Base Load Power Hub (BLPH)

EQUIPMENT MANUFACTURERS RECORD BOOK – COMPLETE – HYDROGEN VENT

Document Number: 1724000887-QC-DB-00014

Document Class: 2

03	16/04/2025	Accepted For Construction (AFC)	AS	SA	ADL
02	25/03/2025	Issue for Review (IFR)	AS	SA	ADL
01	13/03/2025	Issue for Review (IFR)	AS	RV	ADL
00	05/02/2025	Issue for Review (IFR)	AS	RV	ADL
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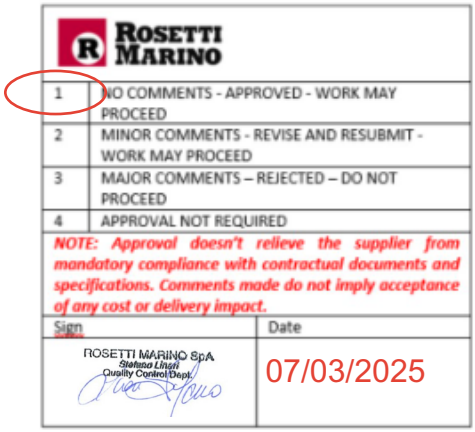
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Base Load Power Hub (BLPH)

EQUIPMENT MANUFACTURERS RECORD BOOK – INDEX – HYDROGEN VENT

Document Number: 1724000887-QC-LIS-00015


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07/03/2025

Document Class: 2

03	21/02/2025	Accepted for Construction (AFC)	SB	RV	ADL
02	23/01/2025	Accepted for Construction (AFC)	SB	RV	ADL
01	06/12/2024	Issue for Review (IFR)	SB	RV	ADL
00	11/10/2024	Issue for Review (IFR)	SB	RV	ADL
Rev.	Date	Description	Prepared	Reviewed	Approved

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00	Issue for Review (IFR)
01	Issue for Review (IFR)
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03	Accepted for Construction (AFC)

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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.

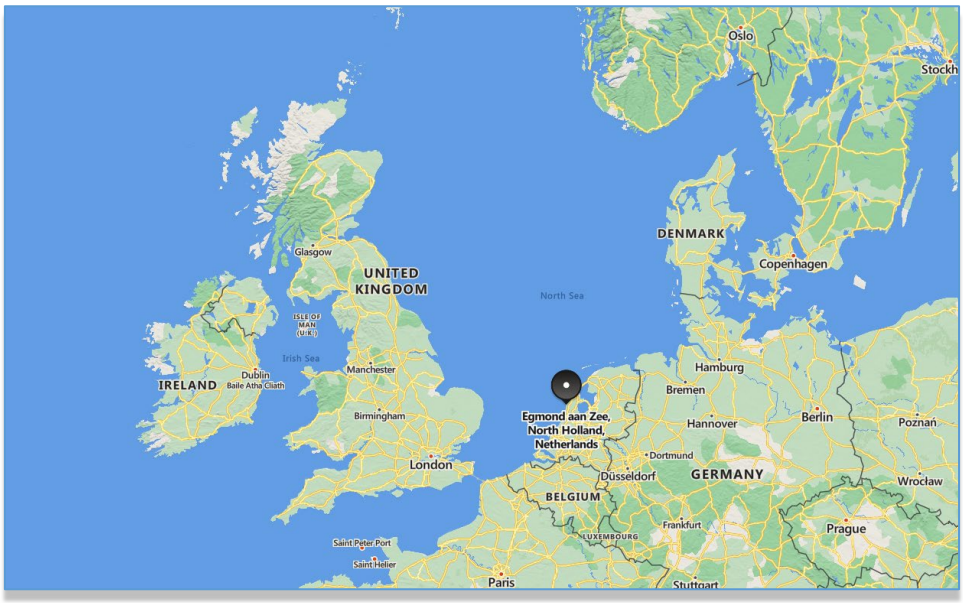


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

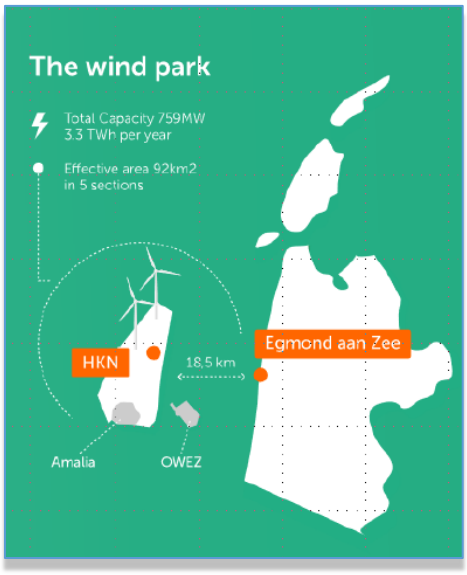


Figure 2 - Wind Park Details

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 located on coordinates E 590719.1, N 5841602.3 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.

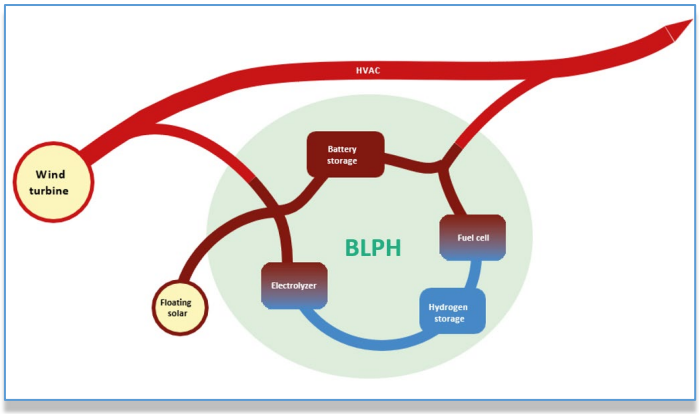


Figure 3 – BLPH Concept

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 s 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

This Document defines the Index of the Manufacturer Data Book

2.1 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	CROSSWIND
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
BLPH	BASE LOAD POWER HUB
BESS	BATTERY ENERGY STORAGE SYSTEM
HKN	HOLLANDSE KUST NOORD
VooW	VAN OORD OFFSHORE WIND
NDE	NON-DESTRUCTIVE EXAMINATION
PED	PRESSURE EQUIPMENT DIRECTIVE
ATEX	Atmosphere Explosive

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- Painting reports
- Survey reports
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1.1 DESIGN DOSSIER

1.1.1 Document Register

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Base Load Power Hub (BLPH)

HYDROGEN VENT

SUPPLIER MASTER INDEX REGISTER (SMIR)

Document Number: 1724000887-MD-LIS-00001

Document Class: 3

00	28/05/2024	Issue for Information (IFI)	G.Palumbo	V.Thevenet	A.Longoni
Rev.	Date	Description	Prepared	Reviewed	Approved

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File: 1724000887-MD-LIS-00001 Rev.00.xlsx

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data / *dated:*	28/05/2024	Codice F./ *S. Code:*	11474720965		
Commessa / *Job:*	23-0193	Indirizzo/ *address* :	Via Cavriana 9, 20134 Milan, Italy		
Descrizione / *Description*	HYDROGEN VENT	Persona di riferim./ *contact person:*	Gianmarco Palumbo gpalumbo@encorecombustion.com +39 02 3056 0120		
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1	1724000887-MD-LIS-00001	00	1724000887-MD-LIS-00001	00	23-0193-0011	00	SUPPLIER MASTER INDEX REGISTER (SMIR) - HYDROGEN VENT	MEC			17/05/2024				I
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2	1724000887-QC-ITP-00002	00	1724000887-QC-ITP-00002	00	23-0193-0010C	00	INSPECTION AND TEST PLAN - HYDROGEN VENT	QUA			31/05/2024			Y	A
							ENGINEERING DOCUMENTS								
3	1724000887-MAC-DA-00003	00	1724000887-MAC-DA-00003	00	23-0193-0101	00	GENERAL ARRANGEMENTS DRAWINGS, INCLUDING FOUNDATION LOADS-HYDROGEN VENT	MEC			07/06/2024		X	Y	A
4	1724000887-MAC-CA-00004	00	1724000887-MAC-CA-00004	00	23-0193-0500	00	MECHANICAL CALCULATION - HYDROGEN VENT	MEC			07/06/2024		X	Y	A
5	1724000887-MAC-DD-00005	00	1724000887-MAC-DD-00005	00	23-0193-0131	00	DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	MEC			28/06/2024				I
6	1724000887-MAC-DS-00006	00	1724000887-MAC-DS-00006	00	23-0193-0401	00	EQUIPMENT DATA SHEETS - HYDROGEN VENT	MEC			31/05/2024			Y	A
7	1724000887-MAC-DG-00007	00	1724000887-MAC-DG-00007	00	23-0193-0170	00	WIRING DIAGRAM (JB AND HT) - HYDROGEN VENT	MEC			28/06/2024				I
							PROCEDURES								
8	1724000887-NDT-PRO-00008	00	1724000887-NDT-PRO-00008	00	23-0193-0022	00	NON-DESTRUCTIVE EXAMINATIONS PROCEDURES (NDE) AND OPERATORS LIST AND QUALIFICATIONS	QUA			19/07/2024				A
9	1724000887-QC-PRO-00009	00	1724000887-QC-PRO-00009	00	23-0193-0033	00	HYDROSTATIC TEST PROCEDURES -HYDROGEN VENT	QUA			19/07/2024				A
10	1724000887-MAT-PRO-00010	00	1724000887-MAT-PRO-00010	00	23-0193-0030	00	PAINTING PROCEDURE- HYDROGEN VENT	QUA			19/07/2024				A
11	1724000887-WEL-PRO-00011	00	1724000887-WEL-PRO-00011	00	23-0193-0014	00	WELD PROCEDURE SPECIFICATION (WPS) WLED LOCATION PLAN (WLP) AND QUALIFICATIONS RECORDS (PQR) WELD OPERATORS LIST and WELDER QUALIFICATIONS RECORDS (WPQ)	WEL			19/07/2024				A
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13	1724000887-MAC-LIS-00013	00	1724000887-MAC-LIS-00013	00	23-0193-AX	00	ATEX CERTIFICATION - HYDROGEN VENT	QUA			13/09/2024				A
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16	1724000887-COM-LIS-00016	00	1724000887-COM-LIS-00016	00	23-0193-SP0	00	SPARE PART INDEX REGISTER (SPIR) - HYDROGEN VENT	COM			30/08/2024				I
17	1724000887-MAC-MAN-00017	00	1724000887-MAC-MAN-00017	00	23-0193-1000	00	INSTALLATION OPERATING AND MAINTENANCE MANUAL (IOM)	MAC			30/08/2024			Y	I
							HANDLING, SHIPPING & SITE INSTALLATION								
18	1724000887-QC-PRO-00018	00	1724000887-QC-PRO-00018	00	23-0193-0035	00	PACKING , SHIPPING HANDLING AND STORAGE PROCEDURES	EXP			30/08/2024				I
19	1724000887-MAC-DD-00019	00	1724000887-MAC-DD-00019	00	23-0193-530A	00	LIFTING DRAWINGS - HYDROGEN VENT	METODI			19/07/2024				A

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1.1.2 Atex Register

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ATEX REGISTER - HYDROGEN VENT

Document Number: 1724000887-QC-LIS-00012

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00	19/09/2024	Issue for Review (IFR)	SB	RV	ADL
Rev.	Date	Description	Prepared	Reviewed	Approved

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1	00	H-ETE-200N1-19-L3-01	Raychem Self-Regulating Heating Cable	Hydrogen Vent	nVent Thermal CC	XTVR2-CT	NA	II 2 GD Ex 60079-30-1 eb IIC T* Gb / Ex 60079-30-1 tb IIIC T**°C Db	1724000887-MAC-DG-00007	XTVR_SGS20ATEX0049X_Iss. 4 1	Zone 2	NA	1724000887	Encore Thermoengineer ing SRL	Hydrogen Vent	NA	NO	YES
2	00	ETB-200N1-19-L3-01	Thermostat V407	Hydrogen Vent	nVent Thermal Belgium NV	ETS-05	5020019	II 2(1)G Ex eb ia mb [ia Ga] IIC T5 Gb -40°C ≤ Ta ≤ +60°C II 2D Ex tb IIIC T100°C Db	1724000887-MAC-DG-00007	ETS-05_Baseefa13ATEX0137 Issue 6	Zone 2	NA	1724000887	Encore Thermoengineer ing SRL	Hydrogen Vent	NA	NO	NO

*Note: ETE confirms that all the Atex equipment are identified in the above table

**Note: refer to Doc. No. 1724000887-MAC-LIS-00013 - Atex Certificate" for certifications

1.1.3 Tag Register

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Tag Number	Tag Description	Class Name	Physical Class Name	Parent Tag	P&ID	P.O.	Vendor	Manufacturer	Model Type Catalogue Number	Serial Number	Model Part No	Hazardous Area Equip Relevant	Hazardous Area Classification	3D Location	Hazardous Area Certificate Standard	Hazardous Area Certifying Authority	ATEX Certificate Number	3D Object	Diagram	Installation Zone	Layout Drawing	Datasheet	Assembly/Dimensional Drawing	General Arrangement	Operating & Maintenance Manual	Wiring Diagram	Spare Part List	Lubricant Document Reference	Criticality	Remarks	Linked 2D	Linked 3D	Vendor Reference Document
ETB-200N1-19-L3-D1	TRACE HEATING - FEEDER 6 (H2 VENT)	ElectricalJunctionBox	ElectricalJunctionBox	DP-200N1		1724000887	Encore Thermoengineering	nVent	ETS-DS	5030019	N/A	True		HAZARDOUS-AREA_6	II 2(1)G Ex eb ia mb [ia Ga] IIC T5 Gb - 40ºC ≤ Ta ≤ +60ºC	SGS Fimko Oy,	Baseefa13ATEX0137 Issue 6			Zone 2	N/A	N/A	1724000887-MAC-DG-00007	1724000887-MAC-DA-00003	1724000887-MAC-MAN-00017	1724000887-MAC-DG-00007		N/A	3		False	True	1724000887-MAC-DG-00007
H-ETE-200N1-19-L3-D1	Self-regulating heat cable	Heating Cable	PowerCable			1724000887	Encore Thermoengineering	nVent	XTVR2-CT	N/A	N/A	True			II 2 GD Ex 60079-30-1 eb IIC T* Gb / Ex 60079-30-1 tb IIIC T**°C Db	SGS Fimko Oy,	XTVR_SGS20ATEX0049X_Iss. 4 1			Zone 2	N/A	N/A	1724000887-MAC-DG-00007	1724000887-MAC-DA-00003	1724000887-MAC-MAN-00017	1724000887-MAC-DG-00007			3		False	False	1724000887-MAC-DG-00007
Q-43004	Hydrogen Vent	Vent				1724000887	Encore Thermoengineering	TICI srl	N/A - CUSTOMIZED	N/A	N/A				N/A	N/A	N/A			N/A	N/A	1724000887-MAC-DS-00006	1724000887-MAC-DD-00005	1724000887-MAC-DA-00003	1724000887-MAC-MAN-00017	1724000887-MAC-DG-00007	1724000887-COM-US-00016	N/A	3				1724000887-MAC-DS-00006

1.1.4 Spare parts List Register

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

SPARE PART INDEX REGISTER (SPIR) - HYDROGEN VENT

Document Number: 1724000887-COM-LIS-00016

ROSETTI MARINO	
1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED
NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.	
Sign	Date
Giuseppe Cavallo	28/11/24

Document Class: 3

01	26/11/2024	Issue for Information (IFI)	AS	RV	ADL
00	19/09/2024	Issue for Information (IFI)	SB	RV	ADL
Rev.	Date	Description	Prepared	Reviewed	Approved

THERMO ENGINEERING AN ENCORE COMBUSTION COMPANY

THERMO ENGINEERING® ADVANCED COMBUSTION SYSTEMS

Revision / Change Log

Rev.	Description
00	Issue for Information (IFI)
01	Issue for Information (IFI)

HOLDS LIST

No.	Description
1	
2	
3	
4	

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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.

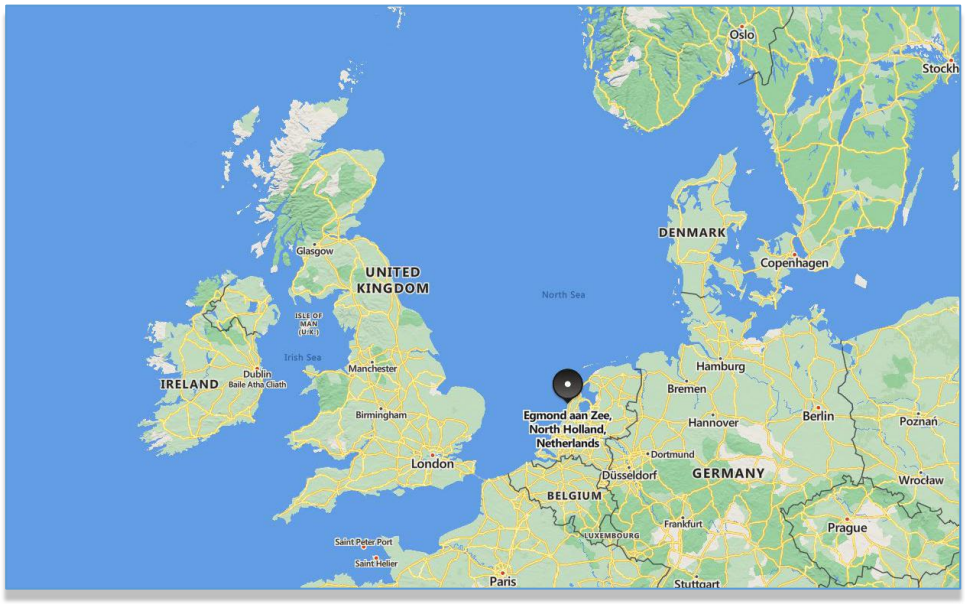


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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 located on coordinates E 590719.1, N 5841602.3 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.

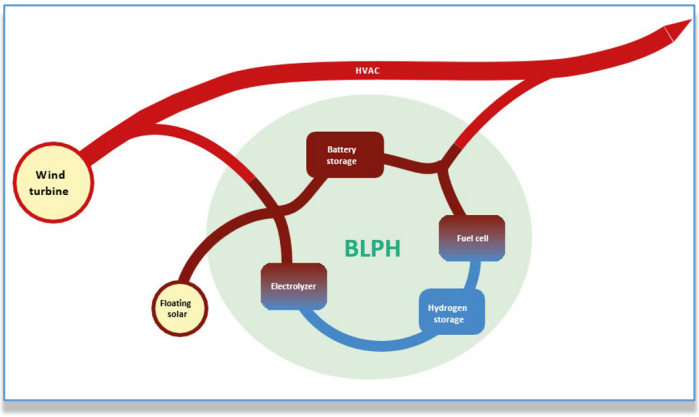


Figure 3 – BLPH Concept

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 s 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

This Document includes the Spare Parts both for Commissioning and 2 years.

