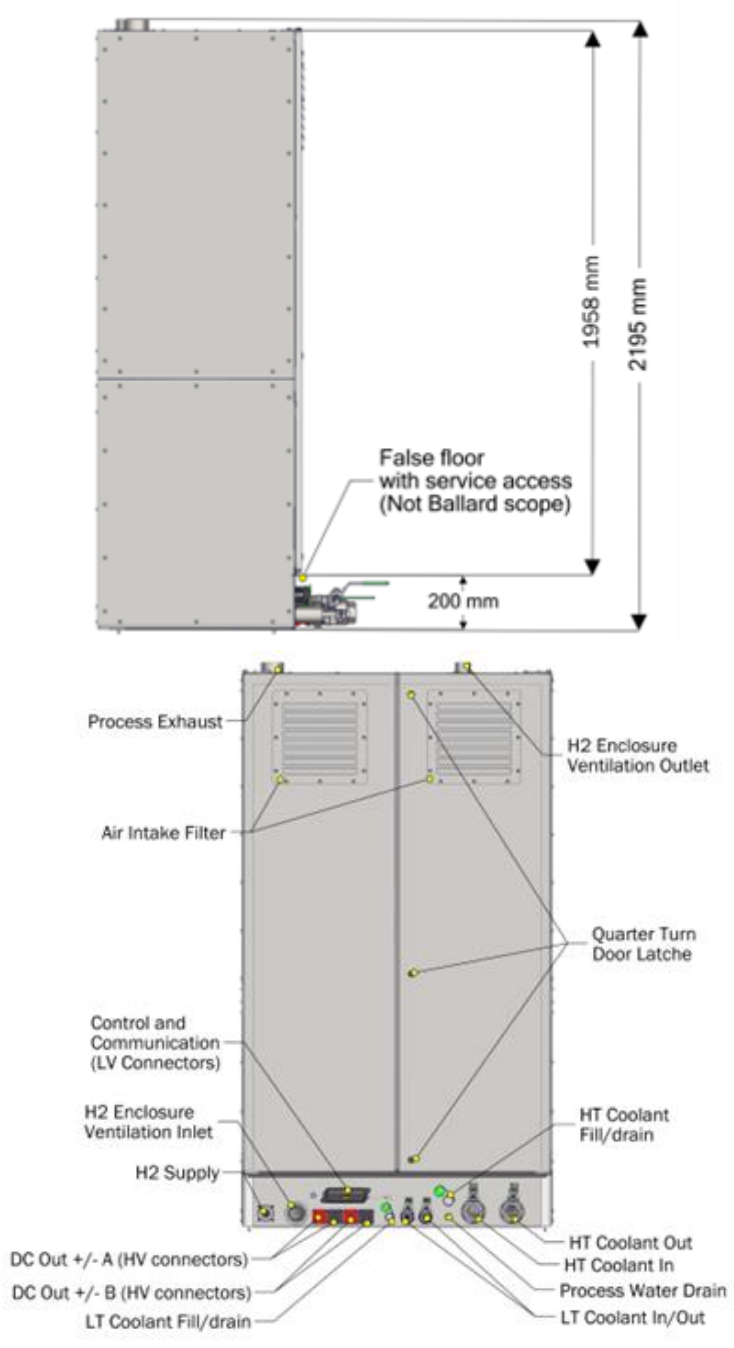
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7.0 General Preparation for Maintenance on the FCwave module

7.1 Interface Connections

The external hydrogen supply, coolant supply, electrical, control and communication connections in the cabinet are installed on the base of the FCwave module. The interface connections are shown in Figure 7-1 (3 figures).



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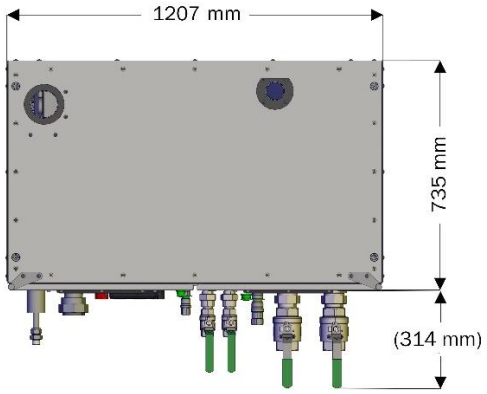


Figure 7-1: FCwave 200 kW module interface connections

7.1.1 Service Access

It is recommended to ensure necessary service space in front of the FCwave module cabinet for lifting of BOP components, removal, and to carry out maintenance operations (

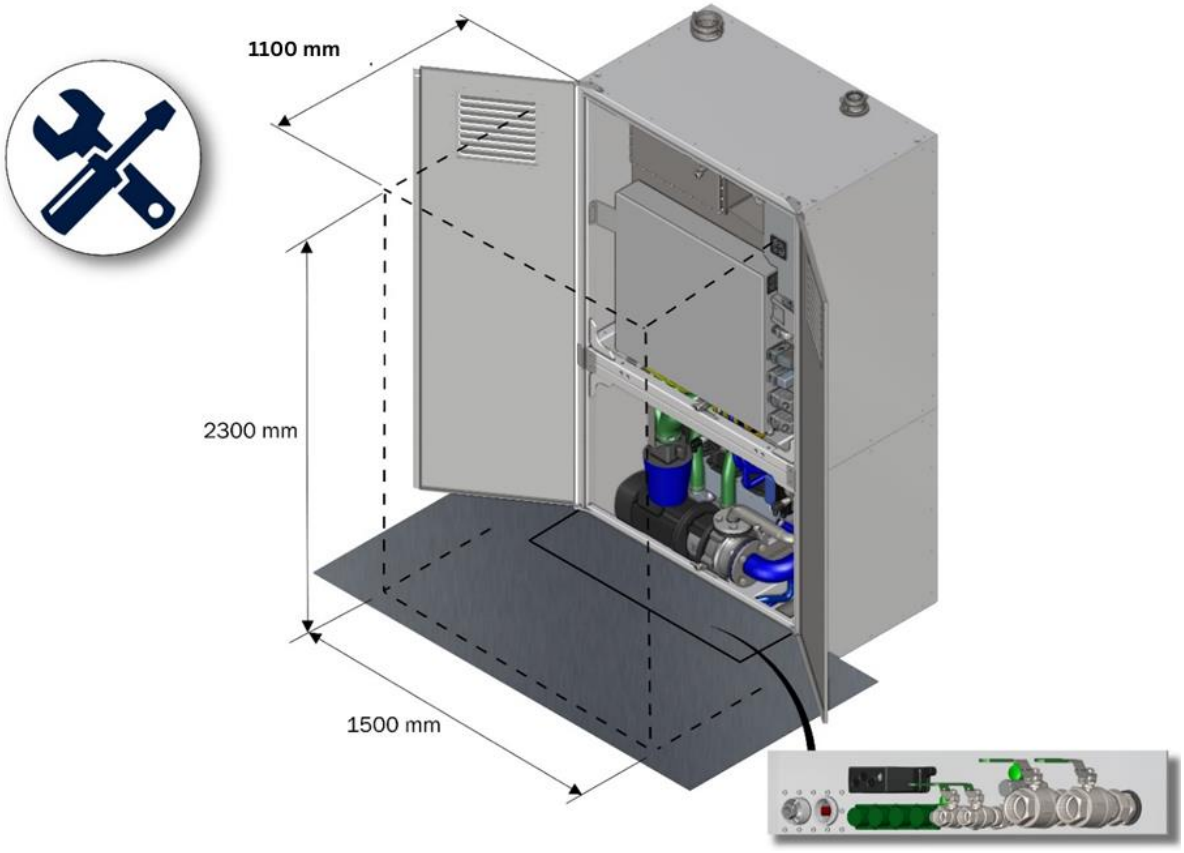


Figure 7-2).

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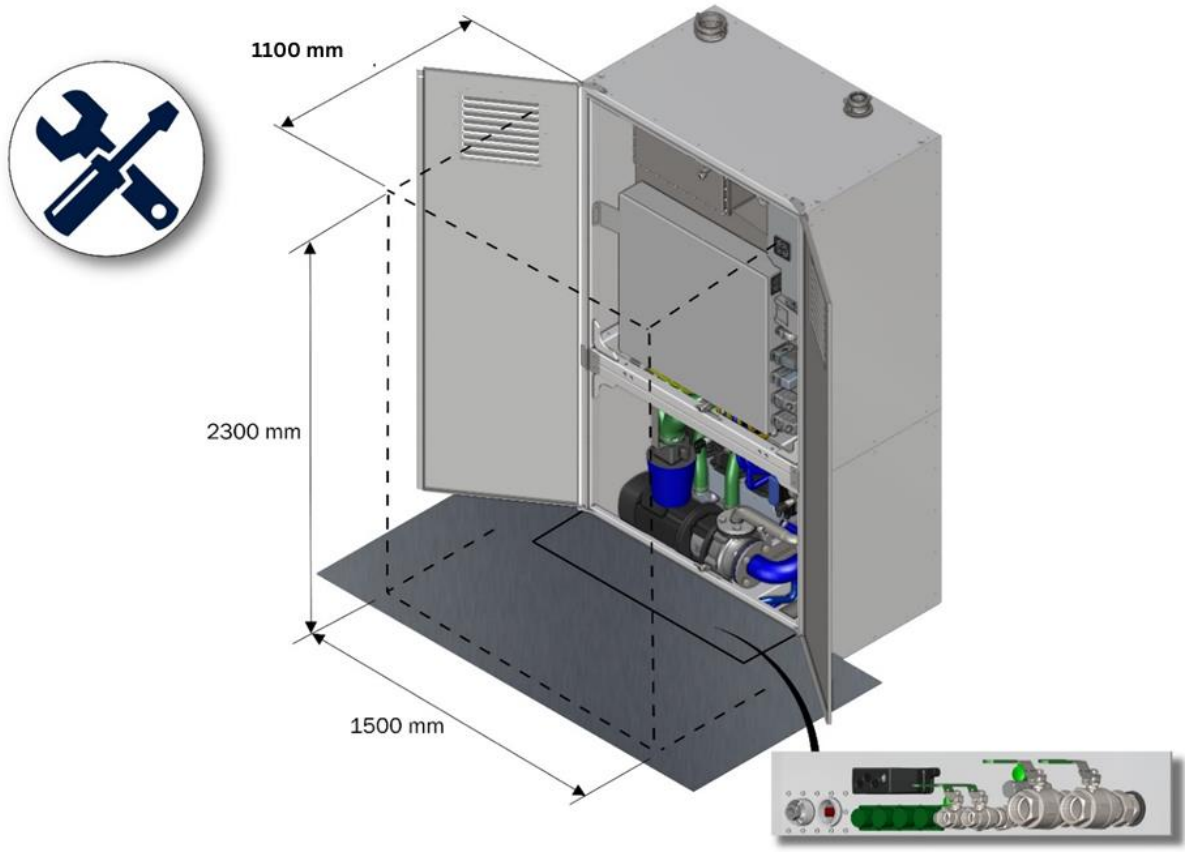


Figure 7-2: Recommended Service access for FCwave module

NOTE: Cabinet doors can be opened to 120°. If necessary, dismantle the cabinet doors to have additional service access during maintenance procedures.

7.2 Module Controller Unit (MCU) usage

The MCU is a marine-approved multi-line 300 controller, specifically for the Power and Paralleling Unit (PPU) 300 variant. The controller communicates with the Vessel Control System (VCS) via hardwires, ethernet, and a dedicated CAN bus. The VCS is in the integrator scope.

The module controller unit (MCU) consists of a main controller and an extension rack, which:

- Is responsible for overall control of the fuel cell and balance of plant (BOP) components power supply.
- Monitors and controls the state of reactants and power flowing to and from the module.
- Monitors and reacts to system conditions with various sensors, including H_2 concentration measurements.
- Has an in-built CPU with SD card for processing, communication, and bus systems.
- Has ethernet connections for rack interconnect and external communication.

An industrial grade SD card in the MCU is utilized for local data logging storage. The ethernet connection to the VCS must provide internet connectivity for the MCU to transmit data to a Ballard server through TCP port 22 (for further information contact BPSE – section 4.1). Furthermore, the ethernet connection must provide internet connectivity through TCP port 123 for time synchronization for the MCU.

NOTE: The MCU interface is primarily used to view operational data for maintenance and troubleshooting tasks. The data is available from the MCU information pages after logging into the engineering interface.

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7.2.1 Software requirements

Any computer that is used with an MCU engineering interface must be configured with the applicable software and settings. Perform this procedure the first time logging into the engineering interface, to initialize the computer for use with the MCU interface.

Setting up the computer IP address:

- Go to computer settings,
- Select 'network and settings'
- Select 'ethernet' in the left side menu
- Select 'change adaptor options' in the right side menu
- Right click on 'Ethernet 2' and select 'Properties'.
- Select 'Internet Protocol Version 4 (TCO/Pv4) and select on 'properties'.
- Insert the IP address from the module, which can be seen as a label on the Low Voltage Panel, and introduce the rest of the setting as showed in the figure below (Figure 7-3).
- Finish off by clicking 'ok'.



Figure 7-3: Settings for setting up IP address

After the computer is correctly configured to communicate with the MCU engineering interface, it is highly recommended to install the Google Chrome web browser. Although the MCU can be used with other web browsers, it was developed for Google Chrome.

For instructions on how to login to the MCU interface the first time, see section 7.2.3.

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7.2.2 Hardware requirements

Connection to the MCU can usually be performed in two separate ways, depending on the integration.

1. The integrator must provide an ethernet connection port onboard or a service access panel onboard the vessel.
2. A technician can connect their computer to this port using an ethernet cable to access the MCU interface, when the MCU is powered by the module or by the onboard system battery.

It is necessary for a technician to be able to connect to 24 V power to the MCU, to keep it running when it is not powered by the module or by the onboard system battery. A service technician can connect their computer to the I/O tester by an ethernet cable to access the MCU engineering interface.

Follow the maintenance procedures that are necessary for the I/O tester, so the MCU can be powered when the module is not in operation.

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7.2.3 Log in to the MCU Engineering Interface

The technician can log in to the MCU interface to perform the preventive maintenance and diagnostic procedures for the FCwave module.

The general procedure for log in to the engineering interface is:

- Connect an ethernet cable from the computer to the connector of the MCU ports located in the LV panel.
- Open Google Chrome (or another web browser). Type the IP address "http://10.10.10.10:8000/ballard.htm" into the address bar at the top of the screen.
- (This IP address does not represent the IP address for any specific module, but is the standard IP address the module is "born" with. The address which will be changed by a BPSE employee during commissioning, where the IP address will be adapted to customer's local network.)
- Make sure the login screen is displayed as shown below.
- Users of different training levels will have different privileges for viewing and forcing tags.
- Operators are given the read-only log in credentials (see Table 7-1) and only have permission to view diagnostics.
- Log in credentials for technicians and integrators, which provide further access privileges, will be given by completion of appropriate level of training.

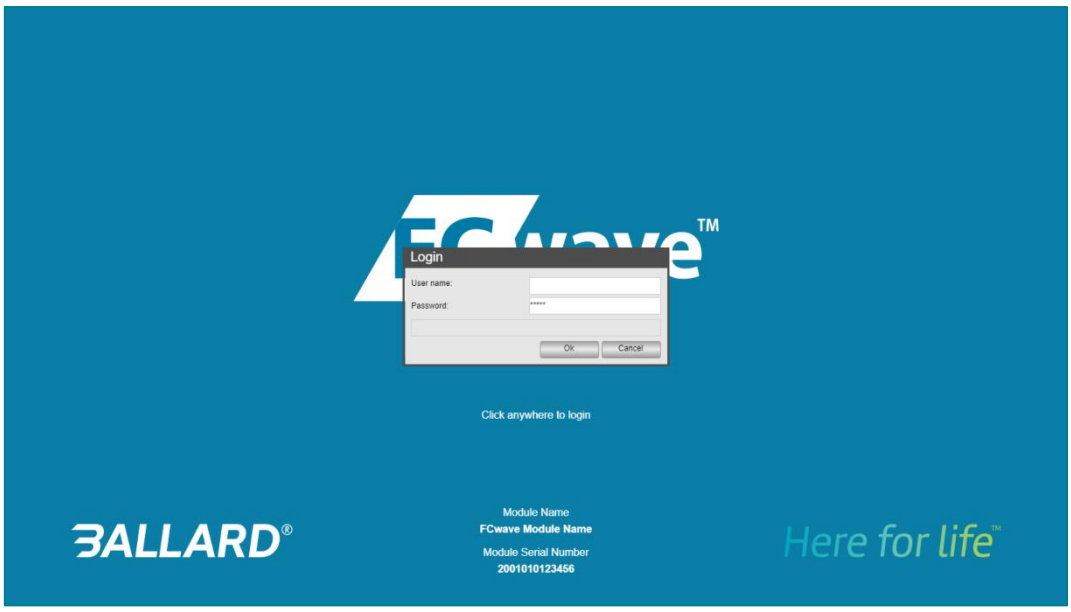


Figure 7-4: MCU Engineering Interface Login screen

User Group	Username	Password
Internal technicians (both Ballard and its partners)	OEM	[Contact BPSE (section 4.1) to get password]
Customer technicians	Customer	
Customer operators	Read-only	Ballard

Table 7-1: MCU interface login credentials

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7.2.4 MCU Engineering Interface usage

1. Use MCU engineering interface to view run-time data and alarm codes, at the time of troubleshooting.
2. After login you will be directed to the State page of the MCU engineering interface (see Figure 7-5: MCU engineering interface State screen).
3. The State screen displays all the run-time data tags which are included in the user's selection of favorites.

- Use the navigation bar on the left of the engineering interface screen to switch between different MCU interface pages.
- Use the I/O page to access the fuel cell control unit's input and output functions.

The status bar in the top band across the screen provides information about the FCwave module's current operating state and active alarms. These are always displayed on all pages of the engineering interface.

The status bar currently displays the MCU State diagram of module page.

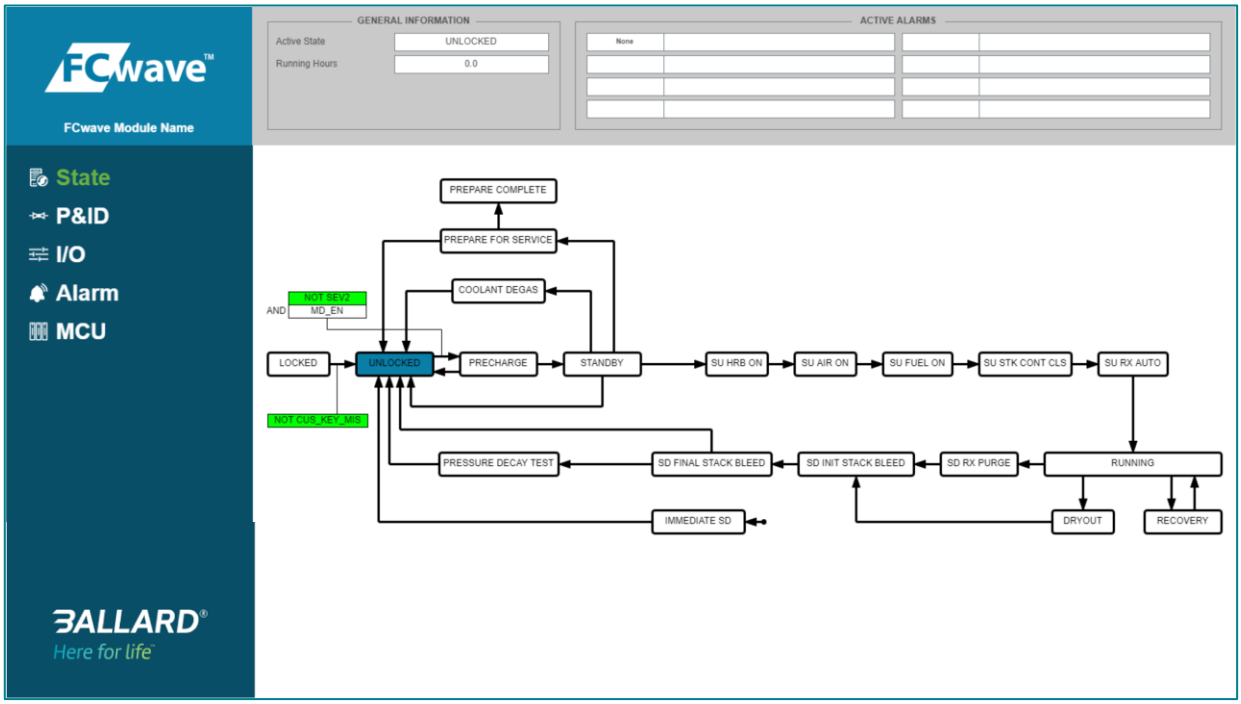


Figure 7-5: MCU engineering interface State screen

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7.2.5 MCU Interface usage

The MCU button in the navigation bar opens the MCU Information Screen.

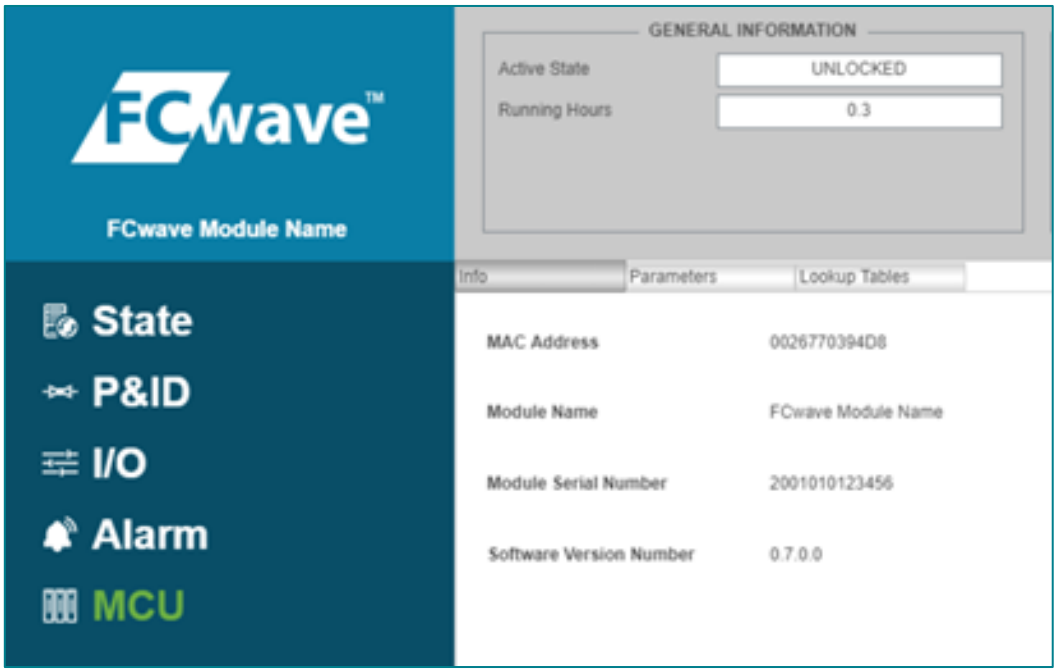


Figure 7-6: MCU Info screen

Check the module serial number.

This can be checked in two ways:

- The module serial number is shown on the login screen (Figure 7-4)
- Select MCU page in the navigation bar and then navigate the info screen to see module serial number as shown in Figure 7-6.

Check the MAC address and Software version number.

- Select MCU page in the navigation bar and then navigate the info screen to see the unique media access control (MAC) address.
- Select MCU button in the navigation bar and then navigate the info screen to see the software version number as shown in Figure 7-6.

Check running hours.

- The running hours record the FCwave module's operational hours. It is displayed on all pages of the engineering interface at the top band in status bar as shown in Figure 7-6.

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7.2.6 I/O Interface usage

It is possible to manually set the value of the various controls and sensors before/while performing any repairs.

1. Log in to the MCU engineering interface as an internal technician or customer technician user and navigate to the I/O page (Figure 7-7).
2. The MCU interface currently displays the I/O page in the navigation tab as shown in Figure 7-7.
3. Depending on the service requirement, maneuver to each I/O page - Fuel, Air, Compressors, Coolant, Electrical, Stack, Cabinet, All Input, All Output and All Calc service tabs as shown in Figure 7-7.



Figure 7-7: I/O Interface page

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7.2.7 PrepForService feature usage

Tools used for procedure	Laptop, 3m ethernet cable

Table 7-2: Tools needed for PrepForService

1. Enable 'PrepforService' by activating the module state "Standby" as shown in Figure 7-8.
2. This function is developed to reduce the time for the fuel cell stacks to de-energize and to ensure safe work environment.
3. After activation, the MCU automatically operates through a protocol that commands the air compressor, the hydrogen recirculation blower, and the coolant pump to start operating with the fuel supply closed.
4. This consumes any residual reactants that can raise the stack voltage during maintenance activities.
5. Though it is intended to bleed-down the voltage to a safe level, technicians must always check the stack voltage with a multimeter before performing any service or maintenance on the module (see section 6.5.1)

'PrepForService' can be requested/forced by any MCU user group account level. It can be found under the I/O tab – 'All inputs'.

CAUTION **The coolant pump operates at a minimum speed while 'PrepForService' is active. DO NOT activate this feature, if the coolant system is already drained.**

Activate 'Standby' state, to start 'PrepForService' function. The protocol continues for 3 minutes but it can be turned off manually if the stack voltage indicates below **10V**.

CAUTION **Always check stack voltage manually with a multimeter after 'PrepForService' operation. Do not fully depend on interface stack bleed-down voltage.**

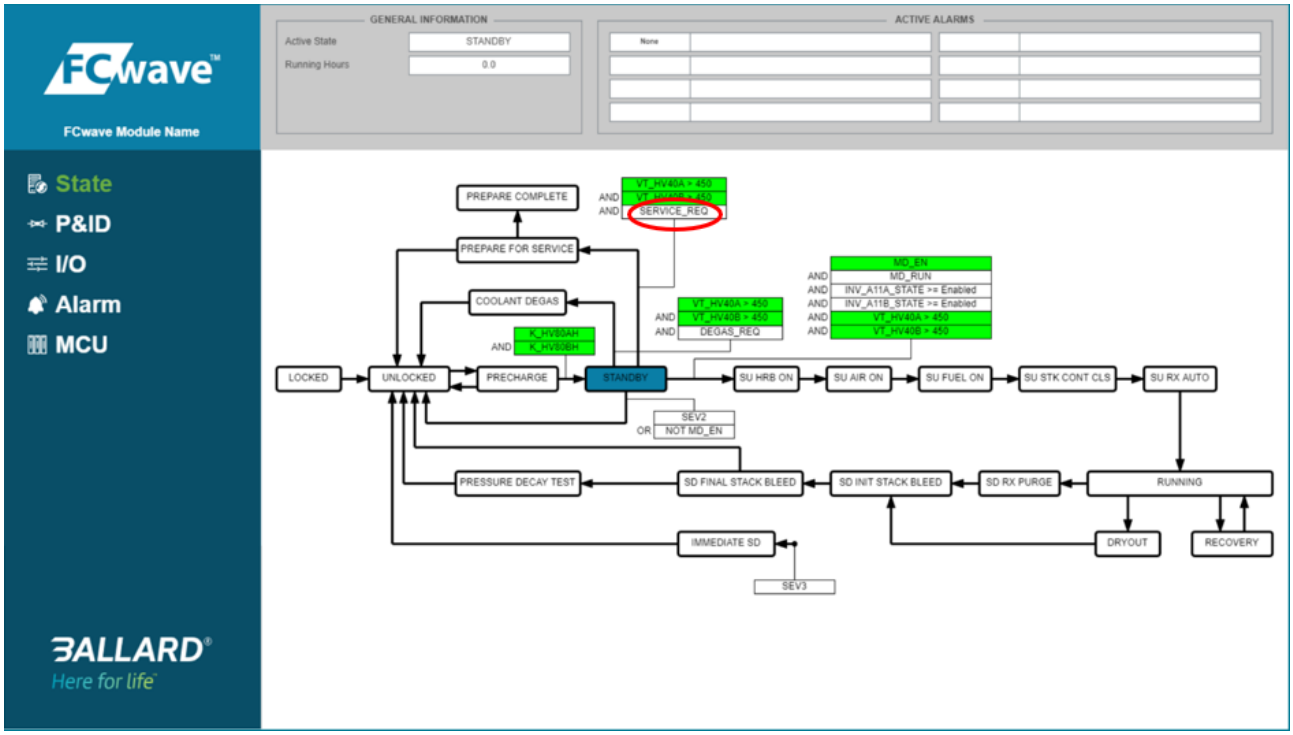


Figure 7-8: 'PrepForService'

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7.2.8 Reset the shutdown alarms

High severity faults on the FCwave module requires specific inspections, to make sure the cause of the fault is corrected for safe operation. The MCU has four levels of alarms called 'Severities'.

1. **Severity 0** – Informational Message. By CAN-Bus to vessel control system
2. **Severity 1** – Warning. By CAN-Bus to vessel control system
3. **Severity 2** – Alarm, leading to shutdown. By CAN-Bus to vessel control system in ≤ 30 sec.
4. **Severity 3** – Immediate shutdown. By CAN-Bus to vessel control system in ≤ 1 sec.
5. **Severity 4** – Emergency shutdown alarm.

The **Severity 4** Emergency shutdown alarm is handled by the safety controller - Safety System Activation (SIS) by using hardwire connection and CAN bus to vessel control system. For this type of alarm activation and actions refer to section 6.9.1.

When any of the high severity fault alarms occur, it activates the hard shutdown alarm to prevent the operator from further module operation.

- When a high severity fault activates the shutdown alarm, contact BPSE for troubleshooting support.
- The shutdown alarm must only be reset after the fault is resolved and verified by a Ballard technician.
- DO NOT use the CLEAR ALARMS button, when the shutdown alarm activates like any other alarms (Also, a shutdown cannot be cleared on its own).
- To reset any shutdown alarm - disable and enable MD_EN function on the MCU I/O page.
- The safety controller will only allow to reset emergency shutdown alarm, when the fault is cleared, no failure on components is found and after power cycling of the module.

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7.3 System de-energization, shut down and stack voltage check.

Perform steps in section 7.2.7 (PrepforService feature usage) and steps in section 6.5.1 (High Voltage safety check before module maintenance) to make sure all components are cooled off to a safe temperature before proceeding.

De-energizing relevant systems before dismounting the BOP components from the cabinet or while performing any maintenance activities.

This procedure can only be performed on a functional module which does not have any known failures. A custom shut down procedure is necessary if there is any failure in the module. Contact BPSE before start of any work (see section 4.1 for information).

The following sections identify safe shut down of each source of energy to be performed in sequential order:

7.3.1 Hydrogen supply shut-off

A hydrogen supply shut-off is necessary before dismantling the FCwave module from any integration, or to perform any work on the hydrogen supply pipelines.

1. It is recommended to use local lock out and tag out, then shut off and bleed the line on the integrated hydrogen supply system to upstream of H_2 inlet fuel cell module (Figure 7-9: Hydrogen supply shut-off). Double block and bleed valve functionality are in the customer scope.
2. Use the Purge valve and Air compressors to release the remaining H_2 pressure from the anode subsystem.
3. H_2 concentration in the process exhaust will be safely diluted by the air flow supplied by the air compressors into the exhaust system.

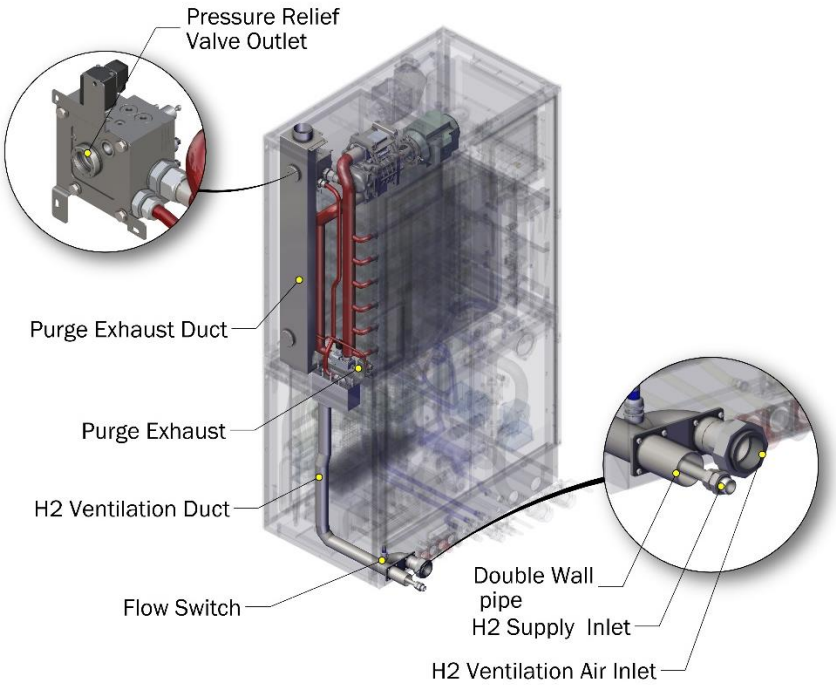


Figure 7-9: Hydrogen supply shut-off

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7.3.2 Check coolant temperature

Perform steps in section 7.2.7 to cool down internal coolant systems to be able to check coolant temperature.

WARNING **The water can be up to 50°C.**

7.3.3 'PrepForService' Operation

1. After shutdown, the module requires at least 20 minutes to de-energize. Run 'PrepForService' via MCU engineering interface to perform any service activity (see section 7.2.7).
2. Make sure that stack voltage transducers indicate less than 10 VDC. If 'PrepForService' fails and the stack voltages CT_HV30A and CT_HV30B do not drop below 10 VDC after 3 minutes, contact Ballard for assistance (see section 4.1).

7.3.4 Electrical system shut down

An electrical system shut down is necessary before removing the FCwave module from the integration or disassembling any of the BOP components from the cabinet.

1. Turn off and disconnect the customer load terminals and outputs that follows the shut-off procedure described by the system integrator.
2. Make sure the power supply(s) is turned off and bled down before performing the next steps.
3. Disconnect the customer low voltage connection from 'HRNS-X_E01' and 24 VDC power connection.
4. Shut down and disconnect all the four terminals that are connected to the module's high voltage output from the customer interface connections (Figure 7-12):
   - HV DC A+ (HRNS-X_HV01)
   - HV DC A- (HRNS-X_HV02)
   - HV DC B- (HRNS-X_HV03)
   - HV DC B+ (HRNS-X_HV04)
5. Listen for any fan or motor operation. All rotating parts should have come to a complete stop.

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7.3.5 Stack voltage check

During servicing to ensure the stack voltage is operating in safe range, follow below maintenance procedures:

1. Make sure the power output connections are disconnected to prevent personnel from starting the module.
2. Make sure the hydrogen supply is shut off upstream of the module and open the HV panel cover.

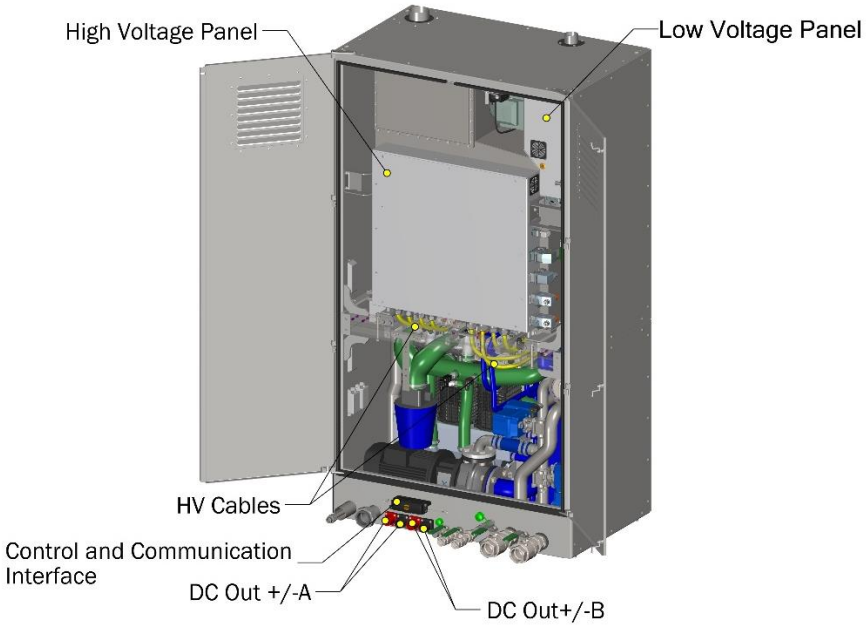


Figure 7-10: Stack voltage connections

3. Examine the components inside the HV panel using an approved multimeter.

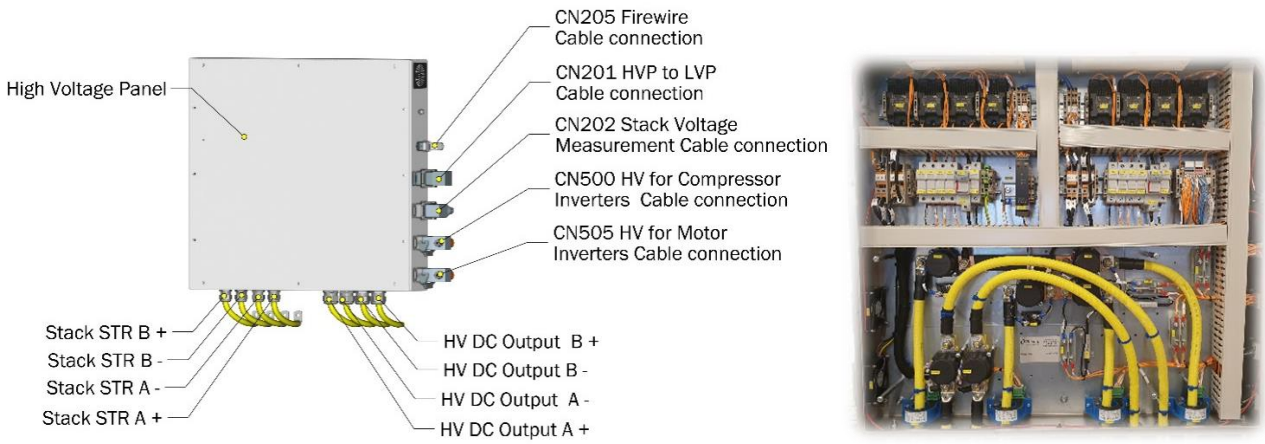


Figure 7-11: Inside the HV Panel

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4. For safety reasons, the absence of dangerous voltage must be measured with a voltage tester (for further information, see section 6.5.1). In case of failure, try to find the root cause using the troubleshooting guide. Alternatively, discharge the electric charge using a resistor in an external circuit. Make sure the measurement criteria from Table 7-3 are met.

Measurement	Pass Criteria
HV DC A+ to STACK OUT B-	≤10 VDC
HV DC B+ to STACK OUT B+	≤10 VDC
HV DC A- to STACK OUT A-	≤10 VDC
HV DC B- to STACK OUT A+	≤10 VDC
LV -X_E01 to -CN100	≤10 VDC
LV -X_E01 to -CN101	≤10 VDC

Table 7-3: Voltage measurement criteria

5. Run PrepForService (section 7.2.7). If voltage is higher than ± 5 V AC or DC between one of the test points, wait at least 15 minutes and perform this step again.

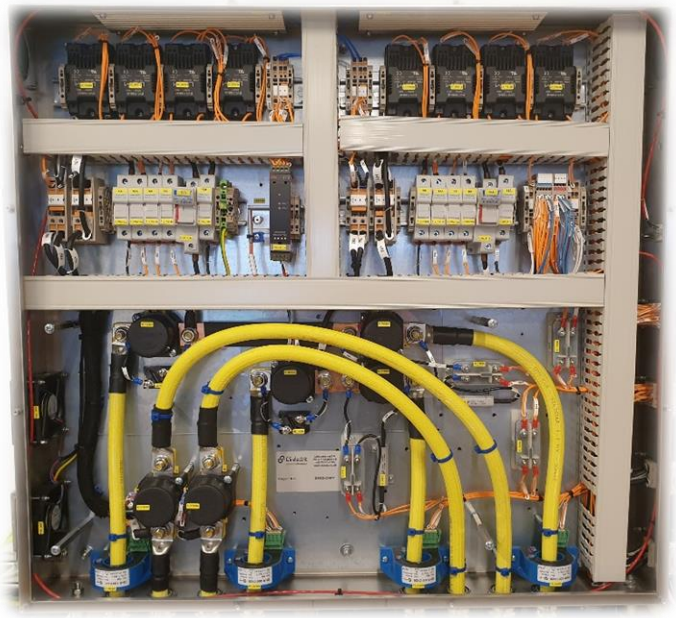


Figure 7-12: HV Panel voltage measurement points

6. Complete all further disconnections necessary by the system integrator before performing work.

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7.3.6 Coolant system shut-off

A coolant system shut-off is necessary before dismantling the FCwave module from the integration, or to perform any work on the cooling systems.

1. Close and shut off all valves on the integrated coolant system to isolate the circuit of the HT external circuit and LT auxiliary coolant loop.
2. Place a clean container below the coolant drain points.
3. There are two drain valves at the lowest point on the integrated cooling system for HT and LT coolant (Figure 7-13: HT and LT Coolant drain ports
4.).
5. Drain the stack HT coolant via drain port located at the interface of lower cabinet (see section 7.1 for Interface connections).
6. Drain the low temperature coolant loop via drain port located at the interface of lower cabinet (see section 7.1).
7. Discard the used coolant according to local environmental regulations.

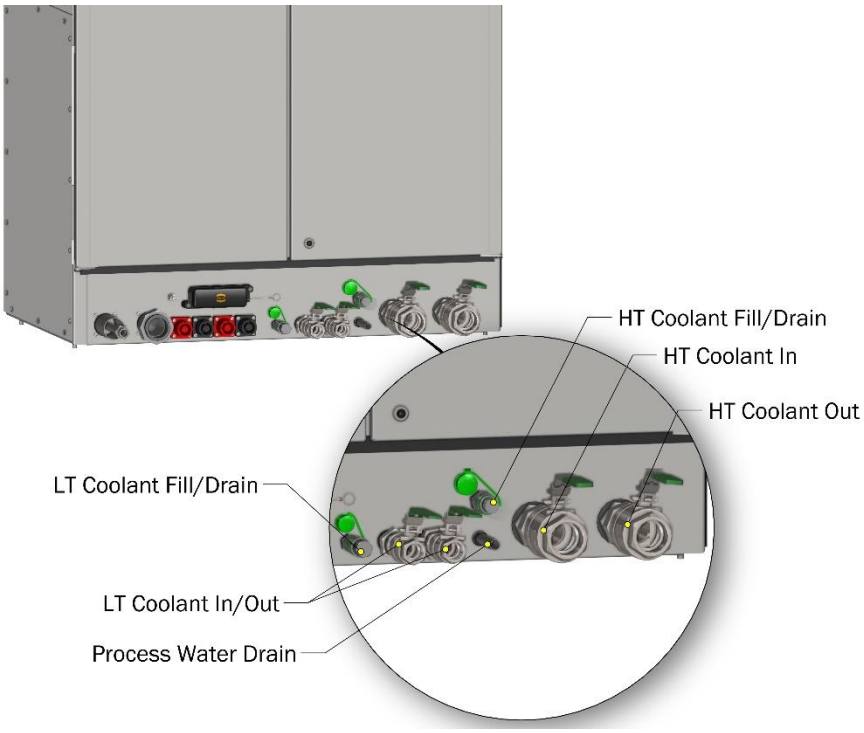


Figure 7-13: HT and LT Coolant drain ports

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7.4 Lifting and Handling of the FCwave™

Lift and handle the FCwave module equipment carefully with slow motions, to avoid sudden movements and shocks. Before installation on the floor, check the alignment of all four bottom and four rear installation points on the vessel.

WARNING **Only approved personnel are allowed to lift and handle the equipment, failure to follow guidelines can cause lifting accident, which leads to personnel injury and damage to equipment.**



Figure 7-14: Lifting and handling of FCwave module

NOTE: Lifting eye bolts, slings and lifting beam are NOT in the Ballard scope of supply.

Follow the guidelines for safe use of lifting the FCwave module:

- Make sure all 4 lifting points provided on the top of cabinet are used, which carry the total weight of the complete FCwave module.
- Make sure all lifting devices are rated for the required load (see technical datasheet for exact dry weight).
- Use shackles, lifting straps, spreader/lifting beam and lifting brackets to equally distribute the load.
- Make sure the lifting points are only loaded vertically. Do not pull the lifting mounts at an angle.
- The use of an overhead electric hoist with a lifting beam is highly recommended.
- For dismounting the upper cabinet from the lower cabinet refer to section 8.5.10.

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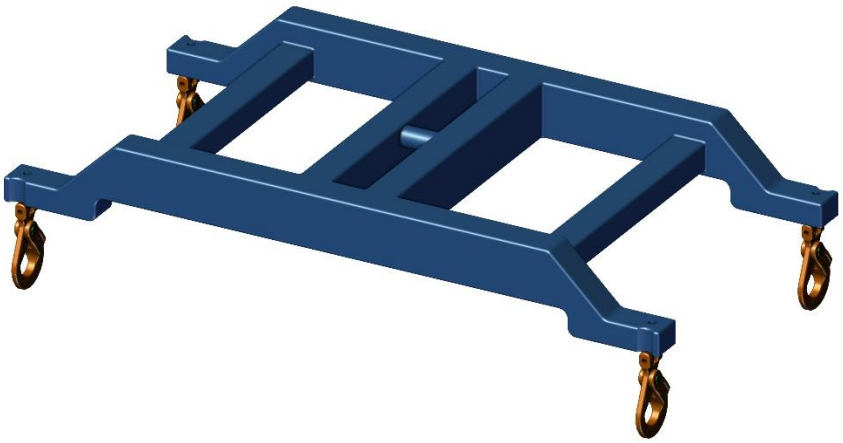


Figure 7-15: Lifting beam

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7.5 Insulation resistance Test

This procedure is currently under development and will be a part of the next revision.

Purpose

Insulation resistance (megohmmeter) tests the electrical resistance of the insulating components in a circuit. The insulation resistance is measured when the voltage is applied to the circuit, to determine if there is enough insulation to isolate the electrical current.

After performing any work on the fuel cell stacks, bus bars, high voltage connectors, contactors, or circuit boards, it is necessary to perform an Insulation resistance test.

Responsibilities

Only trained service technicians must perform this activity. For details refer to section 8.1.3.

Parts and Equipment

A list of parts and special equipment is identified to perform the procedure during the life and operation of the FCwave module.

- Crocodile clips (quantity to be decided)
- Multimeter

Safety

Wear all the required PPE (Nitrile gloves, etc.). Refer to section 8.1.2 to follow the instructions.

To perform an insulation resistance test, proceed as follows:

1. Keep a minimum of 1m safety barrier around the FCwave module with red tape. Remove all other equipment from the work area to allow the personnel to leave the area.
2. Remove all unwanted material or tripping hazards. Furthermore, no hydrogen, coolant or airline must be connected to the module.
3. System needs to be in state “Prepare for complete service”.
4. System doors can be opened safely.
5. Check stack voltage to make sure the module is safe to work.
6. Disconnect all the electrical connections to the module.
7. Locate the HV panel assembly installed in the upper cabinet and remove its front cover bolts (Figure 7-16).

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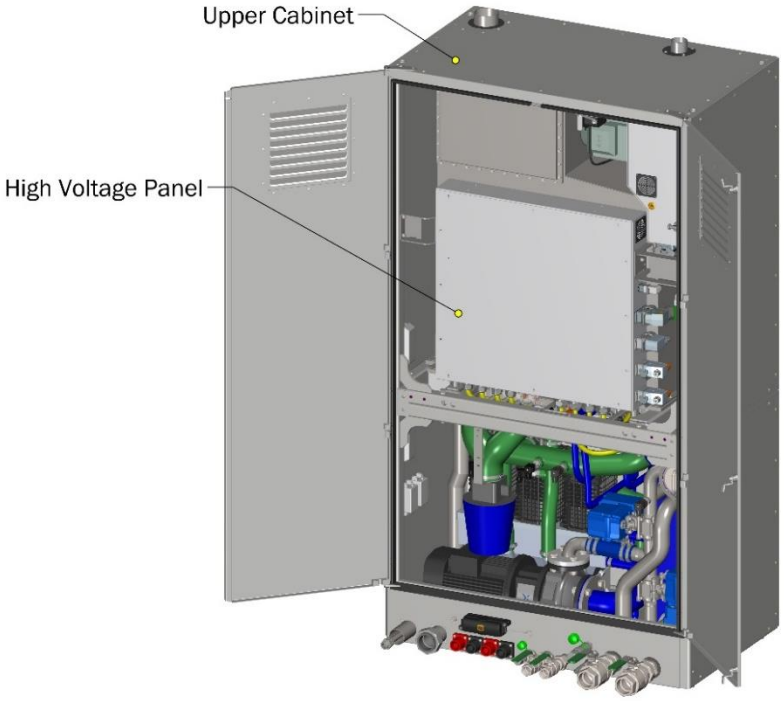


Figure 7-16: High Voltage probe positions for HV insulation test

This procedure is currently under development and will be a part of the next revision.

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7.6 Best Practices

7.6.1 Torque and Fastener Specifications

It is necessary to use the recommended tightening torques for fasteners, hose clamps and sensors for safe operation of the FCwave module.

- Tighten all fasteners to prevent parts from loosening due to vibration.
- Torque tightening must be applied with a calibrated torque wrench.
- Torque requirements depend on the type of materials, the type of part being connected, and if any washers or thread-locking chemicals are utilized.
- Do not apply excessive torque, that can cause damage to the fastener or other components.
- Do checks on torque wrenches and guns regularly, to make sure for correct calibration.
- Record the data in the logbook.

Warning and recommendations when using stainless steel bolts:

- When stainless steel surfaces with the same or similar materials come into contact and undergo friction, the risk of galling increases.
- High contact pressure between the bolt thread and nut can exacerbate galling. As the threads tighten, they can create significant friction, leading to galling if there's insufficient lubrication.
- Proper lubrication between the threads is essential to reduce friction and prevent galling.
- Under high stress and elevated temperatures, the risk of galling increases.
- Apply krytox for bolts used in the H_2 full system and for the process air system.
- To prevent galling with stainless steel bolts and nuts:
  - Apply an appropriate anti-seize lubricant or thread lubricant to the threads before assembly
  - Avoid excessive tightening torque, which can increase the risk of galling
  - Coating the threads with a material like zinc or cadmium can reduce the risk of galling

Usually, fasteners must be tightened with hand before applying the specified torque. If the assembly procedure is in the reverse order of disassembly, torque specifications will be included in its replacement maintenance section. Assembly steps will be given only when the fasteners or parts are critical. Follow manufacturer guidelines where they are applicable.

Refer to Table 7-4 for the FCwave module standard torque values. All fasteners of a given size require the torque of stainless-steel grade 8.8. Few exceptions can be found for parts that are made from a softer material, such as aluminum, plastic, etc. Multiple torque tools can be required for satisfactory torque range and safety of the BOP components.

Fastener	Tool		Torque Specification for FCwave module (Nm)	Exceptions
	Allen key	Wrench		
M3	2.5 mm hex		1.3 ± 0.2	
M4	3 mm hex	7 mm	3.5 ± 0.5	
M5	4 mm hex	8 mm	6.5 ± 0.5	
M6	5 mm hex	10 mm	10 ± 0.5	For Manifold connections M6 bolt must be tightened to 6 Nm only.

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Fastener	Tool		Torque Specification for FCwave module (Nm)	Exceptions
	Allen key	Wrench		
M8	6 mm hex	13 mm	25 ± 0.5	M8 on Compressor, Inverter, Exhaust fit bolts, Humidifier connection brackets– use 15 Nm only. M8 on Heat exchanger bracket – use 9.5 Nm only.
M10	8 mm hex	17 mm	50 ± 5	For H_2 Valve block bracket – use 25 Nm only.
M12	10 mm key	19 mm	85 ± 5	
M14	12 mm key	22 mm	140 ± 5	
M16	14 mm key	24 mm	150 ± 5	
Thread connection 1/4”		19mm Wrench	15 ± 0.5	
Thread connection 1/8”		18mm Wrench	18 ± 0.5	
Thread connection 1/2” Sensors		12, 24x27, 30, 32 mm Wrench	25 ± 0.5	For DI strainer connection – use 30 Nm + PTFE tape, For Valve block vent connection – use 35 Nm.
		IMPORTANT to have a Wrench for counterturn		
Thread connection 3/4”		32 and 41 mm Wrench	50 ± 0.5	
Thread connection 1 ¼”		46x50 mm Wrench	120 ± 0.5	
Fuel supply line		20 mm Wrench	Hand tight + 1.25 turn	For new fittings
Fuel supply line		20 mm Wrench	Hand tight + 0.25 turn	For existing fittings
Contactors to bus bar		15 mm socket	17 ± 1	
HV connector to bus bar		6 mm hex and 13 mm socket	25 ± 1	
HRB controller terminals		7 mm socket	7.0 ± 0.5	
Hose clamps		7 mm socket	5.0 ± 0.5 Nm	

Table 7-4: Fastener torque specifications

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7.6.2 Handling Controllers (MCU)

The MCU controllers are complex and easily damaged components that must be carefully handled. They are vulnerable to electrostatic discharge (ESD).



Figure 7-17: MCU Controller

ESD (also called 'static electricity') can be generated by the movement of a personnel's clothes against the skin or shoes against the floor, so it is easy for a service technician to build up a static charge. The skin is conductive, which allows the static charge to flow around the body and build up. To dissipate this charge, the skin needs to be continually grounded.

An ESD wrist strap has a conductive strap that makes 360-degree contact with the technician's wrist. The cord makes sure the technician is grounded when the clip is attached to a non-painted metal surface or other grounded point.

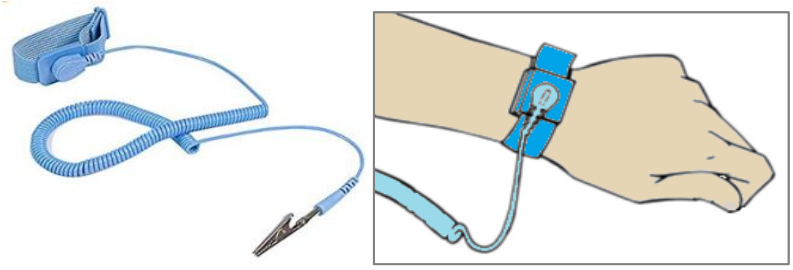


Figure 7-18: ESD wrist strap and cord

Here are a few things to keep in mind when working with controllers:

- ESD can easily damage electrical components in the MCU, even at levels that a technician cannot feel.
- Failure of controllers can happen any time after the electrostatic discharge occurs.
- Always use an ESD anti-static wrist strap and cord.
- Always transport and store controllers in sealed static protection bags (Figure 7-19: Controller cards in shielded bag) or similar containers.

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Figure 7-19: Controller cards in shielded bag

7.6.3 Environmental Protection

The FCwave module is constructed to be in accordance with the ingress protection ratings IP44. The module is designed for installation in a dedicated fuel cell room (Machinery space of category A) fulfilling the relevant fire protection and ventilation requirements as per SOLAS and Classification Society. Although the module is IP44 rated, prevent direct high-pressure water sprays.

7.6.4 Standby to Operation Cycles

Maximum standby to operation cycles: **6 cycles per hour (average)**

To prevent wear of mechanical and electrical components and to preserve the performance of the fuel cell stack, it is necessary that the number of 'Standby to Operation' cycles is limited to 6 cycles/hr. More frequent cycles can result in premature performance loss.

7.6.5 Disposition

All parts removed during maintenance must be disposed of according to section 10.0. The specified disposition is included in the preventive maintenance instructions (refer to section 8.0).

There are 3 disposition specifications:

- **Return to Ballard** — Return faulty part to Ballard for failure analysis, repair, or refurbishment.
- **Scrap** — Discard the faulty part appropriately, according to any local government regulations.
- **Hold** — Hold faulty part until Ballard has been contacted, part may need to be returned.

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8.0 Preventive Maintenance (PM) and Corrective Maintenance (CM)

The FCwave module requires periodic preventive maintenance for safe and reliable operation throughout the service life of the system.

Corrective maintenance of the FCwave module can be required in the case of a component not functioning and needs to be replaced.

8.1 Service Schedule

Adequate maintenance records verifying compliance with these tasks are required to validate warranty coverage. Failure to provide these records to Ballard can result in dismissal of warranty claims.

The end user must comply with these maintenance records:

- Date of each task performed
- Operating hours on the module at the time of each service task
- Calibrations of all service parts
- Date of all service part replacements and serial number of the part (where available)

The FCwave module Preventive Maintenance Checklist can be used as a detailed maintenance record form. Refer to the Customer Portal or contact BPSE (see section 4.1) for the latest revision.

The preventive maintenance activities that are necessary for FCwave module are listed in the preventive maintenance plan, find the newest version in the Customer Portal, which includes reference to relevant section for detailed instructions.

The Service Schedule specifies the necessary service interval for each procedure

- in hours (module operation time)
- months (elapsed time)

Service intervals are based on a duty cycle with an average output power of 67% rated power. Operating at a higher average power, which means exceeding 67% of rated power, will increase maintenance frequency of the module.

8.1.1 Responsibilities

Ballard provides necessary training to customer(s) for the FCwave module installation, operation, and maintenance procedures. This work must only be performed by approved personnel who understand the principle and are aware of the safe operation limits of the fuel cell. Thus, it is the customer's responsibility to get adequate training to operate, install, servicing and proper handling of the FCwave module.

Preventive maintenance of the fuel cell module is necessary for safe operation and is the responsibility of the end user, as described in the preventive maintenance plan.



DO NOT PERFORM MAINTENANCE SERVICE WITHOUT TRAINING OR SUPERVISION FROM BALLARD, AS DOING SO CAN RESULT IN LOSS OF WARRANTY

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8.1.2 Safety Instructions and Precautions

ALL PERSONNEL MUST READ AND FOLLOW THE INSTRUCTIONS BEFORE START OF ANY WORK.



Isolate the hydrogen supply to the upstream of fuel cell system before start of any service procedures.

Always wear adequate PPE. Follow all shipboard vessel safety protocols and general safety guidelines refer to section 6.0.



Components of the fuel cell system can reach a surface temperature of 80°C or higher. Do not perform maintenance procedures immediately after operation or before the module is cooled down.



Fuel cell voltage can exceed 390V during operation. Stack voltage stays even when the system is not in operation. Allow residual voltage decay to below 5V before performing any work. Always check stack voltage before service accessing inside the module.

8.1.3 Training level Certification

At Ballard, training is classified into 3 tiers:

- **Tier 1 – Service technicians and fuelers**
  - 1st point of contact for product support
  - Activities: Cleaning and Fueling

- **Tier 2 – Service technicians and mechanics**
  - 2nd point of contact for product support
  - Activities: Preventive Maintenance, basic troubleshooting, and spare part support

- **Tier 3 – Senior service technicians and engineers**
  - 3rd point of contact for product support
  - Activities: Report design issues, provide Tier 1 and Tier 2 training, advanced support and advanced trouble shooting

Details of roles and responsibilities are reinforced by Ballard's standard Service Level Agreement.

8.1.4 Maintenance Plan

It is required to follow the maintenance plan to ensure trouble-free operation during the lifetime of the FCwave module.

The maintenance tasks for the FCwave module are listed in the preventive maintenance plan. Go to the Customer Portal or contact BPSE, to see the latest revision (see section 4.1).

8.1.5 Maintenance Checklist

To perform periodic service maintenance, refer to the preventive maintenance checklist. Go to the Customer Portal or contact BPSE, to see the latest revision (see section 4.1).

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8.2 H_2 Fuel Anode Sub-system

For detailed P&ID requirements, refer to "Piping and Instrumentation Diagram" (PWR005), which can be found the Customer Portal or by contacting BPSE (see section 4.1 for further information).

8.2.1 Replace Purge Valve

Purpose:

The procedure describes the work instruction to replace a purge valve for the fuel cell system. The solenoid valve controls the purge of excess hydrogen and water from the fuel cell stack outlet, into the process exhaust. This keeps adequate concentration of H_2 in the sub-system and H_2 concentration in the process exhaust is kept below 2% volume.

Responsibilities:

Preventive maintenance of the purge valve is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance (see section 8.1.1)

Parts and equipment:

A list of parts and special equipment is identified to replace the purge valve during the life and operation of the FCwave module.

- FRU, Purge Valve (part no. 7500017)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Purge Valve

Based on the normal conditions, the estimated time for replacement is:

Purge Valve		
Duration	8 hours	
Personnel	1	
Tightening Torque	M4 bolt	3.5 ± 0.5 Nm
	M6 bolt	10 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	M10 bolt	50 ± 5 Nm
	1/8" Thread connection	18 ± 0.5 Nm
	Tool: 3mm, 5mm, 6mm, 8 mm Hex key, 18mm spanner	

Table 8-1: Time to replace the purge valve

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Disconnect all connectors (CN201, CN202, CN500, CN505) in the high voltage panel as shown:

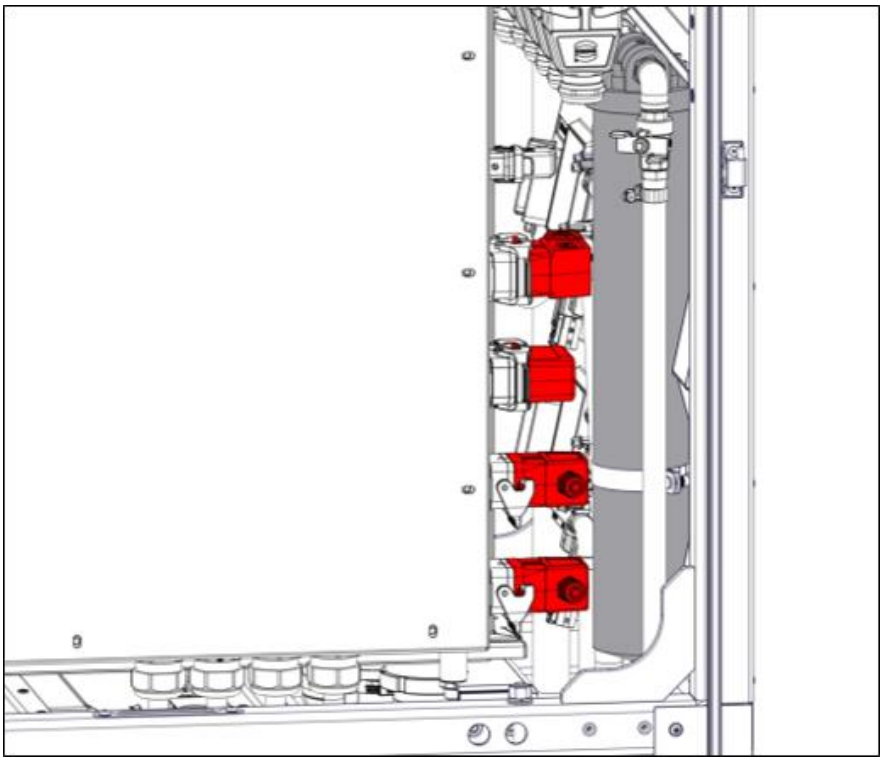


Figure 8-1: Overview of connectors in HV panel

3. Disconnect connection CN205 for fire detection from the side of the high voltage panel.

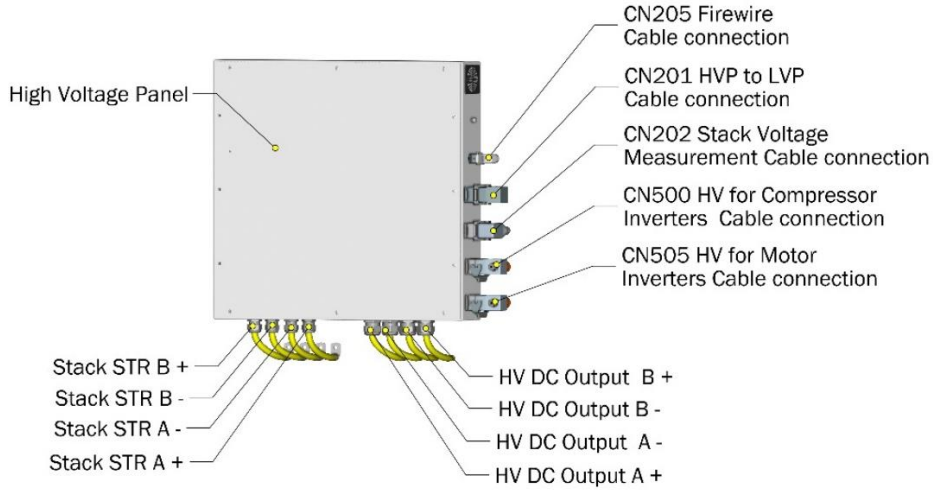


Figure 8-2: Cable connections in HV panel

4. Loosen M32 cable glands to disconnect the HV stack cable connections to positive terminals (A+, B+) and negative terminals (A-, B-).

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5. Loosen M32 cable glands to disconnect the HV DC output cable connections to positive terminals (A+, B+) and negative terminals (A-, B-).
6. Uninstall 2 pcs. M10 bolts and washers used to tighten the HV panel assembly to the bottom of upper cabinet.
7. Uninstall 2pcs. M8 bolts and washers used to tighten the HV panel assembly to the sides of upper cabinet.

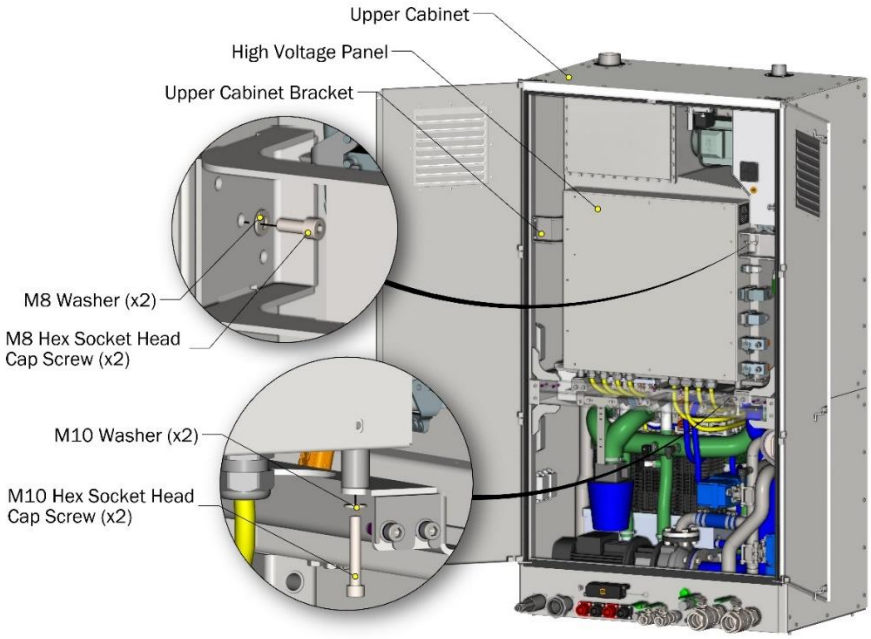


Figure 8-3: Dismount HV panel

8. If applicable, remove the ground fault monitor board.
9. Install eyebolt on each side of the HV panel and carefully lift the panel assembly, with all its hardware inside, out of the cabinet and move to flat work surface.

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10. Uninstall 22 pcs. M6 bolts and washers to remove the purge hatch cover from the H_2 enclosure.

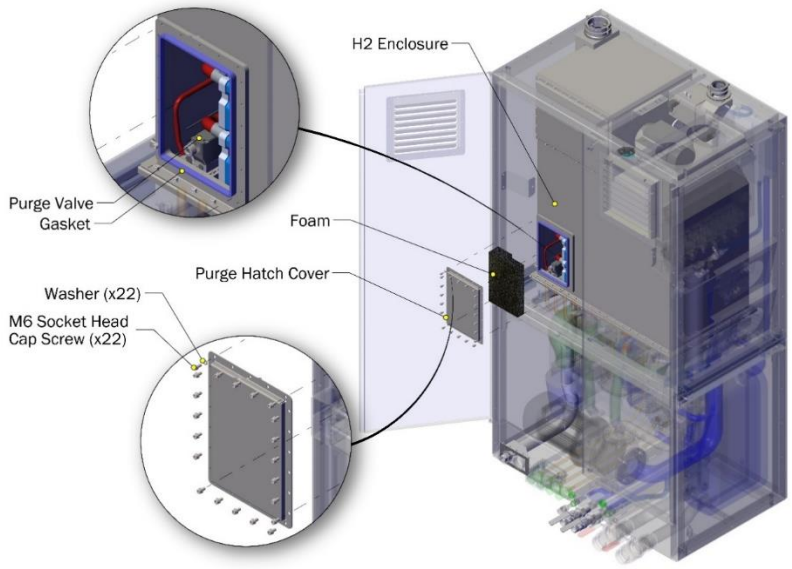


Figure 8-4: Removal of purge hatch cover

11. Remove foam in the enclosure to locate the fuel-out pressure sensor (PT_H50) behind the purge valve.
12. Remove connector (HRNS-300-YV_H50) which is routed all the way through the HRB unit.
13. Locate the H_2 enclosure top hatch and uninstall 34 pcs. M6x12 bolts to access the enclosure.

    Use a protective special plate below the HRB unit to prevent any loose part falling into the stack while servicing.

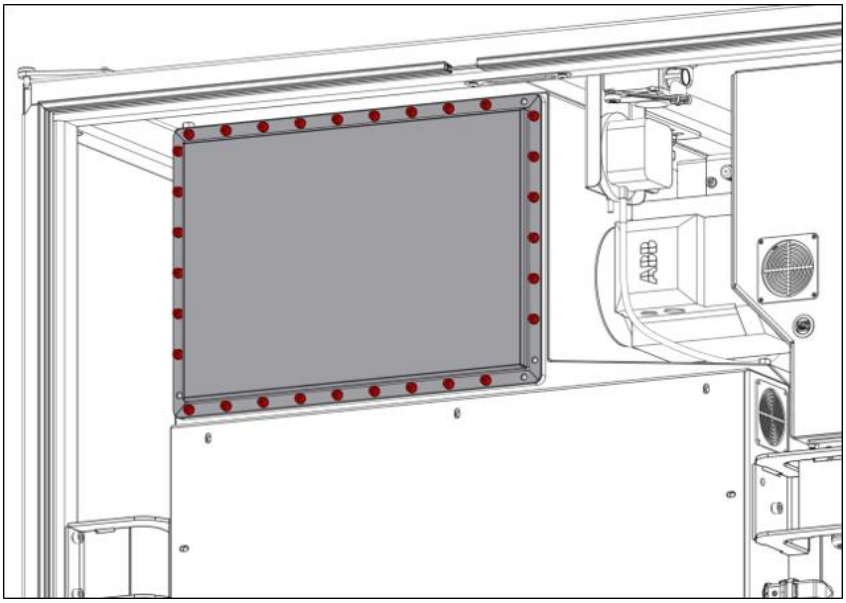


Figure 8-5: Location of H_2 enclosure top hatch

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14. Uninstall 2 pcs. M4 bolts and washers used to tighten the purge valve to the bracket in the purge hatch.

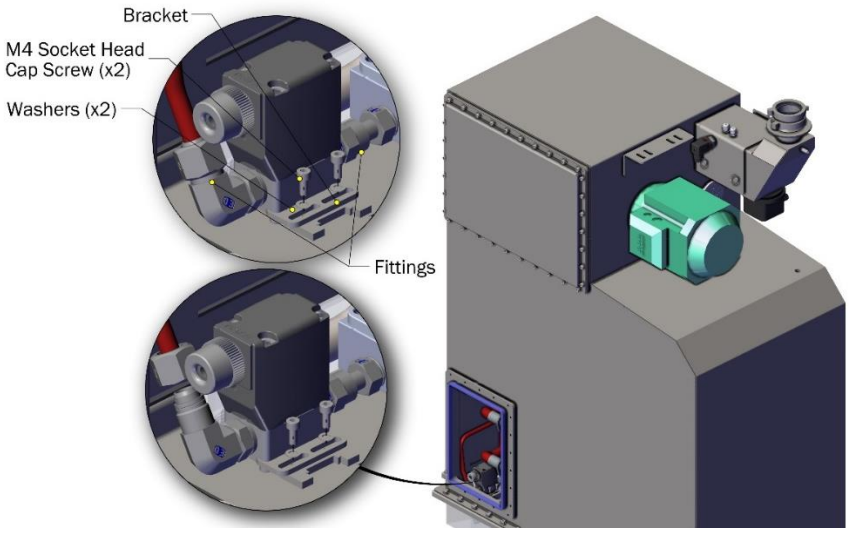


Figure 8-6: Removal of purge valve

15. Dismount the purge valve connection fittings and move to a clean work surface.
16. Uninstall 4 pcs. M4 bolts and washers used to tighten the purge valve to the bracket and remove the used gasket.

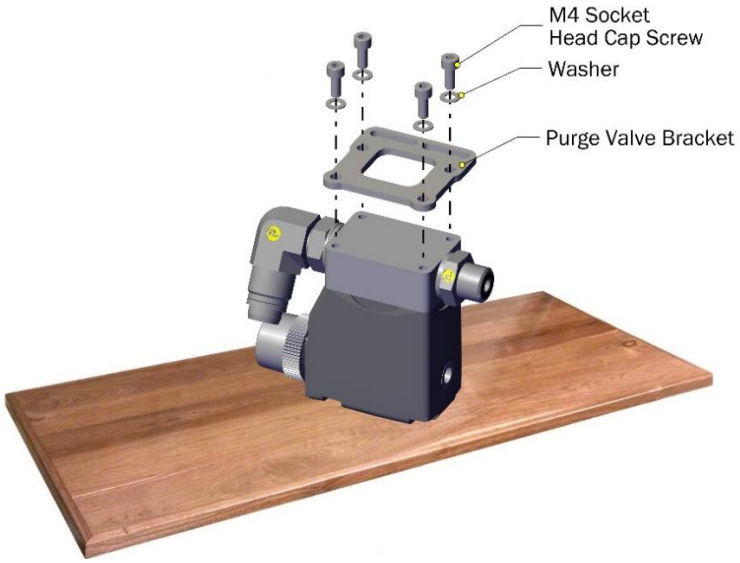


Figure 8-7: Removal of purge valve bracket and gasket

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Assembling procedure:

1. Insert new gasket in the purge valve and use 4 pcs. M4 bolts and washers to install purge valve to the bracket.
2. Place purge valve assembly into position in the purge hatch and connect the purge valve connection fittings.
3. Use 2 pcs. M4 bolts and washers to tighten the purge valve to the bracket in the purge hatch.
4. It is highly recommended to perform a leak test with H_2 sensor after any service maintenance on the purge valve (refer to section 8.2.4).
5. Use 34 pcs. M6x12 bolts and washers to install H_2 enclosure top hatch.
6. Install connector (HRNS-300-YV_H50) and place foam to cover the purge valve.
7. Use 22 pcs. M6 bolts and washers to install the purge hatch cover to the H_2 enclosure.
8. Reverse steps 2 through 9 of the disassembling procedure to install the HV panel assembly.
9. Use 12 pcs. M5x10 bolts and install the high voltage panel cover.
10. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
11. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
12. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.2.2 Hydrogen Recirculation Blower (HRB) Assembly

8.2.2.1 Check Hydrogen Recirculation Blower (HRB) Assembly

Purpose:

The procedure describes how to check the HRB assembly (Unit and Motor).

Responsibilities:

Checking the HRB assembly is necessary for safe operation according to the preventive maintenance plan (see Customer Portal). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to check the HRB Assembly

Based on the normal conditions, the estimated time for check is:

HRB Assembly	
Duration	20 min
Personnel	1
Tools	5mm hex key

Table 8-2: Time to check HRB Assembly

Procedure:

1. Before proceeding with the check, perform all steps in section 7.2.7 and 6.5.1.
2. Locate the hydrogen enclosure top hatch and use 5mm hex key to remove 34 pcs. M6x12 bolts.

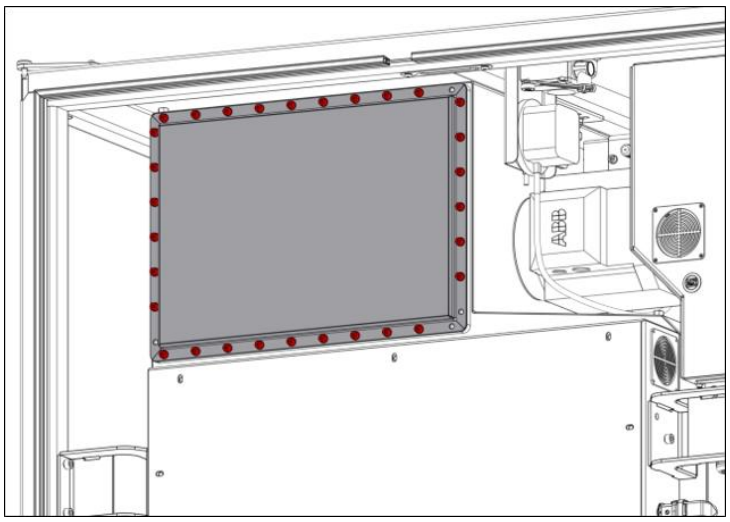


Figure 8-8: Location of H_2 enclosure top hatch

3. Remove the foam and check each piece for oil contamination from the HRB.
4. Check the HRB for oil leakage.

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5. Check the surface below the HRB for oil contamination.
6. Check the coupling material between the motor and HRB for wear.
7. Reinstall the foam and use 34 pcs. M6x12 bolts to reinstall the HRB hatch cover.
   The module is ready to be restored to normal operating state.
8. Confirm the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.2.2.2 Replace Hydrogen Recirculation Blower (HRB) Assembly

The following section describes how to replace the two parts of a hydrogen recirculation blower (HRB) assembly for the fuel cell system. The HRB assembly comprises the HRB unit and HRB motor. Both the HRB unit and HRB motor can be disassembled by disengaging the coupling connection.

8.2.2.2.1 Replace a Hydrogen Recirculation Blower (HRB) Motor

Purpose:

The procedure describes how to replace a hydrogen recirculation blower (HRB) motor assembly for the fuel cell system.

Responsibilities:

Preventive maintenance of HRB motor is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace a HRB motor during the life and operation of the FCwave module:

- FRU, HRB Motor (part no. 7500011)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the HRB motor

Based on the normal conditions, the estimated time for replacement is:

HRB motor		
Duration	2 – 2½ hours	
Personnel	1 – 2	
Tightening Torque	M6 bolts	10 ± 0.5 Nm
	M8 bolts	25 ± 0.5 Nm
	Tool: 5mm, 6mm hex key, air bags, ¼" ratchet, ¼" extension 100mm, 22mm key, 7mm, 8mm hex socket, torque wrench	
Weight	HRB motor	25 kg

Table 8-3: Time to replace the HRB motor

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the H_2 enclosure top hatch and uninstall 34 pcs. M6x12 bolts to access the enclosure.

   Use a protective special plate below the HRB unit to prevent any loose part falling into the stack while servicing.

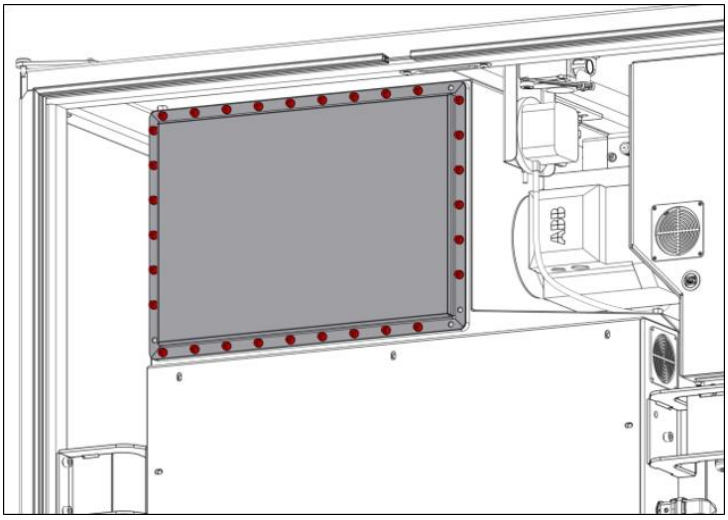


Figure 8-9: Location of H_2 enclosure top hatch

3. Gently remove foams in the enclosure and locate the HRB assembly.
4. Disconnect the CN500 plug from the right side of the HV panel to disable the HV power supply for the HRB motor controller.
5. Uninstall 2 pcs. bolts to open the HRB motor cover.
6. On the HRB motor, disconnect the inverter controller for the HRB motor connection HRN-400-CN_INV_H50 and the ground cable.
7. Uninstall 3 pcs. M8x30 bolts from the top right support bracket of the high voltage panel and remove the bracket.

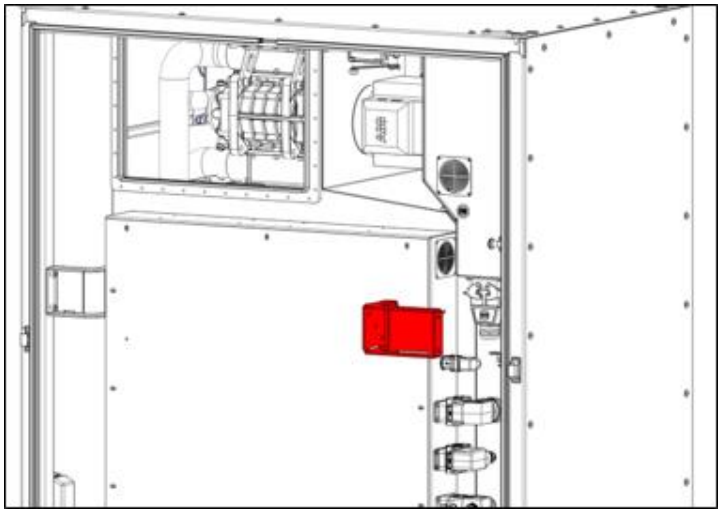


Figure 8-10: Support bracket on HV panel

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8. Slide the LV panel out a bit to make room for removing the HRB motor from the enclosure.
9. Insert 2 pcs. air bags below the HRB motor and inflate to support the motor.
10. Remove 4 pcs. M8x30 bolts.

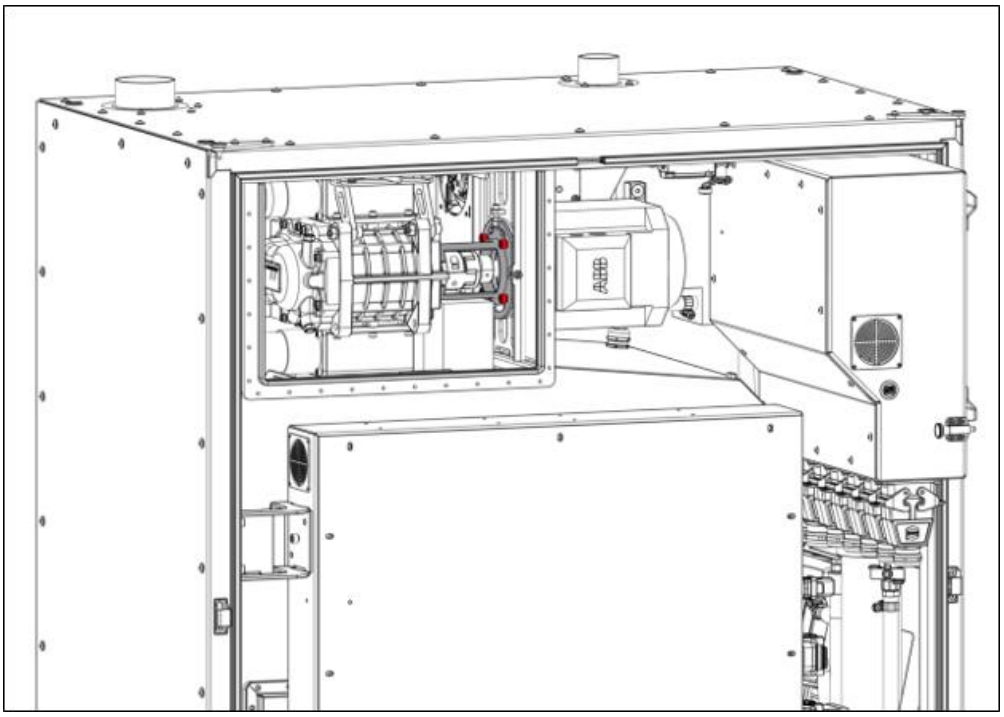


Figure 8-11: Removal of bolts to loosen HRB motor

11. Slide HRB motor to the right, turn and remove from the enclosure. Also remove air bags. Place the motor on a flat surface for service purposes.

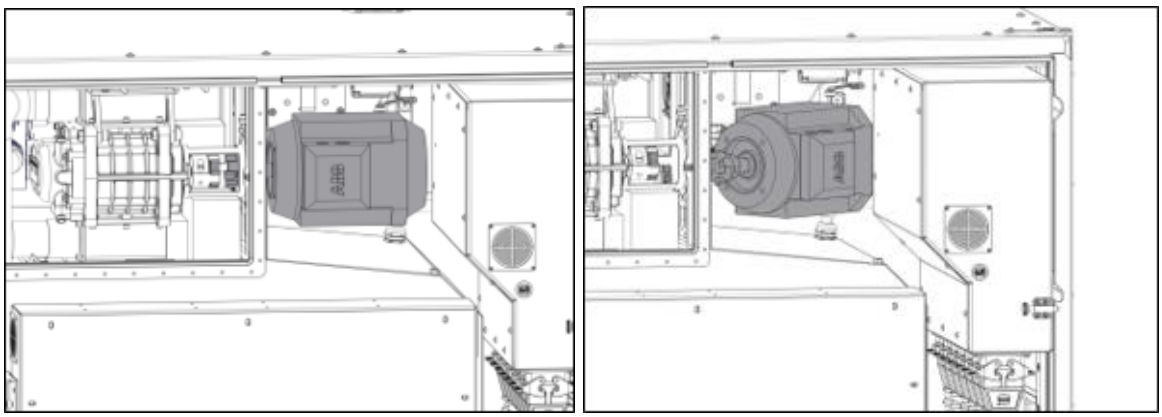


Figure 8-12: Turning and removing HRB motor

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Assembling procedure:

1. Place air bags beside the H_2 enclosure to support the HRB motor.
2. Carefully lift the HRB motor and place it on the air bags. Then carefully slide the motor clamping hub into the enclosure.

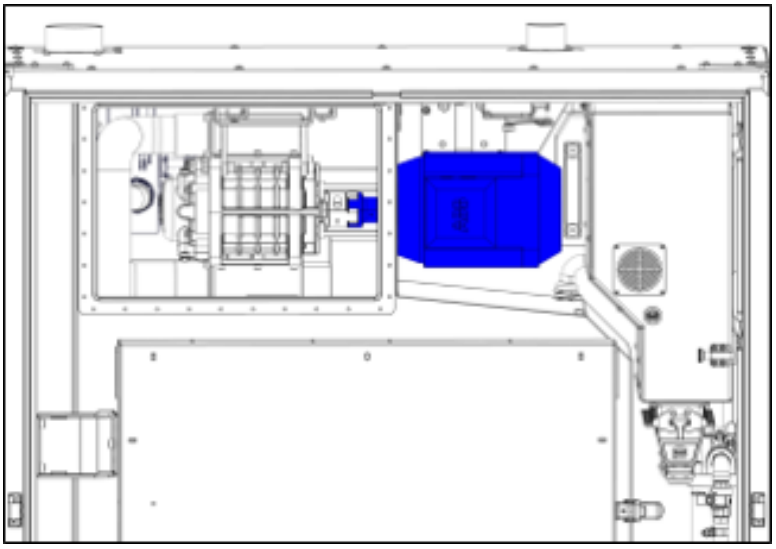


Figure 8-13: Install HRB motor to enclosure

3. Use the M6 alignment bolts to align the motor shaft.
4. Use 4 pcs. lubricated new M8 bolts to install the HRB motor to the enclosure. Tighten to 25 Nm.

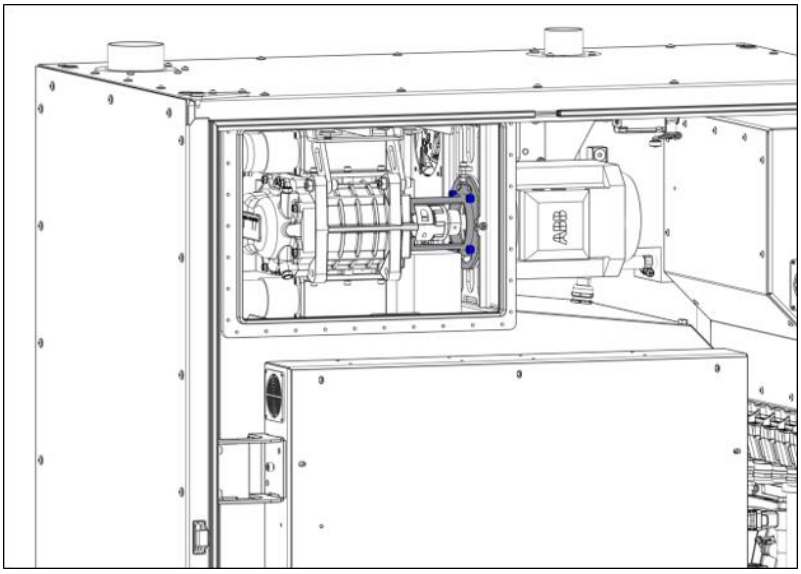


Figure 8-14: Securing motor to enclosure

5. Remove air bags from underneath the motor.
6. Connect both the inverter controller for the HRB motor connection HRNS-400-CN_INV_H50 and the ground cable.
7. Use 2 pcs. M8 bolts to install the HRB motor cover.

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8. Slide in the LV panel.
9. Use 3 pcs. M8x30 bolts and washers to install the right-side bracket of the HV panel. Tighten to 10 Nm.
10. Insert the foam on the front-side of the H_2 enclosure as shown:

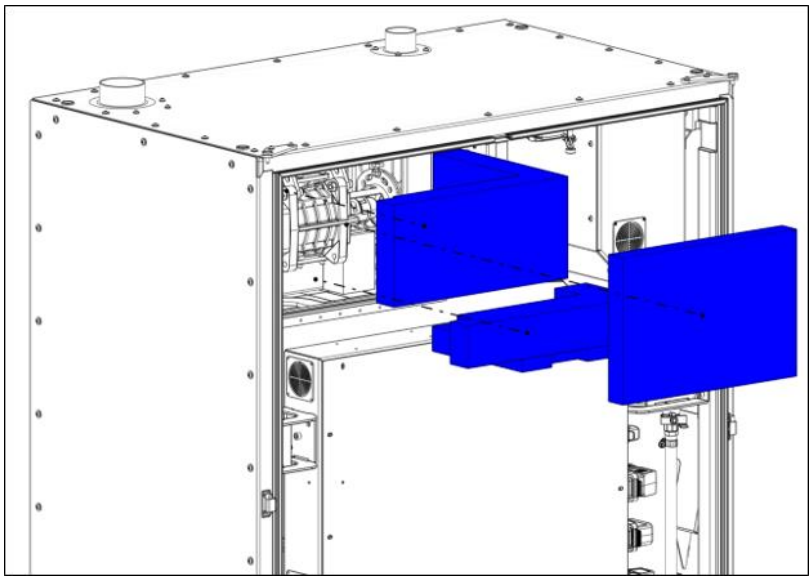


Figure 8-15: Install foam after installing HRB unit

11. Use 34 pcs. M6 bolts to install the H_2 enclosure top hatch cover. Tighten to 6 Nm.
12. Power up the module. Follow the HRB Test procedure to test the HRB alignment by manually activating the HRB motor through the engineering interface. Listen for loud noise and vibrations in the HRB assembly area before proceeding.
13. Contact BPSE customer care to register and reset the hour counter in the engineering interface for the HRB assembly.
14. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
15. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
16. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.2.2.2.2 Replace a Hydrogen Recirculation Blower (HRB) Unit

Purpose:

The procedure describes how to replace a hydrogen recirculation blower (HRB) unit assembly for the fuel cell system.

Responsibilities:

Preventive maintenance of HRB unit is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace a HRB unit during the life and operation of the FCwave module:

- FRU, HRB (part no. 7500007)
- FRU, Coupling (part no. 7500008)
- FRU, Coupling Element (part no. 7500013)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the HRB unit

Based on the normal conditions, the estimated time for replacement is:

HRB unit		
Duration	4 – 4½ hours	
Personnel	1 – 2	
Tightening Torque	M6 bolts	10 ± 0.5 Nm
	M10 bolts	50 ± 5 Nm
	Tool: 5mm + 8mm hex key, 12mm socket, 46mm crow's foot wrench, 17mm spanner, plastic bag/tape, ½" ratchet, ½" extension 400mm, torque wrench	
Weight	HRB unit	18 kg

Table 8-4: Time to replace the HRB unit

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Perform all steps in section 8.2.2.2.1 disassembling (Replace a Hydrogen Recirculation Blower (HRB) Motor) before proceeding.
3. Uninstall 3 pcs. M6 bolts from the fuel inlet manifold fitting. Afterwards cover the opening to prevent any unwanted material from entering the inlet. Slide off the hose as much as possible.

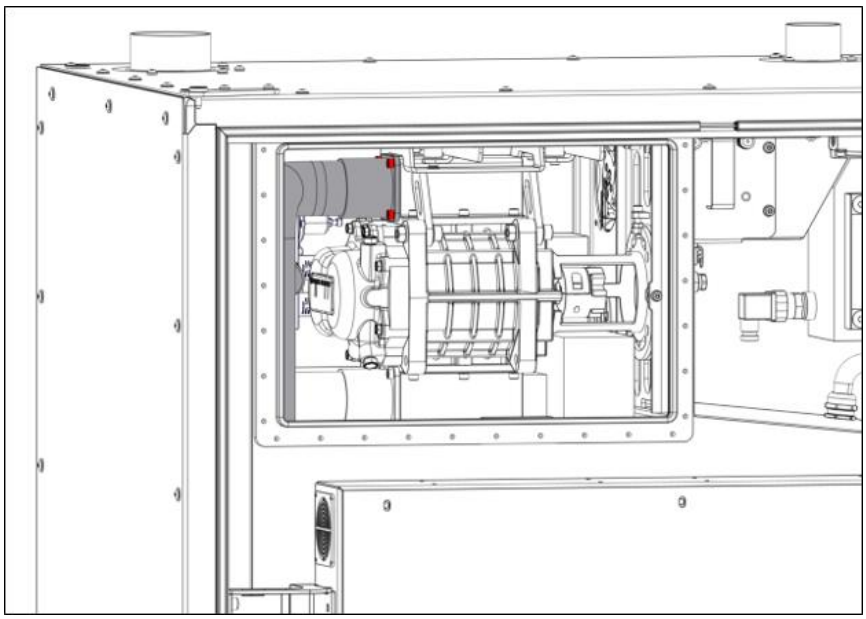


Figure 8-16: Removal of bolts for fuel inlet manifold

4. Uninstall 3 pcs. M6 bolts from the fuel outlet manifold fitting. Afterwards cover the opening to prevent any unwanted material from entering the inlet. Slide off the hose as much as possible.

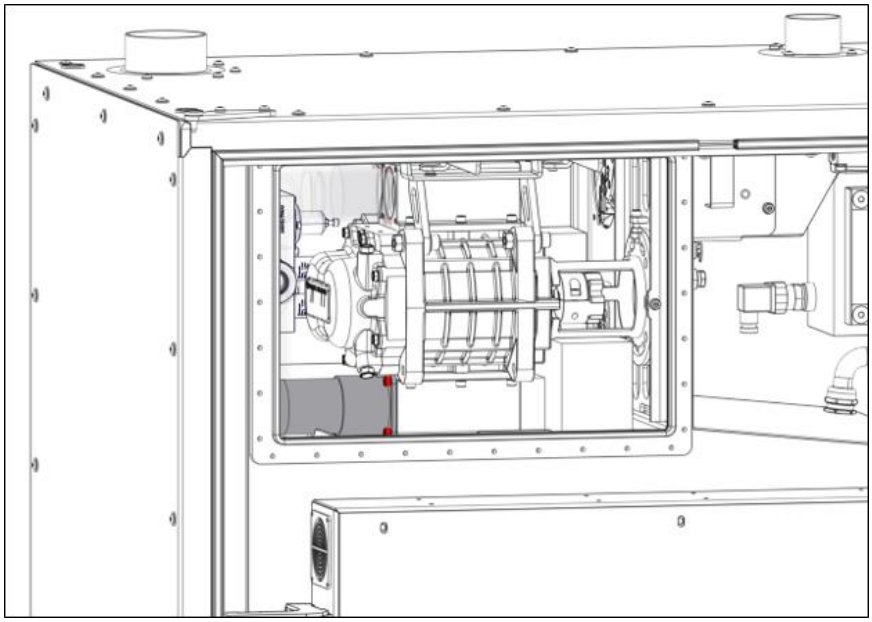


Figure 8-17: Removal of bolts for fuel outlet manifold

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5. Use crow's foot wrench to remove the fuel outlet hose fitting from the valve block.