2.1 REFERENCES

Drawing No.	Rev.	Description	Notes
1724000887-MAC-DA-00003	02	GENERAL ARRANGEMENTS DRAWINGS, INCLUDING FOUNDATION LOADS-HYDROGEN VENT	NA
1724000887-MAC-DD-00005	01	DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	NA
1724000887-MAC-CA-00004	02	MECHANICAL CALCULATION – HYDROGEN VENT	NA

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	CROSSWIND
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Table 1 - Definitions and Abbreviations

ROSETTI MARINO

CROSSWIND

Document Title	Commissioning and 2 years spare parts list					
The document relates to	HOLLANDSE KUST NOORD WIND PARK Project - Base Load Power Hub (BLPH)					Contract: CW-I-WP4-2023-05
Project ID	123A90	Doc. n°	1724000887-COM-LIS-00016	Rev. Issued for Information	Rev. Date 26/11/2024	Status: IFI / Class: 3

The equipment consists of the following units/components

1	Tag no.	n.a
2	Tag description	hydrogen vent
3	Manufacturer model/type no.	n.a
4	Manufacturer serial no.	-
5	No. of units	1
6	Quantity of parts FITTED / INSTALLED per unit/component	

Supplier: ENCORE THERMOENGINEERING SRL	PO Number: 1721002632	PO hydrogen vent	Contact Silvio Dagoberti
Address: Sede legale: Via San Damiano 9, 20122 Milano – Sede operativa: Via Cavriana 9, 20134 Milano		Supplier +39 02 30560114	Contact +39 327 9778080
		E-mail: aftermarket@encorecombustion.com	WEB SITE
General Information:			

Item Number	Total number of identical spares installed	Description of recommended spare parts	Parts/drawing ref. Project Datasheet no.	Parts/drawing ref. Project Detail dwg. no.	Parts/drawing ref. Item ref.	Material	Certificate Type (if applicable)	Certificate Reference (if applicable)	Shelf life (years)	Weight (net)	Weight (gross)	Volume	HS Code	ECCN Code	% US Content	Country of origin	Supplier part no.	Manufacturer part no.	Manufacturer name	Commissioning spares: Quantity ordered	2 Years spares: Quantity ordered	Remarks
7		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	1	GASKET	NA	1724000887-MAC-DD-00005	22	GASKET SHALL BE STAINLESS STEEL, SPIRAL WOUND, GRAPHITE FILLED, EPOXY-COATED CARBON STEEL CENTERING RING AND STAINLESS STEEL INNER RING.													TICI SRL	1	1	
2	1	STUD BOLT AND 2 NUTS	NA	1724000887-MAC-DD-00005	23	SA-193.B7/SA194.2H (HDG)													TICI SRL	1	1	
3	1	HEX BOLT	NA	1724000887-MAC-DD-00005	52	CS(HDG)													TICI SRL	1	1	
4	1	HEX NUT	NA	1724000887-MAC-DD-00005	53	CS(HDG)													TICI SRL	1	1	
5	1	GASKET	NA	1724000887-MAC-DD-00005	102	GASKET SHALL BE STAINLESS STEEL, SPIRAL WOUND, GRAPHITE FILLED, EPOXY-COATED CARBON STEEL CENTERING RING AND STAINLESS STEEL INNER RING.													TICI SRL	1	1	
6	1	STUD BOLT AND 2 NUTS	NA	1724000887-MAC-DD-00005	103	SA-193.B7/SA194.2H (HDG)													TICI SRL	2	2	
7	1	NUT	NA	1724000887-MAC-DD-00005	107	AISI316													TICI SRL	1	1	
8	1	HEX BOLT	NA	1724000887-MAC-DD-00005	116	AISI316													TICI SRL	1	1	
9	1	GRATING FIXING CLAMPS	NA	1724000887-MAC-DD-00005	237	CS													TICI SRL	4	4	
10	1	BOLT	NA	1724000887-MAC-DD-00005	238	8,8													TICI SRL	1	1	
11	1	HEX NUT	NA	1724000887-MAC-DD-00005	239	8													TICI SRL	1	1	
12	1	WASHER	NA	1724000887-MAC-DD-00005	240	CS													TICI SRL	1	1	
13	1	HEX HEAD BOLT	NA	1724000887-MAC-DD-00005	241	8,8													TICI SRL	5	5	
14	1	HEX HEAD NUT	NA	1724000887-MAC-DD-00005	242	8													TICI SRL	5	5	
15	1	FLAT WASHER	NA	1724000887-MAC-DD-00005	243	CS													TICI SRL	5	5	
16	1	HEX HEAD BOLT	NA	1724000887-MAC-DD-00005	244	8,8													TICI SRL	1	1	
17	1	HEX HEAD NUT	NA	1724000887-MAC-DD-00005	245	8													TICI SRL	1	1	
18	1	FLAT WASHER	NA	1724000887-MAC-DD-00005	246	CS													TICI SRL	1	1	
19	1	LADDER CLIP	NA	1724000887-MAC-DD-00005	247	EN10025 S275 JO													TICI SRL	1	1	
20	1	HEXAGONAL HEAD BOLT	NA	1724000887-MAC-DD-00005	408	8,8													TICI SRL	1	1	
21	1	TYPE G- HEXAGONAL HEAD BOLT	NA	1724000887-MAC-DD-00005	409	8,8													TICI SRL	1	1	
22	1	HEXAGONAL NUT	NA	1724000887-MAC-DD-00005	410	8													TICI SRL	1	1	
23	1	FLAT WASHER	NA	1724000887-MAC-DD-00005	411	CARBON STEEL													TICI SRL	1	1	

1.2 DIAGRAMS

1.2.1 Wiring Diagrams

SEE ATTACHED NEXT PAGE

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BASE LOAD POWER HUB (BLPH)

HYDROGEN VENT

WIRING DIAGRAM (HT)

ROSETTI MARINO	
1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED
NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.	
Sign	Date
Giuseppe Cavallo	21/11/2024

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	13/11/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
02	28/10/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
01	10/09/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
00	12/08/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)

THERMO ENGINEERING AN ENCORE COMBUSTION COMPANY

ETE JOB 23-0193

ETE DWG NR. 23-0193-0170

CROSSWIND

ROSETTI MARINO

TITLE : BASE LOAD POWER HUB (BLPH) WIRING DIAGRAM (JB AND HT) FRONT PAGE

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1724000887-MAC-DG-00007

SHEET 001

REV. 03

File Name : 1724000887-MAC-DG-00007 Rev. 03

REV.	SHEET NUMBER	DESCRIPTION	REF. CODE
00	001	FRONT PAGE	
00	002	SUMMARY and GENERAL NOTES	
00	003	WIRING DIAGRAM	XXX
00	004	HEAT TRACING JB LAYOUT	XXX

GENERAL NOTES

1: ALL DIMENSIONS ARE IN MM.
2: THERMOSTAT SHALL BE SUPPLIED LOOSE BY THERMOENGINEERING AT SITE FOR SAFE TRANSPORTATION PURPOSE.
3: THERMOSTAT SHALL BE INSTALLED ON DEDICATED SUPPORT PROVIDED ON STACK SHELL AND WIRED TO EHT CABLE AT SITE BY ROSETTI MARINO.

THERMO ENGINEERING AN ENCORE COMBUSTION COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0170

CROSSWIND

ROSETTI MARINO

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	13/11/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
02	28/10/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
01	10/09/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
00	12/08/2024	SCB	RV	AL	ISSUE FOR INFORMATION

TITLE : BASE LOAD POWER HUB (BLPH)
WIRING DIAGRAM (JB AND HT)
SUMMARY and GENERAL NOTES

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

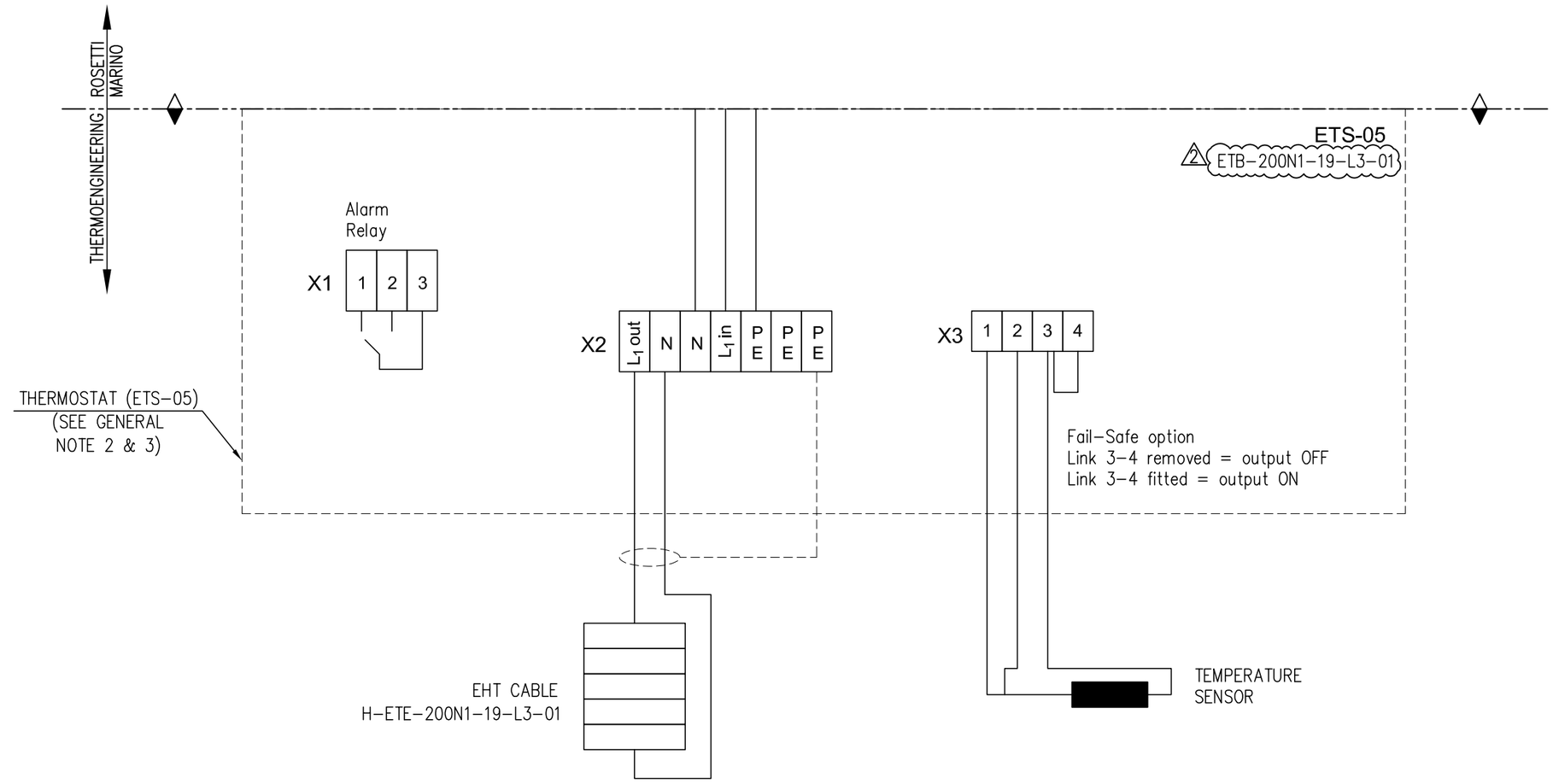
DRAWING NO. 1724000887-MAC-DG-00007

SHEET 002

REV. 03

File Name : 1724000887-MAC-DG-00007 Rev. 03

230 VCA + PE : CUSTOMER POWER SUPPLY
POWER IN CABLE SECTION = 3G6mm²



NOTE:
1. THE SIZE OF THE DISCONNECTOR AND
   THE MTD IS RESPONSIBILITY OF THE CUSTOMER.
2. THE HEAT TRACING START UP CURRENT: 10.1 A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	13/11/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
02	28/10/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
01	10/09/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
00	12/08/2024	SCB	RV	AL	ISSUE FOR INFORMATION

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY
CROSSWIND
ROSETTI MARINO

ETE JOB	23-0193
ETE DWG NR.	23-0193-0170

TITLE : BASE LOAD POWER HUB (BLPH)
WIRING DIAGRAM (JB AND HT)
WIRING DIAGRAM

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1724000887-MAC-DG-00007

SHEET 003

REV. 03

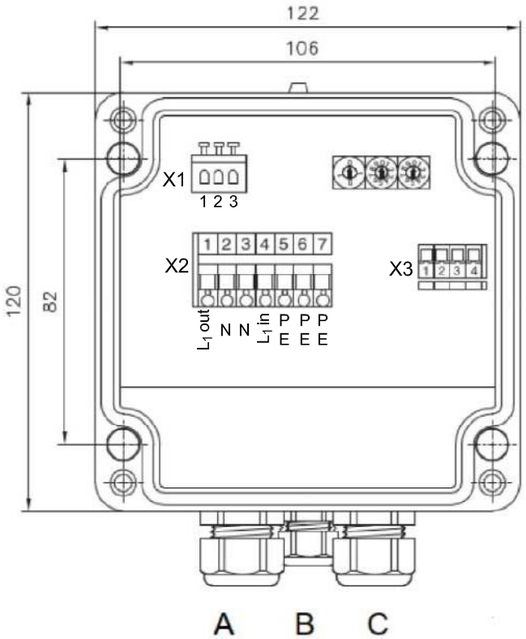
File Name : 1724000887-MAC-DG-00007 Rev. 03

CONNECTION TABLE			
TYPE	QTY	DIMENSION	USER
A	1	M25x1.5	POWER INPUT
B	1	M25x1.5	HEATING CABLE OUTPUT
C	1	M20x1.5	ALARM OUTPUT

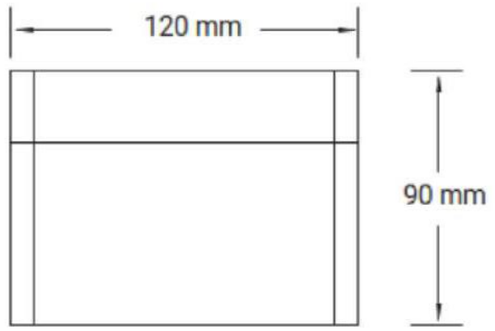
CABLE GLANDS SUPPLIED BY ENCORE

FRONT VIEW

DIMENSIONS ARE IN MM.



SIDE VIEW



ATEX GRP BOX
IN PROTECTION RATING = 66
COLOR : STD MFR
ALL SIZES ARE IN MM

TYPE A:
CABLE GLAND SUITABLE FOR CABLE
POWER SUPPLY TYPE 3G6 mm²
EXTERNAL DIAMETER 19.4 MM
INTERNAL DIAMETER 14.6 MM

THERMO ENGINEERING AN ENCORE COMBUSTION COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0170

CROSSWIND

ROSETTI MARINO

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	13/11/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
02	28/10/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
01	10/09/2024	SCB	RV	AL	ISSUE FOR INFORMATION (IFI)
00	12/08/2024	SCB	RV	AL	ISSUE FOR INFORMATION

TITLE : BASE LOAD POWER HUB (BLPH)
WIRING DIAGRAM (JB AND HT)
HEAT TRACING JB LAYOUT

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK

SCALE : NTS

A3

DRAWING NO. 1724000887-MAC-DG-00007

SHEET 004

REV. 03

File Name : 1724000887-MAC-DG-00007 Rev. 03

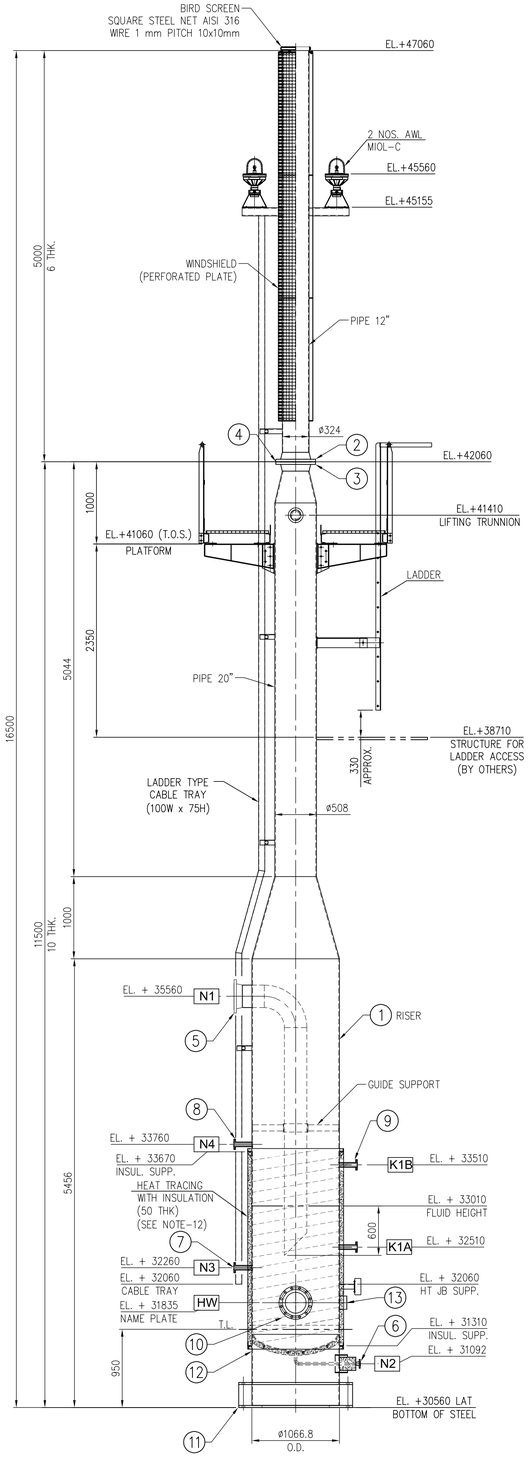
1.3 DRAWINGS

1.3.1 General Arrangement Drawing

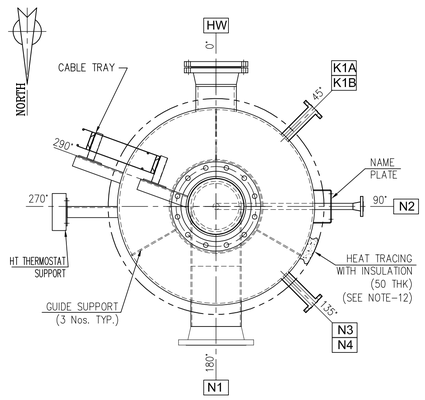
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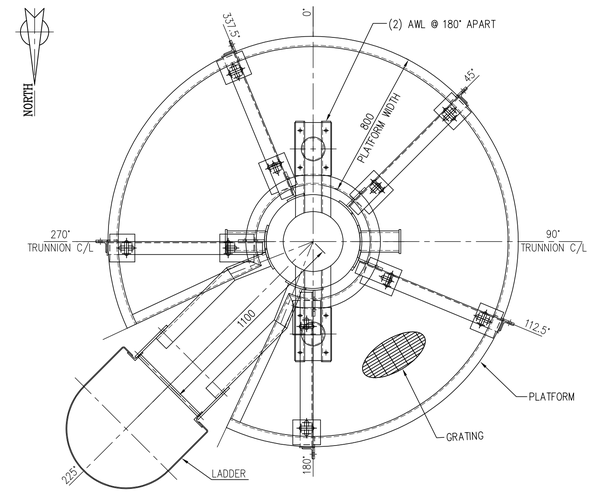


ELEVATION
SCALE 1:36
(FOR TRUE ORIENTATION REFER PLAN VIEWS)

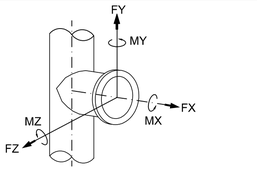


PLAN

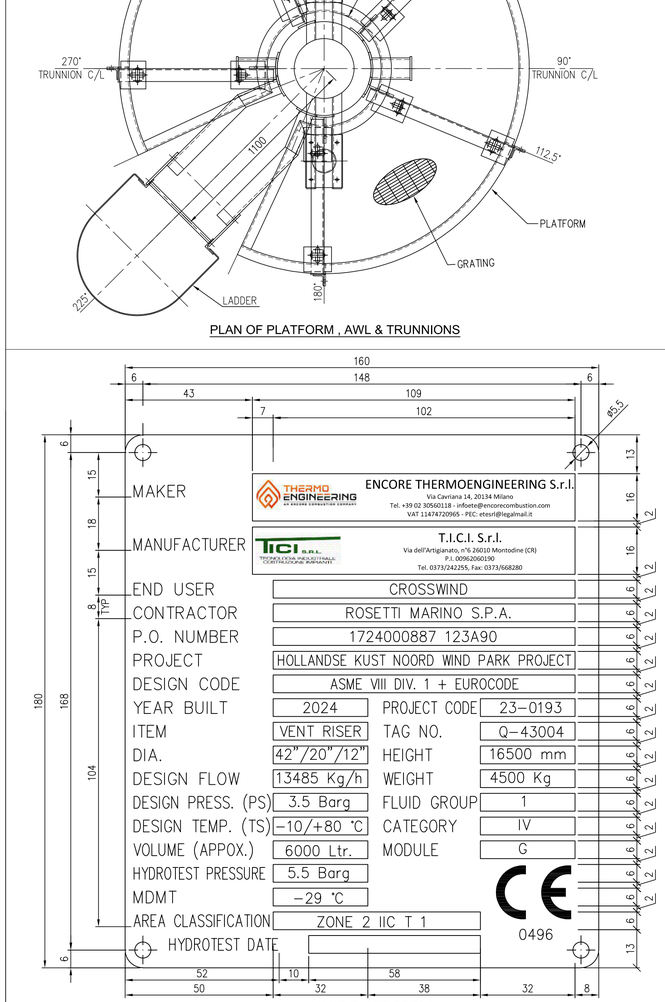
PLATFORM, AWL & TRUNNION NOT SHOWN FOR CLARITY



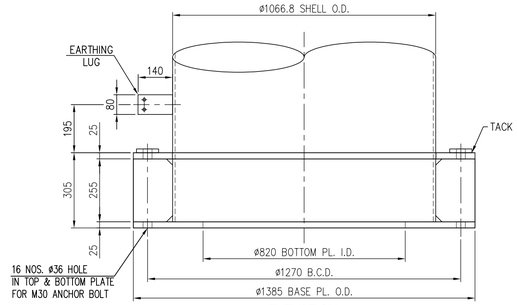
PLAN OF PLATFORM , AWL & TRUNNIONS



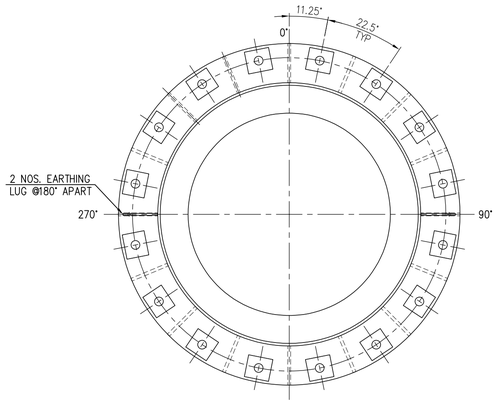
NOZZLE LOADS						
	LOADS [kN]			MOMENTS [kN x m]		
	FX	FY	FZ	MX	MY	MZ
INLET N1 (10")	7.78	14.45	14.45	6.31	4.74	4.74



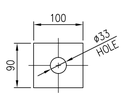
NAME PLATE DETAIL



ELEVATION
ANCHOR CHAIR DETAIL
SCALE 1:12



PLAN VIEW



WASHER DETAIL

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
LIFTING DRAWING - HYDROGEN VENT	1724000887-MAC-DD-00019
-	-

MATERIAL LIST

ITEM	Q.TY	DESCRIPTION	DIMENSION	MATERIALS
1	1	RISER SHELL	42" (1066.8) OD. x 10 THK	A516 GR.60/EQUIV
	1	RISER SHELL	20" (508) OD. x 10 THK	A516 GR.60/EQUIV
		VENT TIP SHELL	12" (323.9) OD. x 6 THK	AISI 316
2	1	VENT TIP FLANGE	ø12" 150# WNRF ASME B16.5	AISI 316L
3	1	RISER OUTLET FLANGE	ø12" 150# WNRF ASME B16.5	A350 GR LF2
4	1	GASKET	ø12" 150#, SPIRAL WOUND	NOTE-10
5	1	VENT INLET FLANGE	ø10" 150# WNRF, SCH.40 ASME B16.5	A350 GR LF2
5A	1	VENT INLET PIPE (DIP PIPE)	ø10" SCH.40 (SMLS)	A333 GR.6
6	1	DRAIN CONNECTION FLANGE	ø1" 150# WNRF, SCH. 80 ASME B16.5	A350 GR LF2
7	1	SWAN NECK CONNECTION FLG.	ø1" 150# LWNRF ASME B16.5	A350 GR LF2
8	1	FILLING LINE FLANGE	ø1" 150# LWNRF ASME B16.5	A350 GR LF2
9	2	LEVEL TRANSMITTER CONNECTION	ø1" 150# LWNRF ASME B16.5	A350 GR LF2
10	1	HAND HOLE FLANGE	ø8" 150# WNRF, SCH.40 ASME B16.5	A350 GR LF2
11	1	ANCHOR CHAIR	-	S275J0 or EQUIV.
12	1	SKIRT SHELL	42" (1066.8) OD.	S275J0 or EQUIV.
13	1	NAMEPLATE	-	AISI 316L

NOZZLES LIST

POS.	Q'TY	SIZE	RATING	FLANGE	SERVICE	PROJECTION FROM RISER C/L
N1	1	10"	150#	WNRF	VENT INLET FROM V-43001 W/ DIP PIPE	750
N2	1	1"	150#	WNRF	DRAIN	800
N3	1	1"	150#	LWNRF	SWAN NECK CONNECTION	750
N4	1	1"	150#	LWNRF	FILLING LINE	750
K1A/B	2	1"	150#	LWNRF	LEVEL TRANSMITTER	750
HW	1	8"	150#	WNRF	HAND HOLE W/ BLIND	750

LOADS AT THE BASE

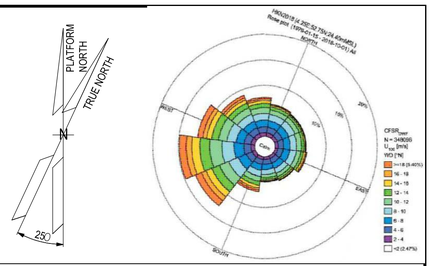
		Vertical [kN]	Shear [kN]	Moment [kN]
DEAD LOAD	DL	-27.66	0.00	0.00
DEAD LOAD CONTENT	DL_O	-17.06	0.00	0.00
LIVE LOAD ON PLATFORM	LL	-13.34	0.00	0.00
NOZZLE LOADS	NL	4.97	24.63	134.99
THERMAL	TL	0.00	0.00	0.00
WIND LOAD	WL	0.00	28.845	235.65
WAVE AND CURRENT LOADS	HL	0.00	-6.99	-55.95

THESE ARE THE RESULTANT FORCES AND THE SHEAR AND MOMENT CAN OCCUR IN ANY DIRECTION.

SHEAR = RESULTANT SHEAR: (FX^2 + FZ^2)^0.5

MOMENT = RESULTANT MOM: (MX^2 + MZ^2)^0.5

VERTICAL LOAD IS POSITIVE UPWARD



NOTES

GENERAL NOTES:

1. ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3. ALL WELDING SHALL BE CONTINUOUS WITH CATHETUS EQUAL TO MINIMUM THK. TO BE WELDED.
4. REFERRING TO MAJOR AXIS FLANGE HOLES SHALL BE SYMMETRICALLY DISPOSED WITH EXCEPTION OF PILOTS FLANGES.
5. ALL FLANGES <= 24" ARE ACCORDING TO ASME B16.5 WITH FINISHING 125 AARH.
6. FOR SURFACE TREATMENT PLEASE REFER TO THE DOCUMENT NO. 1724000887-MAT-PRO-00010 (23-0193-0030).
7. MAIN COMPONENT WEIGHTS (APPROX.):
   RISER WEIGHT : 3950 kg (INCLUDING PLATFORM & LADDER)
   VENT TIP : 450 kg
8. FOR WIRING DIAGRAM (JB AND HT) REFER DOCUMENT NO. 1724000887-MAC-DG-00007 (23-0193-0170)
9. DELETED.
10. GASKET SHALL BE STAINLESS STEEL, SPIRAL WOUND, GRAPHITE FILLED, EPOXY-COATED CARBON STEEL CENTERING RING AND STAINLESS STEEL INNER RING.
11. FOR RISER CONSTRUCTION DETAILS REFER DRAWING NO. 1724000887-MAC-DD-00005 (23-0193-131).
12. HEAT TRACING CABLES AND INSULATION SUPPORTS ARE IN ETE SCOPE OF WORK. INSULATION SUPPLY & INSTALLATION BY OTHERS.

NAME PLATE NOTES:

a. ALL DIMENSIONS ARE IN mm, UNLESS OTHERWISE STATED.
b. NAMEPLATE MATERIAL : AISI 316L
   NAMEPLATE THK. : 2 mm
   TEXT COLOR : BLACK
   TEXT ENGRAVED
C. NAMEPLATE WILL BE FIXED ON VENT RISER REFER TO DOC. 1724000887-MAC-DD-00005 (23-0193-0131).

DESIGN DATA

DESCRIPTION	VALUES
DESIGN CODE	ASME VIII DIV. 1 + EUROCODE
MAX. GAS FLOW	13485 kg/h
AMBIENT TEMPERATURE	-8.4 / +25 °C
OPERATING PRESSURE	ATM barg
DESIGN TEMPERATURE	-10 / +80 °C
DESIGN PRESSURE	3.5 barg
CORROSION ALLOWANCE	3 mm (FOR CARBON STEEL ONLY)
HYDROTEST PRESSURE	5.5 barg
AREA CLASIFICATION	ZONE 2 IIC T 1
MDMT	-29 °C
FLUID GROUP	1
CATEGORY	IV
MODULE	G
SEISMIC	N/A
WIND VELOCITY	28 m/s
TYPE OF FLUID	HYDROGEN GAS
WELDING EFFICIENCY	0.85
RADIOGRAPHY	SPOT RT

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	19/11/24

THERMO ENGINEERING – AN ENCORE COMBUSTION COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0101

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
04	13-11-2024	SCB	VT	AL	ACCEPTANCE FOR CONSTRUCTION
03	10-10-2024	SCB	VT	AL	ACCEPTANCE FOR CONSTRUCTION
02	05-09-2024	SCB	VT	AL	ACCEPTANCE FOR CONSTRUCTION
01	30-07-2024	SCB	VT	AL	ISSUED FOR REVIEW
00	03-06-2024	RJS	SCB	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE :
HYDROGEN VENT
GENERAL ARRANGEMENT
INCLUDING FOUNDATION LOADS

CONTRACT NO./TITLE	CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK	SCALE	1:36
DRAWN RJS	CHECKED SCB	APPROVED AL	DATE 03/06/24
A1	DRAWING NO. 1724000887-MAC-DA-00003	SHEET 001	REV. 04

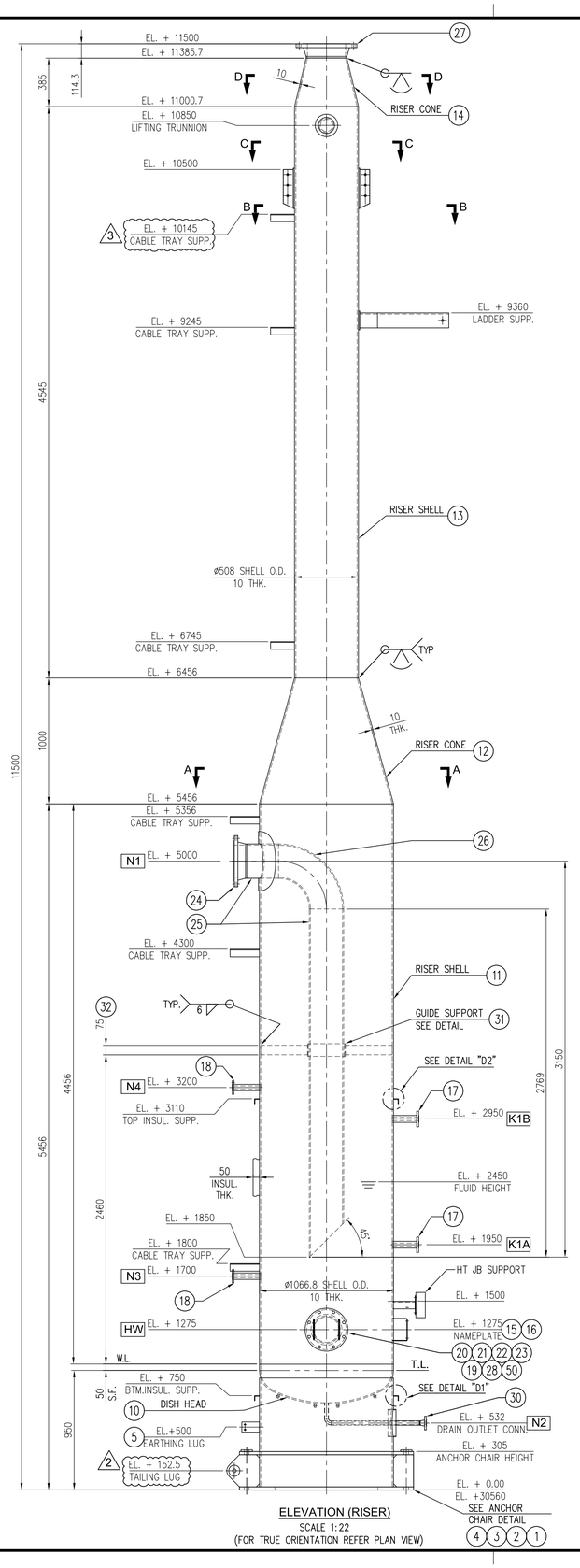
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3.1.2 Detailed Drawing with Part List

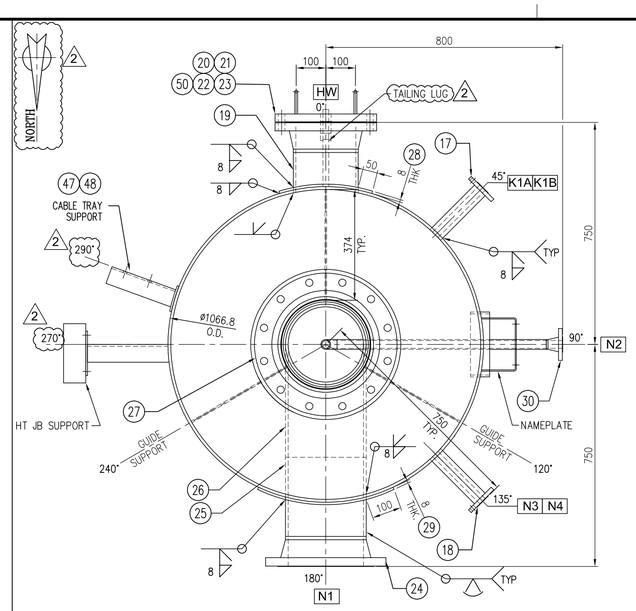
SEE ATTACHED NEXT PAGE

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered an "NOT CONTROLLED" copy

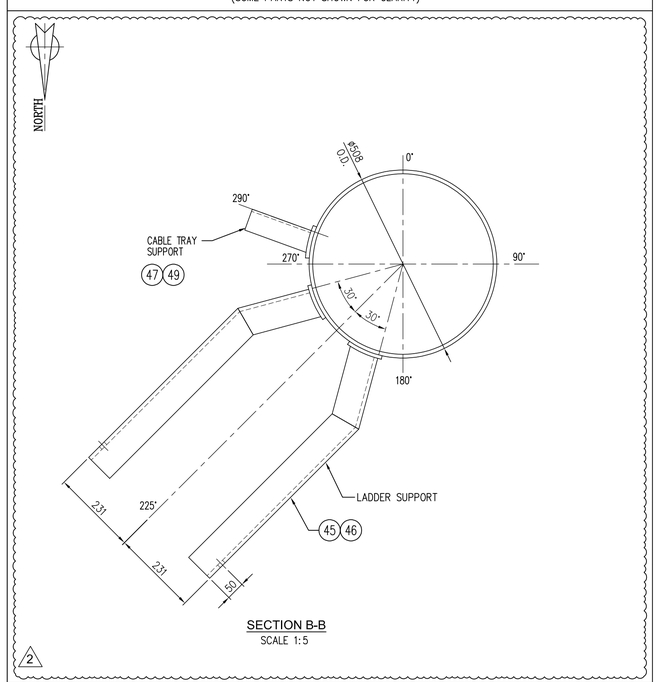
DRAWING NO. 1724000887-MAC-DD-00005_03 REV. 03