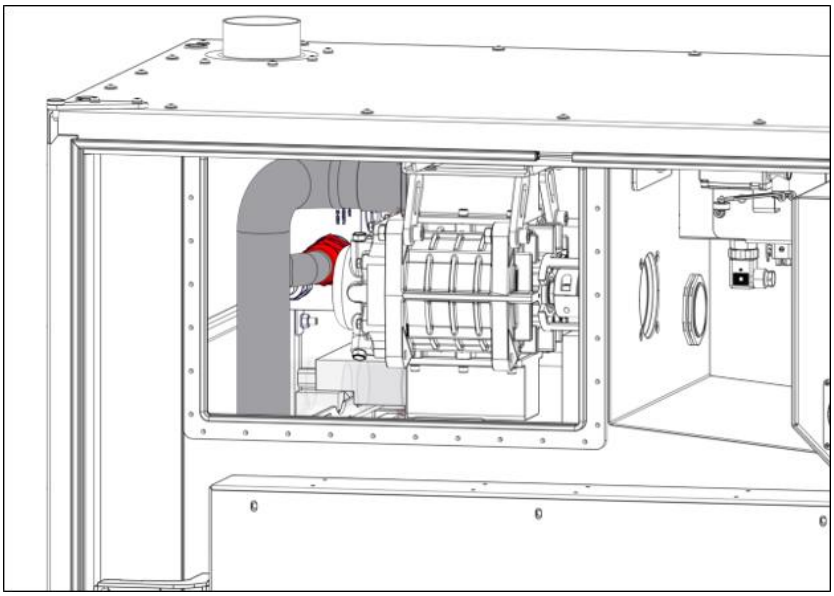


Figure 8-18: Removal of fuel outlet hose fitting

6. Uninstall 3 pcs. M6 bolts from the damper shoe brackets.
7. Carefully slide the HRB unit to the left over the mounting rails to dismount it from the H_2 enclosure. Rotate it 90 degrees horizontally, so the damper shoe bracket faces the enclosure top hatch and remove the HRB unit from the enclosure. Place it on a flat surface for service maintenance.

⚠ CAUTION Wear long sleeves and gloves to prevent cutting yourself on sharp edges when removing the HRB unit.

8. Remove old O-rings from disconnected hoses and open ports and then cover with a clean cap, plastic bag, or tape.
9. Disassemble the HRB compressor as shown:



Figure 8-19: Disassemble HRB compressor

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Assembling procedure:

1. Use 12 pcs. new M6x20 bolts and washers to reassemble the HRB manifolds with new O-rings. Tighten to 10 Nm. Remember to lubricate the bolts and to note down the serial number.
2. If not already there, carefully install the foam behind the HRB assembly.
3. Apply krytox and mount new O-rings in the fuel outlet and fuel inlet manifold fittings.
4. To insert the HRB unit, rotate it 90 degrees horizontally, so the bottom of the HRB faces the H_2 enclosure. Carefully insert the HRB unit inside the enclosure and rotate back to the correct position to mount it on the H_2 enclosure frame.
5. Fasten 3 pcs. M6 bolts to secure the HRB assembly to the H_2 enclosure. Tighten to 6 Nm.

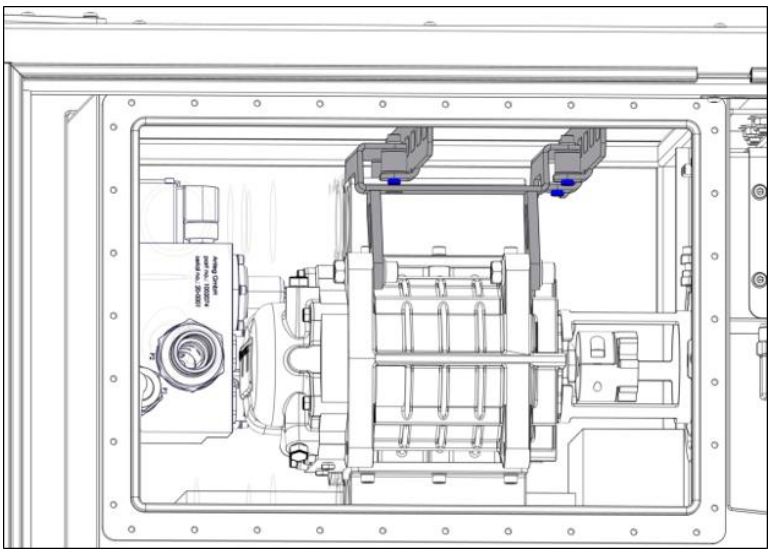


Figure 8-20: Install HRB assembly to bracket

6. Slide the lower hose onto the HRB fitting and make sure not to cut the O-ring. Use 3 pcs. M6 bolts to install it. Tighten to 6 Nm.

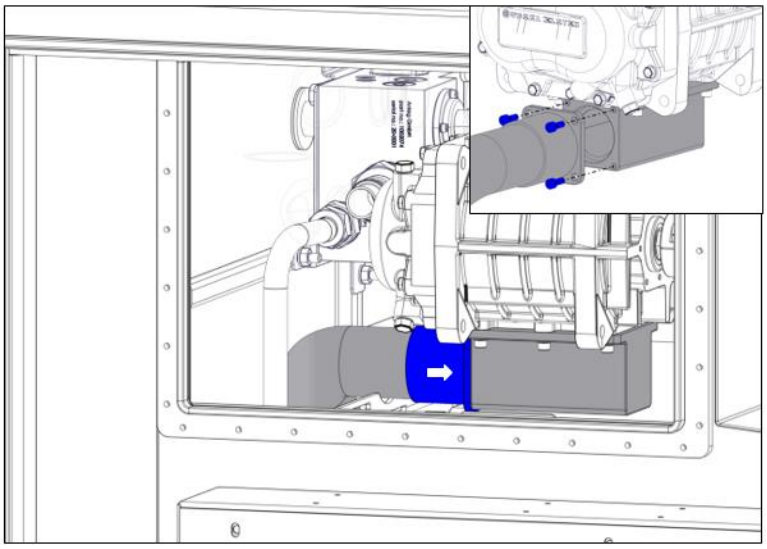


Figure 8-21: Install lower hose to HRB fitting

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7. Apply a bit of krytox to the fitting thread and connect the fuel outlet hose fitting to the valve block. Tighten to 120 Nm.
8. Slide the upper hose onto the HRB fitting and make sure not to cut the O-ring. Use 3 pcs. M6 bolts to install it. Tighten to 6 Nm.
9. Replace the motor gasket.

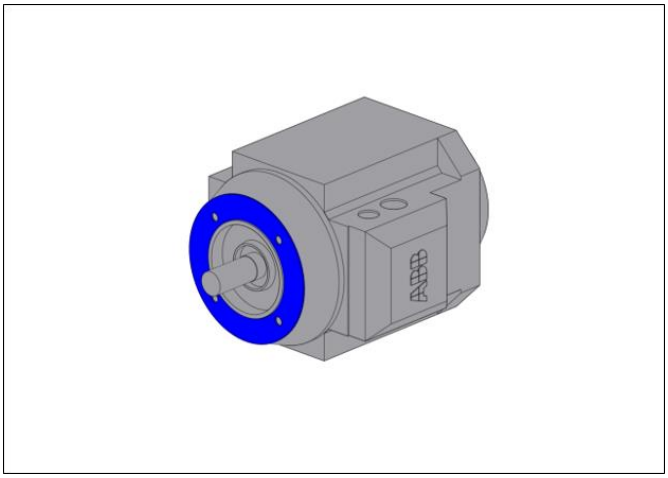


Figure 8-22: Replace motor gasket

10. Mount the new element 24/32 onto the clamping hub of the motor.

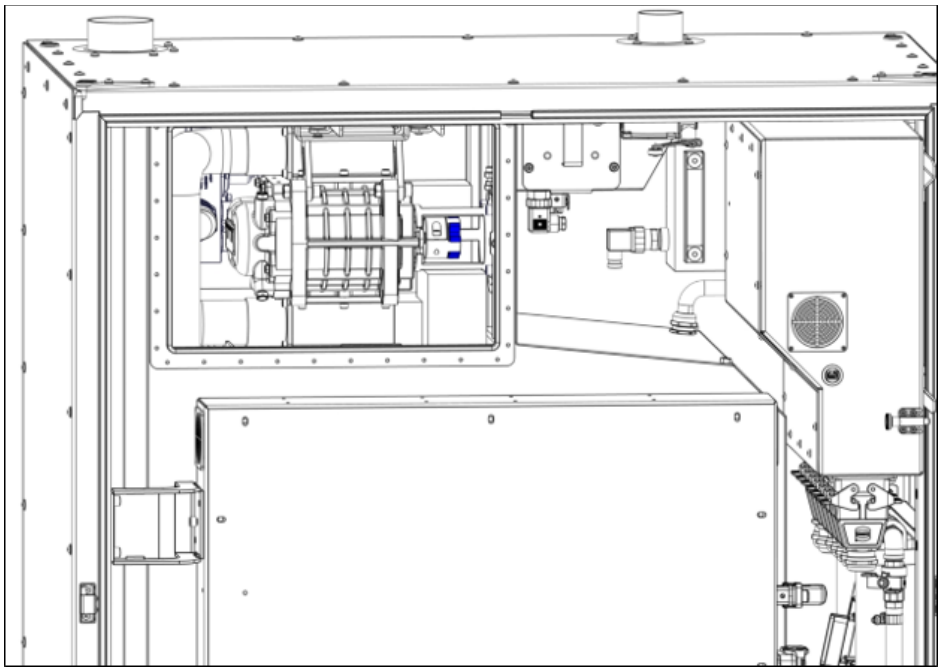


Figure 8-23: Mount new element onto clamping hub

11. Proceed the assembling procedure with all steps in section 8.2.2.2.1 assembling procedure.

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8.2.3 Replace Hydrogen Valve Block

Purpose:

The procedure describes how to replace a hydrogen valve block in the fuel sub-system. The function of the valve block is to start and stop the flow of H_2 fuel supply, and it is comprised of:

- Fuel filter – removes fuel intake impurities to protect the upstream equipment
- Fuel supply solenoid valve – controls the flow of H_2 to the fuel cell
- Fuel pressure control valve – from supply pressure to specified output pressure
- Safety relief valve – shuts off the inlet valve in case of an emergency

The valve block also provides feedback on inlet/outlet pressure and regulation of pressure.

Responsibilities:

Preventive maintenance of the hydrogen valve block is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the valve block during the life and operation of the FCwave module.

- FRU, Hydrogen Valve Block (part no. 7500025)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace H_2 Valve Block

Based on the normal conditions, the estimated time for replacement is:

H_2 Valve Block		
Duration	5 hours (need to remove HRB unit)	
Personnel	1	
Tightening Torque	M6 bolt	10 ± 0.5 Nm
	M10 bolt	
	1/2" Thread connection	25 ± 1 Nm
	3/4" Thread connection	50 ± 1 Nm
	1 1/4" Thread connection	120 ± 2 Nm
	Tool: 5mm + 8mm hex key, 14mm + 17mm spanner, cross-head screwdriver, 13mm hex socket, 20mm extension, 32mm crow's foot wrench, ½" ratchet, ½" extension 400mm, plastic bag/tape, torque wrench	

Table 8-5: Time to replace the H_2 valve block

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Perform all steps in section 8.2.2.2.2 (Replace a Hydrogen Recirculation Blower (HRB) Unit) to remove the HRB unit from the HRB assembly. Next, locate the hydrogen valve block at the top left corner in the H_2 enclosure.
3. Use a wrench to disconnect the H_2 valve block supply fitting.

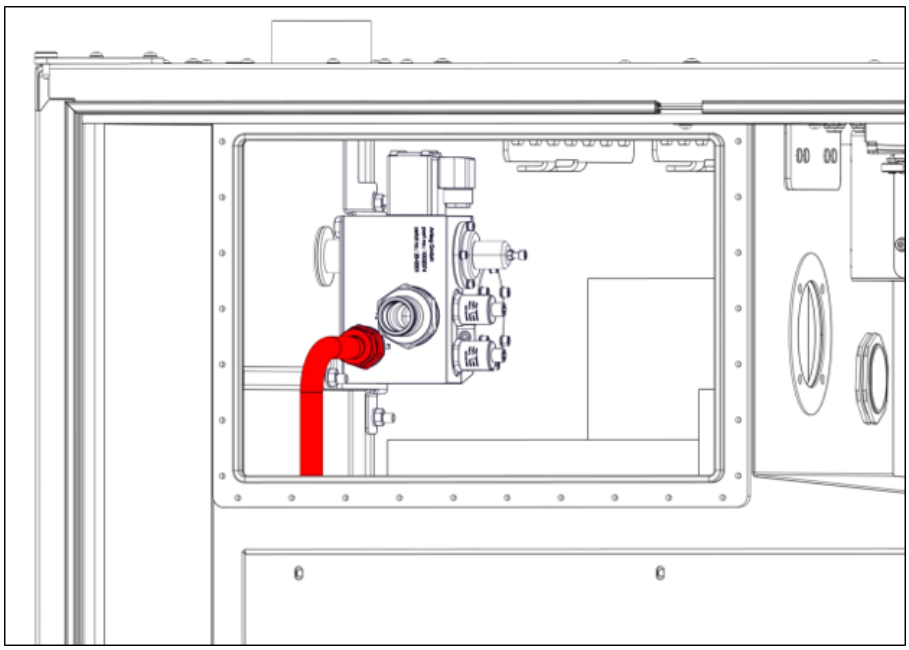


Figure 8-24: Valve block supply fitting

4. Remove the following connectors from the valve block:
   - HRNS-300-CN-YV_H30
   - HRNS-300-CN-PCV_H40
   - HRNS-300-CN-PT_H30
   - HRNS-300-CN-PT_H40

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5. Remove 4 pcs. nuts and washers used to tighten the valve block bracket to the H_2 enclosure.

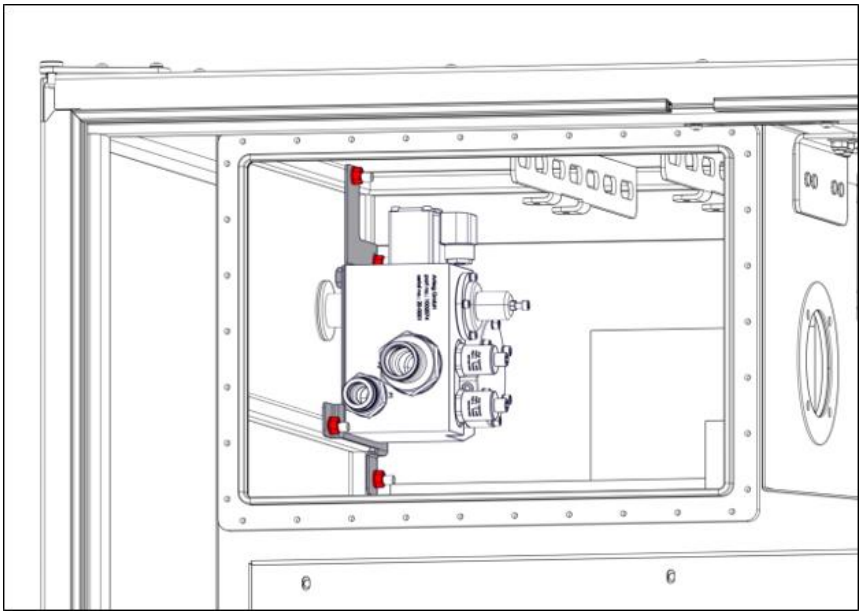


Figure 8-25: Removal of nut/washers of valve block bracket

6. Remove the valve block assembly and place it on a flat surface for service purpose.
7. Cover all disconnected hoses and open ports with clean cap or tape to prevent any unwanted material entering the hoses and open ports.

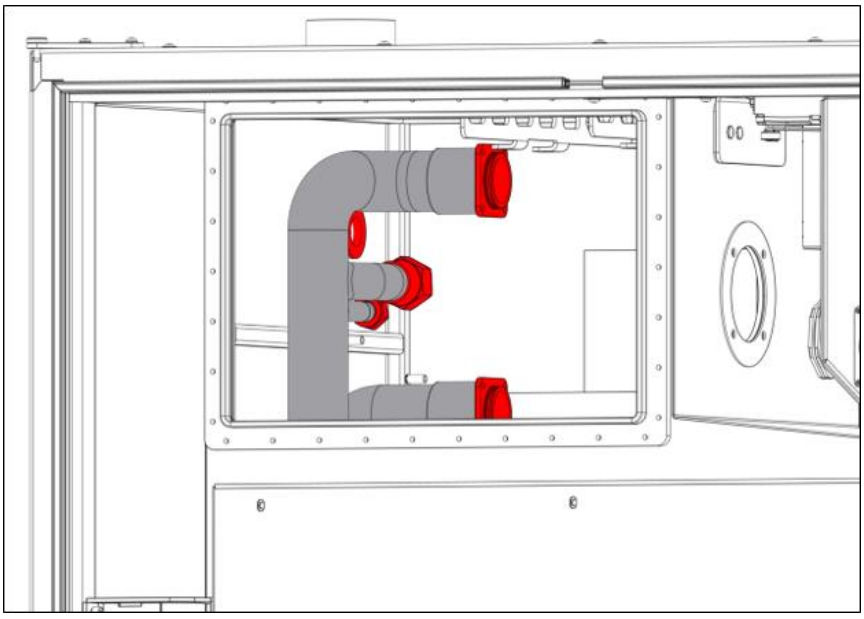


Figure 8-26: Cover up hoses and open ports

8. Remove 4 pcs. M10 bolts and washers and remove the valve block bracket from the valve block.
9. Send the used hydrogen valve block to Ballard for failure analysis (see section 4.1 for contact information).

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Assembling procedure:

1. Install a new bonded seal in the connection tube and install the connection tube on the valve block. Apply krytox to the thread and seal to prevent any damage.
2. Use 4 pcs. M10 bolts and washers to install the valve block to the valve block bracket. Keep the bolts loose while sliding the valve block onto the bracket. Apply ceramic grease to the bolts.
3. Place the valve block assembly on the mounting points. Adjust the valve block to fit the connection tube into the exhaust. Tighten the M10 bolts to 15 Nm to secure the valve block.

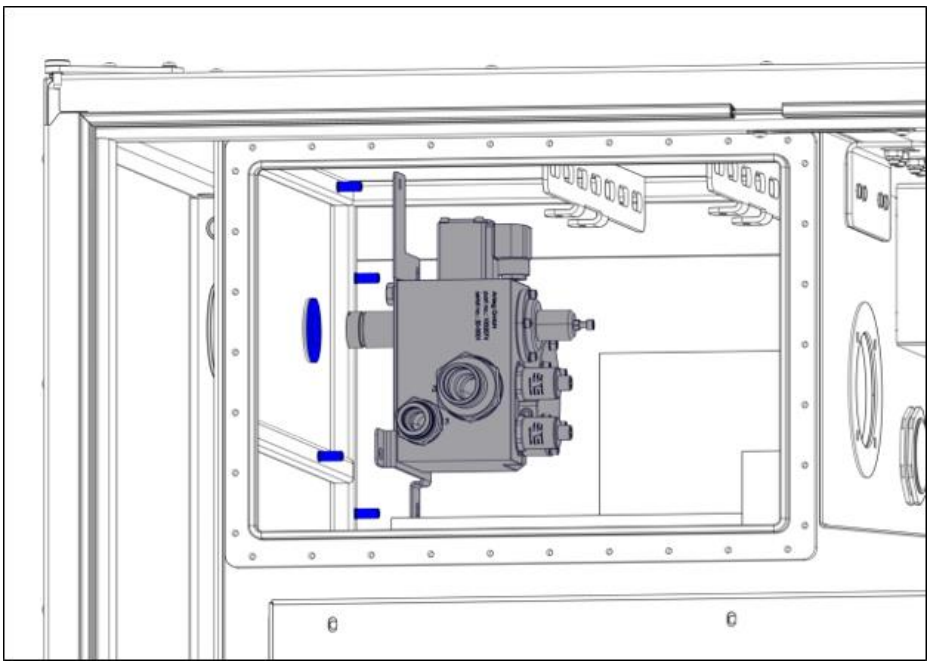


Figure 8-27: Mounting the valve block in the enclosure

4. Apply krytox and install the new O-ring onto the connection tube.

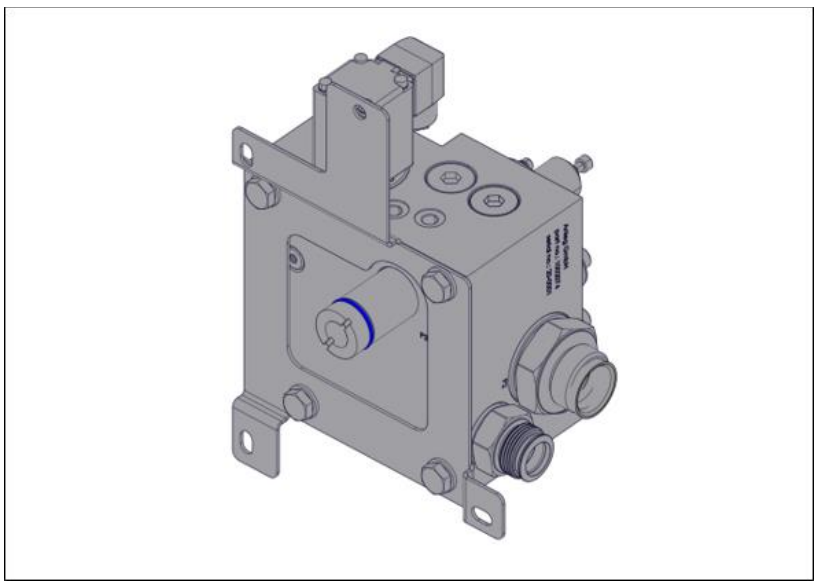


Figure 8-28: O-ring on connection tube

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5. Install the valve block assembly on the mounting points of the H_2 enclosure frame.
6. Use 4 pcs. M8 locknuts and washers to secure valve block bracket to the enclosure. Tighten to 15 Nm.
7. Use a spanner to connect the fuel supply fitting.
8. Install the following connectors to the valve block:
    - HRNS-300-CN-YV_H30
    - HRNS-300-CN-PCV_H40
    - HRNS-300-CN-PT_H30
    - HRNS-300-CN-PT_H40
9. Perform steps 3 through 23 of assembling procedure in section 8.2.2 to reassemble HRB assembly.
10. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
11. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
12. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.2.4 Assurance Procedure – Anode Sub-system leak test

Succes criteria for leak testing:

There is a leak if:

- Values recorded during the test are out of acceptable range provided by the "Leak Test Report Form", which can be found on the Customer Portal (see section 4.1 for further information)
- Unable to create correct pressure in the system
- Escaping air can be heard within the module
- Hydrogen gas and a hydrogen sniffer can be used to identify leaks

There is no leak if:

- All the values recorded during the test are within the accepted range provided by the "Leak Test Report Form" which can be found on the Customer Portal (see section 4.1 for further information)
- No sound coming from the module can be heard

Estimated time to perform the anode sub-system leak test

Based on the normal conditions, the estimated time for testing is:

Anode sub-system Leak Test		
Duration	3 hours	
Personnel	1	
Tightening Torque	M5 bolt	6.5 ± 0.5 Nm
	M6 bolt	10 ± 0.5 Nm
	Tool: 4mm + 5mm hex key, 8mm hex socket, leak tester, leak test hose, 32mm crow's foot wrench, laptop, WLAN cable	

Table 8-6: Time to perform anode sub-system leak test

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Procedure:

1. Secure the area before pressurizing the system components.
   Use warning signs around the working area to ensure safety.
2. Locate the adaptor box, located in the top left corner of the lower cabinet, covering the C-piece.



Figure 8-29: Location of box covering c-piece

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3. From the top of the box, uninstall 5 pcs. M5 bolts and washers.

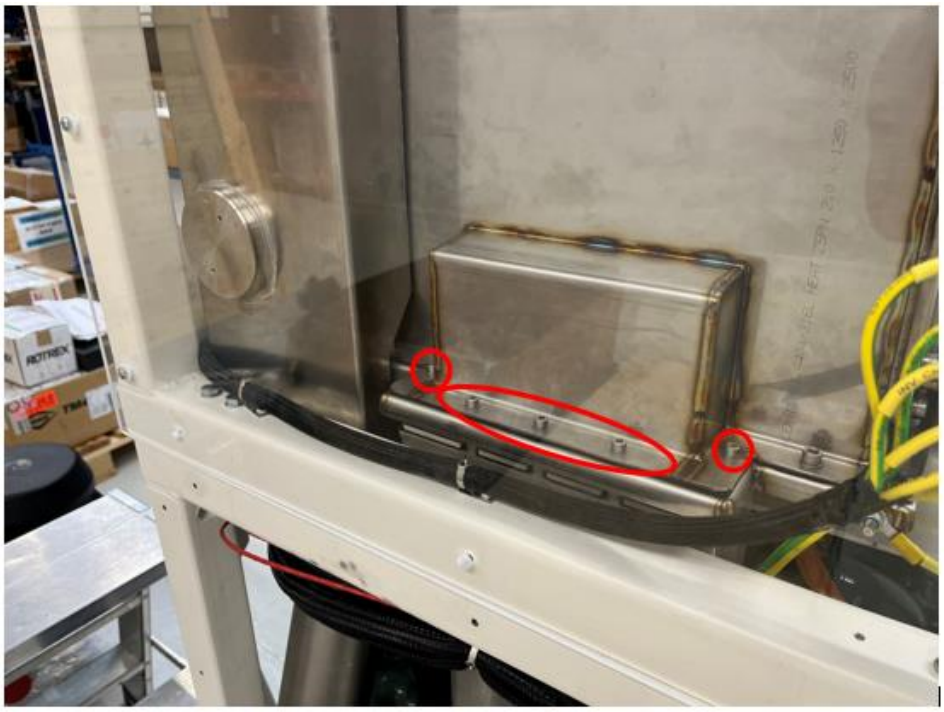


Figure 8-30: Removal bolts top side of adaptor box

4. From the bottom of the box, uninstall 3 pcs. M5 nuts and washers and 4 pcs. M6 bolts and washers.



Figure 8-31: Removal bolts bottom side of adaptor box

5. Slide down the box to access the process exhaust swivel located behind the adaptor box.

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6. Use the special tool (exhaust swivel) to loosen the exhaust swivel and install exhaust blinding plate between the top and bottom part of the process exhaust as indicated.



Figure 8-32: Placement of blinding plate in swivel

7. Re-establish the process exhaust. Tighten to 20 Nm.
8. Remove the C-piece.

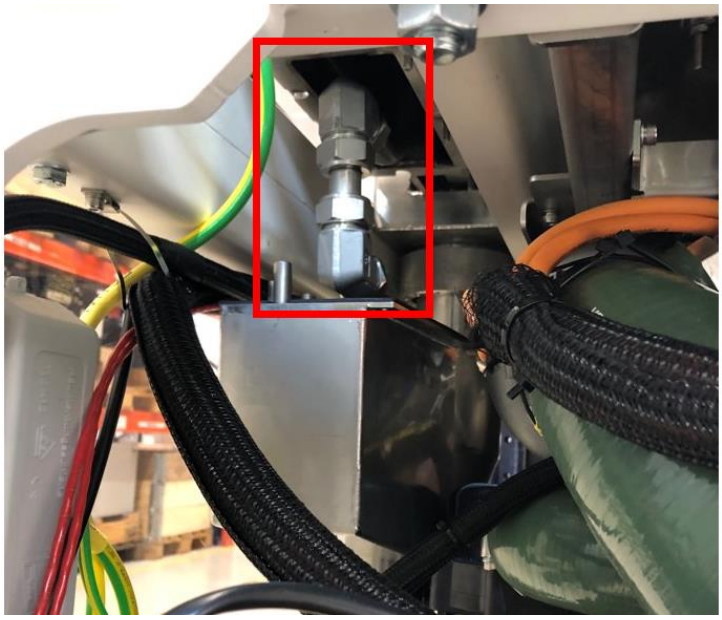


Figure 8-33: Uninstall C-piece

9. Install the pressure inlet plug where the top of the C-piece was installed.

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10. Use laptop to connect to module engineering interface.
11. Navigate to the I/O page and stay on the Fuel tab. Force 'YV_H30' to open and set valve for PCV_CTRL_SP to 1.1 - equivalent to 1.1 bar(g) – not to 1.0 as shown in the picture.



Figure 8-34: Forcing YV_H30 to open

12. Navigate to the P&ID page and check that 'YV_H30' is open and the box above PCV_H40 (PCV_CTRL_SP) is set to 1.1 - equivalent to 1.1 bar(g) – not to 1.0 as shown in the picture.

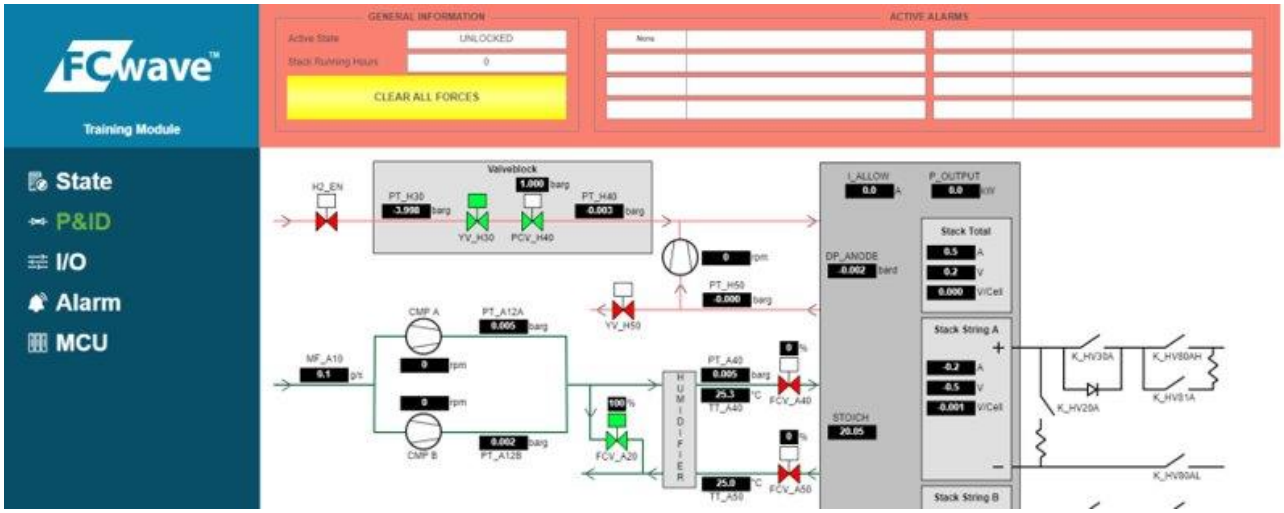


Figure 8-35: Checking YV_H30 is open

13. Prepare the leak tester according to document MAN5100654, which can be found in the customer portal (see section 4.1 for further information).

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14. Connect the leak tester hose to the plugs as shown:

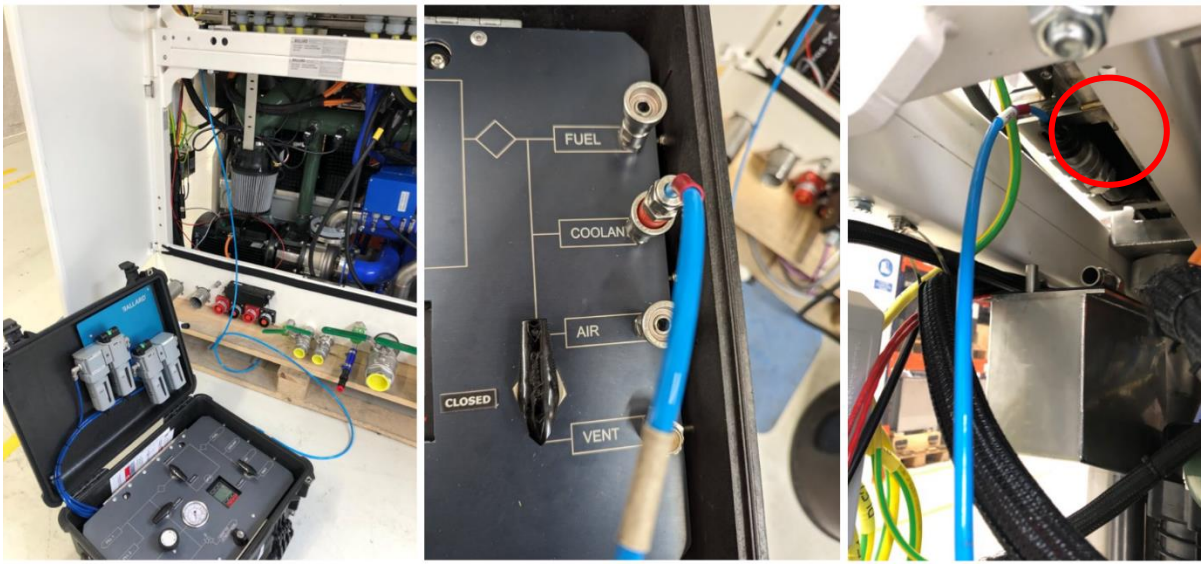


Figure 8-36: Install leak tester hose to pressure inlet plug

15. Slowly turn the pressure regulator clockwise to test pressure of 7 Psi. Let the system stabilize for 5 min.

    Use the digital ALICAT MFM for a more precise reading than the analogue pressure gauge.

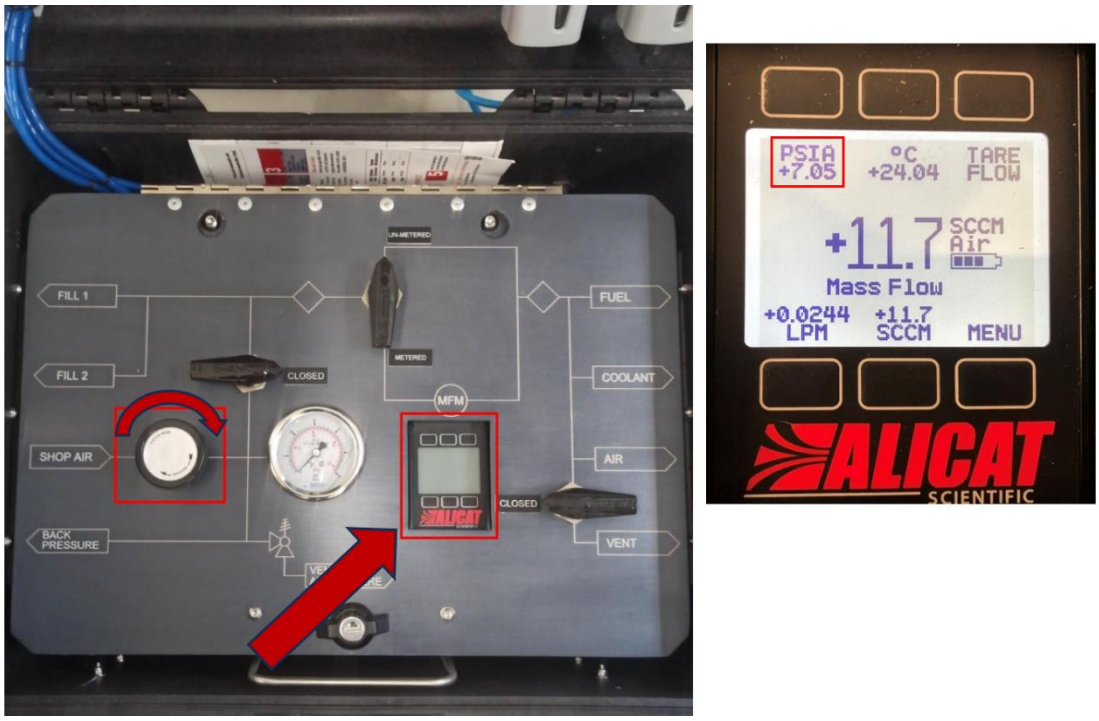


Figure 8-37: Use digital ALICAT MFM for pressure reading

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16. Force valve A to the "un-metered" position. Open valve B. Ensure valve C is in the "closed" position.

    Manometer pressure measurement should be 7 Psi/0.5 bar(g). Verify the pressure on both the manometer and the ALICAT MFM.

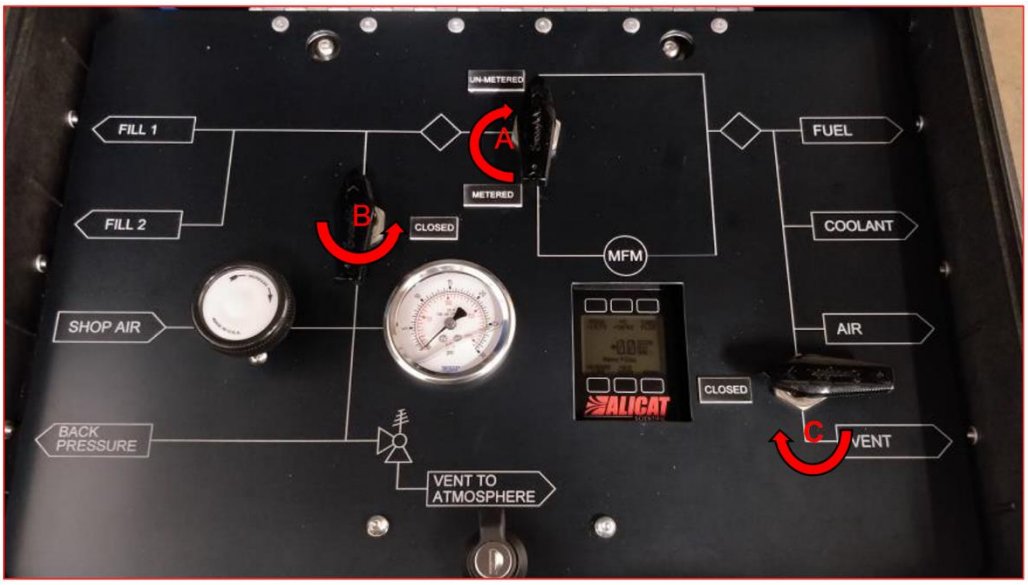


Figure 8-38: Leak tester valves1

17. Gradually force valve A to the "metered" position. Wait for the MFM to stabilize. Read and record the MFM reading in the leak test report form.



Figure 8-39: Leak tester valves2

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18. After completion of the leak test, force valve A to the "un-metered" position. Force valve B to the "closed" position to close off the air supply.

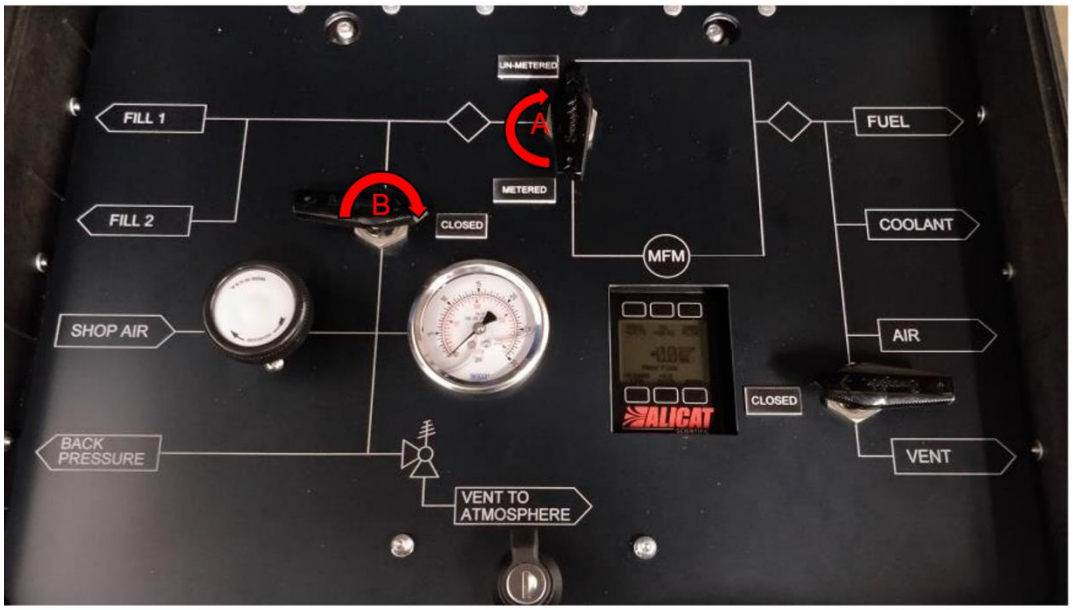


Figure 8-40: Leak tester valves3

19. Slowly force vent valve C to the "open" position to release the buildup pressure. Force the pressure regulator counter-clockwise to dial down the pressure.

    Ensure all hoses are vented before disconnecting from the module.

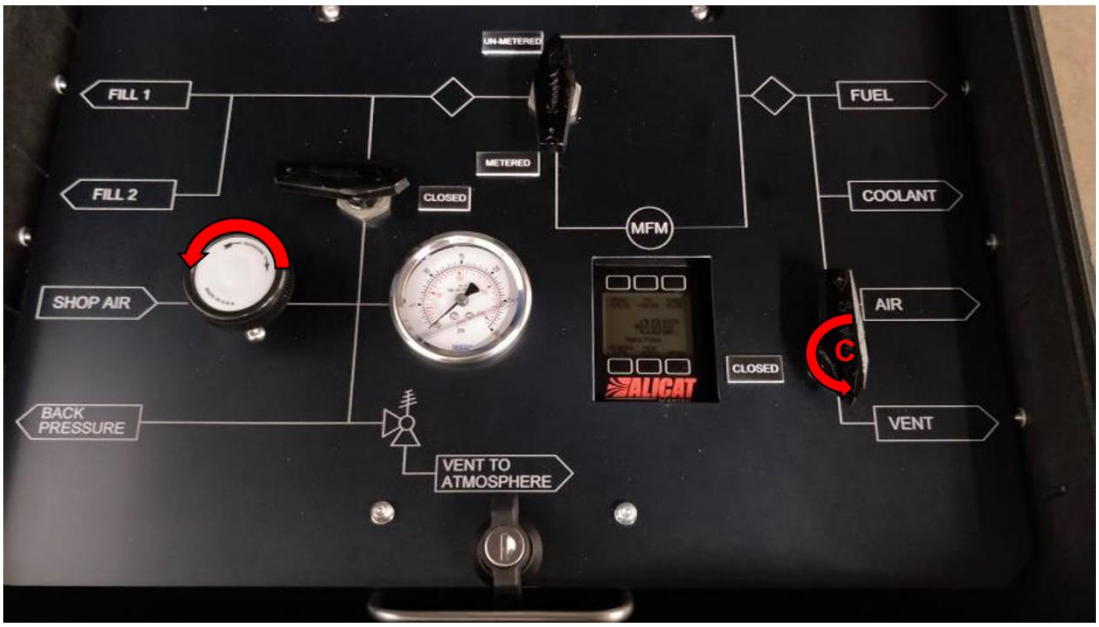


Figure 8-41: Leak tester valves4

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20. Navigate to the I/O page in the engineering interface and press “clear all forces”.
21. Navigate to the P&ID page and check that YV_H30 is closed and the box above PCV_H40 (PCV_CTRL_SP) is set to ‘0’.

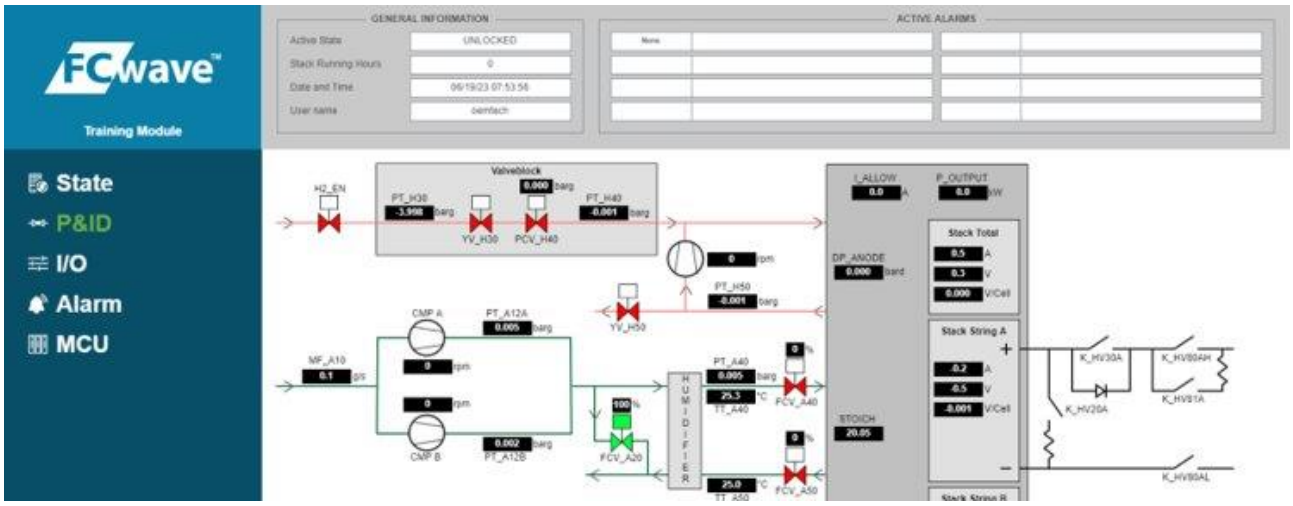


Figure 8-42: Checking YV_H30 is closed

22. Dismount the leak tester hose and reconnect hoses as before leak testing procedure.
23. Loosen process exhaust and remove the blinding plate. Replace O-ring and re-establish process exhaust. Tighten to 20 Nm.
24. Dismount the pressure inlet plug from where the C-piece was mounted and re-install the C-piece. Tighten to 50 Nm.
25. Use 5 pcs. M5 bolts and washers, 4 pcs. M6 bolts and washers, and 3 M5 nuts and washers to re-install the adaptor box. Tighten all to 5 Nm.

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8.3 Process Air Cathode Syb-system

For detailed P&ID requirements, refer to "Piping and Instrumentation Diagram" (PWR005), which can be found the Customer Portal or by contacting BPSE (see section 4.1 for further information).

8.3.1 Replace Process Air Filter/Mass Flow Meter

Purpose:

The procedure describes how to replace a process air filter integrated with mass flow meter for the air compressors in the cathode system. The filter conditions the clean air intake, and the mass flow meter monitors the airflow that enters the air compressors.

Responsibilities:

Preventive maintenance of the air filter/mass flow meter is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace a process air filter during the life and operation of the FCwave module.

- FRU, MAF Sensor & Inlet Filter (part no. 7500059)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Air Filter/Mass Flow Meter

Based on the normal conditions, the estimated time for replacement is:

Air Filter/Mass Flow Meter		
Duration	15 min	
Personnel	1	
Tightening Torque	Hose clamps	5 ± 0.5 Nm
	Tool: 7mm socket, torque wrench	

Table 8-7: Time to replace the air filter/mass flow meter

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the air filter/mass flow meter installed in front of the twin compressors.
3. Disconnect the mass flow meter sensor (FT_A10).

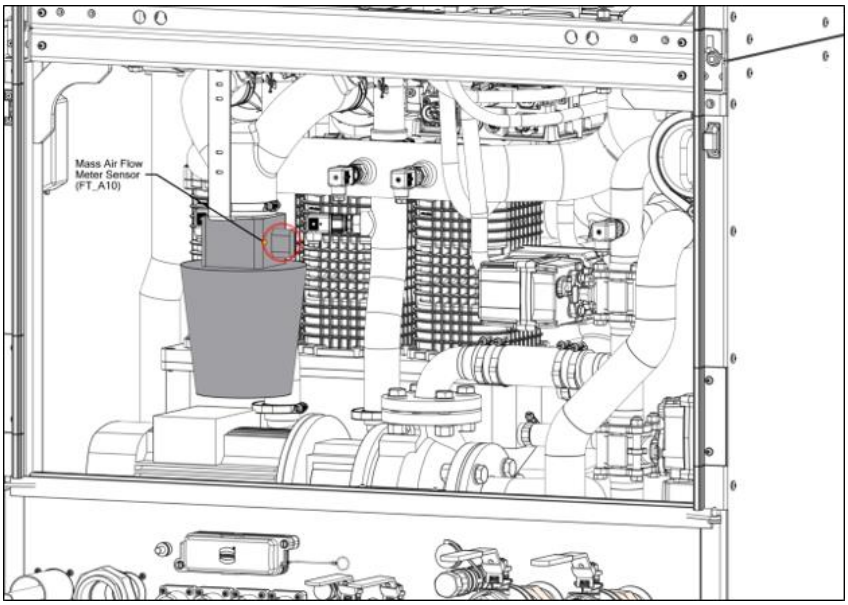


Figure 8-43: Location of mass flow sensor

4. Release the 7mm socket hose clamp to uninstall the filter/mass air flow meter.
5. Slide down the filter unit and take it out.

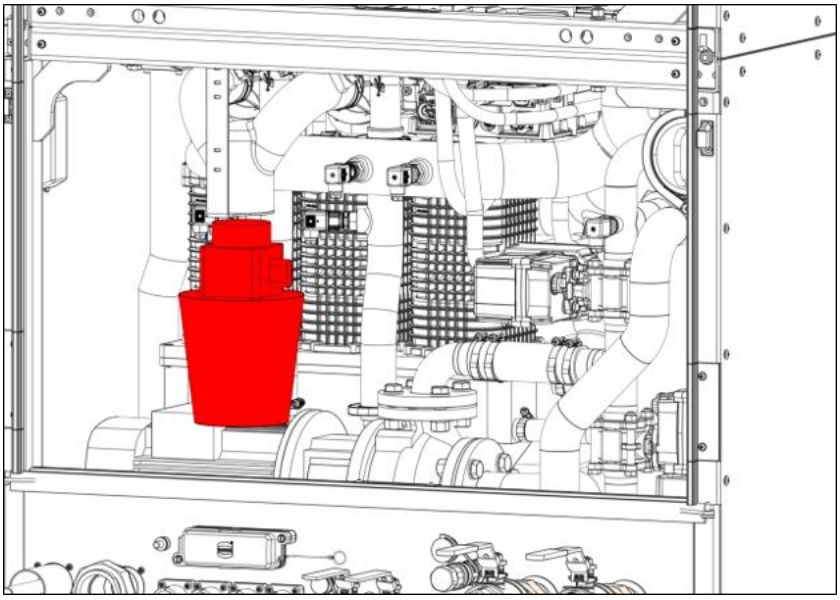


Figure 8-44: Removal of filter unit

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Assembling procedure:

1. Slide on the new unit and secure it with the 7mm socket hose clamp. Tighten to 3.5 Nm.
2. Connect the mass flow meter sensor (FT_A10).

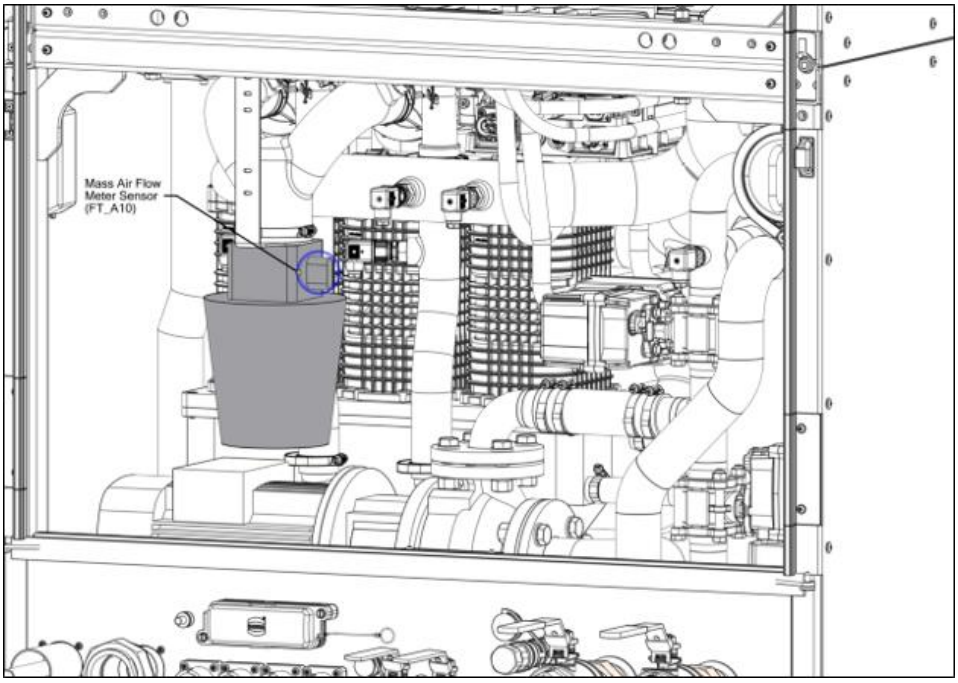


Figure 8-45: Install new mass air flow sensor

3. Use 12 pcs. M5 bolts to install the high voltage panel cover.
4. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
5. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
6. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.3.2 Replace Process Air (cathode) Valves

Purpose:

The procedure describes how to replace air valves in the process air cathode system. There are three air valves, which are used to direct the air flow in the module, to bypass the stacks, and to recirculate the exhaust.

Responsibilities:

Preventive maintenance of the air valves is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the air valves during the life and operation of the FCwave module.

- FRU, Shutoff Valve, 3" (part no. 7500061) x2.
- FRU, Shutoff Valve, 1.75" (part no. 7500068)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Cathode Valves

Based on the normal conditions, the estimated time for replacement is:

Cathode Butterfly Valves		
Duration	30 min	
Personnel	1	
Tightening torque	Hose clamps	5 ± 0.5 Nm
	Tool: 7mm flexible socket, torque wrench	

Table 8-8: Time to replace the cathode valves

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Disconnect the connector from the air process inlet valve (FCV_A40).

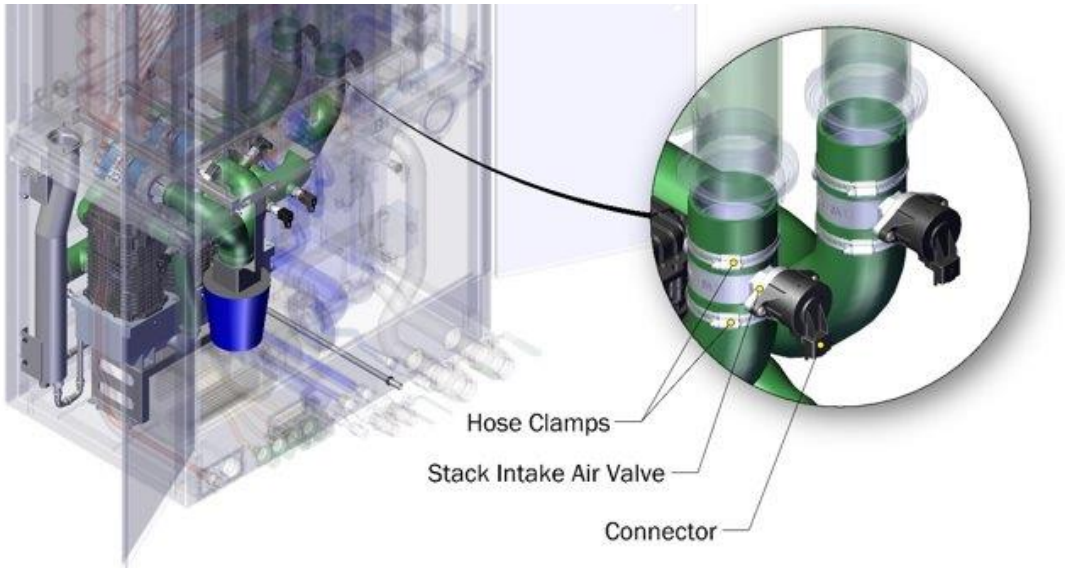


Figure 8-46: Location of air process inlet valve

3. Release 2 pcs. hose clamps securing the valve from above and below.
4. Remove the air process inlet valve (FCV_A40). Remember to cover all disconnected hoses and open ports with a clean cap or tape.
5. Disconnect the connector from the air process outlet valve (FCV_A50).

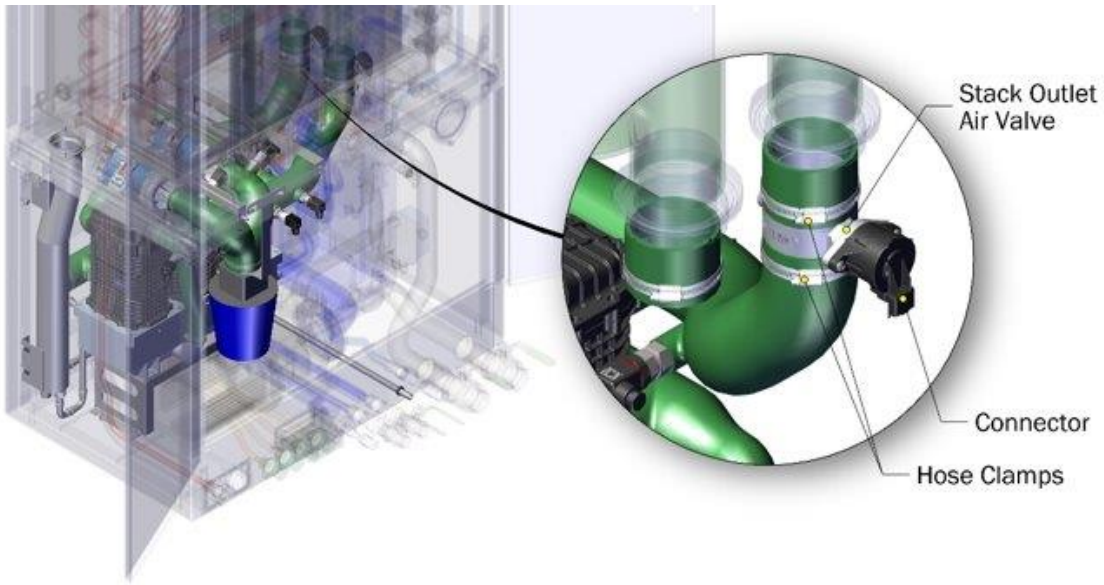


Figure 8-47: Location of air process outlet valve

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6. Release 2 pcs. hose clamps from the oxidant outlet side to remove the valve from the hoses.
7. Press both sides of the bypass air valve and pull to remove connector HRNS-600-CN_FCV_A20.

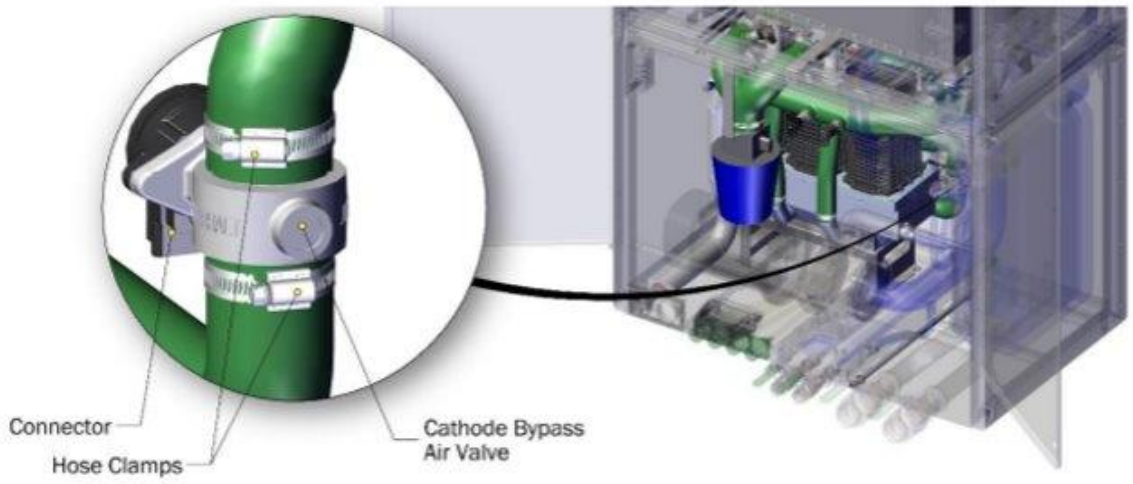


Figure 8-48: Removal of bypass air valve

8. Release 2 pcs. hose clamps on the outer connections of the cathode bypass valve outlet hose to remove the valve from the hoses.

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Assembling procedure:

1. Install the new bypass valve (FCV_A20) and secure it with the hose clamp. Tighten clamp to 3.5 – 4.5 Nm.

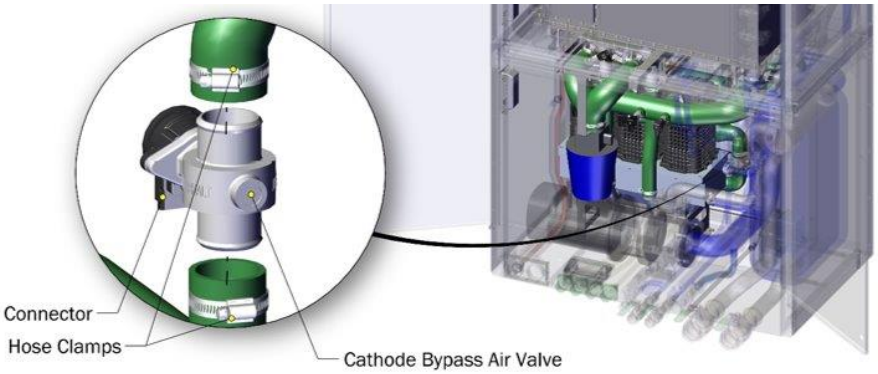


Figure 8-49: Removal of bypass air valve

2. Connect the cathode bypass valve connector.
3. Install the new outlet valve (FCV_A50) and secure it with the hose clamp. Tighten clamp to 3.5 – 4.5 Nm.

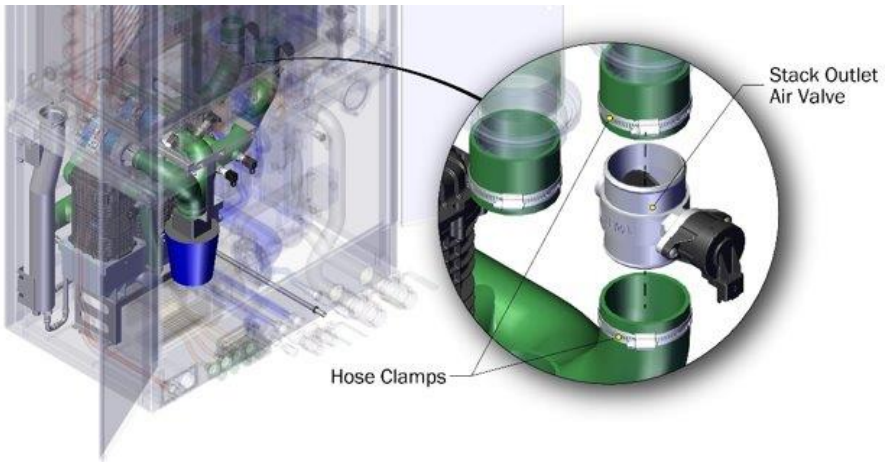


Figure 8-50: Removal of bypass air valve

4. Connect the FCV_A50 connector.

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5. Install the new air inlet valve (FCV_A40) and secure it with the hose clamp. Tighten clamp to 3.5 – 4.5 Nm.

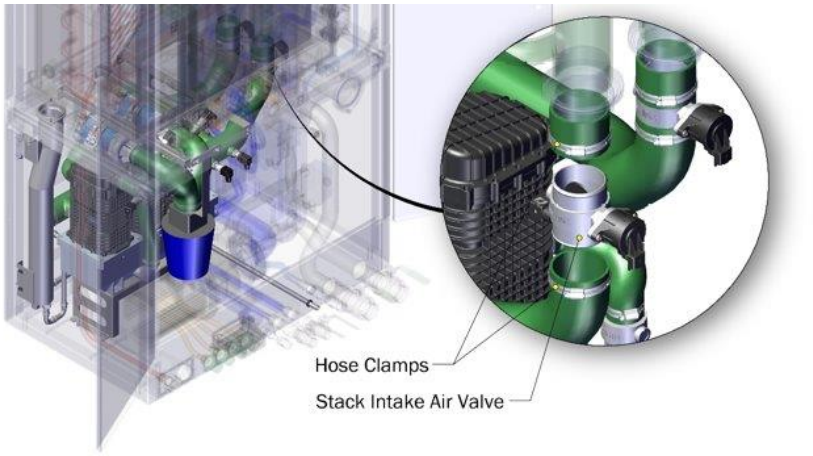


Figure 8-51: Install new air inlet valve

6. Connect the FCV_A40 connector.
7. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
8. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
9. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
10. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.3.3 Replace Humidifier Assembly

Purpose:

The procedure describes how to replace a humidifier assembly for the process air system. The unit exchanges humidity between dry air entering the fuel cell inlet and outlet. This is necessary to maintain minimum fuel cell inlet relative to humidity requirements.

Responsibilities:

Preventive maintenance of the humidifier assembly is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace a humidifier assembly during the life and operation of the FCwave module.

- FRU, Humidifier Assembly v2 (part no. 7500359)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace Humidifier

Based on the normal conditions, the estimated time for replacement is:

Humidifier		
Duration	2 – 2½ hours	
Personnel	1	
Tightening Torque	M5 bolt	6.5 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	Hose clamps	5 ± 0.5 Nm
	Tool: 3mm + 4mm + 6mm hex key, 7mm flexible socket, cross-head screwdriver, cable tie cutter, plastic bag/tape, 6mm hex bit, ¼" ratchet, 500mm extension, 13mm wrench, torque wrench	
Weight	10 kg	

Table 8-9: Time to replace the humidifier assembly

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Perform disassembling procedure of Air Compressor (section 8.3.5) to remove the compressors to gain access to the humidifier.
3. Disconnect sensor TT_A50.

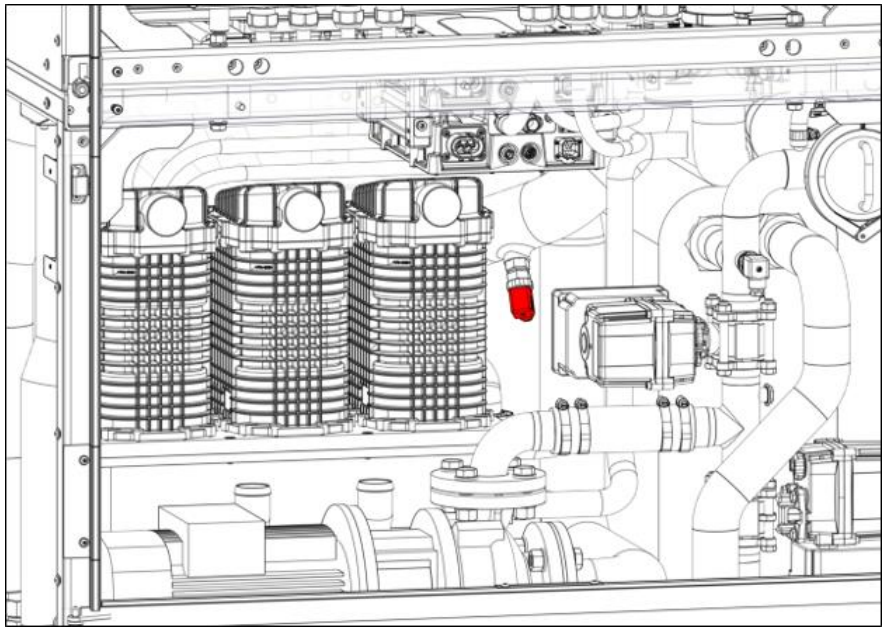


Figure 8-52: Removal of sensor TT_A50

4. Release the hose clamp and slide off the hose connected to the motorized shut-off valve. Remember to cover hoses and open ports.

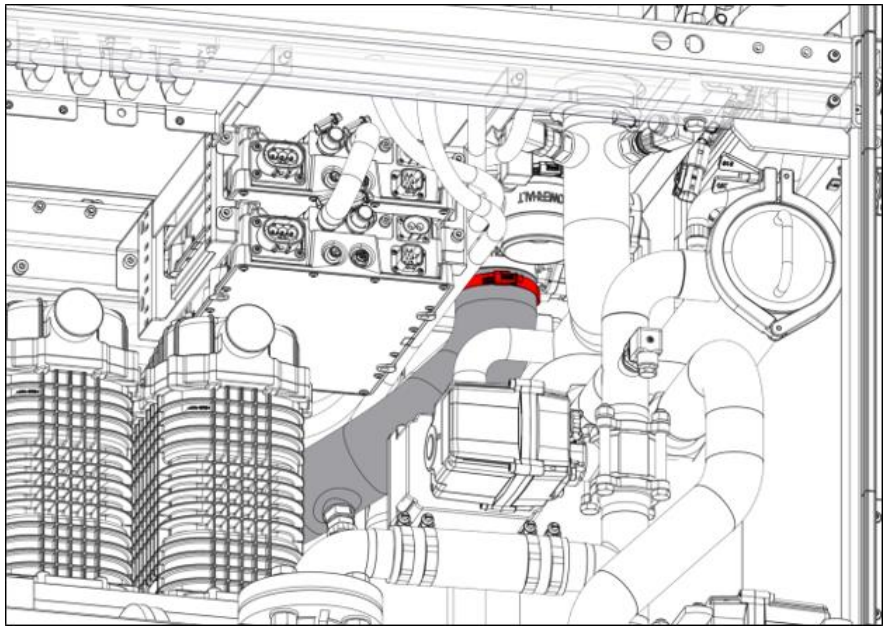


Figure 8-53: Removal of hose to motorized shut-off valve

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5. Cut the cable tie used to tighten the LT coolant hoses to the rear-side humidifier hose.
6. Release the hose clamp used to tighten the bypass valve. Slide hoses off to remove the valve. Disconnect the electrical connection of the bypass valve.

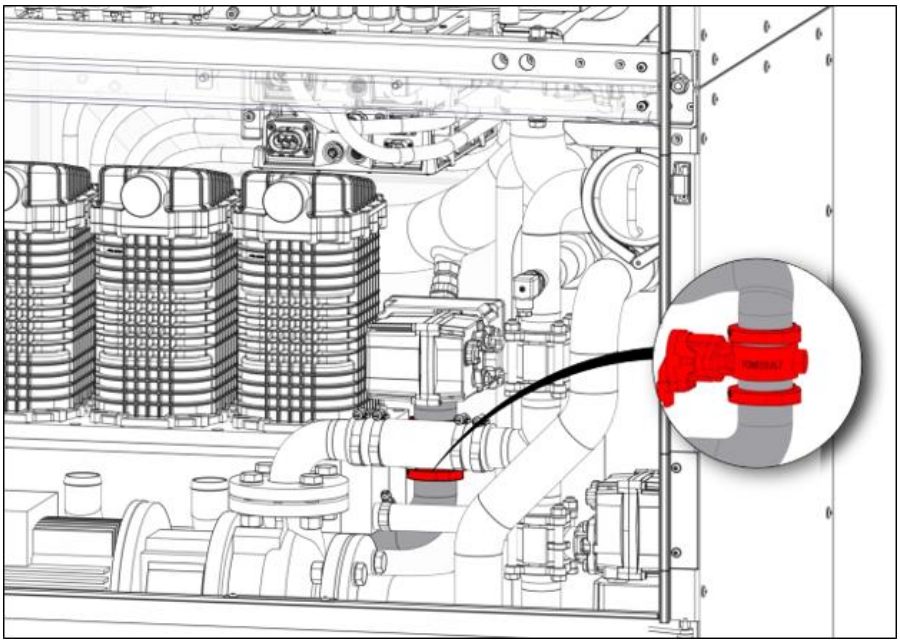


Figure 8-54: Removal of bypass valve for humidifier

7. Release the hose clamp used to tighten the humidifier outlet hose to the exhaust.

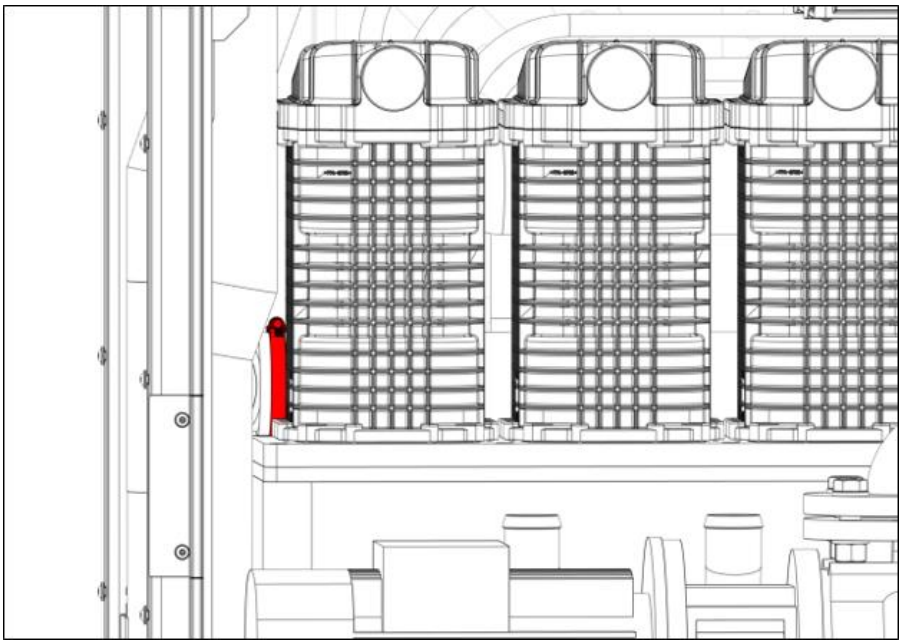


Figure 8-55: Removal of outlet hose to the exhaust

8. Uninstall 8 pcs. M8 bolts used to tighten the humidifier assembly to the aftercooler. Use a magnet to remove the bolts.

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9. Loosen, but not remove, 2 pcs. bolts, washers, and lock washers used to tighten the aftercooler to the mounting bracket.

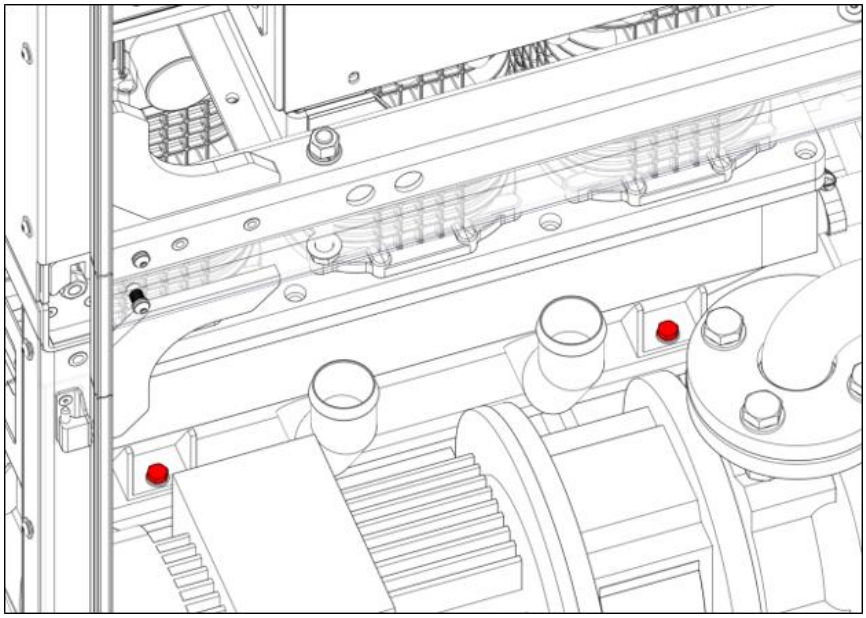


Figure 8-56: Removal of bolts in aftercooler/mounting bracket

10. Insert the lifting table legs in the lower cabinet under 2 pcs. M8 bolts previously loosened and on the module front frame as shown:

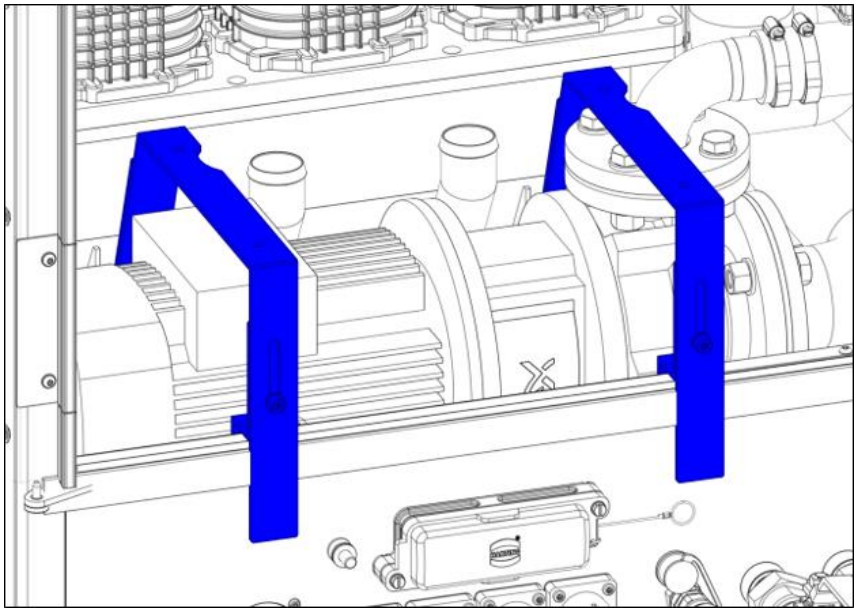


Figure 8-57: Insert lifting table legs

11. Re-tighten 2 pcs. M8 bolts mentioned in step 15 to secure the lifting table legs.
12. Use 4 pcs. M5x20 bolts to install the lifting table on the legs. Align the surface to the plastic slides by adjusting the height of the legs.
13. Carefully lift one side of the humidifier and insert plastic slides all the way as shown. Align the thread of the slides with the M8 bolts on the inlet flange.

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Remember to use the short slide on the right side of the humidifier.

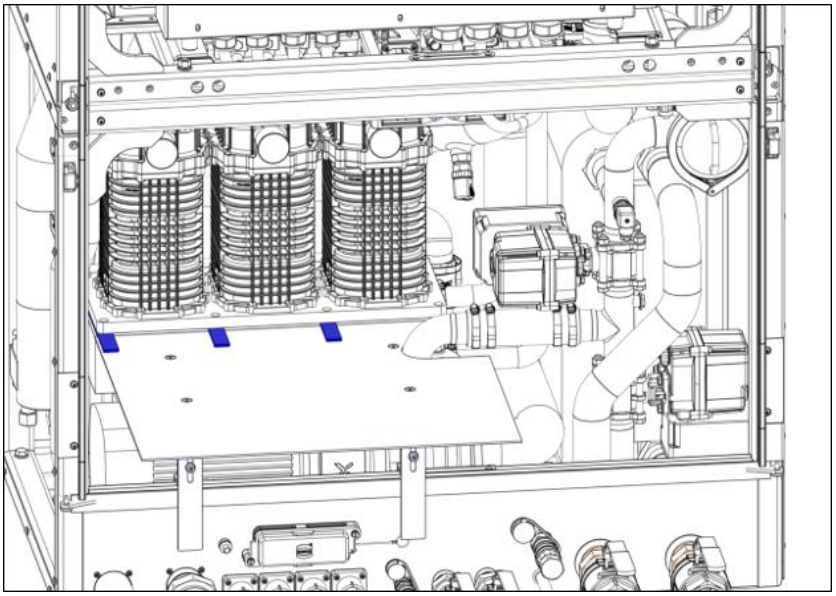


Figure 8-58: Insert slides under humidifier

14. Use 8 pcs. M8 bolts to tighten the humidifier inlet flange to the plastic slides.

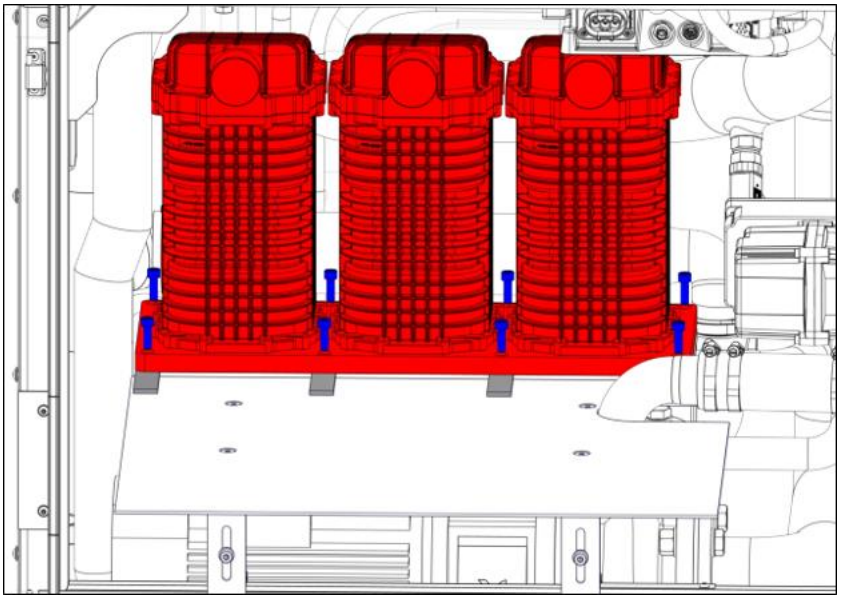


Figure 8-59: Securing humidifier flange to slides

15. Slide the humidifiers a bit to the right to make room for sliding off the air connected to the process exhaust. Cover up open ports and disconnected hoses.
16. Turn the humidifier assembly 90 degrees and move to the left side of the lifting table as shown. Next, carefully move the assembly to a clean, flat surface for service purposes.

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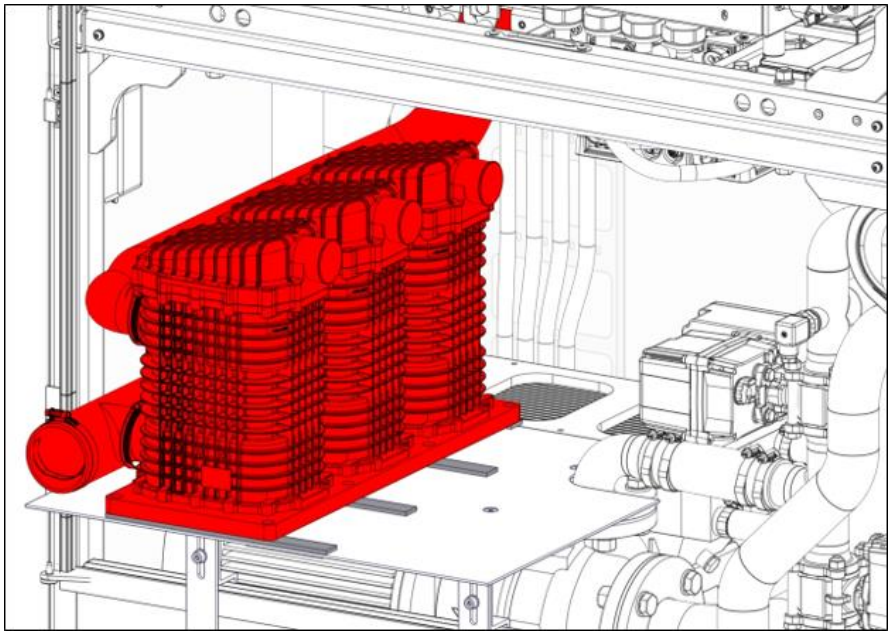


Figure 8-60: Removal of humidifiers

17. Uninstall the wet side inlet hose and wet side outlet hose installed on the back side of the humidifier.

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Assembling procedure:

1. Use 6 pcs. hose clamps to install the wet side inlet hose (upper) and wet side outlet hose (lower) to the back side of the new humidifier. Tighten clamps to 3.5 Nm. Remember to replace the hose clamp if damaged.
2. Flip the humidifier. Apply krytox and install O-rings in all 3 flanges as shown:

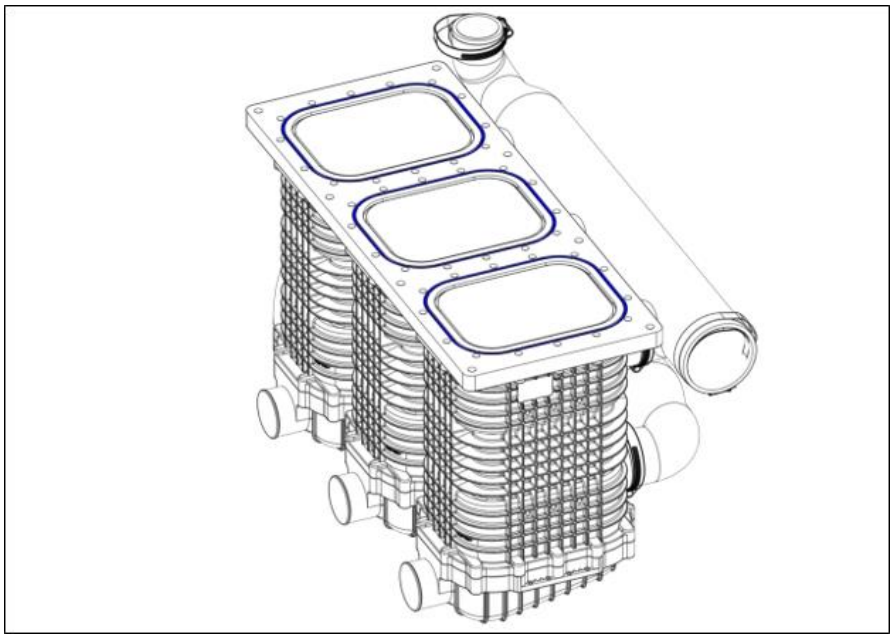


Figure 8-61: O-rings in flanges

3. Use 8 pcs. M8 bolts to install plastic slide to humidifier as shown:

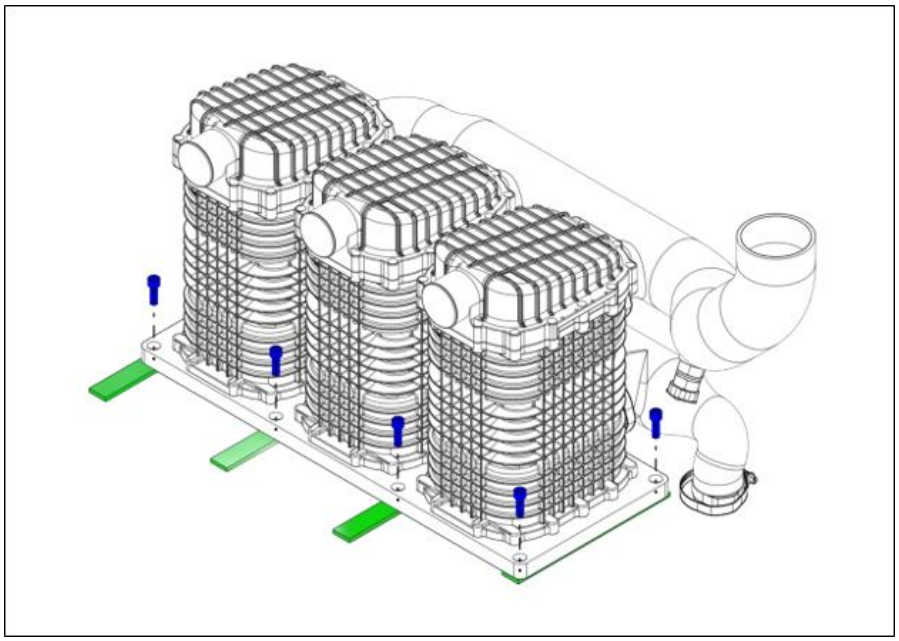


Figure 8-62: slides on new humidifier

4. Lift the humidifier assembly to the lifting table and place it as in the disassembling procedure step 23.

   Remember to clean the surface of the aftercooler to prevent scratches.

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5. Install the hose clamp on the process exhaust connection hose and then slide the humidifier in position on top of the aftercooler.
6. While sliding the humidifier into position to the left, mount the process exhaust connection hose. Tighten the hose clamp to 3.5 Nm.

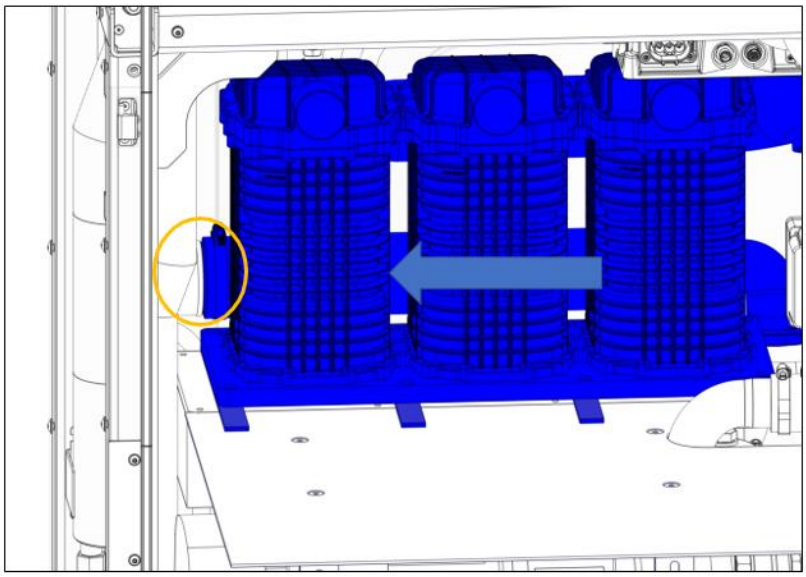


Figure 8-63: Sliding assembly and install process exhaust

7. Uninstall 8 pcs. M8 bolts from the plastic slides and remove the slides. Carefully lower the assembly onto the aftercooler.
8. Uninstall 4 pcs. M5x20 bolts to remove the lifting table.
9. Loosen 2 pcs. M8 bolts to remove the lifting table legs and re-tighten the bolts to 15 Nm.

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10. Use 8 pcs. M8 bolts to install the humidifier assembly to the aftercooler. Follow pattern as shown and tighten to 25 Nm.

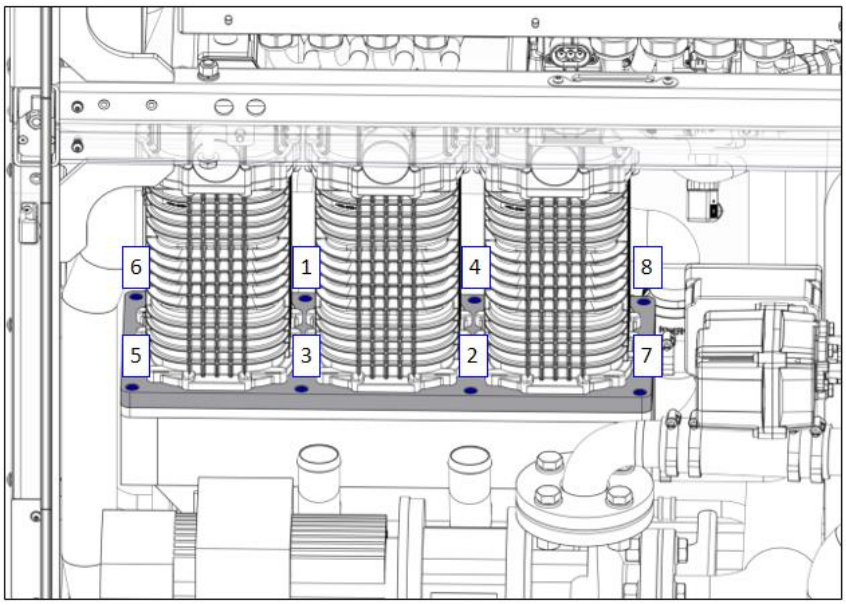


Figure 8-64: Fastening pattern for humidifier assembly to aftercooler

11. Leak test the humidifier and aftercooler assembly according to the humidifier leak test after corrective maintenance procedure.
12. Mount the FCV_A20 valve and tighten the hose clamp to 3.5 Nm.

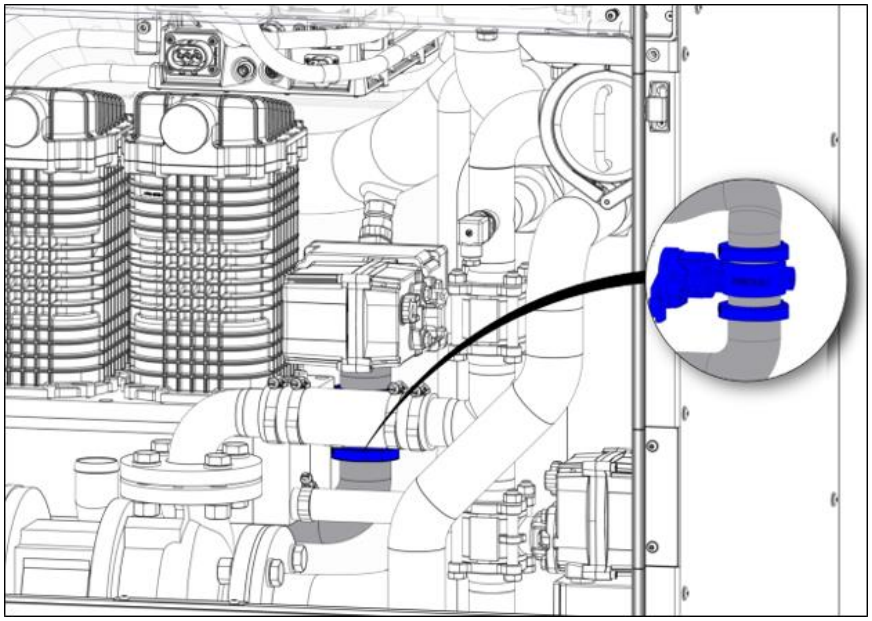


Figure 8-65: Installing the FCV_A20 valve

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13. Use a cable tie to secure the LT coolant hoses to the bypass hose.
14. Connect the upper rear hose from the humidifier to the stack inlet motorized shut-off valve (FCV_A50). Tighten the hose clamp to 3.5 Nm.

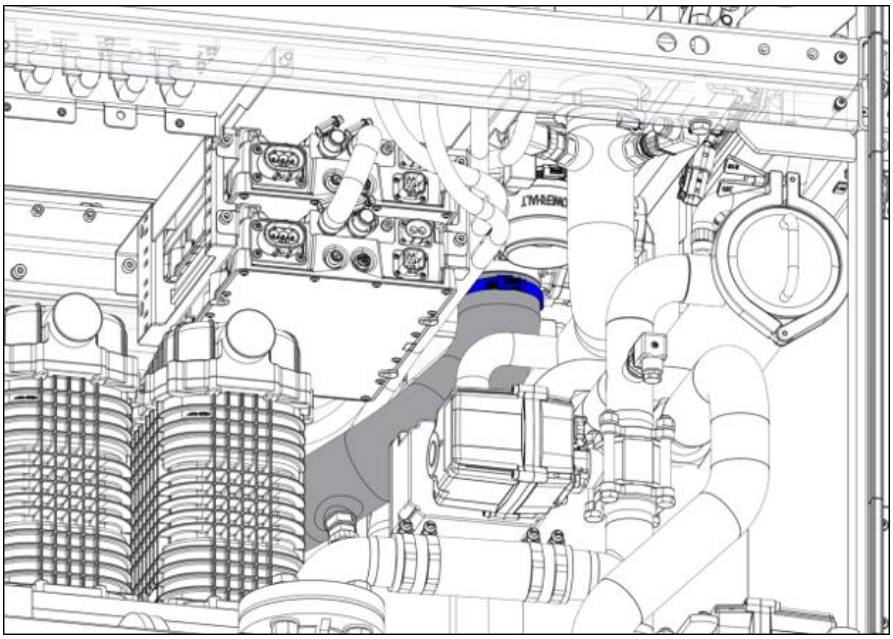


Figure 8-66: Mounting the FCV_A50 valve

15. Connect the temperature sensor (TT_A50) plug.

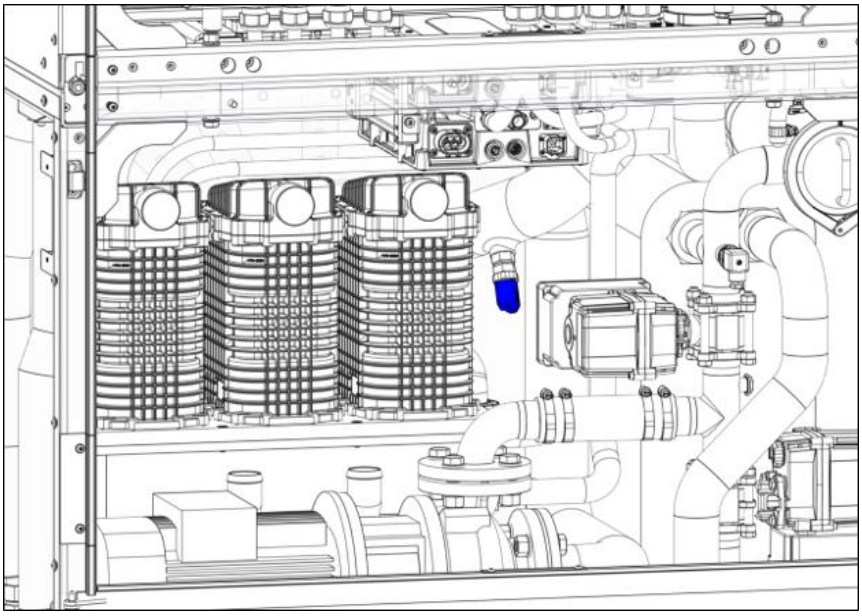


Figure 8-67: Mounting TT_A50 plug

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16. Perform steps in section 8.3.5 to reassemble the twin air compressors.
17. Log into the engineering interface to reset the hour counter for the humidifier assembly.
18. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
19. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
20. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
21. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.3.4 Replace Aftercooler

Purpose:

The procedure describes how to replace an aftercooler assembly for the process air system. The aftercooler cools down the temperature of the process air before it enters the humidifiers.

Responsibilities:

Preventive maintenance of the aftercooler assembly is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace an aftercooler assembly during the life and operation of the FCwave module.

- FRU, Aftercooler (part no. 7500070)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Aftercooler

Based on the normal conditions, the estimated time for replacements is:

Aftercooler		
Duration	3 – 3½ hours	
Personnel	1	
Tightening Torque	M8 bolt	
	Tool: 6mm hex key, 13mm wrench, 7mm socket, plastic bag/tape, torque wrench, hose clamps (if needed to be replaced)	

Table 8-10: Time to replace the aftercooler

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Perform disassembling procedure of Air Compressor (section 8.3.5) and Humidifiers Assembly (section 8.3.3) to remove both parts to access the aftercooler.
3. Remove the lifting table and lifting table legs from the lower cabinet. Remember to tighten M8 bolts and washers. Tighten to 15 Nm.
4. Release 2 pcs. hose clamps on the coolant hoses connected to the aftercooler assembly and slide off hoses. Prepare an empty container to drain leftover coolant to prevent leak inside the module.