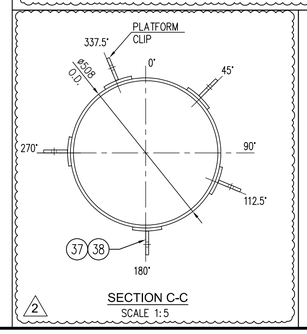
ELEVATION (RISER)
SCALE 1:22
(FOR TRUE ORIENTATION REFER PLAN VIEW)



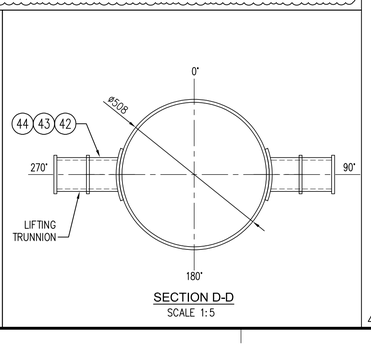
SECTION A-A
SCALE 1:10
(SOME PARTS NOT SHOWN FOR CLARITY)



SECTION B-B
SCALE 1:5



SECTION C-C
SCALE 1:5



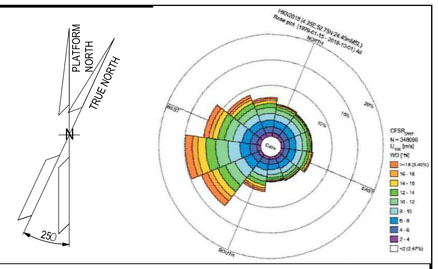
SECTION D-D
SCALE 1:5

BILL OF MATERIAL (RISER)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL	PED
1	1	BOTTOM ANCHOR PLATE	25 THK x 1385 O.D. x 820 I.D.	S275 J0	–
2	1	TOP ANCHOR PLATE	25 THK x 1385 O.D. x 1070 I.D.	S275 J0	–
2 3	15	GUSSET PLATE	12 THK x 159 x 255	S275 J0	–
4	16	WASHER PLATE	15 THK x 90 x 100	S275 J0	–
5	2	EARTHING LUG	6 THK x 80 x 140	AISI 304	–
6	1	SKIRT SHELL	10 THK x 865 LG. x 3320 (ROLL TO 1066.8 O.D.)	S275 J0	–
7	1	SLEEVE PIPE	8", SCH.20 (6.35 THK) x 97 LG.	A333 GR.6	–
8	1	PIPE (N2) (SMLS)	1", SCH.80 (4.55) x 1000 LG. (CUT TO SUIT)	A333 GR.6	ASME/EN
9	1	ELBOW	1", SCH.80 (4.55), 90DEG LR, BW.	A420 WPL6	ASME/EN
10	1	DISH END	2:1 ELLIPSOIDAL HEAD, 50 S.F. 12 THK (BEFORE FORMING) x 1066.8 O.D.	A516 Gr.60 /EQUIV.	ASME/EN
11	1	RISER SHELL	10 THK x 4456 LG. x 3320 (ROLL TO 1066.8 O.D.)	A516 Gr.60 /EQUIV.	ASME/EN
12	1	CONE	ø1066.8 LARGE O.D. x ø508 SMALL OD x 10 THK x 1000 HEIGHT.	A516 Gr.60 /EQUIV.	ASME/EN
13	1	RISER SHELL	10 THK x 4545 LG. x 1565 (ROLL TO 508 O.D.)	A516 Gr.60 /EQUIV.	–
14	1	CONE	ø508 LARGE O.D. x ø323.8 SMALL OD x 10 THK x 385 HEIGHT.	A516 Gr.60 /EQUIV.	–
15	1	NAMEPLATE SUPPORT	4 THK x 210 x 385	A516 Gr.60 /EQUIV.	ASME/EN
16	4	RIVETS	ø5	AISI 316	–
17	2	FLANGE FOR K1A & K1B	ø1" 150# LWNRF x 230 LG. ASME B16.5	A350 GR LF2	ASME/EN
18	2	FLANGE FOR N3 & N4	ø1" 150# LWNRF x 230 LG ASME B16.5	A350 GR LF2	ASME/EN
19	1	PIPE (HW) (SMLS)	8", SCH.40 (8.18 THK) x 122 LG. (CUT TO SUIT)	A333 GR.6	ASME/EN
20	1	FLANGE (HW)	8", SCH.40 (8.18 THK) x 150#, WNRF	A350 GR LF2	ASME/EN
21	1	FLANGE (HW)	8" x 150#, BLRF	A350 GR LF2	ASME/EN
22	1	GASKET (HW)	8", 150# SPIRAL WOUND ASME B16.20	SEE NOTE-9	ASME/EN
23	8	STUD BOLT + 2 NUT FOR (HW)	M20 x 110 LG.	A193 GR. B7/ SA194 GR.2H (HDG)	ASME/EN
24	1	FLANGE (N1)	10", SCH.40 (9.27 THK) x 150#, WNRF	A350 GR LF2	ASME/EN
25	1	PIPE (N1) (SMLS)	10", SCH.40 (9.27 THK) x 3200 LG. (CUT TO SUIT)	A333 GR.6	ASME/EN
26	1	ELBOW	10", SCH.40 (9.27), 90DEG LR, BW.	A420 WPL6	ASME/EN
27	1	FLANGE (RISER OUTLET)	12", SCH.STD (10 THK) x 150#, WNRF	A350 GR LF2	–
28	1	REPAD PLATE (HW)	8 THK x 50 WIDTH (CUT TO SUIT INNER OUTER ELLIPTICAL HOLES)	A516 Gr.60 /EQUIV.	ASME/EN
29	1	REPAD PLATE (N1)	8 THK x 100 WIDTH (CUT TO SUIT INNER OUTER ELLIPTICAL HOLES)	A516 Gr.60 /EQUIV.	ASME/EN
30	1	FLANGE (N2)	1", SCH.80 (4.55 THK) x 150#, WNRF	A350 GR LF2	ASME/EN
31	1	GUIDE SUPP. PLATE	6 THK x 100 LG. x 924 (ROLL TO 300 O.D.)	A516 Gr.60 /EQUIV.	ASME/EN
32	3	GUIDE SUPP. RIBS	6 THK x 75 x 375	A516 Gr.60 /EQUIV.	ASME/EN
3 33		DELETED			–
33A		DELETED			–
3 34		DELETED			–
3 35	2	INSUL. SUPP. ANGLE	L50x50x4 x 3666 LG. (ROLL TO 1146.8 O.D.)	S275 J0	ASME/EN
36	25	SQUARE NUT	M16	A194 GR. 2H (HDG)	–
37	5	PLATFORM CLEAT PAD	10 THK x 100 x 320	A516 Gr.60 /EQUIV.	–
38	5	PLATFORM CLEAT	10 THK x 80 x 300	A516 Gr.60 /EQUIV.	–
39	1	JB SUPP. PAD	6 THK x 90 x 90	A516 Gr.60 /EQUIV.	ASME/EN
40	1	JB SUPP. ANGLE	L60x60x6 x 197 LG.	S275 J0	–
41	1	JB SUPP. PLATE	6 THK x 150 x 150	S275 J0	–
42	2	TRUNNION PLATE	10 THK x ø130	S275 J0	–
43	2	TRUNNION PAD	10 THK x ø180	S275 J0	–
44	2	TRUNNION PIPE	4", SCH.80 (8.56 THK) x 196 LG.	A333 GR.6	–
2 44A	2	TRUNNION STOPPER	10 THK x ø130 O.D. x ø116 I.D.	S275 J0	
45	2	LADDER CLIP	L120x80x10 x 800 LG.	S275 J0	–
46	2	LADDER CLIP PAD	6 THK x 111 x 150	A516 Gr.60 /EQUIV.	–
47	6	CABLE TRAY SUPP. PAD	6 THK x 90 x 90	A516 Gr.60 /EQUIV.	ASME/EN
48	3	CABLE TRAY SUPP.	L60x60x6 x 232 LG.	S275 J0	–
49	3	CABLE TRAY SUPP.	L60x60x6 x 188 LG.	S275 J0	–
50	2	HANDLE (HW)	ø10 ROD x 300 LG.	S275 J0	ASME/EN
51	2	CONNECTION PLATE	6 THK x 30 x 80	S275 J0	–
52	2	HEX BOLT	M10 x 30 LG.	CS (HDG)	–
53	2	HEX NUT	M10 (H=D)	CS (HDG)	–
54	1	TAILING LUG	20 THK x 255 x 260	S275 J0	
2 55	2	TAILING LUG COLLAR PLATE	8 THK x ø90 O.D. x ø30 I.D.	S275 J0	

BILL OF MATERIAL (TIP, WINDSHIELD & BIRD SCREEN)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL	PED
101	1	FLANGE (VENT TIP)	ø12", (6 THK) x 150#, WNRF	AISI 316L	–
102	1	GASKET (VENT TIP CONN.)	ø12", 150# SPIRAL WOUND ASME B16.20	SEE NOTE-9	–
103	12	STUD BOLT + 2 NUT FOR VENT TIP FLG.	M24 x 135 LG.	A193 Gr. B7 SA194 Gr. 2H (HDG)	–
104	1	VENT TIP SHELL	ø12", 6 THK x 4886 LG.	AISI 316	–
105	5	WINDSHIELD SUPP. RING PL.	6 THK x ø416 O.D. x ø328 I.D.	AISI 316	–
106	1	WINDSHIELD & BIRD SCREEN SUPP. RING PL.	6 THK x ø416 O.D. x ø328 I.D. (SEE DETAIL)	AISI 316	–
107	8	NUT	M12	AISI 316	–
108	2	PERFORATED SHEET METAL	2 THK x 1491 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
109	1	PERFORATED SHEET METAL	2 THK x 973 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
110	1	PERFORATED SHEET METAL	2 THK x 139 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
111	1	PERFORATED SHEET METAL	2 THK x 375 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
112	1	BIRD SCREEN MTG. RING PL.	6 THK x ø416 O.D. x ø336 I.D. (SEE DETAIL)	AISI 316	–
113	1	BIRD SCREEN HOLDING SHELL	6 THK x 60 LG. x 1075 (ROLL TO 348 O.D.)	AISI 316	–
114	1	BIRD SCREEN STIFFENER RING	6 THK x 25 LG. x 1119 (ROLL TO 362 O.D.)	AISI 316	–
115	1	BIRD SCREEN	SQUARE STEEL NET WIRE, 1MM PITCH 10x10MM	AISI 316	–
116	8	HEX BOLT	M12 x 35 LG.	AISI 316	–
117	4	AWL SUPP.	UPN100 x 471 LG.	AISI 316	–
118	2	LIFTING LUG	10 THK x 90 x 145	AISI 316	–
119	2	CABLE TRAY SUPP.	L60x60x6 x 295 LG.	AISI 316	–
6 120	1	SPIRAL VENTURI SEAL	12"-SVS-9	AISI 316	–



NOTES

GENERAL NOTES :

1 – ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2 – ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3 – ALL WELDING SHALL BE CONTINUOS WITH CATHETUS EQUAL TO MINIMUN THK. TO BE WELDED.
4 – UNLESS OTHERWISE STATED, FLANGES WILL HAVE BOLT HOLES STRADDLING CENTERLINE.
5 – FOR SURFACE TREATMENT PLEASE REFER TO THE DOCUMENT NO. 1724000887-MAT-PRO-00010 (23-0193-0030).
6 – THE FACES OF FLANGES SHALL BE SMOOTH FINISH. SMOOTH FINISH SHALL BE ACHIEVED IN ACCORDANCE WITH ASME B16.5.
7 – FLANGE UP TO 24" SHALL COMPLY WITH ASME B16.5.
8 – REINFORCING PADS SHALL BE PROVIDED WITH ONE ¼" NPT TELLTALE HOLE. TWO-PIECE REINFORCING PADS SHALL BE PROVIDED WITH TWO TELLTALE HOLES (ONE PER SEGMENT). AFTER TESTING, THE TELLTALE HOLE SHALL BE PLUGGED. REINFORCING PADS SHALL NOT BE LOCATED ON THE WELDED SEAMS.
9 – GASKET SHALL BE STAINLESS STEEL, SPIRAL WOUND, GRAPHITE FILLED, EPOXY-COATED CARBON STEEL CENTERING RING AND STAINLESS STEEL INNER RING.
10 – WELDING FOR BIRD SCREEN (ITEM 114) SHALL BE DONE AFTER PROPER INSERTION OF ITEM 115 BETWEEN ITEM 113 AND 114
11 – RISER TOTAL NET WEIGHT: 3300 kg.
TIP TOTAL NET WEIGHT: 450 kg.
CABLE TRAY & ACCESSORIES NET WEIGHT: 90 kg.
PLATFORM & LADDER NET WEIGHT: 650 kg. (INCLUDING GRATING)
12 – BASE PLATE HOLE SHALL BE USED AS TAILING LUG FOR LIFTING OF RISER.
13 – SUITABLE CUTOUTS SHALL BE TAKEN INTO WINDSHIELD FOR WELDING OF AWL SUPPORT & CABLE TRAY SUPPORTS TO TIP SHELL.

HOLDS

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	21/11/24

THERMO ENGINEERING — AN ENGIE COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0131

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

CROSSWIND — ROSETTI MARINO

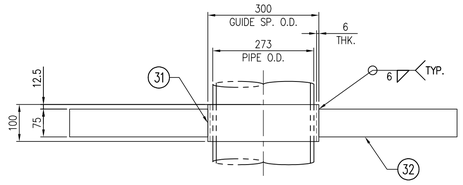
TITLE :
HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:22
DRAWN RJ | CHECKED SCB | APPROVED AL | DATE 02-08-24
A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 001 | REV. 03

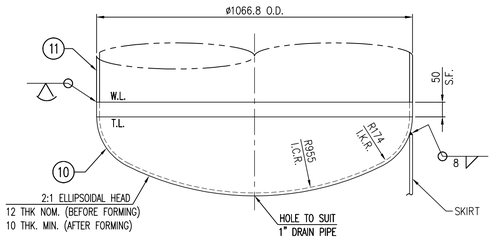
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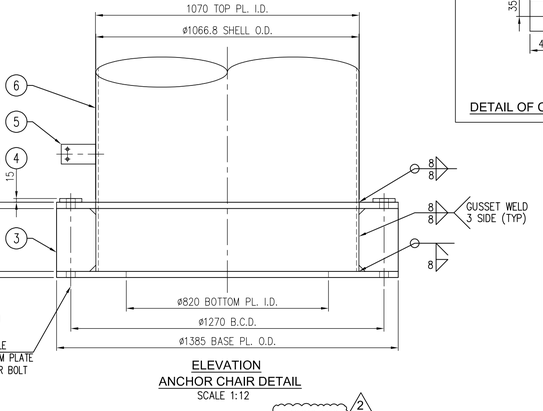
REV. 03



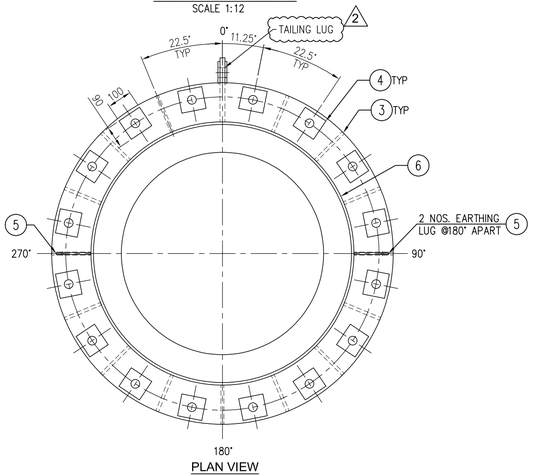
DETAIL OF GUIDE SUPPORT FOR NOZZ. "N1"



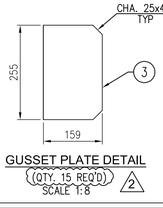
1066.8 O.D. DISH END DETAIL



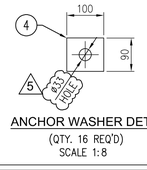
ELEVATION
ANCHOR CHAIR DETAIL
SCALE 1:12



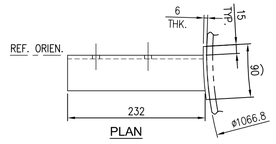
PLAN VIEW



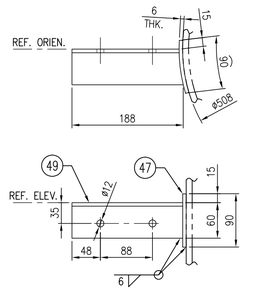
GUSSET PLATE DETAIL
(QTY. 15 REQ'D)
SCALE 1:8
2



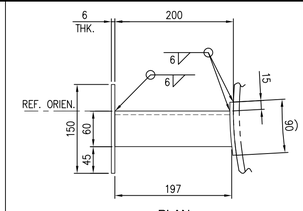
ANCHOR WASHER DETAIL
(QTY. 16 REQ'D)
SCALE 1:8



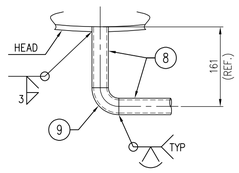
DETAIL OF CABLE TRAY SUPPORT ON Ø1066.8 O.D.



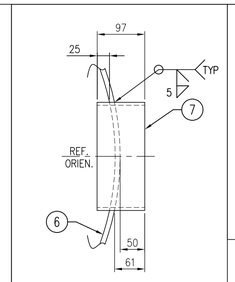
DETAIL OF CABLE TRAY SUPPORT ON Ø508 O.D.



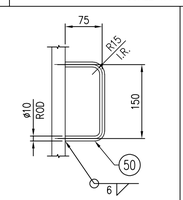
DETAIL OF HT. JB. SUPPORT



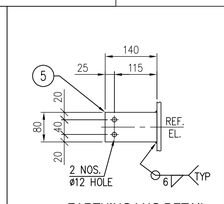
1" DRAIN DETAIL
SCALE 1:6



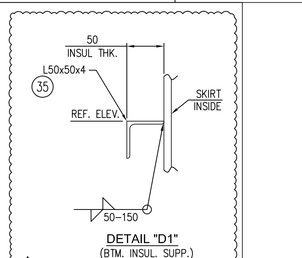
8" PIPE SLEEVE DETAIL
(FOR NOZZLE N2)
SCALE 1:6



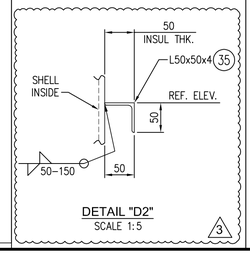
DETAIL OF HANDLE (HW)
SCALE 1:6



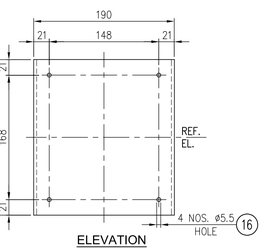
EARTHING LUG DETAIL
SCALE 1:8

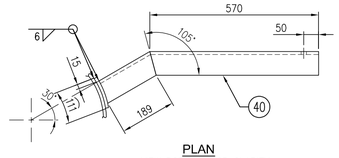


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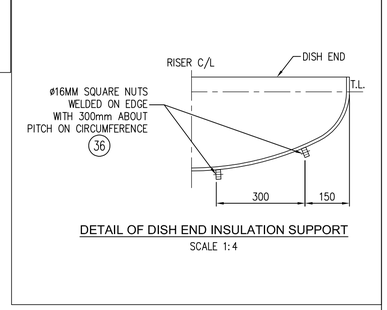


3 DELETED

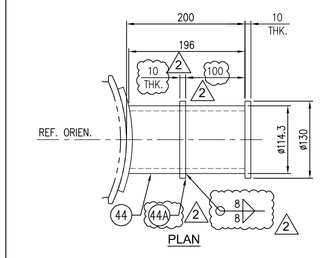




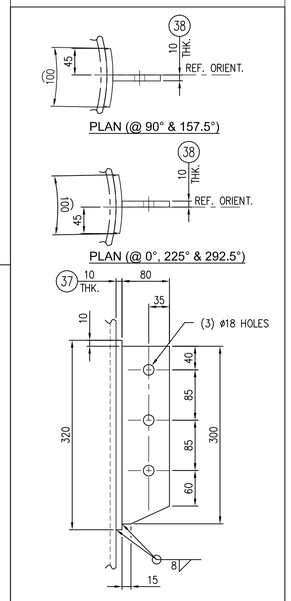
DETAIL OF LADDER SUPPORT

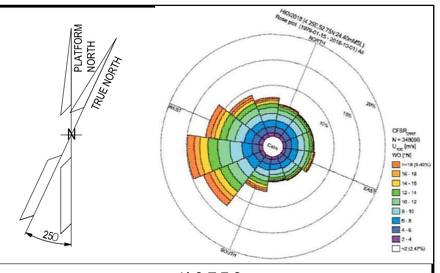


DETAIL OF DISH END INSULATION SUPPORT
SCALE 1:4



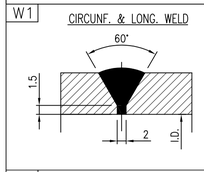
DETAIL OF LIFTING TRUNNION

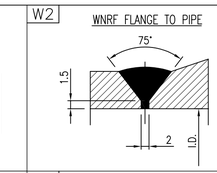


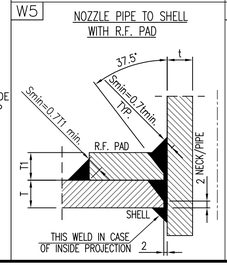


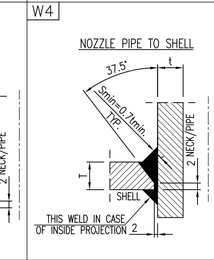
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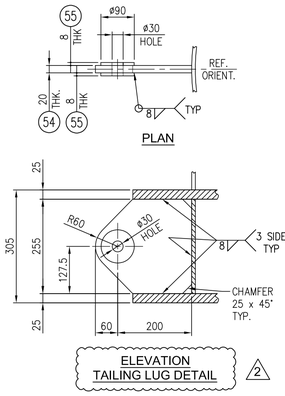
WELDING DETAILS











03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
REV.	DATE	DRN	CHKD	APPD	DESCRIPTION

THERMO ENGINEERING — AN ENCONE COMBUSTION COMPANY

ETE JOB 23-0193

ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

TITLE :

HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:22

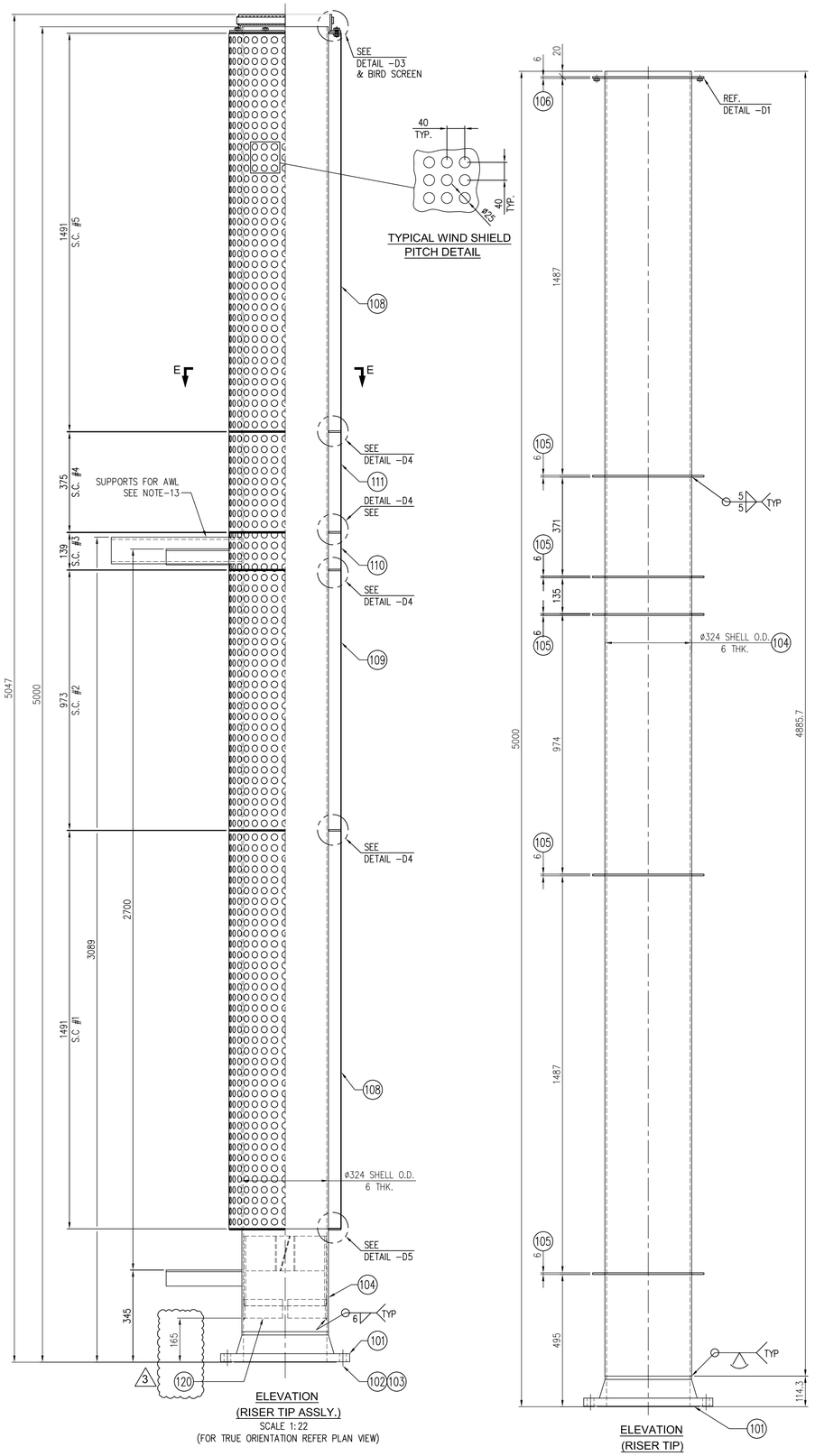
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A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 002 | REV. 03

File Name : 1724000887-MAC-DD-00005_03

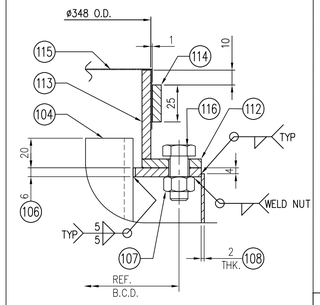
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REV. 03

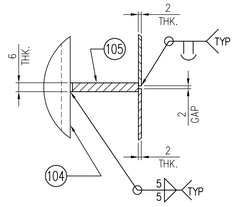


ELEVATION
(RISER TIP ASSLY.)
SCALE 1:22
(FOR TRUE ORIENTATION REFER PLAN VIEW)

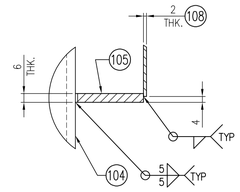
ELEVATION
(RISER TIP)



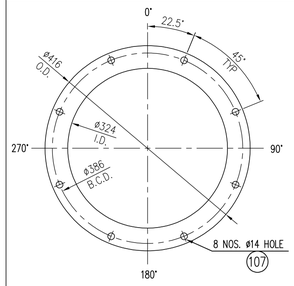
SECTIONAL DETAIL-D3
SCALE 1:2



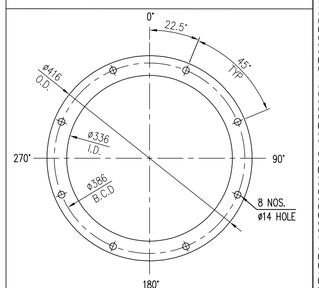
SECTIONAL DETAIL-D4
SCALE 1:2



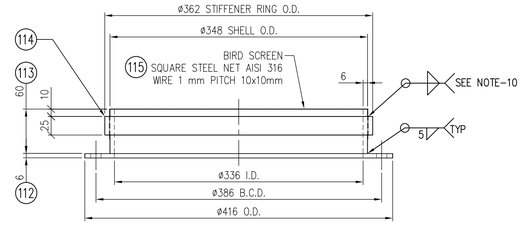
TYPICAL SECTIONAL DETAIL-D5
SCALE 1:2



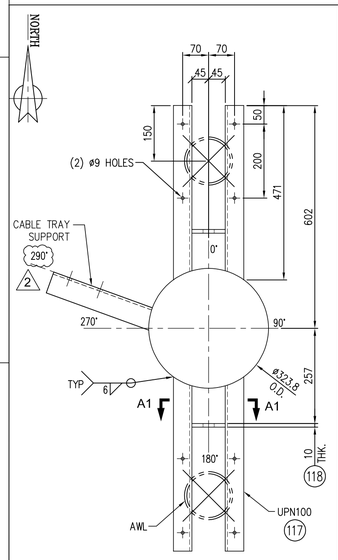
DETAIL OF ITEM (106)
SCALE 1:6



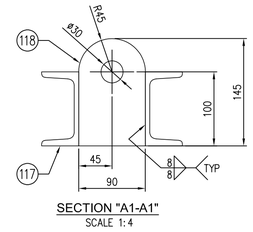
DETAIL OF ITEM (112)
SCALE 1:6



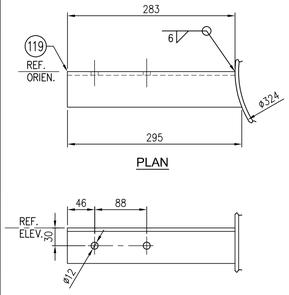
BIRD SCREEN ASSY. DETAIL
SCALE 1:4



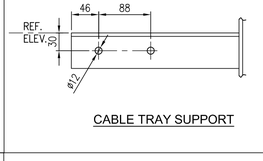
SECTION E-E
SCALE 1:8



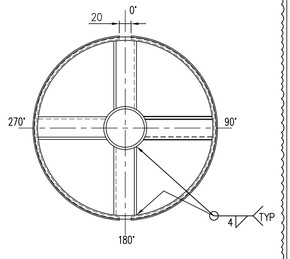
SECTION "A1-A1"
SCALE 1:4



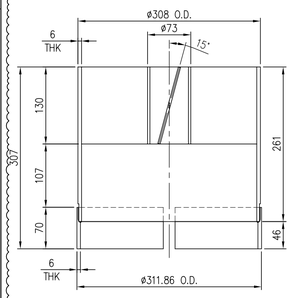
PLAN



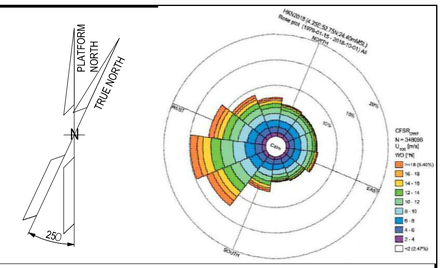
CABLE TRAY SUPPORT



PLAN VIEW



3 DETAIL OF VENTURI SEAL (120)
SCALE 1:6



NOTES

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

THERMO ENGINEERING — AN ENGIE COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

TITLE :

HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE: CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE: 1:22

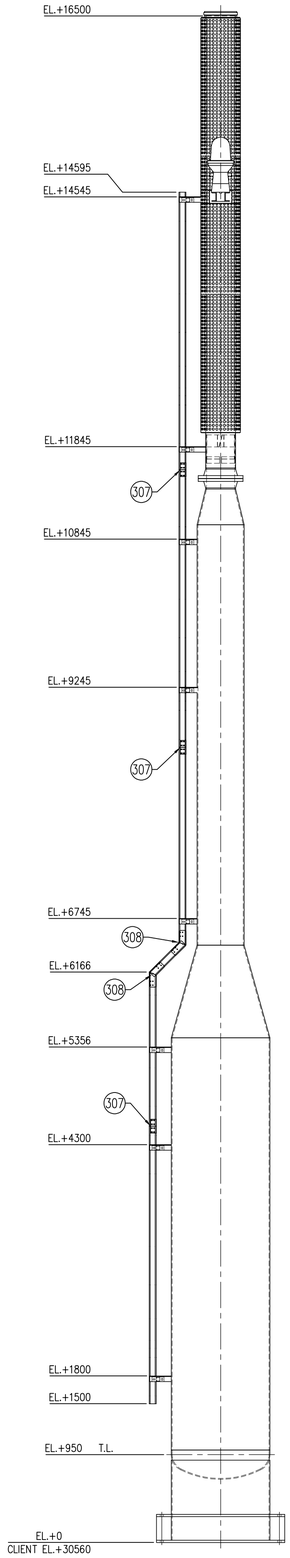
DRAWN: RJ | CHECKED: SCB | APPROVED: AL | DATE: 02-08-24

A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 003 | REV. 03

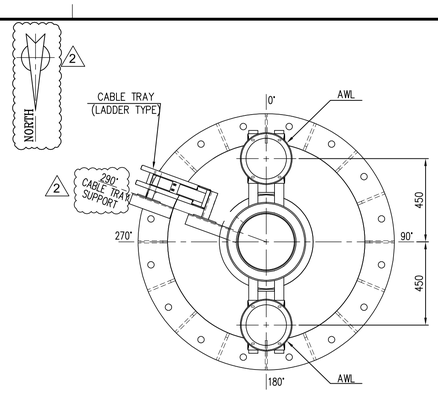
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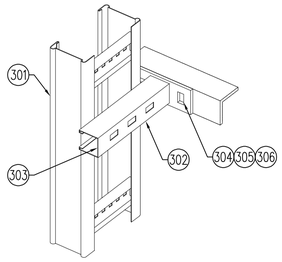
REV. 03



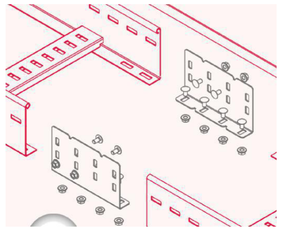
ELEVATION
SCALE 1:32
(REFER THIS VIEW ONLY FOR CABLE TRAY DETAIL)



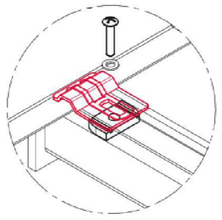
PLAN VIEW
SCALE 1:16
(REFER THIS VIEW ONLY FOR CABLE TRAY)



TYP. CABLE TRAY SUPPORT ARRANGEMENT



TYP. CABLE TRAY JOINT DETAIL
PART NO. 307,313,314



Profili e mensole / Channels and brackets:
UR1

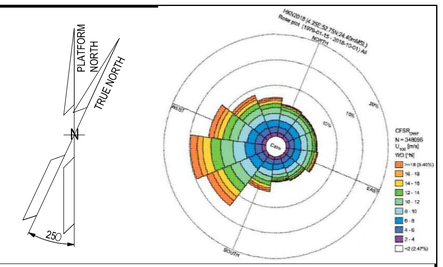
TYP. CABLE TRAY FIXING DETAILS
PART NO. 309,310,311,312



TYP. HINGE JOINT DETAIL
PART NO. 308,313,314

BILL OF MATERIAL (CABLE TRAY)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL
301	14 mtr	CABLE TRAY 100x75	(B2 Z 01B3C100HH10)	HOT DIP GALV.
302	8	58 UR1 SINGLE BRACKET	(A0 Z 58S7R100MU)	HOT DIP GALV.
303	16	PLUG FOR BRACKET FOR UR1	(A0 P 4TXXI040N)	LDPE
304	16	HEX. HEAD BOLT	M10 X 30LG.	CS (HDG)
305	16	HEX. HD. NUT	M10	CS (HDG)
306	16	WASHER	M10	CS (HDG)
307	8	CABLE TRAY JOINT	JOINT (B2 Z 60A4H025M)	HOT DIP GALV.
308	4	VERTICAL HINGE JOINT	(B2 Z 63A5H025M)	HOT DIP GALV.
309	16	NUT FOR CABLE TRAY	M8 (D0C25S08X40 Z)	HOT DIP GALV.
310	16	CABLE TRAY LOCKING DEVICE	(B2 X 84XXXO40M)	HOT DIP GALV.
311	16	WIDE CROWNED HEAD SCREW	M8 (D0C13L08X20 D)	HOT DIP GALV.
312	16	PLANE WASHER	M8 (D0C36S08X17 Z)	HOT DIP GALV.
313	160	ROUND HEAD SCREW WITH SQ. NECK	M6 (D0C10A06X15 E)	HOT DIP GALV.
314	160	FLANGED HEX. NUT	M6 (D0C16S06 E)	HOT DIP GALV.
315	14 mtr	SELF LOCKING COVER	100x15 (B2 Z 05Q3P100D)	HOT DIP GALV.
316	10	EARTHING BAR FOR COVERS EQUIPOTENTIAL CONNECTION W/2 NOS. M6 SCREW	(A3 R 62X1X015M)	HOT DIP GALV.