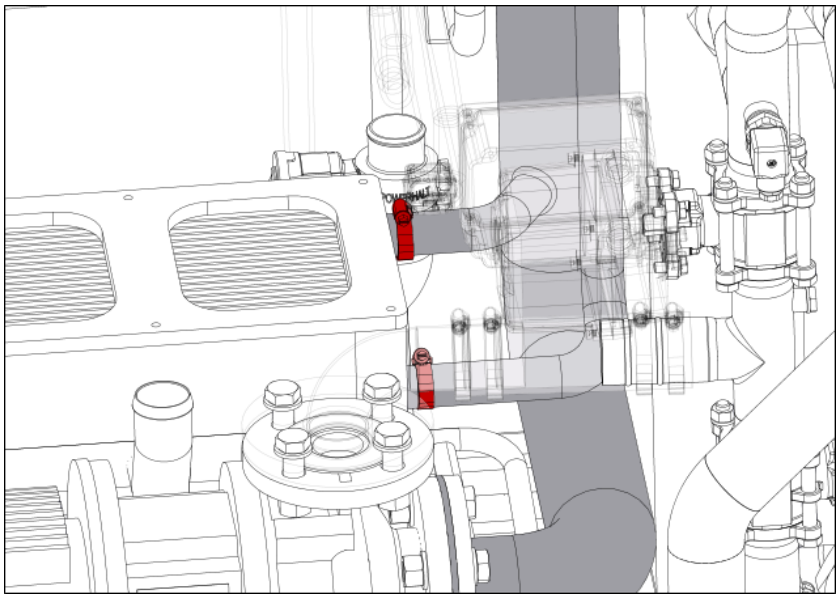


Figure 8-68: Removal of hoses to aftercooler

5. Cover disconnected ports and hoses to prevent leakage while moving the parts.
6. Release hose clamp on the back side of aftercooler and slide off hose.

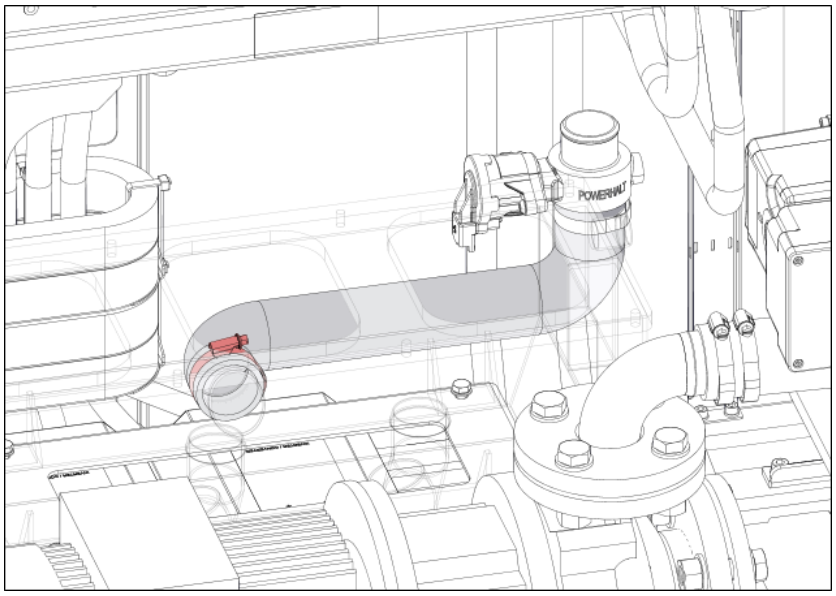


Figure 8-69: Removal of back side hose of aftercooler

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7. Uninstall 4 pcs. M8 bolts, washers and lock washers used to tighten the aftercooler mounting bracket to the base of the cabinet.

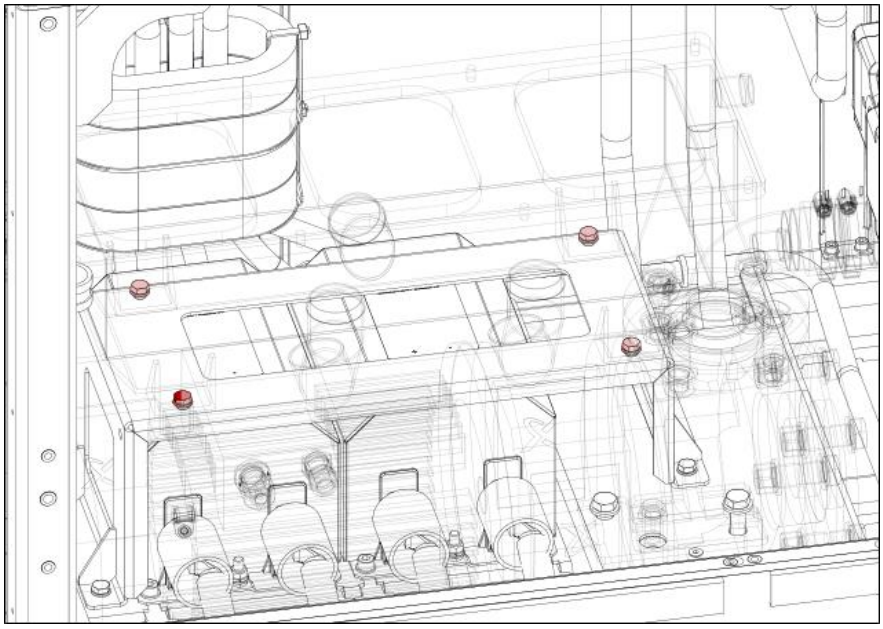


Figure 8-70: Removal of bolts in mounting bracket

8. Cover all disconnected hoses and open ports to prevent any unwanted material from entering, and carefully lift the aftercooler and bracket out of the cabinet. Place on a flat surface.
9. Uninstall 4 pcs. M8 bolts and washers used to tighten the aftercooler to the bracket.



Figure 8-71: Removal of bolts for bracket

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Assembling procedure:

1. Use 4 pcs. M8 bolts and washers to install the new aftercooler to the bracket. Tighten to 15 Nm.
2. Carefully lift the assembly to the lower cabinet. Use 4 pcs. M8 bolts to secure the assembly to the base of the cabinet. Tighten to 20 Nm.
3. Connect the cathode bypass hose to the back side of the aftercooler. Tighten hose clamp to 3.5 Nm. Remember to replace the hose clamp if damaged.
4. Perform assembling procedure of Humidifier Assembly (section 8.3.3) to install the humidifiers and air compressors.

   Make sure new O-rings are mounted and the surface is clean before tightening humidifier assembly to aftercooler assembly.
5. Connect the coolant hoses to the aftercooler. Tighten hose clamps to 3.5 Nm. Remember to replace the hose clamp if damaged.
6. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
7. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
8. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
9. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.3.5 Replace Air Compressors

Purpose:

The procedure describes how to replace an air compressor for the process air cathode system. The air compressors supply pressurized air to the fuel cell stacks. The compressor is sized to deliver the air at a mass flow regulated by the module system controller. The delivery pressure will be a function of air system flow resistance and required inlet pressure to the fuel cell stacks.

Responsibilities:

Preventive maintenance of the air compressors is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace an air compressor during the life and operation of the FCwave module.

- FRU, Gen3 Air Compressor (part no. 7500053)
- FRU, Gen3 Air Compressor to Inverter Sensor Cable (part no. 7500054)
- FRU, Inverter 2.0B Adaptor Cable[2] (part no. 7500361)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Air Compressors

Based on the normal conditions, the estimated time for replacement is:

Air Compressors		
Duration	2 hours	
Personnel	1	
Tightening Torque	M6 bolt	10 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	Hose clamps	5 ± 0.5 Nm
	Tool: 5mm + 6mm hex key, 7mm + 10mm + 13mm socket, side cutting pliers, hose clamp plier set, cross-head screwdriver, plastic bag/tape, cable ties, torque wrench	

Table 8-11: Time to replace the air compressors

[2] Applies ONLY for modules with Inverter 2.0B

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain and purge the LT cooling system.
3. Locate the air filter/mass flow meter installed in front of the twin compressors. Disconnect the mass flow meter sensor (FT_A10).

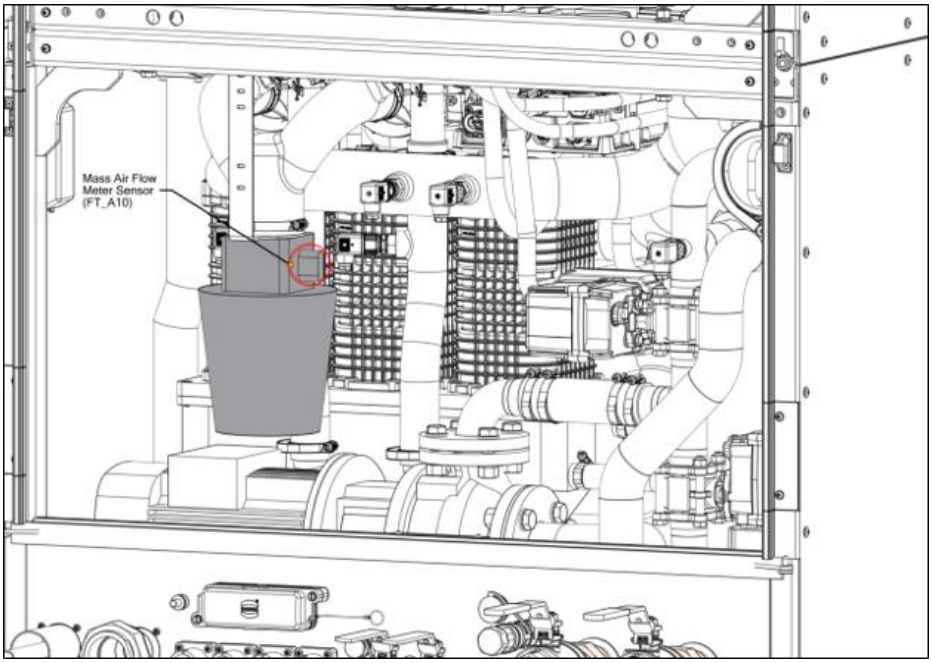


Figure 8-72: Location of mass flow sensor

4. Release the 7mm socket hose clamp to uninstall the filter/mass air flow meter.
5. Slide down the filter unit and take it out.

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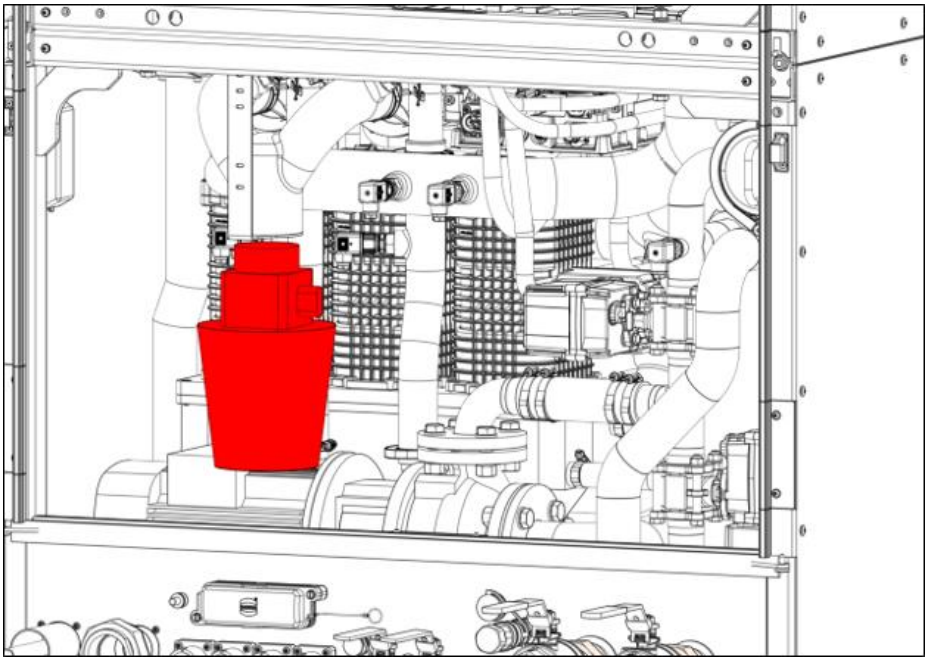


Figure 8-73: Removal of filter unit

6. Cut the cable tie used to secure the harness CN600 to the MAF/filter bracket.
7. Uninstall 2 pcs. M8 bolts and washers used to install the bracket to the cabinet and remove the bracket.

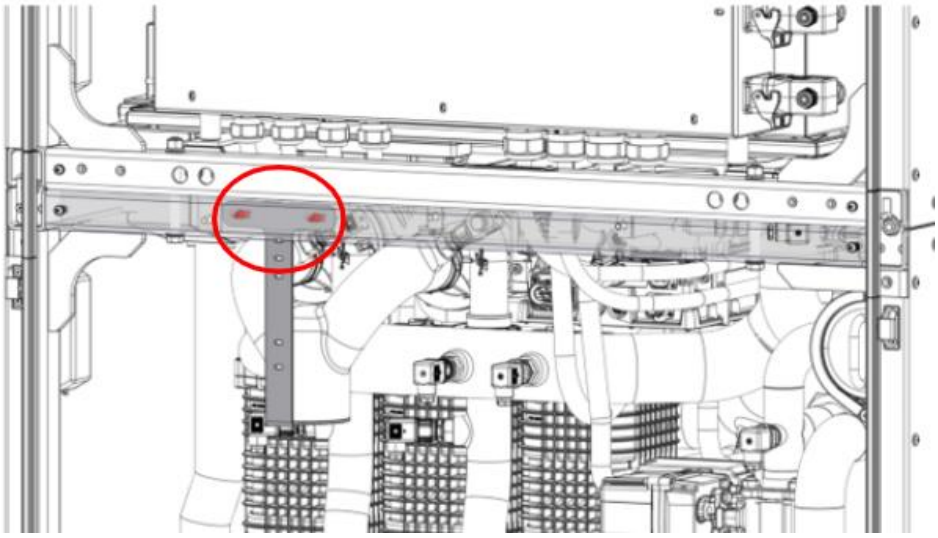


Figure 8-74: Removal of MAF/filter bracket

8. Disconnect all the following sensor connections on the harness CN600: PT_A11A, PT_A11B, PT_A12A, PT_A12B, PT_A40, TT_A40

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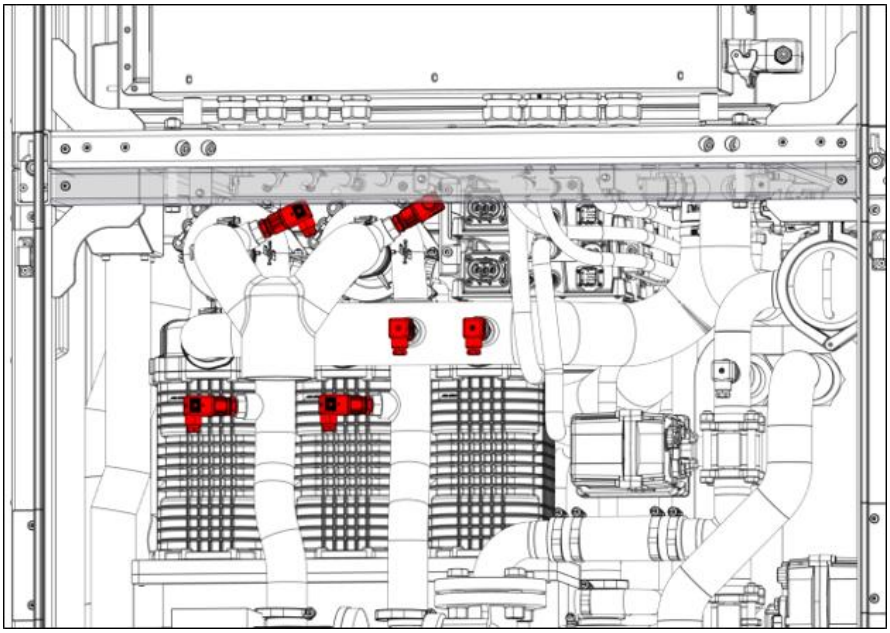


Figure 8-75: Sensor connections on harness CN600

9. Release 2 pcs. hose clamps used to secure the compressor inlet hose to the compressors and remove the hoses.

   Remember to cover all disconnected hoses and open ports.

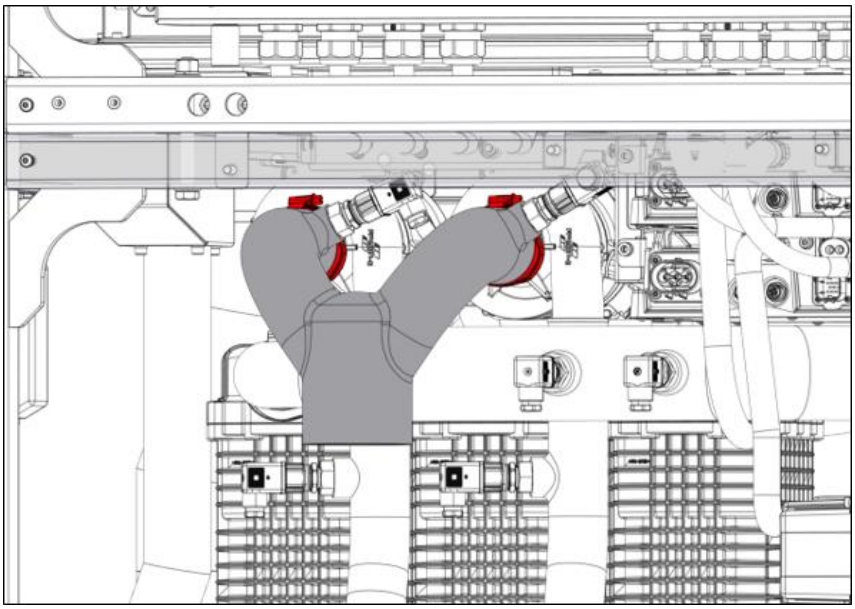


Figure 8-76: Hose clamps for inlet hose to compressors

10. Release 4 pcs. hose clamps used to secure the hose from humidifiers to the motorized shut-off valve and remove the hoses.

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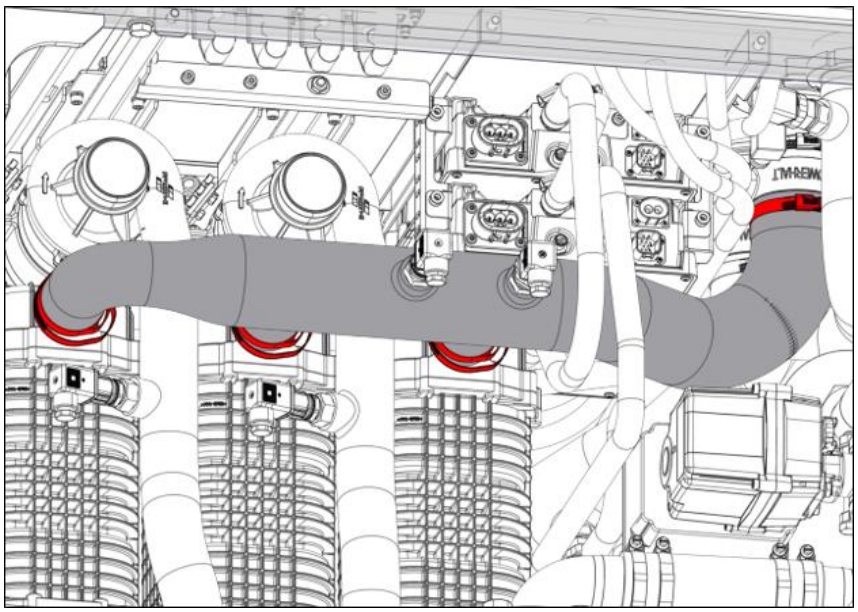


Figure 8-77: Hose clamps on humidifier to motorized shut-off valve hose

11. Release 4 pcs. hose clamps used to secure the hose from aftercooler to the air compressors and remove the hoses.

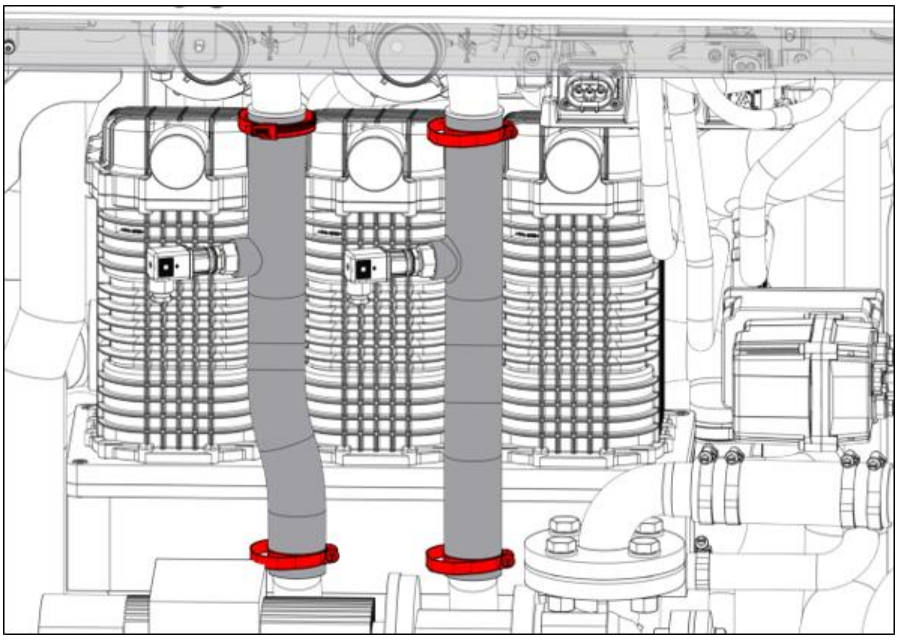


Figure 8-78: Hose clamps on aftercooler to air compressors hose

12. Unplug the HV compressor cables from inverters A and B and remove the protective mesh from the power cables.

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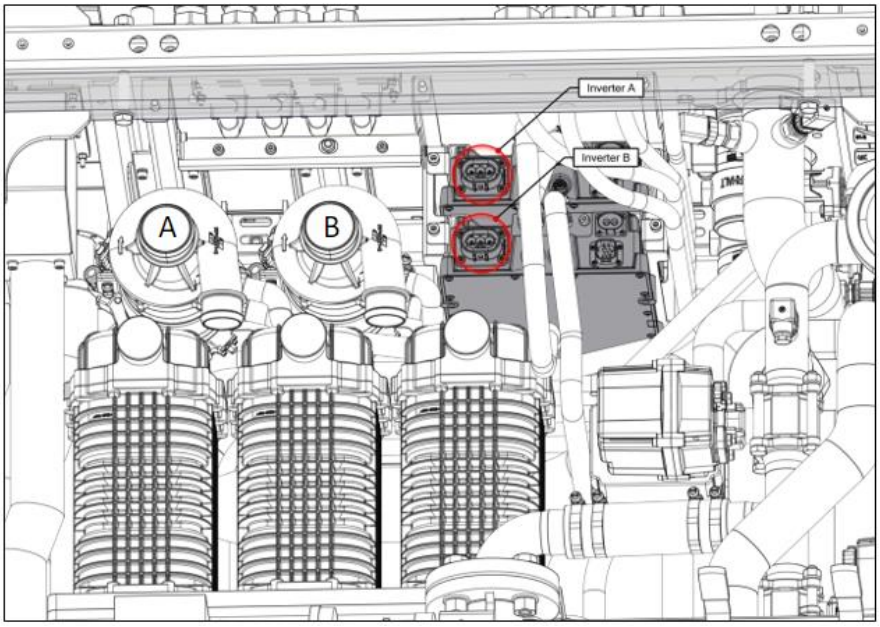


Figure 8-79: Inverters and compressor HV cables

13. Uninstall 4 pcs. M6 bolts from the cross beam bracket above the air compressors and remove the bracket.

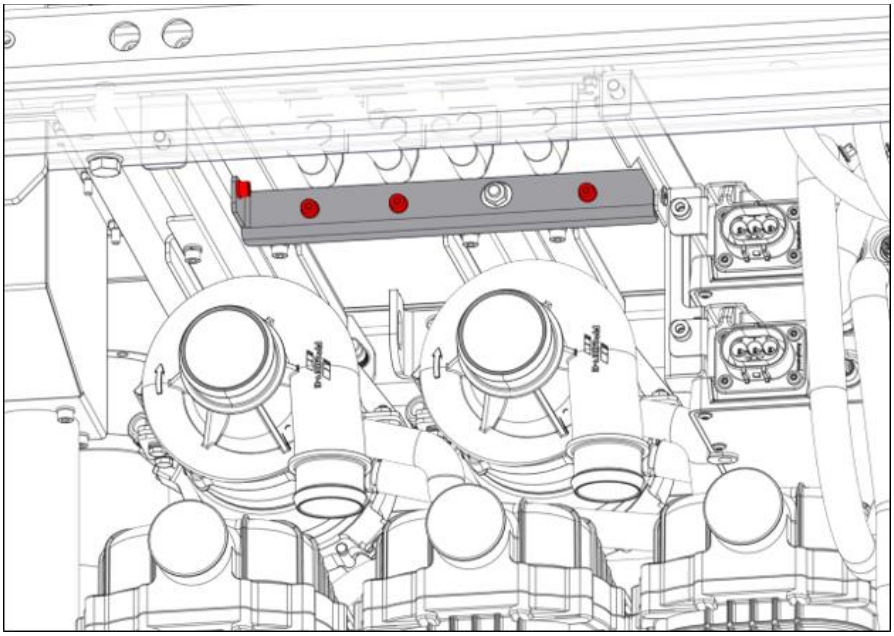


Figure 8-80: Removal of cross beam bracket

14. (This step only applies to early FCwave modules) Cut the cable tie and slide back the linear heat detection cable to give more slack at the compressor back end. Then, cut the cable tie supporting the HV cables. Lastly, remove the linear heat detection cable wrapped around compressors A and B.
15. Uninstall 8 pcs. M6 bolts and spring washers used to tighten the air compressor mounting brackets to the left and right compressor mountings.

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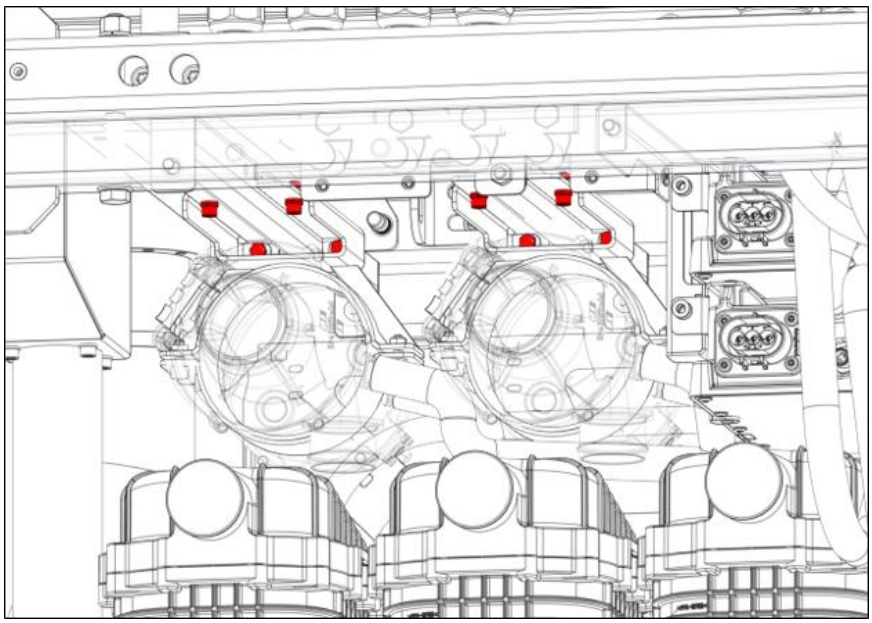


Figure 8-81: Bolts in air compressor mounting brackets

16. Block 2 pcs. LT coolant hoses for compressor A with hose clamp pliers and place paper towels below the compressor to prevent coolant leaking to other components.
17. Slide compressor A about 10cm and release the hose clamp for the air compressor coolant inlet hose and dismount the coolant hose from the compressor. Cover the compressor and the hose with clean caps.
18. Further slide compressor A until it is possible to release the hose clamp for the air compressor coolant outlet hose and dismount the coolant hose from the compressor. Cover the compressor and the hose with clean caps.
19. Unplug the sensor cable from compressor A.

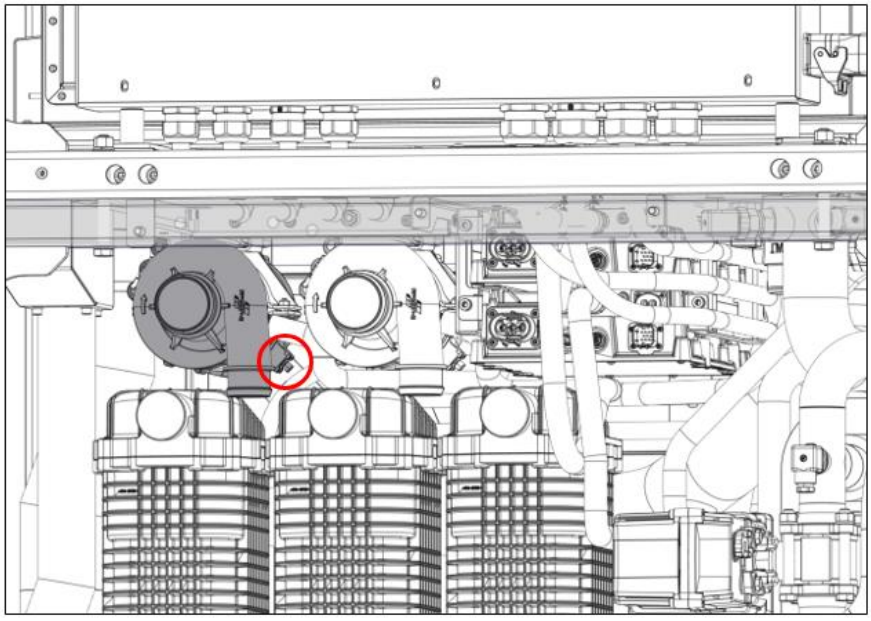


Figure 8-82: Sensor cable on compressor A

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20. Remove the grounding cable from compressor A.
21. Remove compressor A from the module and place it on a clean, flat surface.
22. Remove the grounding cable from compressor B.
23. Block 2 pcs. LT coolant hoses for compressor B with hose clamp pliers and place paper towels below the compressor to prevent coolant leaking to other components.

24. Uninstall the front M8 bolt from the compressor mounting bracket and loosen the rear M8 bolt.

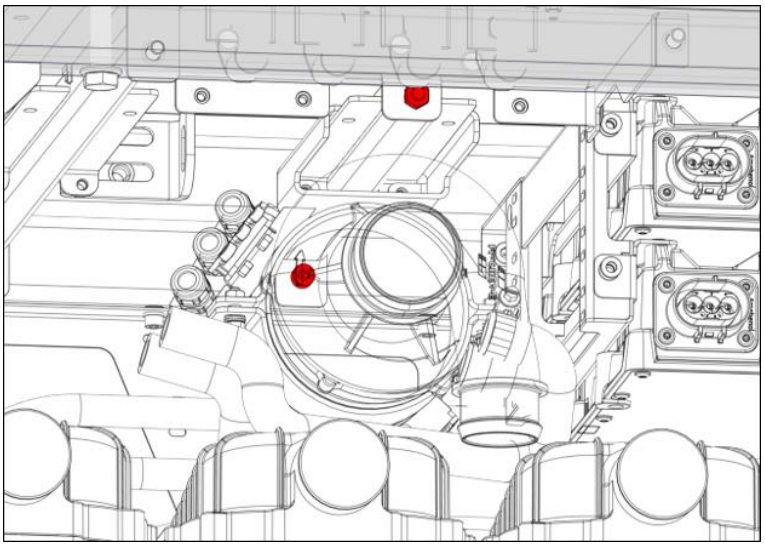


Figure 8-83: Front and rear bolt in compressor mounting bracket

25. Lower the front of the bracket 30mm to make room for the compressor to be removed.
26. Slide compressor B about 10cm and release the hose clamp for the air compressor coolant inlet hose and dismount the coolant hose from the compressor. Cover the compressor and the hose with clean caps.
27. Unplug the sensor cable from compressor B.
28. Remove compressor B from the module and place it on a clean, flat surface. Remove the coolant hose from the compressor. Cover the compressor and the hose with clean caps.
29. Place both verticals in a vertical position. Cut the cable ties used to secure the HV cables to the compressor brackets. Then, uninstall 4 pcs. M6 bolts used to secure the bracket and remove the bracket.

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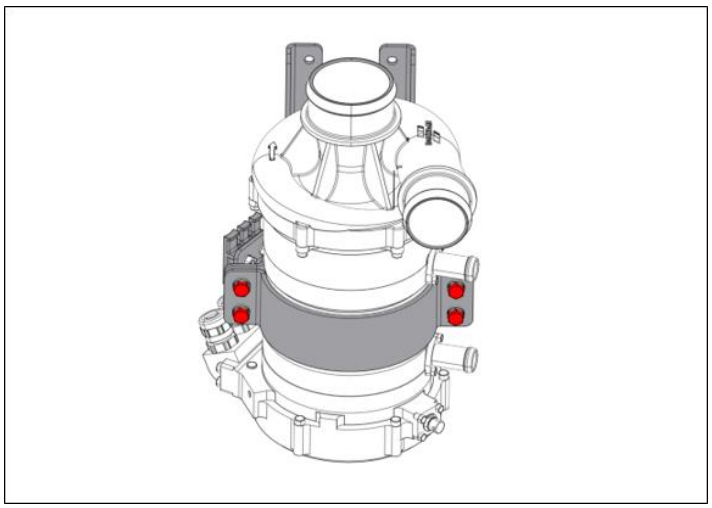


Figure 8-84: Removal of compressor bracket

30. Remove the compressor rubber damper from the compressors.

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Assembling procedure:

1. place the new compressors in a vertical position and mount the rubber damper.

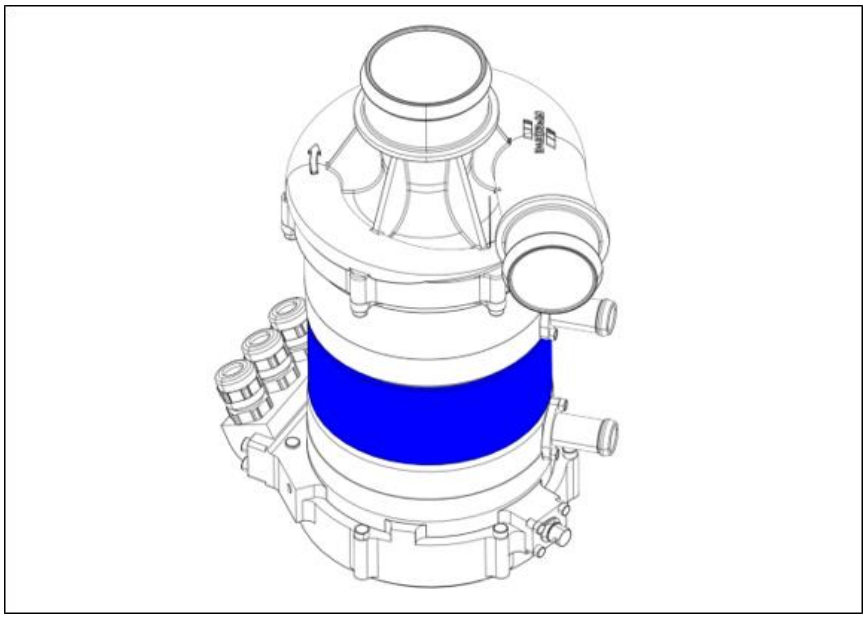


Figure 8-85: Install rubber damper on compressor

2. Use 4 pcs. M6 bolts to install the compressor bracket as shown and install the cable ties used to secure the HV cables to the bracket. Tighten the bolts to 6 Nm. Repeat for both compressors.
3. Secure the HV supply cable with cable ties as shown. Repeat for both compressors.

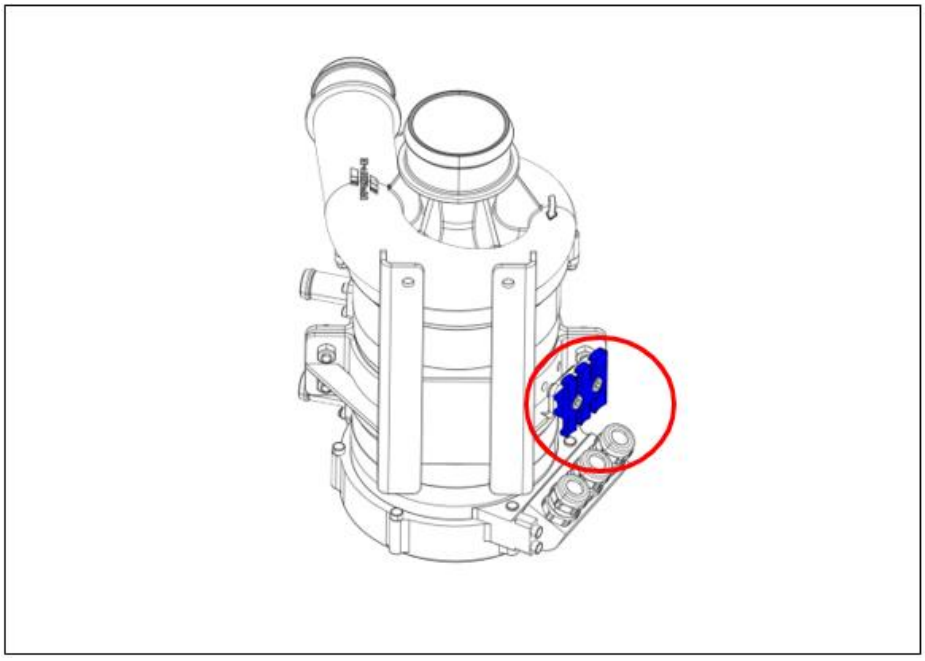


Figure 8-86: Securing HV supply cable

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4. Install the coolant hose to the compressor B coolant outlet and tighten the hose clamp. Tighten to 3.5 Nm.
5. Mount compressor B in the cabinet, slide inwards 10cm and connect the sensor cable.

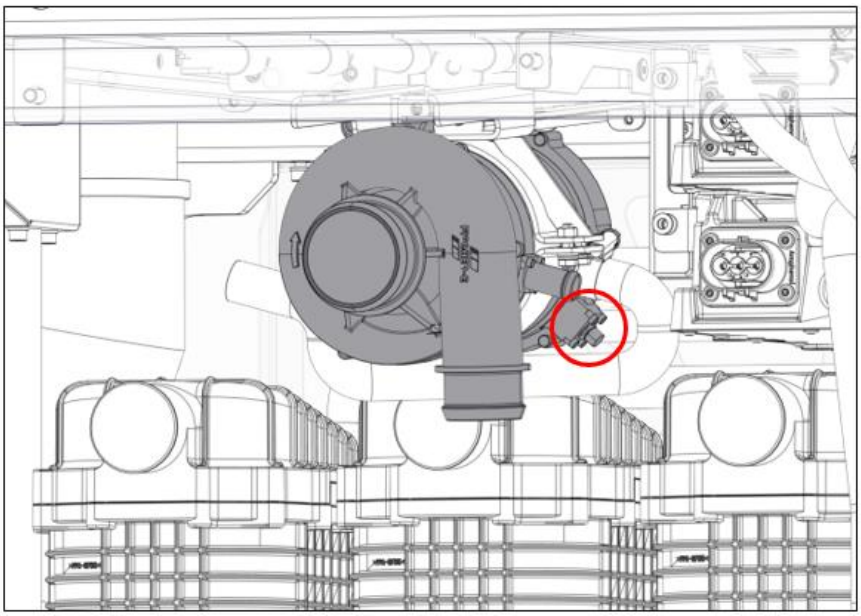


Figure 8-87: Install sensor cable to compressor B

6. Slide compressor B further in until it is possible to mount the coolant inlet hose and mount it. Tighten hose clamp to 3.5 Nm.
7. Slide compressor B into complete mounting position and raise the bracket front into position.
8. Install the front M8 bolt in the mounting bracket and tighten both front and rear M8 bolt to 15 Nm.

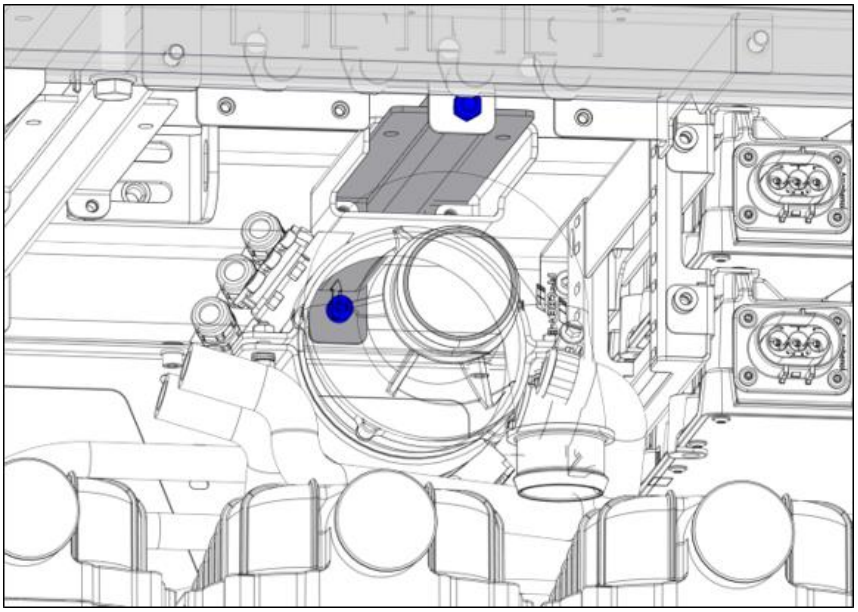


Figure 8-88: Install bolts for mounting bracket

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9. Mount compressor A and slide in 10cm. Connect the sensor cable and mount the coolant hose on the coolant outlet. Tighten hose clamp to 3.5 Nm.

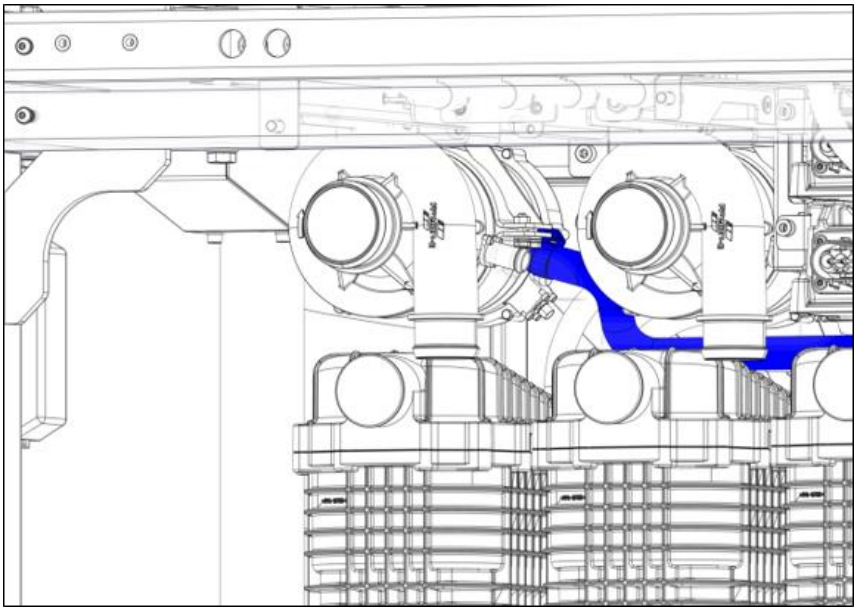


Figure 8-89: Mounting of compressor A

10. Slide compressor A further in until it is possible to mount the coolant inlet hose and mount it. Tighten hose clamp to 3.5 Nm.
11. Slide in compressor A to final mounting position.
12. Use 8 pcs. M6 bolts and washers to secure the bracket as shown. Tighten to 6 Nm.

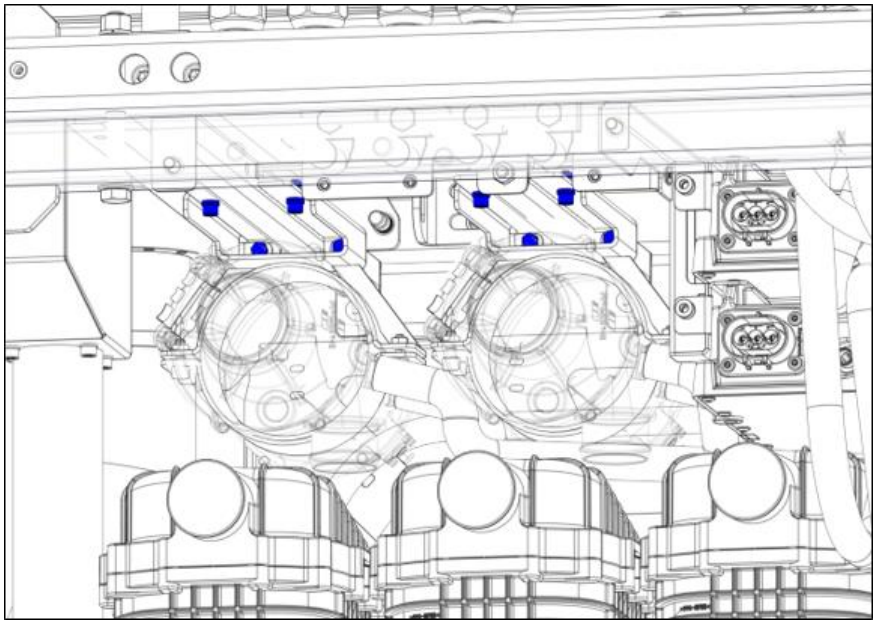


Figure 8-90: Securing mounting brackets

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13. Use 4 pcs. M6 bolts to install the cross beam bracket. Tighten to 6 Nm.
14. Wrap protective mesh around the power cables and secure with 3 pcs. cable ties.
15. Connect the HV cables from the compressors to inverters A and B.
    If you have Inverter 2.0B installed, use 'Inverter 2.0B Adaptor Cable' (part no. 7500631).

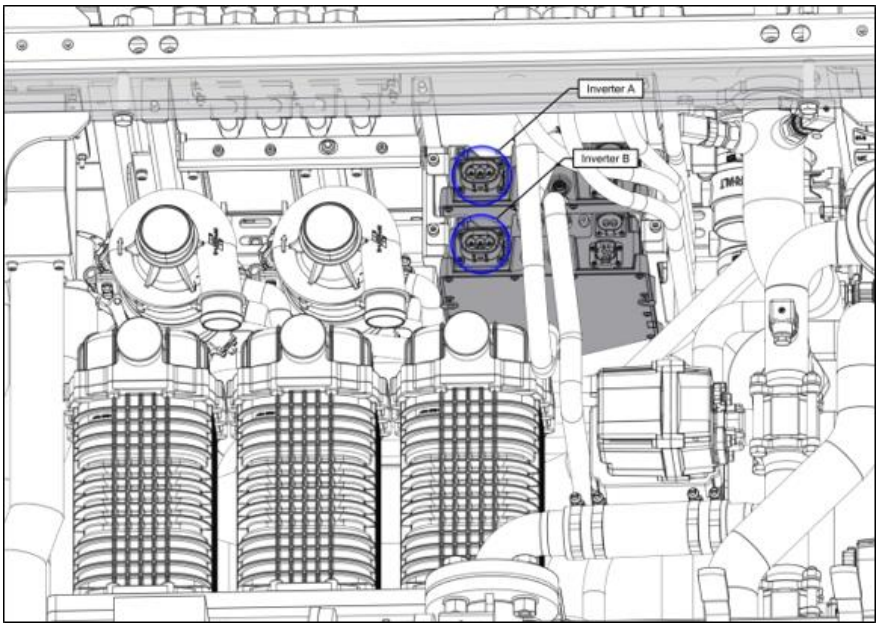


Figure 8-91: HV cables to inverters

16. Use 4 pcs. hose clamps to mount hoses from aftercooler to air compressors as shown. Tighten hose clamps to 3.5 Nm.

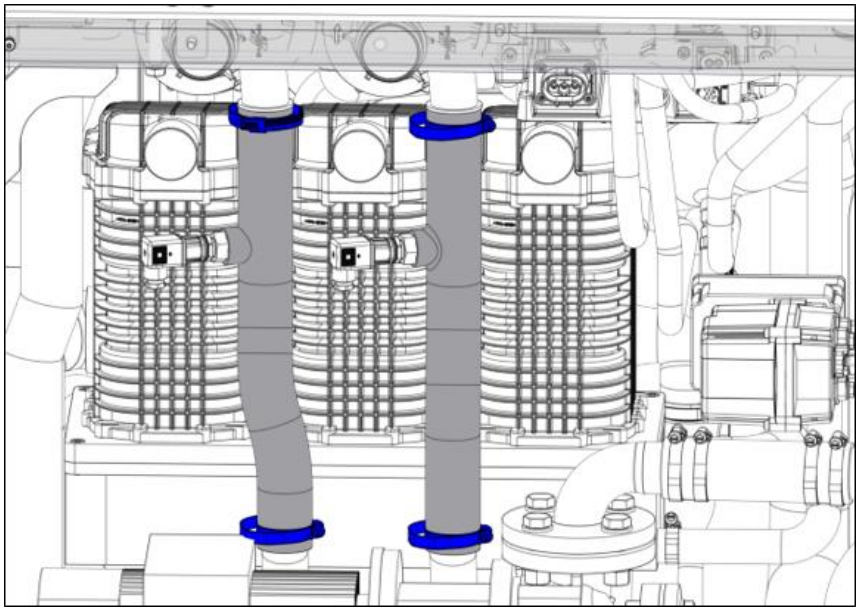


Figure 8-92: Installing hoses from aftercooler to compressors

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17. Use 4 pcs. hose clamps to mount hoses from humidifiers to motorized shut-off valve as shown. Tighten hose clamps to 3.5 Nm.

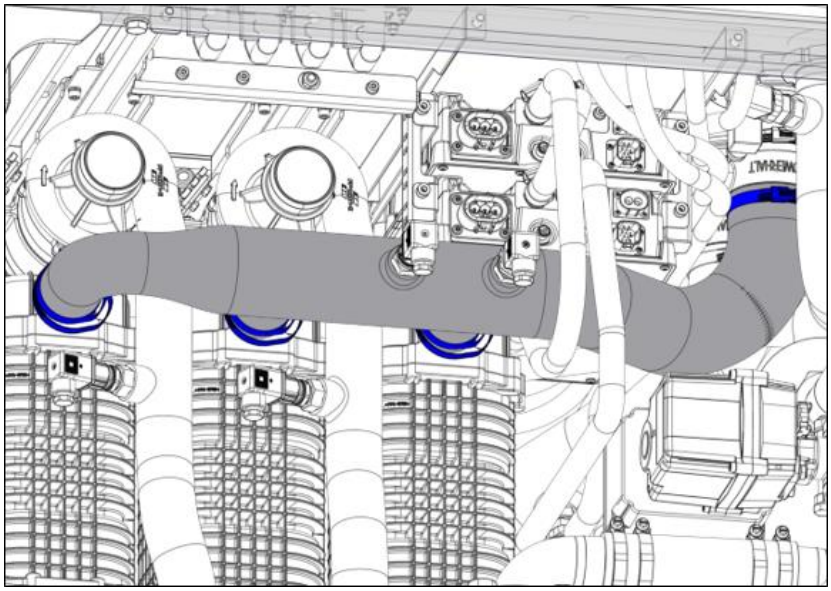


Figure 8-93: Installing hose from humidifiers to shut-off valve

18. Use 2 pcs. hose clamps to install compressor inlet hose to the compressors. Tighten hose clamps to 3.5 Nm.
19. Connect all following sensor connections of harness CN600 as shown: PT_A11A, PT_A11B, PT_A12A, PT_A12B, PT_A40, TT_A40.

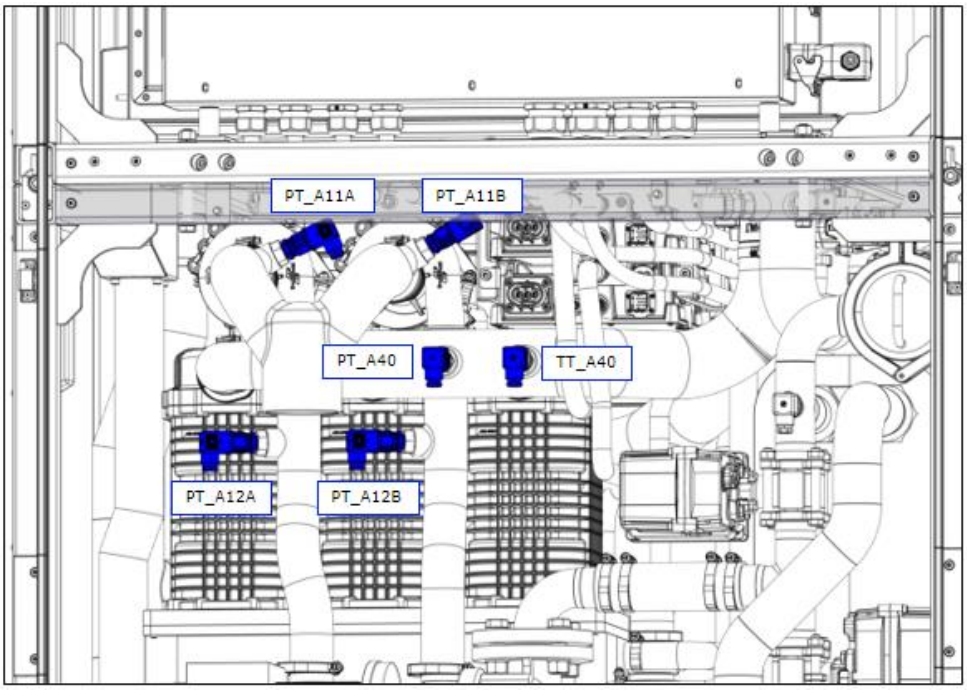


Figure 8-94: installing sensor connections

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20. Use 2 pcs. M8 bolts and washers to install mounting bracket to the cabinet as shown. Tighten to 15 Nm.

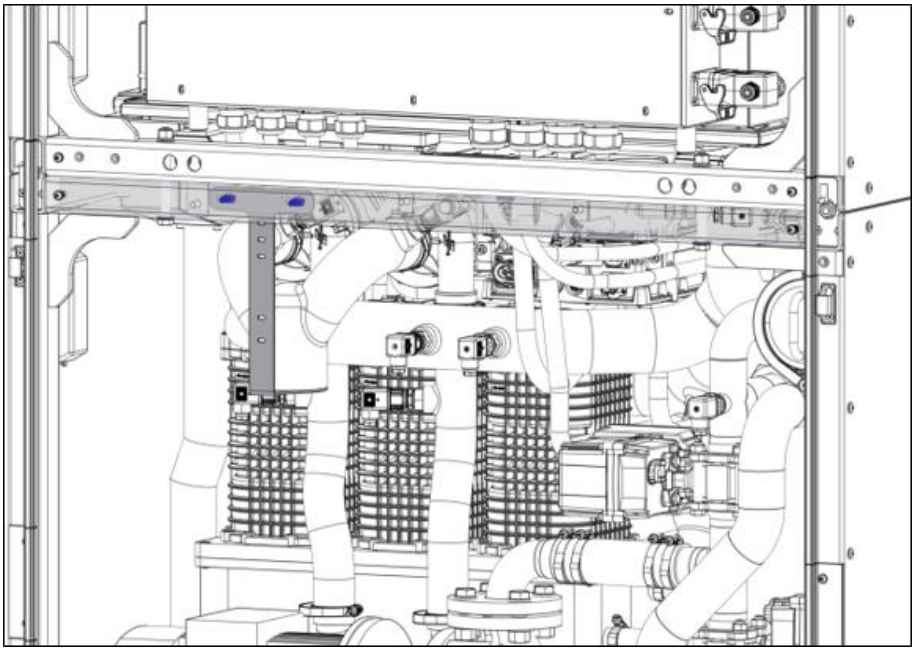


Figure 8-95: Installing mounting bracket to cabinet

21. Mount intake filter on intake hose. Tighten hose clamp to 3.5 Nm.
22. Connect the mass air flow meter sensor (FT_A10).
23. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
24. Run “auxiliary coolant system” from integrator side to fill and de-air the auxiliary coolant system.
25. Test the operation of the air compressors.
26. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
27. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
28. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.3.6 Assurance Procedure – Air Cathode Sub-system leak test

Succes criteria for leak testing:

There is a leak if:

- Values recorded during the test are out of acceptable range provided by the "Leak Test Report Form", which can be found on the Customer Portal (see section 4.1 for further information)
- Unable to create correct pressure in the system
- Escaping air can be heard within the module
- Hydrogen gas and a hydrogen sniffer can be used to identify leaks

There is no leak if:

- All the values recorded during the test are within the accepted range provided by the "Leak Test Report Form" which can be found on the Customer Portal (see section 4.1 for further information)
- No sound coming from the module can be heard

Estimated time to perform the cathode sub-system leak test

Based on the normal conditions, the estimated time for testing is:

Cathode sub-system Leak Test		
Duration	3 hours	
Personnel	1	
Tightening Torque	M5 bolt	6.5 ± 0.5 Nm
	M6 bolt	10 ± 0.5 Nm
	Tool: 4mm + 5mm hex key, leak tester, leak test hose, 3/8" wrench, 8mm hex socket, 7mm socket flex screwdriver, laptop, WLAN cable, 45mm fitting plug, 95mm exhaust blinding plate, 45mm blinding plug	

Table 8-12: Time to perform cathode sub-system leak test

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Procedure:

1. Secure the area before pressurizing the system components.
   Use warning signs around the working area to ensure safety.
2. Locate and loosen 2 pcs. hose clamp on air-out hoses of the air compressor. Disconnect the hoses after clamps is loosened.



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Figure 8-96: Location of hose clamp on air-out hoses

3. Use plugs to cover the disconnected hoses. Use plug with connection for left hose and plug for right hose and use the hose clamps to secure the plugs. Tighten to 5 Nm.

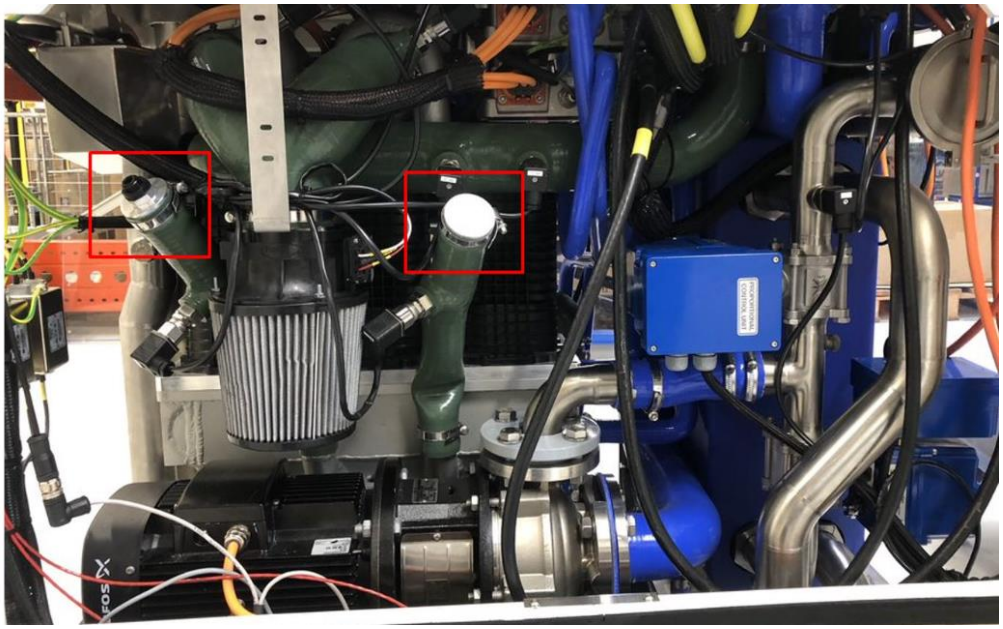


Figure 8-97: Using plugs to cover disconnected air-out hoses

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4. Locate the adaptor box, located in the top left corner of the lower cabinet, covering the C-piece.



Figure 8-98: Location of box covering c-piece

5. From the top of the box, uninstall 5 pcs. M5 bolts and washers.

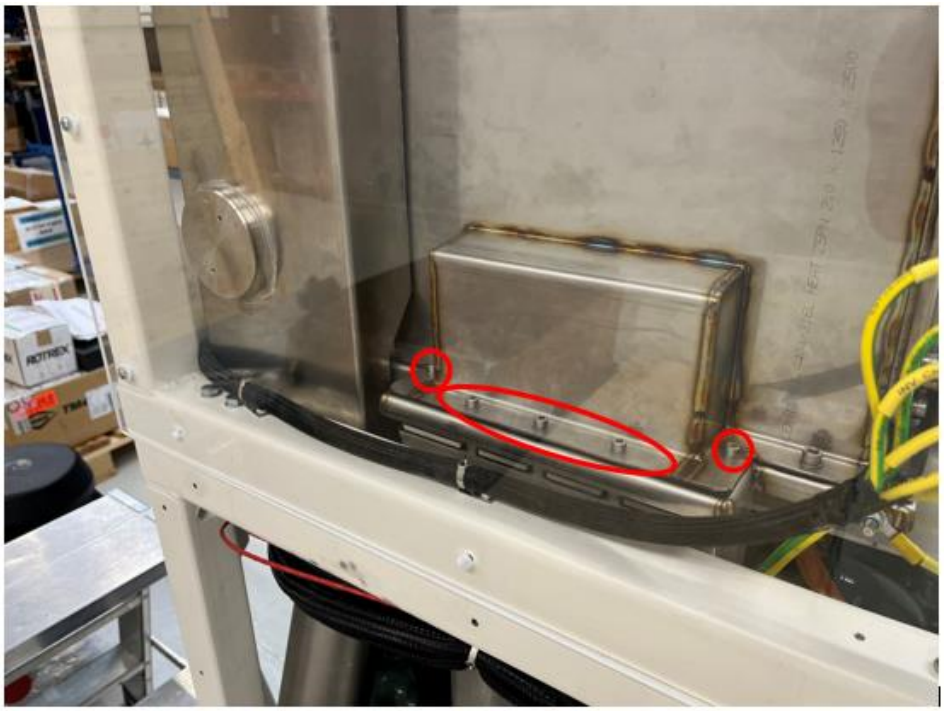


Figure 8-99: Removal bolts top side of adaptor box

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6. From the bottom of the box, uninstall 3 pcs. M5 nuts and washers and 4 pcs. M6 bolts and washers.

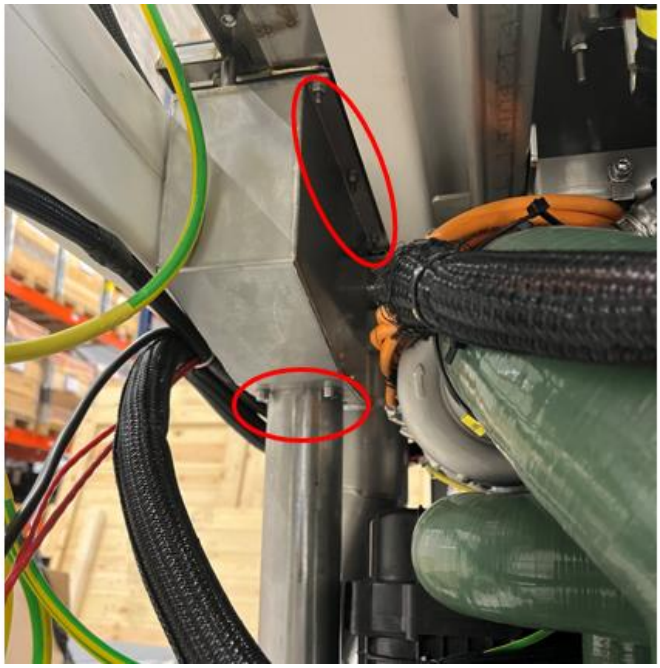


Figure 8-100: Removal bolts bottom side of adaptor box

7. Slide down the box to access the process exhaust swivel located behind the adaptor box.
8. Use the special tool (exhaust swivel) to loosen the exhaust swivel and install exhaust blinding plate between the top and bottom part of the process exhaust as indicated.



Figure 8-101: Placement of blinding plate in swivel

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9. Re-establish the process exhaust. Tighten to 20 Nm.
10. Use laptop to connect to module engineering interface.
11. Navigate to the I/O page and go to the Air tab in the menu.

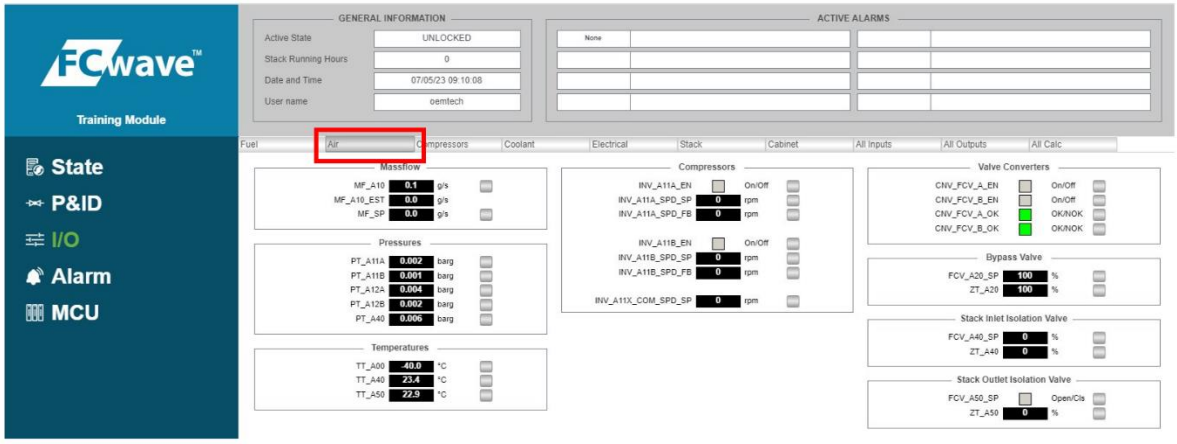


Figure 8-102: Navigate to air tab in the menu

12. Force CNV_FCV_A_EN & CNV_FCV_B_EN to 'on' as shown (1). Force FCV_A20_SP to 50% as shown (2). Force FCV_A40_SP to 50% as shown (3). Force FCV_A50_SP to 'open' as shown (4).

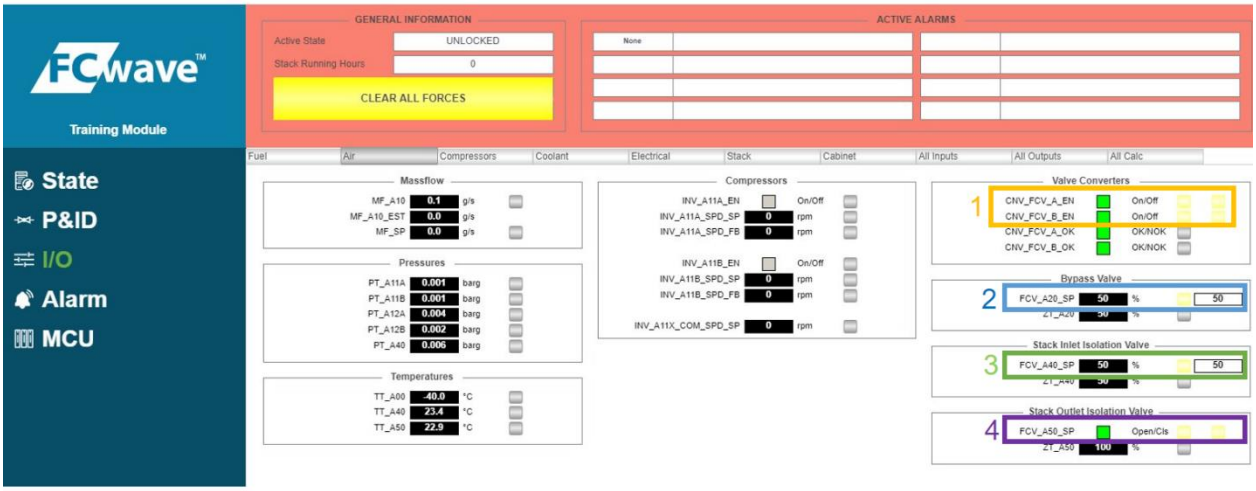


Figure 8-103: Forcing values in air tab

13. Prepare the leak tester according to document MAN5100654, which can be found in the customer portal (see section 4.1 for further information).

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14. Connect the leak tester to the disconnected air compressor hose with the connection plug, marked as (2) in the picture.

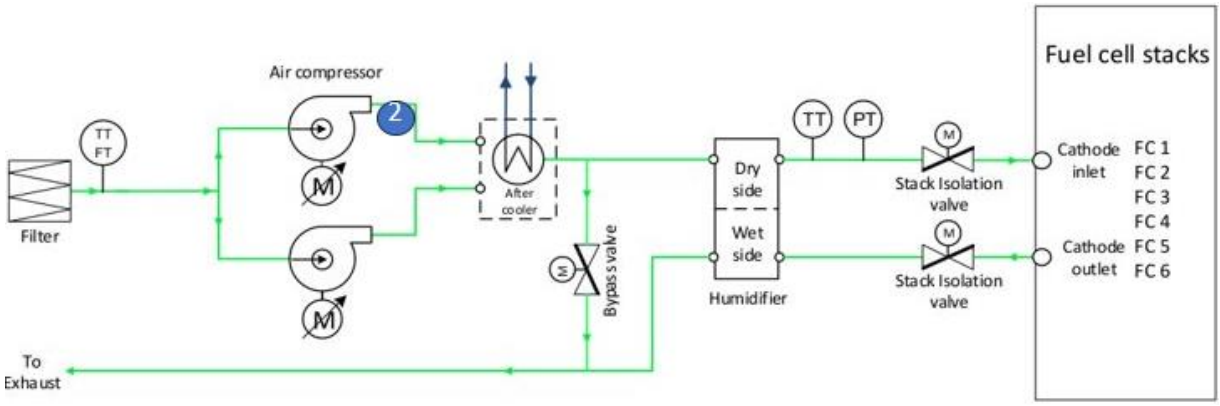


Figure 8-104: Connecting leak tester for cathode sub-system

15. Slowly turn the pressure regulator clockwise to test pressure of 7 Psi. Let the system stabilize for 5 min.

    Use the digital ALICAT MFM for a more precise reading than the analogue pressure gauge.

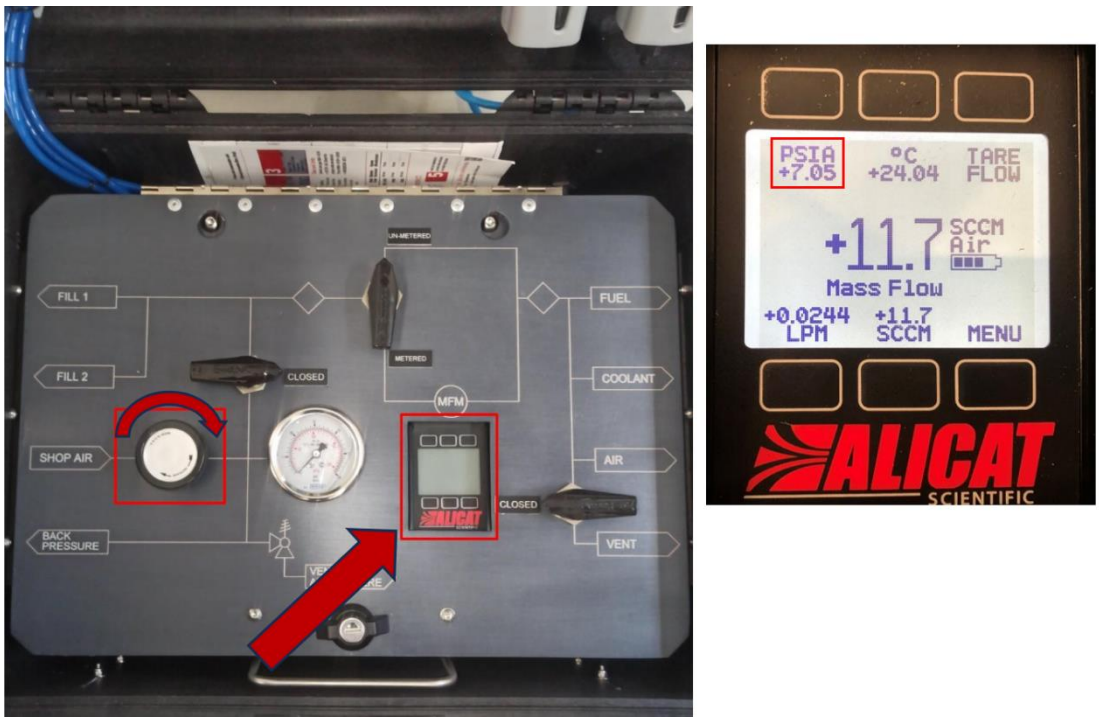


Figure 8-105: Use digital ALICAT MFM for pressure reading

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16. Force valve A to the "un-metered" position. Open valve B. Ensure valve C is in the "closed" position.

    Manometer pressure measurement should be 7 Psi/0.5 bar(g). Verify the pressure on both the manometer and the ALICAT MFM.

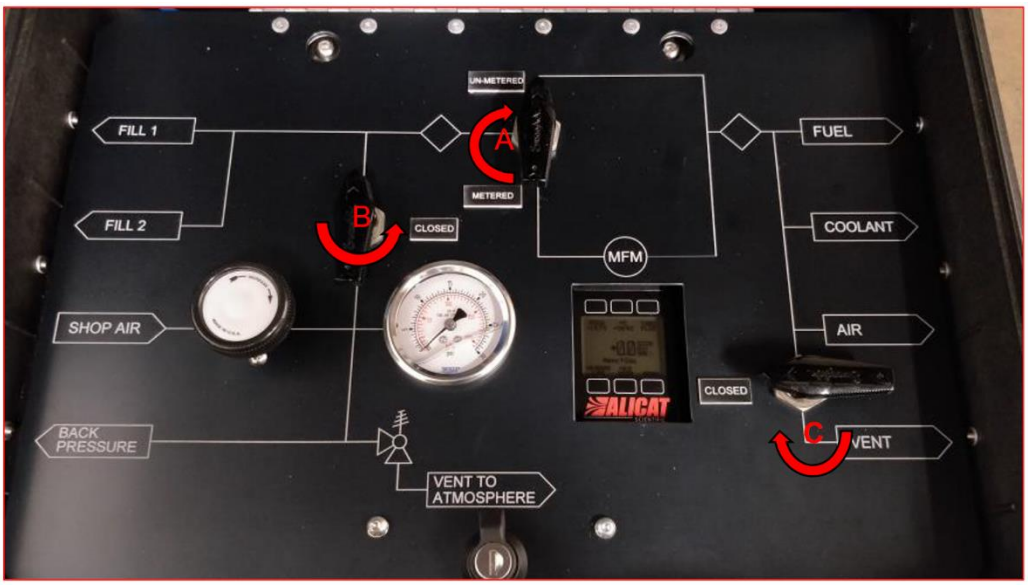


Figure 8-106: Leak tester valves1

17. Gradually force valve A to the "metered" position. Wait for the MFM to stabilize. Read and record the MFM reading in the leak test report form.



Figure 8-107: Leak tester valves2

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18. After completion of the leak test, force valve A to the "un-metered" position. Force valve B to the "closed" position to close off the air supply.

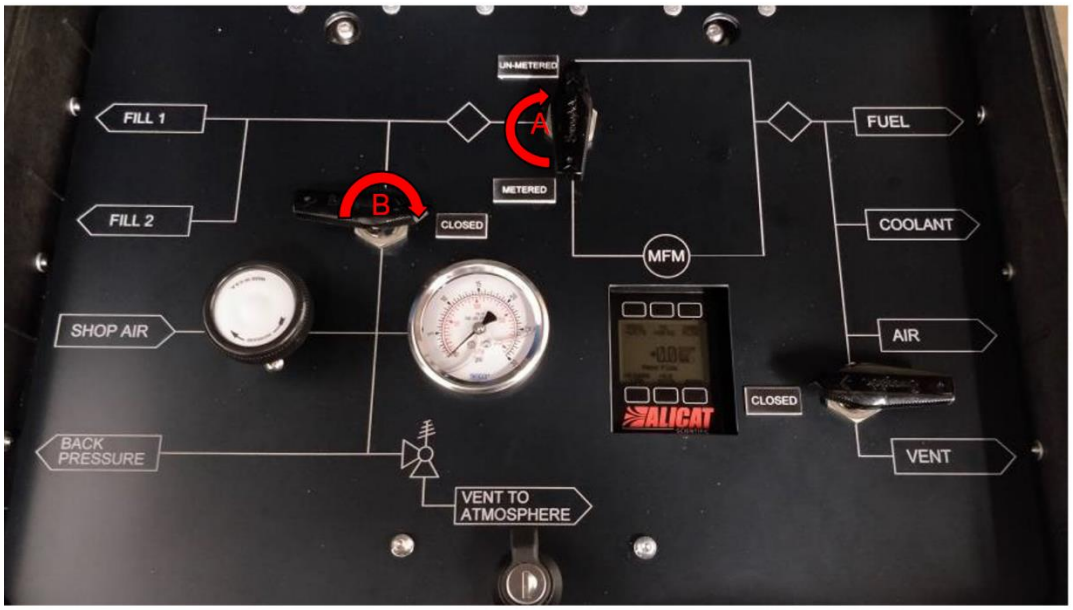


Figure 8-108: Leak tester valves3

19. Slowly force vent valve C to the "open" position to release the buildup pressure. Force the pressure regulator counter-clockwise to dial down the pressure.

    Ensure all hoses are vented before disconnecting from the module.

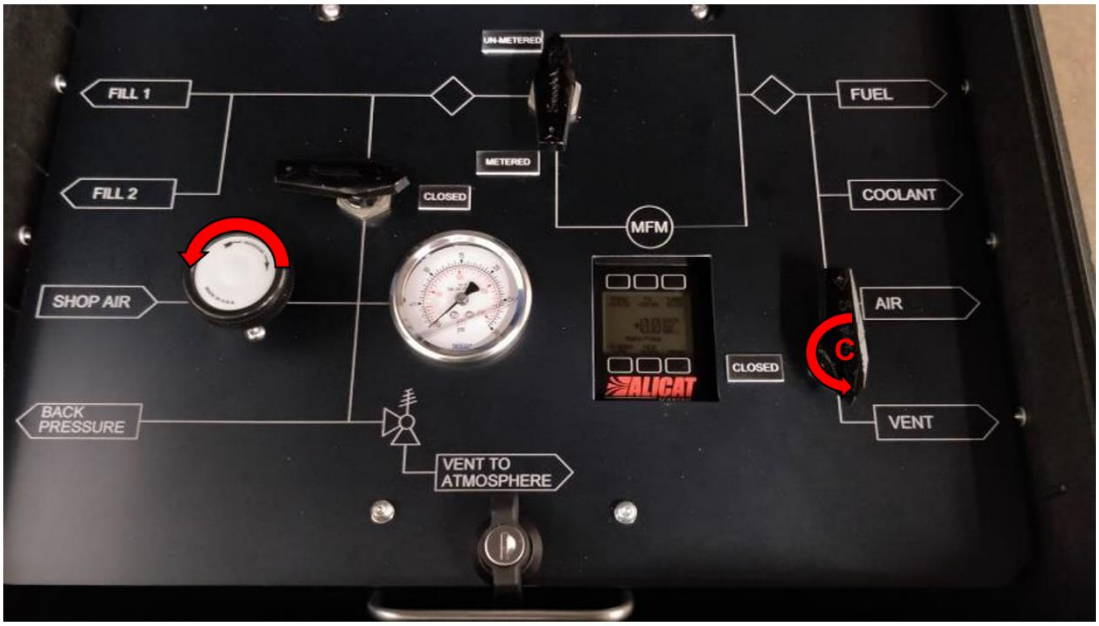


Figure 8-109: Leak tester valves4

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20. Navigate to the I/O page in the engineering interface and press “clear all forces”.
21. Navigate to the P&ID page and check that YV_H30 is closed and the box above PCV_H40 (PCV_CTRL_SP) is set to ‘0’.

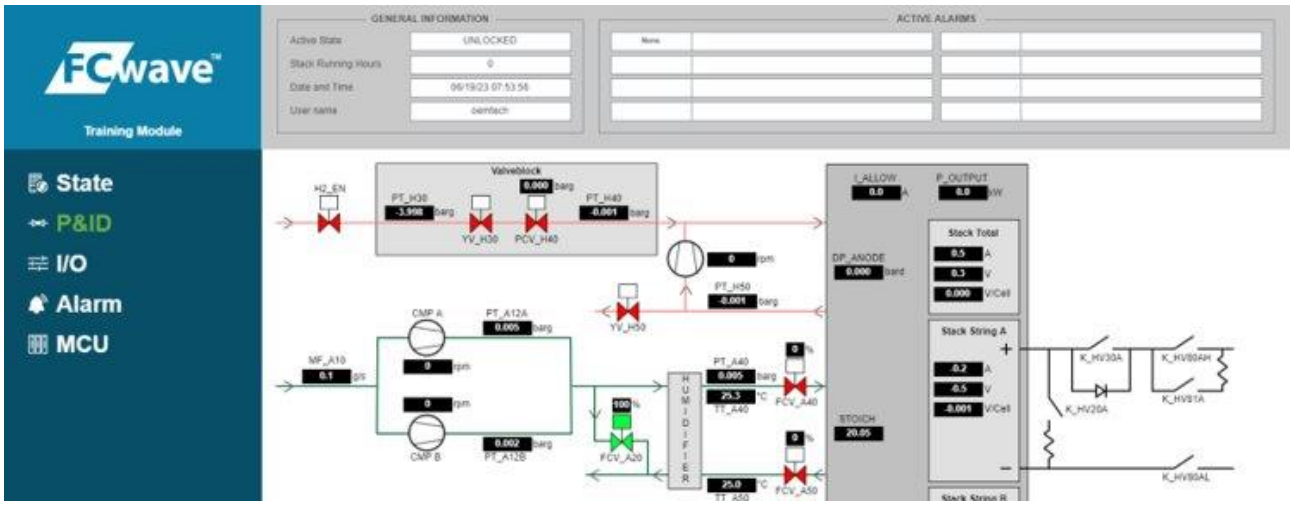


Figure 8-110: Checking YV_H30 is closed

22. Dismount the leak tester hose and reconnect hoses as before leak testing procedure.
23. Loosen process exhaust and remove the blinding plate. Replace the O-ring and re-establish process exhaust. Tighten to 20 Nm.
24. Use 5 pcs. M5 bolts and washers, 4 pcs. M6 bolts and washers, and 3 M5 nuts and washers to re-install the adaptor box. Tighten all to 5 Nm.

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8.4 Cooling Sub-system

For detailed P&ID requirements, refer to "Piping and Instrumentation Diagram" (PWR005), which can be found the Customer Portal or by contacting BPSE (see section 4.1 for further information).

8.4.1 Check for Coolant Leaks

Purpose:

The procedure describes how to visually inspect the cooling system and how to check for leaks or other issues. Components that show signs of damage or problems must be reported to BPSE to determine if any corrective action is necessary.

Responsibilities:

It is the end user's responsibility to do preventive maintenance (refer to section 8.1.1).

Safety:

Refer to section 8.1.2 to follow the instructions.

Procedure:

1. Perform step 1-3 in section 6.5.1 (High Voltage safety check before module maintenance) before proceeding with the disassembling procedure.
2. Visually examine HT coolant and air hoses installed in the upper cabinet and lower cabinet of module.
3. If accessible, examine the hoses connected to the air compressor and motor controllers of the LT coolant loop.
4. Record the observations and findings during inspection. If any leaks or damage are reported, do not operate the module until the issue is corrected. Contact BPSE (see section 4.1) for further support.
5. For coolant hose inspections:
    - Check DI filter housing for cracks or signs of leaks.
    - Check all coolant hoses. Make sure there are no loose clamps, bends, pinching, cuts, or cracks.
    - Check that all bolt fastenings and connections in the coolant circuit are tight and correctly aligned.
    - Check for signs of overheating, wear, or damage — damages of an excessive nature can be sign of more dangerous issues and must be investigated further.
    - Check that there are no visible leak spots, pooled liquid, corrosion, or excessive moisture around the H2 enclosure and in the lower cabinet base.
    - Check the fluid level in the header tank for evidence of any coolant loss.

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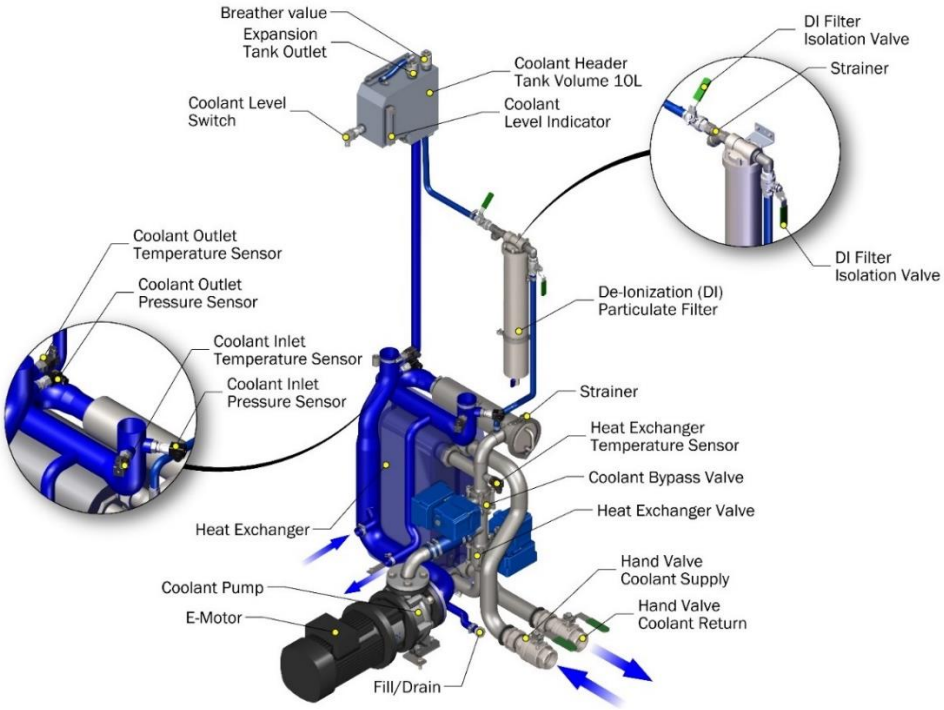


Figure 8-111: Overview of coolant hose inspections

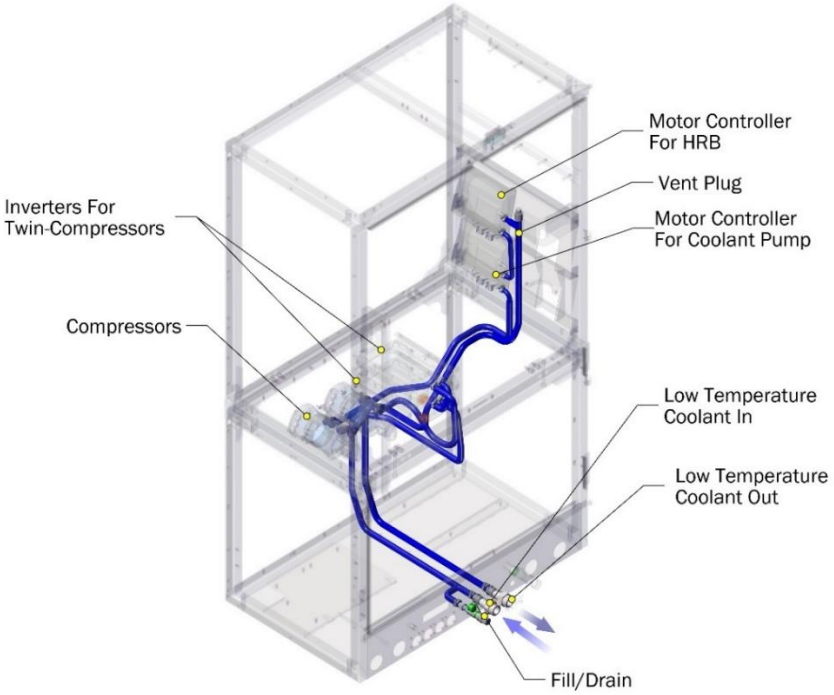


Figure 8-112: Second overview of coolant hose inspections

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8.4.2 Check Stack Coolant Conductivity

Purpose:

The procedure describes how to check the electrical conductivity of a fluid sample collected from the HT coolant circuit, through the DI filter drain valve with a conductivity meter. Higher than expected electrical conductance (5 µS) is an indication to replace the DI particulate filter. This DI filter maintains the cleanliness of the coolant circuit which prevents a conductive path through the circuit.

Responsibilities:

It is the end user's responsibility to do preventive maintenance (refer to section 8.1.1).

Parts and equipment:

A list of parts and special equipment is identified for examination of the cooling system during the life and operation of the FCwave module.

- Cooling sample KIT (part no. 7001351)
- Conductivity meter[3] 0.0 to 99.9 µS/cm or equivalent (part no. 6500424)

Safety:

Refer to section 8.1.2 to follow the instructions.

Procedure:

1. Check that the system has been in operation during the 24 hours before performing the test, to make sure the collected sample is filtered and deionized, so the data collected is representative of electrical conductance that can be expected during operation (coolant conductivity will increase over time when the system is not in operation).
2. If the module has not been in operation during the last 24 hours, operate the FCwave module for 10 minutes to circulate coolant through the DI particulate filter.
3. Perform step 1-3 in section 6.5.1 (High Voltage safety check before module maintenance) before proceeding with the disassembling procedure.
4. Follow the manufacturer instructions to prepare the conductivity meter before taking the sample.
5. Make sure the coolant sample cool to below 40°C, before immersing the conductivity probe in the collected sample.
6. Collect the necessary quantity of fluid from the HT coolant circuit into a clean container through the DI filter drain valve, so the sensing element of the conductivity meter can be immersed to about half of its length. Follow the instructions on the conductivity meter.
7. Stir the probe in the coolant sample and monitor the value until the indication is stable and record the value.
8. Make sure the indication is less than 5 µS. If conductivity indication is initially higher than 5 µS:
   - Replace the coolant DI particulate filter in the system coolant circuit (see section 8.4.8).
   - Locate the ports normally used for filling/draining the HT circuit, use a portable pump secured with mechanical relief valve to fill the HT circuit.
   - Operate the system until it reaches 40°C to deionize the coolant.
   - Collect a new test sample.
   - Measure the conductivity again, until it is below 5 µS.

   Pay attention to disconnect the vent valve connected to H_2 ventilation outlet duct to prevent any coolant spillage in the fuel cell stack during filling procedure.
9. Clean and follow the manufacturer instructions to store the conductivity meter.

[3] Conductivity meter is part of the 'Special Tools Kit FCwave' (part no. 6100062)

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8.4.3 Check the Coolant Particulate Filter

Purpose:

The procedure describes how to check a coolant particulate filter (wedge wire screen) of the HT coolant system and how to replace if necessary. The cooling system contains a wedge wire screen to remove any particulate matter present in the coolant loop.

Responsibilities:

Preventive maintenance of the coolant wedge wire screen is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the H_2 sensors during the life and operation of the FCwave module.

- FRU, Coolant Particulate Filter (part no. 7500087) – if replaced

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to check the Coolant Particulate Filter

Based on the normal conditions, the estimated time for check is:

Coolant Particulate Filter	
Duration	10 min
Personnel	1

Table 8-13: Time to check coolant particulate filter

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Procedure:

1. Before proceeding with the check, perform all steps in section 7.2.7 and 6.5.1.
2. Drain the high temperature (HT) stack coolant circuit.
   Coolant spillage may occur while opening the wedge wire screen.
3. Loosen by hand the clamp securing the filter and then remove. There might be leftover coolant in the filter housing so prepare area for possible coolant spill.

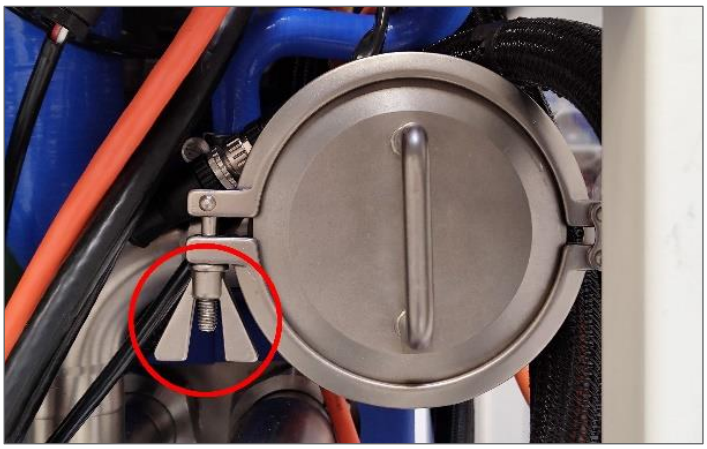


Figure 8-113: Clamp securing particulate filter

4. Grab handle on filter and gently pull out to avoid unnecessary contact with inner side of filter housing.
5. Check the filter for damage and particles. If there are any, rinse off with deionized water (DI).
6. Before reinstalling the filter, make sure the O-ring and gasket on the filter are seated properly.

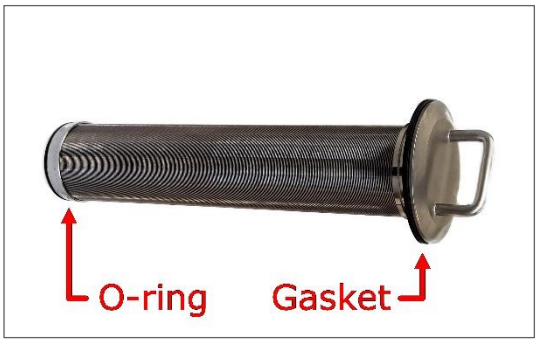


Figure 8-114: Particulate filter gasket and O-ring

7. Gently insert the filter into the housing, making sure the O-ring does not get unseated.
8. Make sure the gasket is properly seated.
   Wiggling the filter by the handle may help the gasket get seated more easily.
9. Reinstall the clamp, securing the filter to the housing, and tighten by hand.
   The module is ready to be restored to normal operating system.
10. Connect a portable pump secured with a mechanical relief valve to the connector, to fill the module with HT coolant as necessary.
11. Confirm that the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.4.4 Check the Coolant Level Indicator

Purpose:

The procedure describes how to visually inspect the coolant level in the header tank. The module contains an internal coolant header tank of no more than 10 litres. It provides a reservoir of coolant, allows for thermal expansion of the coolant, and has a level indicator in the header tank to provide warning for low coolant levels.

Responsibilities:

Preventive maintenance of the coolant level indicator is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Safety:

Refer to section 8.1.2 to follow the instructions.

Procedure:

1. Perform step 1-3 in section 6.5.1 (High Voltage safety check before module maintenance) before proceeding with the disassembling procedure.
2. Locate the level indicator behind the HRB motor in the upper cabinet, which is installed on the coolant header tank.

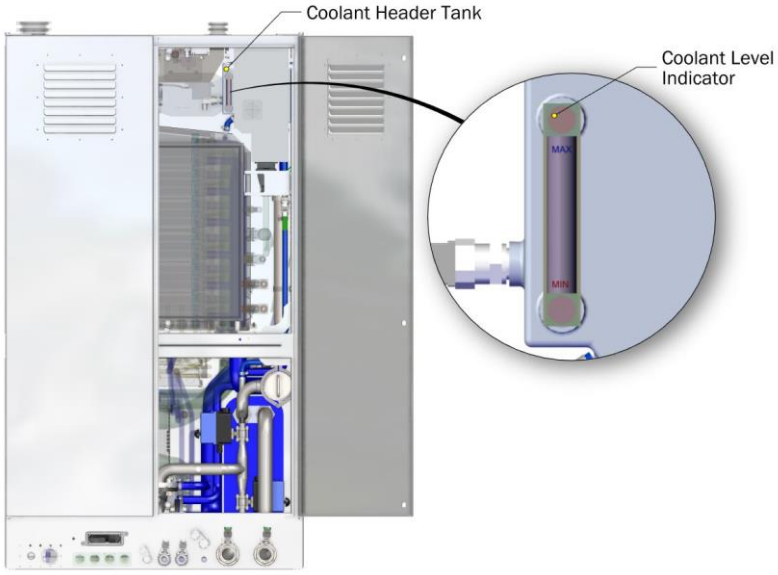


Figure 8-115: Overview of coolant header tank/level indicator

3. Visually examine the sight glass on the header tank, to make sure the coolant level is between maximum and minimum.
4. Do not exceed the maximum level of coolant to avoid any coolant spillage into the system. (During operation coolant level increases due to thermal expansion)
5. Refill the header tank when the coolant is below the minimum level.
6. Connect a portable pump secured with a mechanical relief valve to the connector, to fill the module with HT coolant as necessary.
7. Ensure the air pockets are vented through the vent valve located on the top of header tank.

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Pay attention to disconnect the vent valve connected to the H_2 ventilation outlet duct, to prevent any coolant spillage into the fuel cell stack during the filling procedure.