NOTES

03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
REV.	DATE	DRN	CHKD	APPD	DESCRIPTION

THERMO ENGINEERING — AN ARCADIS COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

TITLE :

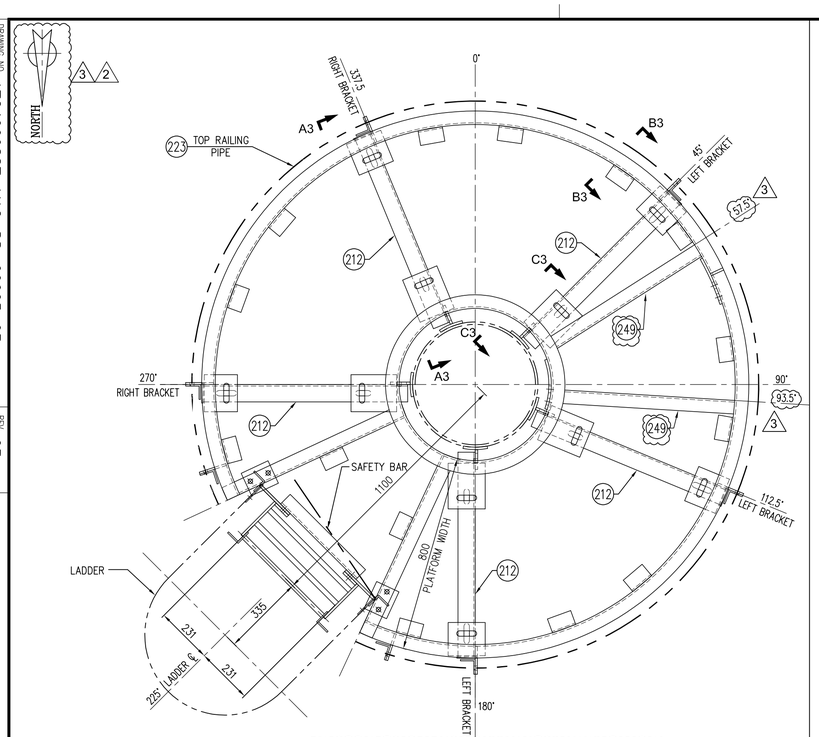
HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK			SCALE 1:22
DRAWN RJ	CHECKED SCB	APPROVED AL	DATE 02-08-24
A1	DRAWING NO. 1724000887-MAC-DD-00005	SHEET 004	REV. 03

File Name : 1724000887-MAC-DD-00005_03

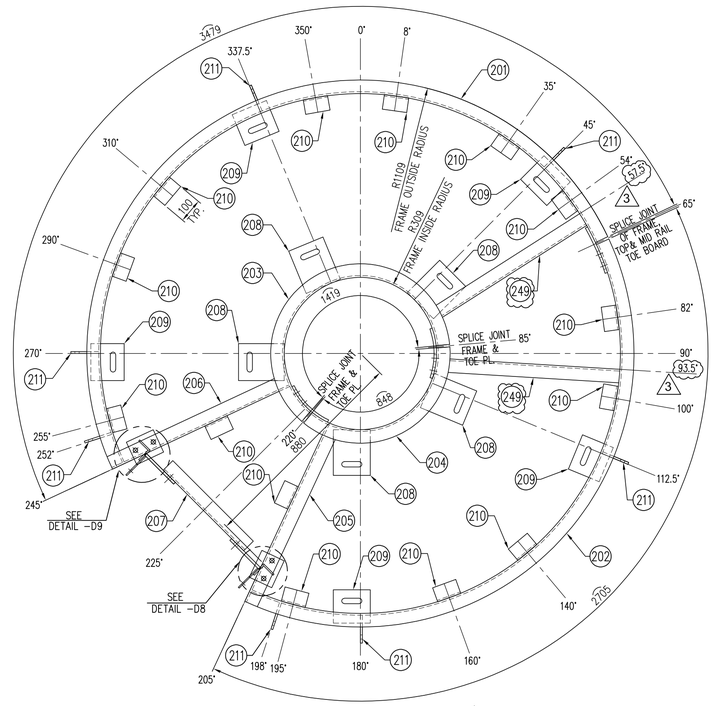
DRAWING NO. 1724000887-MAC-DD-00005_03

REV. 03



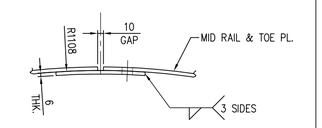
PLAN OF PLATFORM ASSEMBLY AT EL. +41060 (T.O.S.) 2

SCALE 1:12



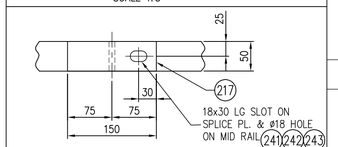
PLATFORM FRAME DETAIL 2

SCALE 1:12



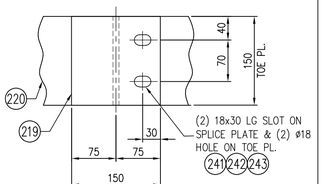
PLAN OF MID RAIL & TOE PL. SPLICE DETAIL

SCALE 1:5



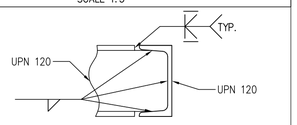
ELEVATION OF MID RAIL SPLICE DETAIL

SCALE 1:5



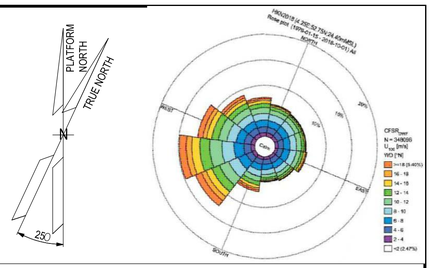
ELEVATION OF TOE PL. SPLICE DETAIL

SCALE 1:5



TYPICAL FRAME CONNECTION DETAIL

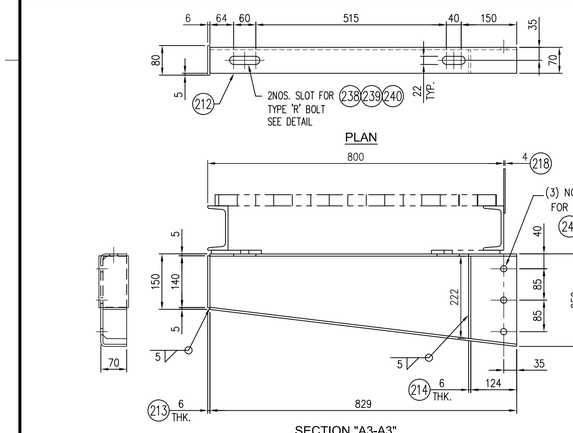
SCALE 1:5



NOTES

GENERAL NOTES :

1 – ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE STATED.
2 – ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3 – BOLTS, NUTS AND WASHERS ARE HOT DIP GALVANIZED.
4 – DIMENSION "S" OF NON-DIMENSIONED FILLET WELDS SHALL AT LEAST BE EQUAL TO 0.8 TIMES THE MINIMUM THICKNESS OF THE SMALLEST ELEMENTS TO BE WELDED.
5 – ALL WELDS SHALL BE CONTINUOUS UNLESS OTHERWISE STATED.
6 – PAINTING CYCLES SHALL BE IN ACCORDANCE WITH DOCUMENT No.23-0193-0030.
7 – A SPARE OF 10% OF NUTS, BOLTS, WASHERS WILL BE SUPPLIED.
8 – No. OF SEPARATIONS OF GRATINGS SHALL BE VERIFIED BY MANUFACTURER.
9 – EACH PANEL OF GRATING WILL BE PROVIDED WITH A MINIMUM OF 4 GRATING CLAMPS.
10 – GRATINGS SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123.
11 – STEEL ASTM A10011/A1011M GRADE 36 [250] TYPE 1 OR EUROPEAN EQUIVALENT (S235 JR EN 10025).
13 – PLATFORMS & LADDER TOTAL WEIGHT : 650 Kg (GRATINGS INCLUDED).



PLAN

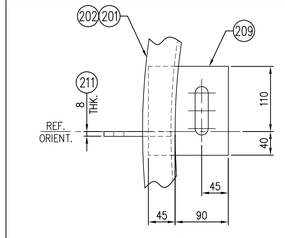
SECTION "A3-A3"

PLATFORM SUPPORT BRACKET DETAIL

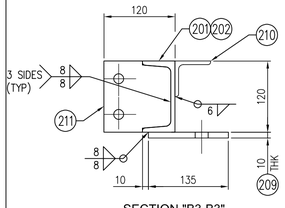
3 NOS. LEFT BRACKET (OPPOSITE)

2 NOS. RIGHT BRACKET (AS SHOWN)

SCALE 1:8

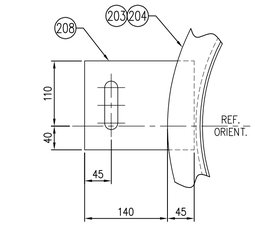


PLAN VIEW

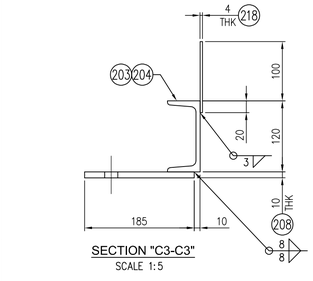


SECTION "B3-B3"

SCALE 1:5

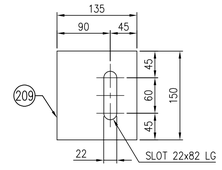


PLAN VIEW



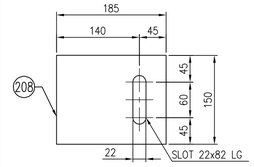
SECTION "C3-C3"

SCALE 1:5



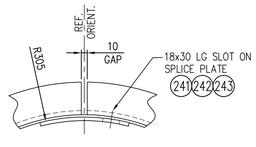
DETAIL OF PART NO. 209

SCALE 1:5

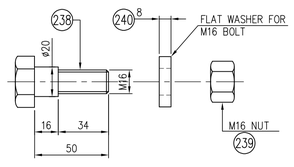


DETAIL OF PART NO. 208

SCALE 1:5

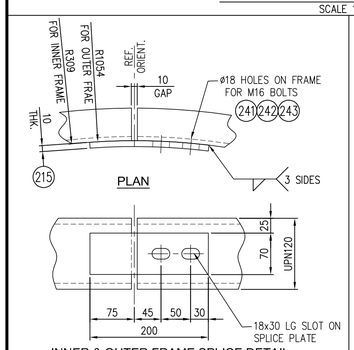


PLAN



BOLT TYPE 'R' DETAIL

(SCALE 1:2)



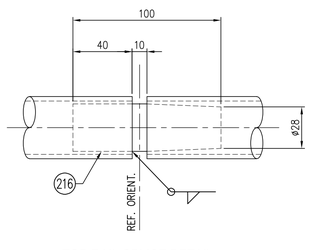
PLAN

INNER & OUTER FRAME SPLICE DETAIL

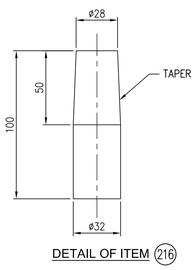
(1 SPLICE @ EXTERNAL FRAME)

(2 SPLICE @ INTERNAL FRAME)

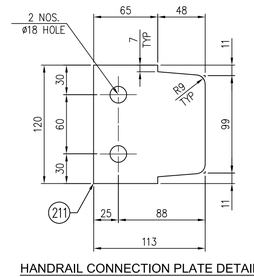
SCALE 1:5



TOP RAIL SPLICE DETAIL

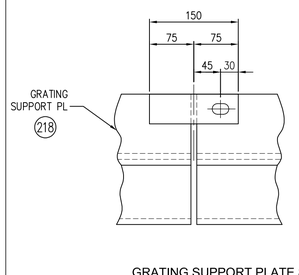


DETAIL OF ITEM 216



HANDRAIL CONNECTION PLATE DETAIL

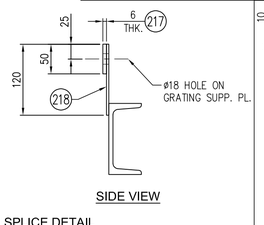
SCALE 1:3



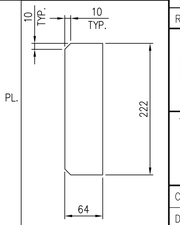
GRATING SUPPORT PLATE SPLICE DETAIL

(2 @ INTERNAL FRAME)

SCALE 1:5



SIDE VIEW



DETAIL OF PART NO. 214

SCALE 1:5

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

THERMO ENGINEERING — AN ENGLOBE CORPORATION COMPANY

ETE JOB 23-0193

ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

TITLE :

HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

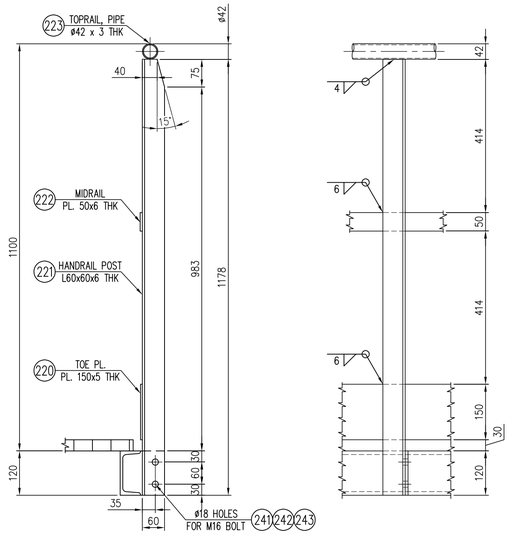
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:22

DRAWN RJ | CHECKED SCB | APPROVED AL | DATE 02-08-24

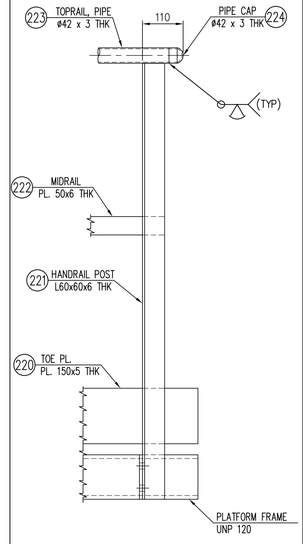
A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 005 | REV. 03

File Name : 1724000887-MAC-DD-00005_03

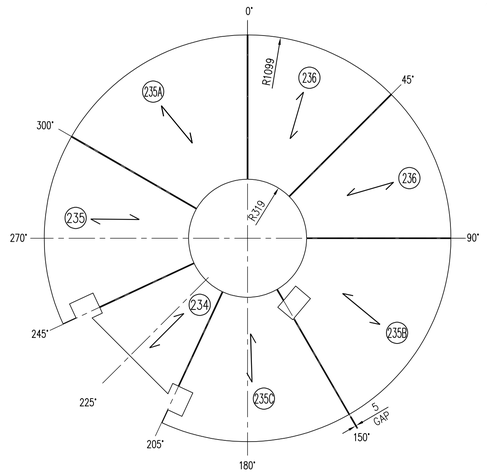
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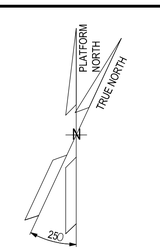
TYPICAL HANDRAIL DETAIL
(TYP. @ 5 PLCS.)
SCALE 1:8

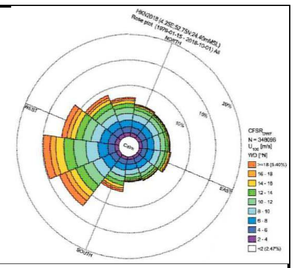


TYPICAL HANDRAIL END DETAIL
(TYP. @ 2 PLCS.)
SCALE 1:8



GRATING FOR PLATFORM DETAIL
(SCALE 1:16)

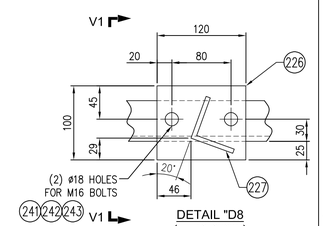




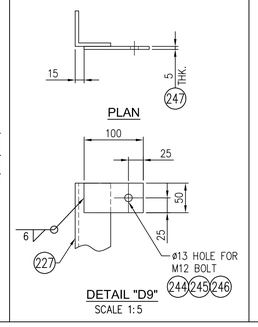
NOTES

BILL OF MATERIAL (PLATFORM)