8. If accessible, examine the hoses connected to the header tank.

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8.4.5 Coolant Tank Level Switch

8.4.5.1 Check Coolant Tank Level Switch

Purpose:

This procedure describes how to check the coolant tank level switch in the FCwave™ module. The switch monitors the High Temperature (HT) coolant level. If the level is too low, it will trigger an alarm.

Responsibilities:

Preventive maintenance of the level switch is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to check the Coolant Tank Level Switch

Based on the normal conditions, the estimated time for check is:

Coolant Tank Level Switch	
Duration	15 min
Personnel	1

Table 8-14: Time to check Coolant Tank Level Switch

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Procedure:

1. Before proceeding with the check, perform all steps in section 7.2.7 and 6.5.1.
2. Connect the low voltage electrical connection (X_E01) and secure it by finger-tightening the bolts.

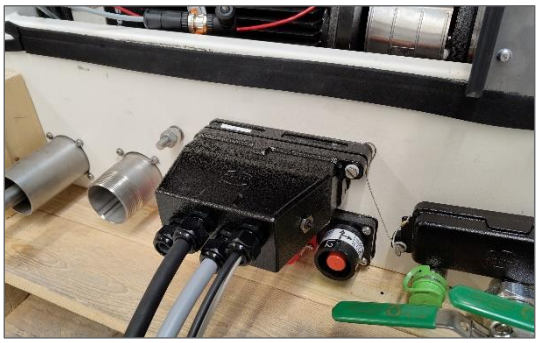


Figure 8-116: Low voltage electrical connection (X_E01)

3. Monitor the MCU engineering interface with the module in "Unlocked" state. Make sure there are no active alarms.
4. Drain the HT coolant via the fill/drain valve.



Figure 8-117: Drain the HT coolant

5. Confirm the following alarm can be seen in the engineering interface:
   - A2_LSL_D25_S_10721
6. Refill with new HT coolant to normal level. The recommended level is 66%, between MIN and MAX on the coolant level indicator.

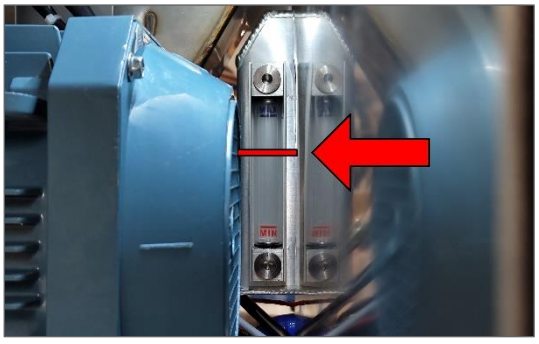


Figure 8-118: Recommended coolant level

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7. Clear the alarm in the engineering interface and confirm it does not reappear.
   Remember to clear all forces.
8. The module is ready to be powered down by disconnecting the X_E01 electrical connection, and the module is ready to be restored to normal operating state.
9. Confirm that the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.4.5.2 Replace Coolant Tank Level Switch

Purpose:

The procedure describes how to replace a coolant tank level switch for the HT coolant system. The level switch monitors the filling level of cooling water in the header tank. The level switch detects when a filling level exceeds or subceeds a set limit.

Responsibilities:

Preventive maintenance of the level switch is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the level switch H_2 sensors during the life and operation of the FCwave module.

- FRU, Coolant Tank Level Switch (part no. 7500078)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Level Switch

Based on the normal conditions, the estimated time for replacement is:

Coolant Tank Level Switch		
Duration	1 – 1½ hours	
Personnel	1	
Tightening Torque	1/2" sensor fittings	25 ± 0.5 Nm
	Tool	27 mm spanner, torque wrench, 10mm hex socket,

Table 8-15: Time to replace the level switch

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain the HT cooling system.
3. To get more space, remove the HRB motor. Follow steps 8 through 17 of the disassembling procedure in section 8.2.2.
4. Locate the level switch behind the HRB motor, installed on the coolant header tank in the upper cabinet.

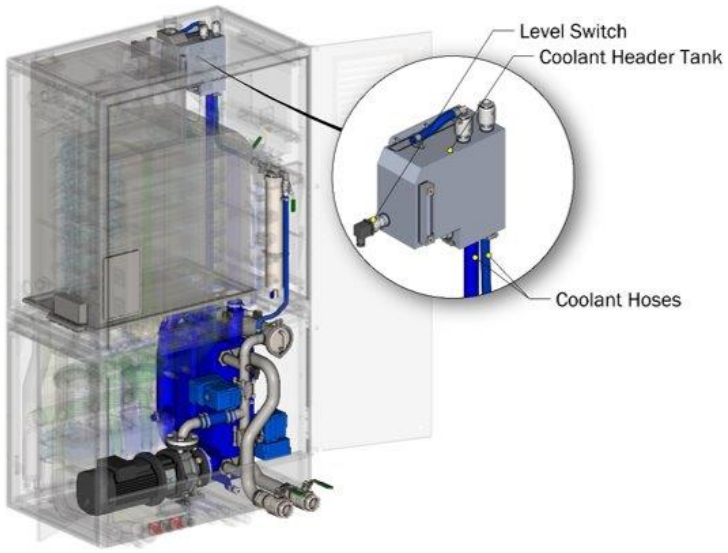


Figure 8-119: Location of the coolant header tank and level switch

5. Disconnect the level switch connection (LSL_D25) by removing the bolt in the middle of the plug.
6. Loosen the level switch and remove it by hand.

Assembling procedure:

1. Install a new level switch. Tighten to 25 Nm.
2. Use the bolt to install the sensor connector.
3. Re-install the HRB motor. Follow steps 11 through 22 of the assembling procedure in section 8.2.2.
4. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
5. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
6. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
7. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.4.6 Replace Coolant Flow Control Valves

Purpose:

The procedure describes how to replace flow control valves for the HT cooling system. A pair of electronically controlled valves regulates the stack coolant inlet temperature. One valve throttles the flow of coolant to the heat exchanger and the other bypasses the heat exchanger, depending on coolant temperature. During start-up, the coolant valves are positioned to bypass the heat exchanger, which allows coolant to recirculate through the stack and reduces warm-up time.

Responsibilities:

Preventive maintenance of the flow control coolant valve is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the coolant flow control valve during the life and operation of the FCwave module.

- FRU, Coolant Valve Actuator (part no. 7500088)
- FRU, Coolant Valve (part no. 7500089)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Coolant Valves

Based on the normal conditions, the estimated time for replacement is:

Coolant Valves		
Duration	1 – 1½ hours	
Personnel	1	
Tightening Torque	M8 bolt	25 ± 0.5 Nm
	M10 bolt	50 ± 5 Nm
	Tool	6mm + 8mm hex key, 13mm + 17mm socket key, 17 mm spanner, torque wrench

Table 8-16: Time to replace the coolant valves

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain and purge the HT cooling system.
3. Locate the coolant bypass valve in the lower cabinet (FCV_D30A).

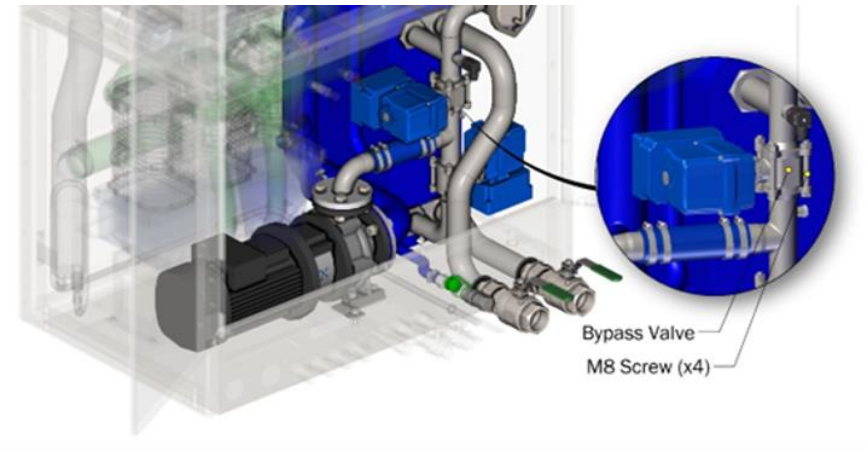


Figure 8-120: Location of coolant bypass valve

4. Uninstall 4 pcs. M8 bolts used to connect the ball valve to the motor and remove the electric actuator.

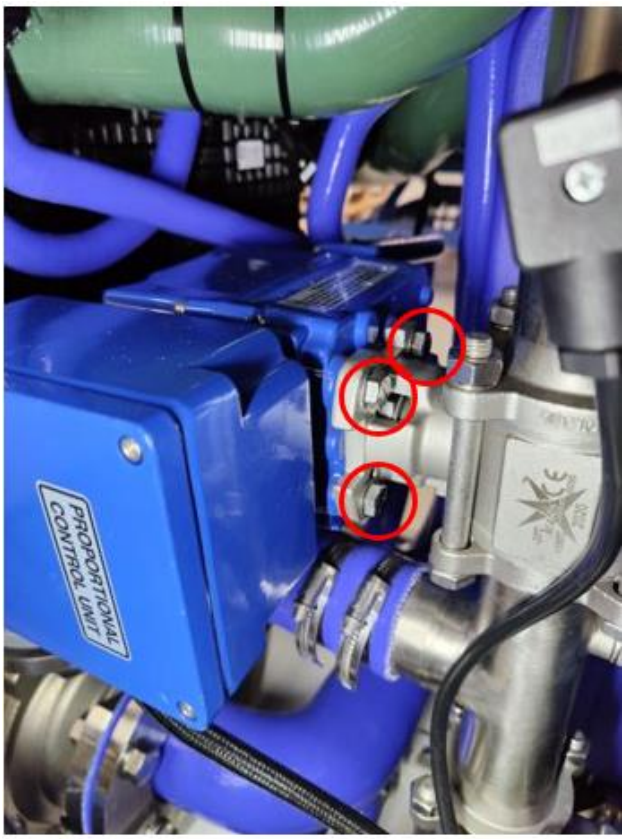


Figure 8-121: Removal of bolts for electric actuator

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5. Uninstall 4 pcs. M10 bolts used to secure the ball valve and slide it out.

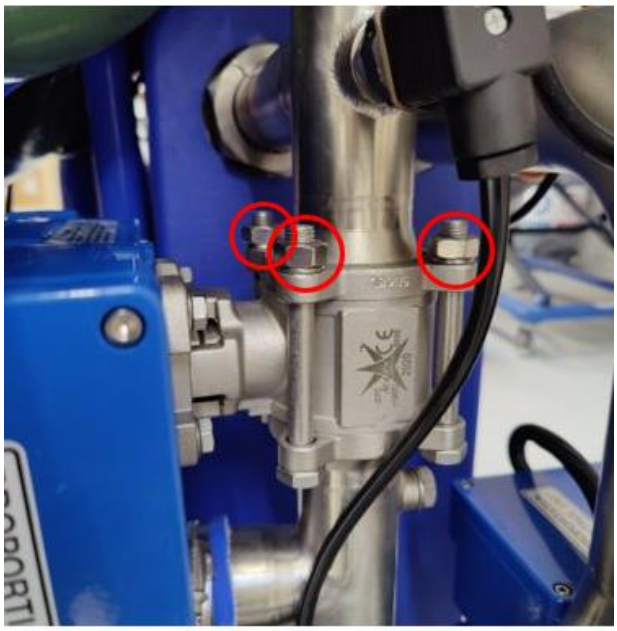


Figure 8-122: Removal of bolts for ball valve

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Assembling procedure:

1. Use 4 pcs. M8 bolts to install the valve motor to the flow control valve. Tighten to 20 Nm.
2. Slide in the new ball valve and secure with 4 pcs. M10 bolts. Tighten to 25 Nm.
3. Disconnect the tank ventilation hose from the ventilation duct. The LV panel can be moved forward if more room is needed.



Figure 8-123: Disconnecting the tank ventilation hose

4. Use the filling valve to refill the HT cooling system. Pay attention to the HT coolant tank level indicator to not overflow the system.
5. Run the degas procedure (refer to 8.4.9).
6. Re-connect the tank ventilation hose from step 3.
7. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
8. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
9. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
10. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.4.7 Replace Coolant Pump

Purpose:

The procedure describes how to replace a coolant pump for the High Temperature (HT) cooling in the FCwave system. The pump re-circulates a mixture of de-ionized water and ethylene glycol through the fuel cell stacks, heat exchanger, valves, hoses, and fittings to transfer the heat generated in the fuel cells to the heat exchanger. The pump speed is controlled to maintain a steady outlet temperature from the fuel cell stack.

Responsibilities:

Preventive maintenance of the coolant pump is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the coolant pump during the life and operation of the FCwave module.

- FRU, Coolant Pump (part no. 7500355)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Coolant Pump

Based on the normal conditions, the estimated time for replacement is:

Coolant Pump		
Duration	4 hours	
Personnel	1	
Tightening Torque	M8 bolt	25 ± 0.5 Nm
	M12 bolt	85 ± 5 Nm
	M16 bolt	150 ± 5 Nm
	Tool: 6mm + 10mm + 14mm hex key, 7mm socket, 18mm + 24mm socket, 19mm + 24mm key, torx screwdriver, plugs/plastic bag, torque wrench,	

Table 8-17: Time to replace coolant pump

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain and purge the LT cooling system.
3. Locate the air filter/mass flow meter installed in front of the twin compressors.
4. Disconnect the mass flow meter sensor (FT_A10).

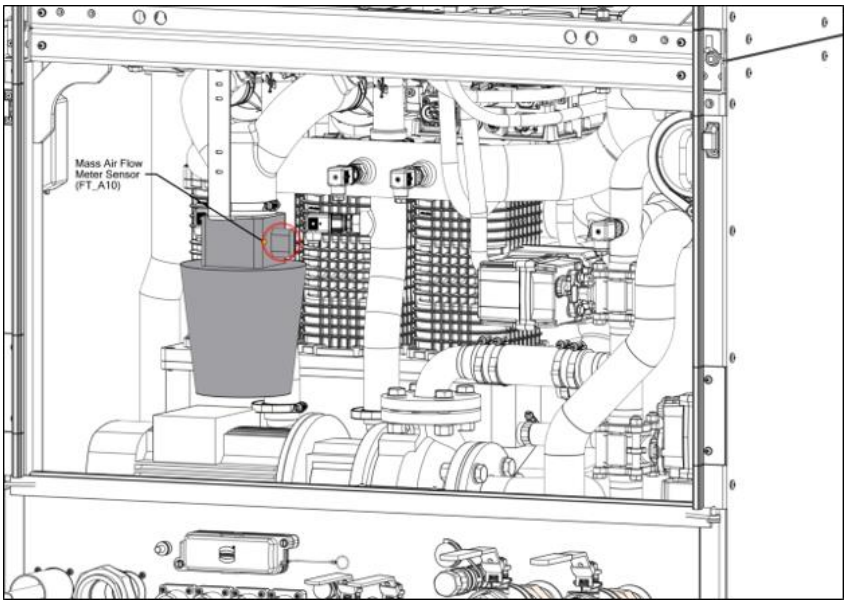


Figure 8-124: Location of mass flow sensor

5. Release the 7mm socket hose clamp to uninstall the filter/mass air flow meter.
6. Slide down the filter unit and take it out.

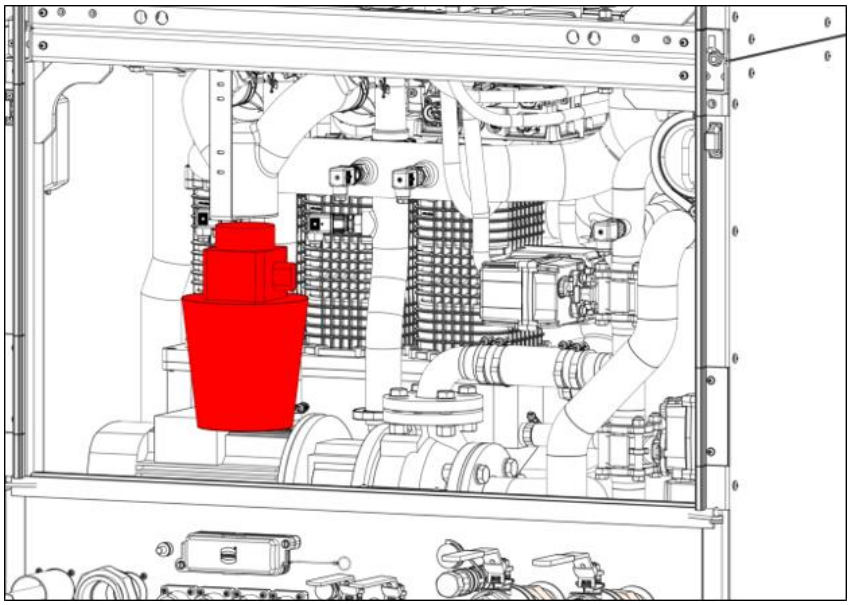


Figure 8-125: Removal of filter unit

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7. Uninstall 2 pcs. M8 bolts and washers used to install the bracket to the cabinet and remove the bracket.

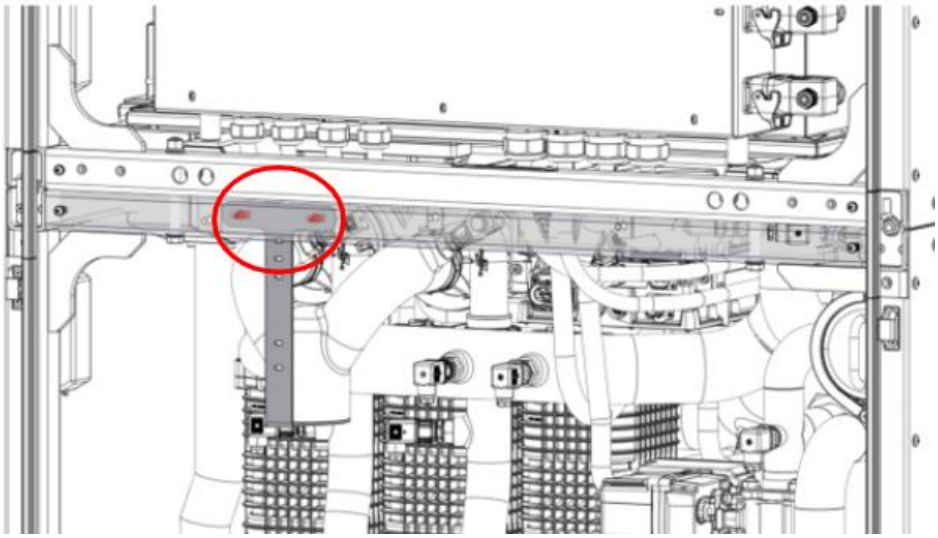


Figure 8-126: Removal of MAF/filter bracket

8. Disconnect all the following sensor connections on the harness CN600: PT_A11A, PT_A11B, PT_A12A, PT_A12B, PT_A40, TT_A40

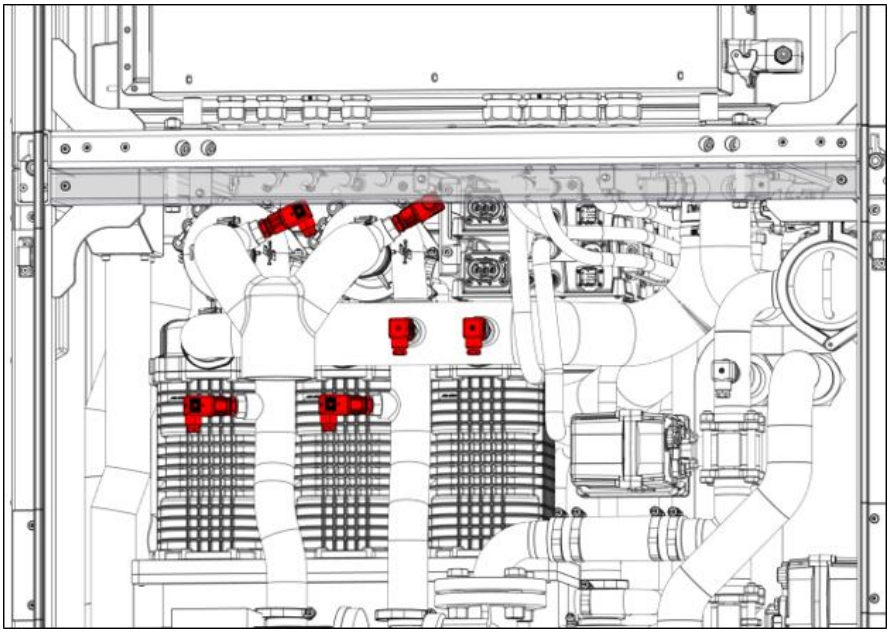


Figure 8-127: Sensor connections on harness CN600

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9. Release 2 pcs. hose clamps used to secure the compressor inlet hose to the compressors and remove the hoses.

   Remember to cover all disconnected hoses and open ports.

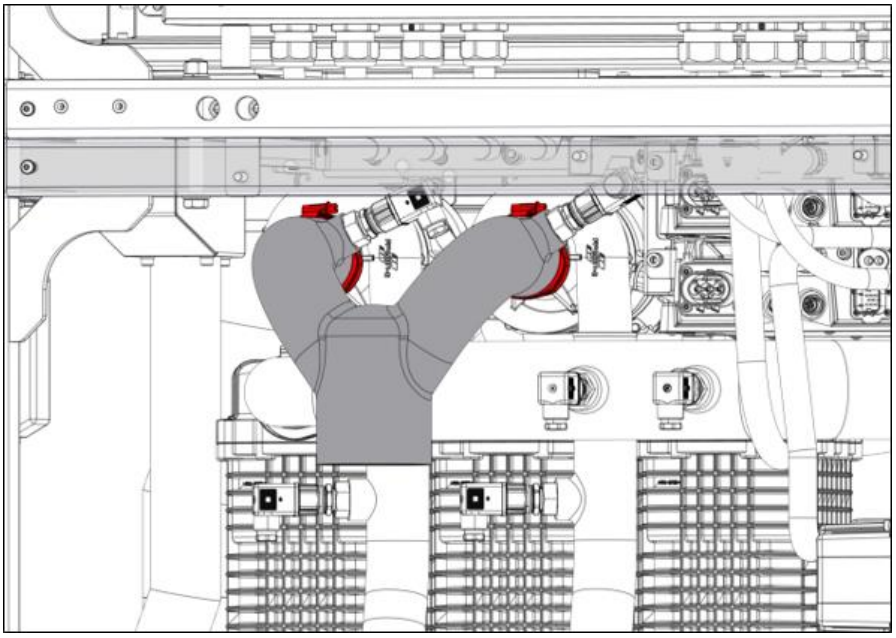


Figure 8-128: Hose clamps for inlet hose to compressors

10. Release 4 pcs. hose clamps used to secure the hose from humidifiers to the motorized shut-off valve and remove the hoses.

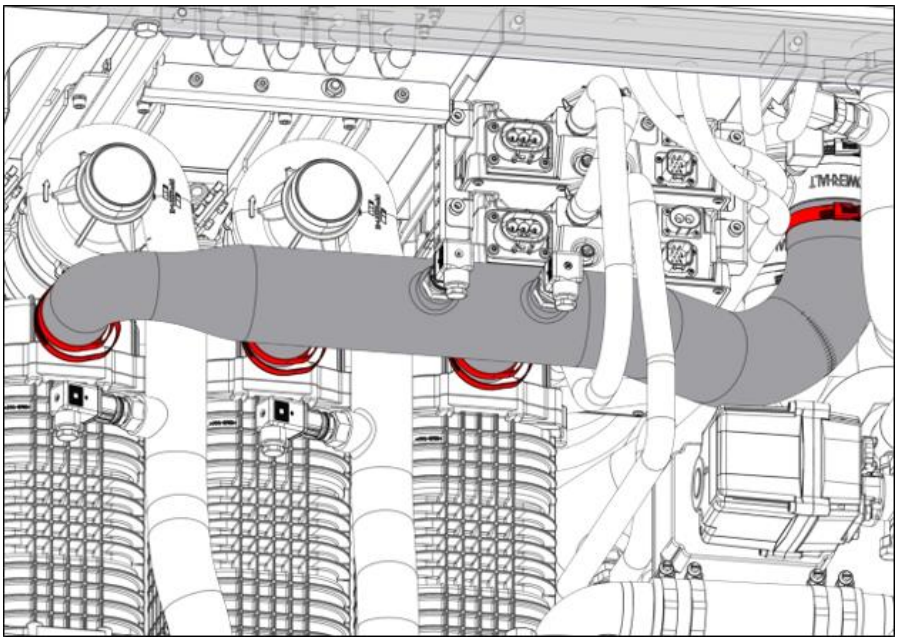


Figure 8-129: Hose clamps on humidifier to motorized shut-off valve hose

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11. (OPTIONAL) Release 4 pcs. hose clamps used to secure the hose from aftercooler to the air compressors and remove the hoses.

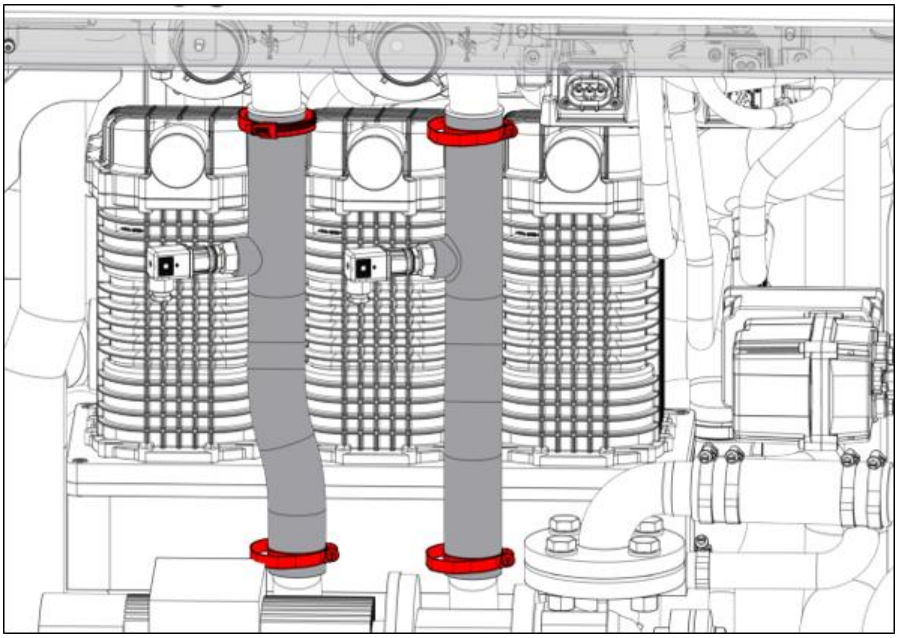


Figure 8-130: hose clamps on aftercooler to air compressors hose

12. Disconnect the coolant pump electrical connection (highlighted in left picture), ground cable, cable gland (highlighted in right picture) and disconnect wires from the three electrical terminals (highlighted in right picture. Pull out cable with cable gland after disconnecting.

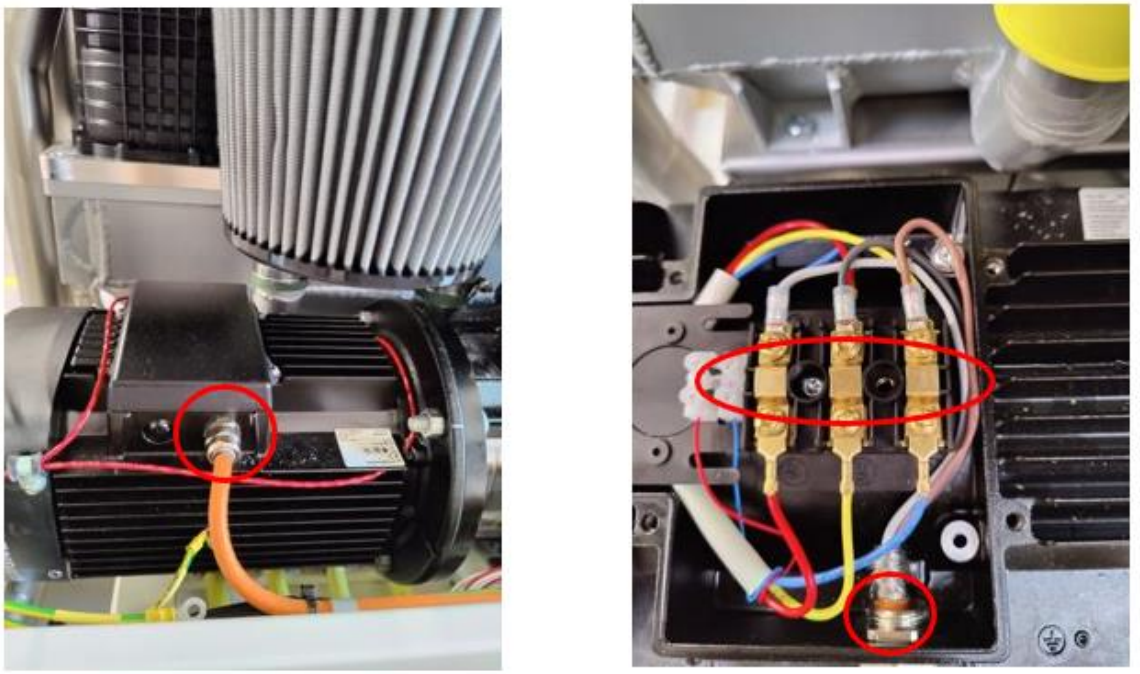


Figure 8-131: Removal of coolant pump electrical connection and control connectors

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13. Release 2 pcs. hose clamps on the coolant hose connected to the coolant pump discharge flange and slide off hose as much as possible.

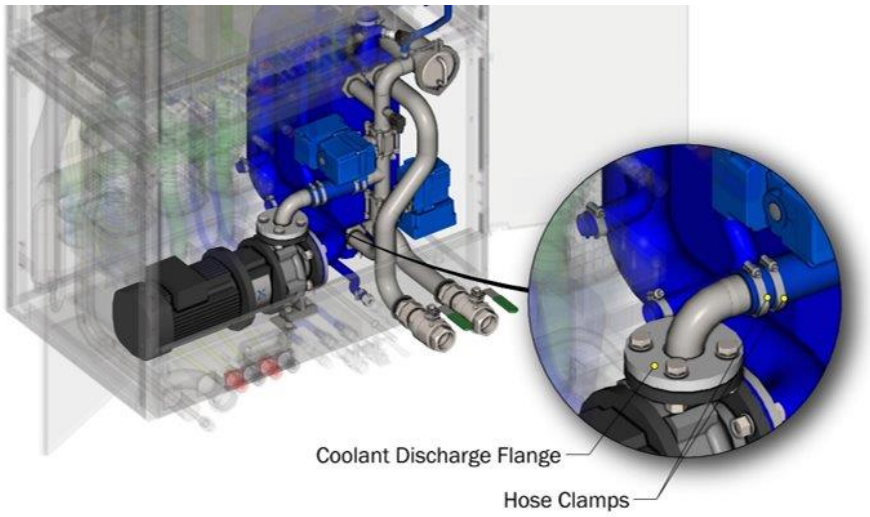


Figure 8-132: Removal of clamps on coolant pump flange

14. Remove 4 pcs. M16 bolts, washers, nuts, and gasket from the coolant pump discharge flange connection.
15. Remove 4 pcs. M16 bolts, washers, and nuts from the coolant pump suction flange connection and slide off hose as much as possible.
16. Attach a lifting device to the frame of the module and to the compressors supporting bracket.
17. Attach lifting chain around the pump and raise it just enough to create tension on the chain.
18. Uninstall 4 pcs. M12 bolts and washers used to tighten the pump mounting bracket to the base of the cabinet.

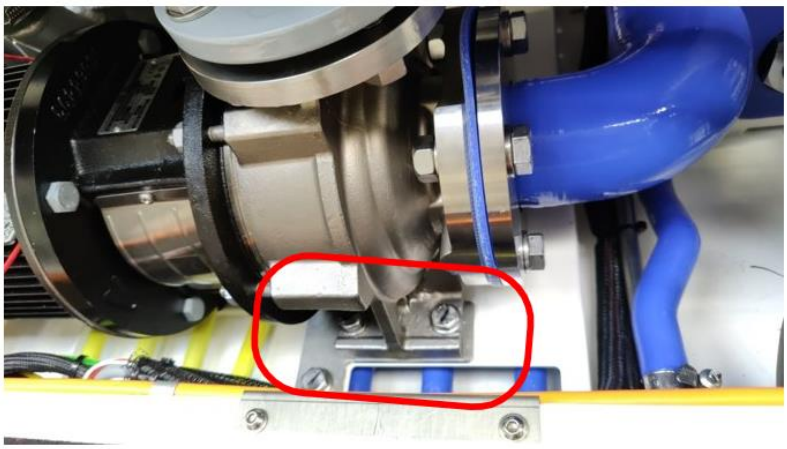


Figure 8-133: Disconnecting pump from base of cabinet

19. Lift the pump and slide it out. Remember to cover all exposed hoses and pump holes with rubber plugs or zip-tied plastic bags to avoid contamination and leaks.

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Assembling procedure:

1. Wipe up any spilled coolant from the module and remove all plugs and plastic bags from the exposed hoses.
2. Use the crane and lift the pump into the module. When in the module, lower the pump just enough so it is possible to attach the mounting bracket to the module frame, by use of 4 pcs. M12 bolts. Tighten to 85 Nm.
3. Release the tension on the crane and dismount it from the module frame.
4. Use 4 pcs. M16 bolts, washers, and nuts to install coolant pump suction flange connection to the pump. Tighten to 40 Nm.
5. Connect the coolant hose to the coolant pump discharge flange, but do not tighten the hose clamps yet.
6. Insert plastic gasket between the hose and the pump discharge flange and secure it with 4 pcs. M16 bolts, nuts, and 8 pcs. washers. Tighten to 150 Nm and tighten hose clamps from step 5 to 3.5 Nm.

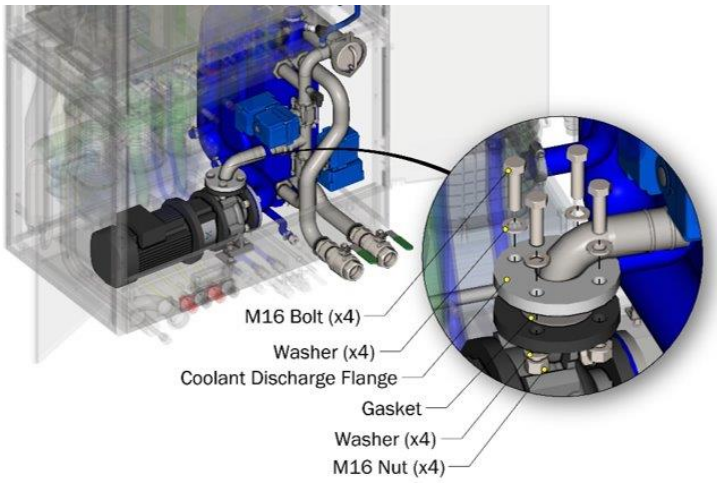


Figure 8-134: Installing plastic gasket

7. Install the orange power cable (the electrical connection) and ground wire to the black control box on top of the coolant pump as shown and secure it to the case.



Figure 8-135: Installing electrical connection to pump

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8. Arrange the fire wire (the grey, black and brown cables) and the cable gland on the electrical connection as show in the control box.

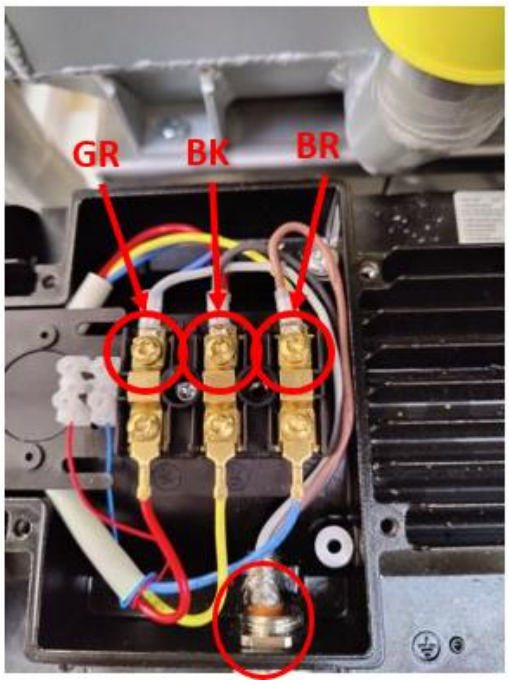


Figure 8-136: Install wire fire in control box

9. (ONLY TO BE DONE, IF YOU REMOVED THESE IN THE DISASSEBMLING PROCEDURE) Use 4 pcs. hose clamps to mount hoses from aftercooler to air compressors as shown. Tighten hose clamps to 3.5 Nm.

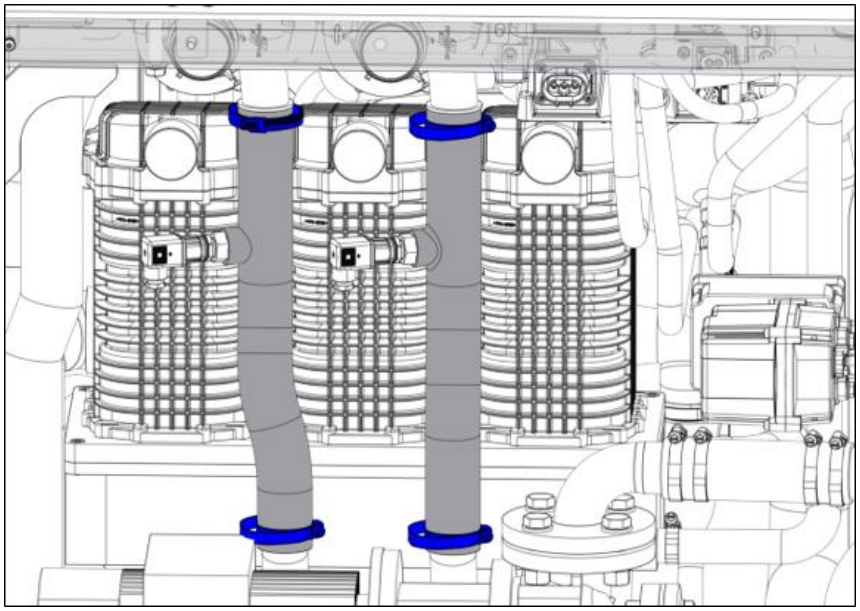


Figure 8-137: Installing hoses from aftercooler to compressors

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10. Use 4 pcs. hose clamps to mount hoses from humidifiers to motorized shut-off valve as shown. Tighten hose clamps to 3.5 Nm.

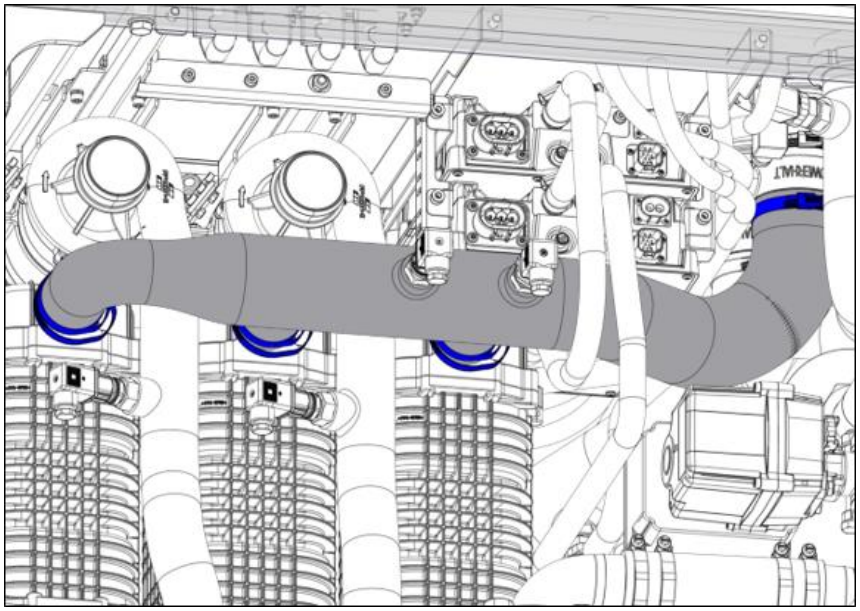


Figure 8-138: Installing hose from humidifiers to shut-off valve

11. Use 2 pcs. hose clamps to install compressor inlet hose to the compressors. Tighten hose clamps to 3.5 Nm.
12. Connect all following sensor connections of harness CN600 as shown: PT_A11A, PT_A11B, PT_A12A, PT_A12B, PT_A40, TT_A40.

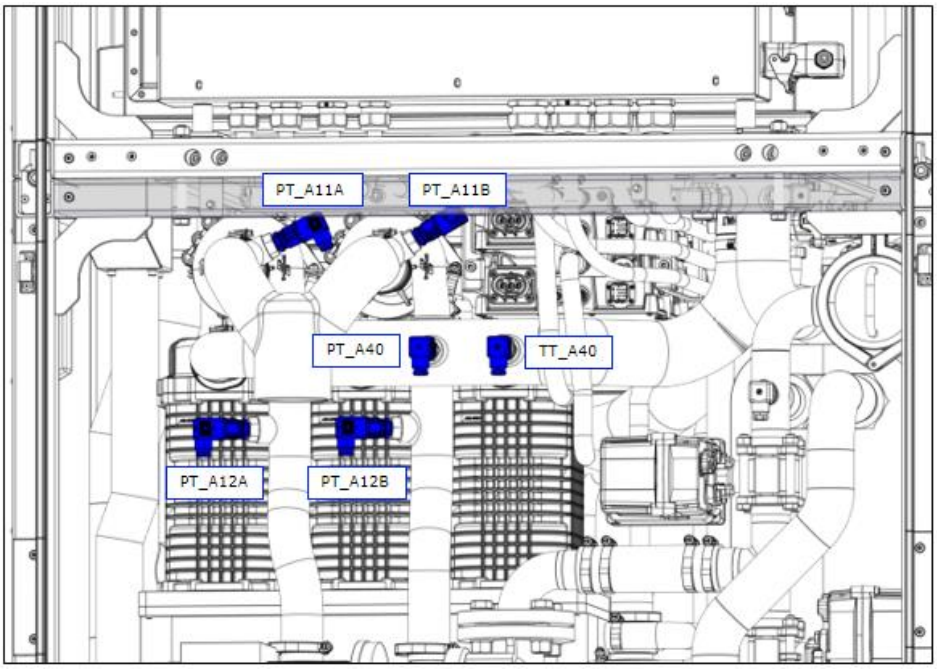


Figure 8-139: Installing sensor connections

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13. Use 2 pcs. M8 bolts and washers to install mounting bracket to the cabinet as shown. Tighten to 15 Nm.

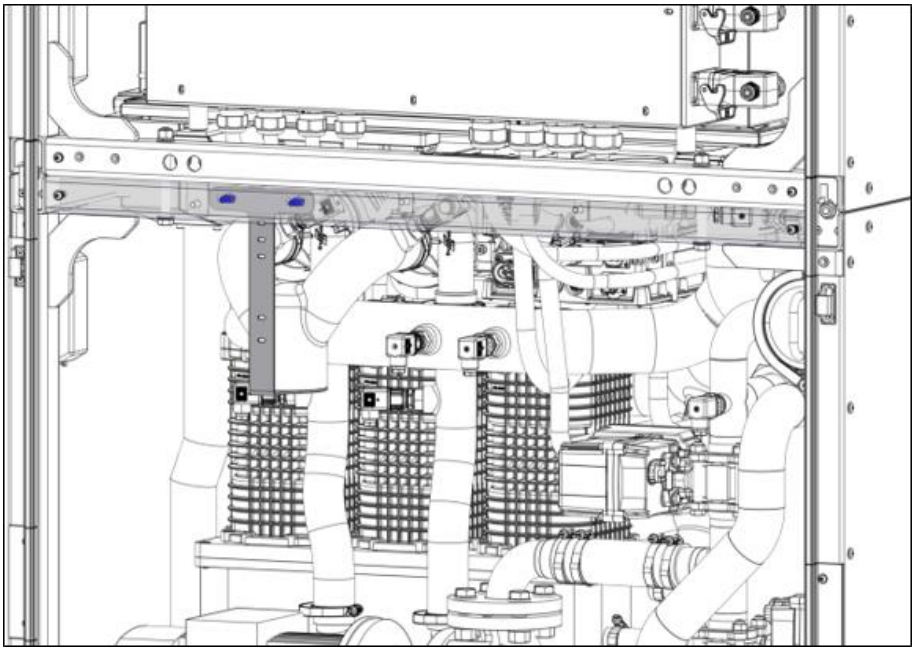


Figure 8-140: Installing mounting bracket to cabinet

14. Mount intake filter on intake hose. Tighten hose clamp to 3.5 Nm.
15. Connect the mass air flow meter sensor (FT_A10).
16. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
17. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
18. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
19. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.4.8 Replace DI Filter Cartridge

Purpose:

The procedure describes how to replace a de-ionization (DI) filter for the HT cooling system. To maintain the stack coolant conductivity below the maximum level, part of the overall coolant flow is diverted to the DI filter to continuously remove ions in the liquid coolant, which minimizes the risk of electrical ground fault.

Responsibilities:

Preventive maintenance of the DI filter is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the DI filter during the life and operation of the FCwave module.

- FRU, DI Filter Cartridge (part no. 7500095)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the DI Filter

Based on the normal conditions, the estimated time for replacement is:

DI Filter		
Duration	15 min	
Personnel	1	
Tightening Torque	M6 bolt	10 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	Tool	5mm + 6mm hex key, clean container, 8.15mm tube, valve, 3/8" BSP to 8mm plastic pipe adaptor

Table 8-18: Time to replace the DI filter

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Uninstall 3 pcs. M8x30 bolts from the top right support bracket of the high voltage panel and remove the bracket.

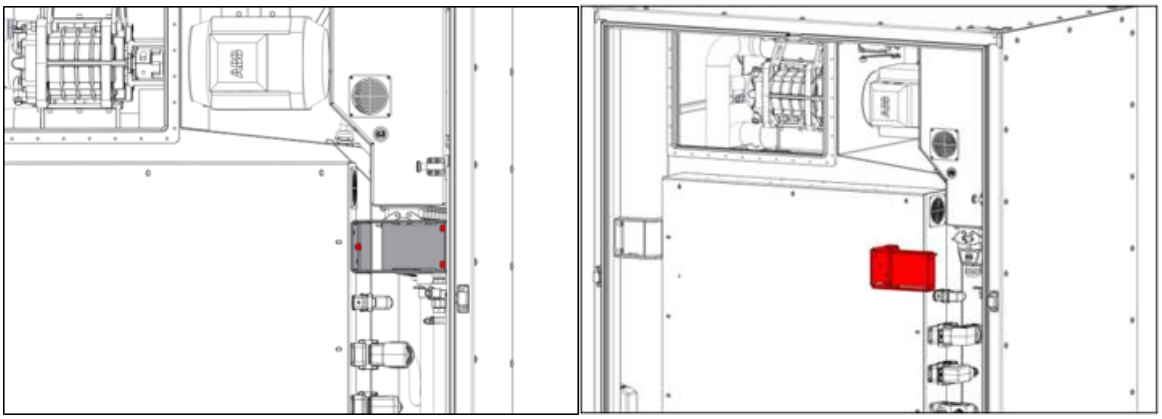


Figure 8-141: Bolts and support bracket in HV panel

3. Disconnect all connectors (CN201, CN202, CN500, CN505) in the high voltage panel as shown.



Figure 8-142: Overview of connectors in HV panel

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4. Disconnect all connectors (CN400, CN303, CN300, CN101, CN100) in the low voltage panel as shown.



Figure 8-143: Overview of all connectors in LV panel

5. Shut off the DI filter isolation valves.
6. Install special tool kit (7500095) on the DI filter housing. Start by installing the pipe adaptor and then the plastic pipe into the adaptor.

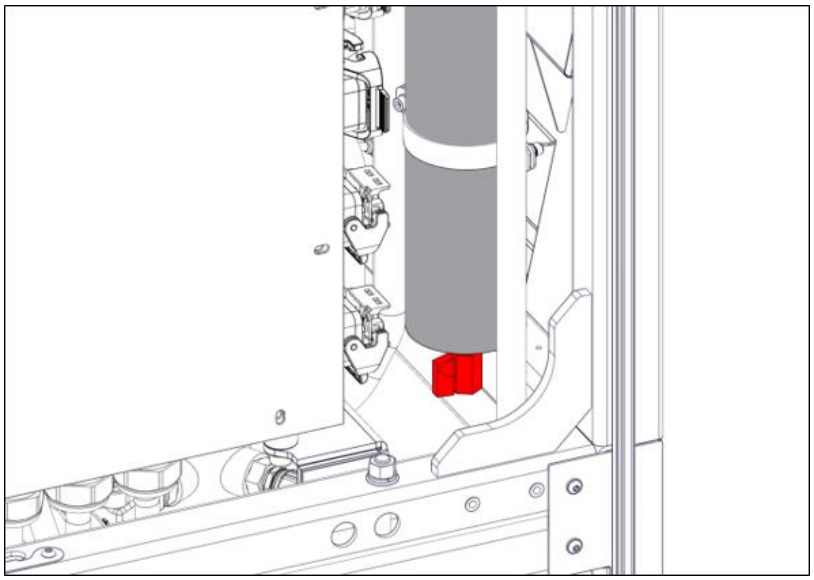


Figure 8-144: Adaptor on the DI filter housing

7. Place the plastic pipe in a clean container. Open the plastic pipe valve and open the drain valve at the bottom of the HT cooling DI filter.
8. Uninstall 2 pcs. M6 bolt and clamp used for securing the DI filter housing.

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9. Remove the DI filter housing nut to release the vacuum in the DI filter housing and drain the DI filter cartridge completely.

   Remember to place paper towels below the filter housing to prevent any spillage.
10. Close the DI filter drain valve and remove the plastic pipe from the adaptor.
11. Remove the DI filter housing from the cabinet and remove the DI filter cartridge from the DI filter housing.

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Assembling procedure:

1. Insert new DI filter cartridge in the DI filter housing with the blue rubber gasket facing up.



Figure 8-145: Install DI filter cartridge

2. Install the DI filter housing. Use the special key to tighten the housing ring.
3. Use 2 pcs. M6 bolts to install the clamp securing the DI filter housing.
   Ensure the drain valve handle is accessible.
4. Open the DI filter isolation valves.
5. Connect the following connectors to the LV panel; CN100, CN101, CN300, CN303, CN400.
6. Connect the following connectors to the HV panel; CN201, CN202, CN500, CN505.
7. Mount the right-side bracket on the high voltage panel.
8. Use 3 pcs. M8x30 bolts and washers to secure the bracket to the frame.

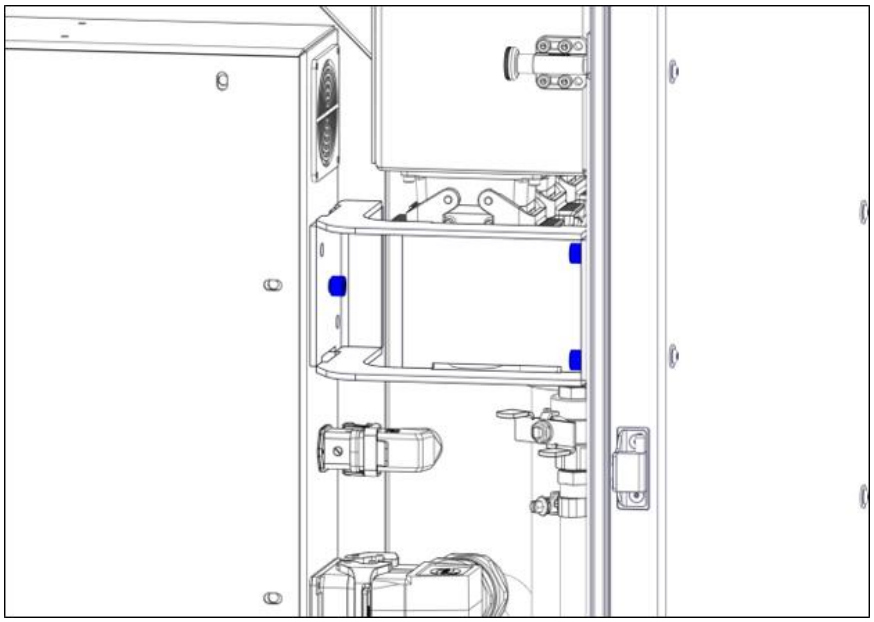


Figure 8-146: Securing bracket to frame

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9. Use 12 pcs. M5x10 bolts and washers to install the high voltage panel cover.
10. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
11. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
12. Check and refill (using new coolant) the coolant level. Run the HT cooling system degas procedure. (refer to 8.4.9).
13. Log into the engineering interface with supplied username and password and reset the hour counter for the DI filter cartridge.
14. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.4.9 Assurance procedure – Cooling Sub-system Degas

Estimated time to perform degas procedure

Based on the normal conditions, the estimated time for procedure is:

Degas procedure	
Duration	1 hour
Personnel	1
Tools needed	Laptop, ethernet cable

Table 8-19: Time to perform degas procedure

Procedure:

1. Secure the area before pressurizing the system components.
   Use warning signs around the working area to ensure safety.
2. Power up the module by enabling the 24 VDC power supply.
3. Log into the engineering interface.
4. In the "unlocked" state, the module is ready to be supplied with the MD_EN signal.
   The "unlocked" state can be reached by providing the customer key from the integrator system via CAN bus.

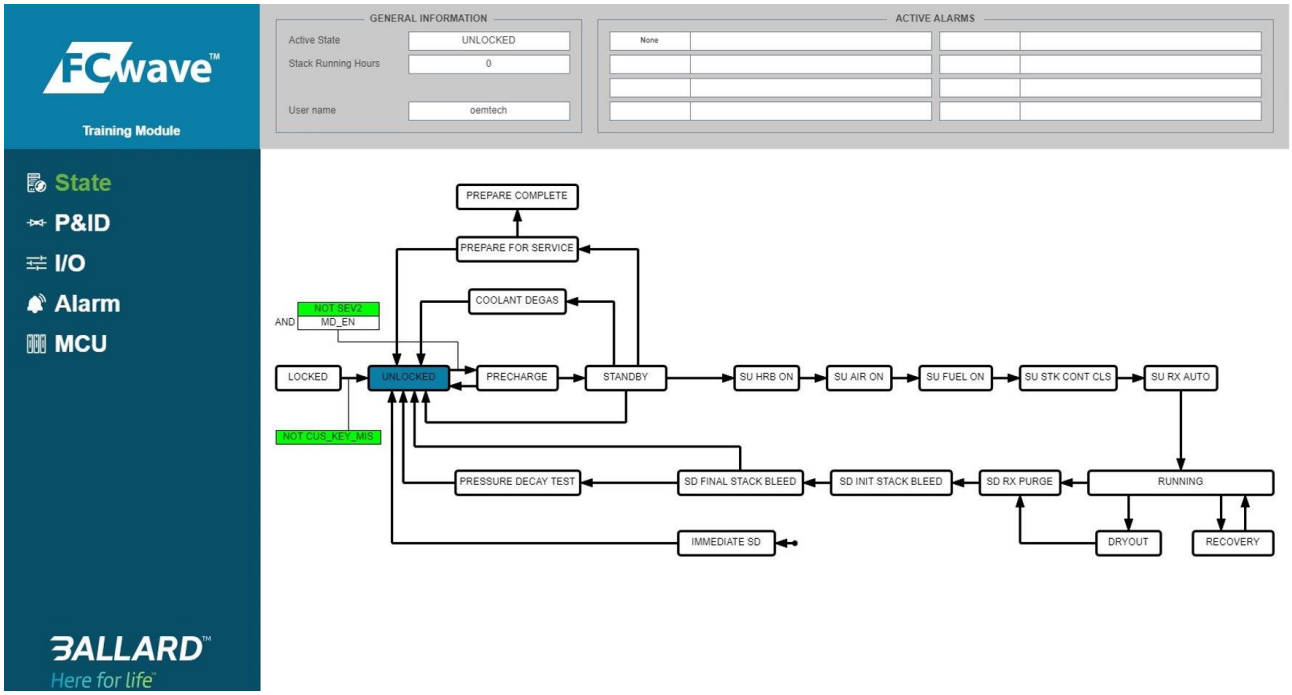


Figure 8-147: overview of unlocked state

5. Supply the module HV with "Min – 350 VDC". In the "unlocked" state, send the MD_EN signal from the integrator system.

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6. After the MD_EN signal is sent, the module will go into "standby" state.

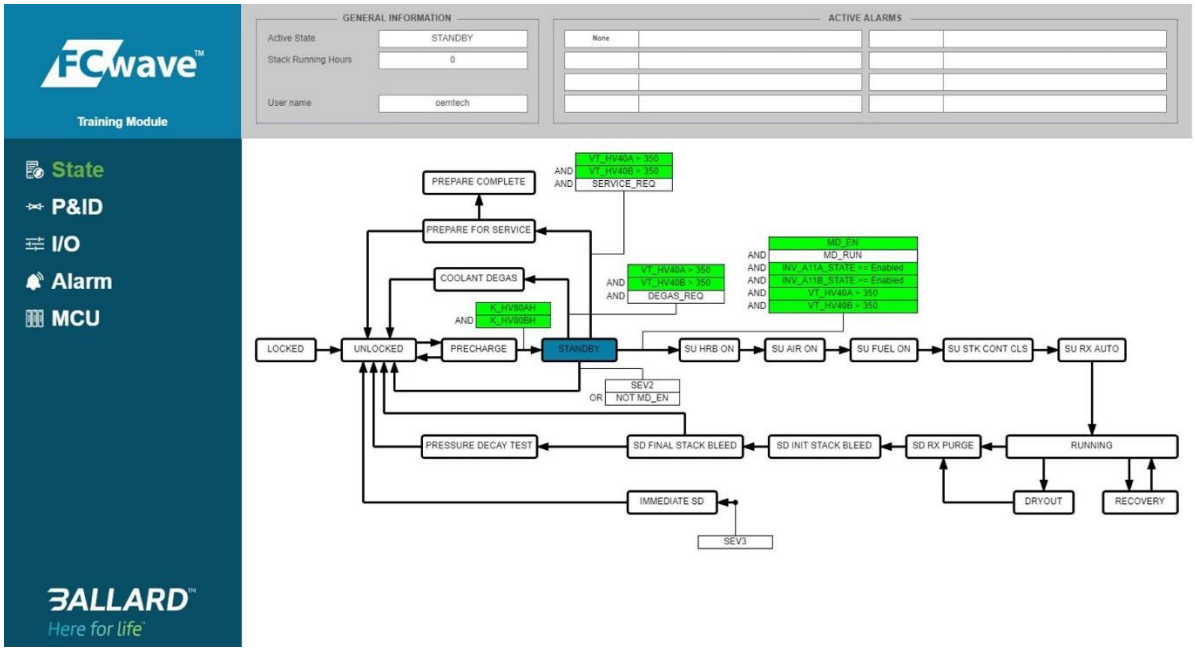


Figure 8-148: Overview of standby state

7. Access the I/O page (1) and select the 'all inputs' tab (2).
   - Enable "degas_req" (3).
   - Let the degas procedure run for at least 30 min.



Figure 8-149: Force values for degas procedure

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8. The degas procedure can be observed from the P&ID page as shown.

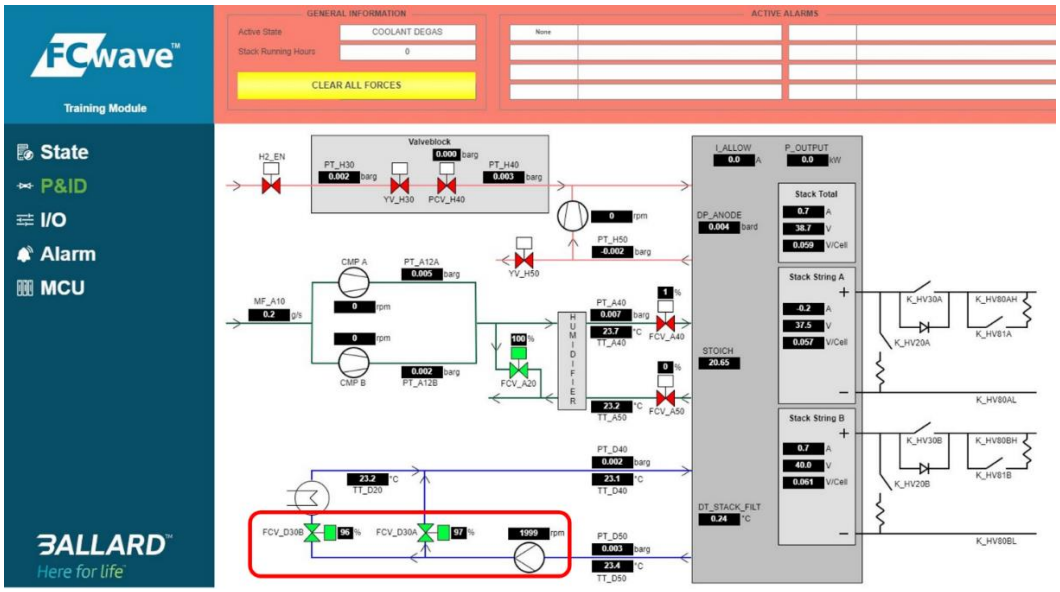


Figure 8-150: Observing the degas procedure

9. Use "clear all forces" after a minimum of 30 min, disable the MD_EN signal from the integrator side and disable the 350 VDC power feed from the integrator to the module.



Figure 8-151: Clear all forces for degas procedure

10. Module will enter the "unlocked" state, log out of engineering interface, and module 24 VDC can be disabled.
11. Remove the warning signs after the test and confirm the module is ready for power up from the integrator side after maintenance. Remove local lockout and tagout when done.

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8.5 H_2 Enclosure Ventilation and Stack Assembly

For detailed P&ID requirements, refer to "Piping and Instrumentation Diagram" (PWR005), which can be found the Customer Portal or by contacting BPSE (see section 4.1 for further information).

8.5.1 Check Linear Heat Detector (LHD) Functionality

Purpose:

The procedure describes how to check the functionality of the LHD (also called the Fire Wire) relay in the module. The LHD will trip a relay, causing a fire alarm based on the resistance in the circuit, if a fire were to occur in the module. The LHD will also trip another relay for a Fire Wire malfunction if the circuit is broken (open circuit).

Responsibilities:

Preventive maintenance of the LHD is necessary for safe operation. It is the end user's responsibility to do preventive maintenance (refer to section 8.1.1). The LHD is considered a Field Instrument as per Classification society rules.

Parts and equipment:

A list of parts and special equipment is identified to check the LHD during the life and operation of the FCwave module.

- HRNS-LHD KIT (part no. 7500131)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to check the LHD:

Based on the normal conditions, the estimated time for check is:

Linear Heat Detector	
Duration	15 min
Personnel	1

Table 8-20: Time to check the LHD

Note:

During the procedure you will trigger the fire detection system. Personnel must coordinate with the vessel representative to ensure that a fire detection signal from the module will not cause activation of the firefighting system or in other ways cause hazard to the personnel or equipment.

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Procedure:

1. Before proceeding with the check, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Disconnect the LHD connector from CN205 in the HV panel and connect the LHD test plug to CN205.

   The switch for 'Malfunction' should be ON, simulating that the Fire Wire circuit is closed and functional.

   The switch for 'Fire' should be OFF, simulating that the Fire Wire's resistance is normal. Meaning that fire has not been detected.
3. Connect the low voltage electrical connection (X_E01) and secure it by finger-tightening the two bolts.
4. Monitor the MCU engineering interface with the module in "Unlocked" state.

   Make sure there are no active alarms.
5. To test the LHD relay for "Fire", confirm the following state of LEDs on the relay 'CNV_AZT_J30':
   - Relay 1: ON
   - Relay 2: ON
6. Toggle the switch for 'Fire' to ON to simulate a change in the LHD's resistance.
7. Confirm the following state of LEDs on the relay 'CNV_AZT_J30':
   - Relay 1: OFF
   - Relay 2: ON



Figure 8-152: LED status relay CNV_AZT_J30

8. Toggle the switch for 'Fire' to OFF
9. Confirm the following alarms can be seen in the engineering interface (as shown in the figure below):
   - A3_SAFETYSTOP_I_10120
   - A2_CNV_FCV_A_OK_I_10020
   - A2_CNV_FCV_A_OK_I_10030

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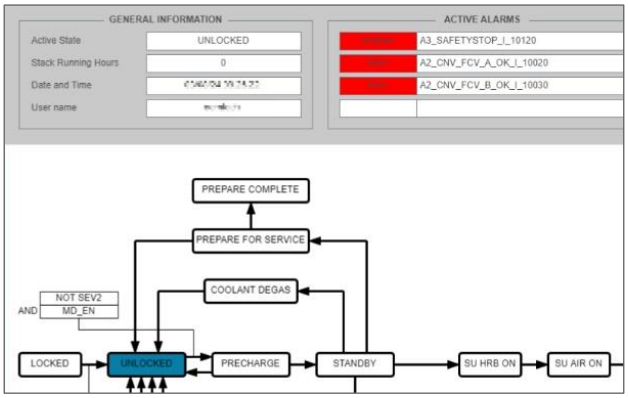


Figure 8-153: Overview of alarms

Disconnect and reconnect the X_E01 to power cycle the module to reset and confirm there are no alarms.

10. To test the LHD relay for "Malfunction", confirm the following state of LEDs on the relay 'CNV_AZT_J30'
    - Relay 1: ON
    - Relay 2: ON
11. Toggle the switch for 'Malfunction' to OFF to simulate the LHD's connection is broken.
12. Confirm the following state of LEDs on the relay 'CNV_AZT_J30':
    - Relay 1: OFF
    - Relay 2: OFF



Figure 8-154: LED status relay CNV_AZT_J30

13. Toggle the switch for 'Malfunction' to ON
14. Confirm the following alarms can be seen in the engineering interface:
    - A3_SAFETYSTOP_I_10120
    - A2_CNV_FCV_A_OK_I_10020
    - A2_CNV_FCV_A_OK_I_10030
15. Power down the module, disconnect the LHD test plug from CN205 and reconnect the LHD connector to CN205.
16. Power up the module and confirm there are no alarms.

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17. Confirm the confirm the following state of LEDs on the relay 'CNV_AZT_J30':
    - Relay 1: ON
    - Relay 2: ON



Figure 8-155: LED status relay CNV_AZT_J30

18. The module can now be powered down by disconnecting the X_E01 and the module is ready to be restored to normal operating state.
19. Confirm that the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.5.2 Check the H_2 Sensor

Purpose:

The procedure describes how to check calibration of the ventilation H_2 sensor. The correct operation of these hydrogen sensors is important to ensure that H_2 concentration gases exiting the FCwave module are in acceptable safe levels. The hydrogen sensors are attached to the ventilation hatch cover.

Responsibilities:

Preventive maintenance of the ventilations H_2 sensors is necessary for safe operation. It is the end user's responsibility to do preventive maintenance (refer to section 8.1.1).

Parts and equipment:

A list of parts and special equipment is identified to service the hydrogen sensors during the life and operation of the FCwave module.

- 2% hydrogen (balance air) calibration test gas mixture — calibration gas must have balance air component for correct operation of hydrogen sensors. Calibration gas with balance nitrogen or other gases is not applicable.
- Pressure regulator with flow rate control — must be used to decrease the pressure from the test gas bottle. A regulator that is sized to minimum flow, equivalent of 0.5 SLPM air, must be sufficient.
- Test nozzle — it is recommended that a simple test nozzle with a built-in needle valve is required to supply the test gas to the H_2 sensor.
- Repeat process with 1.6% hydrogen (balance air) calibration test gas mixture.

Safety:

Refer to section 8.1.2 to follow the instructions.

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Procedure:

1. System needs to be in "prepare for complete service" state.
2. Open system doors.
3. Supply 24V power from the shipboard or connect an I/O tester to power the module MCU engineering interface.
4. Connect a computer to the MCU and log in to the engineering interface (see section 7.2).
5. Connect a pressure regulator to a test gas canister and test the nozzle. Do not flow gas at this point.
6. Locate the ventilation hatch cover in the top right corner of the H2 enclosure behind the HRB motor.

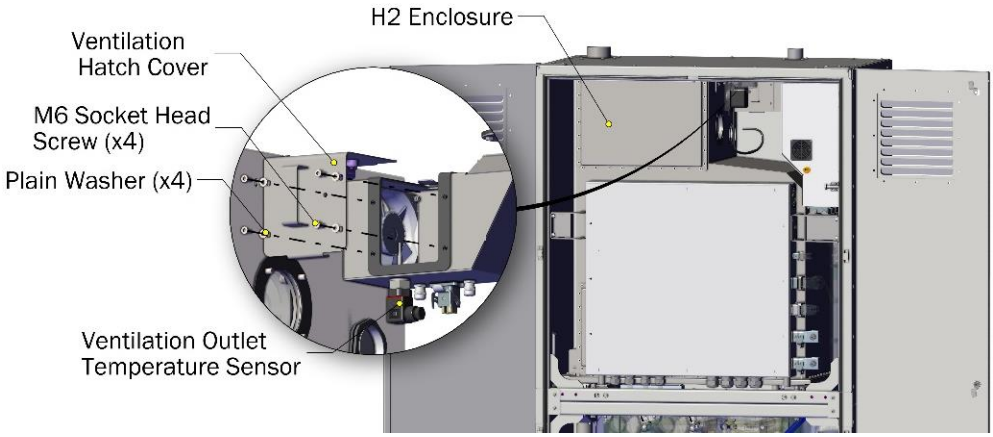


Figure 8-156: Location of ventilation hatch cover

7. Use 5mm hex key to uninstall 4 pcs. M6 bolts and washers to remove the ventilation hatch cover.
8. Disconnect the ventilation H2 sensors connections (HRNS-303-CN_AZT_J50 and CN_AZT_J50B).

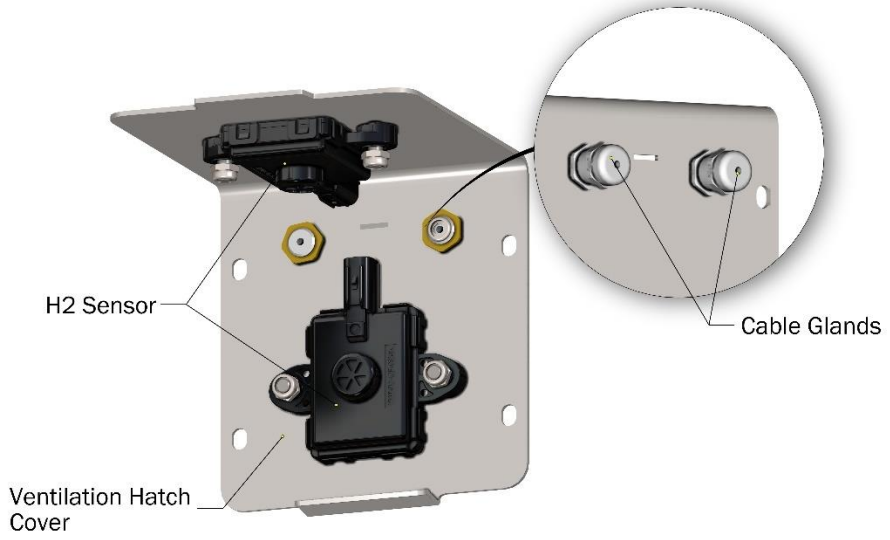


Figure 8-157: H_2 sensors

9. Remove both sensors along with the hatch cover.
10. Position the test nozzle directly over the hydrogen sensor. Make sure the nozzle fully covers the sensor element.

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11. In the MCU engineering interface, go to the I/O page and select the 'Cabinet' tab.
12. Scroll to tag 'AZT_J50A' and record the indication. The indication must be in the range 0 ± 0.2%. If the hydrogen sensor indication is outside the range:
    - Make sure the module is not in 'sleep' condition, as then the H_2 sensors will not be powered. Refer to the MCU user manual for more information. If the module is in 'sleep' condition, force 'on' to start the module that will energize the sensors.
    - Contact BPSE (see section 4.1) for further troubleshooting support.
13. Open the supply valve on the calibration gas. Expose the sensor for 10 – 30 sec until the AZT_J50A reading stabilizes.
14. Hold the sensor head above the nozzle during the test. To store the calibration gas efficiently, close the supply valve immediately after a stable indication is achieved.
15. Make sure the sensor indication is more than 1.4% and less than 2.2% H_2 concentration and record the indications.
16. If the sensor indication is still out of permitted range after performing these steps, replace the hydrogen sensor (see section 8.5.3) and repeat the steps to verify sensor functionality. Contact BPSE (see section 4.1) for further support.
17. Reset the hydrogen connection with the "Reset Lockout" button on the MCU home screen (see section 7.2).
18. Disconnect the gas nozzle from the hydrogen sensor.
19. Log out of the MCU and disconnect the computer.
20. If applicable, power off the IO tester and disconnect it from the module.

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8.5.3 Replace the H_2 Sensors

Purpose:

The procedure describes how to replace a ventilation outlet H_2 sensor and safety H_2 sensor for the FCwave module. To ensure a safe atmosphere inside the H_2 Enclosure two H_2 detectors are installed, to measure the H_2 concentration in ventilation exhaust and to detect leaks in stack seals or HRB circulation piping in the H_2 enclosure.

Responsibilities:

Preventive maintenance of the H_2 sensors is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the H_2 sensors during the life and operation of the FCwave module.

- FRU, Sensor H_2, 0-4% (part no. 7500036) x2

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the H_2 Sensors

Based on the normal conditions, the estimated time for replacement is:

H_2 Sensors		
Duration	15-30 min	
Personnel	1	
Tightening Torque	M6 bolt	
	Tool	5mm hex key, 10mm wrench, torque wrench

Table 8-21: Time to replace the H_2 sensors

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-4 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the ventilation hatch cover, behind the HRB motor, on the top right corner of the H_2 enclosure.
3. Remove 4 pcs. M6 bolts and washers and remove the ventilation hatch cover.

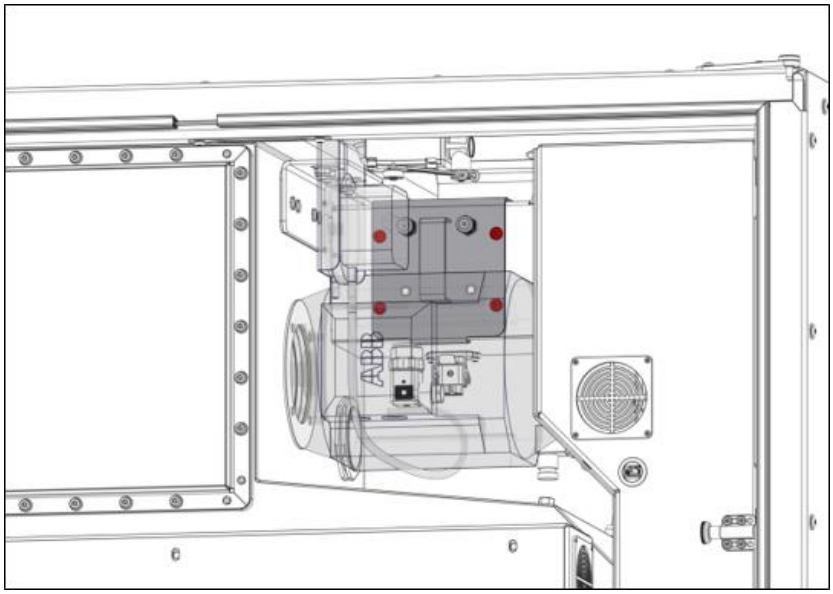


Figure 8-158: Bolts in the ventilation hatch cover

4. Remove the old gasket from the H_2 enclosure.
5. Remove 4 pcs. M6 lock nuts and washers used to tighten the H_2 detection module to the ventilation duct hatch. Then disconnect the ventilation detector connections (CN_AZT_J50A & CN-AZT_J50B) and remove the H_2 sensor from the hatch cover.

Make sure to note down the position of the sensors before removing.

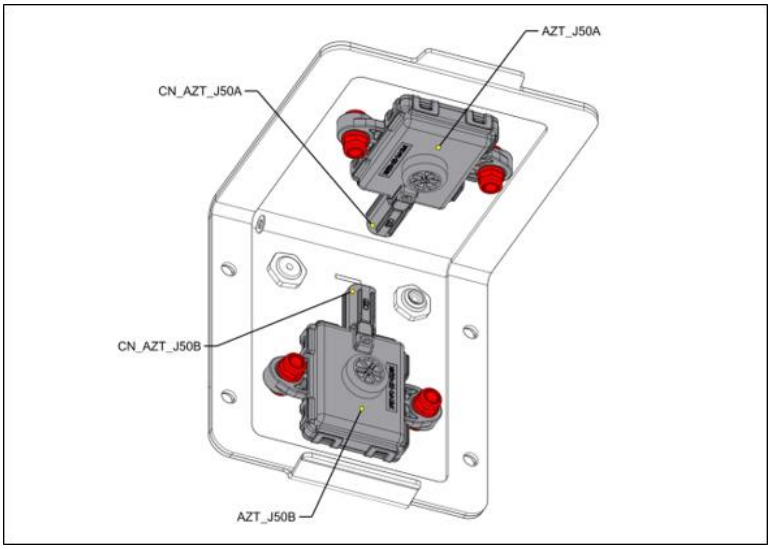


Figure 8-159: Ventilation detector connections

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Assembling procedure:

1. Insert the H_2 detectors in the ventilation hatch cover. Use M6 lock nuts and washers to fasten the H_2 detection module to the ventilation duct hatch. Tighten to 6 Nm. Then connect the ventilation detector connections (CN_AZT_J50A & CN_AZT_J50B).

   Remember to lubricate the bolts with ceramic grease.

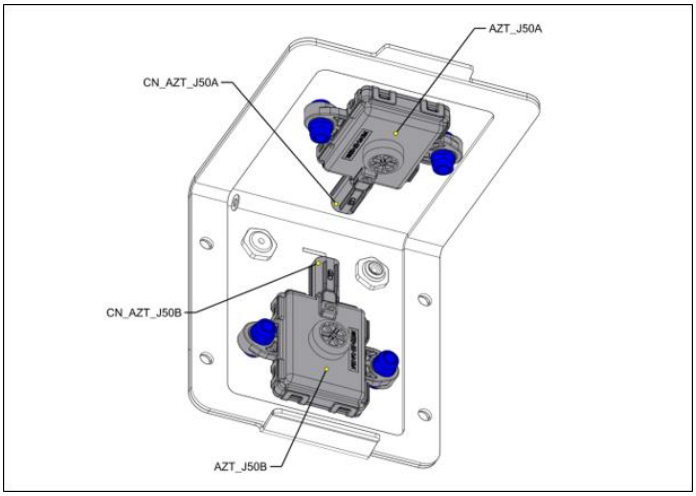


Figure 8-160: Install H_2 detectors to hatch cover

2. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm. Prepare to power up the 24 VDC system.
3. Power up the 24 VDC system. Calibrate and verify the sensor readings before assembling the cover. Refer to 8.5.2
4. Install the new rubber gasket on the H_2 enclosure.
5. Install the ventilation hatch cover to the H_2 enclosure. Use 4 pcs. M6 bolts and washers to tighten the ventilation duct hatch assembly to the ventilation duct. Tighten to 6 Nm. Remember to lubricate the bolts with ceramic grease.

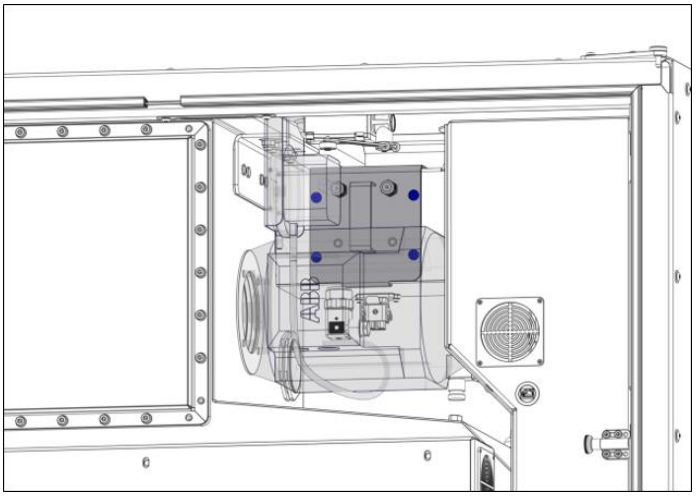


Figure 8-161: Install hatch assembly to ventilation duct

6. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.5.4 Ventilation Inlet Flow Switch

8.5.4.1 Check Ventilation Inlet Flow Switch

Purpose:

The procedure describes how to check a ventilation inlet flow switch in the FCwave™ module. The switch monitors for presence of airflow in the ventilation of the fuel supply and Hydrogen Enclosure (H_2E) and will trigger an alarm if there is no airflow through the system.

Responsibilities:

Checking the ventilation inlet flow switch functionality is necessary for safe operation according to the maintenance plan (refer to the Customer Portal) or after a replacement. It is the end user's responsibility to do preventive maintenance, as stated in section 8.1.1.

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to check the Ventilation Inlet Flow Switch

Based on the normal conditions, the estimated time for check is:

Ventilation Inlet Flow Switch	
Duration	10 min
Personnel	1
Tool	32mm spanner

Table 8-22: Time to check ventilation inlet flow switch

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Procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Installed in the ventilation pipe in front of the coolant pump, locate the flow switch at the bottom left side of the cabinet.

   If possible, and if more convenient, the flow switch can be tested from integrator side by closing the ventilation inlet during the test to stop the airflow. If tested from integrator side, skip step 3.
3. If needed, take a photo of approximate position of flow switch before proceeding.

   Use 32mm spanner or crow foot to loosen the nut used to secure the flow switch. Loosen just enough to turn it by hand, and do not remove the switch nor let it drop down in the cabinet.

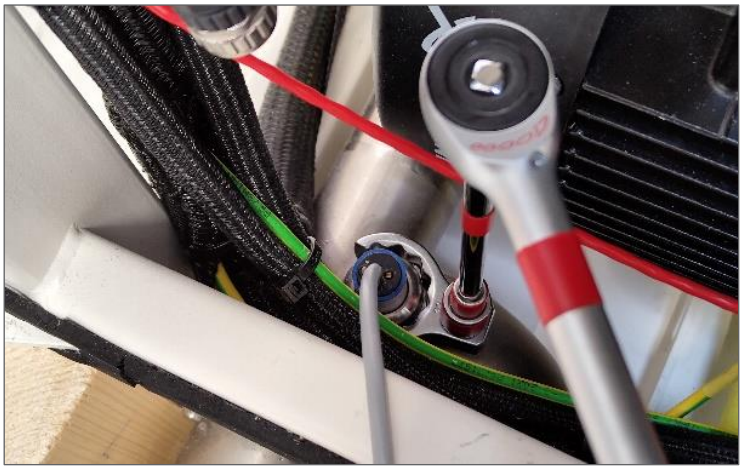


Figure 8-162: Removing inlet flow switch nut

4. Connect the low voltage electrical connection (X_E01) and secure it by finger-tightening the bolts.
5. Monitor the MCU engineering interface with the module in “Unlocked” state.

   Make sure there are no active alarms.
6. To test the flow switch, confirm the LED on the switch is green, indicating there is airflow.
7. Confirm the switch’s LED turn red once removed from the source of airflow. By hand loosen the nut securing the switch to remove it.

   If tested from the integrator side, close the ventilation inlet instead.



Figure 8-163: Inlet flow switch LED testing

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8. Loosely reinstall the switch by hand and check the alarm codes.
9. Confirm the following alarms can be seen in the engineering interface:
    - A3_SAFETYSTOP_I_10120
    - A2_CNV_FCV_A_OK_I_10020
    - A2_CNV_FCV_A_OK_I_10030

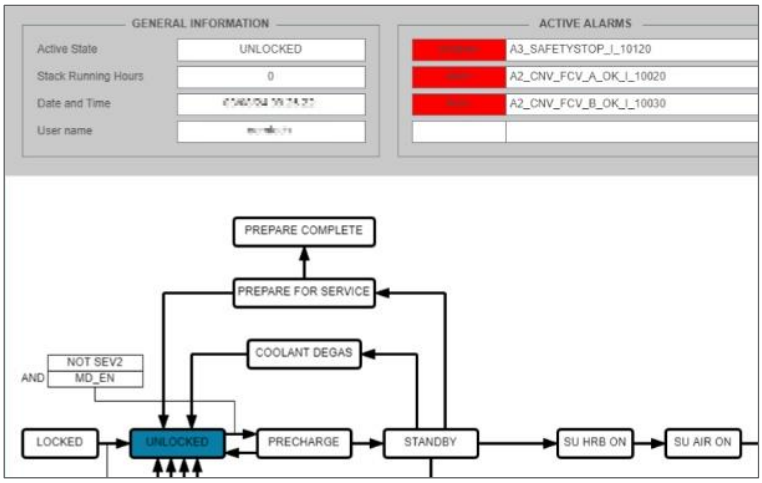


Figure 8-164: Overview of alarms

10. Remove the X_E01 to power off the module.
11. Make sure the switch is installed in the original position and use 32mm spanner or crow foot to secure it by lightly tightening. If tested from integrator side, open the ventilation side.

    Be aware to not overtighten the nut, as it can damage the switch's housing.
12. Power up the module to confirm there are no alarms, and that the switch's LED is green.



Figure 8-165: Inlet flow switch LED testing

13. The module is ready to be powered down by disconnecting the X_E01 electrical connection, and the module is ready to be restored to normal operating state.
14. Confirm that the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.5.4.2 Replace Ventilation Inlet Flow Switch

Purpose:

The procedure describes how to replace a ventilation inlet flow switch for the H2 ventilation intake. The flow switch monitors the airflow through the enclosure ventilation, to ensure the dilution of H2 concentration and verifies that the airflow into H2 enclosure is above the set limit.

Responsibilities:

Preventive maintenance of the flow switch is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the flow switch during the life and operation of the FCwave module.

- FRU, Ventilation Inlet Flow Switch (part no. 7500018)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Ventilation Inlet Flow Switch

Based on the normal conditions, the estimated time for replacement is:

Ventilation Inlet Flow Switch		
Duration	30 - 45 min	
Personnel	1	
Tightening Torque	1/2" sensor fitting	6 ± 0.5 Nm
	Tool	32 mm spanner, torque wrench

Table 8-23: Time to replace the Ventilation Inlet Flow Switch

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-4 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the ventilation inlet flow switch on the bottom left corner of the lower cabinet, installed on the ventilation inlet duct assembly. Disconnect the switch connection (FSZ_J50 - part of the CN300 harness).

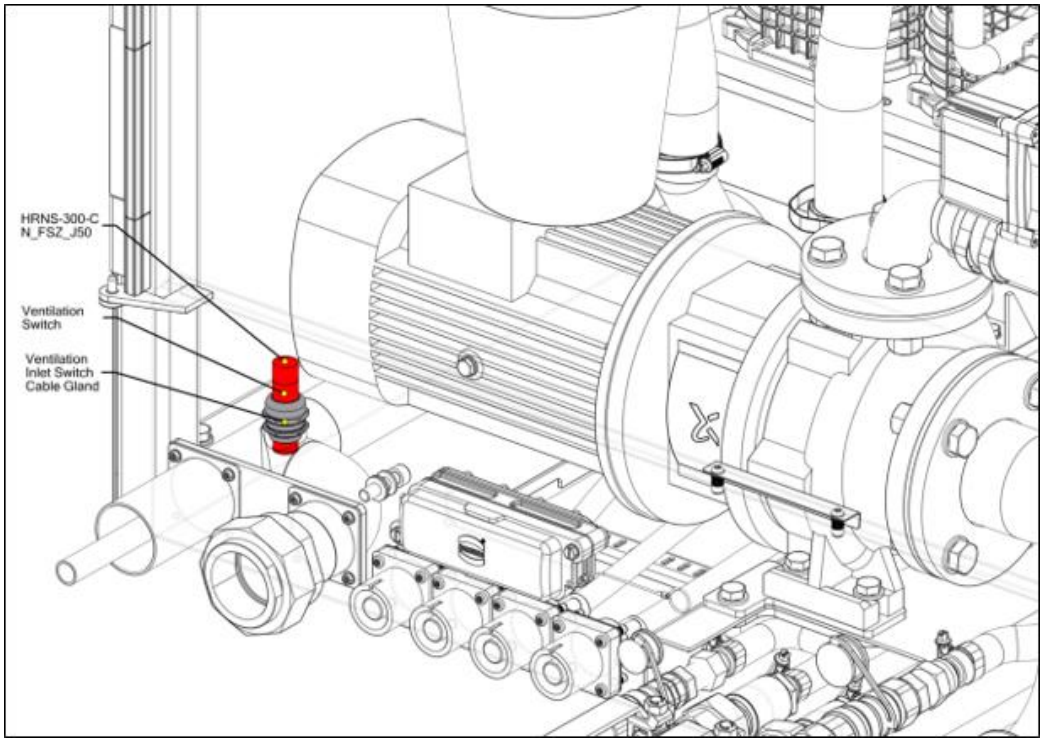


Figure 8-166: Location of ventilation flow switch.

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Assembling procedure:

1. Install the replacement flow switch halfway deep or with the label sticking out. Tighten to 6 ± 0.5 Nm.
2. Connect the ventilation inlet flow switch connection (FSZ_J50).

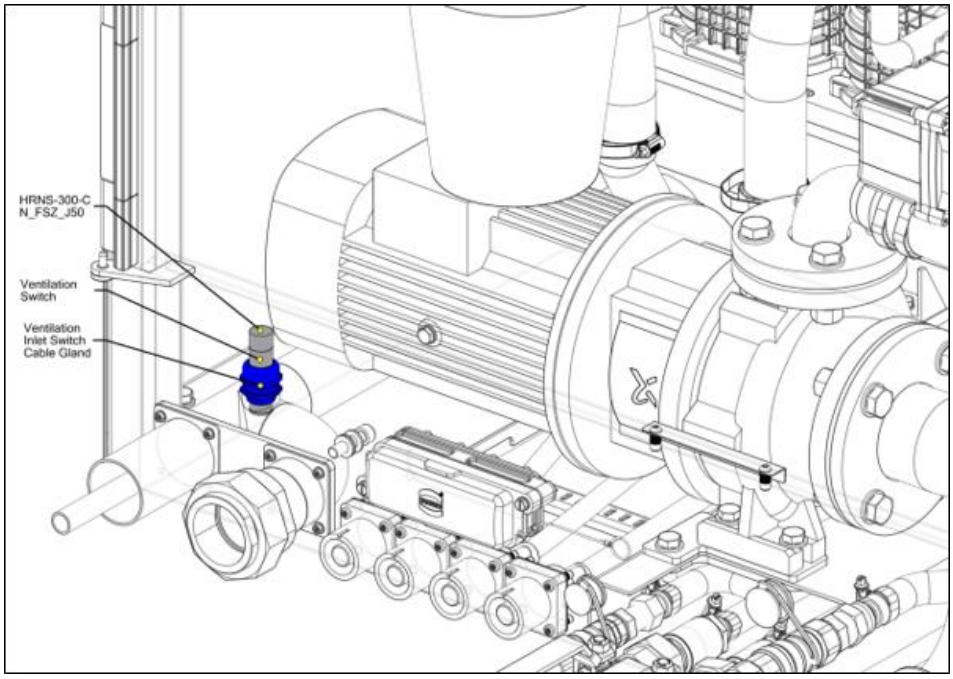


Figure 8-167: Ventilation inlet flow switch connection FSZ_J50.

3. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
4. Power up the 24V system and check if the LED sensor lights up green. Create an air flow restriction to check if the sensor trips and the module has a SafeCon alarm.
5. Close system doors and use the integrator side to confirm the module is ready for power up. Remember to follow local lockout/tagout procedures.

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8.5.5 H_2 Enclosure Water Ingress Sensor

8.5.5.1 Check H_2 Enclosure Water Ingress Sensor

Purpose:

The procedure describes how to check a water ingress sensor in the H_2 enclosure for the FCwave module.

Responsibilities:

Preventive maintenance of the water ingress sensor in the H_2 enclosure is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the H_2 Enclosure Water Ingress Sensor

Based on the normal conditions, the estimated time for replacement is:

H_2 Enclosure Water Ingress Sensor	
Duration	10 – 90 min
Personnel	1
Tool	27mm spanner

Table 8-24: Time to replace water ingress sensor

Note:
The sensor has different locations depending on the module.
Location A is towards the back of the module.
Location B is towards the front of the module.

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Procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. (For location A sensor) Perform steps 6-12 in section 8.5.5.2 to remove the sensor.
3. (For location B sensor) Loosen the bolt in the housing to remove the connector housing from the sensor and use a 27mm spanner to remove the sensor.

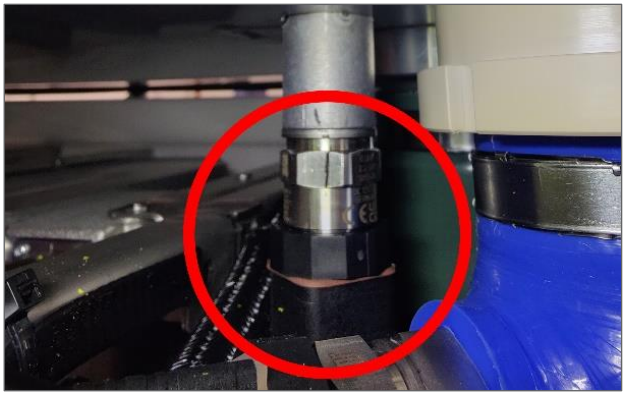


Figure 8-168: H_2 ingress sensor housing

4. Reconnect the connector housing to the sensor. Tighten the bolt if necessary.
5. Connect the low voltage electrical connection (X_E01) and secure it by finger-tightening the bolts.
6. Monitor the MCU engineering interface with the module in "Unlocked" state.
   Make sure there are no active alarms.
7. Test the sensor by one of following three methods:
   a. Cover the sensor's electrode as much as possible by hand.
      This method relies on skin contact and result can vary depending on coverage area and skin moisture.
      Wait up to 30 seconds. If there is an alarm, skip to alarm codes, otherwise try the next method.

   b. Dampen a paper or cloth towel with water and press it against the sensor's electrode, covering as much of it as possible.
      Wait up to 30 seconds. If there is an alarm, skip to alarm codes, otherwise try the next method.

   c. Submerge the sensor's electrode in a container filled with water.
      Wait up to 30 seconds for the alarm to appear.

8. No matter the method, the alarm should disappear as soon as the sensor's electrode is not in contact with the test medium. Confirm the following warning alarm can be seen in the engineering interface:
   - A1_LSH_Z40_S_10700

   Alarm events are logged and can be found in the "Alarm" tab on the menu to the left side of the engineering interface.

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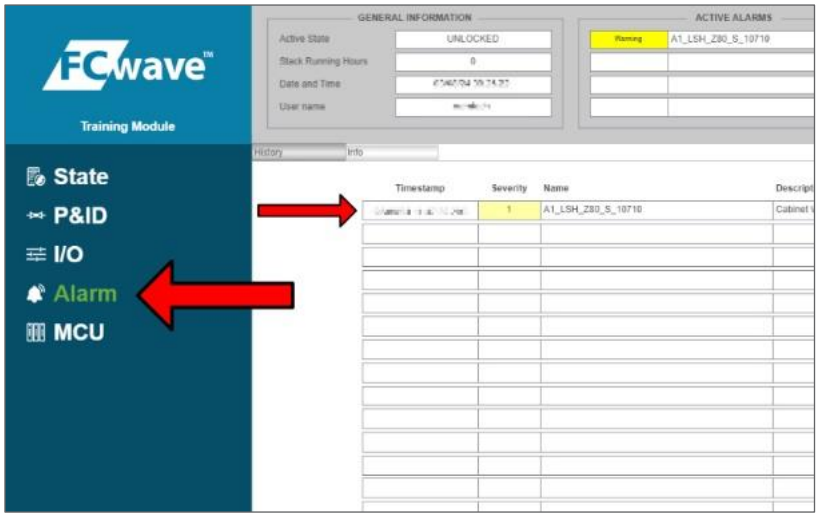


Figure 8-169: A1_LSH_Z40_S_10700 alarm

9. Confirm there are no active alarms and power down the module by disconnecting X_E01.
10. Clean and dry the sensor's electrode and disconnect the connector.
11. Perform step 2 or 3 in reverse order, depending on the location of the sensor, to reassemble the module.
12. If the cathode air hoses were disconnected, perform an air cathode leak test (see section 8.3.6).
13. Confirm that the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.5.5.2 Replace H_2 Enclosure Water Ingress Sensor

Purpose:

The procedure describes how to replace a water ingress sensor in the H_2 enclosure for the FCwave module. The sensor monitors moisture content in the H_2 Enclosure. The level sensor detects when the moisture level exceeds a set limit.

Responsibilities:

Preventive maintenance of the water ingress sensor in the H_2 enclosure is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the differential pressure safety switch during the life and operation of the FCwave module.

- FRU, Sensor, H_2 Enclosure Water Ingress (part no. 7500035)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the H_2 Enclosure Water Ingress Sensor

Based on the normal conditions, the estimated time for replacement is:

H_2 Enclosure Water Ingress Sensor		
Duration	1 – 1½ hours	
Personnel	1	
Tightening Torque	1/2" sensor fitting	25 ± 0.5 Nm
	Tool	27 mm spanner, torque wrench, flathead + cross-head screwdriver, 10mm socket screwdriver, 7mm socket

Table 8-25: Time to replace water ingress sensor

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Disassembling procedure:

The FCwave module was built in two different ways regarding this sensor. Either located in the back of the H_2 enclosure (location A) or located in front of the H_2 enclosure (location B).