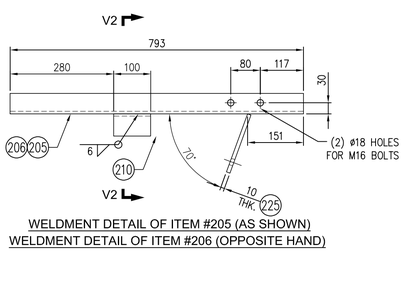
ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL
201	1	PLATFORM FRAME	UPN 120 x 3479 LG.	EN10025 S275 J0
202	1	PLATFORM FRAME	UPN 120 x 2705 LG.	EN10025 S275 J0
203	1	PLATFORM FRAME	UPN 120 x 1419 LG.	EN10025 S275 J0
204	1	PLATFORM FRAME	UPN 120 x 848 LG.	EN10025 S275 J0
205	1	PLATFORM FRAME	UPN 120 x 793 LG.	EN10025 S275 J0
206	1	PLATFORM FRAME	UPN 120 x 793 LG.	EN10025 S275 J0
207	1	PLATFORM FRAME	UPN 120 x 462 LG.	EN10025 S275 J0
208	5	CONNECTION PLATE (BRACKET)	10 THK x 185 x 150	EN10025 S275 J0
209	5	CONNECTION PLATE (BRACKET)	10 THK x 135 x 150	EN10025 S275 J0
210	14	GRATING SUPP. ANGLE	60 x 60 x 6 THK x 100 LG.	EN10025 S275 J0
211	7	CONNECTION PLATE (HANDRAIL POST)	8 THK x 113 x 120 LG.	EN10025 S275 J0
212	3R+2L	SUPPORT BRACKET	6 THK x 829 LG. (SEE DETAIL)	EN10025 S275 J0
213	5	BRACKET END PLATE	6 THK x 80 x 140 LG.	EN10025 S275 J0
214	5	BRACKET GUSSET	6 THK x 64 x 222 LG.	EN10025 S275 J0
215	1EX/2IN	SPLICE PL. (INNER/OUTER FRAME)	6 THK x 70 x 200 LG.	EN10025 S275 J0
216	1	SPLICE PL. (TOP RAIL)	ø32 ROD x 100 LG.	EN10025 S275 J0
217	3	SPLICE PL. (GRATING SUPP. PL.& MIDRAIL)	6 THK x 50 x 150 LG.	EN10025 S275 J0
218	1	GRATING SUPP. PL.	4 THK x 120 x 1950 LG.	EN10025 S275 J0
219	1	SPLICE PL. (TOE PLATE)	6 THK x 150 x 150 LG.	EN10025 S275 J0
220	1	TOE PLATE	5 THK x 150 x 7300 LG. (CUT TO SUIT)	EN10025 S275 J0
221	7	HANDRAIL POST	60 x 60 x 6 THK x 1178 LG.	EN10025 S275 J0
222	1	MID RAIL	6 THK x 50 x 7300 LG.	EN10025 S275 J0
223	1	TOP RAIL	ø42 x 3 THK x 7500 LG.	EN10025 S275 J0
224	2	TOP RAIL PIPE CAP	ø1.1/4" (42) x 3 THK, ASME B16.9	CS
225	2	PLATFORM STEP OVER SUPP. CLIP	10 THK x 120 x 167 LG.	EN10025 S275 J0
226	2	SAFETY GATE HANDRAIL BASE PL.	10 THK x 100 x 120 LG.	EN10025 S275 J0
227	2	SAFETY GATE HANDRAIL	60 x 60 x 6 THK x 1090 LG.	EN10025 S275 J0
228	1	PIPE (SAFETY BAR)	ø1" (33.4) x SCH.STD x 800 LG.	EN10025 S275 J0
229	1	PIPE (SAFETY BAR)	ø1" (33.4) x SCH.STD x 70 LG.	EN10025 S275 J0
230	1	PIPE (SAFETY BAR)	ø1" (33.4) x SCH.STD x 122 LG.	EN10025 S275 J0
231	2	END PLATE	3 THK x ø27	EN10025 S275 J0
232	1	ROD	ø22 x 125 LG.	EN10025 S275 J0
233	1	STOP PLATE	6 THK x 40 x 250 LG.	EN10025 S275 J0
234	1	GRATING	MESH 30x50, PL.30x5 THK, 0.26~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235	1	GRATING	MESH 30x50, PL.30x5 THK, 0.51~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235A	1	GRATING	MESH 30x50, PL.30x5 THK, 0.56~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235B	1	GRATING	MESH 30x50, PL.30x5 THK, 0.56~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235C	1	GRATING	MESH 30x50, PL.30x5 THK, 0.51~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
236	2	GRATING	MESH 30x50, PL.30x5 THK, 0.42~ M² (IN 2 PANELS)	SEE NOTE,8,9,10,11
236A		DELETED		
237	32	GRATING FIXING CLAMPS	STAPLE & CLAMP, WITH M8 x 60LG. HEX. HED. BOLT + 2 SQ. NUT (SEE DETAIL)	CS
238	10	BOLT TYPE 'R' (SEE DETAIL)	M16 x 50 LG.	8.8
239	10	HEX. HEAD NUT	M16 (H=D)	8
240	10	WASHER	8 THK FOR M16 BOLT	CS
241	46	HEX. HEAD BOLT	M16 x 50 LG.	8.8
242	46	HEX. HEAD NUT	M16 (H=D)	8
243	46	FLAT WASHER	M16	CS
244	2	HEX. HEAD BOLT	M12 x 40 LG.	8.8
245	2	HEX. HEAD NUT	M12 (H=D)	8
246	2	FLAT WASHER	M12	CS
247	2	LADDER CLIP	6 THK x 50 x 100	EN10025 S275 J0
248	1	BANDING PLATE	3 THK x 185 x 1500 LG. (CUT TO SUIT)	EN10025 S275 J0
3	249	2	PLATFORM FRAME	UPN 120 x 690 LG.	EN10025 S275 J0



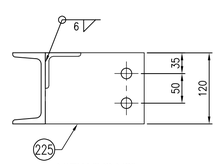
DETAIL "D8"
(1– AS SHOWN)
(1– OPPOSITE)
SCALE 1:5



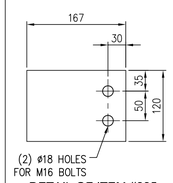
DETAIL "D9"
SCALE 1:5



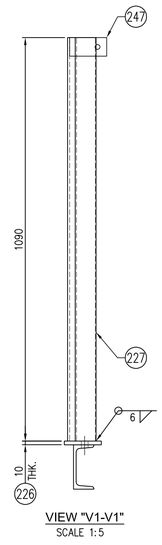
WELDMENT DETAIL OF ITEM #205 (AS SHOWN)
WELDMENT DETAIL OF ITEM #206 (OPPOSITE HAND)



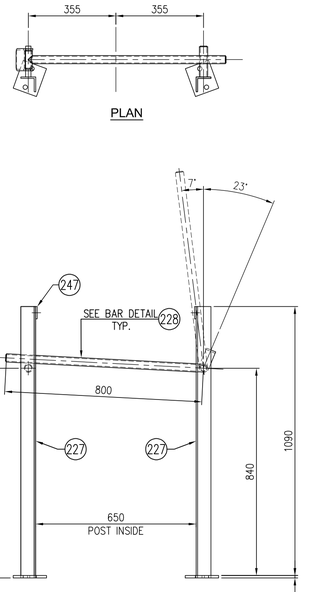
VIEW "V2-V2"
SCALE 1:5



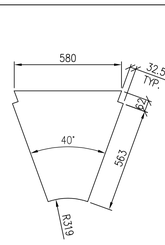
DETAIL OF ITEM #225
SCALE 1:5



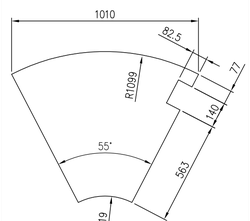
VIEW "V1-V1"
SCALE 1:5



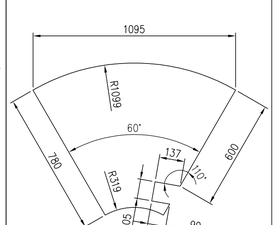
ELEVATION
SAFETY BAR TYPICAL DETAIL



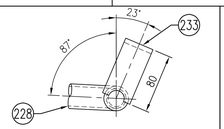
DETAIL OF ITEM #234
(SCALE 1:16)



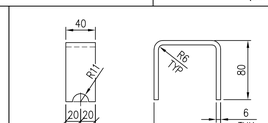
DETAIL OF ITEM #235
(SCALE 1:16)



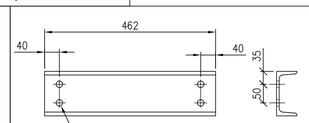
DETAIL OF ITEM #235B
(SCALE 1:16)



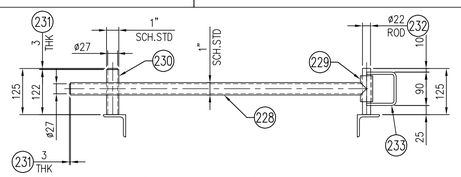
SAFETY BAR TYPICAL DETAIL



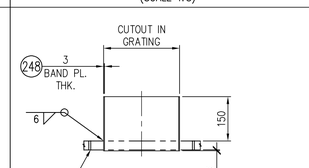
DETAIL PART 233



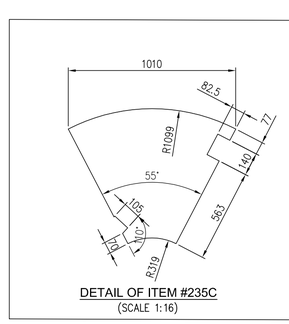
DETAIL OF ITEM #207
(SCALE 1:8)



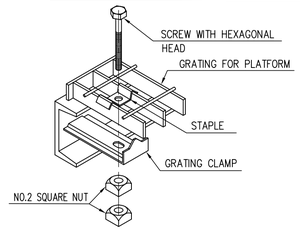
SAFETY BAR TYPICAL DETAIL



TYPICAL CUTOUT BANDING DETAIL



DETAIL OF ITEM #235C
(SCALE 1:16)



GRATING CLAMPS DETAIL 237
MINIMUM No.4 ANCHORS FOR EACH PANEL

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

THERMO ENGINEERING — AN ENGLOBE CORPORATION COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0131

CROSSWIND

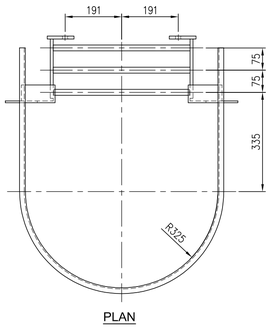
ROSETTI MARINO

TITLE :
HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

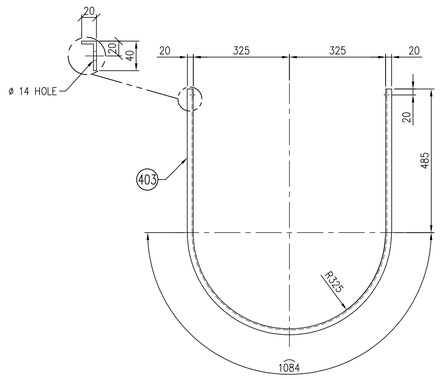
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:22
DRAWN RJ | CHECKED SCB | APPROVED AL | DATE 07-08-24
A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 006 | REV. 03

File Name : 1724000887-MAC-DD-00005_03

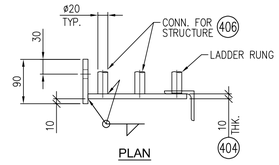
DRAWING NO. 1724000887-MAC-DD-00005_03 | REV. 03



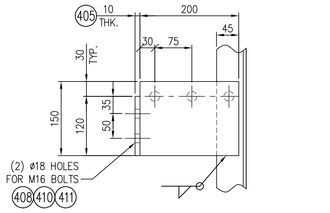
PLAN



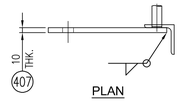
SECTION "A4-A4"



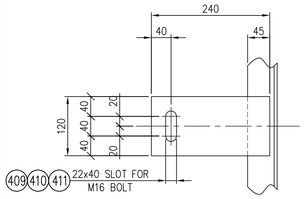
PLAN



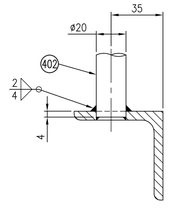
DETAIL #1



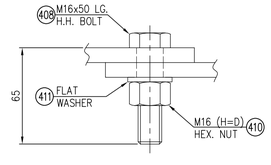
PLAN



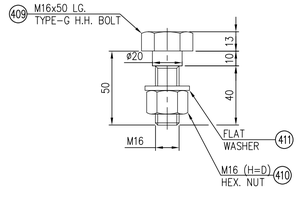
DETAIL #2



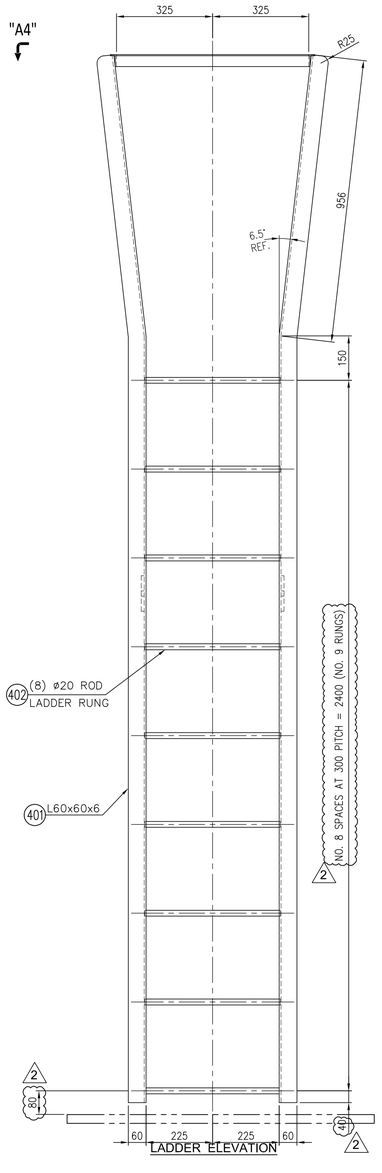
RUNGS WELDING DETAIL



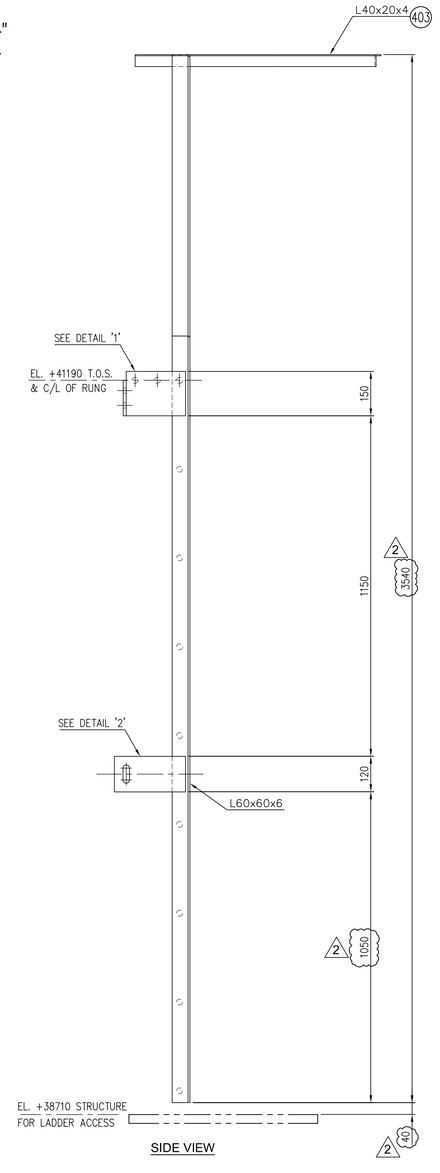
FIXED CLIP FIXING DETAIL



SLIDING CLIP FIXING DETAIL
(TYPE G BOLT)



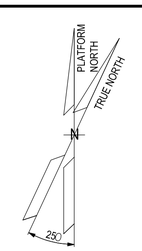
LADDER ELEVATION

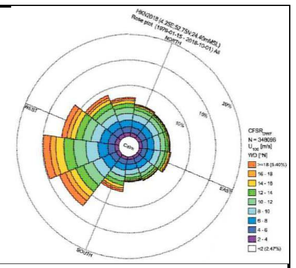


SIDE VIEW

BILL OF MATERIAL (LADDER)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL
401	2	LADDER STRINGER	L 60x60x6 x 3540 LG.	S275 J0
402	9	LADDER RUNG	ROD ø20 x 458 LG.	S275 J0
403	1	TOP HOOP	L 40x20x4 x 2055 LG.	S275 J0
404	2	LADDER CLIP (FIXED)	10 THK x 150 x 200 LG.	S275 J0
405	2	LADDER CLIP (FIXED)	10 THK x 90 x 120 LG.	S275 J0
406	2	CONN. STRUCT. RUNG	ROD ø20 x 462 LG.	S275 J0
407	2	LADDER CLIP (SLIDING)	10 THK x 120 x 240 LG.	S275 J0
408	4	HEXAGONAL HEAD BOLTS	M16 x 50 LG.	8.8
409	2	TYPE-G HEXAGONAL HEAD BOLTS (SEE DETAIL)	M16 x 65 LG.	8.8
410	6	HEXAGONAL NUTS	M16 (H=D)	8
411	6	FLAT WASHER	FOR M16 BOLT	CARBON STEEL





NOTES

THERMO ENGINEERING AN ENCORE COMBUSTION COMPANY				ETE JOB	23-0193
				ETE DWG NR.	23-0193-0131
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
REV.	DATE	DRN	CHKD	APPD	DESCRIPTION

CROSSWIND | ROSETTI MARINO

TITLE :

HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK		SCALE 1:22	
DRAWN RJ	CHECKED SCB	APPROVED AL	DATE 02-08-24
A1	DRAWING NO. 1724000887-MAC-DD-00005	SHEET 007	REV. 03

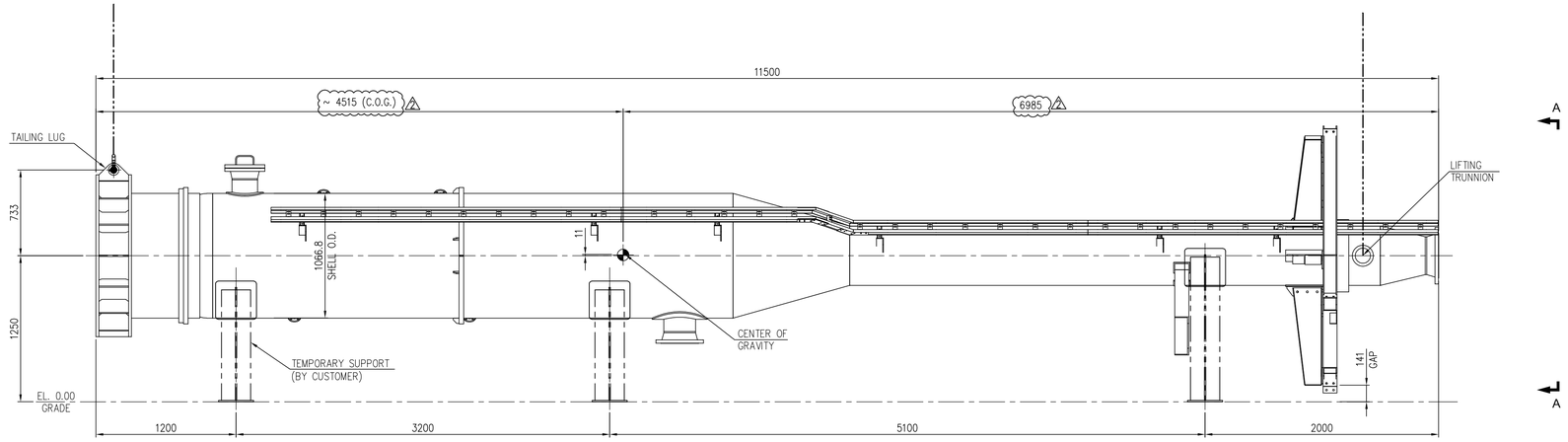
File Name : 1724000887-MAC-DD-00005_03

1.3.3 Lifting Drawings

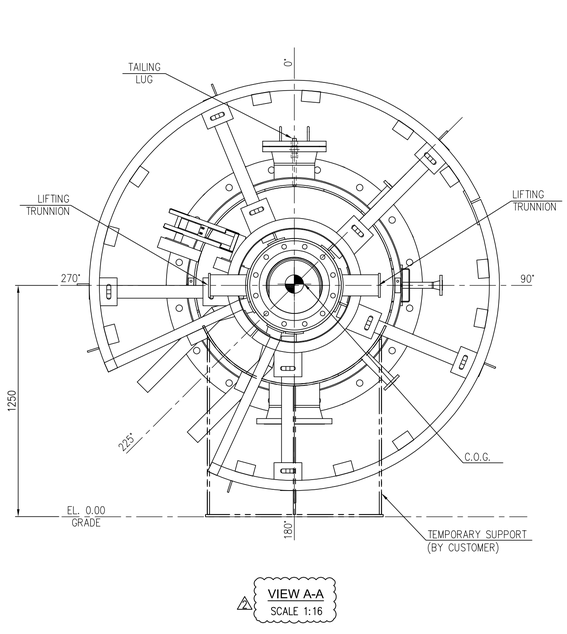
SEE ATTACHED NEXT PAGE

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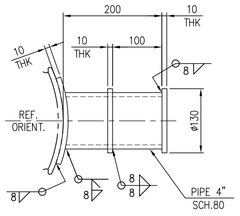
DRAWING NO. 1724000887-MAC-DD-00019_02 REV. 02