Location A	Location B
Perform all steps in section 6.5.1 (High Voltage safety check before module maintenance) before proceeding with the disassembling procedure.	Perform all steps in section 6.5.1 (High Voltage safety check before module maintenance) before proceeding with the disassembling procedure.
1. Drain the HT cooling system	1. Locate the water ingress sensor on the H2 Enclosure in the upper cabinet, which is installed behind the coolant stack outlet connections.
2. Disconnect the 2 sensors on the HT cooling inlet hose (TT_D50 & PT_D50). (Figure 8-170)	2. Disconnect the water ingress sensor connection (LSH_Z40), use spanner to loosen the sensor and remove it.
3. Uninstall bolt keeping the HT cooling inlet hose in place, dismount the hose and tuck it out of the way.	
4. Disconnect the cable from the air inlet control valve (FCV_A40). (Figure 8-171)	
5. Relive the lower hose clamp from the FCV_A40 (no. 1) and take out the air inlet hose.Then relive the hose clamp directly under the H_2 Enclosure (no.2) and take out the FCV_A40 valve. (Figure 8-172)	
6. Disconnect the cable from the air outlet control valve (FCV_A50).	
7. Relive the lower hose clamp from the FCV_A50 and take out the air inlet hose. Then relive the hose clamp directly under the H_2 Enclosure and take out the FCV_A50 valve.	
8. Locate the H_2 enclosure ingress sensor in the back of the module. (Figure 8-173)	
9. Release the bolt in the middle of the plug and remove it. (Figure 8-174)	
10. Use a spanner to disconnect the sensor (LSH_Z40) and remove it.	

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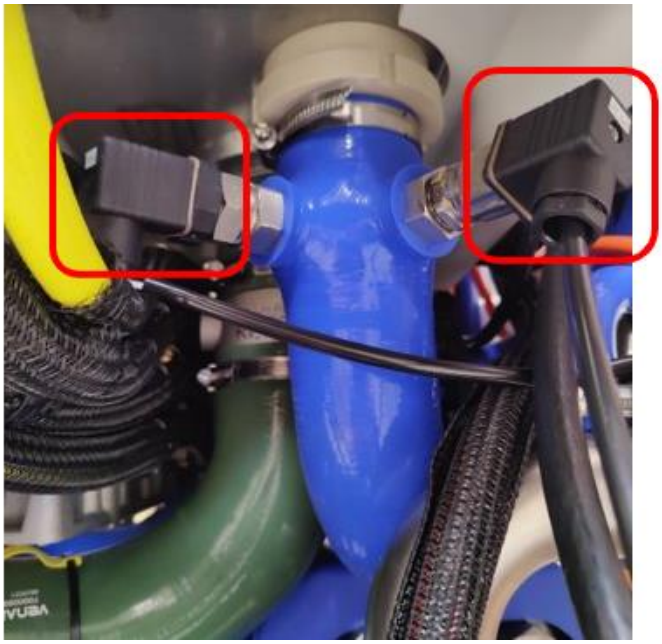


Figure 8-170: 2 sensors on HT cooling inlet hose

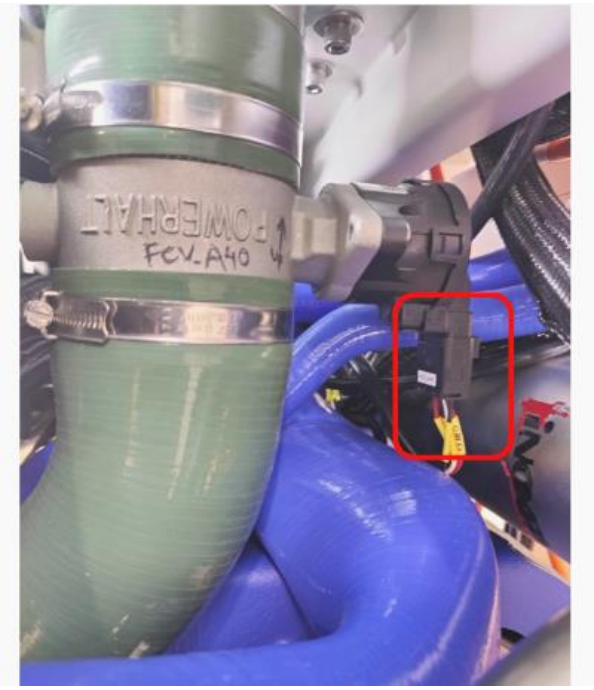


Figure 8-171: Cable on air inlet control valve

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Figure 8-172: Hose clamps on FCV_A40



Figure 8-173: Locate ingress sensor in back of module

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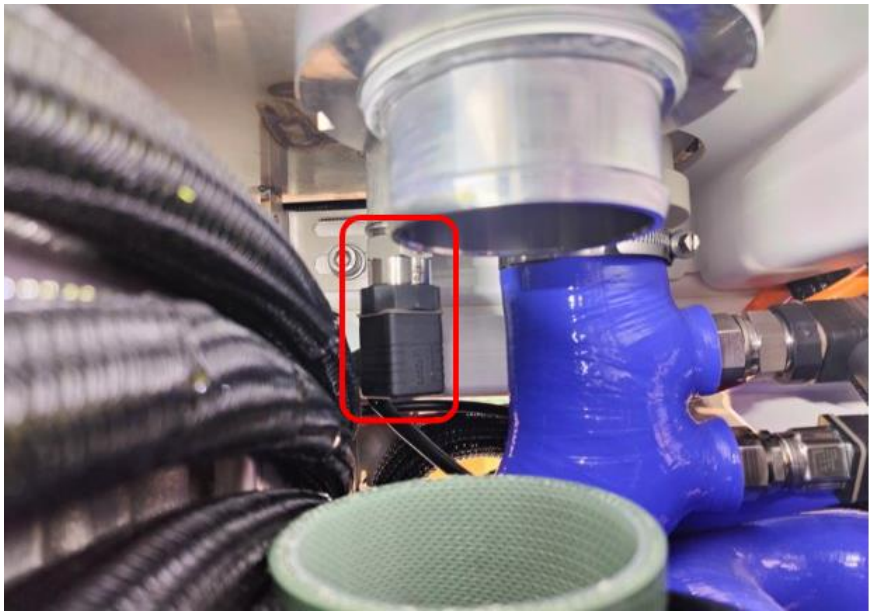


Figure 8-174: Release bolt in middle of plug on ingress sensor

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Assembling procedure:

The FCwave module was built in two different ways regarding this sensor. Either located in the back of the H_2 enclosure (location A) or located in front of the H_2 enclosure (location B).

Location A	Location B
1. Install the new sensor. Tighten to 25 Nm.	1. Install new sensor with a new bonded seal. Tighten to 25 Nm
2. Use the bolt to install the sensor connector.	2. Connect the new sensor to the module.
3. Reinstall the FCV_A50 valve and secure it with the hose clamps. Tighten to 3.5 Nm.	3. Install the high voltage panel cover. Use 12 pcs. M5x10 bolts
4. Reinstall the plug in the FCV_A50 valve connector.	4. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
5. Reinstall the FCV_A40 valve and secure it with the hose clamps. Tighten to 3.5 Nm.	5. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
6. Reinstall the plug in the FCV_A40 valve connector.	6. Close the system doors and confirm that the module is ready for power up from the integrator side after the maintenance. Remove local lockout and tagout procedures when work is done.
7. Remount the HT cooling inlet hose and tighten the hose clamp	
8. Install the pressure and temperature sensors (PT_D50 & TT_D50) on the HT cooling outlet. (Figure 8-175)	
9. Install the high voltage panel cover. Use 12 pcs. M5x10 bolts	
10. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.	
11. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.	
12. Close the system doors and confirm that the module is ready for power up from the integrator side after the maintenance. Remove local lockout and tagout procedures when work is done.	

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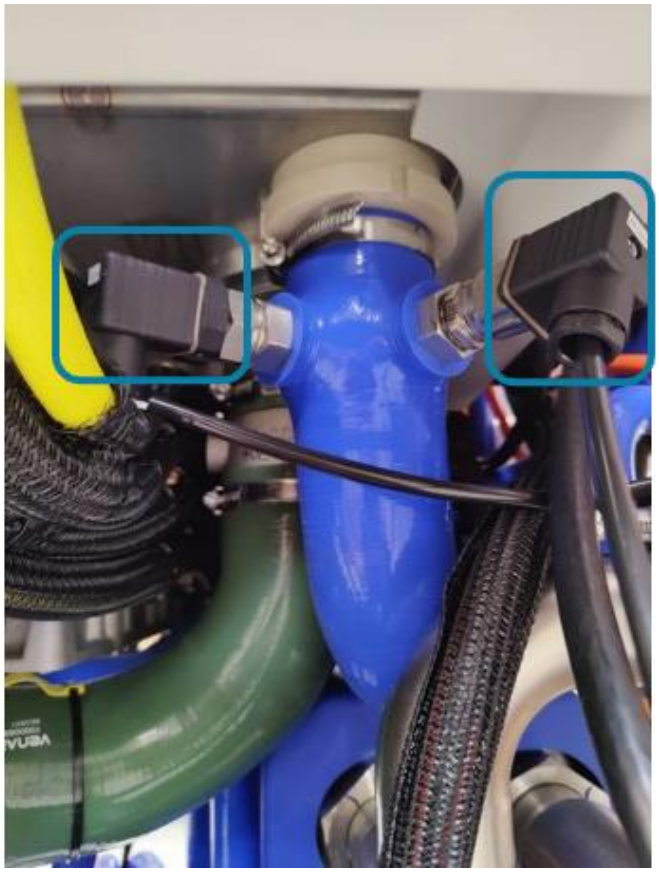


Figure 8-175: Install sensors on the HT cooling outlet

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8.5.6 Differential Pressure Safety Switch

8.5.6.1 Check Differential Pressure Safety Switch

Purpose:

The procedure describes how to check a differential pressure safety switch in the FCwave™ module. The safety switch monitors the air pressure difference between the inside of the Hydrogen Enclosure (H2E) and that of the outside. The switch will trigger an alarm if the air pressure inside the H2E is not lower than the outside pressure.

Responsibilities:

Checking the differential pressure safety switch is necessary for safe operation according to the maintenance plan (refer to the customer portal) or after a replacement. It is the end user's responsibility to do preventive maintenance, as stated in section 8.1.1.

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to check the Differential Pressure Safety Switch

Based on the normal conditions, the estimated time for check is:

Differential Pressure Safety Switch	
Duration	10 min
Personnel	1

Table 8-26: Time to check differential pressure switch

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Procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Connect the low voltage electrical connection (X_E01) and secure it by finger-tightening the bolts.
3. Monitor the MCU engineering interface with the module in "Unlocked" state.
   Make sure there are no active alarms.
4. Between the H_2E and the low voltage panel, locate the differential pressure safety switch below the smoke detector. Gently disconnect the tube attached to the switch.

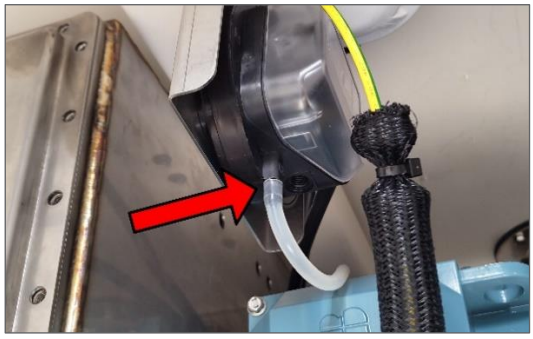


Figure 8-176: Disconnect differential pressure switch tube

5. Confirm the following alarms can be seen in the engineering:
   - A3_SAFETYSTOP_I_10120
   - A2_CNV_FCV_A_OK_I_10020
   - A2_CNV_FCV_A_OK_I_10030

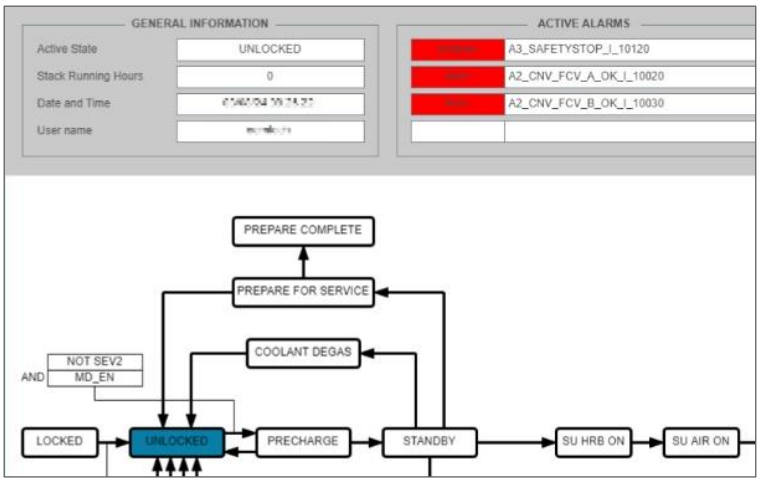


Figure 8-177: Overview of alarms

6. Reconnect the tube to the switch.
7. Power cycle the module to reset and confirm that there are no alarms.
   This can be done by disconnecting and reconnecting the X_E01 electrical connection.
8. The module is ready to be powered down by disconnecting the X_E01 electrical connection, and the module is ready to be restored to normal operating state.
9. Confirm that the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.5.6.2 Replace Differential Pressure Safety Switch

Purpose:

The procedure describes how to replace a differential pressure safety switch for the FCwave module. To safeguard the system, the pressure switch verifies that the pressure within the H2 enclosure is below the pressure outside the H2 enclosure.

It is important that there is a small negative pressure inside the H2 enclosure when it is in operation.

Responsibilities:

Preventive maintenance of the differential pressure switch is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace differential pressure safety switch during the life and operation of the FCwave module.

- FRU, Differential Pressure Safety Switch (Part No. 7500034)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Differential Pressure Safety Switch

Based on the normal conditions, the estimated time for replacement is:

Differential Pressure Safety Switch	
Duration	45 min
Personnel	1
Tool	3mm hex key, flathead + cross-head screwdriver, cross-head bit, hex bit rachet

Table 8-27: Time to replace differential pressure switch

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-4 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the Differential Pressure Safety Switch in the top right corner of the upper cabinet installed on the bracket. Use flathead screwdriver to open the transparent plastic cover of the pressure switch.

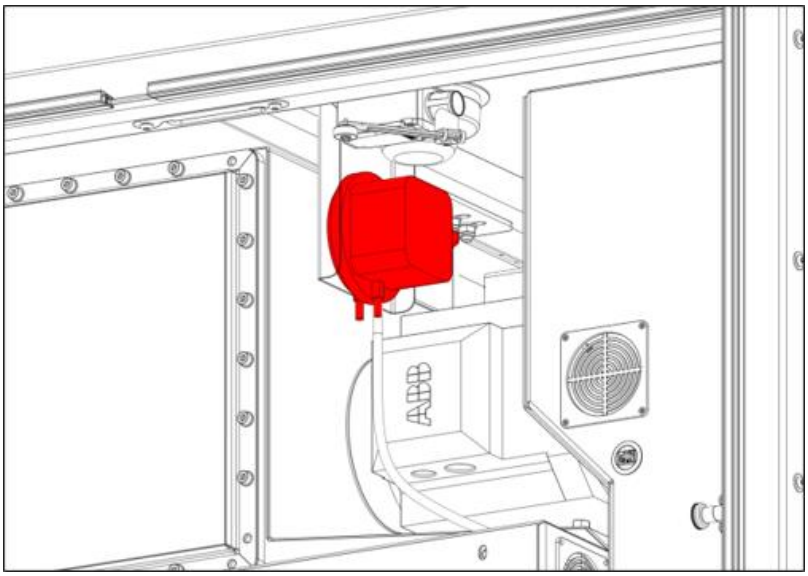


Figure 8-178: Location of differential pressure switch

3. Disconnect the differential pressure switch connection (HRNS-303-CN_PDSZ_J40). Remember to note down the wiring connection order before removing wires from the pressure switch.
4. Remove pressure differential switch silicone tube from pressure differential switch.

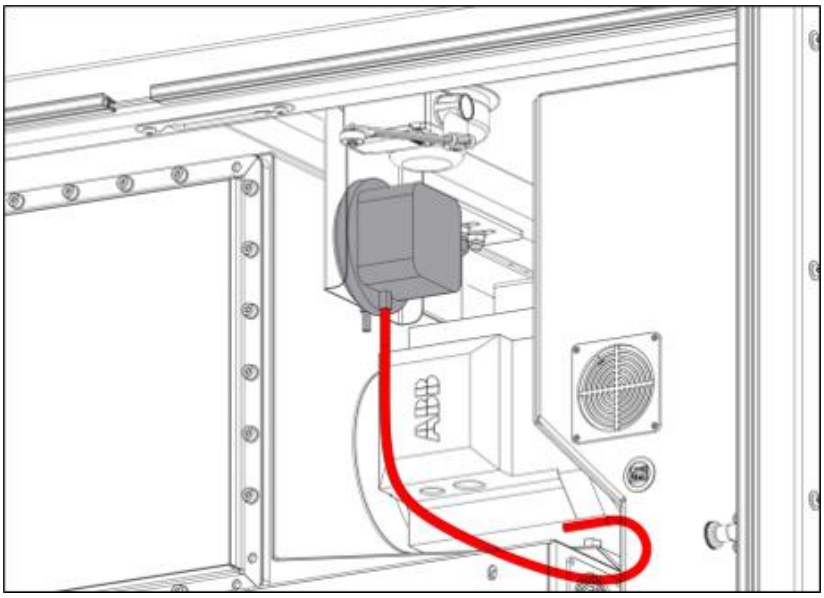


Figure 8-179: Silicone tube on pressure differential switch

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5. Remove 4 sets of panhead bolts/washers used to install the differential pressure switch to the bracket.

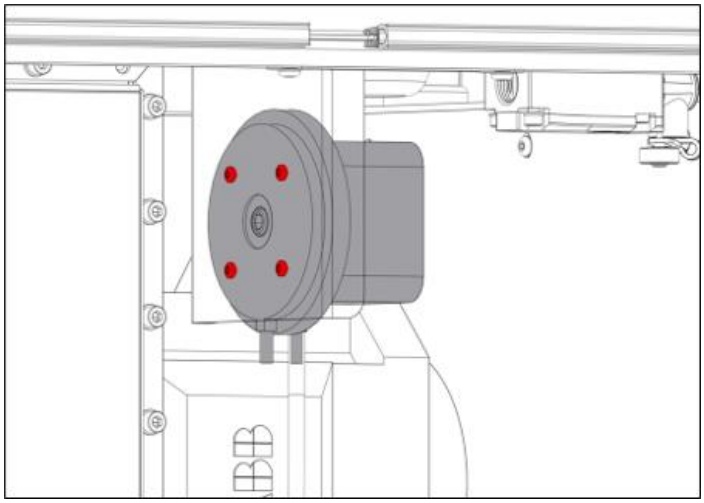


Figure 8-180: Panhead bolts on differential pressure switch bracket

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Assembling procedure:

1. Fasten 4 pcs. panhead bolts used to tighten the H2E differential pressure switch to the bracket. Remember to replace the bolts.
2. Install the end of silicon tube to the differential pressure safety switch.
3. Connect the differential pressure switch connection, HRNS-303-CN_PDSZ_J40.

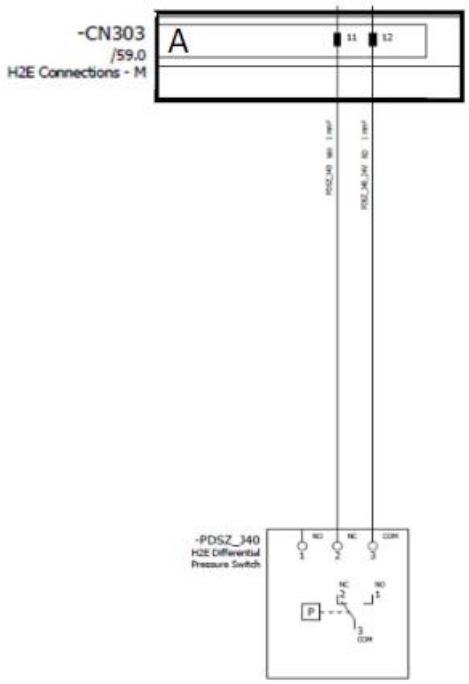


Figure 8-181: Connection HRNS-303-CN_PDSZ_J40

4. Close the transparent plastic cover of the pressure differential switch and tighten the bolt.
5. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
6. Power up the 24V system. Check if the sensor reacts if the HRB hatch is open.
7. Close the doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.5.7 Check Smoke Detector Functionality

Purpose:

The procedure describes how to check correct functionality of the smoke detector for the FCwave module.

Responsibilities:

Preventive maintenance of the smoke detector is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the smoke detector during the life and operation of the FCwave module.

- Smoke Detector Tester[4] (part no. 5129595, 6500524) or equivalent

Safety:

Refer to section 8.1.2 to follow the instructions.

Procedure:

During the procedure you will activate the fire detection system, so make sure to disconnect the automatic firefighting system before starting the procedure.

1. Before proceeding with the check procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Supply 24V power from the shipboard of connect an I/O tester to power up the module MCU.
3. Connect a computer to the MCU and log in to the engineering interface (see section 8.2).
4. Locate the smoke detector installed in the upper cabinet next to the H_2 enclosure.

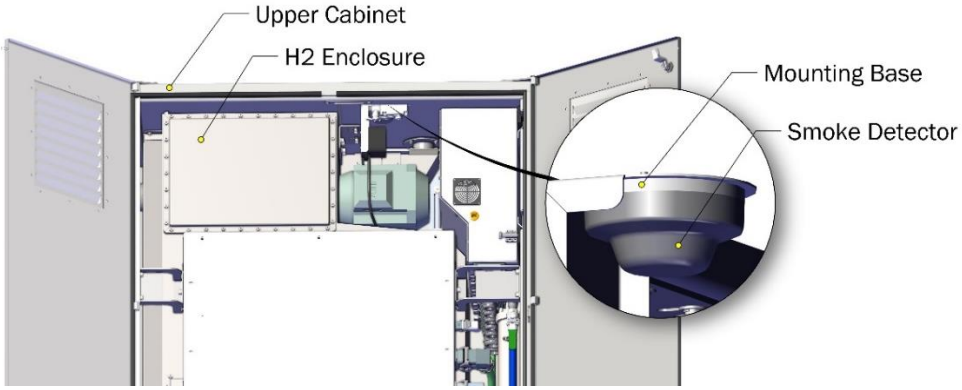


Figure 8-182: Location of smoke detector in upper cabinet

5. Read written instructions on smoke detector and follow as explained to check the smoke detector is not expired.
6. With the module in the "unlocked" state, spray a small quantity of test smoke (press for 2-3 sec) close to the smoke detector. Repeat process a few times.
7. In the engineering interface, navigate to the I/O page and select the All Inputs tab.
8. The tag "SAFETYSTOP" will be activated (ON) (1) and 3 alarms

[4] Smoke Detector Tester is part of the 'Special Tools Kit FCwave' (part no. 6100062)

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- A3_SAFETYSOP_I_10120
- A2_CNV_FCV_A_OK_I_100200
- A2_CNV_FCV_B_OK_I_10030

will appear in the "Active Alarms" list (2).



Figure 8-183: Overview of fire alarms

9. To reset the alarms, cycle both 24V power supply's OFF and ON.
10. Log out of the MCU engineering interface and disconnect the computer.
11. If applicable, shut down the IO tester and disconnect from the module.

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8.5.8 Replace Smoke Detector

Purpose:

The procedure describes how to replace a smoke detector for the FCwave module. The smoke detector senses any smoke in the module's cabinet.

Responsibilities:

Preventive maintenance of the smoke detector is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the smoke detector during the life and operation of the FCwave module.

- FRU, Smoke Detector (part no. 7500149)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace a Smoke Detector

Based on the normal conditions, the estimated time for replacement is:

Smoke Detector	
Duration	5 min
Personnel	1

Table 8-28: Time to replace smoke detector

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the smoke detector in the upper cabinet behind the door switch.
3. Hold the smoke detector and turn it counterclockwise to remove it.

Assembling procedure:

1. Replace the smoke detector by aligning it to the electrical contacts on the relay base and turn it clockwise to lock it in place.

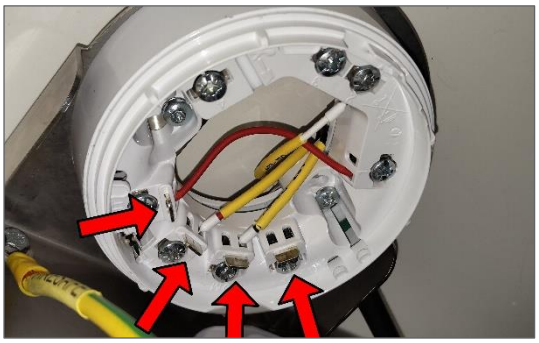


Figure 8-184: Aligning smoke detector

2. Verify the replacement smoke detector by confirming that the module will not cause a fire alarm on the integrator side during the test.
3. Confirm that the module is ready for power up to perform the smoke detector test.
4. Check smoke detector functionality (section 8.5.7).
5. Confirm the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.5.9 Replace Ventilation Fan

Purpose:

The procedure describes how to replace a ventilation fan for the FCwave module. A pair of fans draws ventilation air through the air inlet duct along the length of H_2 enclosure and exhaust through the ventilation outlet duct.

Responsibilities:

Preventive maintenance of the ventilation fan is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the smoke detector during the life and operation of the FCwave module.

- FRU, H_2E Ventilation Fans (part no. 7500038)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Ventilation Fan

Based on the normal conditions, the estimated time for replacement is:

Ventilation Fan		
Duration	15 – 30 min + 2 – 2½ hours for HRB Motor	
Personnel	1	
Tightening Torque	M4 nut	3.5 ± 0.5 Nm
	M6 bolt	10 ± 0.5 Nm
	Tool: 3mm + 5 mm hex key,	

Table 8-29: Time to replace ventilation fan

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the ventilation hatch cover on the top right corner of the H_2 enclosure, which is behind the HRB Motor. It is high likely necessary to remove the HRB motor, to create proper access. Refer to section 8.2.2.2.1.

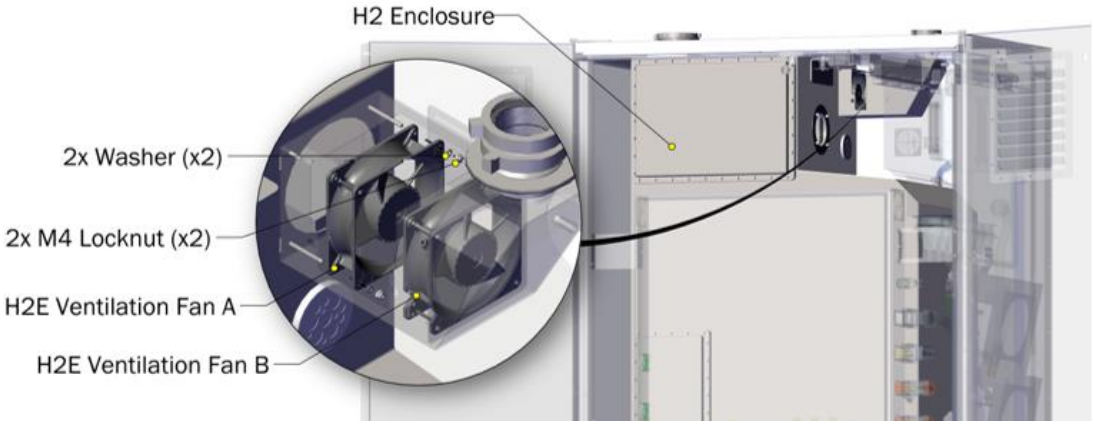


Figure 8-185: Location of ventilation hatch cover

3. Remove 4 pcs. M6 bolts and washers to disassemble the ventilation hatch cover.

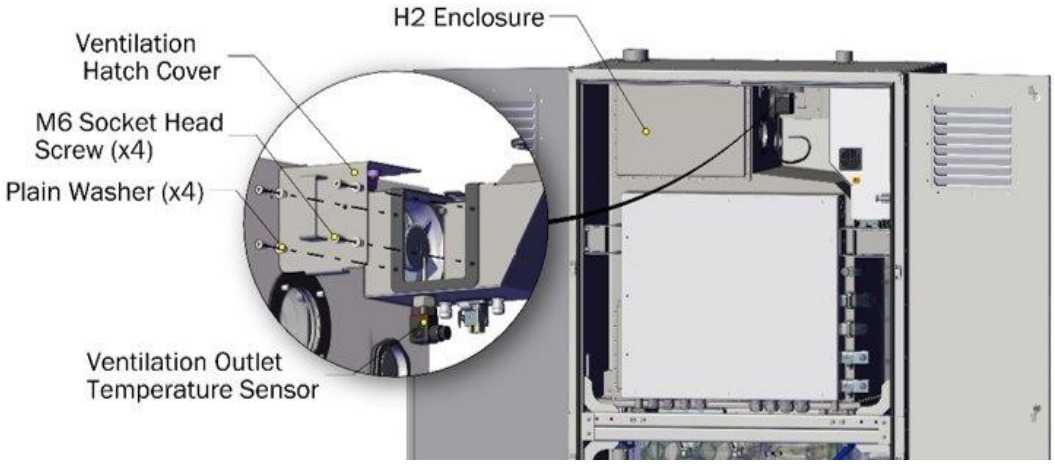


Figure 8-186: Disassemble the ventilation hatch cover

4. Disconnect the ventilation blower connection, HRNS-303-CN-FAN_J10A and CN-FAN_J10B.
5. Remove 2 pcs. M4 lock nuts and washers used to tighten the ventilation fan A to the ventilation outlet duct and remove fan. Do similarly to ventilation fan B if needed.

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Assembling procedure:

1. Use 2 pcs. M4 lock nuts and washers to tighten the ventilation fan A to the ventilation outlet duct. Do similarly to ventilation fan B if needed.
2. Reconnect the ventilation blower connection – HRNS-303-CN-FAN_J10A and CN-FAN-J10B.
3. Use 4 pcs. M6 bolts and washers to install the ventilation hatch cover.
4. If HRB Motor was removed to create access, reinstall the motor. Refer to section 8.2.2.2.1.
5. Install 12 pcs. M5x10 hex head bolts to install the high voltage panel cover.
6. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
7. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
8. Close the doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.5.10 Replace Fuel Cell Stack Assembly/Module Top Cabinet Swap

Purpose:

The procedure describes how to replace a fuel cell stack assembly for the FCwave module. The fuel cell stack delivers the required power, current, and voltage to the system. The fuel cell stack assembly is installed at the center of the H_2 enclosure. Only qualified service personnel shall install, inspect, and service the fuel cell stack assembly.

Responsibilities:

Preventive maintenance of the fuel cell stack assembly is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment:

A list of parts and special equipment is identified to replace the fuel cell stack during the life and operation of the FCwave module.

- FRU, FCwave Top Module Swap Unit (part no. 7500164)

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Fuel Cell Stack Assembly

Based on the normal conditions, the estimated time for replacement is:

Fuel Cell Stack Assembly		
Duration	10 hours	
Personnel	1 - 2	
Tightening Torque	M6 bolt	10 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	M10 nut	50 ± 5 Nm
	M12 bolt	85 ± 5 Nm
	Fuel supply fitting (20mm)	Hand tight + 1.25 turn
	Tool	5mm + 6mm + 8mm + 10mm hex key, 10mm + 12mm + 20mm spanner

Table 8-30: Time to replace fuel cell stack

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain the internal HT and LT coolant loop.
3. Disconnect the LV panel connections (see section 8.6.15).
4. Disconnect the HT panel connections (see section 8.6.14).
5. Disconnect the external connections to process exhaust and H_2 enclosure ventilation output of the upper cabinet of the module.

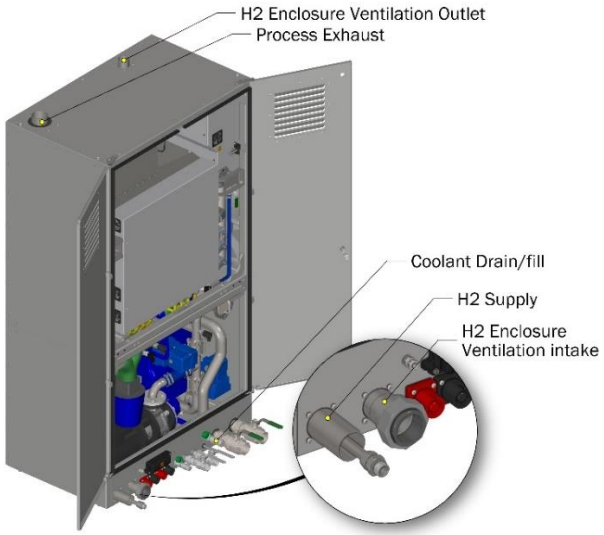


Figure 8-187: Dismounting exhaust and ventilation outlet external connections

6. Disconnect the LT cooling connections to the HRB and coolant pump motor controllers (see section 8.6.4).
7. Release the hose clamp on the bulkhead fittings of the coolant inlet hose manifold. Slide off the hoses attached with a pressure sensor and temperature sensor to have service access.

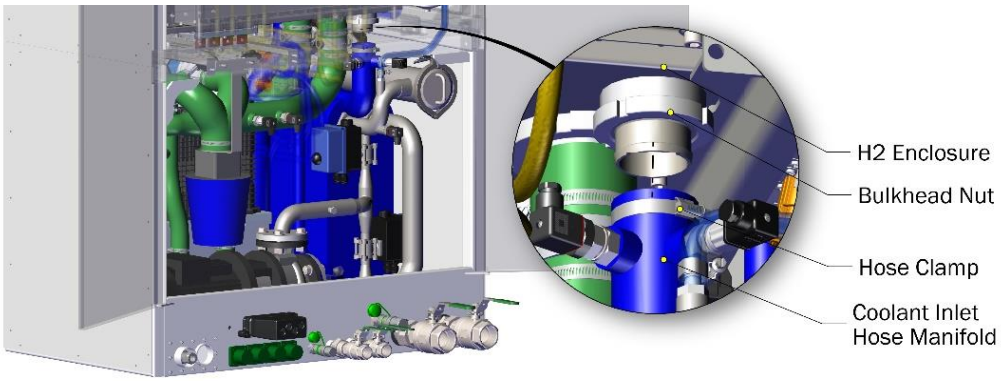


Figure 8-188: Removal of hose clamp for coolant inlet

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8. Release the hose clamp on the bulkhead fittings of the oxidant inlet hose manifold. Slide off the hoses to have service access.

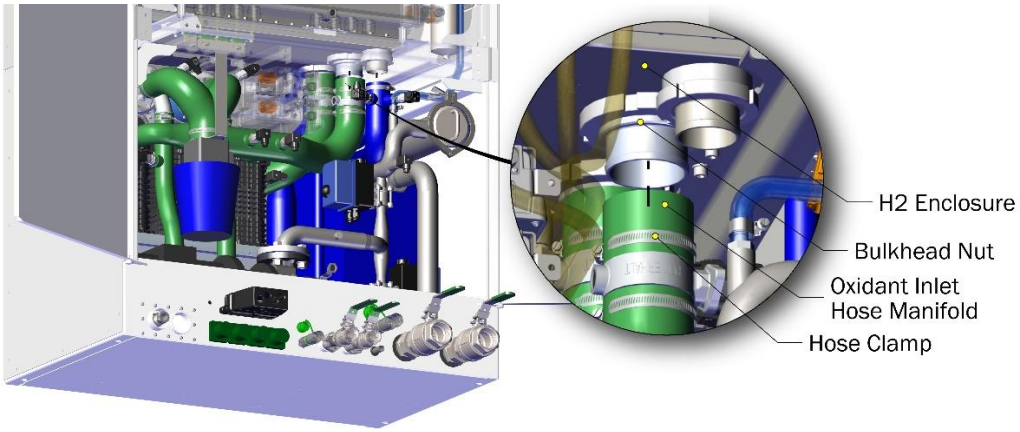


Figure 8-189: Removal of hose clamp for oxidant inlet

9. Release the hose clamp on the bulkhead fittings of the oxidant outlet hose manifold. Slide off the hoses to have service access.

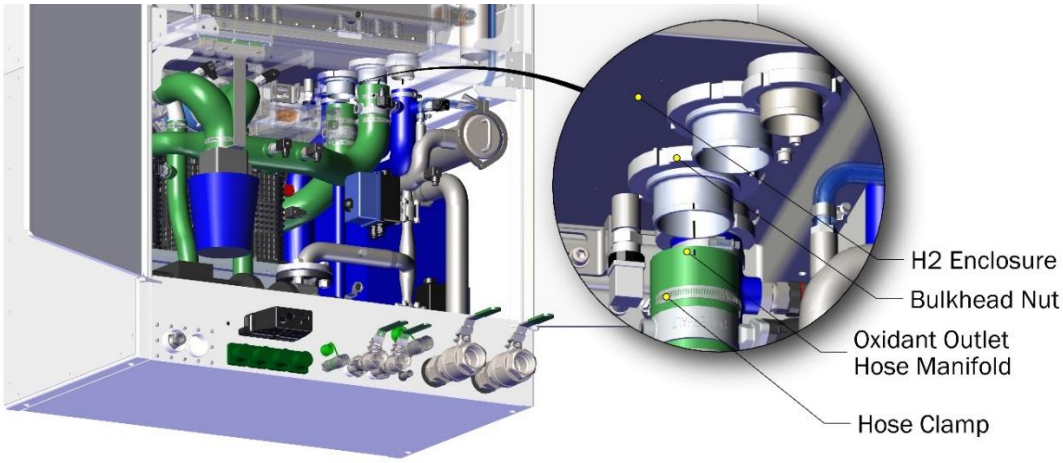


Figure 8-190: Removal of hose clamp for oxidant outlet

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10. Release the hose clamp on the bulkhead fittings of the coolant outlet hose manifold. Slide off the hoses attached a with pressure sensor and temperature sensor to have service access.

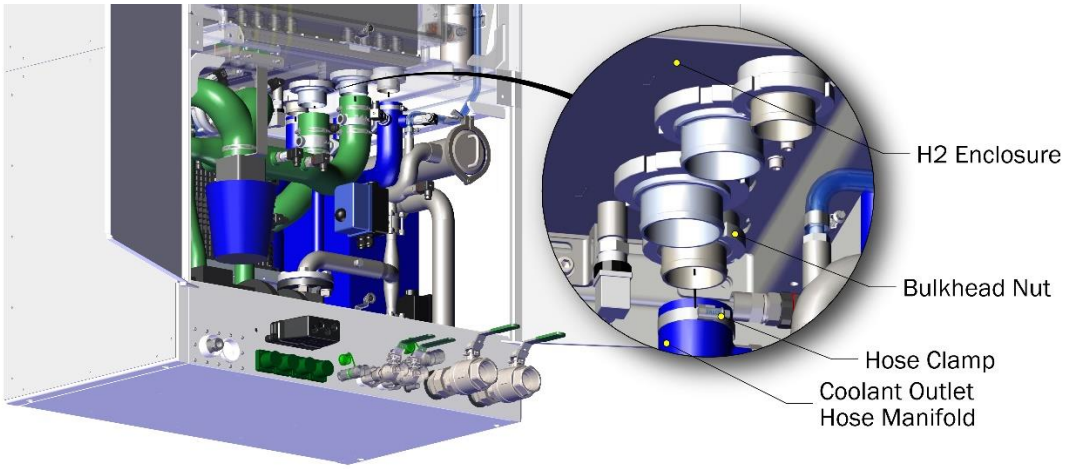


Figure 8-191: Removal of hose clamp for coolant outlet

11. Release the coolant hoses connected to the header tank and from the DI filter outlet.

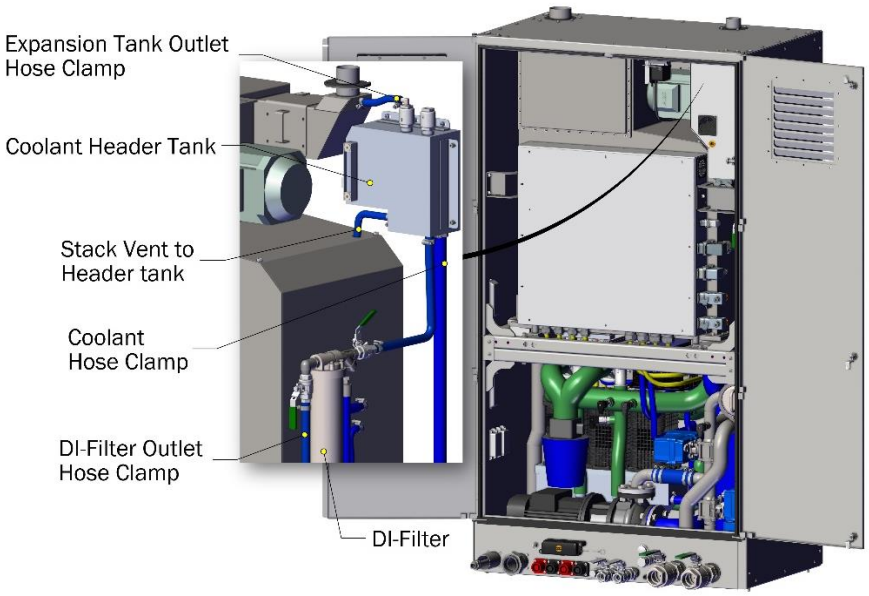


Figure 8-192: Dismounting coolant hoses connected to header tank and Di filter

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12. Remove 4pcs. M6 bolts on the bottom side of H_2 pipe top adapter box, gasket and lower the box.

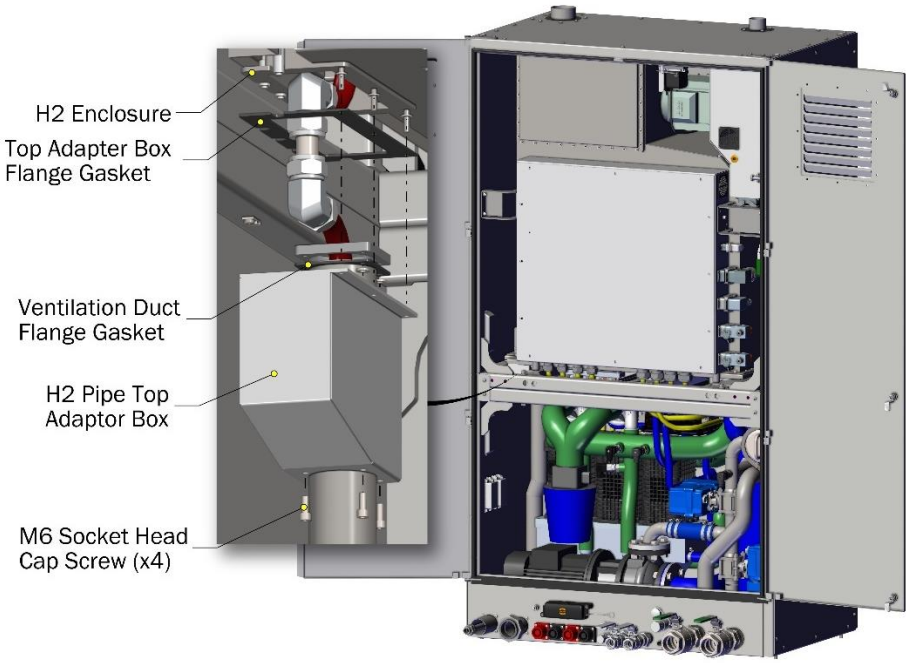


Figure 8-193: Removal of bolts of H_2 pipe top adapter box

13. Disconnect the internal H_2 fuel pipe supply union nut fitting to disconnect the lower ventilation duct.

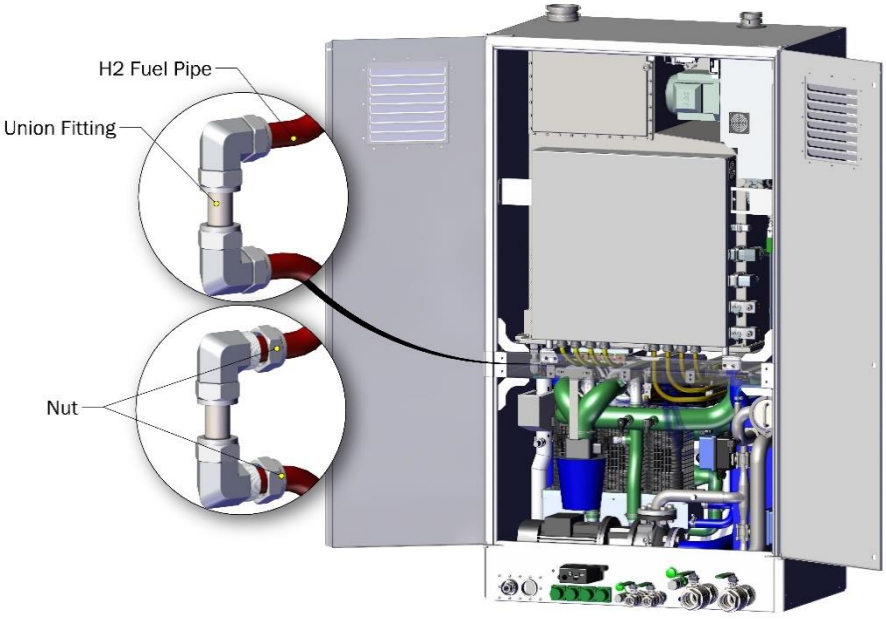


Figure 8-194: Disconnect internal H_2 supply

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14. Uninstall 2 pcs. M6 bolts and washers of the process exhaust flange and rotate counter-clockwise to dismount the connection to the exhaust duct.

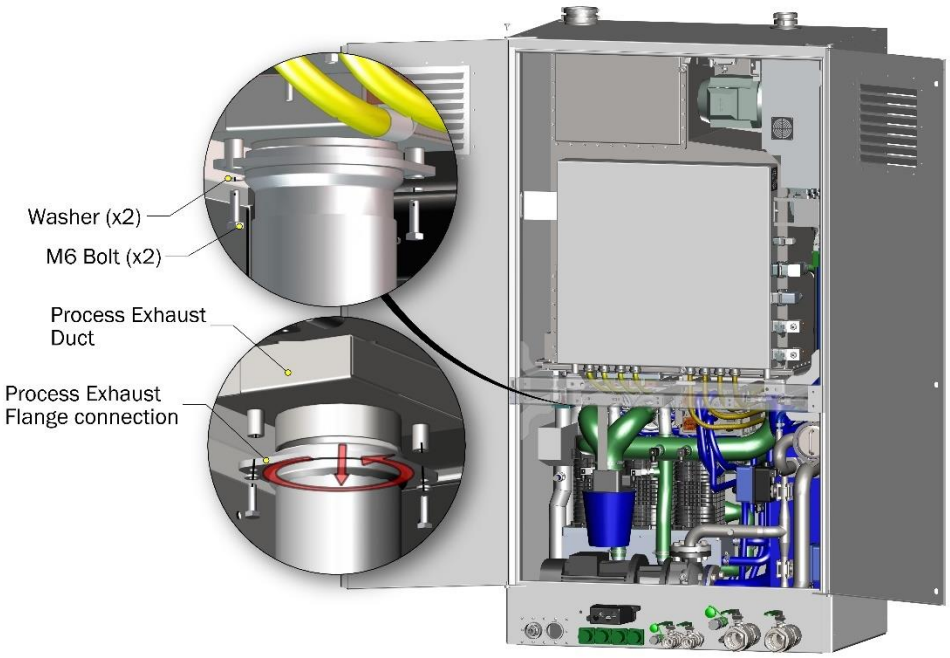


Figure 8-195: Dismounting process exhaust flange connection

15. Dismount the right and left doors of the integrated upper and lower cabinet by uninstalling the detachable M12 anchoring bolts.

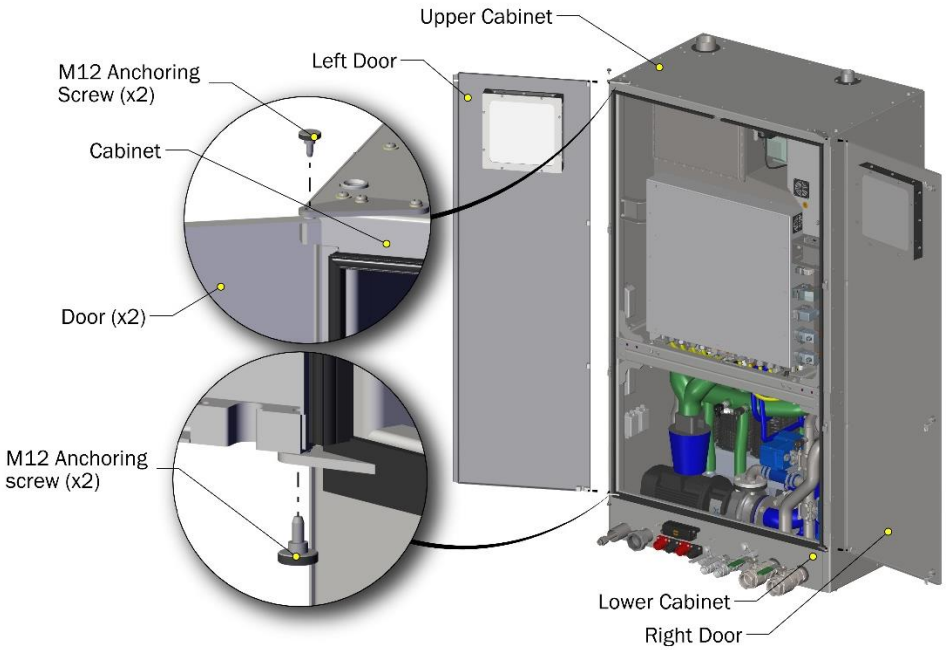


Figure 8-196: Dismounting anchoring bolts for the doors

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16. Uninstall 2 pcs. M6 bolts to access the sliding lock mechanism to dismount the upper cabinet.

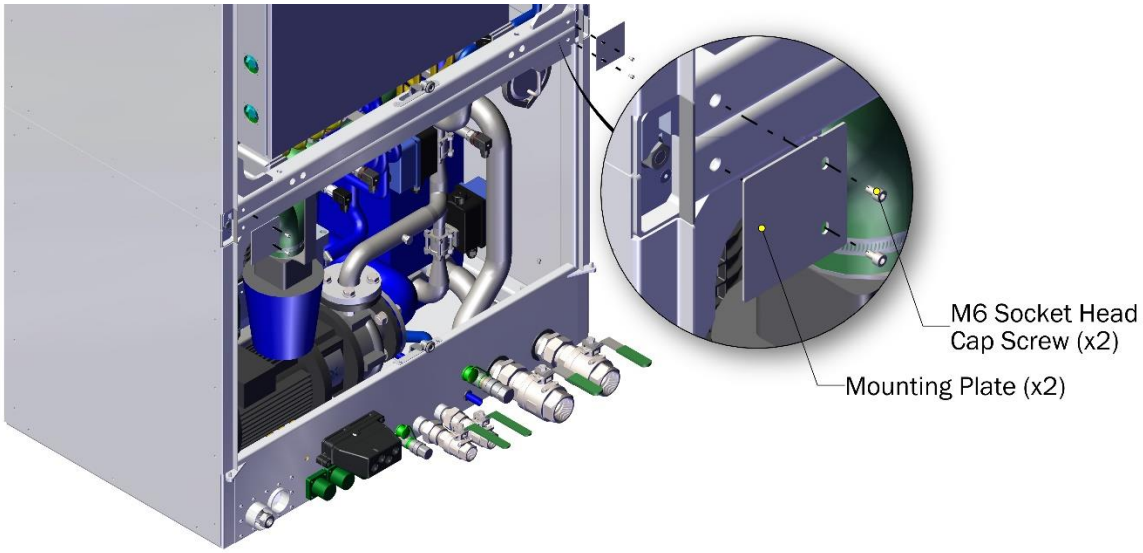


Figure 8-197: Dismounting mounting plate

17. Loosen the M10 nut on the movable lock shaft, which unlocks the locking bracket mounted on the locking pin and remove the movable lock shaft unit.

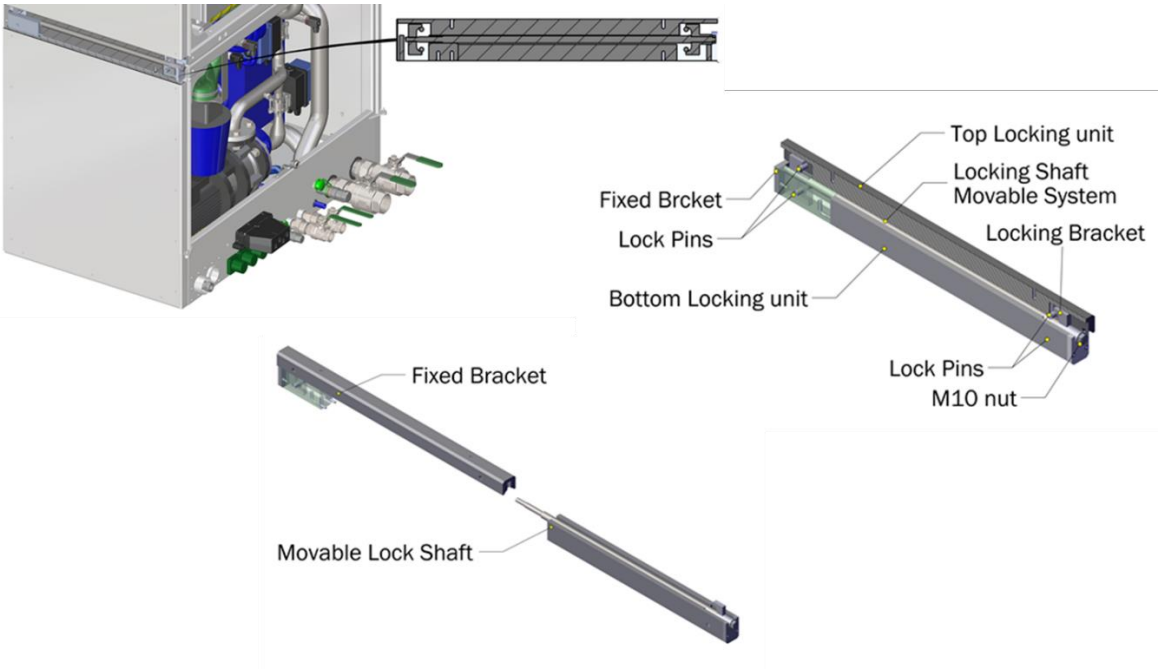


Figure 8-198: Removal of movable lock shaft unit

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18. Dismount the movable lock shaft system from the cabinet assembly with the top unit connected to the upper cabinet assembly.

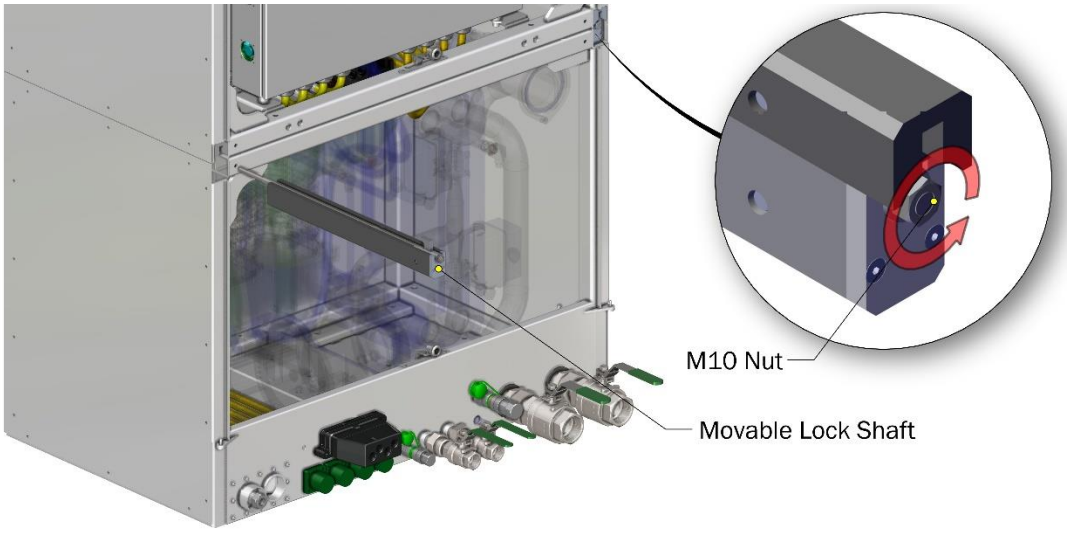


Figure 8-199: Removal movable lock shaft

19. Place the special lifting tool in the cabinet assembly below the top locking unit to lift and slide out the upper cabinet on to the lifting table.

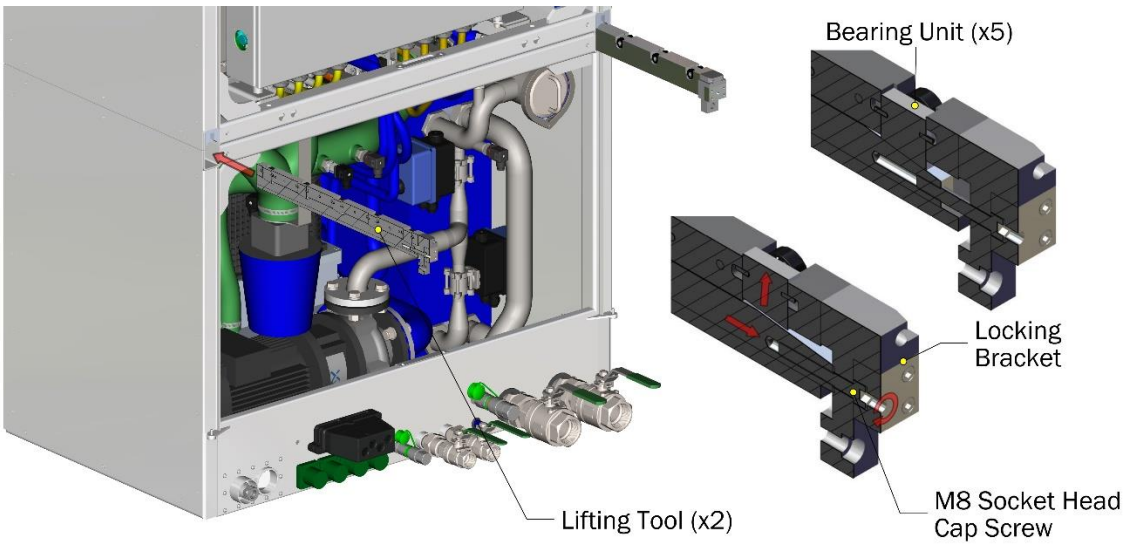


Figure 8-200: Removal upper cabinet

20. Tighten M8 bolts connected to the beam to lift the upper cabinet to engage 5 pcs. bearing units of lifting tool.

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21. Sliding out the upper cabinet includes the H_2 enclosure unit, HV panel, LV panel, coolant header tank, DI filter, and motor controllers. Slide onto a specially designed adjustable lifting equipment to pull out the upper cabinet.

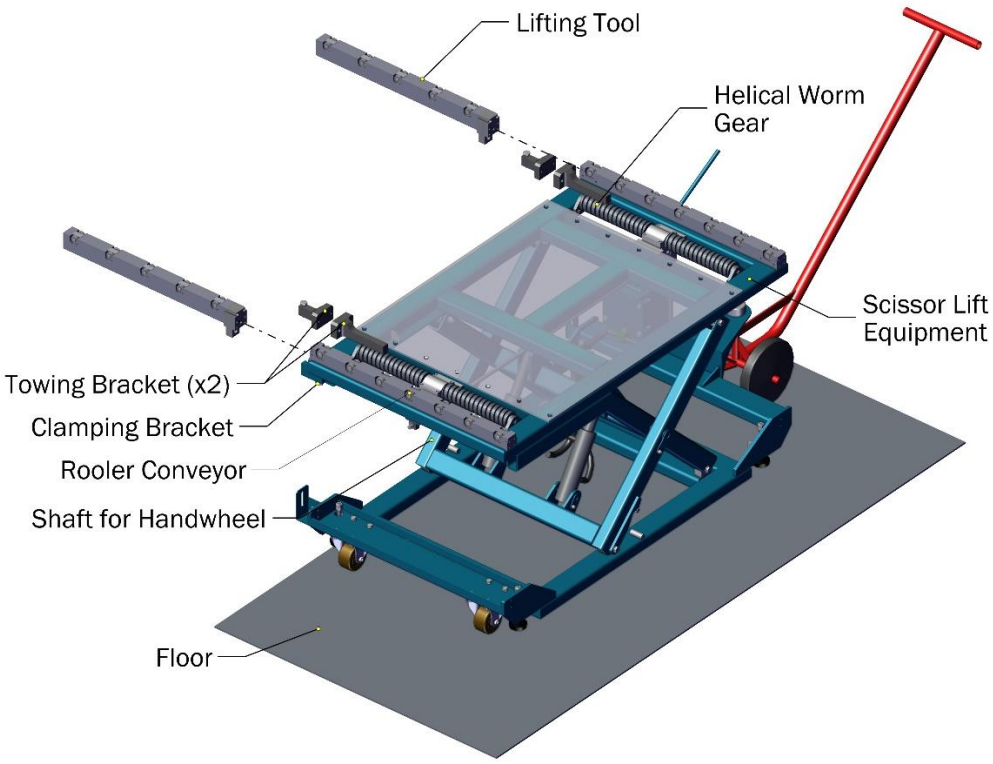


Figure 8-201: Special scissor lift equipment

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22. The lifting table is placed in front of the cabinet and the fixing plate is connected to the lifting mechanism tool with 2 pcs. M10 bolts on both sides.

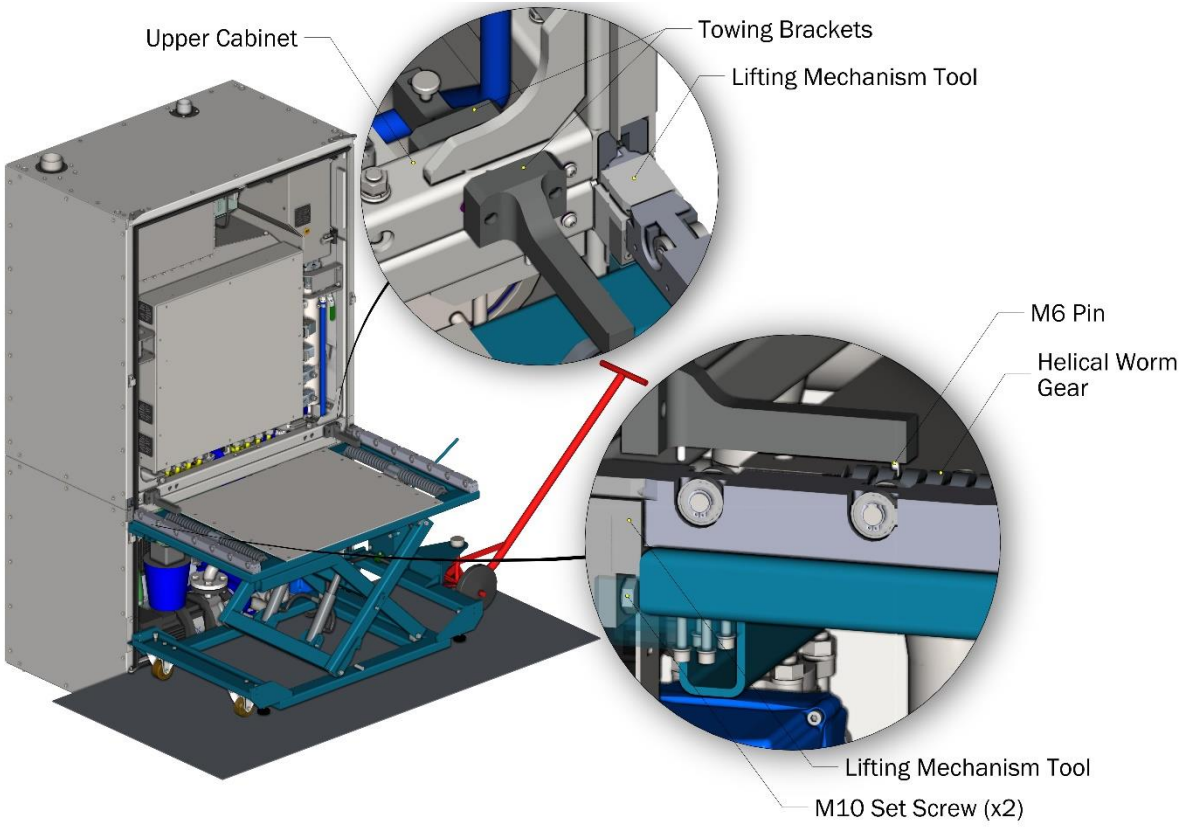


Figure 8-202: Fixing lifting table to upper cabinet

23. Install towing brackets on the front beams of the upper cabinet and the extended end of the towing bracket guide pin should be engaged on the helical bolt of the worm gear.
24. Remove all cable ties from the wire harness connections in the upper cabinet.
25. When the worm gear shaft is rotated by handwheel, the gear pulls out the upper cabinet from the cabinet assembly. Lifting and handling the upper cabinet must be performed slowly to avoid sudden jerks and movements.
26. For safety reasons, connect the four lifting points with eye bolts on top of the cabinet to the overhead electric hoist with a lifting beam while disassembly.

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27. Mount the upper cabinet onto the scissor lift equipment.

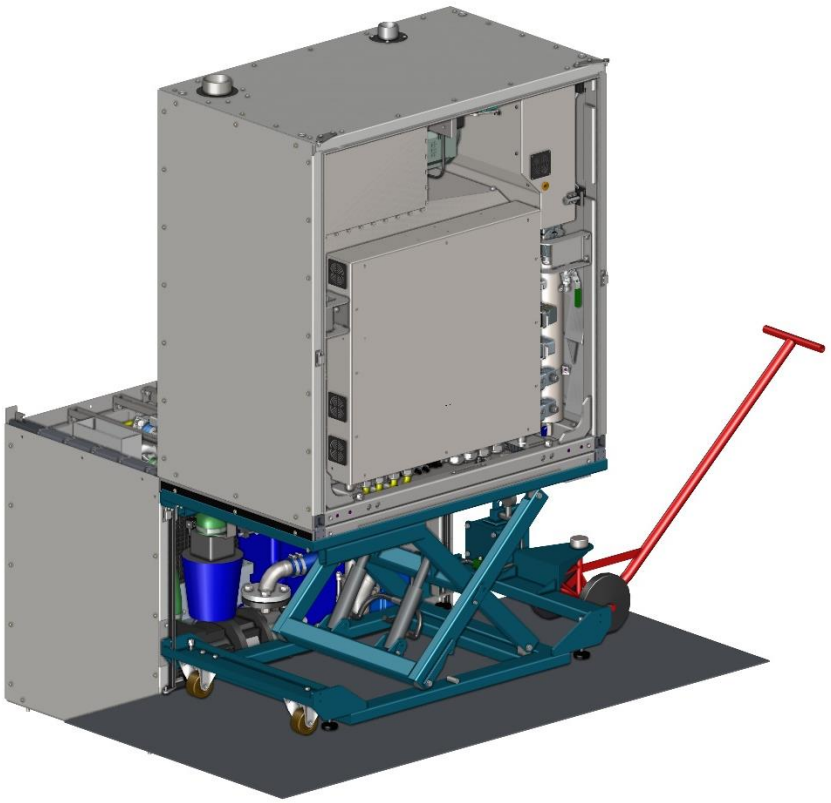


Figure 8-203: Placing upper cabinet of scissor lift

28. Make sure to cover all disconnected ports and hoses with a clean cap or tape.
29. Cover the coolant inlet and outlet ports of the stack assembly to prevent any unwanted material from falling into it.
30. Cover the oxidant inlet and outlet ports of the stack assembly to prevent any unwanted material from falling into it.
31. Cover the fuel inlet and outlet ports of the stack assembly to prevent any unwanted material from falling into it.
32. Assemble in reverse order with replacement fuel cell stack assembly.
    It is highly recommended to perform a leak test with smoke detector and H_2 sensor after any service maintenance (refer to section 8.2.4).
33. Pack and send the used fuel cell stack assembly with complete upper cabinet to Ballard, as service maintenance and stack assembly replacement requires Level-III certified service personnel from Ballard (see section 4.1 for contact information).

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8.6 Electrical Sub-system

For detailed in-depth electrical document, contact BPSE (see section 4.1) to get sent document 'CMS010' (Schematic Description of IO Circuits).

8.6.1 Check Fuel Cell Module BOP Components

Purpose:

The procedure describes how to visually inspect the BOP components of the FCwave module. Any damage or deformation of the parts in BOP must be reported to BPSE to find out if corrective action is necessary, as it can lead to potentially dangerous issues.

Responsibilities:

It is the end user's responsibility to do preventive maintenance (refer to section 8.1.1).

Safety:

Refer to section 8.1.2 to follow the instructions.

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Procedure:

1. Perform step 1-3 in section 6.5.1 (High Voltage safety check before module maintenance) before proceeding with the check procedure.
2. Visually check the cabinet BOP components for signs of damage, corrosion, missing or loose fasteners, or unusual wear patterns that could identify more dangerous issues. If possible, check by removing the HRB hatch and purge valve hatch covers on the H_2 enclosure.



Figure 8-204: Overview of cabinet BOP

3. Record the observations and findings during inspection. If any leaks or damages are reported, do not operate the module until the issue is corrected. Contact BPSE (see section 4.1) for further support.

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8.6.2 Check External Harnesses and Electrical Components

Purpose:

The procedure describes how to visually inspect the external harnesses and electrical components of the FCwave module. Harnesses or hoses that show signs of damage or problems must be reported to BPSE to find out if corrective action is necessary, as it can lead to potentially dangerous issues.

Responsibilities:

It is the end user's responsibility to do preventive maintenance (refer to section 8.1.1).

Safety:

Refer to section 8.1.2 to follow the instructions.

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Procedure:

1. Perform steps in section 6.5.1 (High Voltage safety check before module maintenance) before proceeding with the check procedure.
2. Make sure the connectors are securely plugged in.
3. Uninstall the bolts to remove the LV panel cover.

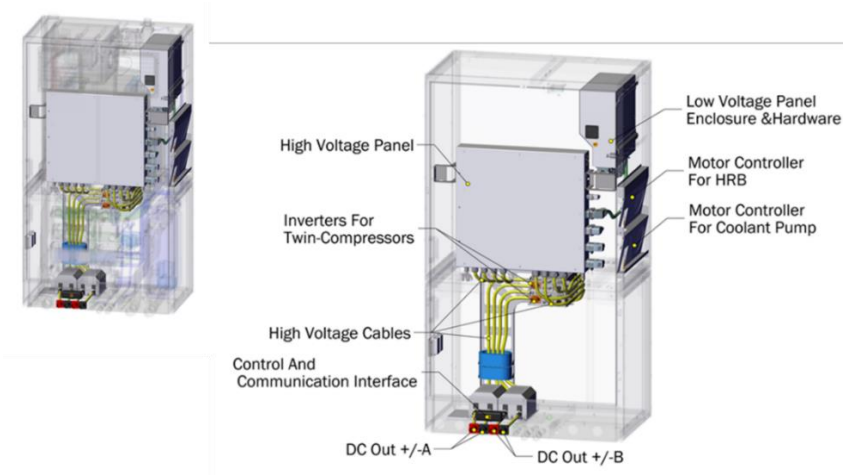


Figure 8-205: Overview of HV and LV panel covers

4. Visually examine the external harnesses and electrical components in the HV panel, LV panel, and in the BOP of the FCwave module.
5. If accessible, examine the harnesses connected to air compressor controllers and on the HRB and coolant pump controllers.
6. For inspection of harnesses and electrical components:
   - Check all the harnesses and hoses. Make sure there are no loose clamps, bends, pinching, cuts, or cracks.
   - Check that all bolt fastenings and connections are tight and correctly aligned.
   - Check that terminal boots and other covers are correctly installed.
   - Check that cable ties provides cable strain relief at vulnerable points.
   - Check that the module bonding stud and bonding harnesses are correctly installed on both upper and lower cabinet and free of corrosion.
   - Check for signs of overheating, wear, or damage — Damages of an excessive nature can be sign of more dangerous issues and must be investigated.
   - Check that there are no visible leak spots, pooled liquid, corrosion, or excessive moisture in the enclosures.
7. Record the observations and findings during inspection. If any damages are reported, do not operate the module until the issue is corrected. Contact BPSE (see Section 4.1) for further support.

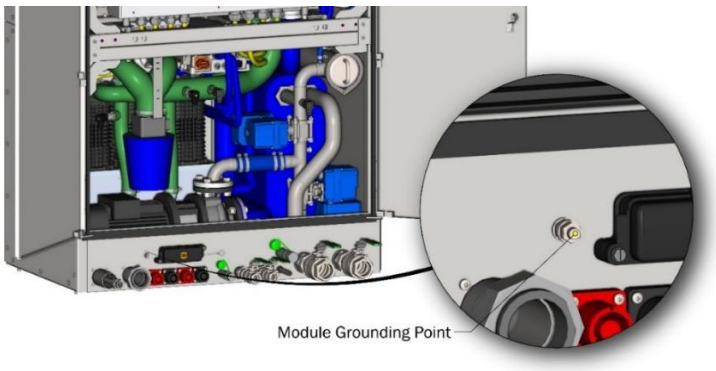


Figure 8-206: Overview of module grounding port

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8.6.3 Check Ground Fault Monitor Functionality

This is part of customer scope of supply, refer to the instructions and written procedures for periodic test of ground fault monitor.

8.6.4 Replace HRB Motor and Coolant Pump Controllers

Purpose

The procedure describes how to replace an HRB motor and coolant pump controllers for the FCwave module. Both the motor controllers are installed on the right side of the upper cabinet below the low voltage panel.

Responsibilities

Preventive maintenance of the motor controllers is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment

A list of parts and special equipment is identified to replace the motor controllers during the life and operation of the FCwave module.

- FRU, HRB Motor Controller (part no. 7500112)
- FRU, Coolant Pump Motor Controller (part no. 7500113)

Safety

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Motor Controllers

Based on the normal conditions, the estimated time for replacement is:

Motor Controllers		
Duration	1 hours	
Personnel	1	
Tightening Torque	M6 bolt	10 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	Fitting 1/4"	15 ± 0.5 Nm
	Tools	5mm + 6mm hex key, special tool (7500211), clean container, valve, 8mm plastic pipe, 8mm plastic pipe adaptor, 7mm + 10mm + 19mm socket, torque wrench

Table 8-31: Time to replace motor controllers

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Uninstall 3 pcs. M8x30 bolts from the top right support bracket of the high voltage panel. Remove the bracket on the right side of the high voltage panel.

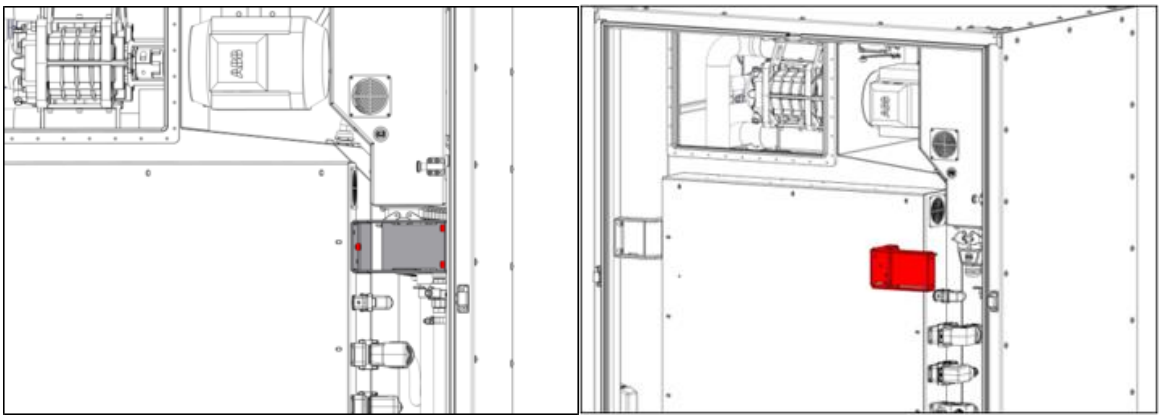


Figure 8-207: Bolts and support bracket in HV panel

3. To get service access, disconnect all connectors in the high voltage panel.

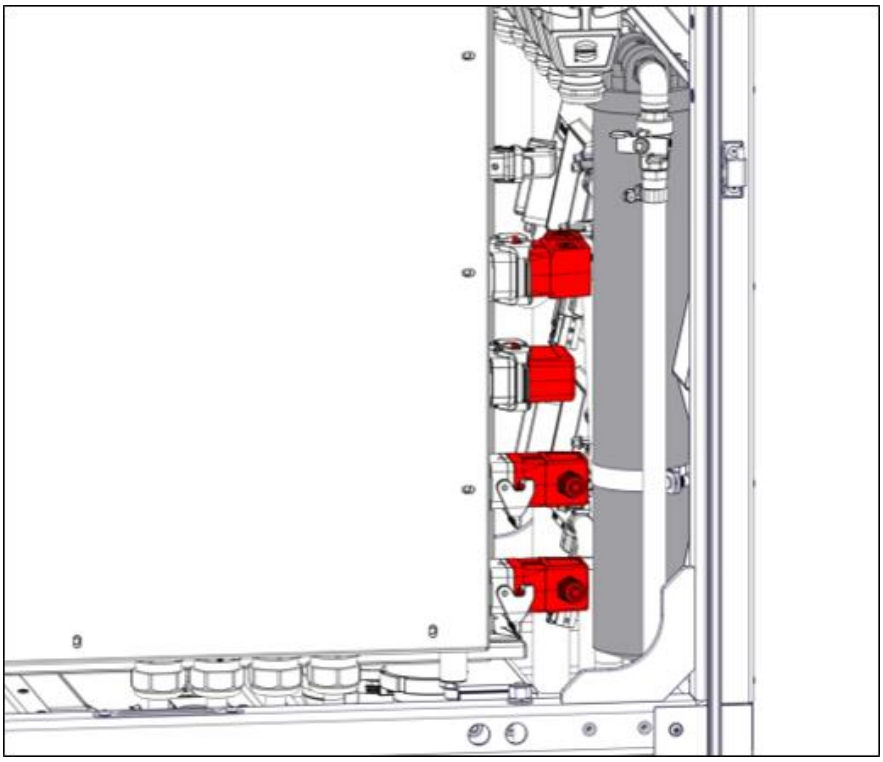


Figure 8-208: overview of connectors in HV panel

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4. To get service access, disconnect all connectors in the low voltage panel.



Figure 8-209: Overview of all connectors in LV panel

5. Shut off the DI filter isolation valves.
6. Install special tool kit (7500211) on the DI filter housing. Start by installing the pipe adaptor and then the plastic pipe into the adaptor.

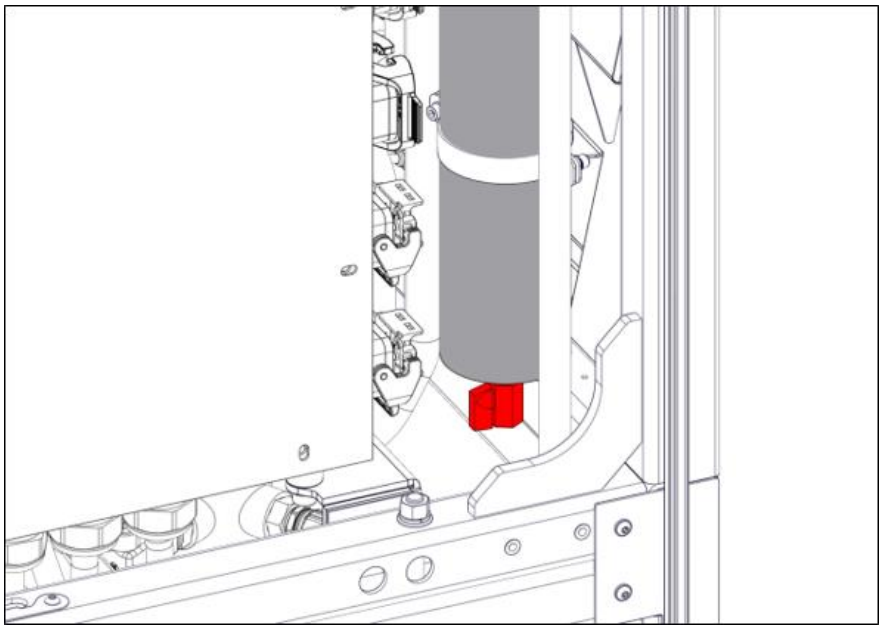


Figure 8-210: Adaptor on the DI filter housing

7. Uninstall 2 pcs. M6 bolts and clamp used for securing the DI filter housing.
8. Remove the DI filter housing nut to release the vacuum in the DI filter housing and drain the DI filter cartridge completely. Then remove the housing.

   Remember to place paper towels below the housing to prevent any spillage.

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9. Shut off the external coolant connection valves to the module.

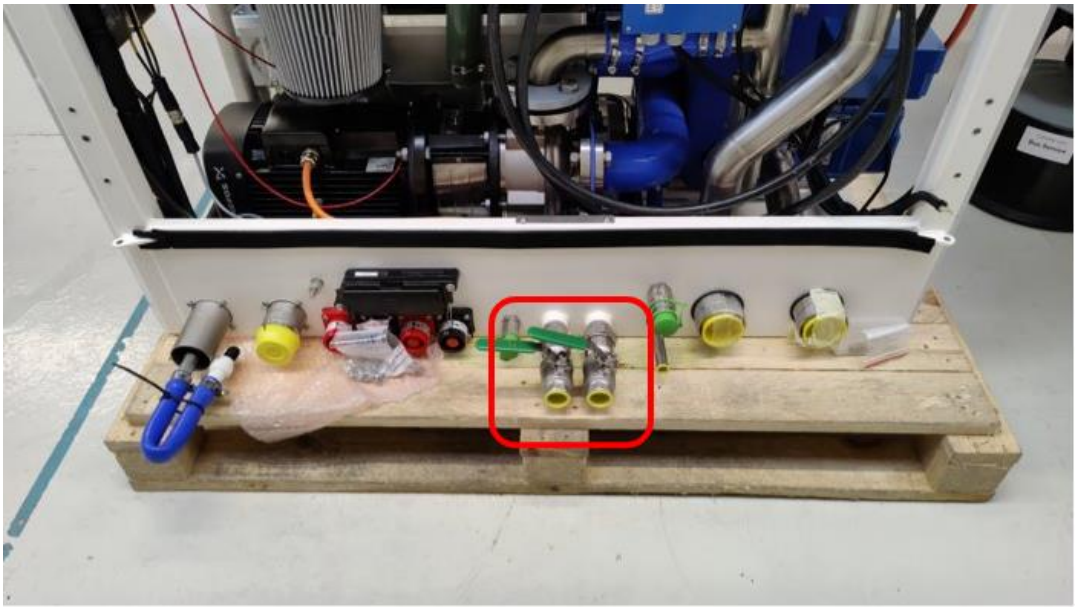


Figure 8-211: External coolant connection valves

10. Open the vent plug deaerator of the coolant loop which is located near the motor controllers.

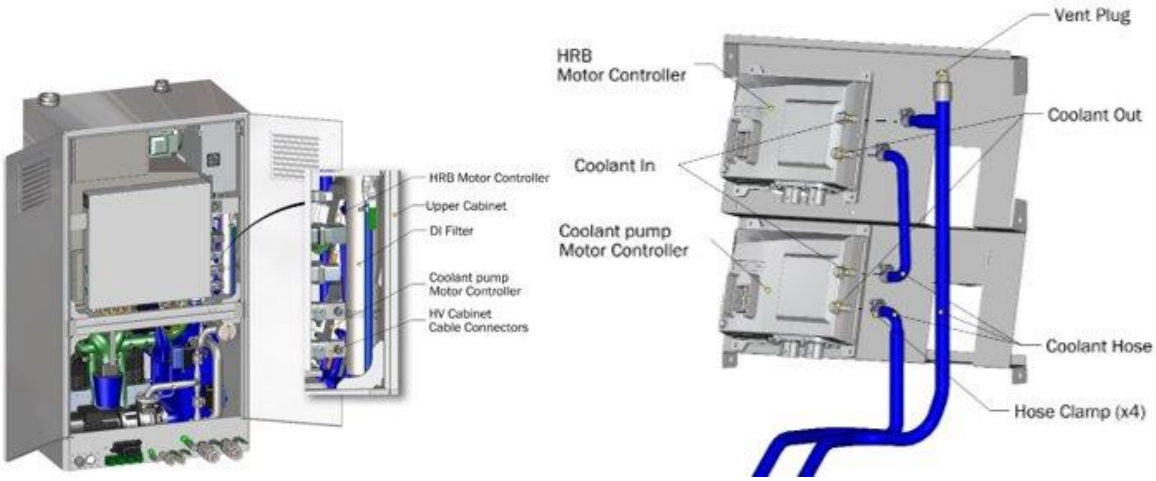


Figure 8-212: Overview of vent plug deaerator

11. Use the drain/fill dry plug, located just left of the external coolant connection valves, and drain the LT coolant system.
12. Release 4 pcs. hose clamps on the LT coolant hoses connected to the motor controllers and remove the hoses.
13. Remove all electronic connections from the HRB motor and the coolant pump controller.

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14. Press the clip to remove both communication port connections (INV_H50 & INV_D10) from the motor controllers.

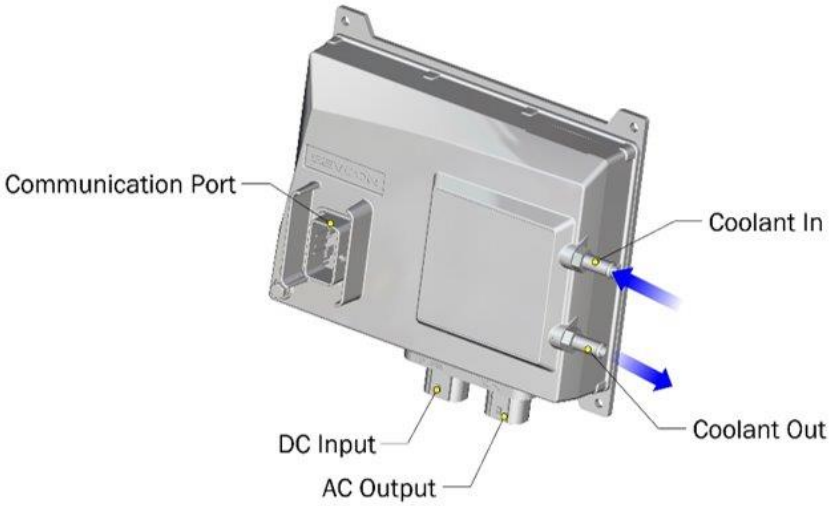


Figure 8-213: Comm port, DC input & AC output on motor controller

15. Press the tab and slide the lock bottom to remove the DC input connector plugs.
16. Press the tab and slide the lock bottom to remove the AC output connector plugs.
17. Remove 4 pcs. M6 studs, washers and nuts used to tighten the controllers to the bracket in the upper cabinet.

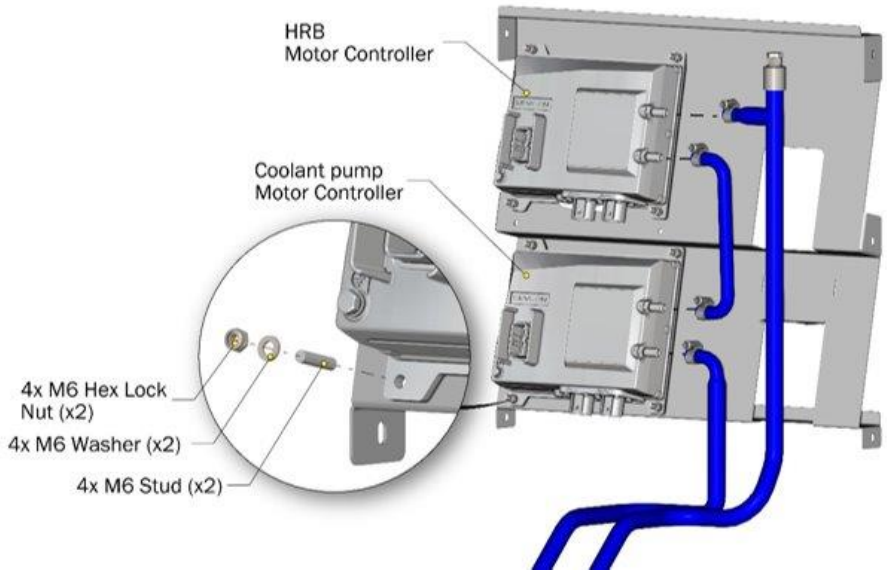


Figure 8-214: Controller studs on bracket

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Assembling procedure:

1. Use new M6 nuts and washers to install the new controllers.
2. Connect the LT cooling hoses and secure with hose clamps. Tighten to 3.5 Nm. Remember to tighten the vent plug.
3. Connect the communication port, the DC and AC cables to the controller.
4. Install the DI filter cartridge. Use the special key to tighten the housing ring.
5. Use 2 pcs. M6 bolts to install the clamp securing the DI filter housing.
   Ensure the drain valve handle is accessible.
6. Open the DI filter isolation valves.
7. Connect the following connectors to the low voltage panel; CN100, CN101, CN300, CN303, CN400.
8. Connect the following connectors to the high voltage panel; CN201, CN202, CN500, CN505.
9. Mount the right-side bracket on the high voltage panel.
10. Use 3 pcs. M8x30 bolts and washers to secure the bracket to the frame.

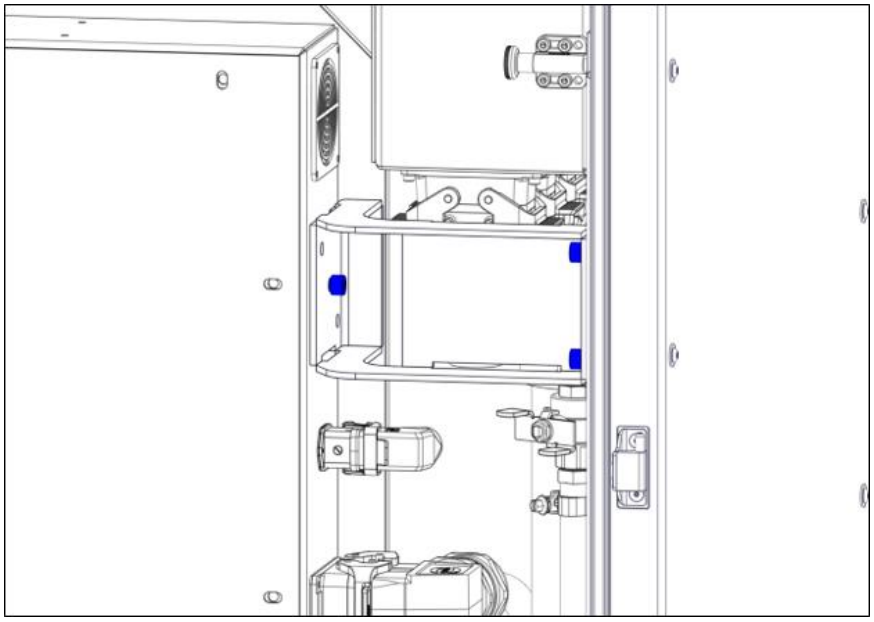


Figure 8-215: Securing bracket to frame

11. Use 12 pcs. M5x10 bolts and washers to install the high voltage panel cover.
12. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
13. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
14. Check and refill (using new coolant) the coolant level. Run the HT cooling system degas procedure. (refer to 8.4.9).
15. Log into the engineering interface with supplied username and password and reset the hour counter for the DI filter cartridge.
16. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.6.5 Replace Air Compressor Controllers

Purpose

The procedure describes how to replace the air compressor controllers for the FCwave module. These controllers have a built-in inverter, cooling channels, and interface connections to energize the air compressor unit.

Responsibilities

Preventive maintenance of the air compressor controllers is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment

A list of parts and special equipment is identified to replace the motor controllers during the life and operation of the FCwave module.

- FRU, Gen3 Air Compressor Inverter 2.0B (part no. 7500360)
- FRU, Inverter 2.0B, Adaptor Cable (part no. 7500361)

Safety

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Air Compressor Controllers

Based on the normal conditions, the estimated time for replacement is:

Air Compressor Controllers		
Duration	10 hours	
Personnel	1	
Tightening Torque	M6 bolt	10 ± 0.5 Nm
	M10 nut	50 ± 5 Nm
	Fitting 1/4"	15 ± 0.5 Nm
	Tools	Flathead screwdriver, 5mm hex bit, bent nose pliers, hose clamp pliers, 7mm hex socket flexible screwdriver, wire cutter, 15mm hex socket, clip removal tool, 5mm torx bit

Table 8-32: Time to replace air compressor controllers

Note

Based on the module, the installed inverter will be either 'Inverter 2' or the updated 'Inverter 2.0B'. The disassembling procedure will show/tell the procedure for both, while the assembling procedure will only instruct how to install a new inverter (Inverter 2.0B).

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Disassembling procedure for 'Inverter 2':

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Shut off the external coolant connections valves to the module.
3. Locate the air compressor controllers in the lower cabinet next to the air compressors.

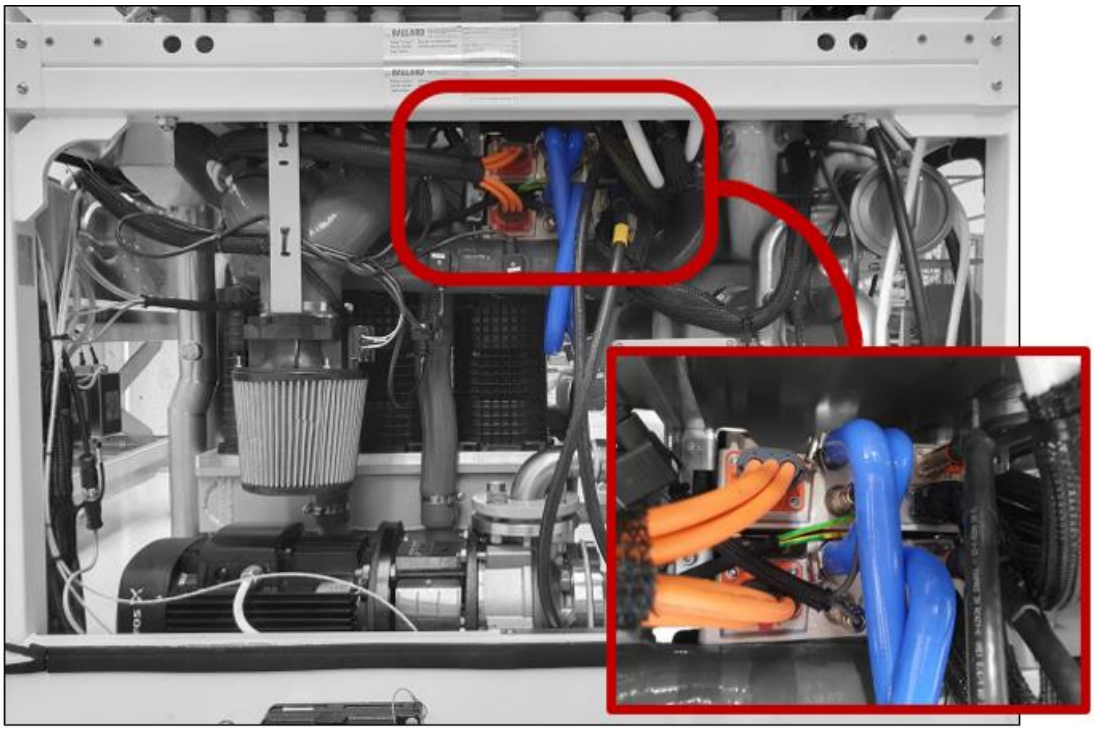


Figure 8-216: Location of air compressor controllers

4. Disconnect the HRNS-400-AC output connector plugs by pulling back and pressing the red clip.

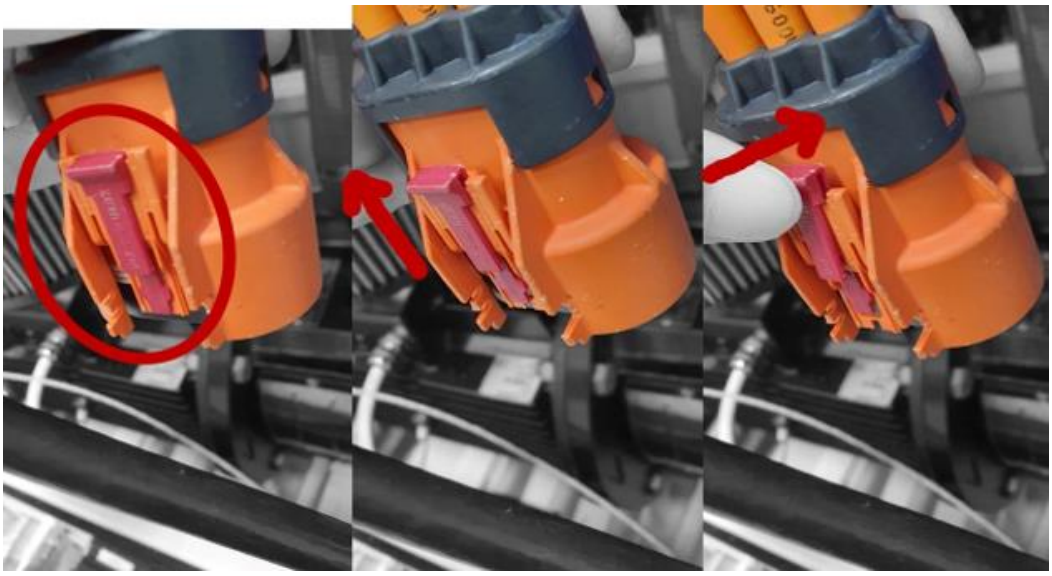


Figure 8-217: Disconnecting the HRNS-400-AC output connector

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5. Use a flathead screwdriver to press the clip away from the connector to disconnect the HRNS-400-CN-INV_A11A and the HRNS-400-CN-INV_A11B plug.
6. Disconnect the HRNS-400-DC Input connector plugs by pushing in and pressing down the orange piece on the clip to uninstall.



Figure 8-218: Disconnecting the HRNS-400-DC input connector

7. Remove the grounding wire terminals.
8. To carefully loosen and remove the air compressor sensor connector plugs, turn the knurled nut with a bent nose pliers.

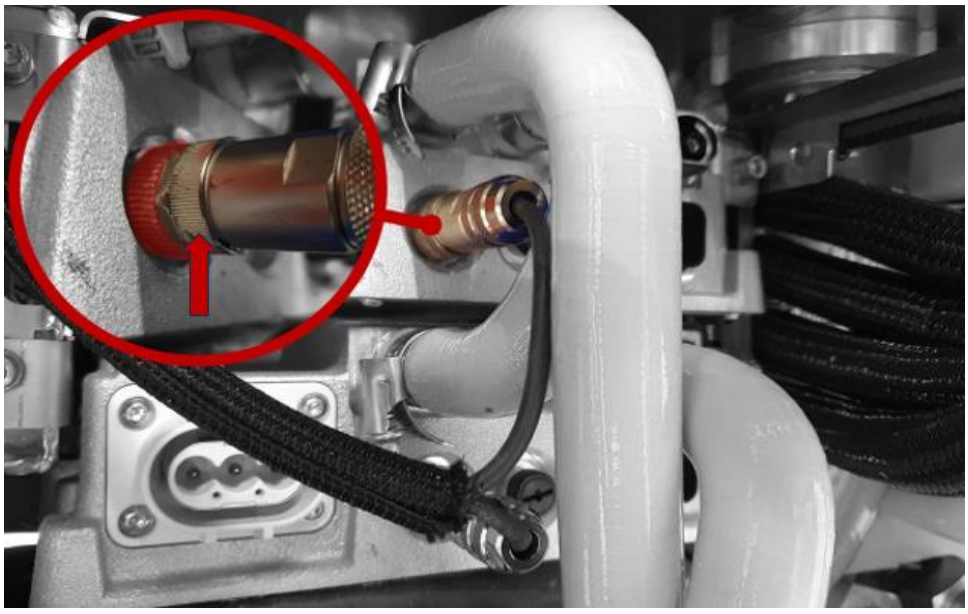


Figure 8-219: Remove air compressor sensor connector plugs

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9. Clamp the LT coolant inlet hose and the LT outlet hose for the two controllers with hose clamp pliers. DO NOT clamp the hose that connects them serially.
10. Release 4 pcs. hose clamps on the LT coolant hoses connected to the compressor controllers and remove the hoses.

    Place an open container below the hoses to collect the coolant and prepare towers to wipe off possible coolant spillage.

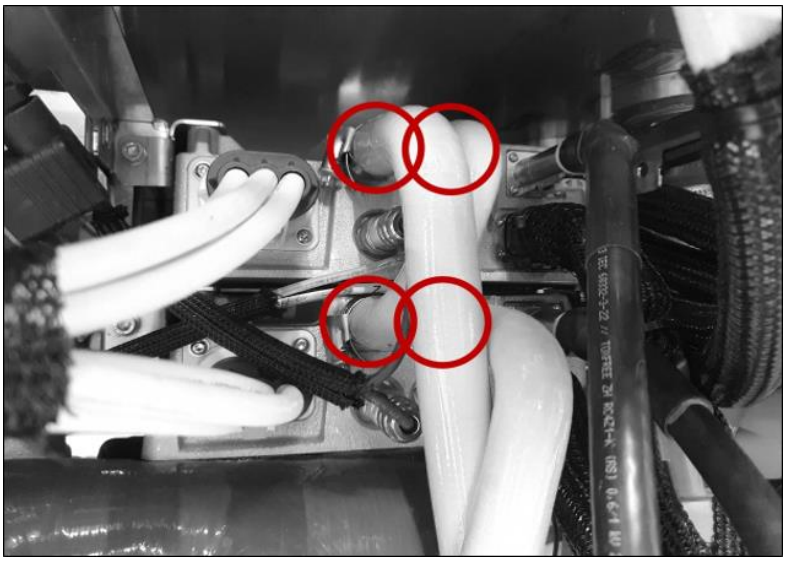


Figure 8-220: Hose clamps on LT coolant hoses

11. In the HV panel, cut the 4 pcs. zip ties for harness B+ and B- connected to the HV contractors on the A2/+ side.

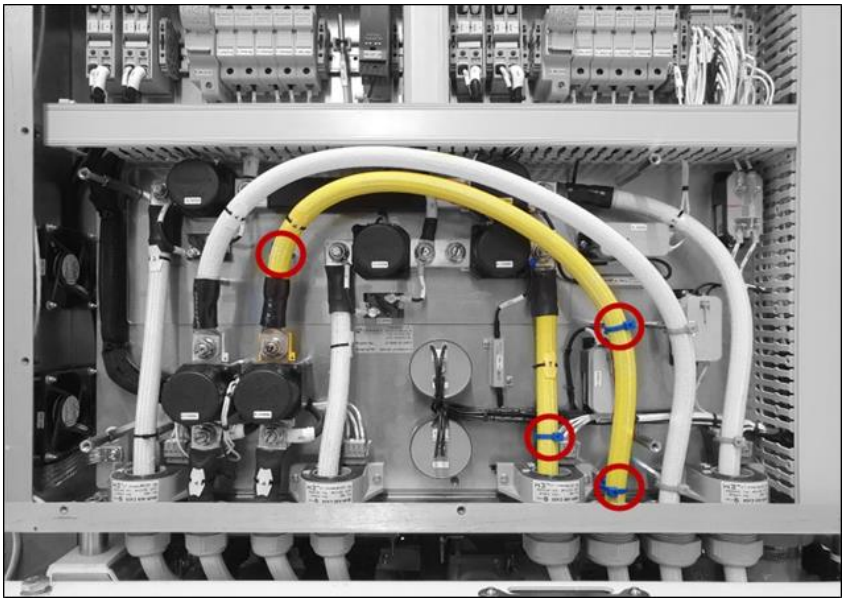


Figure 8-221: Zip ties in the HV panel

12. Uninstall 2 pcs. M10 nuts and remove harness B+ and B- from the HV contactor studs A2/+.

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13. Carefully pull out a bit of the harnesses out of the HV panel, enough to make room for sliding out the air compressor controllers.
14. Support controller B (the bottom one) from below to make sure it does not drop and remove the lower 2 pcs. M6 bolts used to tighten the controller to the bracket in the lower cabinet.

    There might be leftover coolant in the controller.
15. Slide out controller B from the lower cabinet and remove it.
16. Remove the upper 2 pcs. M6 bolts used to tighten the controller to the bracket in the lower cabinet.
17. Remove controller A by pulling it out a little where the bolt head will obstruct the controller. Gently use the clip removal tool to force the bracket around the bolt head.

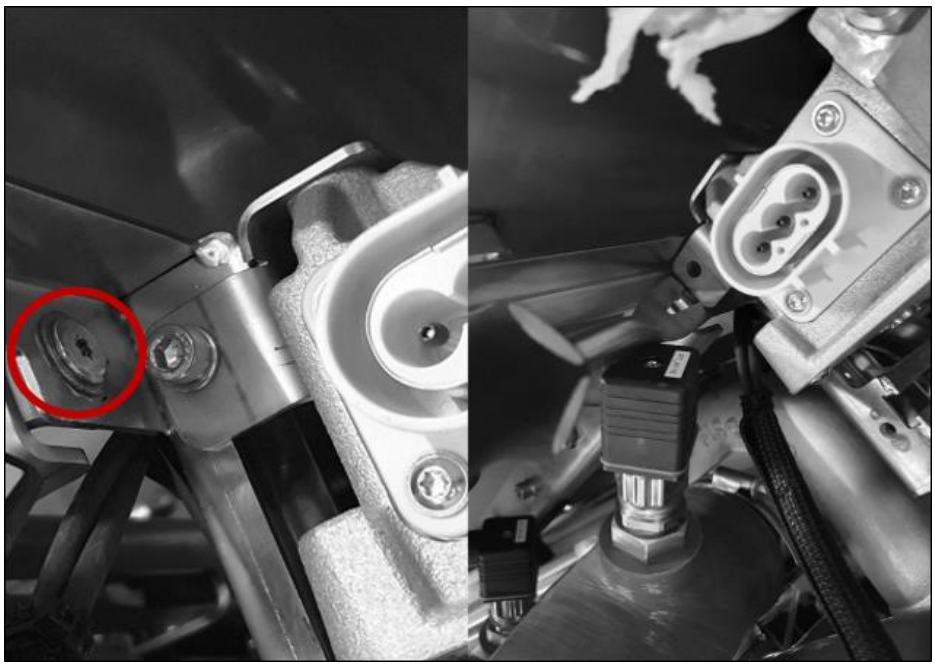


Figure 8-222: Bolt head in the way, removal of A controller

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18. Carefully push up the back of controller A, so the two pins at the rear sits on top of the rails and then slide out the controller.



Figure 8-223: Removal of controller A

19. Remove 12 pcs. M6 bolts used to tighten the left and right mounting bracket to the controller.

Disassembling procedure for 'Inverter 2.0B':

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Shut off the external coolant connections valves to the module.
3. Locate the air compressor controllers in the lower cabinet next to the air compressors.
4. Disconnect the HRNS-400-AC output connector plugs by pulling back and pressing the red clip.

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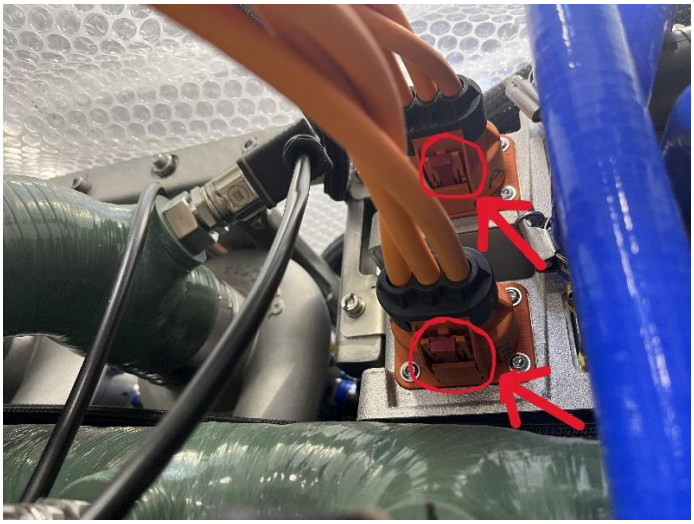


Figure 8-224: Red clip on HRNS-400-AC output connector

5. Disconnect the HRNS-400-DC Input connector plugs from both controller by pushing in and pressing down the orange piece on the clip to uninstall.

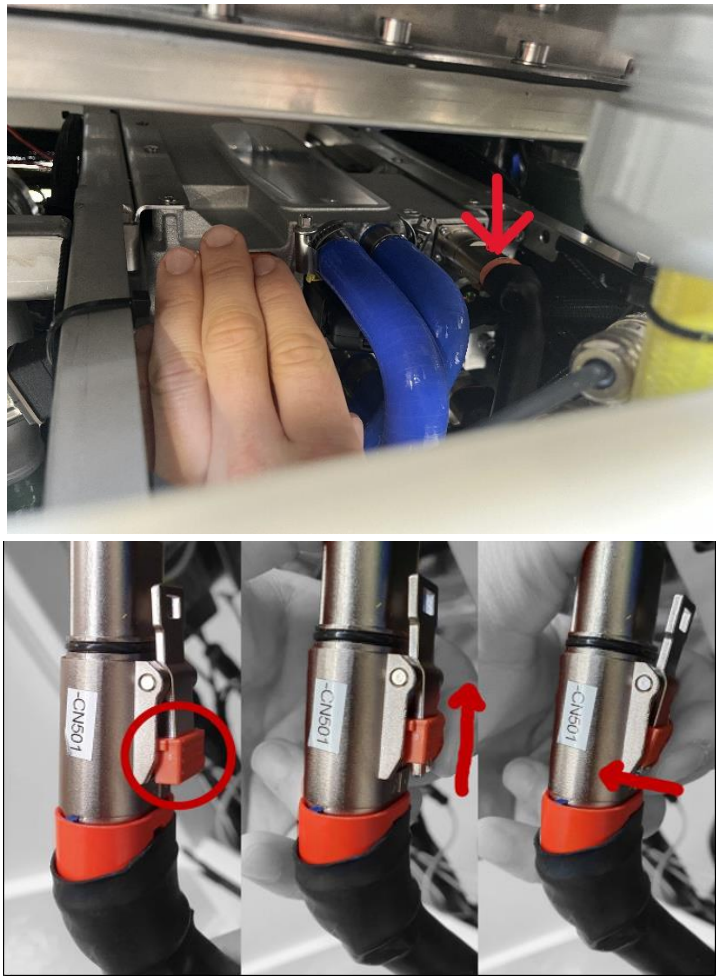


Figure 8-225: Disconnecting the HRNS-400-DC input connector

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6. Use a flathead screwdriver for the connector clip to disconnect the LV and sensor connector (HRNS-400-CN-INV_A11A & HRNS-400-CN-INV_A11B) from the controller.

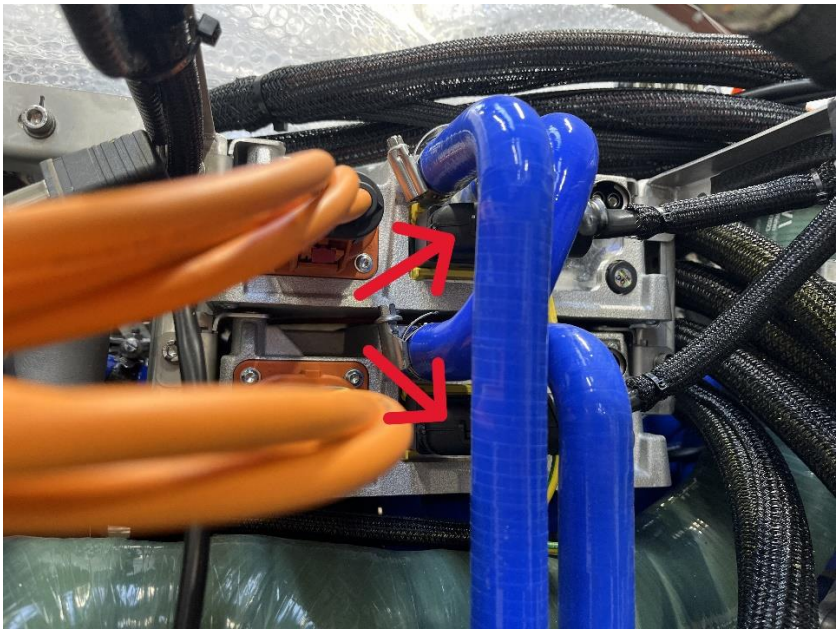


Figure 8-226: Disconnecting the LV and sensor connector plugs

7. Remove the grounding wire terminals.
8. Clamp the LT coolant inlet hose and the LT outlet hose for the two controllers with hose clamp pliers. DO NOT clamp the hose that connects them serially.
9. Release 4 pcs. hose clamps on the LT coolant hoses connected to the compressor controllers and remove the hoses.

   Place an open container below the hoses to collect the coolant and prepare towers to wipe off possible coolant spillage.

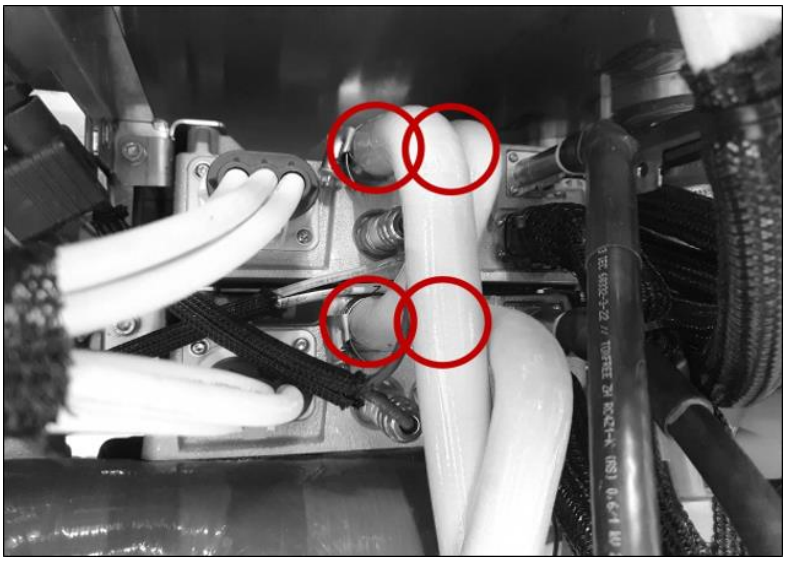


Figure 8-227: Hose clamps on LT coolant hoses

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10. In the HV panel, cut the 4 pcs. zip ties for harness B+ and B- connected to the HV contractors on the A2/+ side.

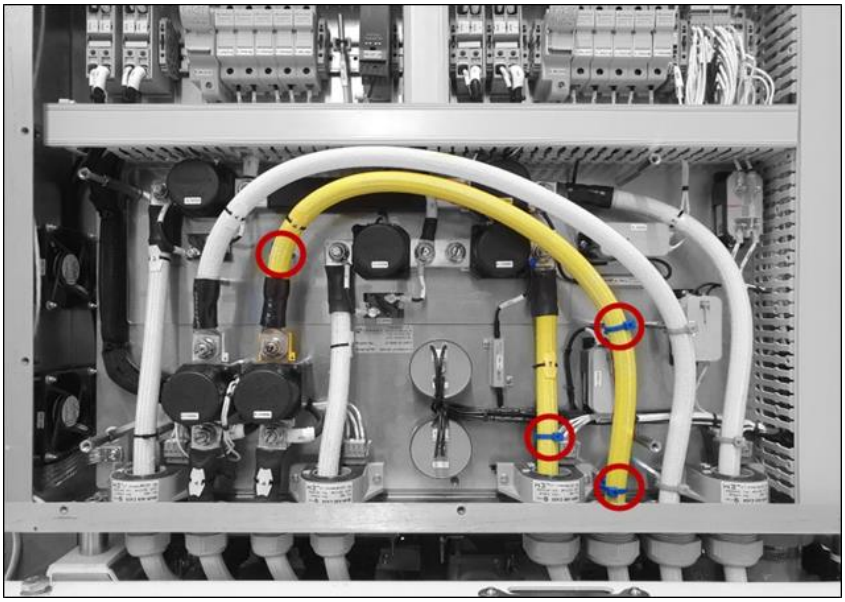


Figure 8-228: Zip ties in the HV panel

11. Uninstall 2 pcs. M10 nuts and remove harness B+ and B- from the HV contactor studs A2/+.
12. Carefully pull out a bit of the harnesses out of the HV panel, enough to make room for sliding out the air compressor controllers.
13. Support controller B (the bottom one) from below to make sure it does not drop and remove the lower 2 pcs. M6 bolts used to tighten the controller to the bracket in the lower cabinet.

    There might be leftover coolant in the controller.
14. Slide out controller B from the lower cabinet and remove it.
15. Remove the upper 2 pcs. M6 bolts used to tighten the controller to the bracket in the lower cabinet.
16. Remove controller A by pulling it out a little where the bolt head will obstruct the controller. Gently use the clip removal tool to force the bracket around the bolt head.

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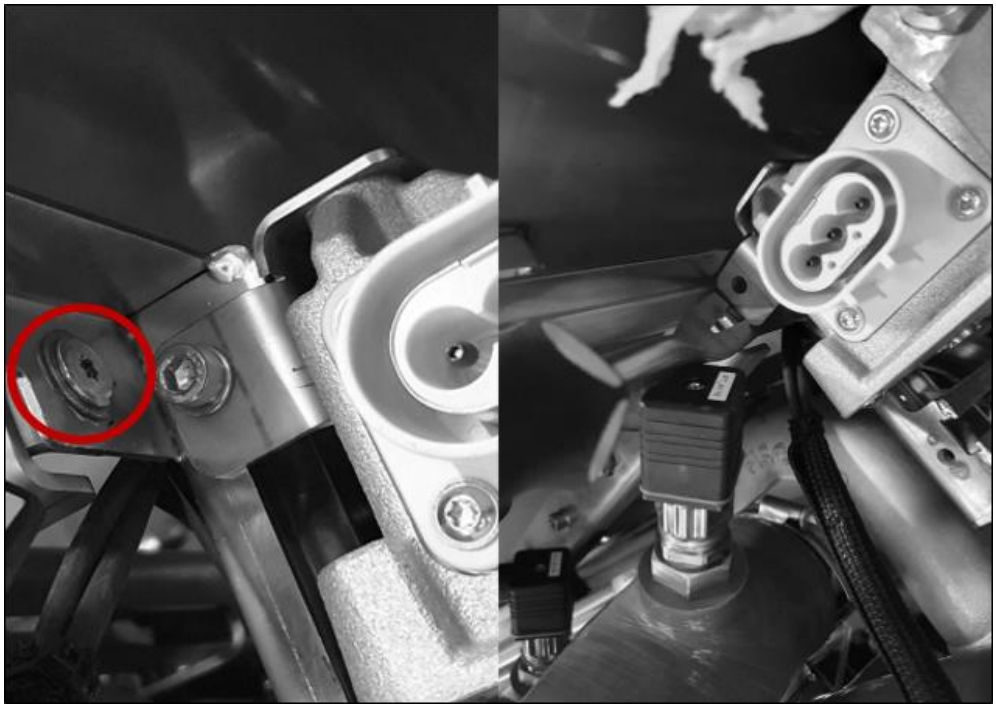


Figure 8-229: Bolt head in the way, removal of A controller

17. Carefully push up the back of controller A, so the two pins at the rear sits on top of the rails and then slide out the controller.



Figure 8-230: Removal of controller A

18. Remove 12 pcs. M6 bolts used to tighten the left and right mounting bracket to the controller.

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Assembling procedure:

1. With the pins facing away from the connector side, use 12 pcs. M6 bolts to install the mounting brackets for the two air compressor controllers.
2. Install controller A, with connectors facing down/out, in the upper slot by inserting it at an angle from below, so the pins sit on top of the rails.
3. Slide in controller A and gently force the bracket around the obstructing bolt head with a clip removal tool. Also ensure that the pins at the rear will fall into place.
4. Install 2 pcs. M6 bolts to tighten the controller to the bracket in the lower cabinet.

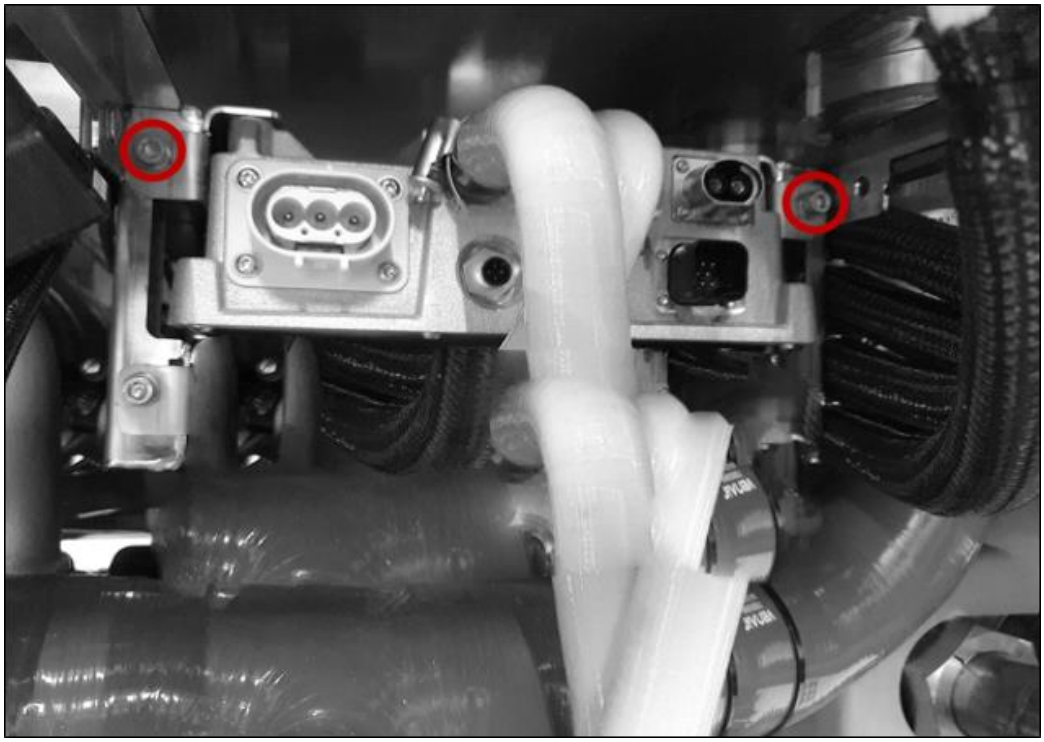


Figure 8-231: Install controller A

5. Slide in controller B in the slot below controller A. Then install 2 pcs. M6 bolts to tighten the controller to the bracket in the lower cabinet.

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6. Install the coolant hoses to the controllers and tighten 4 pcs. hose clamps.

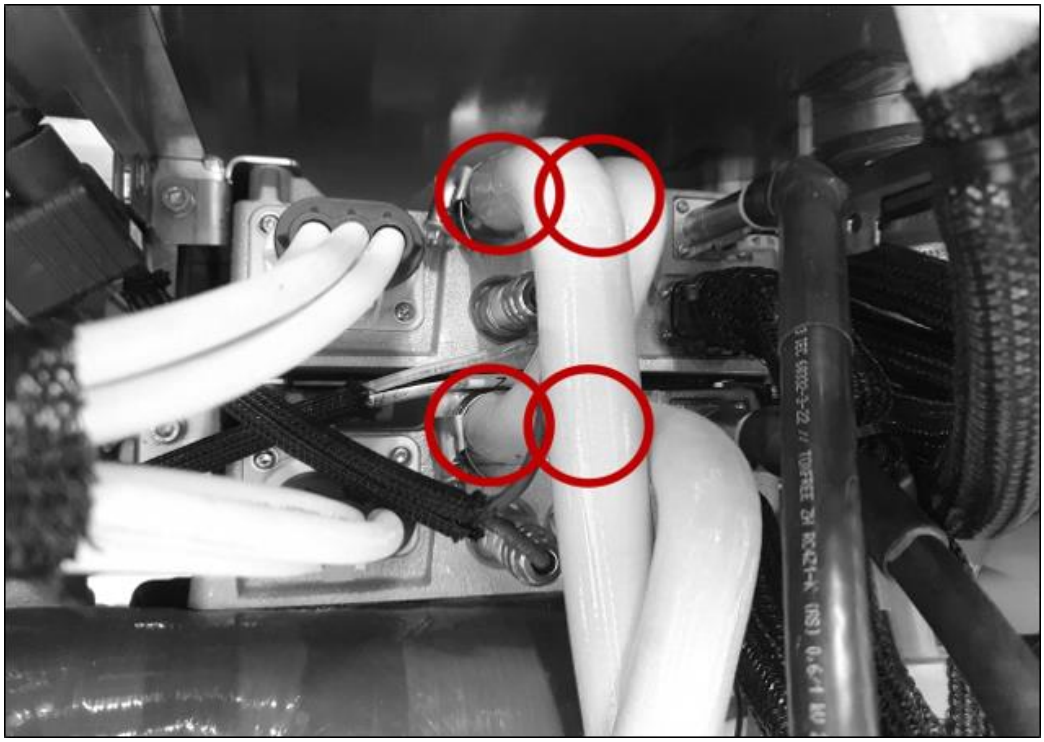


Figure 8-232: Install coolant hoses on controller

7. Install the grounding wire with M6 bolts.
8. Connect the LV and sensor connector plug (HRNS-400-CN-INV_A11A & HRNS-400-CN-INV_A11B) to the controllers.

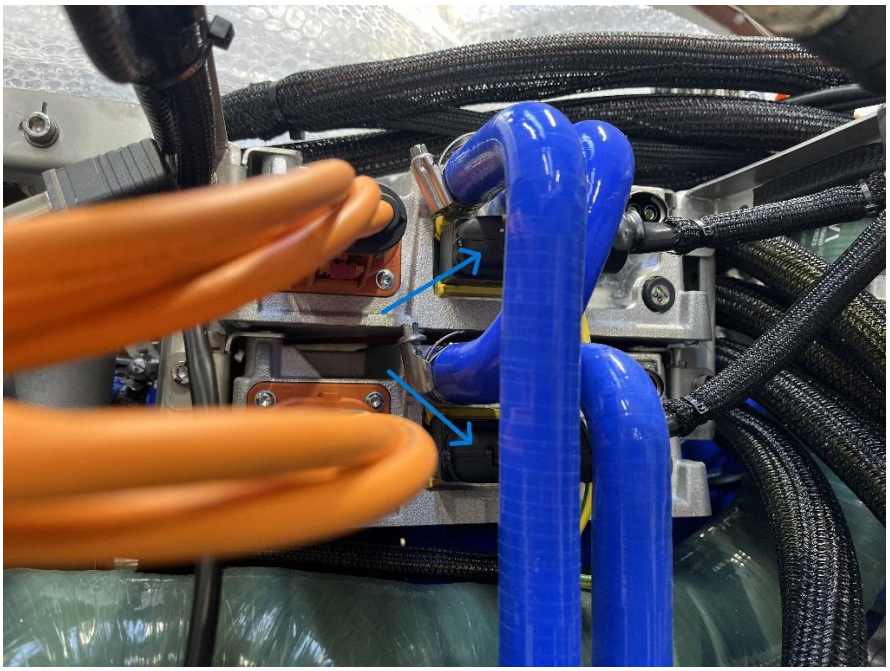


Figure 8-233: Install the LV and sensor connector plugs

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9. In the top right corner of the controllers, install the HRNS-400-DC input connector plugs by pushing in and then press down the orange piece to connect it.

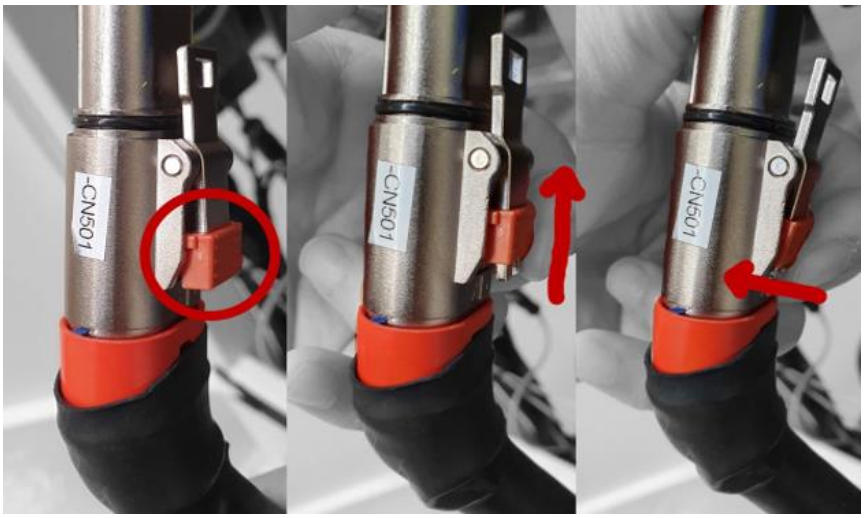


Figure 8-234: Install the HRNS-400-DC plugs

10. Install the HRNS-400-AC output connector plugs by pushing in and press in the red clip to lock the connector.

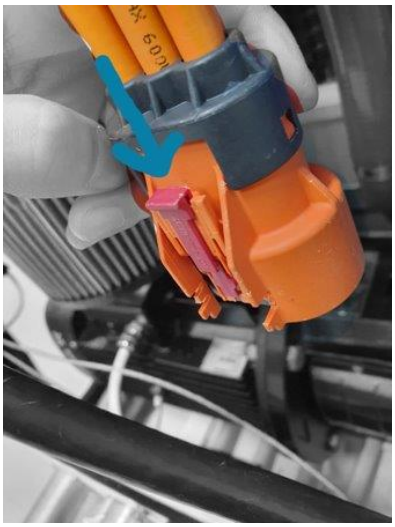


Figure 8-235: Install the HRNS-400-AC plugs

11. In the HV panel, use M10 nuts to install the B+ harness, B- harness and the pre-charge resistor's ring terminal.
12. Tighten the harnesses with 4 pcs. cable ties and cut off excess length.

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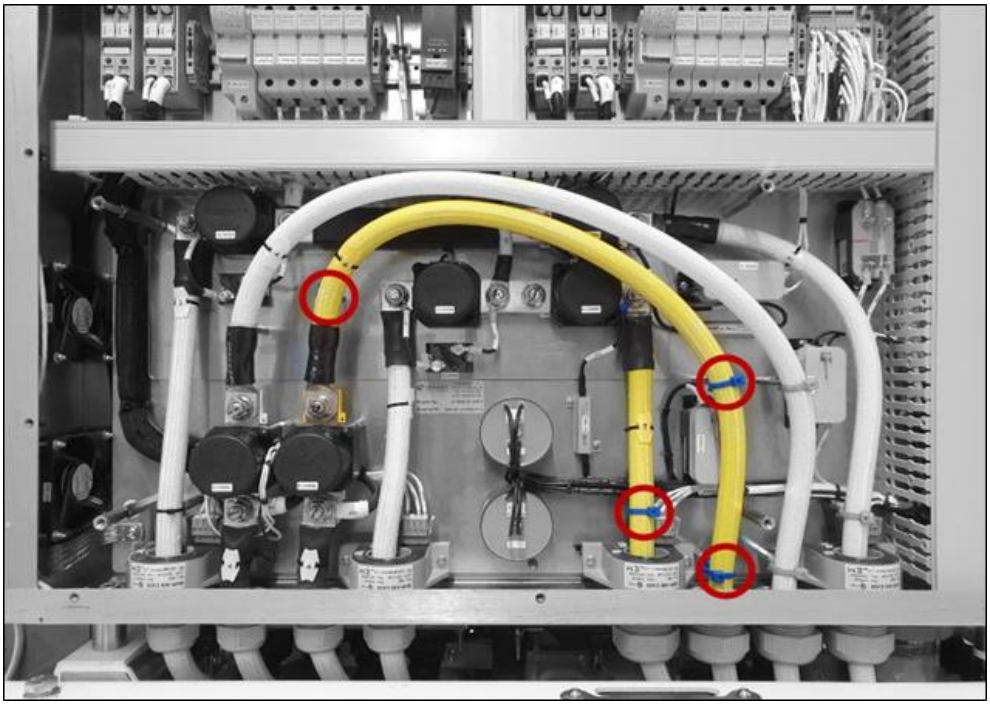


Figure 8-236: Install cable ties on harnesses

13. Use 12 pcs. M5 bolts to install the high voltage panel cover.
14. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
15. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
16. Connect a portable pump secured with mechanical relief valve to the connector, to fill the module with LT coolant as necessary.
17. Open the vent plug deaerator in the coolant loop located near the motor controllers.

    Pay attention to release the 1/4" vent plug slowly to prevent any coolant spillage in the cabinet, while filling procedure and then tighten to specified torque value.
18. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.6.6 Replace Current Transducer

Purpose

The procedure describes how to replace a current transducer for the FCwave module. There are four current transducers installed in the High voltage (HV) panel assembly.

Responsibilities

Preventive maintenance of the current transducer is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment

A list of parts and special equipment is identified to replace the motor controllers during the life and operation of the FCwave module.

- FRU, DHR 400 C420 Current Measurement KIT (part no. 7500115)

Safety

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Current Transducer

Based on the normal conditions, the estimated time for replacement is:

Current Transducer		
Duration	1 – 1½ hours	
Personnel	1	
Tightening Torque	M4 bolt	3.5 ± 0.5 Nm
	M10 nut	50 ± 5 Nm
	Tool: 3mm hex key, cross-head screwdriver, cutting pliers, 10mm socket + 15mm socket, torque wrench	

Table 8-33: Time to replace current transducer

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate all 4 current transducers in the high voltage panel.

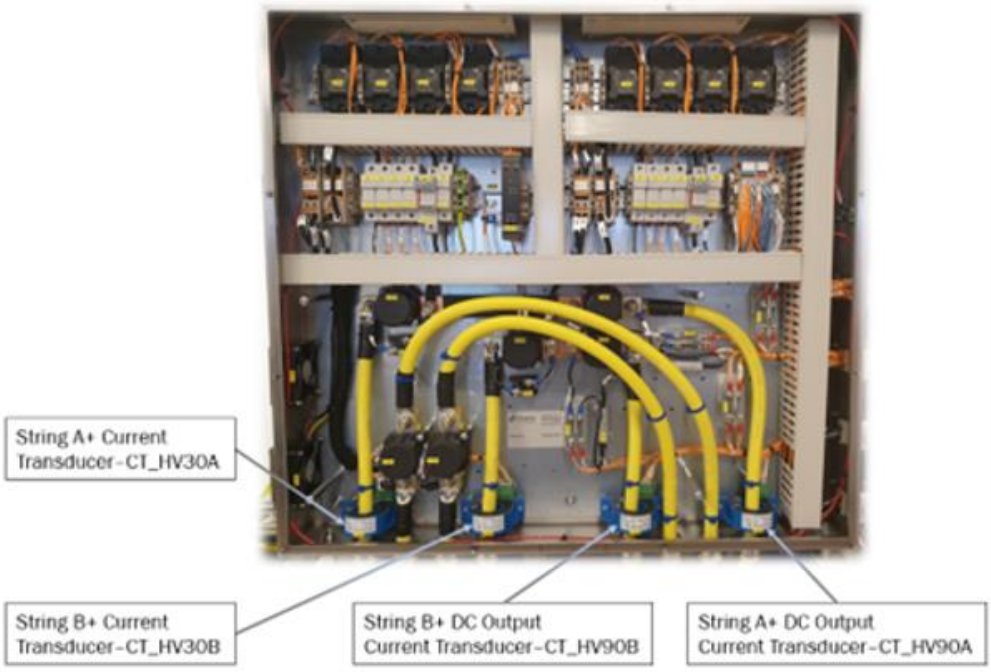


Figure 8-237: Overview of current transducers

As the process is the same for all current transducers, only 1 will be showcased in the following process, replacing 'CT_HV30A' on 'A+ String'.

3. Uninstall the M10 nut of the HV stack contactor K_HV30A connected to the bus bar.
4. Remove the cable ties install on the mounting bracket of the current transducer and loosen 2 pcs. M4 bolts on the mountings.



Figure 8-238: Cable ties on a current transducer

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5. Disconnect the current transducer's connector (CN-CT_HV30A) and remove the current transducer from the high voltage bus bar by sliding it up and out.



Figure 8-239: Current transducer's connector

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Assembling procedure:

1. Slide on the new current transducer and connect to harness HRNS-882.
2. Secure the transducer with 2 pcs M4 bolts. Tighten to 3.5 Nm. Then secure the A+ stack output cable with the M10 nut. Tighten to 25 Nm.
3. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
4. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
5. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
6. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.6.7 Replace a Voltage Contractor

Due to late changes, this section will be included in the next revision.

8.6.8 Replace a Voltage Transducer

Due to late changes, this section will be included in the next revision.

8.6.9 Replace a Fuse

Due to late changes, this section will be included in the next revision.

8.6.10 Replace a Bleed Down and Precharge Resistor

Due to late changes, this section will be included in the next revision.

8.6.11 Replace a Diode

Due to late changes, this section will be included in the next revision.

8.6.12 Replace an Electrical Panel Ventilation Fan

Due to late changes, this section will be included in the next revision.

8.6.13 Reset a LV Electronic Circuit Breaker

Due to late changes, this section will be included in the next revision.

8.6.14 Replace a HV Panel Assembly

Due to late changes, this section will be included in the next revision.

Parts and equipment

A list of parts and special equipment is identified to replace the motor controllers during the life and operation of the FCwave module.

- FRU, HV Panel (part no. 7500128)

8.6.15 Replace a LV Panel Assembly

Due to late changes, this section will be included in the next revision.

Parts and equipment

A list of parts and special equipment is identified to replace the motor controllers during the life and operation of the FCwave module.

- FRU, LV Panel (part no. 7500130)

8.6.16 Replace a Module Controller Unit (MCU)

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8.7 Cabinet and Customer Interface Sub-system

8.7.1 Replace Intake Air Filter

Purpose

The procedure describes how to check and replace the air filter for the FCwave module. The filters installed on the front panel of the cabinet clean the intake air from NOx, Sox, salts, and other chemicals entering the module.

Responsibilities

Preventive maintenance of the air filters is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment

A list of parts and special equipment is identified to replace the air filters during the life and operation of the FCwave module.

- FRU, Intake Air Filters (part no. 7500162)

Safety

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Intake Air Filter

Based on the normal conditions, the estimate time for replacement is:

Intake Air Filter		
Duration	10 – 15 min	
Personnel	1	
Tightening Torque	M6 nut	10 ± 0.5 Nm
	Tool: 5mm hex key, 10mm flex head ratcheting combination wrench	

Table 8-34: Time to replace intake air filter

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-3 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the 2 air intake filter frames on the front panel of the cabinet.
3. Uninstall 8 pcs. M6 nuts used to tighten the filter back frame to the inside of the cabinet doors and remove the filter.

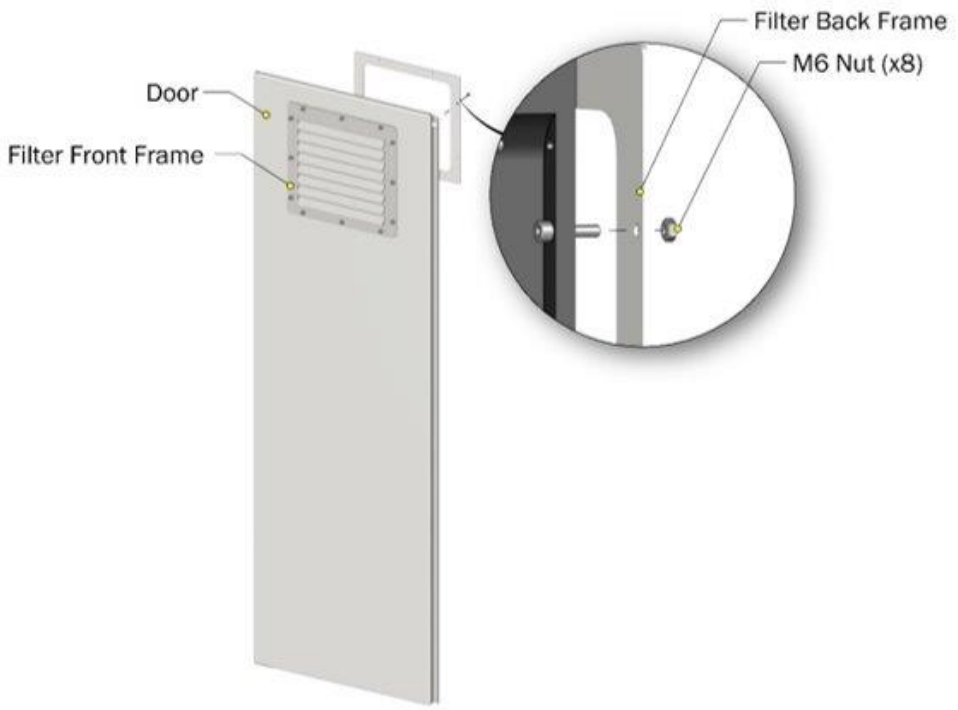


Figure 8-240: Overview air intake filter

4. Examine the air intake filter for cleanliness and check for blockages or unwanted material around it.

Assembling procedure:

1. Use 8 pcs. M6 nuts to tighten the filter back frame to the inside of the cabinet door.
2. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.7.2 Cabinet Water Ingress Sensor

8.7.2.1 Check Cabinet Water Ingress Sensor

Purpose:

The procedure describes how to check a cabinet water ingress sensor in the FCwave™ module. The sensor monitors for water ingress in the cabinet and will trigger a warning alarm when it encounters liquid.

Responsibilities:

Checking the water ingress sensor functionality is necessary for safe operation according to the maintenance plan (refer to the customer portal) or after a replacement. It is the end user's responsibility to do preventive maintenance, as stated in section 8.1.1.

Safety:

Refer to section 8.1.2 to follow the instructions.

Estimated time to check the Cabinet Water Ingress Sensor

Based on the normal conditions, the estimated time for check is:

Cabinet Water Ingress Sensor	
Duration	10 min
Personnel	1
Tools	4mm hex key

Table 8-35: Time to check differential pressure switch

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Procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Connect the low voltage electrical connection (X_E01) and secure it by finger-tightening the bolts.
3. Monitor the MCU engineering interface with the module in "Unlocked" state.

   Make sure there are no active alarms.
4. Mounted in the bottom of the of the cabinet frame, locate the water ingress sensor in front of the heat exchanger.

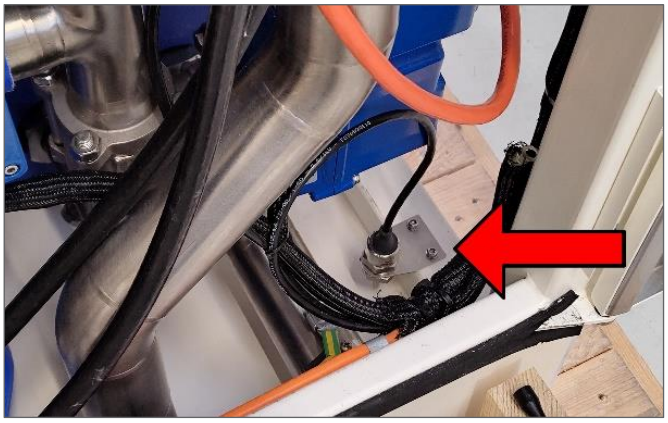


Figure 8-241: Location of water ingress sensor

5. There are 3 different methods to check the sensor. Method A and B avoids disassembly, while method C allows the sensor's electrode to be submerged in a container of liquid. Choose the most suitable.

   Be aware that the high temperature coolant pipes could be hot after a recent system shutdown.

   a) Cover the sensor's electrode as much as possible by hand. The method relies on skin contact and the result can vary depending on coverage area and skin moisture. Wait up to 30 seconds, if there is an alarm, skip to step 6, otherwise try the next method.

   b) Dampen a paper or cloth towel with water and press it against the sensor's electrode, covering as much of it as possible. Wait up to 30 seconds. If there is an alarm, skip to step 6, otherwise try the next method.

   c) Use a 4mm hex to remove 2 pcs. bolts and demount the bracket with the sensor. Cover the sensor's electrode either by hand, a damped towel, or submerge in a container filled with water. Wait up to 30 seconds for the alarm to appear.
6. No matter the method, the alarm should disappear as soon as the sensor's electrode is not in contact with the test medium. Confirm the following warning alarm can be seen in the engineering interface:
   - A1_LSH_Z80_S_10710

   Alarm events are logged and can be found in the "Alarm" tab on the menu to the left side of the engineering interface.

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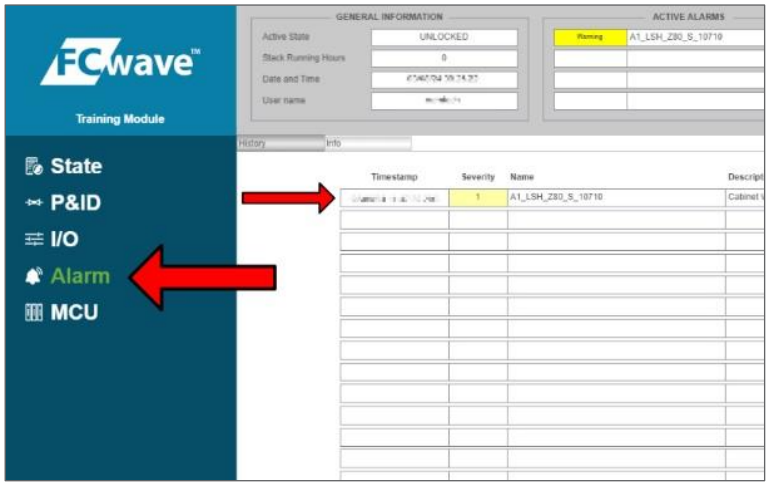


Figure 8-242: Overview alarm water ingress sensor

7. Clean and dry the sensor's electrode. Remount if it was removed.
8. Confirm there are no alarms.
9. The module can be powered down by disconnecting the X_E01 electrical connection and then the module is ready to be restored to normal operating state.
10. Confirm that the module is ready for normal operation and remove local lockout and tagout when work is done.

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8.7.2.2 Replace Cabinet Water Ingress Sensor

Purpose

The procedure describes how to replace the water ingress sensor in the lower cabinet for the FCwave module. The sensor monitors the leakage of water-based liquids like coolants or condensation. The level sensor detects when the water level exceeds the switch point.

Responsibilities

Preventive maintenance of the water ingress sensor is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment

A list of parts and special equipment is identified to replace the water ingress sensor during the life and operation of the FCwave module.

- FRU, Sensor, Cabinet Water Ingress (part no. 7500151)

Safety

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Water Ingress Sensor

Based on the normal conditions, the estimated time for replacement is:

Water Ingress Sensor		
Duration	15 – 30 min	
Personnel	1	
Tightening Torque	1/2" sensor fitting	25 ± 0.5 Nm
	Tool: spanner	

Table 8-36: Time to replace water ingress sensor

How to test a level sensor

Inspect the wires, check voltage of the level switch wire with a multimeter set to 20V DC. The level switch must read 24V in presence of water and 0V when there is no water. A poor connection with the signal wire can cause inaccurate readings. Check all wires for any signs of damage and follow the manufacturer instructions.

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Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-4 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Mounted on the cabinet frame bracket, disconnect the water ingress sensor connection (HRNS-601-CN_LSH_Z80).

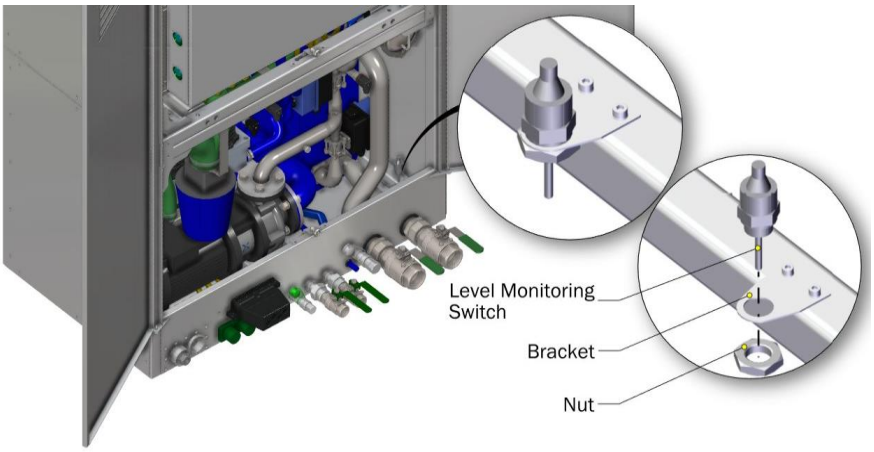


Figure 8-243: Removal of water ingress sensor

3. Use a spanner to remove the sensor.

Assembling procedure:

1. Use a spanner to install the new sensor.
2. Connect the sensor connection and make sure the correct harness is connected by checking the label.
3. Test the new sensor according to the short section just above.
4. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
5. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8 Replace Temperature Sensor

Purpose

The procedures in section 8.8 describe how to replace the temperature sensors for the FCwave module. The module has eight temperature sensors, which measure the temperature of the process air, stack coolant, ventilation outlet, HV panel, and LV panel.

Responsibilities

Preventive maintenance of the temperature sensors is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment

A list of parts and special equipment is identified to replace the temperature sensors during the life and operation of the FCwave module.

- FRU, Sensor, Temperature PT-100, L 50mm, ø 3.5mm (part no. 7500037) x3. For section 8.8.1 + 8.8.2 + 8.8.6
- FRU, Sensor, Temperature PT-100, L 150mm, ø 8mm (part no. 7500090). For section 8.8.3
- FRU, Sensor, Temperature PT-100, L 50mm, ø 8mm (part no. 7500085) x2. For section 8.8.4 + 8.8.5

Safety

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Temperature Sensors

Based on the normal conditions, the estimated time for replacement is:

Temperature Sensors		
Duration	5 – 10 min	
	Except for coolant sensors, which requires 1 hour additional time for draining the coolant circuit	
Personnel	1	
Tightening Torque	M5 bolt	6.5 ± 0.5 Nm
	M6 bolt	10 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	1/2" sensor fittings	25 ± 0.5 Nm
	Tool: 4mm + 5mm + 6mm hex key, 27 mm spanner (x2), crow foot's wrench, cross-head + flathead screwdriver, Phillips bit (PH2), torque wrench, tie cutter, cable ties	

Table 8-37: Time to replace temperature sensors

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8.8.1 Replace the Humidifier Outlet Air Temperature Sensor (TT_A40)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-4 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Uninstall bolt on the connector TT_A40 to uninstall the temperature sensor.

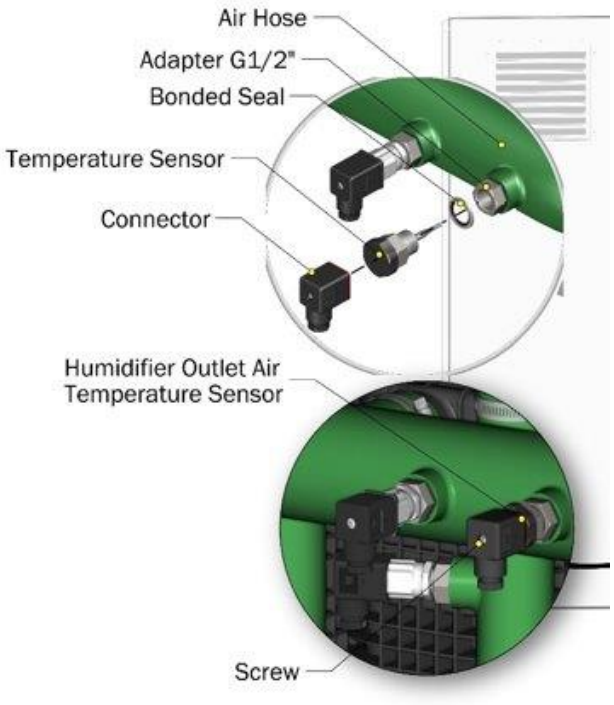


Figure 8-244: Overview of air temperature sensor

3. Uninstall the temperature sensor and the bonded seal washer.

   Remember to use a second spanner for counter turn on the silicon hose fitting to prevent any damage to the threaded insert.

Assembling procedure:

1. Install the new bonded seal washer, insert adaptor G1/2”, and then install the temperature sensor using the bolt. Tighten to 25 Nm.
2. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
3. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8.2 Replace the Stack Outlet Air Temperature Sensor (TT_A50)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-4 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Uninstall bolt on the connector TT_A50 to uninstall the temperature sensor.

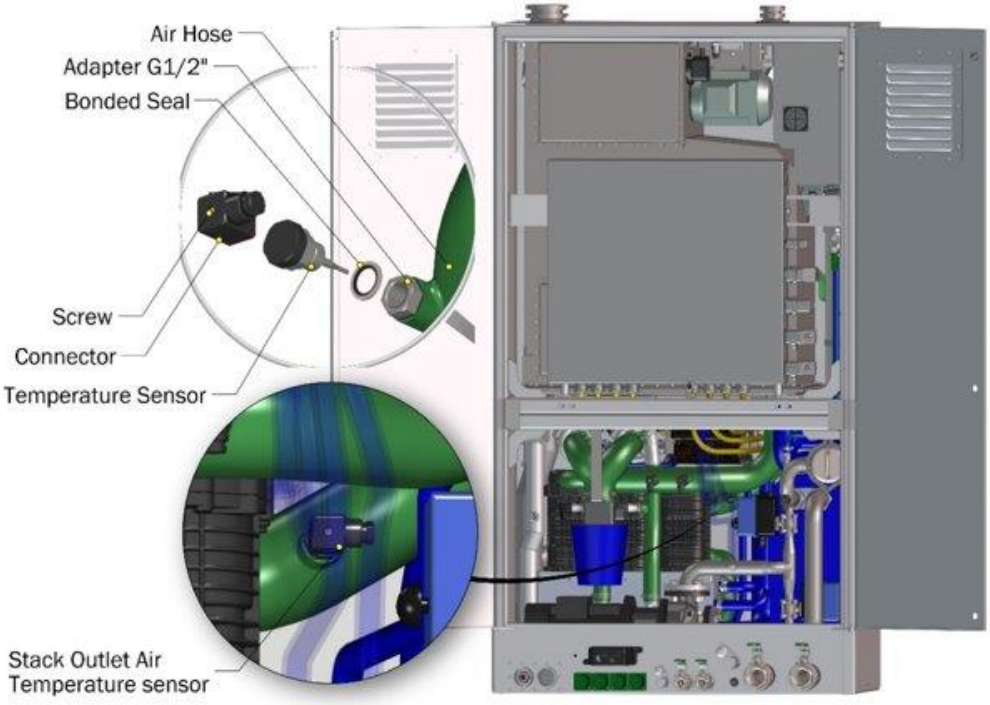


Figure 8-245: Overview of stack outlet temperature sensor

3. Uninstall the temperature sensor and the bonded seal washer.

   Remember to use a second spanner for counter turn on the silicon hose fitting to prevent any damage to the threaded insert.

Assembling procedure:

1. Install the new bonded seal washer and insert the temperature sensor. Tighten to 25 Nm.
2. Install the connector and secure it with the bolt.
3. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
4. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8.3 Replace the Heat Exchange Temperature Sensor (TT_D20)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and steps 1-4 of section 6.5.1 (High Voltage safety check before module maintenance).
2. Drain and purge the LT cooling system.
3. Locate TT_D20 temperature sensor on the control valve assembly in the cooling system.

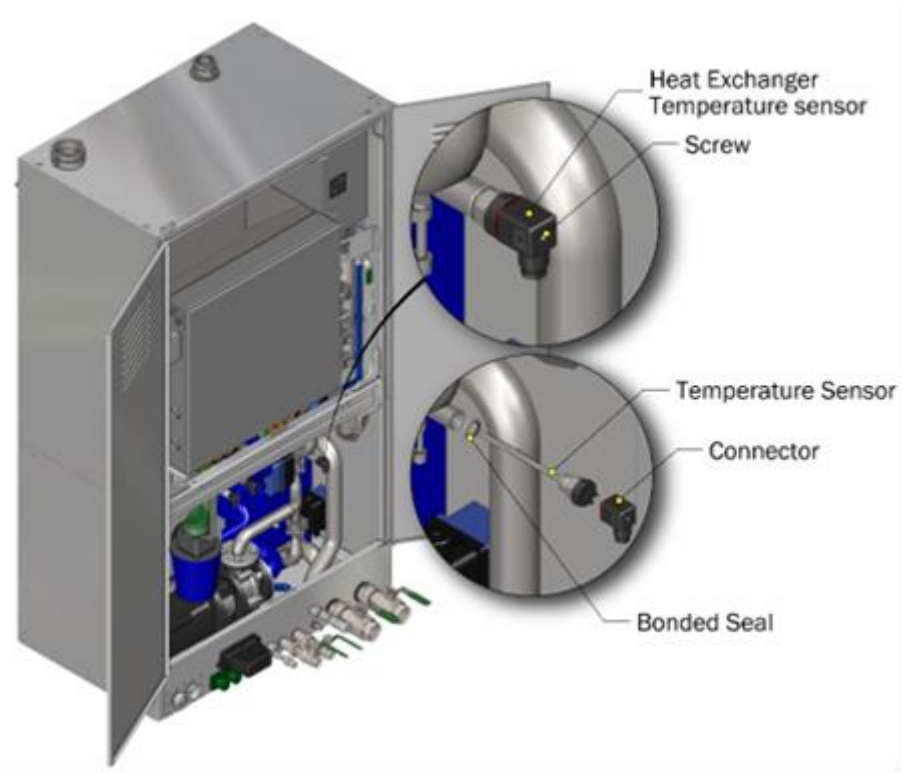


Figure 8-246: Overview of heat exchange temperature sensor

4. Disconnect the HT coolant connections of the module and drain the stack coolant system.
5. Uninstall bolt on the connector TT_D20 to uninstall the temperature sensor.
6. Uninstall the temperature sensor and the bonded seal washer.

   Remember to use a second spanner for counter turn on the silicon hose fitting to prevent any damage to the threaded insert.

Assembling procedure:

1. Install the new bonded seal washer, insert adaptor G1/2”, and then install the temperature sensor using the bolt. Tighten to 25 Nm.
2. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
3. Use the coolant pump to refill the HT coolant system and run the degas procedure (refer to section 8.4.9)
4. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8.4 Replace the Coolant-In Temperature Sensor (TT_D40)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain and purge the high temperature cooling system.
3. Locate the coolant-in temperature sensor on the stack coolant inlet hose.

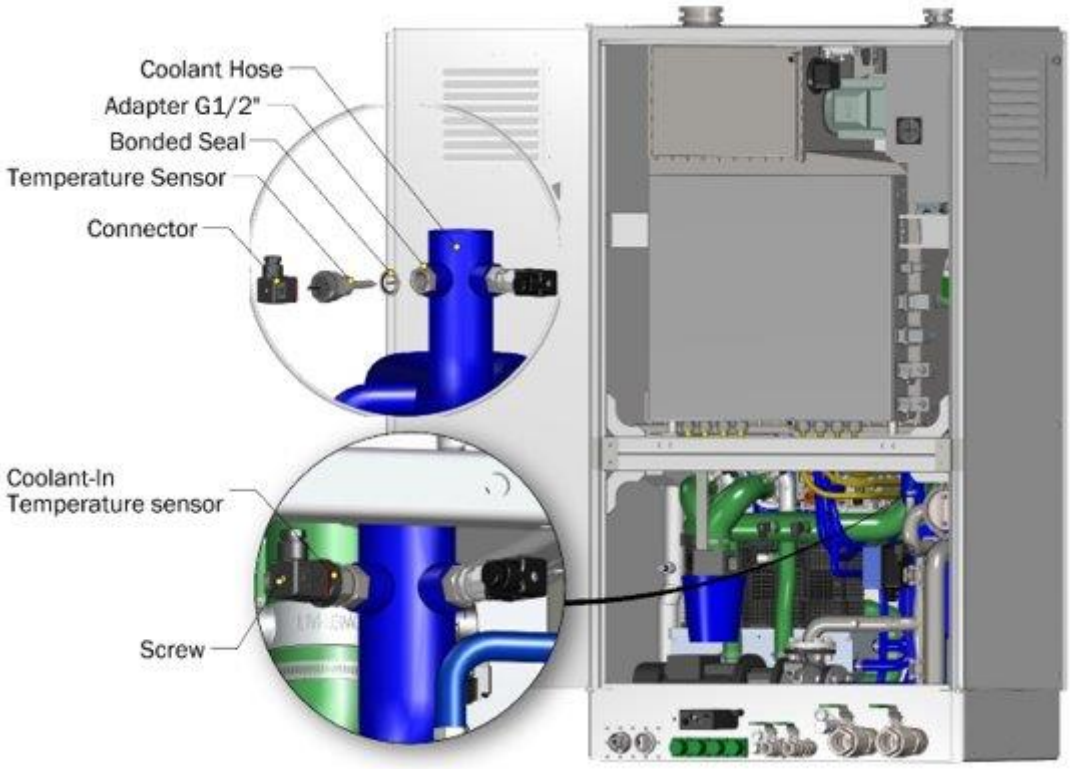


Figure 8-247: Overview of coolant-in temperature sensor

4. Uninstall bolt on the connector TT_D40 to uninstall the temperature sensor.
5. Uninstall the temperature sensor and the bonded seal washer.

   Remember to use a second spanner for counter turn on the silicon hose fitting to prevent any damage to the threaded insert.

Assembling procedure:

1. Install the new bonded seal washer, insert adaptor G1/2”, and then install the temperature sensor using the bolt. Tighten to 25 Nm.
2. Use the coolant pump to refill the HT coolant system.

   Remember to pay attention to the HT coolant tank’s level indicator while refilling.
3. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
4. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
5. Run the degas procedure (refer to section 8.4.9).
6. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8.5 Replace the Coolant-Out Temperature Sensor (TT_D50)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain the coolant to a level where the sensor can be removed without coolant spillage.
3. To gain access to the temperature sensor, loosen the hose clamp securing the coolant hose to the inlet fitting and pull down to create space. Keep the hose clamp on the coolant hose for assembling procedure.

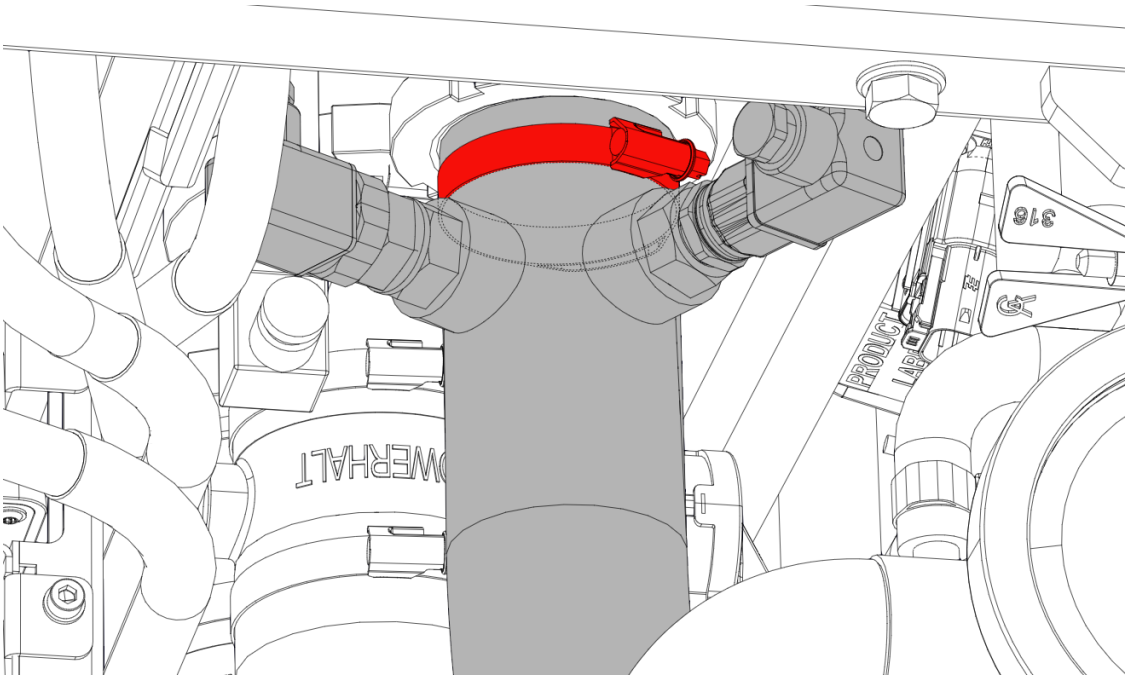


Figure 8-248: Hose clamp on coolant hose to make room

4. Loosen the lower hose clamp securing the air inlet hose to the process inlet valve and pull the hose away to create space. Keep the hose clamp on the hose for assembling procedure.

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5. Disconnect the connector from the air process inlet valve.

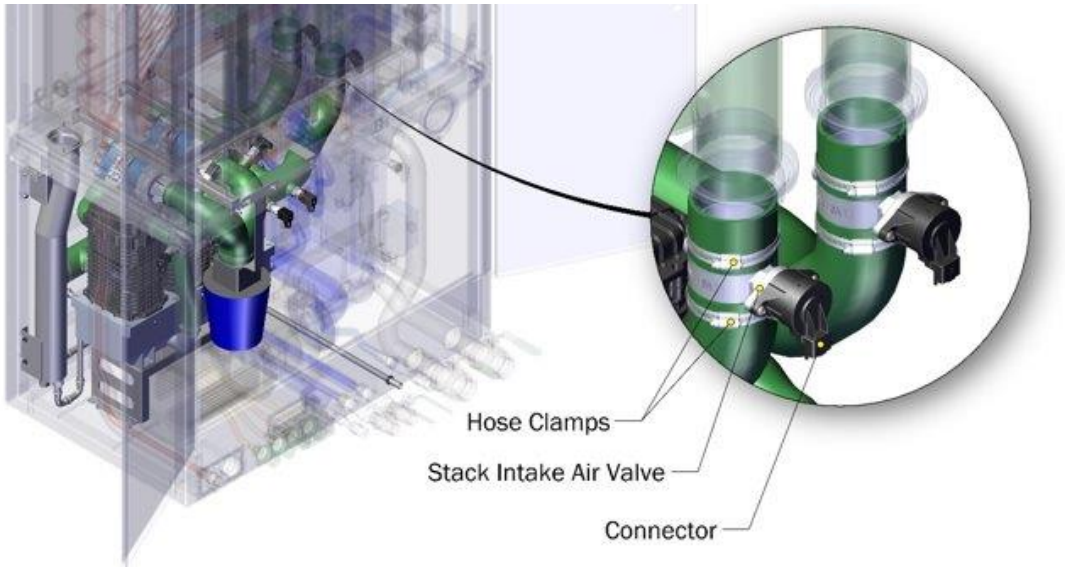


Figure 8-249: Location of air process inlet valve

6. Loosen the upper hose clamp used to secure the process inlet valve to the inlet fitting and pull out the air process inlet valve. Remember to cover all disconnected hoses and open ports with a clean cap or tape and keep the hose clamp on the hose for assembling procedure.

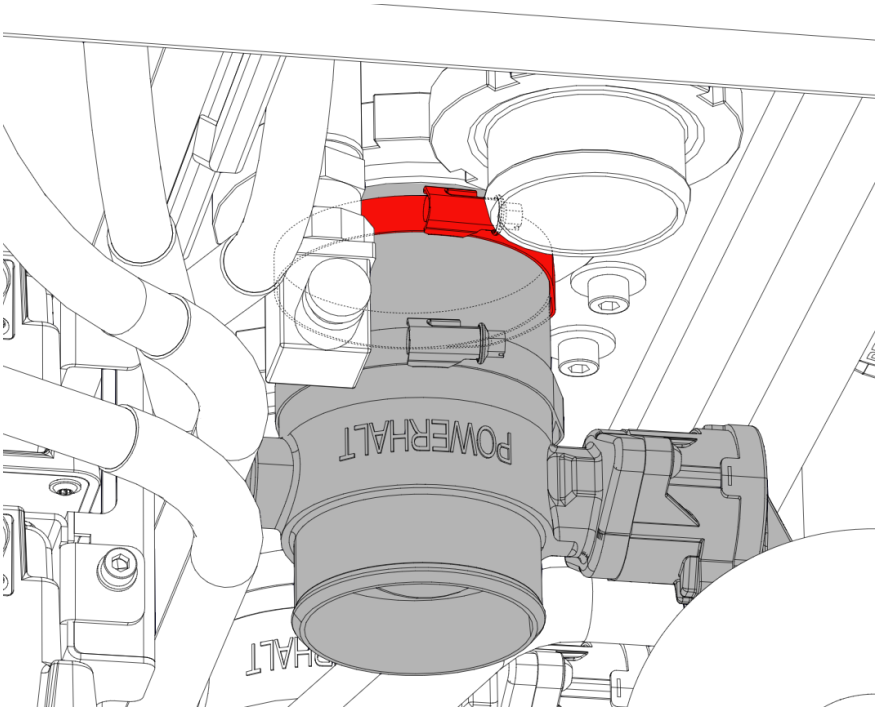


Figure 8-250: Hose clamp on air inlet hose to make room

7. Loosen the lower hose clamp securing the air outlet hose to the process outlet valve and pull the hose away to create space. Keep the hose clamp on the hose for assembling procedure.

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8. Disconnect the connector from the air process outlet valve.

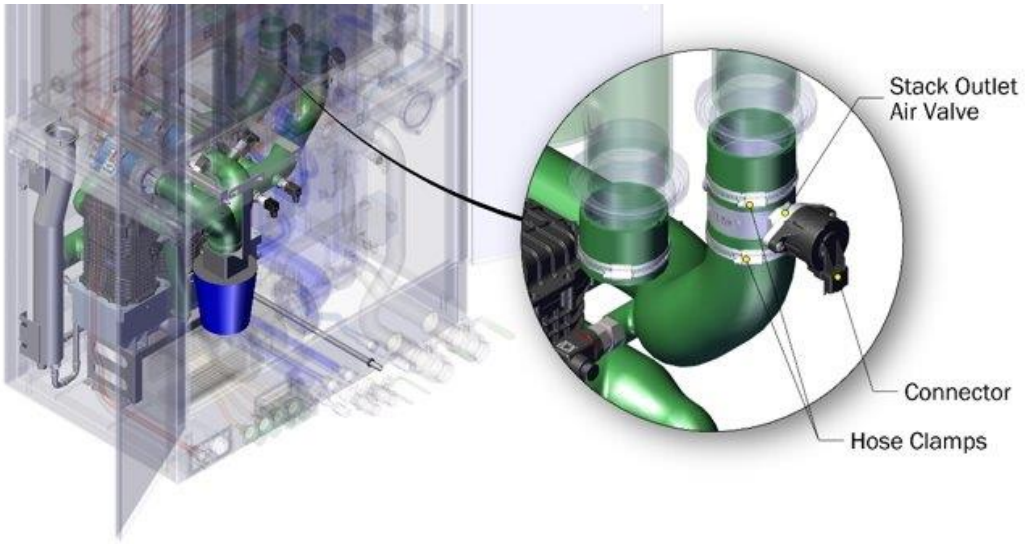


Figure 8-251: Location of air process outlet valve

9. Loosen the upper hose clamp used to secure the process outlet valve to the outlet fitting and pull out the air process outlet valve. Remember to cover all disconnected hoses and open ports with a clean cap or tape and keep the hose clamp on the hose for assembling procedure.

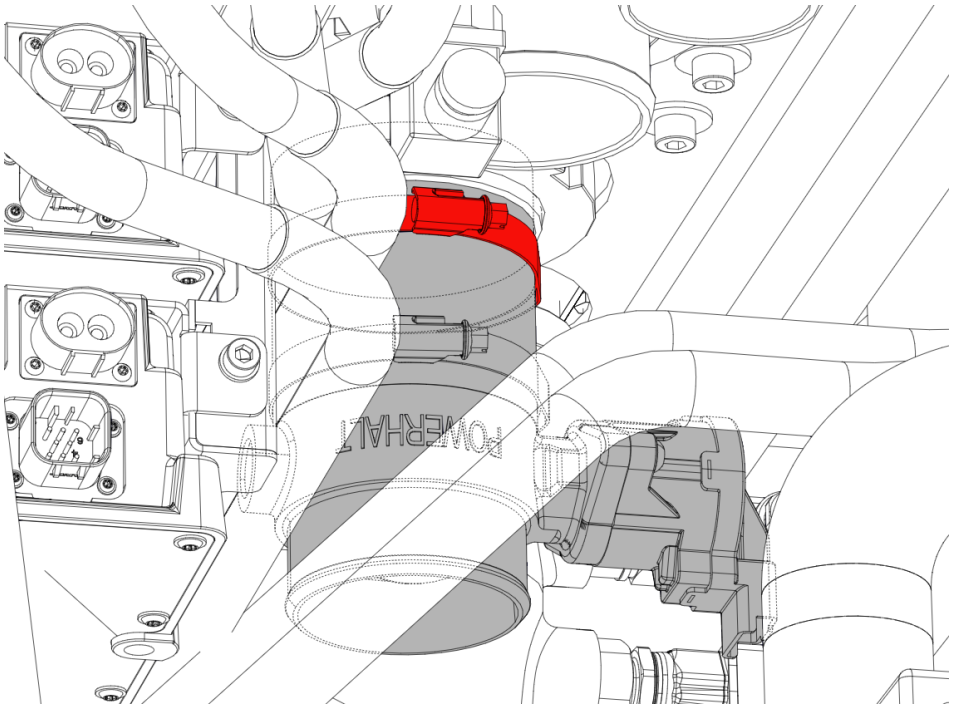


Figure 8-252: Hose clamp on air outlet hose to make room

10. Disconnect the temperature sensor connector (TT_D50).

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11. Remove the temperature sensor. Use a spanner as a contra to not damage the thread connection on the hose.

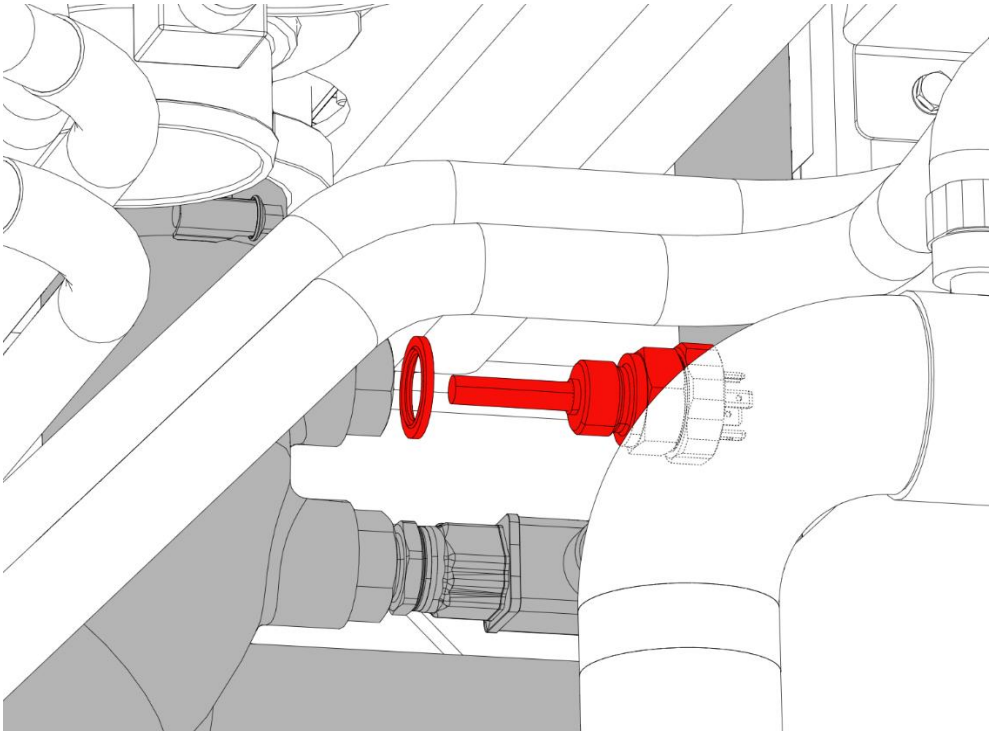


Figure 8-253: Removal of temperature sensor TT_D50

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Assembling procedure:

1. Install new bonded seal washer and lubricate the thread with krytox before installing the new temperature sensor (TT_D50). Tighten to 25 Nm.
2. Connect the TT_D50 connector.
3. Use the hose clamp to secure the air outlet process valve to its fitting. Tighten clamp to 3.5 – 4.5 Nm.
4. Reconnect the FCV_A50 connector to the air process outlet valve.
5. Use the hose clamp to secure the air outlet hose to the process outlet valve. Tighten clamp to 3.5 – 4.5 Nm.
6. Use the hose clamp to secure the air inlet process valve to its fitting. Tighten clamp to 3.5 – 4.5 Nm.
7. Reconnect the FCV_A40 connector to the air process inlet valve.
8. Use the hose clamp to secure the air inlet hose to the process inlet valve. Tighten clamp to 3.5 – 4.5 Nm.
9. Use the hose clamp to secure the coolant hose to its fitting. Tighten clamp to 3.5 – 4.5 Nm.
10. Refill the coolant.
11. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
12. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
13. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
14. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8.6 Replace the Ventilation Outlet Temperature Sensor (TT_J30)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Uninstall 3 pcs. M8x30 bolts from the top right support bracket of the high voltage panel. Remove the bracket on the right side of the high voltage panel.

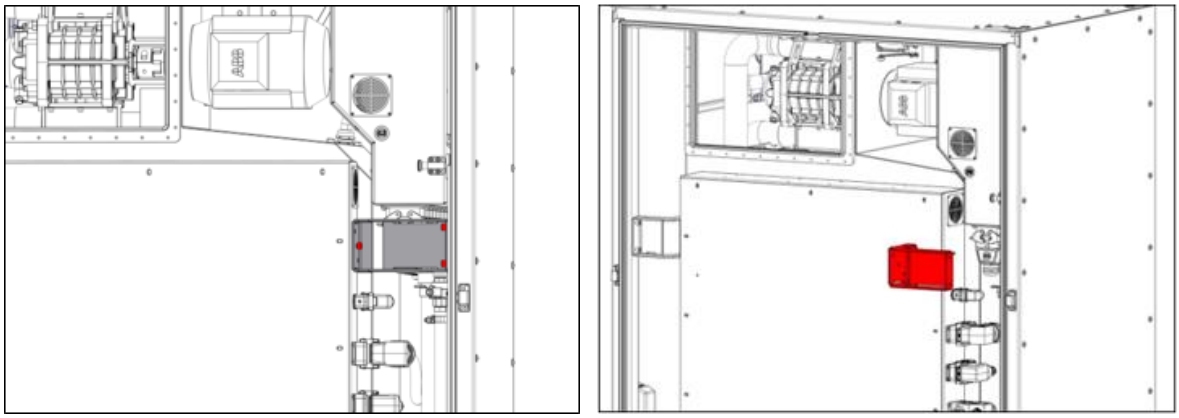


Figure 8-254: Bolts and support bracket in HV panel for TT_J30

3. Loosen the spring-loaded lock pin that locks the low voltage panel assembly to the slide on the mounting bracket.
4. Disconnect all following connectors from the bottom of the low voltage panel: CN400, CN303, CN300, CN101, CN100, CN601, CN600
5. Disconnect the CN201 connector from the side of the high voltage panel.
6. Disconnect the grounding wire from the back of the low voltage panel.
7. Remove the low voltage panel by using the rails to slide out the panel. The spring-loaded locking pin in the back will need to be loosened during the dismantling.

   Make the right precautions is taken as the panel is heavy.
8. Uninstall 4 pcs. bolts and carefully remove the ventilation hatch cover.



Figure 8-255: Ventilation hatch cover dismounting

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9. Disconnect the temperature sensor connector and use a crowfoot for the contra nut and a spanner for the sensor to remove the temperature sensor.



Figure 8-256: Removal of ventilation temperature sensor

Assembling procedure:

1. Install new bonded seal washer and lubricate the thread with krytox before installing the new temperature sensor using the crowfoot on the contra nut and the spanner on the sensor. Install the sensor by hand and re-tighten to 25 Nm.
2. Mount the ventilation hatch. Make sure the hatch slides in between the hooks on top and bottom. Install the sensor by hand and re-tighten to 10 Nm.
3. Connect the temperature sensor connector.
4. Slide in the low voltage panel a little so it is placed steady and stable. Connect the grounding wire.
5. Connect all the following connectors in the low voltage panel: CN400, CN303, CN300, CN101, CN100, CN601, CN600
6. Connect the CN201 connector to the side of the high voltage panel.
7. Use 3 pcs. M8x30 bolts to install the top right support bracket to the high voltage panel.
8. Use 12 pcs M5x10 bolts to install the high voltage panel cover.
9. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
10. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
11. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8.7 Replace the High Voltage Panel Temperature Sensor (TT_J50)

To test a new or existing temperature sensor in the high voltage panel temperature sensor (TT_J50), connect the black and the red lead of the meter to the leads from the PT1000 sensor. A typical reading for a temperature sensor on the service interface shows approx. 1078 ohms at 20° C.

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Remove the marked cable rail covers.

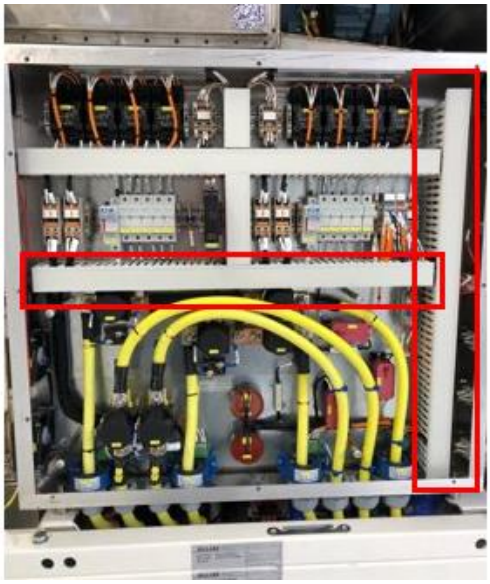


Figure 8-257: Overview of cable rail covers

3. Disconnect the CC-TT_J50 (CN201) connector.
4. Cut the cable tie securing temperature sensor TT_J50.

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5. Use a flathead screwdriver to disconnect the cable from the connector terminal.



Figure 8-258: Cable in connector terminal for TT_J5

6. Remove marked cable from the cable rail.



Figure 8-259: Remove sensor cable from cable rail

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Assembling procedure:

1. Install new temperature sensor TT_J50 with a new cable tie.



Figure 8-260: New sensor cable installed

2. Use a flathead screwdriver to connect TT_J50 cable to the correct terminals.
3. Fit cable back into cable rail and reinstall cable rail covers.
4. Connect CN-TT_J50 (CN201) connector.
5. Use 12 pcs. M5x10 bolts to install high voltage panel cover.
6. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
7. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
8. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.8.8 Replace the Low Voltage Panel Temperature Sensor (TT_J40)

To test a new or existing temperature sensor in the low voltage panel temperature sensor (TT_J40), connect the black and the red lead of the meter to the leads from the PT1000 sensor. A typical reading for a temperature sensor on the service interface shows approx. 1078 ohms at 20° C.

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Uninstall 3 pcs. M8x30 bolts from the top right support bracket of the high voltage panel. Remove the bracket on the right side of the high voltage panel.

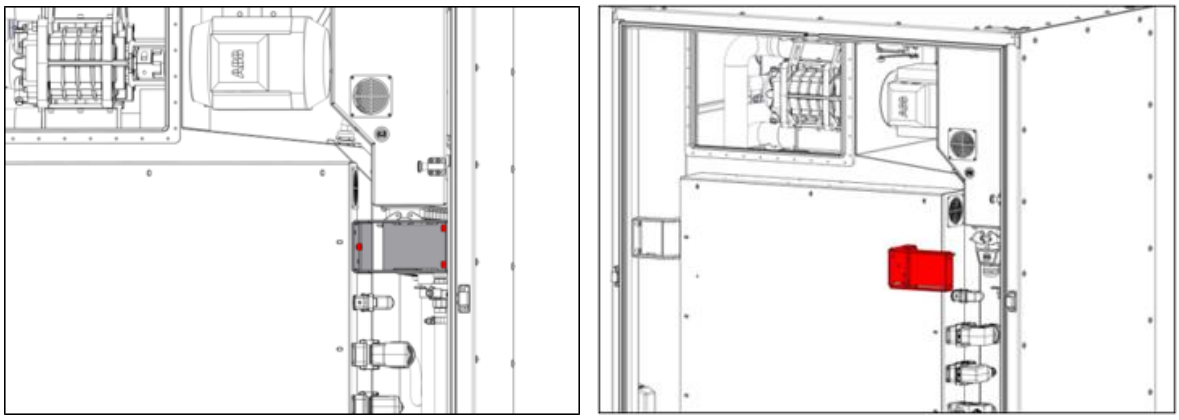


Figure 8-261: Bolts and support bracket in HV panel for TT_J30

3. Loosen the spring-loaded lock pin that locks the low voltage panel assembly to the slide on the mounting bracket.
4. Uninstall 14 pcs. M5 bolts to remove the low voltage panel cover.
5. Cut the cable tie holding the TT_J40.



Figure 8-262: Cable tie holding TT_J40

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6. Disconnect the terminal for the TT_J40 cable.
7. Use a flathead screwdriver to disconnect the cables from the terminal.
8. Remove the temperature sensor and cut the cable ties where needed to remove the cable.

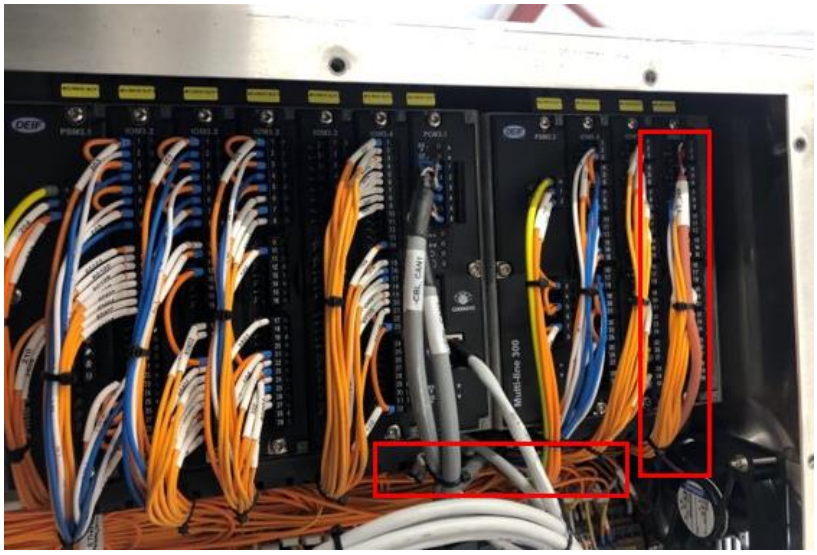


Figure 8-263: Overview of cable ties to be cut

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Assembling procedure:

1. Install the new temperature sensor (TT_J40) with a new cable tie.
2. Use a flathead screwdriver to install the new temperature sensor cables in the terminal.
3. Route the new temperature sensor cable and replace the cable ties that were removed.
4. Install the connector to the unit.



Figure 8-264: Mount connector to unit

5. Use 14 pcs. M5 bolts to install the top plate on the low voltage panel.
6. Carefully slide the low voltage panel halfway into place.
7. Connect all plugs to the low voltage panel from back to front but starting with the grounding cable.

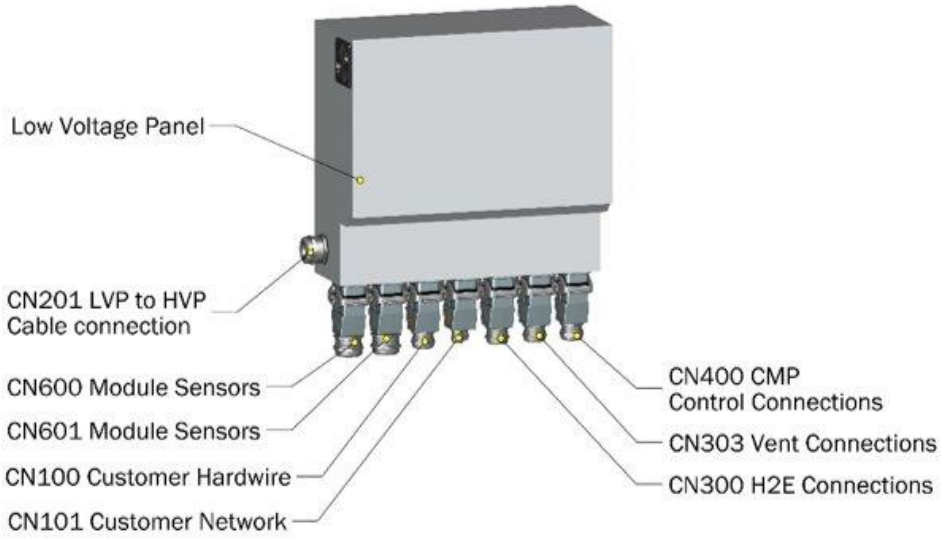


Figure 8-265: Overview of cables installed on LVP

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8. Use 3 pcs. M8 bolts to install the bracket used to secure the right side of the high voltage panel to the module frame.
9. Use 12 pcs. M5x10 bolts to install the high voltage panel cover.
10. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
11. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
12. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.9 Replace Pressure Sensors

Purpose

The procedures in section 8.9 describe how to replace the pressure sensors for the FCwave module. The module has eight pressure sensors that are a part of H_2 Fuel anode, oxidant cathode and stack coolant sub-systems.

Responsibilities

Preventive maintenance of the pressure sensors is necessary for safe operation, according to the preventive maintenance plan (see Customer Portal for newest revision of the plan). It is the end user's responsibility to do preventive maintenance, refer to section 8.1.1.

Parts and equipment

A list of parts and special equipment is identified to replace the pressure sensors during the life and operation of the FCwave module.

- FRU, Sensor, Pressure 0-4 bar(g) (part no. 7500016) x6. For section 8.9.2 + 8.9.4 + 8.9.5 + 8.9.6 + 8.9.7.
- FRU, Sensor, Air Compressor Pressure 0-1 bar(g) (part no. 7500058) x2. For section 8.9.3

Safety

Refer to section 8.1.2 to follow the instructions.

Estimated time to replace the Pressure Sensors

Based on the normal conditions, the estimated time for replacement is:

Pressure Sensors		
Duration	5 – 10 min	
	Except for coolant sensors, which requires 1 hour additional time for draining the coolant circuit	
Personnel	1	
Tightening Torque	M5 bolt	6.5 ± 0.5 Nm
	M6 bolt	10 ± 0.5 Nm
	M8 bolt	25 ± 0.5 Nm
	M10 bolt	50 ± 5 Nm
	1/2" sensor fittings	25 ± 0.5 Nm
	Tool: 4mm + 5mm + 6mm + 8mm hex key, 27 mm spanner (x2), cross-head screwdriver, Phillips bit (PH2), torque wrench, krytox	

Table 8-38: Time to replace pressure sensors

Test a Pressure Sensor

It is important to test a new or existing pressure sensor before replacement.

2-Wire Current Pressure Sensor:

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- Connect the +ve terminal of the sensor to the +ve terminal of the power supply
- Connect the -ve terminal of the sensor to the +ve lead on the multimeter
- Connect the –ve lead of the multimeter to the –ve terminal on the power supply

Under no-load conditions, the sensor must produce a current ranging from 4 to 20mA. Refer to the datasheet and verify if the sensor is working within specifications.

8.9.1 Pressure Sensors on the Hydrogen Valve Block

See section 8.2.3 for instructions on how to replace the entire hydrogen valve block which contains the fuel-out pressure sensor. Do not replace only the sensors in the valve block.

8.9.2 Replace the Fuel-Out Pressure Sensor (PT_H50)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Disconnect all connectors (CN201, CN202, CN500, CN505) in the high voltage panel as shown.



Figure 8-266: Overview of connectors in HV panel

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3. Disconnect connection CN205 for fire detection from the side of the high voltage panel.

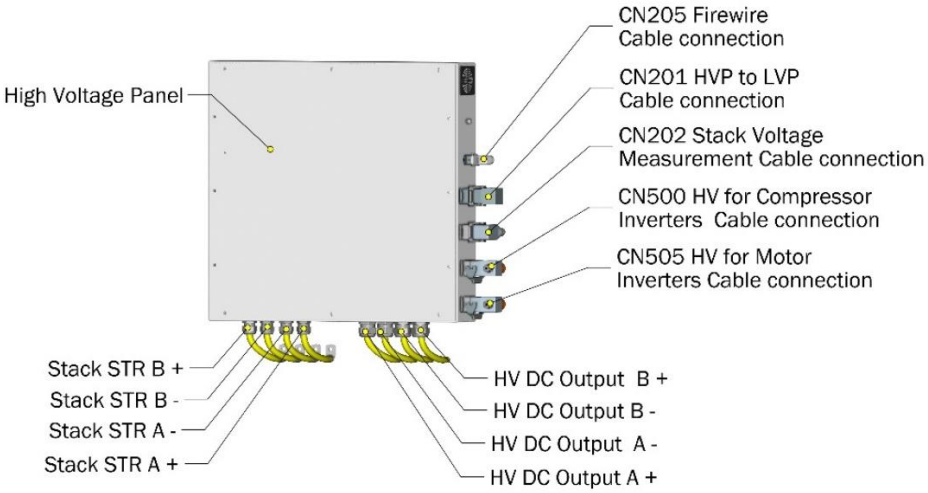


Figure 8-267: Cable connections in HV panel

4. Loosen M32 cable glands to disconnect the HV stack cable connections to positive terminals (A+, B+) and negative terminals (A-, B-).
5. Loosen M32 cable glands to disconnect the HV DC output cable connections to positive terminals (A+, B+) and negative terminals (A-, B-).
6. Uninstall 2 pcs. M10 bolts and washers used to tighten the HV panel assembly to the bottom of upper cabinet.
7. Uninstall 2pcs. M8 bolts and washers used to tighten the HV panel assembly to the sides of upper cabinet.

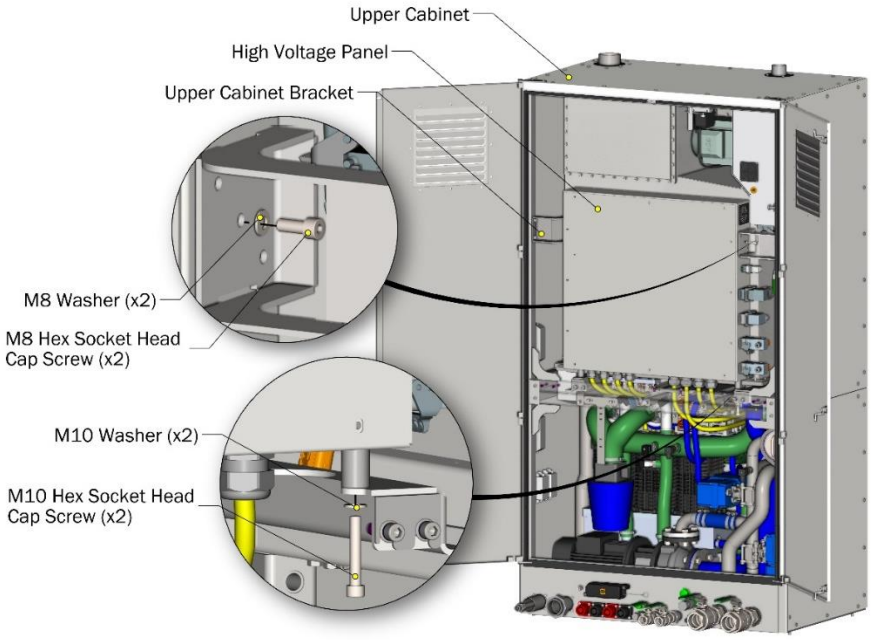


Figure 8-268: Dismount HV panel

8. If applicable, remove the ground fault monitor board.

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9. Install eyebolt on each side of the HV panel and carefully lift the panel assembly, with all its hardware inside, out of the cabinet and move to flat work surface.
10. Uninstall 22 pcs. M6 bolts and washers to remove the purge hatch cover from the H_2 enclosure.

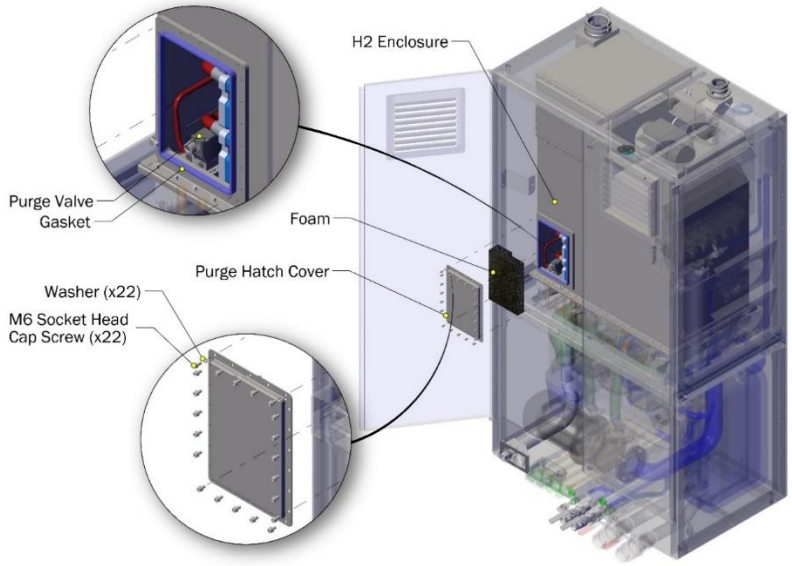


Figure 8-269: Removal of purge hatch cover

11. Remove foam in the enclosure to locate the fuel-out pressure sensor (PT_H50) behind the purge valve.
12. Uninstall the bolt in the connector (HRNS-300-CN_PT_H50) and dismount the pressure sensor.

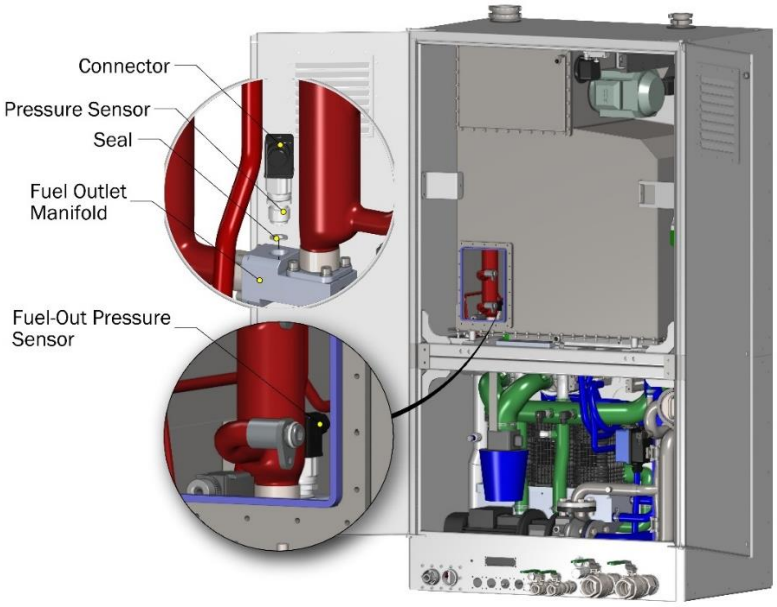


Figure 8-270: Removal of fuel-out pressure sensor

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Assembling procedure:

1. Install new PFTE gasket in the sensor adaptor and install new pressure sensor by hand. Re-tighten to 25 Nm.
2. Use a new bolt to install the connector.
3. Install new foam and use 22 pcs. M6 bolts and washers to install the purge hatch cover to the H_2 enclosure.
4. Reverse steps 8 through 15 of the disassembling procedure to install the HV panel assembly.
5. Use 12 pcs. M5x10 bolts and install the high voltage panel cover.
6. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
7. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
8. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.9.3 Replace the Dual Inlet Air Pressure Sensors (PT_A11A & PT_A11B)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the pressure sensors (PT_A11A & PTA11B) on the inlet compressor hose and uninstall the bolt in both sensor connectors to dismount the connectors and rubber seals.

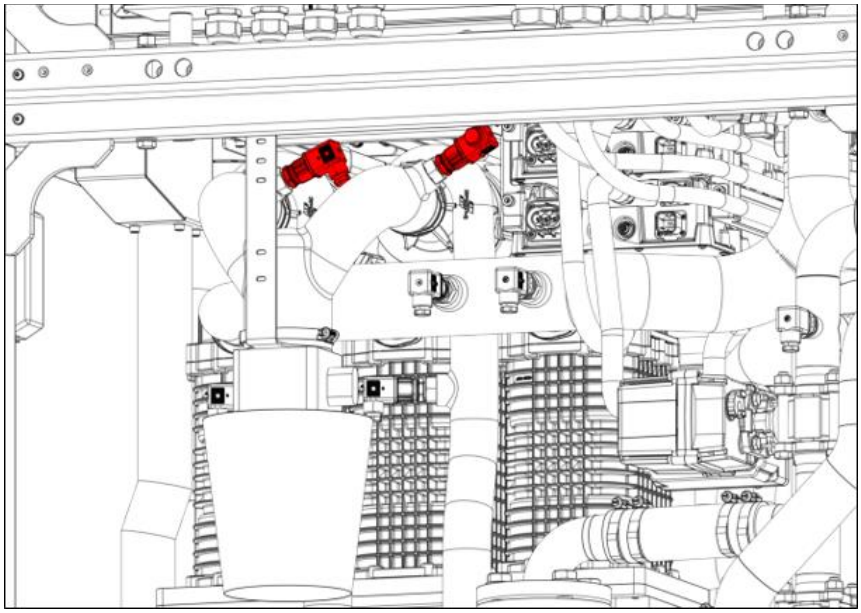


Figure 8-271: Removal of pressure sensors on dual inlet compressor hose

3. Use 2 spanners (1 as counter on the silicon hose fitting to avoid damaging the threaded insert) to uninstall both sensors and PTFE gaskets.

Assembling procedure:

1. Install new PFTE gaskets in both sensor adaptors and install new pressure sensor by hand. Re-tighten to 25 Nm.
2. Connect the sensors to harness CN_600 and mount the rubber seal and the connectors for the sensors.
3. Use 12 pcs. M5x10 bolts and install the high voltage panel cover.
4. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
5. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
6. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.9.4 Replace the Dual Outlet Air Pressure Sensors (PT_A12A & PT_A12B)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the connectors for both sensors (PT_A12A & PT_A12B) and disconnect them.

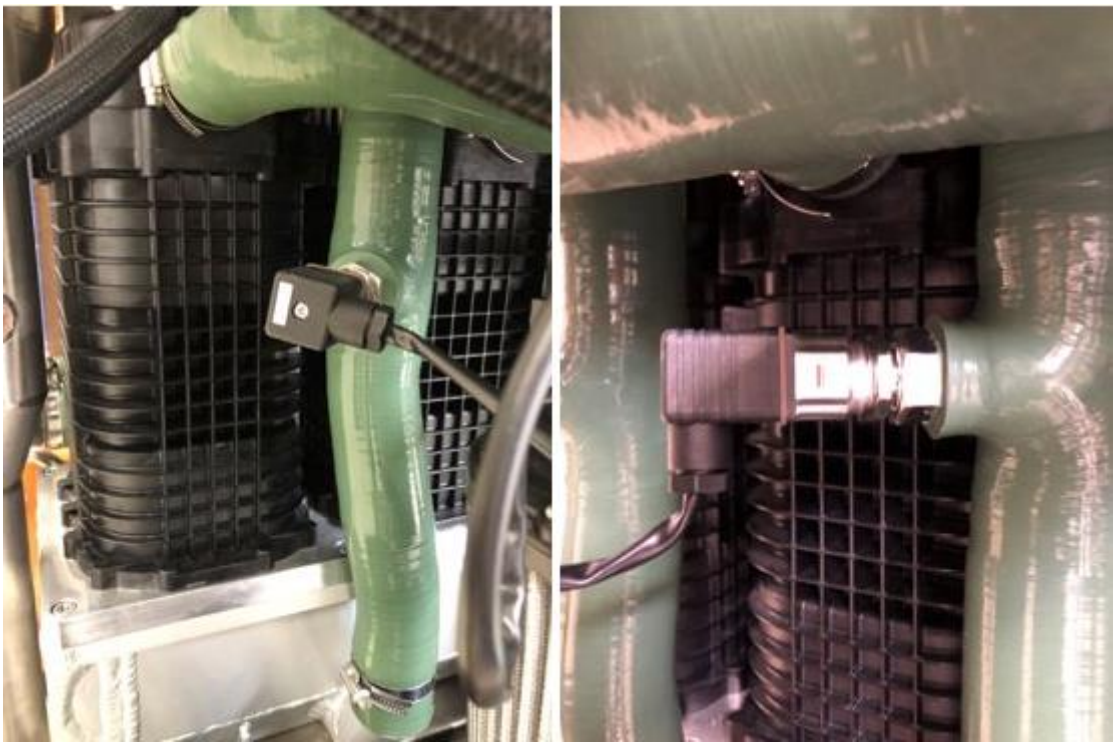


Figure 8-272: Overview of connector sensor for output air

3. Use 2 spanners (1 as counter on the nut to avoid damaging the connection) to uninstall both sensors and remove the PTFE gasket from both sensors.

Assembling procedure:

1. Install new PFTE gaskets in both sensors.
2. Lubricate thread with krytox and install new sensors. Tighten to 25 Nm.
3. Install connectors on sensors.
4. Use 12 pcs. M5x10 bolts and install the high voltage panel cover.
5. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
6. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
7. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.9.5 Replace the Stack Inlet Air Pressure Sensor (PT_A40)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Locate the PT_A40 pressure transducer and remove the bolt in the connector to uninstall the pressure sensor.

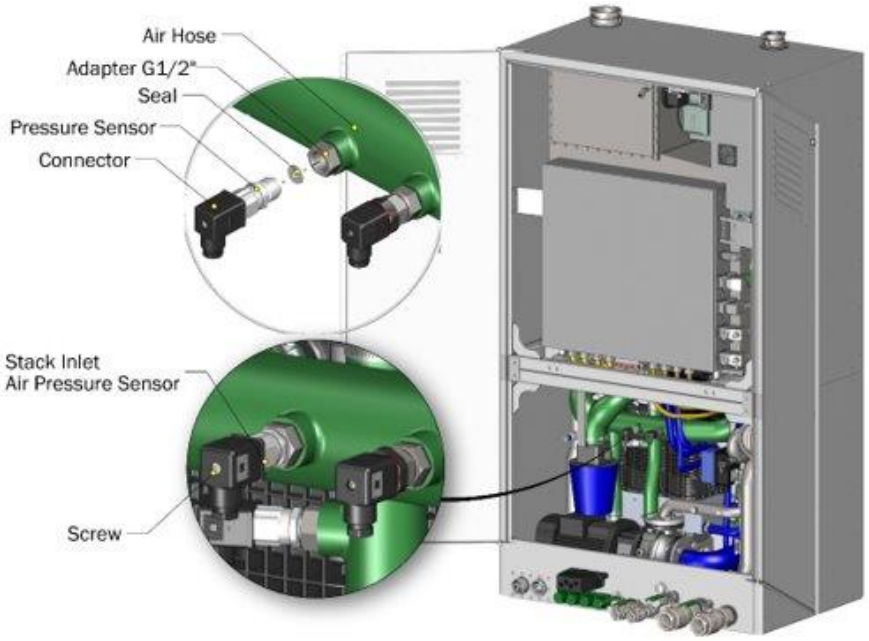


Figure 8-273: Overview of pressure transducer

3. Use a spanner to remove the pressure sensor fitting and use another as counter turn on the silicon hose fitting to avoid any damage to the threaded insert.

Assembling procedure:

1. Apply krytox to the new sensor and install sensor and seal. Tighten to 25 Nm.
2. Use the bolt to install the connector to the sensor.
3. Use 12 pcs. M5x10 bolts and install the high voltage panel cover.
4. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
5. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
6. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.9.6 Replace the Coolant-In Pressure Sensor (PT_D40)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain the HT cooling system.
3. Locate the PT_D40 pressure sensor on the coolant inlet hose and remove the bolt holding socket to disconnect the socket.

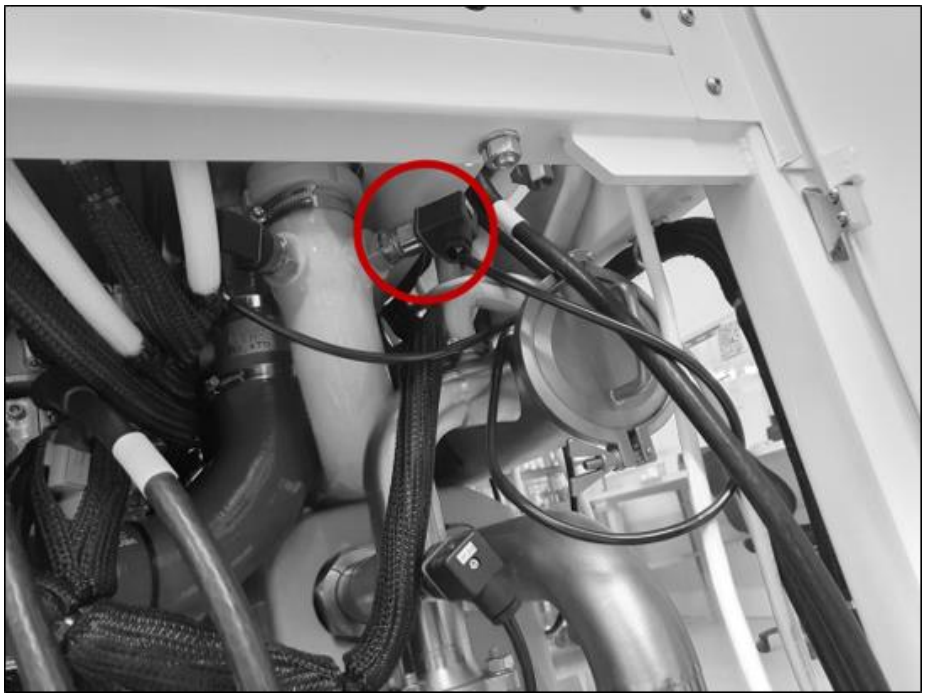


Figure 8-274: Location of PT_D40 pressure sensor

4. Use a spanner to loosen the pressure sensor fitting and use another as counter turn on the silicon hose fitting to avoid any damage to the threaded insert.
5. Remove the pressure sensor, seal washer, and wipe off any leftover grease in the hose fitting.

Assembling procedure:

1. Grease the pressure sensor thread and the new seal washer.
2. Install the new PT_D40 sensor by hand. Use spanner to re-tighten it to 25 Nm.
3. Connect socket to PT_D40 and use the bolt to install it. Check the label to make sure the right harness is connected.
4. Use 12 pcs. M5x10 bolts and install the high voltage panel cover.
5. Connect a portable pump, secured with mechanical relief valve, to the connector to fill the module with HT coolant.
6. Ensure the air pockets are vented through the vent valve located on top of the header tank.
7. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
8. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
9. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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8.9.7 Replace the Coolant-Out Pressure Sensor (PT_D50)

Disassembling procedure:

1. Before proceeding with the disassembling procedure, perform all steps in section 7.2.7 (PrepForService feature usage) and 6.5.1 (High Voltage safety check before module maintenance).
2. Drain the HT cooling system.
3. Locate the PT_D50 pressure sensor on the coolant outlet hose and remove the bolt in the connector to dismount the pressure sensor.

   If necessary, release the hose clamp to remove the oxidant outlet fittings to get better access to the sensor.

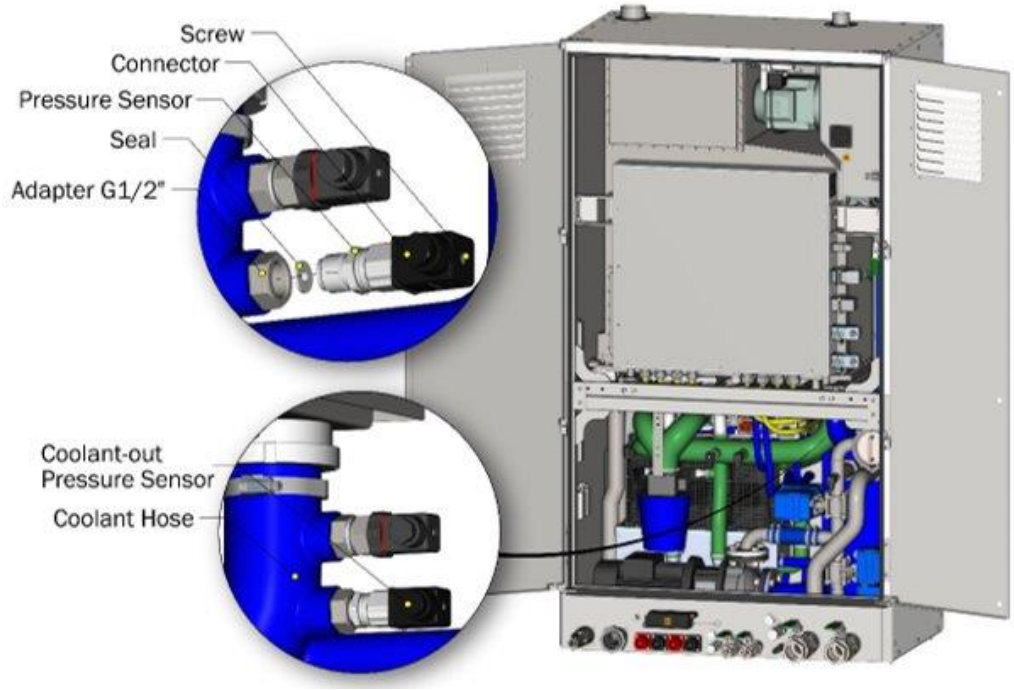


Figure 8-275: Location of PT_D50 pressure sensor

4. Use a spanner to loosen the pressure sensor fitting and use another as counter turn on the silicon hose fitting to avoid any damage to the threaded insert.
5. Remove the pressure sensor, seal washer, and wipe off any leftover grease in the hose fitting.

Assembling procedure:

1. Insert the new pressure sensor and seal in the adaptor. Tighten to 25 Nm.
2. Insert the bolt in the connector and mount the pressure sensor.
3. Use the coolant pump to refill the HT cooling system.
4. Use 12 pcs. M5x10 bolts and install the high voltage panel cover.
5. Insert the high voltage electrical plugs and turn clockwise to install in the front of the module.
6. Use 2 pcs. M6 bolt to install the low voltage electrical connection (X_E01) with attached cables to the module. Tighten to 5 Nm.
7. Run degas procedure for 30-60 min. Refer to 8.4.9.
8. Close the system doors and confirm that the module is ready for power up from the integrator side after maintenance. Remember to remove local lockout and tagout when work is done.

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9.0 Appendices

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10.0 Handling of defective or worn-out components and disposal

Table 10-1: Handling of defective or worn-out components and disposal





The Fuel Cell system is designed to last for many years. When the time comes for the unit to be re-cycled, the unit should be recycled according to national rules and procedures to protect the environment.

- Return faulty part to BPSE for failure analysis, repair, or refurbishment in original packing.

  Every year thousands of fuel cell stacks are recycled. We seek to keep every fuel cell in use for as long as possible.
- Any parts removed during installation or maintenance should be disposed according to any local government regulations.

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Sub Section N02

Recommended Start-up & Commissioning Spares

Ballard Power Systems Europe A/S
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	25/10/2024	First Issue
002	27/11/2024	Updated to as-built and according to comments
003	28/01/2025	updated additional parts added

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Purchase Order:	CWIWP4202202
Code:	K02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	N02 – Spare Part List for Commissioning
Full Title	N02 – Spare Part List for Commissioning
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	First Release	Adnane	February, 2022
2.0	Spare Parts For commissioning updated	KHE	24 January, 2025
3.0	Spare parts added	KHE	29. January 2025

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2.0 Commissioning Spare Part List 4

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1.0 Purpose

The purpose of this document is to provide a list of Spare Parts that will be delivered to commissioning Site for commissioning and start up of the Ballard 1MW fuel cell container.

2.0 Commissioning Spare Part List

The complete list of Spare Parts for commissioning and start up of 1MW fuel cell container (MEGABLOCK) is shown below.

Item	Technical Details	Quantity	Manufacture	MFG ID
DC Measurement Fuse	10x38mm, 2A, 1000VDC	1 package, 10 pcs	SIBA	5021526.2
DC/AC Fuse	10x38mm, 10A, 1000VDCAC	1 package, 10 pcs	SIBA	5019906.10
Main DCAC Fuse	SQB3, 500A, 1250V	1 package, 2 pcs	SIBA	2078032.500
DCDC Cabinet Fuse	SQB1, 315A, 1250V	1 package, 3 pcs	SIBA	2071532.315
Smoke Detector	Optical Smoke Detector	2 pcs, with holder	Apollo	ORB-OP-42001-MAR
10ft Control Cabinet door	Cubic 4x4 door with mounting kits	1 door with 2 mounting kits	CUBIC	Na
H2 Detector 0-4%	H2 Detector for Fcwave module	6 pce	Ballard FRU Part	7500036
Fuse kit	Different fuses for Fcwave module	1 kit	Ballard FRU Part	7500349
Solenoid valve	Valve for H2 manifold	1 pce	ASCO	NA
Ventilation inlet flow switch	FRU Part FCwave	3 Pce	Ballard FRU Part	7500018
Differential pressure switch	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500034
Sensor, air compressor pressure 0 - 1 bar	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500058

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Sensor, temperature PT-100, L=50mm, ø 3,5mm	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500037
Sensor, H2 enclosure water ingress	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500035
Sensor, pressure 0-4 barg	FRU Part for FCwave	3 Pce	Ballard FRU Part	7500016
Coolant tank level switch	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500078
Sensor, temperature PT-100, L50mm, ø 8mm	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500085
Sensor, cabinet water ingress	FRU Part for FCwave	1 Pce	Ballard FRU Part	7500151
Sensor, temperature PT-100, L150mm, ø 8mm	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500090
HRB coupling element	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500013
DI filter cartridge	FRU Part for FCwave	2 Pce	Ballard FRU Part	7500095
Temp. & Pressure transmitter Sealing KIT	FRU Part for FCwave	1 Pce	Ballard FRU Part	7500167

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Sub Section N03

Recommended Spares for 2 Years

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Revision history		
Rev.	**Date.**	**Description**
001	2/17/2023	First Issue
002	9/1/2025	Updated list
003	9/18/2025	Update, added PM for 3 parts

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ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

ACCEPTED	(Code 1) ____
ACCEPTED WITH COMMENTS	(Code 2) ____
NOT ACCEPTED	(Code 3) ____
NOT REVIEWED	(Code 4)

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DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - Recommended Spares for 2 Years Operating**
Document Number:	K559-2254-CWIWP4202202-N03-001
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Code:	N03
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

BALLARD

May-27-2025

Field Replaceable Unit List, Container Solution, Crosswinds

Part Number	Superseded / Equivalent	Description	UoM	Preventive Maintaince	Quantity	Unit Price (EUR)	Extended Price (EUR)	Lead Time in Weeks
FCwave (Top Unit)								
7000040-001	7500038	FRU, H2E Ventilation Fans	Ea		2	€ 658	€ 1,316	30 weeks
7000107-001	7500017	FRU, Purge Valve	Ea	PM	6	€ 1,058	€ 6,348	11 weeks
7000111-001	7500018	FRU, H2E Ventilation Airflow Switch	Ea		2	€ 734	€ 1,468	13 weeks
7000113-001	7500037	FRU, Sensor, Temperature PT-100, L=50mm, Ø3.5mm	Ea		2	€ 524	€ 1,048	17 weeks
7000116-001	7500016	FRU, Sensor, Pressure 0-4 barg	Ea		2	€ 467	€ 934	17 weeks
7000123-001	7500034	FRU, Differential Pressure Safety Switch	Ea		2	€ 420	€ 840	12 weeks
7000690-001	7500035	FRU, Sensor, H2 Enclosure Water Ingress	Ea		2	€ 486	€ 972	11 weeks
7000949-001	7500007	FRU, HRB	Ea		2	€ 7,343	€ 14,686	37 weeks
7000950-001	7500025	FRU, Hydrogen Valve Block Assembly	Ea		2	€ 11,286	€ 22,572	27 weeks
7001155-001	7500011	FRU, HRB Motor	Ea		1	€ 2,315	€ 2,315	37 weeks
7001345-001	7500036	FRU, Sensor, H2 , 0 - 4%	Ea	PM	24	€ 620	€ 14,880	13 weeks
7100274-001	-	FRU, HRB Motor Controller, Programmed	Ea		1	€ 2,896	€ 2,896	26 weeks
7100275-001	-	FRU, Coolant Pump Motor Controller, Programmed	Ea		1	€ 2,896	€ 2,896	26 weeks
7100276-001	-	FRU, Gen3 Air Compressor Inverter 2.0B, Programmed	Ea		1	€ 3,781	€ 3,781	44 weeks
FCwave (Bottom Unit)								
7000008-001	7500355	FRU, Coolant Pump	Ea		1	€ 8,124	€ 8,124	37 weeks
7000114-001	7500058	FRU, Sensor, Air Compressor Pressure	Ea		1	€ 524	€ 524	17 weeks
7000118-001	7500085	FRU, Sensor, Temperature PT-100, L=50mm, Ø8mm	Ea		1	€ 629	€ 629	17 weeks
7000119-001	7500090	FRU, Sensor, Temperature PT-100, L=150mm, Ø8mm	Ea		1	€ 505	€ 505	17 weeks
7000130-001	75000128	FRU, HV Panel	Ea		1	€ 15,800	€ 15,800	20 weeks
7000131-001	75000130	FRU, LV Panel	Ea		1	€ 28,953	€ 28,953	19 weeks
5155847-001	7500359	FRU, Humidifier, Membrane v2	Ea	PM	6	€ 2,772	€ 16,632	35 weeks
7000146-001	7500061	FRU, Shutoff Valve, 3"	Ea		3	€ 1,943	€ 5,829	11 weeks
7000156-001	7500095	FRU, DI Filter Cartridge	Ea	PM	12	€ 496	€ 5,952	13 weeks
7000165-001	7500349	FRU, Fuse Bundle	Ea		2	€ 1,086	€ 2,172	11 weeks
7000309-001	7500162	FRU, Intake Air Filters	Ea	PM	24	€ 743	€ 17,832	11 weeks
7000322-001	7500068	FRU, Shutoff Valve, 1.75"	Ea		3	€ 800	€ 2,400	11 weeks
7000689-001	7500078	FRU, Coolant Tank Level Switch	Ea		2	€ 553	€ 1,106	11 weeks
7000910-001	7500053	FRU, Gen3 Air Compressor	Ea		1	€ 18,277	€ 18,277	42 weeks
7000917-001	7500088	FRU, Coolant Valve Actuator	Ea		1	€ 1,029	€ 1,029	11 weeks
7000976-001	7500149	FRU, Smoke Detector	Ea	PM	12	€ 210	€ 2,520	11 weeks
7000978-001	N/A	FRU, Humidifier Assembly O-Ring Seals	Ea		12	€ 162	€ 1,944	11 weeks
7001509-001	7500059	FRU, MAF Sensor & Inlet Filter	Ea	PM	6	€ 705	€ 4,230	17 weeks
							#REF!	
CONTAINER UNIT								
7001548		Pressure sensor for LT Circuit	Ea		1	€ 316	€ 316	In Ballard stock
7001812		Ventilation Box - Filter (Medium)	Ea	PM	32	€ 194	€ 6,199	TBC
7001813		Ventilation Box - Filter (large)	Ea	PM	8	€ 194	€ 1,550	LT pending
7002680		Battery (set of 2) for 24V UPS system	Ea		2	€ 195	€ 389	In Ballard stock
601456B - ACM31		For main PLC, IO Card	Ea		1	€ 589	€ 589	In Ballard stock
7000297		For main PLC, IO Card	Ea		1	€ 621	€ 621	In Ballard stock
7000298		For main PLC, IO Card	Ea		1	€ 684	€ 684	In Ballard stock
7000299		For main PLC, IO Card	Ea		1	€ 468	€ 468	In Ballard stock
2CTB802346R2500		Surge Supressor for AUX AC Supply	Ea		1	€ 448	€ 448	TBC
7001597		Ventilation Intake/Outlet Damper Motor	Ea		2	€ 264	€ 528	In Ballard stock
7001550		Ventilation Intake Sensor	Ea		2	€ 118	€ 236	In Ballard stock
4007861		Isolation Monitor	Ea		1	€ 3,859	€ 3,859	In Ballard stock
Ethyleneglycol		Top up at each service visit (no more than 6 months)	Ea	PM	1	€ 937	€ 937	1 week
601456B - 5021526		DCAC Fuse (1 package, 10pcs)	Ea		1	€ 309	€ 309	TBC
601456B - 5021526		DC Measurement Fuse (1 package, 10pcs)	Ea		1	€ 309	€ 309	TBC
601456B - 2078032		Main DCAC Fuse	Ea		2	€ 305	€ 609	TBC
601456B - 071532		DCDC Cabinet Fuse	Ea		2	€ 308	€ 615	TBC
601456B - 5101		Temperature Sensor for process monitoring	Ea		1	€ 165	€ 165	In Ballard stock
601456B - 1050		Temperature Sensor for process monitoring	Ea		1	€ 173	€ 173	In Ballard stock
601456B - 4104		Flow/Temp Sensor	Ea		1	€ 668	€ 668	In Ballard stock
930S043801		H2 Manifold Pressure Sensor	Ea		1	€ 145	€ 145	In Ballard stock
601456B - LMT01A		H2 Heater Level Sensor	Ea		1	€ 481	€ 481	TBC
601456B - PA3589		Header Tank Level Sensor	Ea		1	€ 532	€ 532	In Ballard stock

Notes:

1. Suggested Spare Parts List for 2 years of operation, based on 1,255 hours/year, and 6 FCwave fuel cell modules
2. All Prices are in EUR, and do not include customs duties, import/export brokerage and associated fees, commodity or sales/use taxes.
3. Delivery based on EXW, Ballard Facilities, Hobro, Denmark (Incoterms 2020)
4. Warranty period is 6 months from date of Delivery.
5. Prices are valid until July 31, 2025

Sub Section N04

Special Tools List

Ballard Power Systems Europe A/S
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	2/17/2023	First Issue
002	9/11/2025	General updates
003	11/3/2025	Sheet number update in header

Document Title:	**BLPH Project - Special Tools List**
Document Number:	K559-2254-CWIWP4202202-N04-001
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Short Title	N04 – Special Tools List
Full Title	N04 – Special Tools List
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	PBL	February 2023
2.0	General Updates	RKN	September 2025
3.0	Update sheet numbers	JTA	November 2025

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1.0 Purpose

The purpose of this document is to outline the special tools required to go through a 2 year maintenance period.

2.0 References

Table 1: Reference Documents

Document ID	Document Title	Source
K559-2254-CWIWP4202202-N03-001Rev002	Recommended Spares for 2 Years	Ballard
K559-2254-CWIWP4202202-N01-003Rev003	Service and Maintenance Manual	Ballard

3.0 Remarks to Special Tools List

This list reflects the special tools needed for 2 years of maintenance. General hand tools are not considered on this list. As a reference see Recommended Spares for 2 Years K559-2254-CWIWP4202202-N03-001Rev002. Further information can be found in the Service and Maintenance Manual K559-2254-CWIWP4202202-N01-003Rev003.

Special Toolkit

Item	Kit	Part Number	Description	Qty.
1	6100062		Special tools Kit FC Wave EU	1
		6500524	(OEM)Solo Smoke Sabre	1
		6100039	RS PRO Black PVC Cat5e Cable F/UTP, 5m Male RJ45/Male RJ45 -	1
		6100060	Portable Hydrogen Leak Detector (Snooper Mini H2) - EU	1
		6500424	Hanna Instruments conductivity Meter - EU	1
		6100014	Calibration Adapter, RKI Hydrogen Sensor - EU	1
		7001347	Key for the Cabinet Door	1
		6100045	ESD wrist strap and cord	1
6	6100063		Elma 9200BT Bluetoth tangamperemeter	1
7	6100064		Elma BM878 isolationstester og Sand RMS KAT IV multimeter	1
8	7001348		Lifting tool	
10	7000466		Test box for customer interface	1
11	7001283		STAHLWILLE 03190032 CROW-RING-SPANNER 440 32, SIZE 32 MM	1
12	7001285		STAHLWILLE 03190046 CROW-RING-SPANNER 440 46, SIZE 46 MM	1
13	7001284		STAHLWILLE 03190050 CROW-RING-SPANNER 440 50, SIZE 50 MM	1
14	7001316		Krytox GPL 205, NLGI 2, 6 grams plasttube 16x65mm	1
15	6100065		MEG Test lead kit	1
		6100066	Staubli Krokodillenæb, Rød, Messing-kontakter, 32A	5
		6100067	Staubli Krokodillenæb, Sort, rød, 32A	2
		6100068	Hirschmann Test & Measurement, Prøveledning, Rød, 1000V ac/dc, 32A, 500mm	8
		6100069	Hirschmann Test & Measurement, Prøvespids med ledning og 4 mm stik, Rød, 1000V ac/dc, 32A, 1m	2
		6100070	Hirschmann Test & Measurement, Prøvespids med ledning og 4 mm stik, Sort, 1000V ac/dc, 32A, 1m	2
		6100071	Raaco Sortimentsæske, 10 Rum, Blå, PP, 57mm x 338mm x 261mm	1
		6100072	24 V interface Jumper	1
16	7001172		LHD Test Plug	1
17	7001350		DI Filter Special key	1
18	7001351		Cooling sample kit	1
19	7001352		Cooling filling pump with adapters	1

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Sub Section N07

Chemicals and Catalysts

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	4/14/2023	First Issue
002	3/8/2024	Updated according to comments

Document Title:	**BLPH Project - Chemicals and Catalysts**
Document Number:	K559-2254-CWIWP4202202-N07-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-N07-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	N07
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	N07 - Chemicals and Catalysts
Full Title	List of chemicals and catalysts for maintenance of 1MW hydrogen fuel cell container for Crosswind/Shell
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	RBS	9th of March 2023
1.1	Updated specifications	RBS	14th of March 2023
1.2	Coolant levels added	RBS	13th of April 2023
2.0	Update specifications	RBS	15th of February 2024
2.1	Updated system description	RBS	8th of March 8, 2024

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1.0 Purpose

The purpose of this document is to provide an overview of the chemicals and catalytic materials consumed by the 1MW fuel cell container (MEGABlock) provided by Ballard Power Systems Europe to Crosswind/Shell.

2.0 References

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
MAN-0002	Fuel cell module integration manual V2.2.0	Ballard
MAN001	FCwave™ service manual rev1.1.1	Ballard
	Datasheet HT and LT coolers	Evapco
	Header tank calculation	Ballard

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3.0 Chemicals overview

As stated in the integration manual, the only chemicals contained in the fuel cell system is the coolant. The coolant consists of a mixture of DI-water (De-ionized water) and ethylene glycol.

3.1 Circuit overview

There will be 2 different types of coolant circuits, internal meaning the FCwave™ and external meaning HT and LT coolant circuits.

3.1.1 Internal circuit

For the internal high temperature circuit, a specific Fuel cell grade coolant “BASF Glysantin J21725” I used. The mixture is determined by the application and the temperature surrounding the fuel cell module. For this application, a pre-mix of 50/50 is used. The module will be filled with the coolant before leaving the factory. Filling of the coolant levels is approximately 45L+<10L in the expansion tank per module.

3.1.2 External circuits

As for the low temperature (LT) and high temperature (HT) circuits, the external heat exchanger manufacturer specifies the use of 50/50% ethylene glycol. For this application “Glad Long Life Ethylene Glycol” is used.

3.2 Quantity of chemicals

The following list shows the total amount of chemicals expected to be used in the MEGABlock installation.

Specifications			
Coolant circuit	Chemical	Quantity (L)	Notes
Internal HT loop	BASF Glysantin J21725 Premix 50%	300	
External HT loop	Glad Long Life Ethylene Glycol Premix 50%	1,396	
External LT loop	Glad Long Life Ethylene Glycol Premix 50%	365	
	Total	2,061	

Table 1 - List of chemical quantities.

3.3 Consumption of chemicals

Service for the above-mentioned chemicals is done every 20,000 hours or 2 years, whichever comes first. Under normal operation, there will be no direct consumption of the coolant. However, coolant level will be topped up during general service on the overall system.

4.0 Catalysts overview

As stated in the integration manual for the FCwave™ module, no catalytic material is consumed by the fuel cells in the Shell/Crosswind 1MW container. Additionally, no catalytic material is needed for the external systems to work. This also means that the overall system will not have any initial filling of catalytic materials either.

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Sub Section N08

Lubricants List

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	10/03/2023	First Issue
002	10/07/2024	Expanded to include lubricants used during manufacturing

Document Title:	**BLPH Project - Lubricants List**
Document Number:	K559-2254-CWIWP4202202-N08-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-N08-001Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	N08
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	N08 - Lubricants
Full Title	List of Lubricants needed for installing and operation of 1MW hydrogen fuel cell container for Crosswind/Shell
Abstract	

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Revision Record

Rev #	Description	Revised By	Date
1.0	Initial Release	RBS	March 10, 2023
2.0	Expanded to incl. lubricants used during manufacturing	EZE	July 10, 2024

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1.0 Purpose

The purpose of this document is to provide an overview of all lubricants used in the 1MW fuel cell container (MEGABLOCK) provided by Ballard Power Systems Europe to Crosswind.

2.0 References

Document ID	Document Title	Source
K559-2254-DM-PRO-001	Supplier Documentation Requirements Listing (SDRL) Definitions	KBR
MAN-002	Fuel cell module integration manual V2.2.0	Ballard

3.0 Lubricants Overview

As stated in the integration manual for the FCwave™ module, no lubricants are needed for the installation and operation of the fuel cell modules in the CrossWind 1MW container. This is also the case for all the surrounding systems that make up the container solution. This means that the system does not normally require any lubrication after delivery.

For reference and completeness, the list of lubricants used during manufacturing is shown below.

Manufacturer	Lubricant	Description / Use	Sub-assembly
Putoline®	Ceramic Grease PV.20.01	High-grade assembly paste and high temperature lubricant grease without metal particles used for lubrication of bolts.	Container Solution
Chemours™	Krytox™ GPL 205	Chemically inert, PTFE thickened grease based on perfluoropolyether (PFPE) oils that is safe for use around hazardous chemicals, these lubricants are non-flammable and safe for use in oxygen service. They can be used in extreme conditions, such as continuous high temperatures of up to 204 °C (400 °F) and will survive short-term peak temperatures of up to 220 °C (429 °F).	FCwave™
	Krytox™ GPL 206	Chemically inert, PTFE thickened grease based on perfluoropolyether (PFPE) oils that is safe for use around hazardous chemicals, these lubricants are non-flammable and safe for use in oxygen service. They can be used in extreme conditions, such as continuous high temperatures of up to 260 °C (500 °F) and will survive short-term peak temperatures of up to 270 °C (518 °F).	

4.0 Safety Data Sheets

4.1 Putoline® Ceramic Grease PV.20.01

Ceramic Grease

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878
Issue date: 29-8-2018 Revision date: 21-6-2024 Supersedes version of: 13-10-2022 Version: 1.3

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Product form : Mixture
Trade name : Ceramic Grease
Product code : PV.20.01
Type of product : Paste
Product group : Trade product

1.2. Relevant identified uses of the substance or mixture and uses advised against

1.2.1. Relevant identified uses

Main use category : Industrial use,Professional use,Consumer use
Use of the substance/mixture : Lubricant
Function or use category : Lubricants and additives

1.2.2. Uses advised against

No additional information available

1.3. Details of the supplier of the safety data sheet

Putoline Oil
Dollegoorweg 15
NL 7602 EC Almelo
Netherlands
T 0031 (0)546 81 81 65
vib@putoline.com

1.4. Emergency telephone number

Country/Area	Organisation/Company	Address	Emergency number	Comment
Ireland	National Poisons Information Centre Beaumont Hospital	PO Box 1297 Beaumont Road 9	+353 1 809 2566 (Healthcare professionals-24/7) +353 1 809 2166 (public, 8am - 10pm, 7/7)	
United Kingdom	National Poisons Information Service (Cardiff Centre) University Hospital Llandough	Penlan Road CF64 2XX	0344 892 0111	Only for healthcare professionals

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Classification according to Regulation (EC) No. 1272/2008 [CLP]

Not classified

Adverse physicochemical, human health and environmental effects

To our knowledge, this product does not present any particular risk, provided it is handled in accordance with good occupational hygiene and safety practice.

2.2. Label elements

Labelling according to Regulation (EC) No. 1272/2008 [CLP]

No labelling applicable

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according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

2.3. Other hazards

The mixture does not contain substance(s) included in the list established in accordance with Article 59(1) of REACH for having endocrine disrupting properties, or substance(s) are not identified as having endocrine disrupting properties in accordance with the criteria set out in Commission Delegated Regulation (EU) 2017/2100 or Commission Regulation (EU) 2018/605 at a concentration equal to or greater than 0,1 %

SECTION 3: Composition/information on ingredients

3.1. Substances

Not applicable

3.2. Mixtures

This mixture does not contain any substances to be mentioned according to the criteria of section 3.2 of REACH Annex II

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : If you feel unwell, seek medical advice.
First-aid measures after inhalation : Remove person to fresh air and keep comfortable for breathing.
First-aid measures after skin contact : Wash skin with plenty of water.
First-aid measures after eye contact : Rinse eyes with water as a precaution.
First-aid measures after ingestion : Call a poison center or a doctor if you feel unwell.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/effects after inhalation : Although no appropriate human or animal health effects data are known to exist, this material is expected to be an inhalation hazard.
Symptoms/effects after skin contact : None under normal conditions.
Symptoms/effects after eye contact : None under normal conditions.
Symptoms/effects after ingestion : None under normal conditions.

4.3. Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Water spray. Dry powder. Foam. Carbon dioxide.
Unsuitable extinguishing media : Do not use a heavy water stream.

5.2. Special hazards arising from the substance or mixture

Fire hazard : Combustible liquid.
Explosion hazard : No direct explosion hazard.
Hazardous decomposition products in case of fire : Incomplete combustion releases dangerous carbon monoxide, carbon dioxide and other toxic gases.

5.3. Advice for firefighters

Firefighting instructions : Fight fire from safe distance and protected location. Do not enter fire area without proper protective equipment, including respiratory protection.
Protection during firefighting : Do not attempt to take action without suitable protective equipment. Self-contained breathing apparatus. Complete protective clothing.

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according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures : Stop leak if safe to do so. Notify authorities if product enters sewers or public waters. Absorb spillage to prevent material damage.

6.1.1. For non-emergency personnel

Protective equipment : Wear recommended personal protective equipment.
Emergency procedures : Ventilate spillage area.

6.1.2. For emergency responders

Protective equipment : Do not attempt to take action without suitable protective equipment. For further information refer to section 8: "Exposure controls/personal protection".
Emergency procedures : Evacuate unnecessary personnel. Stop leak if safe to do so.

6.2. Environmental precautions

Avoid release to the environment.

6.3. Methods and material for containment and cleaning up

For containment : Absorb spilled material with sand or earth. Contain any spills with dikes or absorbents to prevent migration and entry into sewers or streams. Stop leak without risks if possible.
Methods for cleaning up : Mechanically recover the product.
Other information : Dispose of materials or solid residues at an authorized site.

6.4. Reference to other sections

For further information refer to section 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Additional hazards when processed : Not expected to present a significant hazard under anticipated conditions of normal use.
Precautions for safe handling : Ensure good ventilation of the work station. Wear personal protective equipment.
Hygiene measures : Do not eat, drink or smoke when using this product. Always wash hands after handling the product.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Keep in a cool, well-ventilated place away from heat.
Storage conditions : Keep cool. Protect from sunlight.
Storage temperature : < 40 °C
Packaging materials : Store always product in container of same material as original container.

7.3. Specific end use(s)

No additional information available

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

8.1.1 National occupational exposure and biological limit values

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Ceramic Grease	
EU - Indicative Occupational Exposure Limit (IOEL)	
Exposure limits/standards for materials that can be formed when handling this product. When mists/aerosols can occur the following is recommended	5 mg/m³ - ACGIH TLV (inhalable fraction).

8.1.2. Recommended monitoring procedures

No additional information available

8.1.3. Air contaminants formed

No additional information available

8.1.4. DNEL and PNEC

No additional information available

8.1.5. Control banding

No additional information available

8.2. Exposure controls

8.2.1. Appropriate engineering controls

Appropriate engineering controls:
Ensure good ventilation of the work station.

8.2.2. Personal protection equipment

Personal protective equipment:
Wear recommended personal protective equipment.

Personal protective equipment symbol(s):



8.2.2.1. Eye and face protection

Eye protection:
Safety glasses

8.2.2.2. Skin protection

Skin and body protection:
Wear suitable protective clothing

Hand protection:
Protective gloves

8.2.2.3. Respiratory protection

Respiratory protection:
In case of insufficient ventilation, wear suitable respiratory equipment

8.2.2.4. Thermal hazards

No additional information available

8.2.3. Environmental exposure controls

Environmental exposure controls:
Avoid release to the environment.

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SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Liquid
Colour	:	Beige.
Appearance	:	Paste.
Odour	:	characteristic.
Odour threshold	:	Not available
Melting point	:	Not applicable
Freezing point	:	Not applicable
Boiling point	:	Not available
Flammability	:	Non flammable.
Lower explosion limit	:	Not available
Upper explosion limit	:	Not available
Flash point	:	Not applicable
Auto-ignition temperature	:	Not applicable
Decomposition temperature	:	Not available
pH	:	Not available
Viscosity, kinematic	:	Not applicable
Solubility	:	Water: Insoluble / Slightly miscible
Partition coefficient n-octanol/water (Log Kow)	:	Not available
Vapour pressure	:	Not available
Vapour pressure at 50°C	:	Not available
Density	:	1,03 – 1,13 g/cm³
Relative density	:	Not applicable
Relative vapour density at 20°C	:	Not available
Particle characteristics	:	Not applicable

9.2. Other information

9.2.1. Information with regard to physical hazard classes

No additional information available

9.2.2. Other safety characteristics

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

The product is non-reactive under normal conditions of use, storage and transport.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Reacts violently with (strong) oxidizers.

10.4. Conditions to avoid

None under recommended storage and handling conditions (see section 7).

10.5. Incompatible materials

No additional information available

10.6. Hazardous decomposition products

Under normal conditions of storage and use, hazardous decomposition products should not be produced.

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SECTION 11: Toxicological information

11.1. Information on hazard classes as defined in Regulation (EC) No 1272/2008

Acute toxicity (oral)	:	Not classified
Acute toxicity (dermal)	:	Not classified
Acute toxicity (inhalation)	:	Not classified
Skin corrosion/irritation	:	Not classified
Serious eye damage/irritation	:	Not classified
Respiratory or skin sensitisation	:	Not classified
Germ cell mutagenicity	:	Not classified
Carcinogenicity	:	Not classified
Reproductive toxicity	:	Not classified
STOT-single exposure	:	Not classified
STOT-repeated exposure	:	Not classified
Aspiration hazard	:	Not classified

Ceramic Grease	
Viscosity, kinematic	Not applicable

11.2. Information on other hazards

No additional information available

SECTION 12: Ecological information

12.1. Toxicity

Ecology - general	:	The product is not considered harmful to aquatic organisms nor to cause long-term adverse effects in the environment.
Hazardous to the aquatic environment, short–term (acute)	:	Not classified
Hazardous to the aquatic environment, long–term (chronic)	:	Not classified

12.2. Persistence and degradability

Ceramic Grease	
Persistence and degradability	Rapidly degradable

12.3. Bioaccumulative potential

No additional information available

12.4. Mobility in soil

No additional information available

12.5. Results of PBT and vPvB assessment

No additional information available

12.6. Endocrine disrupting properties

No additional information available

12.7. Other adverse effects

No additional information available

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SECTION 13: Disposal considerations

13.1. Waste treatment methods

Regional waste regulation	:	Disposal must be done according to official regulations.
Waste treatment methods	:	Dispose of contents/container in accordance with licensed collector's sorting instructions.
Sewage disposal recommendations	:	Disposal must be done according to official regulations.
Product/Packaging disposal recommendations	:	Disposal must be done according to official regulations.
Additional information	:	Do not re-use empty containers.

SECTION 14: Transport information

In accordance with ADR / IMDG / IATA / ADN / RID

ADR	IMDG	IATA	ADN	RID
14.1. UN number or ID number				
Not regulated for transport				
14.2. UN proper shipping name				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
14.3. Transport hazard class(es)				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
14.4. Packing group				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
14.5. Environmental hazards				
Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
No supplementary information available				

14.6. Special precautions for user

Overland transport
Not regulated

Transport by sea
Not regulated

Air transport
Not regulated

Inland waterway transport
Not regulated

Rail transport
Not regulated

14.7. Maritime transport in bulk according to IMO instruments

Not applicable

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according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

15.1.1. EU-Regulations

REACH Annex XVII (Restriction List)

Contains no substance(s) listed on REACH Annex XVII (Restriction Conditions)

REACH Annex XIV (Authorisation List)

Contains no substance(s) listed on REACH Annex XIV (Authorisation List)

REACH Candidate List (SVHC)

Contains no substance(s) listed on the REACH Candidate List

PIC Regulation (Prior Informed Consent)

Contains no substance(s) listed on the PIC list (Regulation EU 649/2012 concerning the export and import of hazardous chemicals)

POP Regulation (Persistent Organic Pollutants)

Contains no substance(s) listed on the POP list (Regulation EU 2019/1021 on persistent organic pollutants)

Ozone Regulation (1005/2009)

Contains no substance(s) listed on the Ozone Depletion list (Regulation EU 1005/2009 on substances that deplete the ozone layer)

Dual-Use Regulation (428/2009)

Contains no substance subject to the COUNCIL REGULATION (EC) No 428/2009 of 5 May 2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items.

Explosives Precursors Regulation (2019/1148)

Contains no substance(s) listed on the Explosives Precursors list (Regulation EU 2019/1148 on the marketing and use of explosives precursors)

Drug Precursors Regulation (273/2004)

Contains no substance(s) listed on the Drug Precursors list (Regulation EC 273/2004 on the manufacture and the placing on market of certain substances used in the illicit manufacture of narcotic drugs and psychotropic substances)

15.1.2. National regulations

No additional information available

15.2. Chemical safety assessment

No chemical safety assessment has been carried out

SECTION 16: Other information

Indication of changes

Section	Changed item	Change	Comments
	Revision date	Modified	
	Supersedes	Modified	
4.1	First-aid measures general	Added	
4.2	Symptoms/effects after eye contact	Added	
4.2	Symptoms/effects after ingestion	Added	
4.2	Symptoms/effects after inhalation	Added	
4.2	Symptoms/effects after skin contact	Added	
5.2	Explosion hazard	Added	
5.2	Hazardous decomposition products in case of fire	Modified	
5.3	Firefighting instructions	Added	

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according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

Indication of changes			
Section	**Changed item**	**Change**	**Comments**
6.1	Protective equipment	Added	
6.1	Emergency procedures	Added	
6.1	General measures	Added	
6.3	For containment	Added	
7.1	Additional hazards when processed	Added	
7.2	Technical measures	Added	
7.2	Packaging materials	Added	
7.2	Storage conditions	Modified	
8.2	Personal protective equipment	Added	
10.3	Possibility of hazardous reactions	Modified	
13.1	Additional information	Added	
13.1	Sewage disposal recommendations	Added	
13.1	Waste disposal recommendations	Added	
13.1	Regional waste regulation	Added	
13.1	H code	Added	

Abbreviations and acronyms:	
ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
ATE	Acute Toxicity Estimate
BCF	Bioconcentration factor
BLV	Biological limit value
BOD	Biochemical oxygen demand (BOD)
COD	Chemical oxygen demand (COD)
DMEL	Derived Minimal Effect level
DNEL	Derived-No Effect Level
EC-No.	European Community number
EC50	Median effective concentration
EN	European Standard
IARC	International Agency for Research on Cancer
IATA	International Air Transport Association
IMDG	International Maritime Dangerous Goods
LC50	Median lethal concentration
LD50	Median lethal dose
LOAEL	Lowest Observed Adverse Effect Level
NOAEC	No-Observed Adverse Effect Concentration
NOAEL	No-Observed Adverse Effect Level
NOEC	No-Observed Effect Concentration

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Ballard Confidential

Printed on: Wednesday, July 10, 2024

Ceramic Grease

Safety Data Sheet

according to the REACH Regulation (EC) 1907/2006 amended by Regulation (EU) 2020/878

Abbreviations and acronyms:	
OECD	Organisation for Economic Co-operation and Development
OEL	Occupational Exposure Limit
PBT	Persistent Bioaccumulative Toxic
PNEC	Predicted No-Effect Concentration
RID	Regulations concerning the International Carriage of Dangerous Goods by Rail
SDS	Safety Data Sheet
STP	Sewage treatment plant
ThOD	Theoretical oxygen demand (ThOD)
TLM	Median Tolerance Limit
VOC	Volatile Organic Compounds
CAS-No.	Chemical Abstract Service number
N.O.S.	Not Otherwise Specified
vPvB	Very Persistent and Very Bioaccumulative
ED	Endocrine disrupting properties

Safety Data Sheet (SDS), EU

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.

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4.2 Krytox™ GPL 205

SAFETY DATA SHEET
According to REACH Regulation (EC) No 1907/2006, as amended by UK REACH Regulations SI 2019/758

Chemours™

Krytox™ GPL 205

Version	Revision Date:	SDS Number:	Date of last issue: 02.11.2023
3.3	29.05.2024	9582423-00007	Date of first issue: 15.09.2021

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Trade name : Krytox™ GPL 205

SDS-Identcode : 130000024223

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of the Substance/Mixture : Lubricant

Recommended restrictions on use : For industrial use only.
Do not use or resell Chemours™ materials in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless agreed to by Seller in a written agreement covering such use. For further information, please contact your Chemours representative.

1.3 Details of the supplier of the safety data sheet

Company : Chemours Netherlands B.V.
Baanhoekweg 22
3313 LA Dordrecht Netherlands

Telephone : +31-(0)-78-630-1011

Telefax : +31-78-6163737

E-mail address of person responsible for the SDS : sds-support@chemours.com

1.4 Emergency telephone number

+(44)-870-8200418 (CHEMTREC - Recommended)

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Classification (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

Not a hazardous substance or mixture.

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2.2 Label elements

Labelling (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

No hazard pictogram, no signal word, no hazard statement(s), no precautionary statement(s) required

2.3 Other hazards

This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.
The thermal decomposition vapours of fluorinated plastics may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

Components

Remarks : No hazardous ingredients

SECTION 4: First aid measures

4.1 Description of first aid measures

Protection of first-aiders : No special precautions are necessary for first aid responders.

If inhaled : If inhaled, remove to fresh air.
Get medical attention if symptoms occur.

In case of skin contact : Wash with water and soap as a precaution.
Get medical attention if symptoms occur.

In case of eye contact : Flush eyes with water as a precaution.
Get medical attention if irritation develops and persists.

If swallowed : If swallowed, DO NOT induce vomiting.
Get medical attention if symptoms occur.
Rinse mouth thoroughly with water.

4.2 Most important symptoms and effects, both acute and delayed

Symptoms : Inhalation may provoke the following symptoms:
Irritation
Lung oedema

Eye contact may provoke the following symptoms
Blurred vision
Discomfort

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Lachrymation

Skin contact may provoke the following symptoms:
Irritation
Redness

Inhalation may provoke the following symptoms:
Irritation
Shortness of breath

4.3 Indication of any immediate medical attention and special treatment needed

Treatment : Treat symptomatically and supportively.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media : Not applicable
Will not burn

Unsuitable extinguishing media : Not applicable
Will not burn

5.2 Special hazards arising from the substance or mixture

Specific hazards during fire-fighting : Exposure to combustion products may be a hazard to health.

Hazardous combustion products : Hydrogen fluoride
carbonyl fluoride
potentially toxic fluorinated compounds
aerosolized particulates
Carbon oxides

5.3 Advice for firefighters

Special protective equipment for firefighters : Wear self-contained breathing apparatus for firefighting if necessary. Use personal protective equipment.

Specific extinguishing methods : Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Use water spray to cool unopened containers.
Remove undamaged containers from fire area if it is safe to do so.
Evacuate area.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Personal precautions : Follow safe handling advice (see section 7) and personal pro-

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tective equipment recommendations (see section 8).

6.2 Environmental precautions

Environmental precautions : Avoid release to the environment.
Prevent further leakage or spillage if safe to do so.
Retain and dispose of contaminated wash water.
If spillage enters rivers or watercourses, inform the Environment Agency (emergency telephone number 0800 807060).

6.3 Methods and material for containment and cleaning up

Methods for cleaning up : Soak up with inert absorbent material.
For large spills, provide dyking or other appropriate containment to keep material from spreading. If dyked material can be pumped, store recovered material in appropriate container.
Clean up remaining materials from spill with suitable absorbent.
Local or national regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which regulations are applicable.
Sections 13 and 15 of this SDS provide information regarding certain local or national requirements.

6.4 Reference to other sections

See sections: 7, 8, 11, 12 and 13.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Technical measures : See Engineering measures under EXPOSURE CONTROLS/PERSONAL PROTECTION section.

Local/Total ventilation : Use only with adequate ventilation.

Advice on safe handling : Handle in accordance with good industrial hygiene and safety practice, based on the results of the workplace exposure assessment
Take care to prevent spills, waste and minimize release to the environment.

Do not breathe decomposition products.

Hygiene measures : If exposure to chemical is likely during typical use, provide eye flushing systems and safety showers close to the working place. When using do not eat, drink or smoke. Wash contaminated clothing before re-use.

7.2 Conditions for safe storage, including any incompatibilities

Requirements for storage : Keep in properly labelled containers. Store in accordance with

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areas and containers — the particular national regulations.

Advice on common storage : No special restrictions on storage with other products.

Further information on storage stability : No decomposition if stored and applied as directed.

7.3 Specific end use(s)

Specific use(s) : No data available

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Occupational Exposure Limits

Contains no substances with occupational exposure limit values.

Occupational exposure limits of decomposition products

Components	CAS-No.	Value type (Form of exposure)	Control parameters	Basis
hydrofluoric acid	7664-39-3	TWA	1.8 ppm 1.5 mg/m3 (Fluorine)	GB EH40
		STEL	3 ppm 2.5 mg/m3 (Fluorine)	GB EH40
		TWA	1.8 ppm 1.5 mg/m3	2000/39/EC
	Further information: Indicative			
		STEL	3 ppm 2.5 mg/m3	2000/39/EC
	Further information: Indicative			
Carbonyl difluoride	353-50-4	TWA	2.5 mg/m3 (Fluorine)	2000/39/EC
	Further information: Indicative			
Carbon dioxide	124-38-9	TWA	5,000 ppm 9,150 mg/m3	GB EH40
		STEL	15,000 ppm 27,400 mg/m3	GB EH40
		TWA	5,000 ppm 9,000 mg/m3	2006/15/EC
	Further information: Indicative			
Carbon monoxide	630-08-0	TWA	30 ppm 35 mg/m3	GB EH40
		STEL	200 ppm 232 mg/m3	GB EH40
		TWA	20 ppm 23 mg/m3	GB EH40
		STEL	100 ppm	GB EH40

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			117 mg/m3	
		STEL	100 ppm 117 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			
		STEL	100 ppm 117 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			

8.2 Exposure controls

Engineering measures

Processing may form hazardous compounds (see section 10).
Ensure adequate ventilation, especially in confined areas.
Minimize workplace exposure concentrations.

Personal protective equipment

Eye/face protection : Wear the following personal protective equipment:
Safety glasses
Equipment should conform to BS EN 166

Hand protection

Remarks : Wash hands before breaks and at the end of workday.

Skin and body protection : Skin should be washed after contact.

Respiratory protection : If adequate local exhaust ventilation is not available or exposure assessment demonstrates exposures outside the recommended guidelines, use respiratory protection.
Equipment should conform to BS EN 14387

Filter type : Combined particulates, acidic gas/vapour and organic vapour type (AE-P)

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance : Grease

Colour : white

Odour : odourless

Odour Threshold : No data available

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pH	:	7
Melting point/freezing point	:	320 °C
Initial boiling point and boiling range	:	No data available
Flash point	:	Method: Pensky-Martens closed cup Not applicable
Evaporation rate	:	Not applicable
Flammability (solid, gas)	:	Will not burn
Upper explosion limit / Upper flammability limit	:	No data available
Lower explosion limit / Lower flammability limit	:	No data available
Vapour pressure	:	Not applicable
Relative vapour density	:	Not applicable
Relative density	:	1.89 - 1.93 (24 °C)
Solubility(ies) Water solubility	:	insoluble
Partition coefficient: n-octanol/water	:	Not applicable
Auto-ignition temperature	:	No data available
Decomposition temperature	:	300 °C
Viscosity Viscosity, kinematic	:	Not applicable
Explosive properties	:	Not explosive
Oxidizing properties	:	The substance or mixture is not classified as oxidizing.

9.2 Other information

Particle size	:	No data available

SECTION 10: Stability and reactivity

10.1 Reactivity

Not classified as a reactivity hazard.

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10.2 Chemical stability
Stable under normal conditions.

10.3 Possibility of hazardous reactions
Hazardous reactions : Hazardous decomposition products will be formed at elevated temperatures.

10.4 Conditions to avoid
Conditions to avoid : None known.

10.5 Incompatible materials
Materials to avoid : None.

10.6 Hazardous decomposition products
Thermal decomposition : hydrofluoric acid
Carbonyl difluoride
Carbon dioxide
Carbon monoxide

SECTION 11: Toxicological information

11.1 Information on toxicological effects
Information on likely routes of exposure : Skin contact
Ingestion
Eye contact

Acute toxicity
Not classified based on available information.

Skin corrosion/irritation
Not classified based on available information.

Serious eye damage/eye irritation
Not classified based on available information.

Respiratory or skin sensitisation

Skin sensitisation
Not classified based on available information.

Respiratory sensitisation
Not classified based on available information.

Germ cell mutagenicity
Not classified based on available information.

Carcinogenicity
Not classified based on available information.

Reproductive toxicity
Not classified based on available information.

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STOT - single exposure
Not classified based on available information.

STOT - repeated exposure
Not classified based on available information.

Aspiration toxicity
Not classified based on available information.

SECTION 12: Ecological information

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment

Product:

Assessment	:	This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

12.6 Other adverse effects

Product:

Endocrine disrupting potential	:	This substance/mixture does not contain components considered to have endocrine disrupting properties for environment according to UK REACH Article 57(f).

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product	:	Dispose of in accordance with local regulations. According to the European Waste Catalogue, Waste Codes are not product specific, but application specific. Waste codes should be assigned by the user, preferably in discussion with the waste disposal authorities. Do not dispose of waste into sewer.
Contaminated packaging	:	Empty containers should be taken to an approved waste handling site for recycling or disposal.

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If not otherwise specified: Dispose of as unused product.

SECTION 14: Transport information

14.1 UN number

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.2 UN proper shipping name

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.3 Transport hazard class(es)

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.4 Packing group

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA (Cargo)	:	Not regulated as a dangerous good
IATA (Passenger)	:	Not regulated as a dangerous good

14.5 Environmental hazards
Not regulated as a dangerous good

14.6 Special precautions for user
Not applicable

14.7 Transport in bulk according to Annex II of Marpol and the IBC Code
Remarks : Not applicable for product as supplied.

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SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Relevant EU provisions transposed through retained EU law

UK REACH List of restrictions (Annex 17)	:	Not applicable
UK REACH Candidate list of substances of very high concern (SVHC) for Authorisation	:	Not applicable
The Persistent Organic Pollutants Regulations (retained Regulation (EU) 2019/1021 as amended for Great Britain)	:	Not applicable
Regulation (EC) No 1005/2009 on substances that deplete the ozone layer	:	Not applicable
UK REACH List of substances subject to authorisation (Annex XIV)	:	Not applicable
GB Export and import of hazardous chemicals - Prior Informed Consent (PIC) Regulation	:	Not applicable

Control of Major Accident Hazards Regulations 2015 (COMAH)
Not applicable

15.2 Chemical safety assessment

A Chemical Safety Assessment has not been carried out.

SECTION 16: Other information

Other information	:	Krytox™ and any associated logos are trademarks or copyrights of The Chemours Company FC, LLC. Chemours™ and the Chemours Logo are trademarks of The Chemours Company. Before use read Chemours safety information. For further information contact the local Chemours office or nominated distributors. Items where changes have been made to the previous version are highlighted in the body of this document by two vertical lines.

Full text of other abbreviations

2000/39/EC	:	Europe. Commission Directive 2000/39/EC establishing a first list of indicative occupational exposure limit values
2004/37/EC	:	Europe. Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens

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		at work
2006/15/EC	:	Europe. Indicative occupational exposure limit values
2017/164/EU	:	Europe. Commission Directive 2017/164/EU establishing a fourth list of indicative occupational exposure limit values
GB EH40	:	UK. EH40 WEL - Workplace Exposure Limits
2000/39/EC / TWA	:	Limit Value - eight hours
2000/39/EC / STEL	:	Short term exposure limit
2004/37/EC / STEL	:	Short term exposure limit
2004/37/EC / TWA	:	Long term exposure limit
2006/15/EC / TWA	:	Limit Value - eight hours
2017/164/EU / STEL	:	Short term exposure limit
2017/164/EU / TWA	:	Limit Value - eight hours
GB EH40 / TWA	:	Long-term exposure limit (8-hour TWA reference period)
GB EH40 / STEL	:	Short-term exposure limit (15-minute reference period)

ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways; ADR - Agreement concerning the International Carriage of Dangerous Goods by Road; AIIC - Australian Inventory of Industrial Chemicals; ASTM - American Society for the Testing of Materials; bw - Body weight; CLP - Classification Labelling Packaging Regulation; Regulation (EC) No 1272/2008; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardisation; DSL - Domestic Substances List (Canada); ECHA - European Chemicals Agency; EC-Number - European Community number; ECx - Concentration associated with x% response; ELx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 - Half maximal inhibitory concentration; ICAO - International Civil Aviation Organization; IECSC - Inventory of Existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial Safety and Health Law (Japan); ISO - International Organisation for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal Concentration to 50 % of a test population; LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose); MARPOL - International Convention for the Prevention of Pollution from Ships; n.o.s. - Not Otherwise Specified; NO(A)EC - No Observed (Adverse) Effect Concentration; NO(A)EL - No Observed (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Co-operation and Development; OPPTS - Office of Chemical Safety and Pollution Prevention; PBT - Persistent, Bioaccumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals; RID - Regulations concerning the International Carriage of Dangerous Goods by Rail; SADT - Self-Accelerating Decomposition Temperature; SDS - Safety Data Sheet; SVHC - Substance of very high concern; TCSI - Taiwan Chemical Substance Inventory; TECI - Thailand Existing Chemicals Inventory; TSCA - Toxic Substances Control Act (United States); UN - United Nations; UNRTDG - United Nations Recommendations on the Transport of Dangerous Goods; vPvB - Very Persistent and Very Bioaccumulative

Further information

Sources of key data used to compile the Safety Data Sheet	:	Internal technical data, data from raw material SDSs, OECD eChem Portal search results and European Chemicals Agency, http://echa.europa.eu/

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The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and shall not be considered a warranty or quality specification of any type. The information provided relates only to the specific material identified at the top of this SDS and may not be valid when the SDS material is used in combination with any other materials or in any process, unless specified in the text. Material users should review the information and recommendations in the specific context of their intended manner of handling, use, processing and storage, including an assessment of the appropriateness of the SDS material in the user's end product, if applicable.

GB / EN

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4.3 Krytox™ GPL 206

SAFETY DATA SHEET
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Chemours™

Krytox™ GPL 206

Version	Revision Date:	SDS Number:	Date of last issue: 02.11.2023
3.3	17.05.2024	9582813-00006	Date of first issue: 15.09.2021

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Trade name : Krytox™ GPL 206

SDS-Identcode : 130000031500

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of the Substance/Mixture : Lubricant

Recommended restrictions on use : For industrial use only.
Do not use or resell Chemours™ materials in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless agreed to by Seller in a written agreement covering such use. For further information, please contact your Chemours representative.

1.3 Details of the supplier of the safety data sheet

Company : Chemours Netherlands B.V.
Baanhoekweg 22
3313 LA Dordrecht Netherlands

Telephone : +31-(0)-78-630-1011

Telefax : +31-78-6163737

E-mail address of person responsible for the SDS : sds-support@chemours.com

1.4 Emergency telephone number

+(44)-870-8200418 (CHEMTREC - Recommended)

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Classification (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

Not a hazardous substance or mixture.

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2.2 Label elements

Labelling (REGULATION (EC) No 1272/2008) as amended by GB-CLP Regulation, UK SI 2019/720, and UK SI 2020/1567)

No hazard pictogram, no signal word, no hazard statement(s), no precautionary statement(s) required

2.3 Other hazards

This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.
The thermal decomposition vapours of fluorinated plastics may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

Components

Remarks : No hazardous ingredients

SECTION 4: First aid measures

4.1 Description of first aid measures

Protection of first-aiders : No special precautions are necessary for first aid responders.

If inhaled : If inhaled, remove to fresh air.
Get medical attention if symptoms occur.

In case of skin contact : Wash with water and soap as a precaution.
Get medical attention if symptoms occur.

In case of eye contact : Flush eyes with water as a precaution.
Get medical attention if irritation develops and persists.

If swallowed : If swallowed, DO NOT induce vomiting.
Get medical attention if symptoms occur.
Rinse mouth thoroughly with water.

4.2 Most important symptoms and effects, both acute and delayed

Symptoms : Inhalation may provoke the following symptoms:
Irritation
Lung oedema

Eye contact may provoke the following symptoms
Blurred vision
Discomfort

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Lachrymation

Skin contact may provoke the following symptoms:
Irritation
Redness

Inhalation may provoke the following symptoms:
Irritation
Shortness of breath

4.3 Indication of any immediate medical attention and special treatment needed

Treatment : Treat symptomatically and supportively.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media : Not applicable
Will not burn

Unsuitable extinguishing media : Not applicable
Will not burn

5.2 Special hazards arising from the substance or mixture

Specific hazards during fire-fighting : Exposure to combustion products may be a hazard to health.

Hazardous combustion products : Hydrogen fluoride
carbonyl fluoride
potentially toxic fluorinated compounds
aerosolized particulates
Carbon oxides

5.3 Advice for firefighters

Special protective equipment for firefighters : Wear self-contained breathing apparatus for firefighting if necessary. Use personal protective equipment.

Specific extinguishing methods : Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Use water spray to cool unopened containers.
Remove undamaged containers from fire area if it is safe to do so.
Evacuate area.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Personal precautions : Follow safe handling advice (see section 7) and personal pro-

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tective equipment recommendations (see section 8).

6.2 Environmental precautions

Environmental precautions : Avoid release to the environment.
Prevent further leakage or spillage if safe to do so.
Retain and dispose of contaminated wash water.
If spillage enters rivers or watercourses, inform the Environment Agency (emergency telephone number 0800 807060).

6.3 Methods and material for containment and cleaning up

Methods for cleaning up : Soak up with inert absorbent material.
For large spills, provide dyking or other appropriate containment to keep material from spreading. If dyked material can be pumped, store recovered material in appropriate container.
Clean up remaining materials from spill with suitable absorbent.
Local or national regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which regulations are applicable.
Sections 13 and 15 of this SDS provide information regarding certain local or national requirements.

6.4 Reference to other sections

See sections: 7, 8, 11, 12 and 13.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Technical measures : See Engineering measures under EXPOSURE CONTROLS/PERSONAL PROTECTION section.

Local/Total ventilation : Use only with adequate ventilation.

Advice on safe handling : Handle in accordance with good industrial hygiene and safety practice, based on the results of the workplace exposure assessment
Take care to prevent spills, waste and minimize release to the environment.

Do not breathe decomposition products.

Hygiene measures : If exposure to chemical is likely during typical use, provide eye flushing systems and safety showers close to the working place. When using do not eat, drink or smoke. Wash contaminated clothing before re-use.

7.2 Conditions for safe storage, including any incompatibilities

Requirements for storage : Keep in properly labelled containers. Store in accordance with

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areas and containers — the particular national regulations.

Advice on common storage : No special restrictions on storage with other products.

Further information on storage stability : No decomposition if stored and applied as directed.

7.3 Specific end use(s)

Specific use(s) : No data available

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Occupational Exposure Limits

Contains no substances with occupational exposure limit values.

Occupational exposure limits of decomposition products

Components	CAS-No.	Value type (Form of exposure)	Control parameters	Basis
hydrofluoric acid	7664-39-3	TWA	1.8 ppm 1.5 mg/m3 (Fluorine)	GB EH40
		STEL	3 ppm 2.5 mg/m3 (Fluorine)	GB EH40
		TWA	1.8 ppm 1.5 mg/m3	2000/39/EC
	Further information: Indicative			
		STEL	3 ppm 2.5 mg/m3	2000/39/EC
	Further information: Indicative			
Carbonyl difluoride	353-50-4	TWA	2.5 mg/m3 (Fluorine)	2000/39/EC
	Further information: Indicative			
Carbon dioxide	124-38-9	TWA	5,000 ppm 9,150 mg/m3	GB EH40
		STEL	15,000 ppm 27,400 mg/m3	GB EH40
		TWA	5,000 ppm 9,000 mg/m3	2006/15/EC
	Further information: Indicative			
Carbon monoxide	630-08-0	TWA	30 ppm 35 mg/m3	GB EH40
		STEL	200 ppm 232 mg/m3	GB EH40
		TWA	20 ppm 23 mg/m3	GB EH40
		STEL	100 ppm	GB EH40

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			117 mg/m3	
		STEL	100 ppm 117 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2017/164/EU
	Further information: Indicative			
		TWA	20 ppm 23 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			
		STEL	100 ppm 117 mg/m3	2004/37/EC
	Further information: Carcinogens or mutagens			

8.2 Exposure controls

Engineering measures

Processing may form hazardous compounds (see section 10).
Ensure adequate ventilation, especially in confined areas.
Minimize workplace exposure concentrations.

Personal protective equipment

Eye/face protection : Wear the following personal protective equipment:
Safety glasses
Equipment should conform to BS EN 166

Hand protection

Remarks : Wash hands before breaks and at the end of workday.

Skin and body protection : Skin should be washed after contact.

Respiratory protection : If adequate local exhaust ventilation is not available or exposure assessment demonstrates exposures outside the recommended guidelines, use respiratory protection.
Equipment should conform to BS EN 14387

Filter type : Combined particulates, acidic gas/vapour and organic vapour type (AE-P)

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance : Grease

Colour : white

Odour : odourless

Odour Threshold : No data available

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pH	:	7
Melting point/freezing point	:	320 °C
Initial boiling point and boiling range	:	No data available
Flash point	:	Method: Pensky-Martens closed cup Not applicable
Evaporation rate	:	Not applicable
Flammability (solid, gas)	:	Will not burn
Upper explosion limit / Upper flammability limit	:	No data available
Lower explosion limit / Lower flammability limit	:	No data available
Vapour pressure	:	Not applicable
Relative vapour density	:	Not applicable
Relative density	:	1.89 - 1.93 (24 °C)
Solubility(ies) Water solubility	: :	 insoluble
Partition coefficient: n-octanol/water	:	Not applicable
Auto-ignition temperature	:	No data available
Decomposition temperature	:	300 °C
Viscosity Viscosity, kinematic	: :	 Not applicable
Explosive properties	:	Not explosive
Oxidizing properties	:	The substance or mixture is not classified as oxidizing.

9.2 Other information

Particle size	:	No data available

SECTION 10: Stability and reactivity

10.1 Reactivity

Not classified as a reactivity hazard.

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10.2 Chemical stability
Stable under normal conditions.

10.3 Possibility of hazardous reactions
Hazardous reactions : Hazardous decomposition products will be formed at elevated temperatures.

10.4 Conditions to avoid
Conditions to avoid : None known.

10.5 Incompatible materials
Materials to avoid : None.

10.6 Hazardous decomposition products
Thermal decomposition : hydrofluoric acid
Carbonyl difluoride
Carbon dioxide
Carbon monoxide

SECTION 11: Toxicological information

11.1 Information on toxicological effects
Information on likely routes of exposure : Skin contact
Ingestion
Eye contact

Acute toxicity
Not classified based on available information.

Skin corrosion/irritation
Not classified based on available information.

Serious eye damage/eye irritation
Not classified based on available information.

Respiratory or skin sensitisation

Skin sensitisation
Not classified based on available information.

Respiratory sensitisation
Not classified based on available information.

Germ cell mutagenicity
Not classified based on available information.

Carcinogenicity
Not classified based on available information.

Reproductive toxicity
Not classified based on available information.

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STOT - single exposure
Not classified based on available information.

STOT - repeated exposure
Not classified based on available information.

Aspiration toxicity
Not classified based on available information.

SECTION 12: Ecological information

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment

Product:

Assessment	:	This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

12.6 Other adverse effects

Product:

Endocrine disrupting potential	:	This substance/mixture does not contain components considered to have endocrine disrupting properties for environment according to UK REACH Article 57(f).

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product	:	Dispose of in accordance with local regulations. According to the European Waste Catalogue, Waste Codes are not product specific, but application specific. Waste codes should be assigned by the user, preferably in discussion with the waste disposal authorities. Do not dispose of waste into sewer.
Contaminated packaging	:	Empty containers should be taken to an approved waste handling site for recycling or disposal.

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If not otherwise specified: Dispose of as unused product.

SECTION 14: Transport information

14.1 UN number

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.2 UN proper shipping name

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.3 Transport hazard class(es)

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA	:	Not regulated as a dangerous good

14.4 Packing group

ADN	:	Not regulated as a dangerous good
ADR	:	Not regulated as a dangerous good
RID	:	Not regulated as a dangerous good
IMDG	:	Not regulated as a dangerous good
IATA (Cargo)	:	Not regulated as a dangerous good
IATA (Passenger)	:	Not regulated as a dangerous good

14.5 Environmental hazards
Not regulated as a dangerous good

14.6 Special precautions for user
Not applicable

14.7 Transport in bulk according to Annex II of Marpol and the IBC Code
Remarks : Not applicable for product as supplied.

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SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Relevant EU provisions transposed through retained EU law

UK REACH List of restrictions (Annex 17)	:	Not applicable
UK REACH Candidate list of substances of very high concern (SVHC) for Authorisation	:	Not applicable
The Persistent Organic Pollutants Regulations (retained Regulation (EU) 2019/1021 as amended for Great Britain)	:	Not applicable
Regulation (EC) No 1005/2009 on substances that deplete the ozone layer	:	Not applicable
UK REACH List of substances subject to authorisation (Annex XIV)	:	Not applicable
GB Export and import of hazardous chemicals - Prior Informed Consent (PIC) Regulation	:	Not applicable

Control of Major Accident Hazards Regulations 2015 (COMAH)
Not applicable

15.2 Chemical safety assessment

A Chemical Safety Assessment has not been carried out.

SECTION 16: Other information

Other information	:	Krytox™ and any associated logos are trademarks or copyrights of The Chemours Company FC, LLC. Chemours™ and the Chemours Logo are trademarks of The Chemours Company. Before use read Chemours safety information. For further information contact the local Chemours office or nominated distributors. Items where changes have been made to the previous version are highlighted in the body of this document by two vertical lines.

Full text of other abbreviations

2000/39/EC	:	Europe. Commission Directive 2000/39/EC establishing a first list of indicative occupational exposure limit values
2004/37/EC	:	Europe. Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens

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		at work
2006/15/EC	:	Europe. Indicative occupational exposure limit values
2017/164/EU	:	Europe. Commission Directive 2017/164/EU establishing a fourth list of indicative occupational exposure limit values
GB EH40	:	UK. EH40 WEL - Workplace Exposure Limits
2000/39/EC / TWA	:	Limit Value - eight hours
2000/39/EC / STEL	:	Short term exposure limit
2004/37/EC / STEL	:	Short term exposure limit
2004/37/EC / TWA	:	Long term exposure limit
2006/15/EC / TWA	:	Limit Value - eight hours
2017/164/EU / STEL	:	Short term exposure limit
2017/164/EU / TWA	:	Limit Value - eight hours
GB EH40 / TWA	:	Long-term exposure limit (8-hour TWA reference period)
GB EH40 / STEL	:	Short-term exposure limit (15-minute reference period)

ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways; ADR - Agreement concerning the International Carriage of Dangerous Goods by Road; AIIC - Australian Inventory of Industrial Chemicals; ASTM - American Society for the Testing of Materials; bw - Body weight; CLP - Classification Labelling Packaging Regulation; Regulation (EC) No 1272/2008; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardisation; DSL - Domestic Substances List (Canada); ECHA - European Chemicals Agency; EC-Number - European Community number; ECx - Concentration associated with x% response; ELx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 - Half maximal inhibitory concentration; ICAO - International Civil Aviation Organization; IECSC - Inventory of Existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial Safety and Health Law (Japan); ISO - International Organisation for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal Concentration to 50 % of a test population; LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose); MARPOL - International Convention for the Prevention of Pollution from Ships; n.o.s. - Not Otherwise Specified; NO(A)EC - No Observed (Adverse) Effect Concentration; NO(A)EL - No Observed (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Co-operation and Development; OPPTS - Office of Chemical Safety and Pollution Prevention; PBT - Persistent, Bioaccumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals; RID - Regulations concerning the International Carriage of Dangerous Goods by Rail; SADT - Self-Accelerating Decomposition Temperature; SDS - Safety Data Sheet; SVHC - Substance of very high concern; TCSI - Taiwan Chemical Substance Inventory; TECI - Thailand Existing Chemicals Inventory; TSCA - Toxic Substances Control Act (United States); UN - United Nations; UNRTDG - United Nations Recommendations on the Transport of Dangerous Goods; vPvB - Very Persistent and Very Bioaccumulative

Further information

Sources of key data used to compile the Safety Data Sheet	:	Internal technical data, data from raw material SDSs, OECD eChem Portal search results and European Chemicals Agency, http://echa.europa.eu/

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Section Q

Quality Documentation

Sub Section Q01

Quality Manual

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	10/02/2023	First Issue

KBR
ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

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ACCEPTED WITH COMMENTS	(Code 2)
NOT ACCEPTED	(Code 3)
NOT REVIEWED	(Code 4)

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DISCIPLINE _____ BY _____
DATE _____

Document Title:	**BLPH Project - Quality Manual (incl. Quality System Cert.)**
Document Number:	K559-2254-CWIWP4202202-Q01-001
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Purchase Order:	CWIWP4202202
Code:	Q01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Bureau Veritas Certification

Ballard Power Systems Europe A/S

Majsmarken 1, 9500 Hobro, Denmark

Bureau Veritas Certification Denmark A/S certifies that the Management System of the above organization has been audited and found to be in accordance with the requirements of the management system standards detailed below.

Standard

ISO 9001:2015

Scope of certification

Development, Sales, Production, and Service of Fuel Cell Generators.

Original Cycle Start Date:	**05-01-2015**
Expiry date of previous cycle:	**NA**
Certification/Recertification Audit date:	**NA**
Certification/Recertification cycle start date:	**05-01-2021**
Subject to the continued satisfactory operation of the organization's Management System, this certificate expires on:	**04-01-2024**

Certificate No.: **DK013471** Version: **1** Issue Date: **13-11-2020**

DANAK
SYSTEM Reg.nr. 5005

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Oldenborggade 25-31, 7000 Fredericia, Denmark

Further clarifications regarding the scope of this certificate and the applicability of the Management System requirements may be obtained by consulting the organization. To check this certificate validity, please call: (+45) 77 311 000.

Name	Process owner
Assembly & Test	Supply Chain Manager
Bus Commissioning	Field Service Manager
Calibration Measuring Equipment	Supply Chain Manager
Continous Improvement Activities	Product Manager
Corrective Action Request	Quality Manager
COVID-19 Procedure	Safety Environment Group
Customer Care Management & Customer Complaint Handling	Field Service Manager
Customer Care Management Administration	Field Service Manager
Customer Satisfaction Survey	Commercial Director
ECR/ECO	VP T&PD
Employee Departure	People & Culture Director
Employee Development	People & Culture Director
Employee Training	People & Culture Director
Employment Abroad	
ESD Handling	Manufacturing Manager
Evaluating training activities	People & Culture Director
Expenditure Policies	CEO
Expenditure Policy - Budgeted Projects	CEO
Expenditure Policy - Day to Day Purchase	CEO
Expenditure Policy - For Stock	CEO
Freight Management	Supply Chain Manager
Handling bus warranty parts (Out of ISO Scope)	Field Service Manager
Handling Nonconformities	Supply Chain Manager
Handling Nonconformities measuring device	VP T&PD
Handover and Maintenance of Work Instruction	Manufacturing Manager
Idea Generation	Market Development Manager
Installation Process	Field Service Manager
Internal Audits	Quality Manager
Introduction new chemicals / Hjælpestoffer	Safety Environment Group
Invoice Acceptance	CFO
IT onboarding	IT Manager
Lessons Learned	Quality Manager
Management Review	Quality Manager
NDA Process	CEO
Nonconformity Handling Administration	Supply Chain Manager
Norms and Standards	Regulatory Affairs Manager
Overdue Payment follow-up	CFO
Phase 1 Planning and Pre-development	VP T&PD
Phase 2 Design and Development	VP T&PD
Phase 3 Verification	Supply Chain Manager
Phase 4 Product Launch	Supply Chain Manager
Phase 5 Product Launch_obsolete	Supply Chain Manager
Prepare finished goods for delivery	Supply Chain Manager
Prepare Installation & Service manuals	Product Manager
Process Guide Element Explanation	Quality Manager
Product Management	Product Manager

Product Waiver Routine	Quality Manager
Production at subsupplier	Supply Chain Manager
Project Closure	Market Development Manager
Project Implementation & Administration	Market Development Manager
Purchase according to order	Supply Chain Manager
QMS Waiver Routine	Quality Manager
Quality Change Request	Quality Manager
Quality Improvement	Quality Manager
REACH Analysis	Supply Chain Manager
Recruitment process	People & Culture Director
Re-evaluation existing Suppliers	Supply Chain Manager
Reporting Quality Status	Supply Chain Manager
Review of Templates & Business Processes	Quality Manager
Risk Assessment	VP T&PD
Sales Process	Commercial Director
Sourcing	Supply Chain Manager
Stage 3.0, Preliminary Engineering	
Stage 3.1 Initial Development	
Stage 3.2, Preliminary Verification	
Stage 4.0. Prototyping	
Stage 4.1 Production of prototype	
Stage 4.2 Prototype Review	
Stage 4.3, Verification	
Stage 4.4 Test Review	
Stage 4.5 Pre-Qualification	
Stage 4.6 Prepare PreQualification Production	
Stage 4.7 PreQualification Production	
Strategy Process	CEO
Supplier complaint handling	Supply Chain Manager
Travel request and Expenses documentation	CFO
Warranty Spare Parts Handling	Field Service Manager

Sub Section Q02

Quality Control Plan - ITP

Ballard Power Systems Europe A/S
Majsmarken 1
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Revision history		
Rev.	**Date.**	**Description**
001	05/04/2023	First Issue
002	22/09/2023	Expanded according to comments
003	27/11/2023	Re-issue according to comments

Document Title:	**BLPH Project - Quality Control Plan/ITP**
Document Number:	BPSE-INN-BPH-ITP-00005
Legacy Number:	K559-2254-CWIWP4202202-Q02-001
Revision:	Rev003
Sequence Number:	001
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Purchaser Job:	K559-2254
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Code:	Q02
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Title:	Quality Control Plan - Inspection and Test Plan (High Level)	Version:	Rev003
Description:	1 MW Fuel Cell Power Container	Date:	November 27, 2023

Step No.	Inspection and Test Plan Activity	Reference Document	Acceptance Criteria	Verifying Document	Expected Completion Date	Actual Completion Date	Client Witnessing
FCwave™ 200 kW Fuel Cell Modules							
1	Goods received	Delivery note	Specification	ERP system DAX			
2	Incoming inspection	IQC control plan / Aiman	Specification	ERP system DAX			
3	Inline production control	Work instruction / Aiman	Specification	Aiman			
4	Birth certificate is issued	Standard birth certificate	Completed birth certificate	Birth certificate			
5	1.0 FAT 001 Pre-operational tests	FAT procedure / FAT report	Specification	FAT report	November 15, 2023		Review
6	2.0 FAT 001 SYS LVL function check	FAT procedure / FAT report	Specification	FAT report	November 30, 2023		Review
7	3.0 FAT 001 Post FAT check	FAT procedure / FAT report	Specification	FAT report	November 30, 2023		Review
8	Down pol curve	FAT procedure / FAT report	Specification	FAT report	November 30, 2023		Review
9	Certificate of performance (CoA)	FAT procedure / FAT report	Specification	CoA certificate	December 1, 2023		Review
1 MW Fuel Cell Power Container							
10	Goods received (container components)	Delivery note	Specification	1. ERP system DAX (internal) 2. Copy of materials receipt with receival date (to client)	December 15, 2023		Review / Approval [MS05]
11	Incoming inspection	IQC control plan	Specification	ERP system DAX	December 15, 2023		-
12	Container build control (Assembly Verification)	Work instruction	Specification	Aiman (tbc)	February 29, 2024		Review
13	Container birth certificate is issued	Standard birth certificate	Completed birth certificate	Birth certificate	April 1, 2024		-
14	Container FAT (*Pre-operational Testing*)	FAT procedure / FAT report	Specification	FAT report	March 15, 2024		Review
	Container FAT (*Operational Testing*)				April 22, 2024		Witness
15	Container certificate of performance (CoA)	FAT procedure / FAT report	Specification	CoA certificate	April 26, 2024		Review
16	Container ready for receipt Ex-Works	FAT procedure / FAT report	Specification	Signed HANDOVER CERTIFICATE	April 30, 2024		Approval [MS06]

Sub Section Q99

ATEX inspections during manufacturing

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Revision history		
Rev.	**Date.**	**Description**
001	01/05/2025	First Issue
002	13/05/2025	Document number corrected

Document Title:	**BLPH Project - ATEX Inspections during Manufacturing**
Document Number:	BPSE-INN-BPH-ITP-00005
Legacy Number:	K559-2254-CWIWP4202202-Q99-001
Revision:	Rev002
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-Q99-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	Q99
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

SPC ID 0203 Pipework inspection and leakage test check sheet

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Revision Record

Rev #	Description	Revised By	Date dd-mm-yyyy
-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on expected leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 Heater+Container, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 1	1-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 2	2-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 3	3-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 4	4-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 5	5-C-CUR-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 Heater+Container, String 6	6-C-CUR-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater+Container string 1,2,3,4,5,6



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

H2 Container pipe to FCwave



M: Manifold
H: Heater
C: Container
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.

SPC ID 0203 Pipework inspection and leakage test check sheet

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-	Initial Draft	TAN	21-08-2024
1	Released	TAN	30-8-2024

Checked by: MHA	Date: 29/08-2024
Approved by: MHA	Date: 30/08-2024

Project	601456B Crosswind BLPH
Date	30-08-2024
Identification of piping system (photo or P&ID) [✓ or -]	✓
Inspected by	MKD
Document Approved by	MFO
Filing date	02-09-2024

Follow the procedure in section 5.4 of *SPC ID 0104 Leakage Test Procedure*

*=Pass criteria according to inspection tool user instruction

**=Calculated value based on allowable leakage rate plus sniffing tool uncertainty

*** Not applicable due to refitting/preswaging of joint/Not a ferrule fitting

		Visual inspection	Gauge Inspection*	Auditorial inspection	Sniffing inspection		Overall result
Item type	**Item ID**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass/fail**	**Pass criteria** [PPM]**	**[Pass/fail]**
H2 heater, String 1	1-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 1	1-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 1	1-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 2	2-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 3	3-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 3	3-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 4	4-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓

H2 heater, String 5	5-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 5	5-H-CUA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-BV-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CLA-1	✓	NA***	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-1	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-2	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-3	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CMC-G-4	✓	✓	✓	✓	35ppm	✓
H2 heater, String 6	6-H-CUA-1	✓	NA***	✓	✓	35ppm	✓

H2 Heater string 1,2,3 Inlet

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





H2 Heater string 4,5,6 Inlet



H2 Heater string 1,2,3,4,5,6 Shut-off Valve & Pipes

M: Manifold
H: Heater
BV: Ball Valve
MANO: Manometer
PRV: Pressure Relief Valve
CUR: Reducing Union
CTR: Reducing Tee
CMC: Male Connector
CLA: Union Elbow
CTA: Union Tee
CSWC: Tube Socket Weld Connector
CPA: Plug
Red Arrow indicates inspected item.





Short Title	**ATEX Inspection Checklist**
Full Title	**ATEX Inspection Checklist, 601456B Crosswind Hydrogen Manifold**
Abstract	-

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Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	RBS	2. September 2024

Checked by: RBS	Date: Sept 2024
Approved by: PBL	Date: Sept 2024

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• Purpose and Scope

The purpose of this document is to provide a checklist for the Crosswind ATEX area containing the hydrogen manifold.

• References

Document	Name	Author
IEC 60079-17	Explosive atmospheres - Part 17: Electrical installations inspection and maintenance	IEC
JEVI 1953 861 100	Datasheet "Ex D-8640 Immersion Heater, 9kW 3x400VAC"	Sinus JEVI
	Datasheet "ASCO Solenoid Valves 210 series"	Emerson
	Datasheet "ASCO Solenoid NF series"	Emerson
	Datasheet "IFM LMT01A"	IFM
	Datasheet "HUBA 520 pressure sensor"	HUBA
	Datasheet "IFM TT1050-01"	IFM
	Datasheet "PR electronic 9202	PR electronic
	Datasheet "PR electronic 9113"	PR electronic
	Datasheet "PR electronic 9106"	PR electronic

- **Checklist:**

1.1 Hydrogen heater element

1.1.1 Test

The test is done accordingly to the test schematics in IEC 60079-17 Tabel C.1 following descriptions of the test will be below if applicable.

1.1.2 Relevant Standard / document

- IEC 60079-17
- JEVI datasheet 1953 861 100

1.1.3 Brief Test Plan

- Inspection will be done in respect to the datasheet, standards and Visual inspection prior to startup.

1.1.4 Pass/Fail criteria.

- The pass/fail criteria is specified for each inspection element is shown in Table 1.

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Table 1: Heater Inspection – Test Result

Item	Criteria	Result	Pass/Fail	Notes
Equipment is appropriate to the EPL/Zone requirement of the location	Gc or better	GB	✓	
Equipment group is correct	IIC	IIC	✓	
Equipment temperature class is correct	T1	T4	✓	
Degree of protection (IP grade) of the equipment is appropriate for the level of protection/group/conductivity	>IP55	IP66	✓	
Equipment circuit identification is correct	Present	✓	✓	
Equipment circuit identification is available	Yes	✓	✓	
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	NA	—	—	—
There is no damage or unauthorized modifications	None	none	✓	
There is no evidence of unauthorized modification	None	none	✓	
Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight	Yes		✓	
Threaded covers on enclosures are of the correct type, are tight and secured	Yes		✓	
Joint surfaces are clean and undamaged and gaskets, if any, are satisfactory and positioned correctly	Yes		✓	
Condition of enclosure gaskets is satisfactory	Yes		✓	
There is no evidence of ingress of water or dust in the enclosure in accordance with the IP rating	No		✓	

Dimensions of flanged joint gaps are: – within the limits in accordance with the manufacturer's documentation or – within maximum values permitted by the relevant construction standard at time of installation or – within maximum values permitted by site documentation	—	—	—	—
Electrical connections are tight	Yes		✓	
Unused terminals are tightened	Yes		✓	
Type of cable is appropriate	Voltage and Environmental		✓	
There is no obvious damage to cables	No		✓	
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	Not relevant	Not relevant	Not relevant	Not relevant
Stopping boxes and cable boxes are correctly filled	Yes		N/A	N/A
Integrity of conduit system and interface with mixed system maintained	No leaks			
Earthing connections, including any supplementary earthing bonding connections are satisfactory (for example connections are tight and conductors are of sufficient cross-section)	Inspection		✓	Gnd connected inside housing
Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	<100mOhm	32mΩ	✓	
Automatic electrical protective devices are set correctly (auto-reset not possible)	Not present	Not present	Not present	Not present
Automatic electrical protective devices operate within permitted limits	Not present	Not present	Not present	Not present
Specific conditions of use (if applicable) are complied with	None	none	N/A	

Cables not in use are correctly terminated	Yes		✓	
Obstructions adjacent to flameproof flanged joints are in accordance with IEC 60079-14	Not present		N/A	
Variable voltage/frequency installation complies with documentation	Not present	Not present	Not present	Not present
Temperature sensors function according to manufacturer's documents	Not present	Not present	Not present	Not present
Safety cut off devices function according to manufacturer's documents	Inspected		✓	
The setting of the safety cut off is sealed	Yes		✓	
Reset of a heating system safety cut off possible with tool only	Yes		✓	
Auto-reset is not possible	Yes		✓	
Reset of a safety cut off under fault conditions is prevented	Yes		✓	
Safety cut off independent from control system	Yes		✓	
Level switch is installed and correctly set, if required	Yes (External to heater)		✓	
Flow switch is installed and correctly set, if required	NA		N/A	
Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	Yes = X in product number	IP66 SS ect	✓	
No undue accumulation of dust and dirt	No		✓	

1.2 H2 Shut Off Valve

1.2.1 Test

The test is done accordingly to the test schematics in IEC 60079-17 Tabel C.1 following descriptions of the test will be below if applicable.

1.2.2 Relevant Standard / document

- IEC 60079-17
- Datasheet "ASCO solenoid valves 210 series"
- Datasheet "ASCO Solenoid NF series"

1.2.3 Brief Test Plan

- Inspection will be done in respect to the datasheet, standards and Visual inspection prior to startup.

1.2.4 Pass/Fail criteria.

- The pass/fail criteria are specified for each inspection element is shown in Table 2.

Table 2: Hydrogen Valve Inspection – Test Result

Item	Criteria	Result	Pass/Fail	Notes
Equipment is appropriate to the EPL/Zone requirement of the location	Gc or better	Gb	✓	
Equipment group is correct	IIC	IIc	✓	
Equipment temperature class is correct	T1	T4	✓	
Degree of protection (IP grade) of the equipment is appropriate for the level of protection/group/conductivity	>IP55	IP67	✓	
Equipment circuit identification is correct	Present		✓	
Equipment circuit identification is available	Present		✓	
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	Not applicable	Not applicable	Not applicable	Not applicable
There is no damage or unauthorized modifications	None		✓	
There is no evidence of unauthorized modification	None		✓	
Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight	Yes		✓	
Threaded covers on enclosures are of the correct type, are tight and secured	No threaded cover	No threaded cover	No threaded cover	No threaded cover
Joint surfaces are clean and undamaged and gaskets, if any, are satisfactory and positioned correctly	Yes		✓	
Condition of enclosure gaskets is satisfactory	Yes		✓	
There is no evidence of ingress of water or dust in the enclosure in accordance with the IP rating	No		✓	

Dimensions of flanged joint gaps are: – within the limits in accordance with the manufacturer's documentation or – within maximum values permitted by the relevant construction standard at time of installation or – within maximum values permitted by site documentation	Tightened to 85 Nm on bonded seal connection	85 Nm	✓	
Electrical connections are tight	Yes		✓	
Unused terminals are tightened	Yes		NA	
Type of cable is appropriate	Voltage and Environmental		✓	
There is no obvious damage to cables	None		✓	
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	Tightness – refer to leakage test		Leakage Passed ✓	
Stopping boxes and cable boxes are correctly filled	Not applicable	Not applicable	Not applicable	Not applicable
Integrity of conduit system and interface with mixed system maintained	Not applicable	Not applicable	Not applicable	Not applicable
Earthing connections, including any supplementary earthing bonding connections are satisfactory (for example connections are tight and conductors are of sufficient cross-section)	Inspection		✓	Gnd connected inside
Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	<100mOhm	<40mΩ	✓	
Automatic electrical protective devices are set correctly (auto-reset not possible)	Not present	Not present	Not present	Not present
Automatic electrical protective devices operate within permitted limits	Not present	Not present	Not present	Not present
Specific conditions of use (if applicable) are complied with	X= stainless steel	Ok	✓	

Cables not in use are correctly terminated	Pass		✓	no loose cables
Obstructions adjacent to flameproof flanged joints are in accordance with IEC 60079-14	Not present	Not present	Not present	Not present
Variable voltage/frequency installation complies with documentation	Not present	Not present	Not present	Not present
Temperature sensors function according to manufacturer's documents	Not present	Not present	Not present	Not present
Safety cut off devices function according to manufacturer's documents	Not present	Not present	Not present	Not present
The setting of the safety cut off is sealed	Not relevant	Not relevant	Not relevant	Not relevant
Reset of a heating system safety cut off possible with tool only	Not relevant	Not relevant	Not relevant	Not relevant
Auto-reset is not possible	Not relevant	Not relevant	Not relevant	Not relevant
Reset of a safety cut off under fault conditions is prevented	Not relevant	Not relevant	Not relevant	Not relevant
Safety cut off independent from control system	Not relevant	Not relevant	Not relevant	Not relevant
Level switch is installed and correctly set, if required	Not relevant	Not relevant	Not relevant	Not relevant
Flow switch is installed and correctly set, if required	Not relevant	Not relevant	Not relevant	Not relevant
Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	Yes = X in product number	Yes	✓	
No undue accumulation of dust and dirt	No		✓	

1.3 Sensing elements

1.3.1 Test

The test is done accordingly to the test schematics in IEC 60079-17 Tabel C.2 following descriptions of the test will be below if applicable.

1.3.2 Relevant Standard / document

- IEC 60079-17
- Datasheet "IFM LMT01A"
- Datasheet "HUBA 520 pressure sensor"
- Datasheet "IFM TT1050-01"
- Datasheet "PR electronic 9202"
- Datasheet "PR electronic 9113"
- Datasheet "PR electronic 9106"

1.3.3 Brief Test Plan

- Inspection will be done in respect to the datasheet, standards and Visual inspection prior to startup.

1.3.4 Pass/Fail criteria.

- The pass/fail criteria are specified for each inspection element is shown in Table 3.

Table 3: Sensing Elements – Test Result

Item	Criteria	Result	Pass/Fail	Notes
Circuit and/or equipment documentation is appropriate to the EPL/zone	Gc or better	Ga + Gb	✓	
Equipment installed is that specified in the documentation	Yes		✓	
Circuit and/or equipment category and group correct	Yes		✓	
IP rating of equipment is appropriate to the Group III material present	>IP55	IP67 IP66	✓	
Equipment temperature class is correct	T1	T4, T4	✓	
Ambient temperature range of the apparatus is correct for the installation	-10°C to +25°C		✓	
Service temperature range of the apparatus is correct for the installation	0°C to 40°C		✓	
Installation is clearly labelled	Yes			needs label on PT+LT
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	Not applicable	Not applicable	Not applicable	Not applicable
Cable glands and blanking elements are the correct type, complete and tight	Yes		✓	
There are no unauthorized modifications	None		✓	
There is no evidence of unauthorized modifications	None		✓	
Diode safety barriers, galvanic isolators, relays and other energy limiting devices are of the approved type, installed in accordance with the certification requirements and securely earthed where required	Yes		✓	

Condition of enclosure gaskets is satisfactory	Yes; if applicable	N/A	✓	
Electrical connections are tight	Yes		✓	
Printed circuit boards are clean and undamaged	Yes	N/A	N/A	N/A
The maximum voltage Um of the associated apparatus is not exceeded	Yes		✓	
Cables are installed in accordance with the documentation	Yes		✓	
Cable screens are earthed in accordance with the documentation	Yes		✓	
There is no obvious damage to cables	None		✓	
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	Yes		N/A	
Point-to-point connections are all correct	Yes		✓	
Earth continuity is satisfactory (e.g. connections are tight, conductors are of sufficient cross-section) for non-galvanically isolated circuits	<100mOhm	<35mΩ	✓	
Earth connections maintain the integrity of the type of protection	Yes		✓	
Intrinsically safe circuit earthing is satisfactory	Yes		✓	
Insulation resistance is satisfactory	Yes		✓	
Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common distribution boxes or relay cubicles	Yes			Partly
Short-circuit protection of the power supply is in accordance with the documentation	Yes		✓	

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Specific conditions of use (if applicable) are complied with			N/A	
Cables not in use are correctly terminated	Yes		✓	
Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	Yes		✓	
No undue external accumulation of dust and dirt	Yes		✓	

Inspection performed by: RBS

Ballard Power Systems Product Solution

Date:

03/09-2024

Executed

30/08-2024

Section R

Packing, Shipping and Site Preservation

Sub Section R01-001

Storage Procedures and Winterization

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	05/04/2024	First official issue

Document Title:	**Storage Procedures and Winterization**
Document Number:	K559-2254-CWIWP4202202-R01-001
Revision:	Rev001
Sequence Number:	001
File Name:	K559-2254-CWIWP4202202-R01-001Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	R01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Short Title	Storage Procedures and Winterization
Full Title	Crosswind/Baseload Power Hub Fuel Cell Package Storage Procedures and Winterization
Abstract	This document presents the options for both extremely high ambient temperatures and below freezing conditions. In both cases, if supplied with power, the FC package can both ventilate and heat the internal space. If power is not available, procedures are available for winterizing the fuel cell container. The winterization process requires some hydrogen to accomplish and to restore the fuel cell to operating conditions, Ballard personnel is required.

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Revision Record

Rev #	Description	Revised By	Date
1	Initial Release	PBL	11th Mar 2024
1.1	Update to include hot conditions considerations	PBL	April 2024

Checked by:	Date:
Approved by:	Date:

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1.0 Purpose and Scope

The purpose of this document is to outline storage procedures and winterization for the Baseload Power Hub Fuel Cell Package container.

The goal for the fuel cell package container internal temperature is to stay between 5 and 40 degrees. The lower bound for the internal temperature is driven by the requirement to keep the fuel cell modules above freezing and the upper bound is the highest ambient temperature for electronics components.

The reader is expected to be familiar with the following documents:

- B01 General Arrangements
- C03 Process and Instrumentation Diagrams
- C06 Single Line Diagrams

2.0 Reference Documents

Table 1: Reference Documents

Document ID	Document Title	Revision
B01	General Arrangement	Newest
C03	Process and Instrumentation Diagram	Newest
C06	Single Line Diagram	Newest
E14	Electrical Load List	Newest

3.0 Summer Storage Options

The FC package can self-ventilate during stand still for extended periods in very hot conditions.

Under normal conditions, no action is needed but days with high ambient conditions and direct sun internal ventilation is required.

3.1 Ambient Conditions

If the ambient conditions do not exceed 35 degrees and direct sun is not expected, no action is needed.

3.2 Excessively hot days.

If ambient conditions exceed 35 degrees and periods with direct sun is expected, the container should be allowed to self-ventilate to manage internal temperatures.

To do this, the container should be connected to AUX power and be allowed to run the fans. The expected power consumption is approx. 2kW.

If it is not possible to allow AUX supply to the container, a sun-shield can also be erected as an alternative. Please confer with Ballard.

4.0 Winter Storage option overview

The FC package can be stored in several different ways:

- Fully Off
  - Everything depowered and disabled, prepared for long term storage.
- Control system active, heating disabled.
  - Control and safety system enabled.
  - Heating system disabled.
  - Fuel Cells winterized.
- Standard with Winterization
  - Control and safety system enabled.
  - Heating system enabled.
  - Fuel Cells winterized but kept above freezing by the heating system.
- Standard
  - As above, but fuel cells are not winterized.

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Each of the options are outlined with pros ands cons are outlined in the following sections.

Table 2: Storage Option Overview

System	Fully Off	Minimum	Standard with Winterization	Standard
Control System	Off	On	On	On
Safety System	Off	On	On	On
Heating	Off	Off	On	On
Fuel Cell Modules	Winterized	Winterized	Winterized	Normal

5.0 Winter Storage Methods

5.1 Fully Off

In this storage method, everything is disabled, and fuel cell modules are winterized.

This method sets the least requirements to the storage facility, but the largest pre and post storage work, including work from Ballard service technicians.

Table 3: Fully Off – Pro/Con list

Pro	Con
No requirements to storage facility	No monitoring of package condition
Can handle down to -30°C	Requires Ballard intervention to restart and recondition fuel cell modules
No power demand from AUX supply	Cannot deliver full power before reconditioning cycle is completed on modules
	No safety system active

5.2 Shipping

For shipping under known conditions or other short storage periods, the winterization can be skipped if the ambient conditions are known and guaranteed to be non-freezing.

This will save personnel hours both before and after the storage period to prepare the fuel cells for the winterization and to restore them from the winterized state after the storage.

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5.3 Minimum Power

In this storage method, the control system is powered, and fuel cell modules are winterized. The heating system for the container is disabled to minimize power usage.

This method has minor requirements to the storage facility, but still has the same pre and post storage work as the no-power solution, including work from Ballard service technicians.

Table 4: Minimum Power – Pro/Con list

Pro	Con
Control and Safety Systems active	Requires AUX Supply active
Can handle down to -30°C	Requires Ballard intervention to restart and recondition fuel cell modules
Monitoring of FC package condition	Cannot deliver full power before reconditioning cycle is completed on modules
Low power demand	

5.4 Standard with Winterization

In this storage method, the control system is powered, and the heating system is also active, thus maintaining the container at a above-freezing temperature. This will consume additional power if ambient conditions are around or below freezing.

Fuel Cell Modules are winterized to prevent damage in the cause of a prolonged power outage at the storage site if conditions are uncertain or response time to outages are expected to exceed a few hours.

This method has some requirements to the storage facility, but still has the same pre and post storage work as the no-power solution, including work from Ballard service technicians.

Table 5: Standard with Winterization – Pro/Con list

Pro	Con
Control and Safety Systems active	Requires AUX Supply active, up to 20kW
Can handle down to -20°C	Requires Ballard intervention to restart and recondition fuel cell modules
Monitoring of FC package condition	Cannot deliver full power before reconditioning cycle is completed on modules

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No damage if loss of power occurs	Higher power demand

5.5 Standard

In this storage method, the control system is powered, and the heating system is also active, thus maintaining the container at a above-freezing temperature. This will consume additional power if ambient conditions are around or below freezing.

Fuel Cell Modules are *NOT* winterized to prevent damage and will be damaged in the cause of a prolonged power outage in freezing conditions.

Damage can be prevented if personnel can respond and restore power before the container freezes. That is estimated to take about one day, shorter on very cold days.

This method has some requirements to the storage facility, but no requirements for Ballard personnel or pre/post storage procedures.

Table 6: Standard – Pro/Con list

Pro	Con
Control and Safety Systems active	Requires AUX Supply active up to 20kW
Can handle down to -20°C	Higher power demand
Monitoring of FC package condition	
Ready for operation with no special actions	

6.0 Procedure for Winterization of FC Module

The procedure for winterizing a FCwave module is known internally as a dry-out of the module.

The procedure for doing the winterization is described in this section, split into what is required for the entire FC package and what is needed for the FC module.

6.1 Fuel Cell Preparation

The fuel cell module requires the surrounding support systems to be active, as described in the following section.

The fuel cell module itself has control interfaces capable of starting the winterization process.

This is accomplished by starting the fuel cell module without load applied and sending a command signal to start the sequence. This then causes the fuel cell to disconnect its DC bus and use internal power to displace water out of the fuel cell membrane by a hot, dry operation regime.

Prior to installation or if needed, a Ballard service technician can use portable equipment to start the fuel cell and perform the winterization without the primary AC connection or DC link active.

When it is desired to operate the fuel cell as normal again, a reconditioning is needed to achieve full performance.

6.2 Requirements – Standard Installation

The FC package requires several interfaces to be active to perform the winterization:

- MV Link must be active and capable of providing <10kW of power for the following systems:
  - MV Transformer Energization
  - Electronics cooling
  - Process cooling (at idle)
  - Startup power for the fuel cell module
- Alternatively, a Ballard service person has portable equipment which allows the fuel cell to start.
- Gas supply must be able to provide H2 for the winterization process.
  - Typically, <200g H2 pr module.
- Liquid drain must handle displaced water.
  - Typically, <200mL pr module

The process takes about 5-7 minutes pr module and can be done in parallel.

6.3 Requirements – Ballard Service Technician Onsite

If the standard installation is not available or not yet commissioned, a Ballard service technician can accomplish the winterization with portable equipment:

- An on-site 400V 3phase power must be available for the service technician to use.
- If the hydrogen installation is not ready, a portable gas bottle (50L) can provide enough hydrogen to perform dryout for an installation of 6 modules.
- Liquid water can be drained or collected in a bucket and disposed of.

- Typically, <200mL pr module

The process takes about 10-15 minutes pr module.

6.4 Procedure – Standard Installation

Using the operator interface for the FC package, perform the following steps.

1. Coordinate with BLPH to enable DC link.
2. Enable 24V to all modules that needs dryout.
3. Start DC Link
4. For each module, start module with 0kW setpoint.
    a. When running, within 10 seconds of reaching “Running”, send “Dryout” command bit.
5. Allow module to perform dryout sequence. It will take approximately 2 minutes pr module.
6. Multiple modules can perform dryout sequence simultaneously.
7. Disable DC link.
8. Depower modules.

6.5 Module Restart

Refer to service manual for FCwave modules.

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7.0 Periodic Visual Inspection

When the FC package is stored for extended periods without operation, periodic visual inspection is desired.

The purpose of the inspection is to confirm the condition of the container and to spot any issues before they develop into more severe problems.

7.1 Interval

The package should be inspected at least every 14 days (every other week) and after each significant weather event (storm, blizzard, etc).

7.2 Tools

The person inspecting the package shall wear all relevant PPE, as stated on the warning placards and local HSSE requirements.

The person should bring the following tools:

- Flashlight or inspection light
- Camera or other device to document issues
- Container access keys
- Electrical cabinet keys

7.3 External Inspection

The person should walk around the package, inspecting the following items:

- Accumulation of dust and grime
    - Any build up of dust and grime
    - Particularly around air intakes and access doors, should be removed.
- Signs of coolant spillage
    - Coolant contains blue dye, spillage will lead to blue discoloration or stains
    - Inspections sites include:
        - Primary coolant connection between 40ft container and coolant skid
        - Hydrogen heater tank
- Cables and cable trays
    - Any cables not firmly seated in cable tray or other mechanical fasteners.
- Intake and outlet louvres
    - Both on 40ft and 10ft container
    - Should be firmly closed, with no visible openings.

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7.4 Internal Inspection – 40ft Container

The person should open the door to the 40ft container and step inside, while minimizing dust and dirt into the container.

- Liquid spills
  - Inside on the container door, below false floor
  - LT coolant rack
  - HT coolant entry point (below ventilation intake fans)
- Cable inspection
  - Cable visual inspection for damage and disturbance
- Dust
  - Vacuum any dust or debris from inside container.
  - DO NOT use compressed air to shift dust around.
- Fuel Cell Module Inspection
  - Using electrical cabinet key, open FCwave front panel
  - Using inspection light, inspect bottom of cabinet for dust or liquid spill.

7.5 Internal Inspection – 10ft container

Internal inspection for dust and liquid.

1. Inside control panel access door, press the emergency stop.
2. Open container end door, and without stepping inside the container, inspect the floor for liquids and debris.
3. Close container door, reset emergency stop circuit.

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Sub Section R01-002

Transport and Handling Manual

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	28/06/2024	First Issue
002	15/08/2024	Updated according to comments
003	04/11/2024	Replaced attached GA to Rev008 and added reference to document B99-002

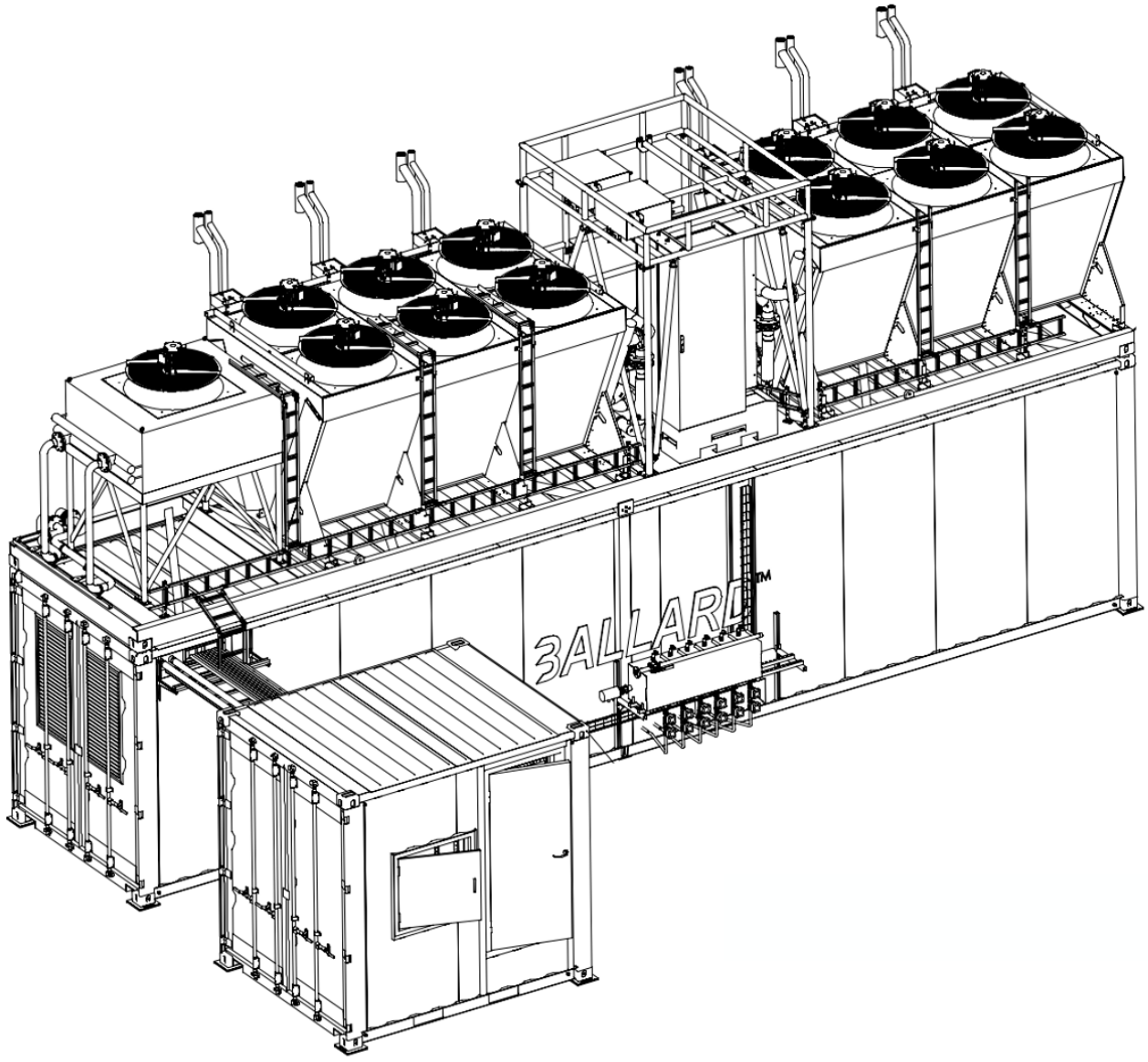
Document Title:	**Transport and Handling Manual**
Document Number:	K559-2254-CWIWP4202202-R01-002
Revision:	Rev003
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Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	R01-002
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

FC Megablock 1000 kW

Part no.: 5550003

Configuration: 40ft Fuel Cell Container w. 6 FCwave's
10ft Grid Interface Container, 6,6 kVAC

Transport and Handling Manual



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1.0 Disclaimer

NOTE: READ THIS BEFORE ATTEMPTING ANY PROCEDURES DESCRIBED IN THIS MANUAL

There are inherent risks in the operation of a fuel cell module that can result in death or bodily injury or loss or damage to property. It is therefore necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device. Persons who install, operate, and service the device are required to be technically qualified and experienced in working with electrical equipment, compressed gases, and H2.

This manual includes certain safety guidelines and recommendations; however, this manual is not intended to cover all situations. The customer is responsible for determining the suitability of the customer's particular design or application, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. Ballard Power Systems Europe A/S ("BPSE") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the operating recommendations in the manual. The customer is responsible for being aware of, and complying with, all applicable laws and regulations. BPSE has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

Procedures described in any part of the manual can only be attempted once the customer has read this entire manual. Failure to follow any instruction or recommendation could result in death or bodily injury or loss or damage to property.

BPSE intends for the device to be installed, operated, and serviced only by approved technically qualified and experienced people who understand the principles of fuel cell technology, are aware of the safe operating limits of fuel cells, and are familiar with the risks posed by operating a fuel cell module. BPSE relies on customers to use their own knowledge and experience when installing, operating, and servicing the device. BPSE also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual.

Information in this manual is subject to change without notice. BPSE makes no commitment to update or keep current the information in this manual and reserves the right to make updates or other changes to this manual and/or to the products described in this manual, at any time without notice. Updates and other changes to the manual may be posted on the BPSE website and may be accessed through the customer portal; it is the customer's responsibility to check for any such updates or changes.

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2.0 Manual Introduction

2.1 Purpose and scope

This manual provides information regarding land-based transportation and handling of the 3 major components of the solution. It is intended to be used for transportation from the manufacturer to the area of designated placement, where the system will be permanently installed.

As an addition, anchoring of the components has been included.

For details regarding special transportation methods, se referrals.

2.2 Intended audience

The intended user of this manual is personnel qualified in the preparation of and execution of transportation and handling of freight, e.g. shipping and/or crane personnel.

As an addition, information regarding anchoring of the system onto the platform is provided for the integrator.



Before commencing transportation and handling of this solution, manual users must read and apply this Transportation and handling Manual

2.3 Manual series

The Manual Series provides manuals covering different life-phases of the system, as defined in Table 2-1:

Table 2-1: Manual series contents

Document no.	Title	Brief purpose description	Intended user(s)
7003672	Transportation and Handling Manual	As described in section 2.1	As described in section 2.2
7003718	Integration Manual	Enables integrators to design designated site and subsystems required within the intended use and limits of the system.	Integrators partaking in designing the designated site and subsystems, and commissioning.
7003717	Operator Manual	Provides information to personnel for safe operation of the solution, instructions for operator-based maintenance, safety rules and recommendations	Operators, Integrators, Installers, Service and Maintenance personnel, personnel working in or near the system, and persons instructing visitors.
7003719	Service and Maintenance Manual	Provide information regarding Service and Maintenance schedules and related safety.	Service and Maintenance personnel.

Ballard Power Systems Europe may update the provided manuals on an ongoing basis.

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2.4 References

Table 2-2: Reference documents Document no.:	Document name:
K559-2254-CWIWP4202202-D05-001	Material Safety Data Sheets
K559-2254-CWIWP4202202-B01-001	General Arrangement
K559-2254-CWIWP4202202-B99-001	Structural calculations - Reactions from 40ft container and flatbed with coolers on sea type barge (300' x 90' x 20' or larger)
K559-2254-CWIWP4202202-B99-002	40ft Flatbed - calculations report

2.5 Readers Guide

Prior to engaging in work covered by the manual, the manual user must read and apply this section.

2.5.1 Safety Indications

Throughout the manuals, hazard symbols are used to indicate objectives, hazards or prohibitions the manual user must be aware of.

Table 2-3: Hazard symbols	
	**MANDATORY ACTIONS**: are marked with blue action-points. This indicates actions that must be performed. Ignoring may result in an accident, which could cause damage to equipment or other property, and could cause bodily injury if not promptly detected and remedied.
	**PROHIBITIONS**: are marked with red prohibition-signs. This indicates a forbidden action. Ignoring may result in immediate bodily injury, loss of life, or could cause damage to equipment or other property
	**WARNINGS**: are marked with yellow triangles and/or square warning. Indicates hazards that may result in an accident, which could cause immediate bodily injury or loss of life or could cause damage equipment or other property.
	**CAUTION** in this manual indicates actions that may result in an accident, which could cause damage to equipment or other property, and which could cause bodily injury if not promptly detected and remedied.
	**ELECRICAL HAZARD** Obey ALL warnings, cautions, and safety instruction related to electricity. Failure to do so may result in electrical shock leading to personal injury or death.

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3.0 Safety

Please take notice and read this section very carefully prior to transport and handling of the system.

It is the responsibility of the operator to read and understand this transport and handling manual and other information provided, and to use the correct operating procedures.

The product should only be operated by qualified (trained) personnel. Failure to do so can result in personal injury or equipment damage.

This section contains general safety-related information. It describes the potential hazards and associated warnings for the system and the precautions that must be taken to minimize these hazards.

Figure 1: General safety precautions



Manual users must adhere to safety precautions

3.1 Batteries

The system houses 24VDC (2x12v in series) lead battery modules. This requires tools to access.

Prior to transport and handling: Check that 24VDC UPS batteries are securely fastened and remove the fuses on the module connection boards.

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3.2 Coolant



The Coolers may hold a small quantity, less than 100l, of Proviflow® Neo coolant in the HT and LT cooling circuit.

Each FCwave™ in the container contains Glysantin® FC G20.

Refer to Material Safety Data Sheets for details.

General rules are:

- Avoid contact with eyes and skin.
- Use protective gloves and tightly sealed googles.
- Avoid ingestion and inhalation of vapors.
- Spillage – do not allow to enter sewers/surface or ground water, absorb with a liquid–binding material, dilute with water.
- Disposal must be made according to official regulations.

3.3 Component displacements

The MV transformer is a heavy component that resides inside the 10ft container.

Fixation must be supplemented with applicable tools i.e. straps, prior to transport and handling.

After transportation and handling, the following visual inspection must be performed:

- Open the container door to access the transformer compartment.
- Visually inspect that the transformer has not been displaced, so that it does not fall over a person when opening the door container doors.

3.4 Lifting equipment

Personnel lifting the component(s) must adhere to local rules and legislation regarding the applicable lifting equipment. Improper use of equipment could result in severe injury.

3.5 Placing of components

The components must always be supported in such a way that the structural integrity of both the component and the underlying surface or structure is not damaged.

It is recommended to use applicable grillage or plating to evenly distribute the weight on surfaces (e.g. soft surfaces)

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4.0 Anchoring/assembly on designated site

Order of procedure for placing on designated site:

1. 40ft Fuel cell container placed and anchored as described in section 5.4.
2. Cooling Platform placed and anchored onto 40ft fuel cell container as described in section 6.4.
3. 10ft Container placed and anchored as described in section 7.4.



Transporting the system with the Cooling Platform mounted on top of the container is prohibited.



Notice that when the Cooling Platform is anchored to the Fuel Cell Container the structure is 6,11m in heigh. Windy conditions will create high tension forces in the anchoring points of the Fuel Cell Container – refer to "Structural calculations - Reactions from 40ft container and flatbed with coolers on sea type barge"

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5.0 Fuel Cell Container

5.1 Technical Data

Table 5-1: Key figures for 40ft Fuel Cell Container	
Container type	Modified 40ft High Cube ISO Container
Dimensions (l/w/h)	12.2/2.5/2.9 m
Weight (dry)	21680 kg

Refer to General Arrangement for CoG or attached document.

5.2 Packaging

The Fuel Cell Container needs proper packaging, and this is the responsibility of Ballard.



The LT and HT cooling circuits shall be drained from coolant to the extent possible prior to transportation and handling

5.2.1 Loose parts

Components may be shipped as loose parts inside the container if they are secured against sliding or other unintended movement, which could damage the container or component.

Loose parts may include:

- Exhaust chimney
- Ventilation chimney
- Cooler pipes wall passthrough and piping, dried from coolant

5.2.2 Preparation for transport

Preparing the Fuel Cell container for transportation from manufacturer site is a Ballard responsibility.

The following must be completed:

- If risk of frost, the FCwave must have a dry-out procedure performed prior to shipment
- Disassembly and packaging of chimneys
  Open pipes must be covered by a protective plug/cover.
- Disassembly and packaging of cooling pipes
  Open pipes must be covered by a protective plug/cover.
- Disassembly and packaging of H2 heater
  Open pipes must be covered by a protective plug/cover.
- All wall passthroughs must be covered to ensure no ingress
- Check that all floor plates are securely fastened.
- Check that air intake and exhausts are closed.
- Check that 24VDC UPS batteries er securely fastened, and that voltage is disconnected.

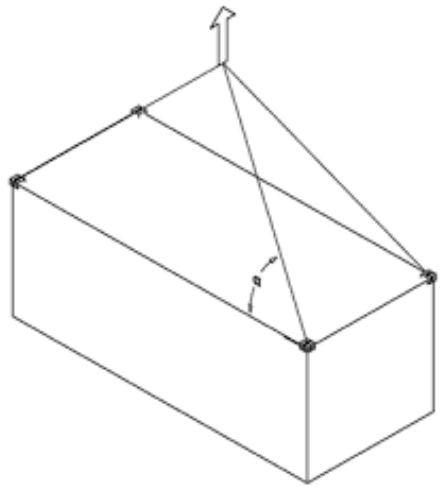
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- Check that all cabinets are securely locked.
- Check that access doors and container doors are securely locked against unauthorized access.
- Check that loose parts placed inside the container is fixated.
- Wrap the container if needed, to prevent dust and dirt from entering the container during transport.

5.3 Handling and Transportation

The Fuel Cell Container can be transported and craned using ordinary truck and craning equipment, suitable for handling an ISO container as per ISO 3874. It is the responsibility of the handler to read and decide the applicable method.

Figure 2: 40ft Container lifting example



Recommended lifting method, since the bottom corners might need to meet anchor points of the designated site.

The driver must make sure that the container is adequately secured on the truck for transport.

Standard safety procedures, approved tools and Personal Protective Equipment must be used. Ballard will inform the crane operator of any additional on-site regulations that must be adhered to.

Craning must always be supervised by Ballard responsible, however this does not remove the responsibility for the crane operator to ensure that the craning and crane equipment in use is done safely, and it does not remove the responsibility for damages incurred during craning from the operator.

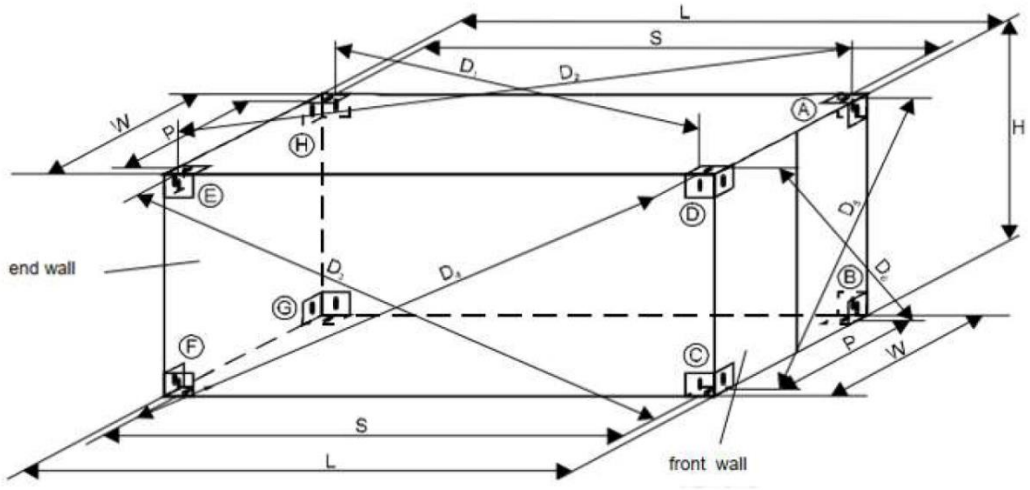
5.4 Anchoring on designated site

To anchor the Fuel Cell Container on the designated site, integrator must use the standard ISO corners of the container.

Integrators of the system are recommended to anchor the container onto the designated site with ground-plate twist-locks. If anchoring is done using the bottom-side of the ISO corners (B, C, F, G in Figure 3), e.g. ground-plate twist-locks, verify the corner-distances of the containers prior to design of site.

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Figure 3: 40ft Container ISO corners distances



P = 2260 (+3) (-5) mm.
S = 11989 (+3 (-10) mm.

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6.0 Cooling Platform

6.1 Technical Data

The Cooling Platform has standard ISO 1161 corners for anchoring during transportation and for final assembly onto the 40ft Fuel Cell Container.

Table 6-1: Key figures of Cooling Platform	
Dimensions (l/w/h)	12.2/2.5/2.5 m
Flat Support Plate location (Figure 5)	From left to middle: 6232 mm From right to middle: 5960 mm
Weight (dry)	10060 kg

Refer to General Arrangement for CoG or attached document.

6.2 Packaging

The Cooling Platform needs packaging, and this is the responsibility of Ballard.



The coolant circuit(s) must be drained of coolant to the extend possible before transportation and handling.

6.2.1 Preparation for transport

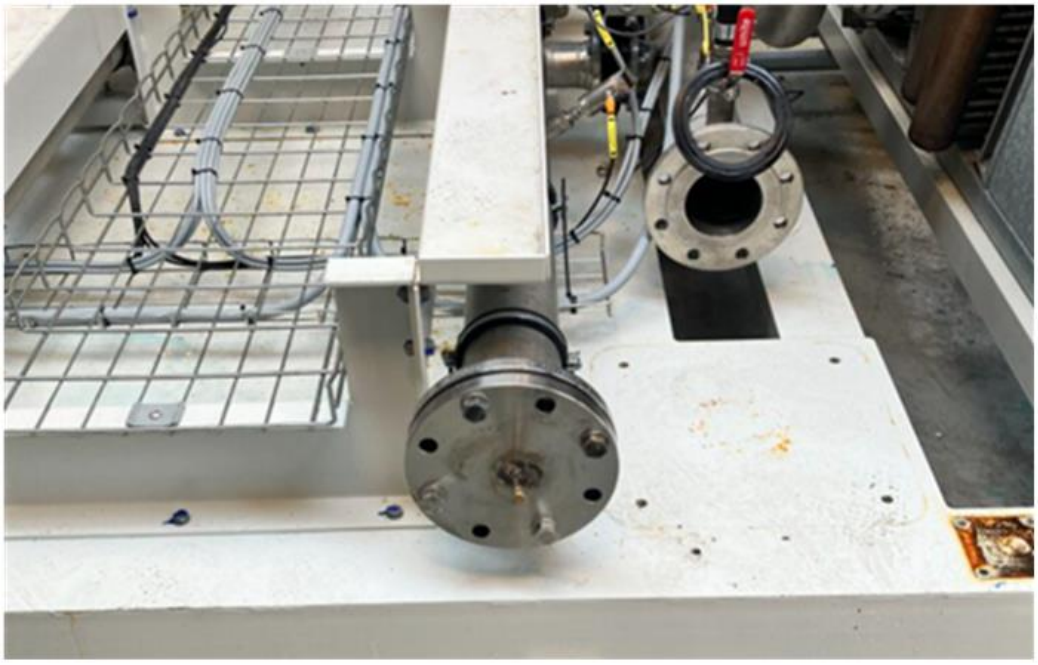
Do not strap any loose parts onto the platform for shipping. Loose parts should be shipped separately.

The following must be completed:

- Conduct visual inspection and document the condition of the cooler fins before and after transportation.
- Disassembly and packaging of exhaust frame
- Disassembly and packaging of cooling pipes
  Open pipes must be covered by a protective flange cover.
- Check that all floor plates are securely fastened.
- Check that 24VDC UPS batteries in Cooling control cabinet is securely fastened, and that voltage is disconnected.
- Check that the cabinet is securely locked.
- Wrap the platforms to protect it from dust and dirt.

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Figure 4: Prepared for shipment



Indicative picture of piping covered prior to transportation

6.2.2 Coolers fixation

The coolers must be fitted with supplementary fixation to the platform for transportation. This ensures that they do not move under de- and acceleration.

It is recommended to use straps and edge protectors.

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6.3 Handling and Transport

The Cooling Platform must be maneuvered, craned/lifted, and transported according to the information below. Special consideration is to be taken to protect the platform frame from deformation.

Standard safety procedures, approved tools and Personal Protective Equipment must be used. Ballard will inform the crane operator of any additional on-site regulations that must be adhered to.

Craning/lifting must always be supervised by Ballard responsible, however this does not remove the responsibility for the crane operator to ensure that the craning and crane equipment in use is done safely, and it does not remove the responsibility for damages incurred during craning from the operator.

More details on the structure can be found in 40ft Flatbed - calculations report.

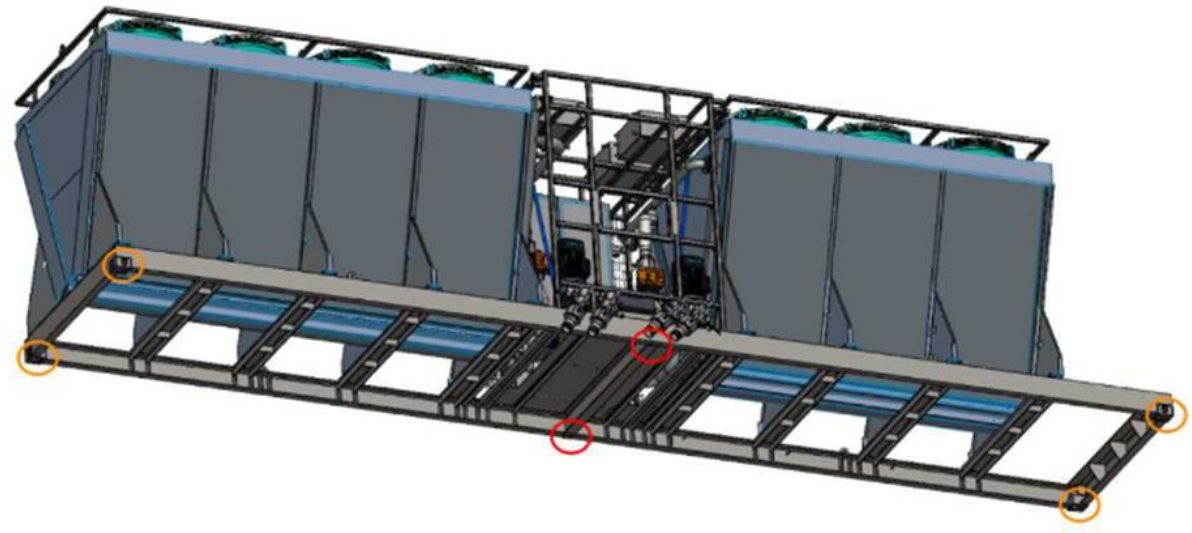
6.3.1 Support

When the Cooling Platform carries its own weight, it must be supported at the 6 points indicated in Figure 5.

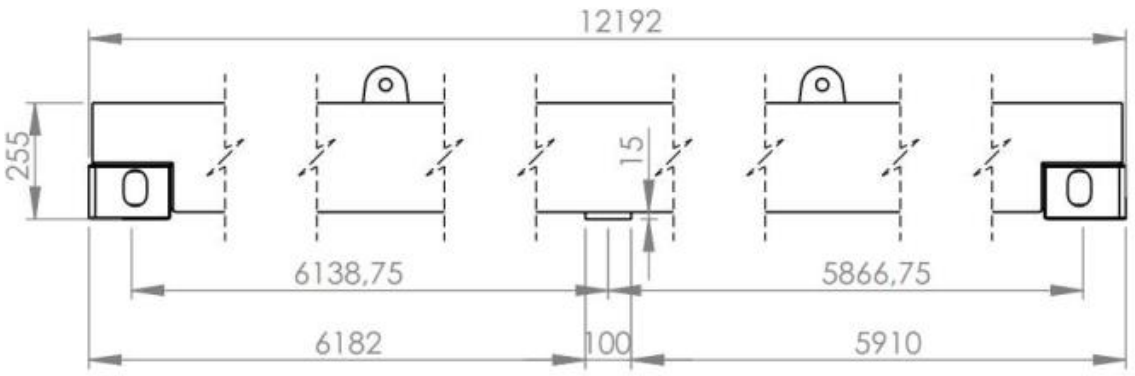
The Cooling Skid must always be supported vertically at the ends and at the Flat Support Plates.

(Figure 5– Orange, ISO Corners. Red, middle Flat Support Plates).

Figure 5: Cooling Platform support points



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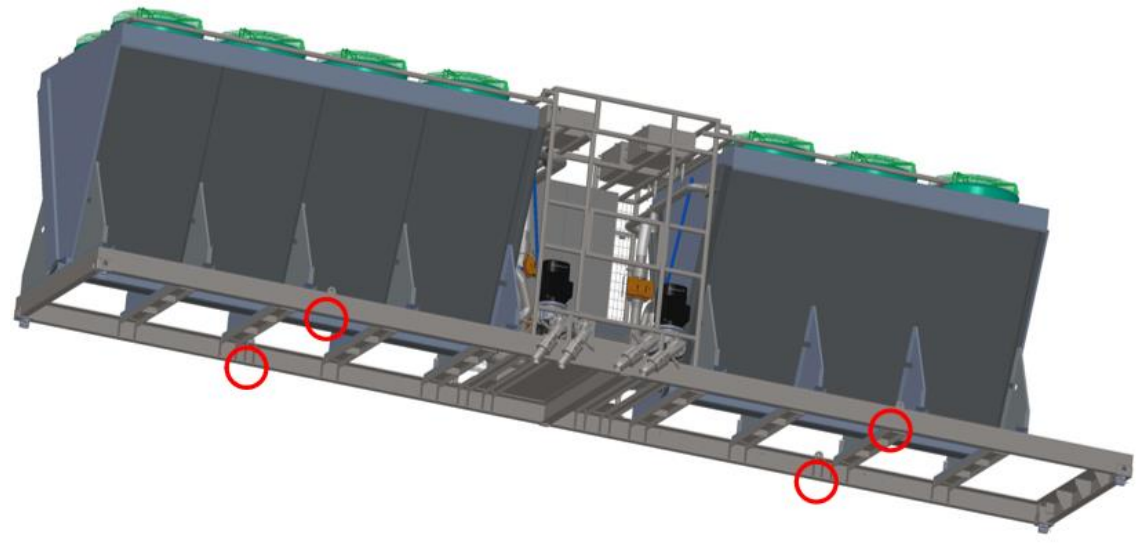
Support points of the Cooler skid, consisting of standard ISO container corners, and flat plates near the middle. Measurements in mm.

6.3.2 On-ground maneuvering

Maneuvering the platform on ground is possible with the use of Dolley's, Machine Skates, or rollers.

Placement of these must be under the designated lifting-points, as indicated in Figure 6.

Figure 6: Platform support points for on-ground maneuvering



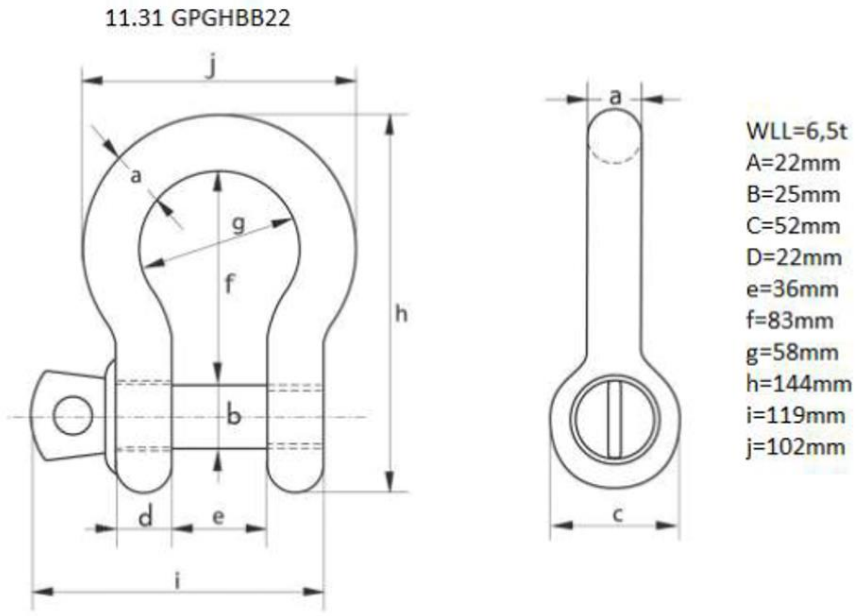
The platform may be supported directly below the 4 lifting points during storage or for maneuvering on Dolley’s, machine skates, or rollers.

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6.3.3 Craning/Lifting

	**Using any other method of lifting than described in the following is prohibited.**
	**Do not use the standard ISO corners as lifting points, as the platform frame may deform.**
	**The center of gravity is displaced from the center of the platform. See section 6.1.**
	**It is recommend to use of bow shackle in the provided lifting points, Approved for minimum 6T, maximum pin diameter 25,4 mm**

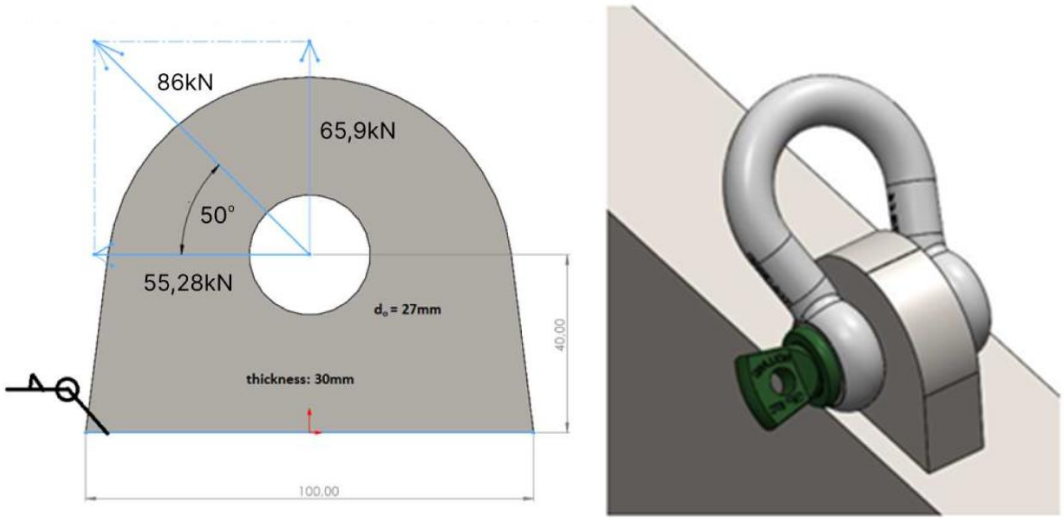
Figure 7: Example of mounted Bow shackle



Safety factor assumed by manufacturer: 6:1
WLL of the product: 6,5 ton

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Figure 8: Example of mounted Bow shackle

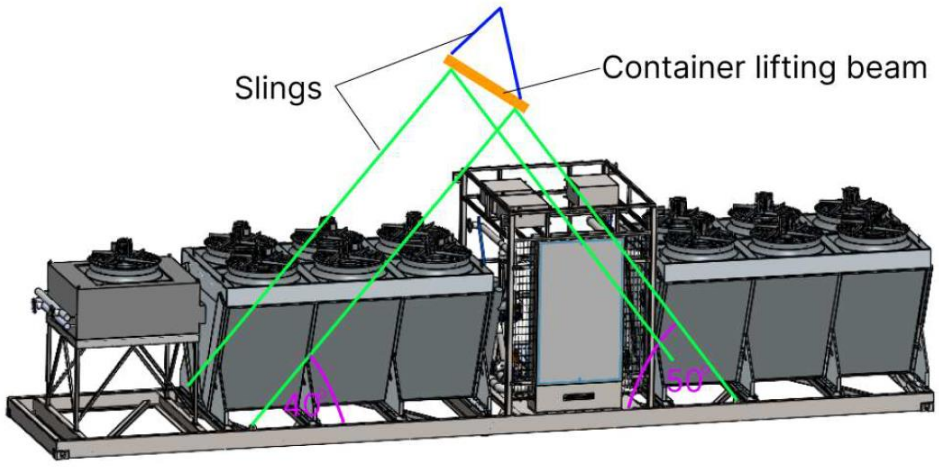


Indicative figure if needed bow shackles and worst-case scenario of forces applied to padeye with the following lifting scenarios.

6.3.3.1 Single lift

Requires one Container Lifting Beam (2368mm between green slings at lifting beam) to prevent damage on coolers.

Figure 9: Cooler platform single lift



Colors in the figure **does not** indicate any recommended lifting capacity

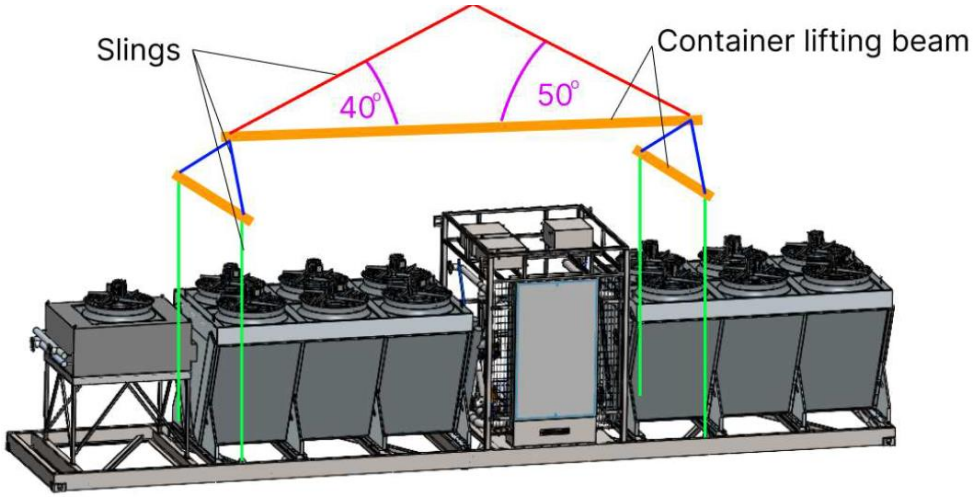
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6.3.3.2 Vertical lift

Requires two lifting beams no. 1: 2368mm between green slings at lifting beam

Require one container lifting beam no 2: 6692mm – distance between blue slings at lifting beam

Figure 10: Cool platform vertical lift



A Cross-lifting beam or H-lifting beam must be used to prevent slings to damage the coolers. Colors in the figure **does not** indicate any recommended lifting capacity

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6.3.4 Transportation method

Transportation of the Cooling Platform is recommended to be done with a semi-trailer for standard ISO containers, enabling fixation with the use of the standard ISO 1161 corners.

The driver must make sure that the platform is adequately secured for transport.

	**Transporting the platform mounted on top of an applicable Fuel Cell Container is prohibited.**
	**During transport, the Cooling platform must always be supported as described in section 6.3.1.**
	**The semitrailer needs locks for ISO corners for anchoring and appropriate middle support.** **Or** **Applicable fixations points and appropriate middle support.**

6.4 Anchoring/assembly on designated site

The Cooling skid is to be permanently mounted onto the 40ft Fuel Cell container.

Tools needed:

4x Twist-lock.

1. The 40ft Fuel Cell container needs to be placed and anchored to the designated site, prior to mounting of the Cooling skid.
2. Place the 4 twist-lock in the container corners
3. Lift and handle the cooling skid as described in this manual.
4. Line-up the twist-lock-applied container corners with the corners of the Cooling skid and lower the cooling skid onto the twist-locks.
5. Lock all 4 twist locks

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7.0 Grid Interface Container

7.1 Technical Data

Table 7-1: Key figures of Grid Interface Container	
Container type	Modified 10ft High Cube ISO Container
Dimensions (l/w/h)	3.0/2.5/2.9 m
Weight (dry)	7350 kg

Refer to General Arrangement CoG or attached document.

7.2 Packaging

The Grid Interface Container needs proper packaging, and this is the responsibility of Ballard when transporting from manufacturer.



The cooling circuits shall be drained from coolant to the extent possible prior to transportation and handling

7.2.1 Loose parts

No loose parts may be placed or temporarily fixated in the container for transport.

7.2.2 Preparation for transport

Preparing the Grid Interface Container for transportation is a Ballard responsibility.

The following must be completed:

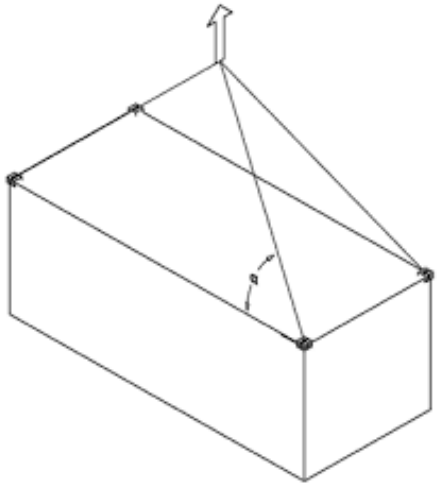
- Disassembly and packaging of cooling pipes.
  Open pipes must be covered by a protective plug/cover.
- All wall passthroughs must be covered to ensure no ingress
- Check that air intake and exhaust are closed.
- Check that 24VDC UPS batteries are securely fastened
- Ensure that the State of Charge on the UPS is <30%.
- Isolate the UPS batteries by noting the placement of fuses and remove them
- Fixated the MV transformer with the transportation spacer (Item 7003674-04).
- Check that all cabinets are securely locked.
- Check that access doors and container doors are securely locked against unauthorized access.
- Wrap the container if needed, to prevent dust and dirt from entering the container during transport.

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7.3 Handling and Transport

The Grid Interface Container can be transported and craned using ordinary truck and craning equipment, suitable for handling an ISO container as per ISO 3874. It is the responsibility of the handler to read and decide the applicable method.

Figure 11: 40ft Container lifting example



Recommended lifting method, since the bottom corners might need to meet anchor points of the designated site.

The driver must make sure that the container is adequately secured on the truck for transport.

Standard safety procedures, approved tools and Personal Protective Equipment must be used. Ballard will inform the crane operator of any additional on-site regulations that must be adhered to.

Craning must always be supervised by Ballard responsible, however this does not remove the responsibility for the crane operator to ensure that the craning and crane equipment in use is done safely, and it does not remove the responsibility for damages incurred during craning from the operator.

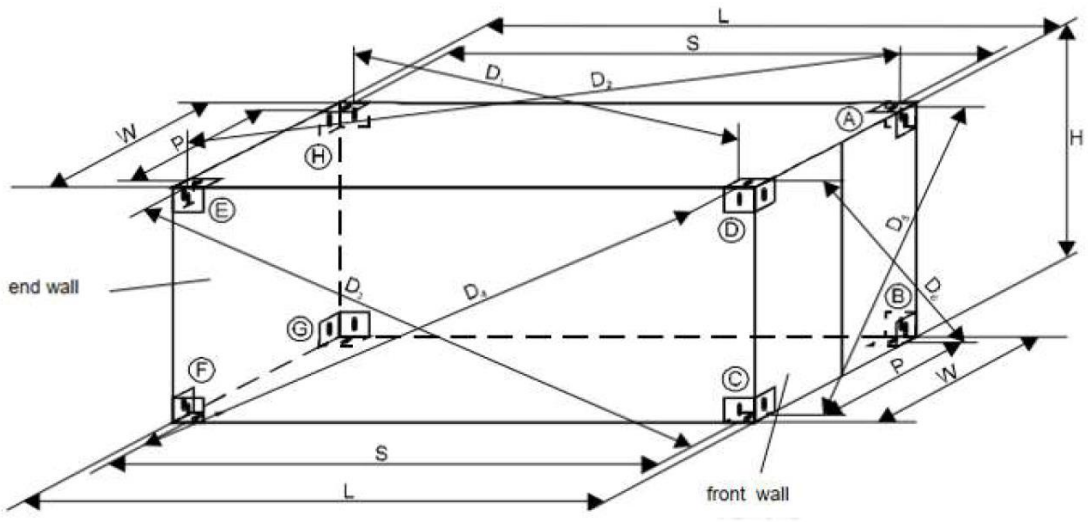
7.4 Anchoring on designated site

To anchor the Grid Interface Container on the designated site, integrator must use the standard ISO corners of the container.

Integrators of the system are recommended to anchor the container onto the designated site with ground-plate twist-locks. If anchoring is done using the bottom-side of the ISO corners (B, C, F, G in Figure 12), e.g. ground-plate twist-locks, verify the corner-distances of the containers prior to design of site.

Figure 12: 10ft Container ISO corners distances

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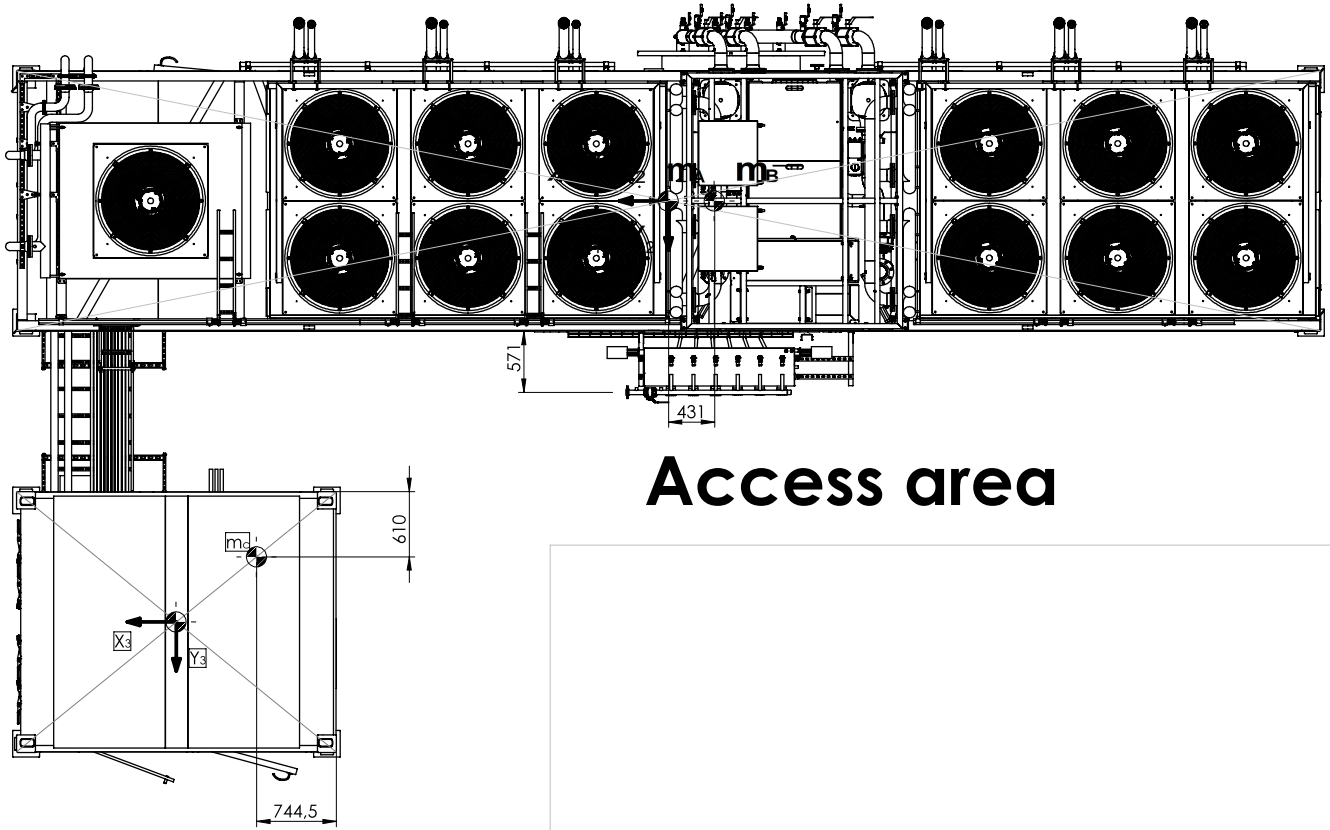


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TOP VIEW - Center of Gravity

Access area



Access area



NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

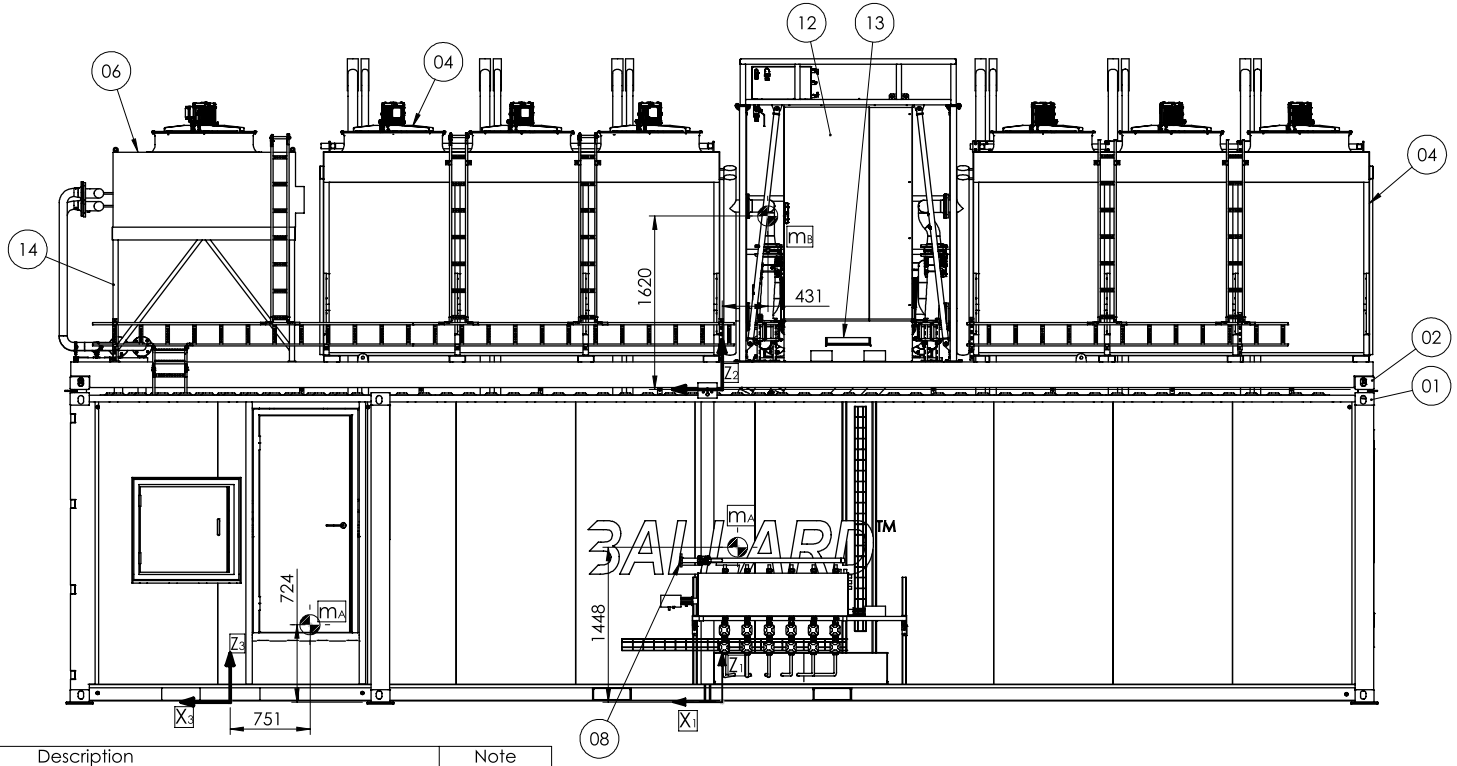
MATERIAL			
Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)			
Tolerances for linear and angular dimensions without individual tolerance according to ISO 668		By	Date
	Drawn	ASM	20-02-2024
Surface appearance, if not specified, according to reference table LZT 142 0001, category 6	Revision		
	Released		
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WEIGHT		SIZE	SHEET	SCALE	PART NUMBER:	REVISION
24943288 g	1st angle projection	A3	9/14	1:50	601456B	8

BALLARD™

General arrangement

FRONT VIEW - Center of Gravity
(LOOKING SOUTH)



	Description	Note
01	40ft High Cube Container	
02	40ft Custom Designed Flatbed	
03	10ft High Cube Container	
04	HT (High Temperature) Cooler - 1050kW (Evapco)	
05	High Temperature Coolant IN/OUT (CHS 114,3x3 [mm])	
06	LT (Low Temperature) Cooler - 110 kW (Evapco)	
07	Low Temperature Coolant IN/OUT (CHS 88,9x3 [mm])	
08	H2 supply interface - TP 010	CIP
09	Process exhaust (CHS 88,9x2 [mm])	
10	H2 Enclosure; Ventilation Exhaust (CHS 60,3x2 [mm])	
11	Ventilation Unit (Air Intake) - 40ft container	
12	Coolant System Electrical Cabinet	
13	Coolant System Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
14	Structure below LT Cooler	
15	Container Interconnect Cabling (750V DC)	
16	Container Interconnect Cabling (400V 3P-N-PE, Ethernet, Hardwired)	
17	Aux Power Supply Input (400V 3P-N-PE, 32A)	CIP
18	Customer Interface Cabling (Ethernet, Hardwired)	CIP
19	Drain interface - TP 015	CIP
20	~~Cover of hydrogen manifold~~	Optional
21	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
22	Customer MV Connection (6,6kV AC 3P, 92A)	CIP
23	Ventilation Unit (Air Intake) - 10ft container	
	CHS = Circular Hollow Section	
	CIP - Customer Interface Point	

NOTE:
1.) Location relative to the directions of the world on the top view (sheet 3/14)
2.) Reactions forces and mounting details are described on sheets 13 and 14
3.) A ladder is required to access the platform above 40ft Container
4.) 40ft flatbed structure meets requirements of EN1090-2 - Execution class: EXC2.

MATERIAL

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Tolerances for linear and angular dimensions without individual tolerance according to ISO 668

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	ASM	20-02-2024
Revision		
Released		

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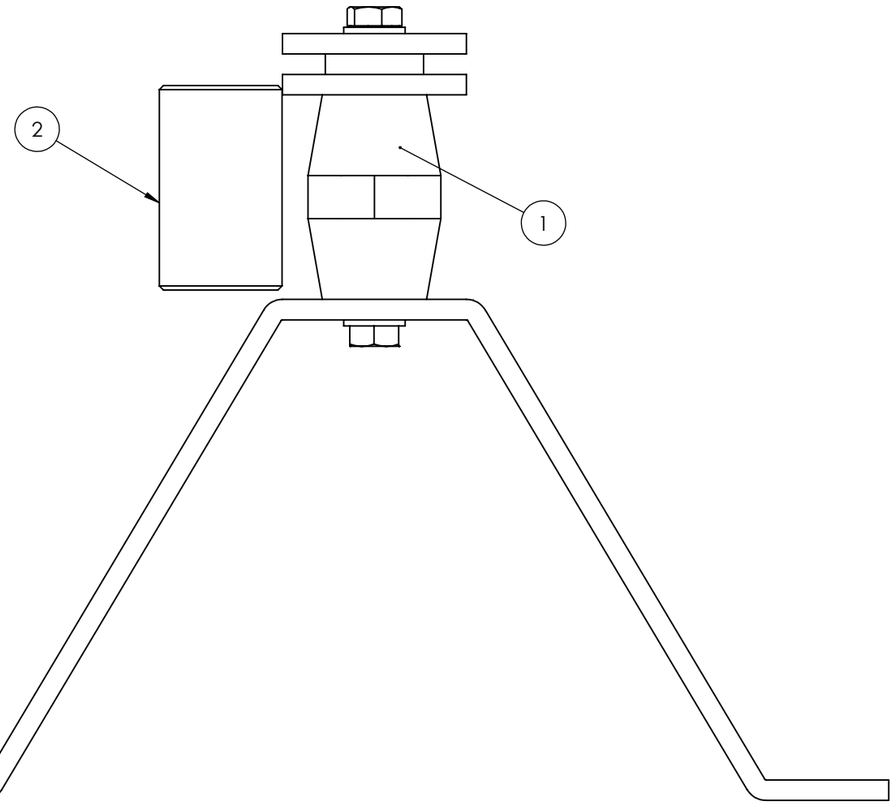
WEIGHT 24943288 g

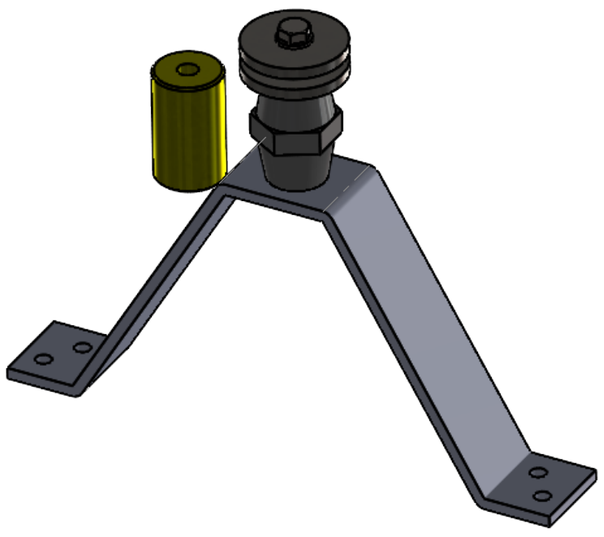
1st angle projection

BALLARD™

General arrangement

SIZE	SHEET	SCALE	PART NUMBER:	REVISION
A3	10/14	1:50	601456B	8





ITEM	Number	DESCRIPTION	QTY.
1	7003673	ISO - INSULATORS	1
2	7003674-04	Spacer used under transpotation (Swap with 7003673)	1

MATERIAL

Material must comply to Directive 2002/95/EC of the European Parliament (RoHS) and to Regulation (EC) No 1907/2006 of the European Parliament (Reach)

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Tolerances for linear and angular dimensions without individual tolerance according to

Surface appearance, if not specified, according to reference table LZT 142 0001, category 6

	By	Date
Drawn	GRK	01-07-2024
Revision		
Released		

Main Transformer Bracket

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WEIGHT	SIZE	SHEET	SCALE	PART NUMBER:	REVISION
4207 g	A3	1/1	1:5	7003674	

1st angle projection

Sub Section R01-003

Post-Transport Checklist

Ballard Power Systems Europe A/S
Majsmarken 1
9500 Hobro
Denmark

Revision history		
Rev.	**Date.**	**Description**
001	12/08/2024	First Issue

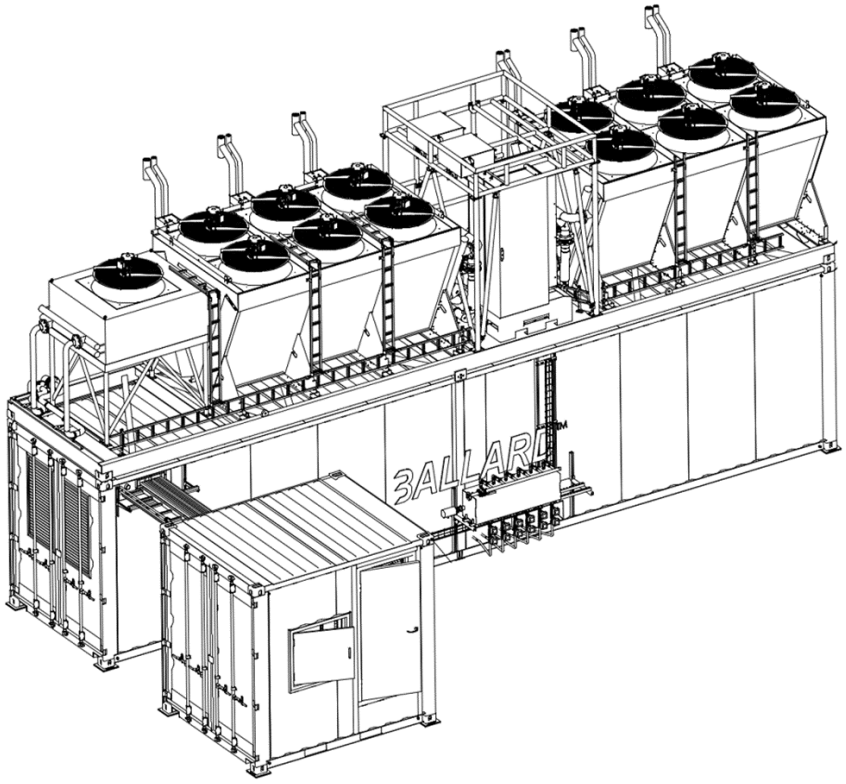
Document Title:	**BLPH Project - Post-Transport Checklist**
Document Number:	K559-2254-CWIWP4202202-R01-003
Revision:	Rev001
Sequence Number:	003
File Name:	K559-2254-CWIWP4202202-R01-003Rev001
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	R01
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

FC Megablock 1000 kW

Part no.: 5550003

Configuration: 40ft Fuel Cell Container w. 6 FCWave™
10ft Grid Interface Container, 6,6 kVAC

Post-transportation Checklist



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Post-transport Checklist		
Packaging and Transportation checklist	N/A	Comment
External packaging Inspect the packaging for any signs of damage, such as tears, dents, or moister exposure.		
Transportation Labels Check that handling and orientation labels are intact and visible.		
Seals and Fasteners Ensure that all seals, bolts, and fasteners used during transportation are intact and have not been tampered with.		
Transportation brackets Exchange Transportation spacer with isolator at the MV Transformer.		
External Visual Inspection	N/A	Comment
Surface condition Look for scratches, dents, rust, or paint damage on all external surfaces.		
Integrity of Enclosures Verify that all panels, doors, and covers are securely attached and free from damage.		
Labels and Markings Check that all labels, including nameplate, safety warnings, and identification tags, are present and legible.		
Alignment and Assembly Ensure that the machine components are properly aligned and assembled according to the specifications.		
Mechanical Components	N/A	Comment
Moving parts Manually operate any moving parts, such as belts, gears, and pulleys, to check for smooth operation without binding or excessive play.		
Bearing and Seals Inspect bearings for proper lubrication and seals for any signs of leakage.		
Fasteners Ensure that all bolts, nuts, and screws are properly tightened, and no parts are loose.		
Hydraulic and Pneumatic systems Check hoses, fittings, and coolers for signs of wear, leaks, or damage.		
Electrical Components	N/A	Comment

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Post-transport Checklist		
Wiring and cables Inspect all electrical wiring for proper insulation, secure connections, and the absence of damage or exposed wires.		
Control panels Open control panels to verify that internal wiring is neat, components are securely mounted, and no loose connections exist.		
Electrical terminals Ensure that all terminals are correctly labels and free of corrosion or loose connections		
Grounding Confirm that the machine is properly grounded and that all grounding connections are intact.		

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Sub Section R04

Preservation and ready for Sail Away

Ballard Power Systems Europe A/S
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Revision history		
Rev.	**Date.**	**Description**
001	29/04/2025	First Issue
002	13/05/2025	Document number corrected

Document Title:	**BLPH Project Preservation and ready for Sail Away**
Document Number:	K559-2254-CWIWP4202202-R04-002
Revision:	Rev002
Sequence Number:	002
File Name:	K559-2254-CWIWP4202202-R04-002Rev002
Purchaser Job:	K559-2254
Purchase Order:	CWIWP4202202
Code:	R04
Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

Contents

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Preservation of the FCwave module:

Dry Out

When all Sat tests are completed, and it is agreed no more operation of the modules will take place the System is requested to run the Dry out program.

The Purpose of running Dry Out is to remove liquid water from the module, such that stacks are in a “dry” condition after completing this procedure. This is intended to be the final part of the last operations cycle before long time storage or transport of the module, where temperatures may reach freezing conditions.

The request to start Dry Our is communicated via MODBUS.

When requested to start Dry Out, the module ramps I_Allow to 0A. This will prevent the module from delivering current. When current is reduced to < 5A the module begins the dry out process.

Internally in the system the module will ramp up temperature and airflow to accomplish the dry out process. During this state the air compressors are operating at high power level.

When the module has completed the dry out process or 6 min has elapsed, the module will perform a controlled shutdown process, identical to normal operation shutdown. After the shutdown, the module is prepared for long time storage, for 6 month or longer.

<u>Restarting after Dry Out and Long Time Storage:</u>

When the module is to be operated again after long time storage/Dry Out procedure, integrator must operate the module in a low power regime (50 to 75kW) for at least 20 minutes before increasing power. This allows the stack to return to proper humidification conditions.

Expect that performance is impacted until stacks are re-humidified. This is temporary and can be helped by performing a conditioning cycle – contact Ballard for details.

The procedure is described in the Integration Manual for the FCwave modules.

Drainage of internal HT cooling water in the FCwave module:

Drainage of glycol within the closed HT cooling loop circuits of the FCwave modules is not recommended / required according to Ballard. However, it is for the integrator to decide if draining of the HT system is required.

The internal HT cooling loop can be filled and drained by a connection installed in the base of each Fcwave module. An external pump is connected and used for filling as well as draining. Connecting point shown in drawing below.

Each FCwave module contains 45 litre of cooling liquid.



Draining of external cooling systems.

The draining of both external HT and LT cooling system will be performed by Ballard.

Small quantities of cooling located at low points in the HT and LT external cooling system is considered as insignificant.

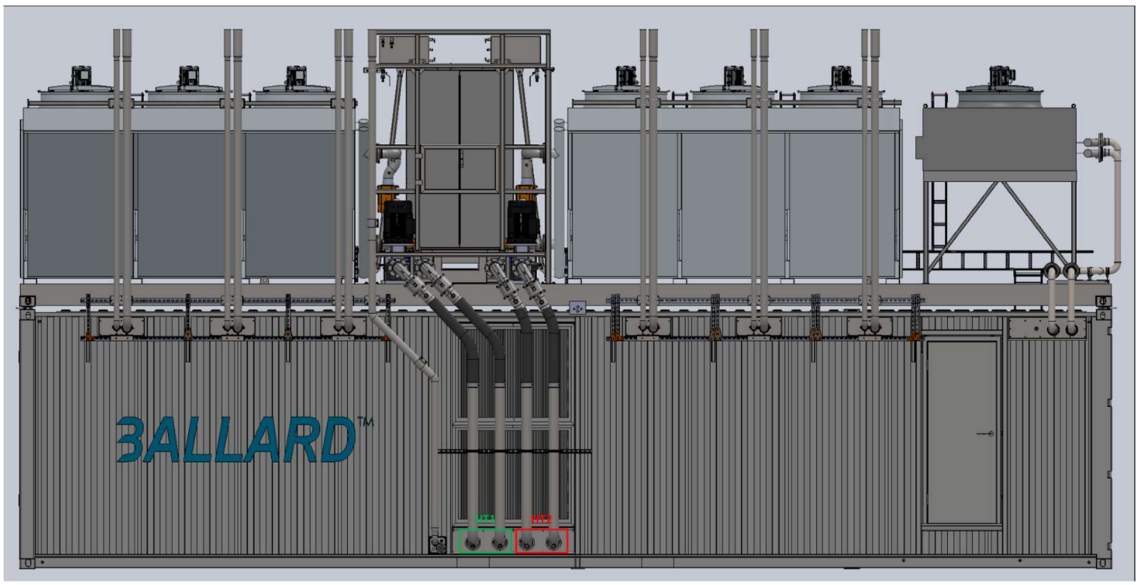
External HT cooling Loop

The HT cooling loop is divided into two loops. When the cooling media is drained of the HT system each loop must be drained.

Connect a hose to the interface at the filling/drain valve. Each system is equipped with two valves. (only one valve to be connected and opened)

Have a tank of sufficient size connected to collect the cooling water. Each HT loop contains 700 litre of cooling liquid.

The HT cooling loop is an open system as the expansion-/header tank is equipped with venting to atmosphere. The system is drained by gravity.



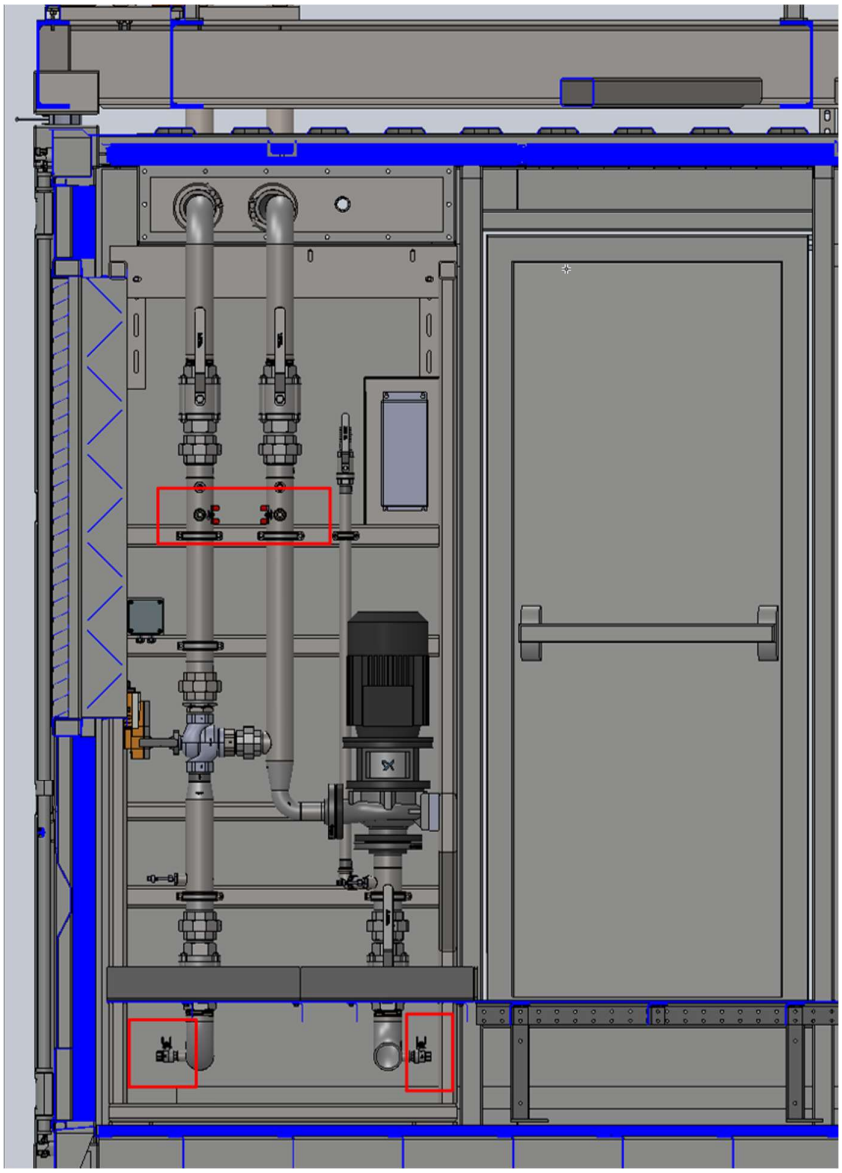
External LT cooling loop

The LT cooling system is a single system. The drain valve is located inside the container.

Connect a hose to the interface at the filling/drain valve. As the system is equipped with 4 valves it is possible to choose which valve to use. (only one valve to be connected and opened)

Have a tank of sufficient size connected to collect the cooling water. The LT cooling loop contains 400 litre of cooling liquid.

The LT cooling loop is an open system as the expansion-/header tank is equipped with venting to atmosphere. The system is drained by gravity.



When the BLPH is at location and before system is taken into operation the system must be filled again. Air trapped in the system must be vented out.

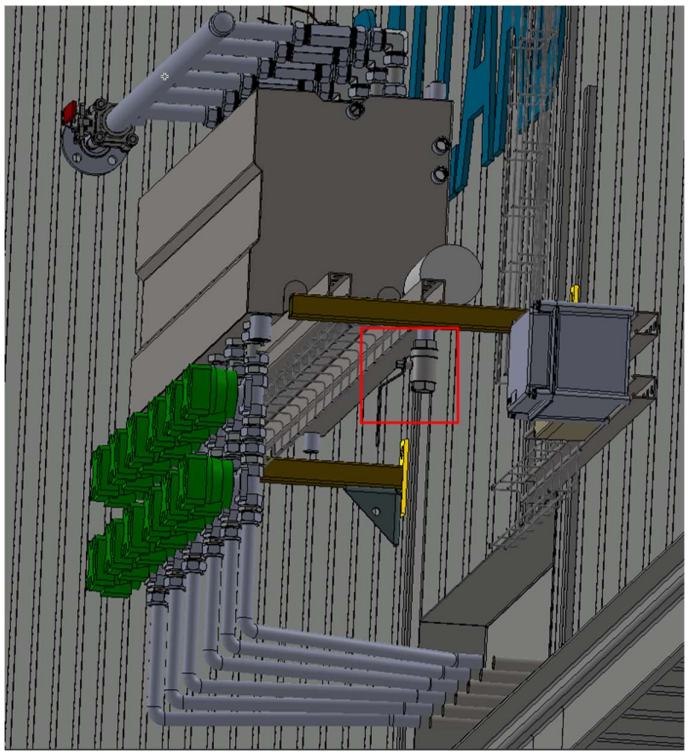
Draining of H2 manifold heater.

The H2 heater is filled with water/glycol. This system must also be drained before Sea Trail. It is an independent closed system.

Connect a hose to the interface at the filling/drain valve.

Have a tank of sufficient size connected to collect the cooling water. The H2 heater contains 200 litre of cooling liquid.

The H2 heater tank is equipped with venting to atmosphere. The system is drained by gravity.



When the BLPH is at location and before system is taken into operation the system must be filled again. Air trapped in the system must be vented out.

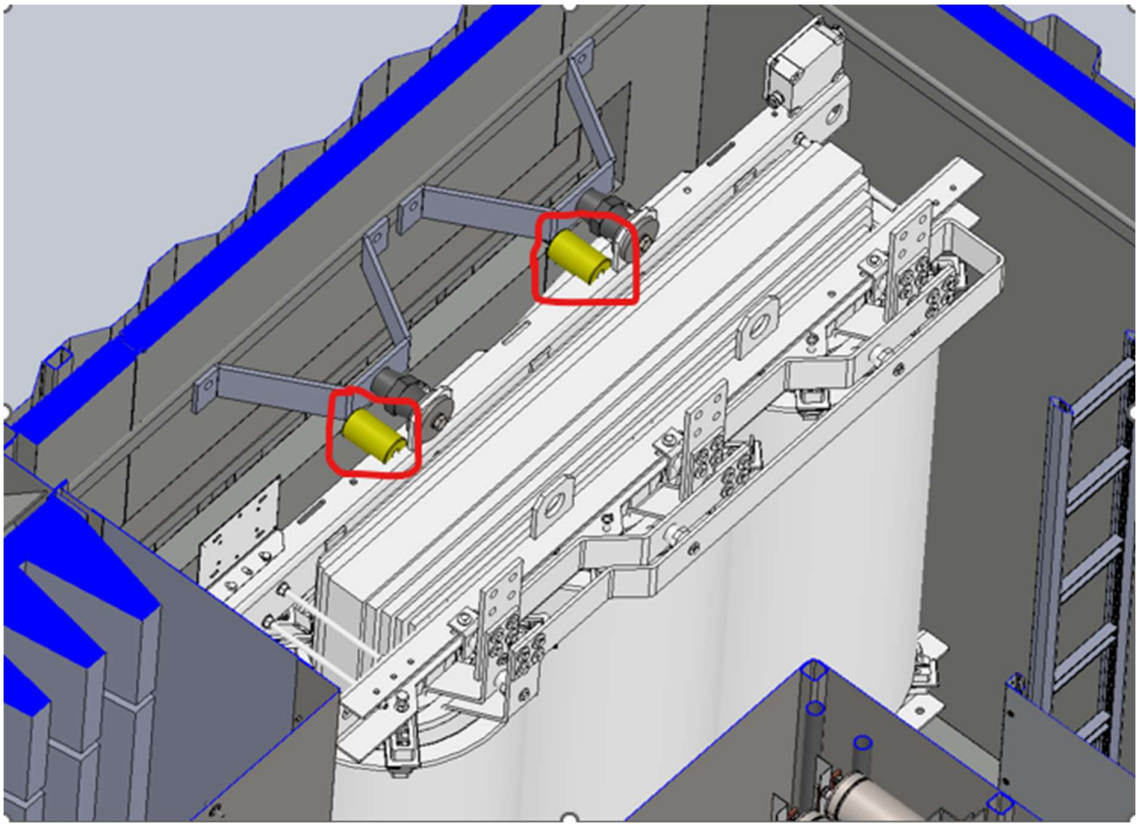
Preservation of container(s)

No other preservation actions are needed for the fuel cell package.

Sea Fastening

Preparation of transformer for sea trail.

Two Transport Brackets must be installed to ensure transformer is ready for the Sea trail. Ballard will deliver the brackets (Identification -brackets are painted yellow). Brackets will be delivered to Site by Ballard.



When the BLPH is at location and system is taken into operation the Transport Brackets must be replaced again with support brackets.

Sea fastening of external coolers.

Equipment outside the container must be secured for the Sea Trail. This will require additional support/straps that will be strapped to the container itself. Straps and other material will be delivered by Yard. The installation of the sea fastening straps will be performed by Ballard.

When the BLPH is at location and system is taken into operation the support and straps must be removed.

Sea Fastening of H2 manifold heater

The H2 manifold heated must be prepared for the Sea Train by building some wooden support or other support for mitigation of damage to installation and piping. Will be installed by Ballard just after completion of SAT. Materials will be delivered by the Yard.

When the BLPH is at location and system is taken into operation the wooden support must be removed.

Sea fastening of container doors.

All external doors to containers must be strapped to prevent unintended opening during the Sea Trail. Materials will be delivered by Yard. The installation of the sea fastening straps will be performed by Ballard.

Specification for materials for Sea Fastening

A sketch for the sea fastening straps is attached to this document with reference to each strap.

In total 8 are required for Sea fastening. Straps are listed below:

Pos No	Specification
1	Standard 50 mm lash, x 6-10 meter
2	Standard 50 mm lash, x 6-10 meter
3	Standard 50 mm lash, x 6-10 meter
4	Standard 50 mm lash, x 6-10 meter
5	Standard 50 mm lash, x 15 meter
6	Standard 50 mm lash, x 5 meter
7	Standard 50 mm lash, x 5 meter
8	Standard 50 mm lash, x 15 meter

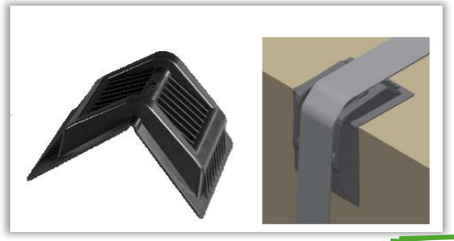
Furthermore 4 protection corners are needed for protection of the cooler metal frame

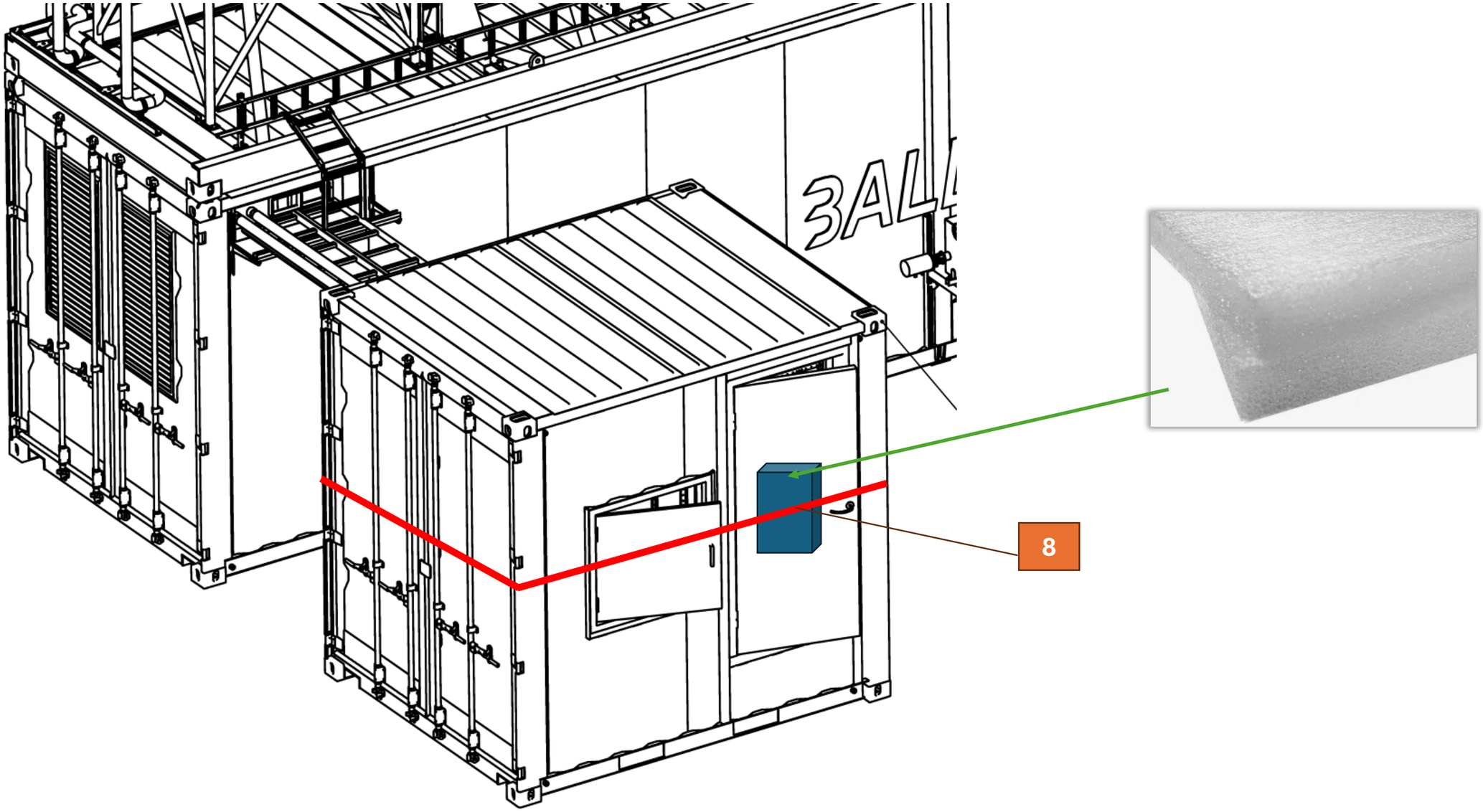
Finally, 3 pieces of structural foam blocks for support at doors. Foam blocks must be at least 200 mm thick

Sea Transport

Provided the preservation and sea fastening steps outlined above have been completed, no further precautions must be taken during the sea transport. No need for temperature or moisture control in the containers or record keeping.

ISOMETRIC VIEW




8