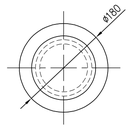
ELEVATION
⚠2 LIFTING WITHOUT INSTALLED TIP
SCALE 1:25



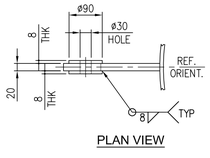
VIEW A-A
SCALE 1:16



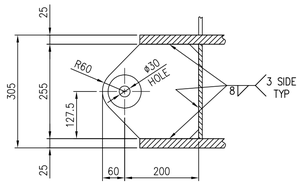
ELEVATION
LIFTING TRUNNION DETAIL



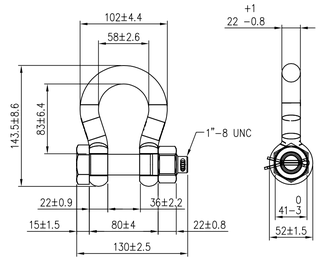
SIDE VIEW



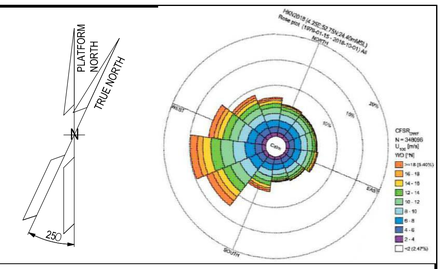
PLAN VIEW



ELEVATION
TAILING LUG DETAIL



SHACKLE DETAIL
GREEN PIN® BOW SHACKLE BN
GROUP : G-4163
PART : GPGHMB22
WLL :6.5t



NOTES

GENERAL NOTES:

1. ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3. DELETED..
4. THE LIFTING TRUNNIONS ARE PROVIDED TO LIFT THE ASSEMBLY IN FULLY DRESSED CONDITION.
5. VENT TIP, HANDRAIL, LADDER AND GRATINGS SHALL BE INSTALLED IN VERTICAL POSITION OF EQUIPMENT.
6. TOTAL LIFTING WEIGHT APPROX. : 4050 KG. (WITH 10% CONTINGENCY)

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	09/12/24

THERMO ENGINEERING — AN ENCONA COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0530A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

TITLE : HYDROGEN VENT LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

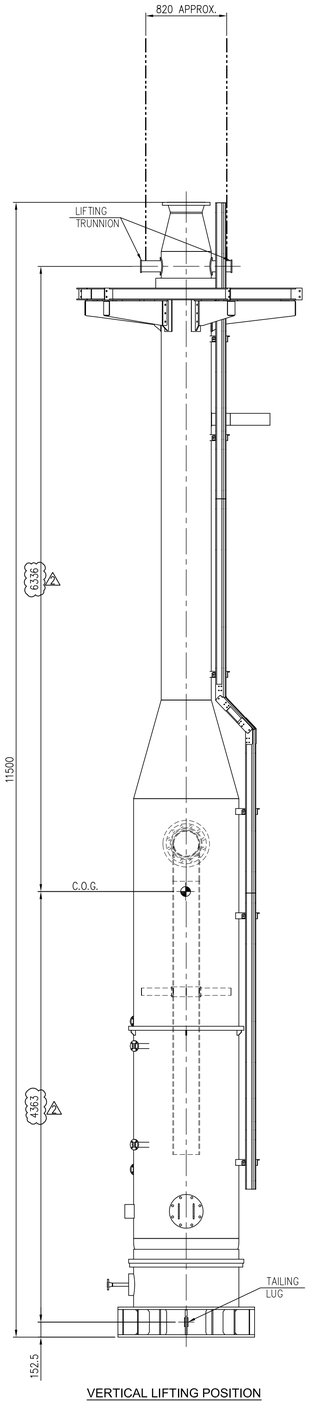
DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 001 | REV. 02

File Name : 1724000887-MAC-DD-00019_02

DRAWING NO. 1724000887-MAC-DA-00003_02

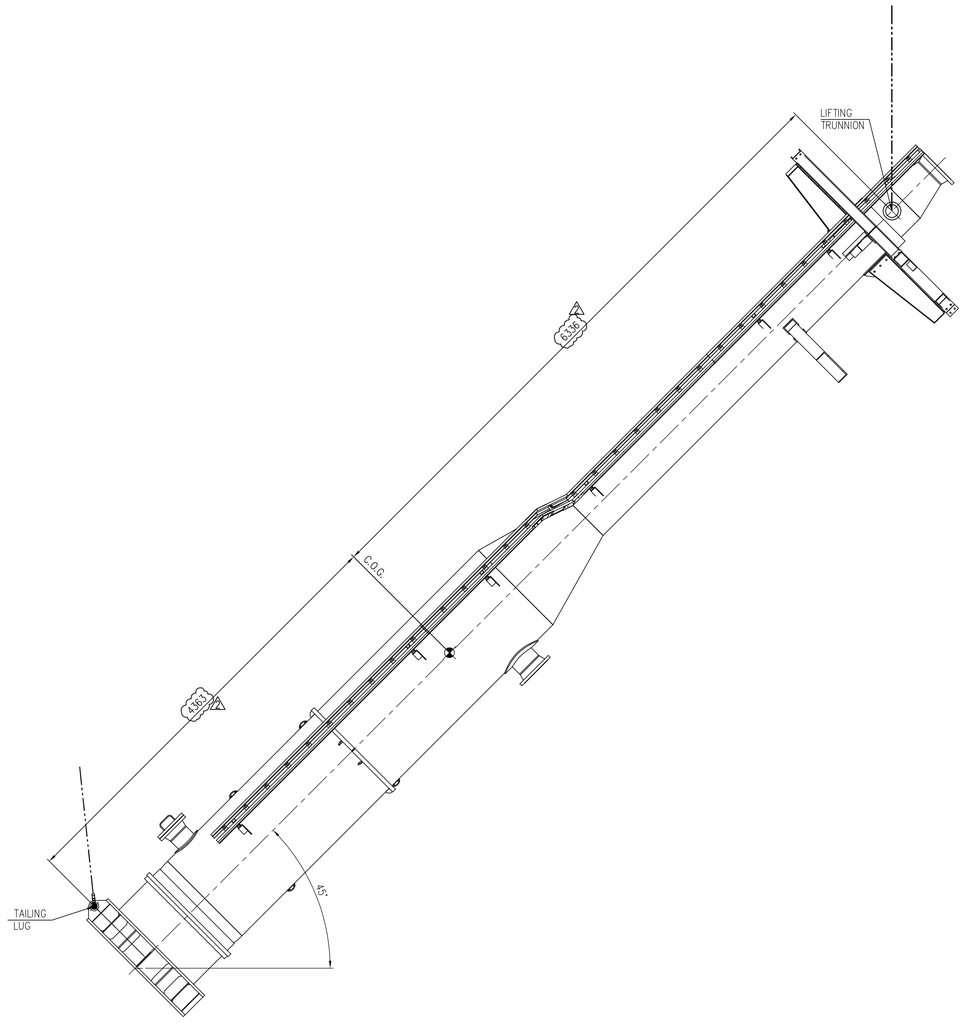
REV. 02



VERTICAL LIFTING POSITION

SCALE 1:30

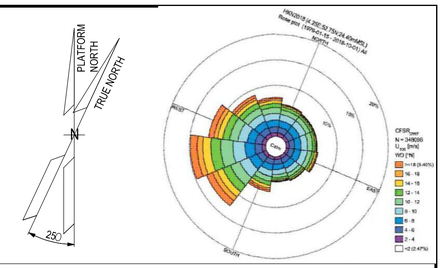
VIEW ROTATED FOR LIFTING TRUNNION CLARIFICATION



LIFTING VIEW AT 45° POSITION

SCALE 1:40

LIFT ANGLE Deg.	LIFTING LOAD kN	TAILING LOAD kN
0	24.95	34.62
10	25.37	34.20
20	25.80	33.77
30	26.29	33.29
40	26.86	32.71
50	27.60	31.97
60	28.68	30.89
70	30.51	29.06
80	34.76	24.82
90	59.57	0.00



NOTES

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY

ETE JOB 23-0193

ETE DWG NR. 23-0193-0530A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE : HYDROGEN VENT LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

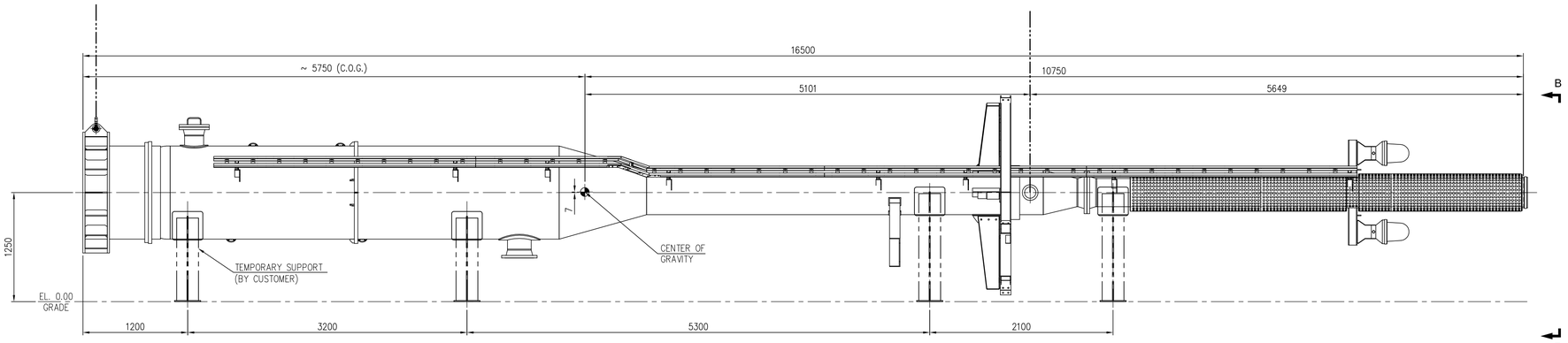
DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 002 | REV. 02

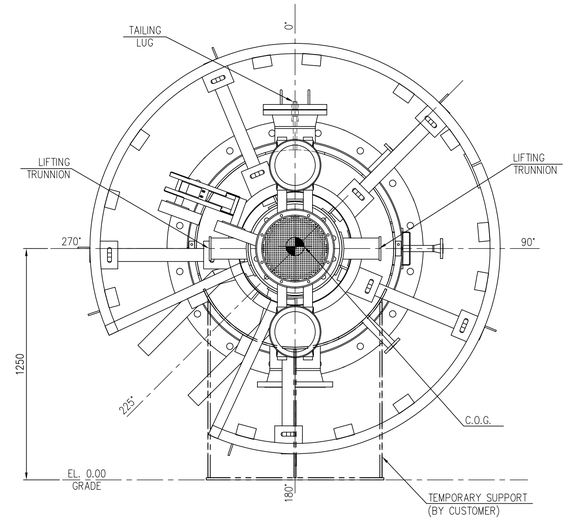
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DRAWING NO. 1724000887-MAC-DD-00019_02

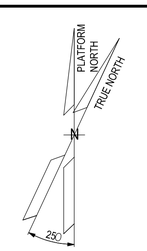
REV. 02

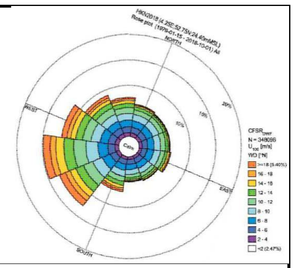


ELEVATION
LIFTING WITH INSTALLED TIP
SCALE 1:30



VIEW B-B
SCALE 1:16





NOTES

GENERAL NOTES:

1. ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3. DELETED..
4. THE LIFTING TRUNNIONS ARE PROVIDED TO LIFT THE ASSEMBLY IN FULLY DRESSED CONDITION.
5. VENT TIP, HANDRAIL, LADDER AND GRATINGS SHALL BE INSTALLED IN VERTICAL POSITION OF EQUIPMENT.
6. TOTAL LIFTING WEIGHT APPROX. : 4600 KG. (WITH 10% CONTINGENCY)

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY

ETE JOB	23-0193
ETE DWG NR.	23-0193-0530A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE : HYDROGEN VENT LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

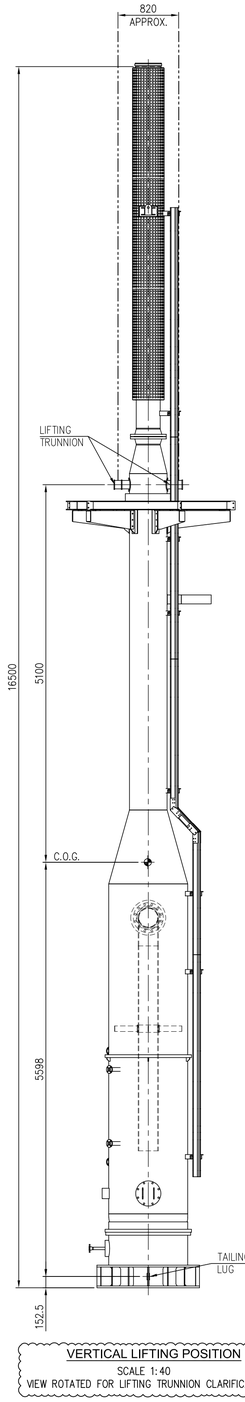
DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 001 | REV. 02

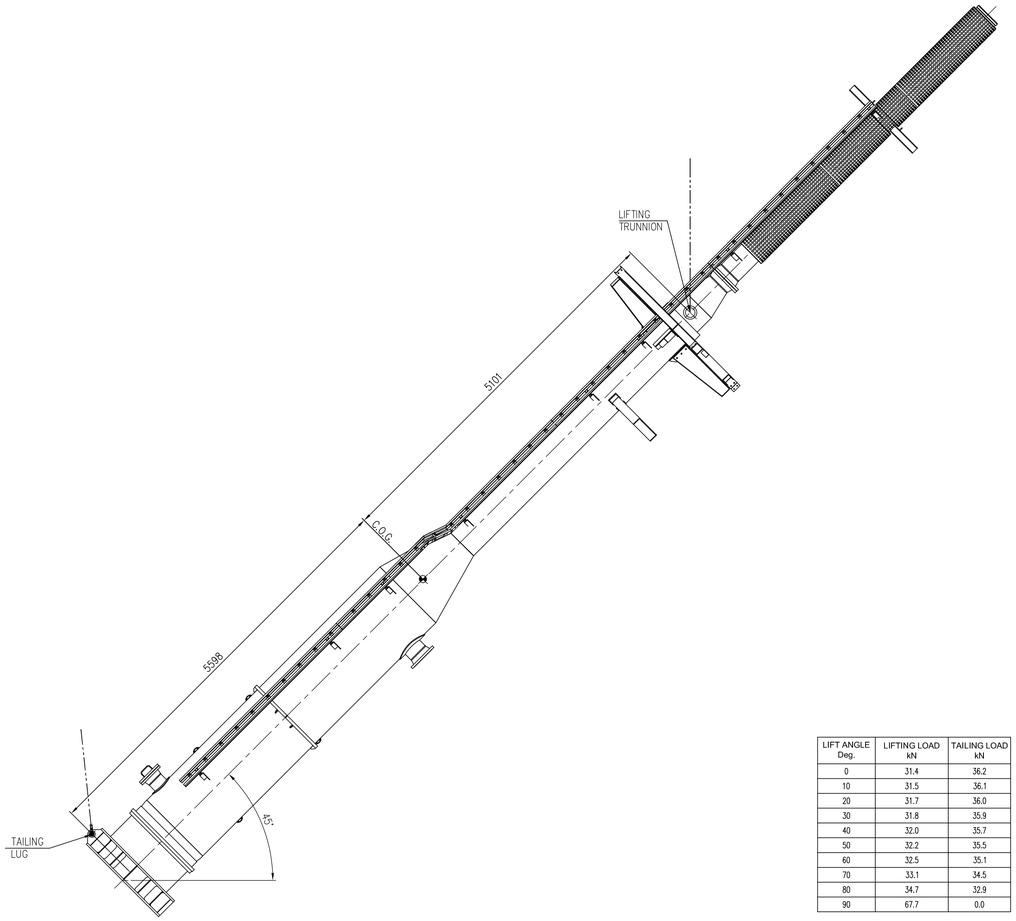
File Name : 1724000887-MAC-DD-00019_02

DRAWING NO. 1724000887-MAC-DD-00019_02

REV. 02

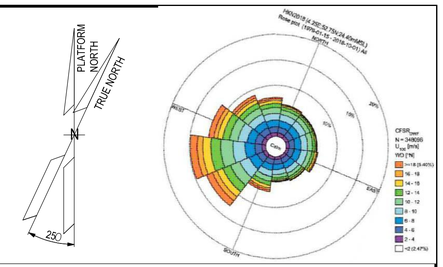


VERTICAL LIFTING POSITION
SCALE 1:40
VIEW ROTATED FOR LIFTING TRUNNION CLARIFICATION



LIFT ANGLE Deg	LIFTING LOAD kN	TAILING LOAD kN
0	31.4	36.2
10	31.5	36.1
20	31.7	36.0
30	31.8	35.9
40	32.0	35.7
50	32.2	35.5
60	32.5	35.1
70	33.1	34.5
80	34.7	32.9
90	67.7	0.0

LIFTING VIEW AT 45° POSITION
SCALE 1:40



NOTES

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY

ETE JOB	23-0193
ETE DWG NR.	23-0193-0530A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE : HYDROGEN VENT LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 001 | REV. 02

File Name : 1724000887-MAC-DD-00019_02

1.4 PROJECT PROCEDURES AND SPECIFICATION

1.4.1 Hydrostatic Test Procedures

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

HYDROSTATIC TEST PROCEDURES – HYDROGEN VENT Q-43004

Document Number: 1724000887-QC-PRO-00009

Document Class: 2

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	05/11/2024

Rev.	Date	Description	Prepared	Reviewed	Approved
02	31/10/2024	Acceptance for Construction (AFC)	MD	RV	ADL
01	15/10/2024	Acceptance for Construction (AFC)	MD	RV	ADL
00	06/09/2024	Issue for Review (IFR)	MD	RV	ADL

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THERMO ENGINEERING ADVANCED COMBUSTION SYSTEMS

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Accepted for Construction (AFC)
02	Accepted for Construction (AFC)

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1	
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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.

1.1.1 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.

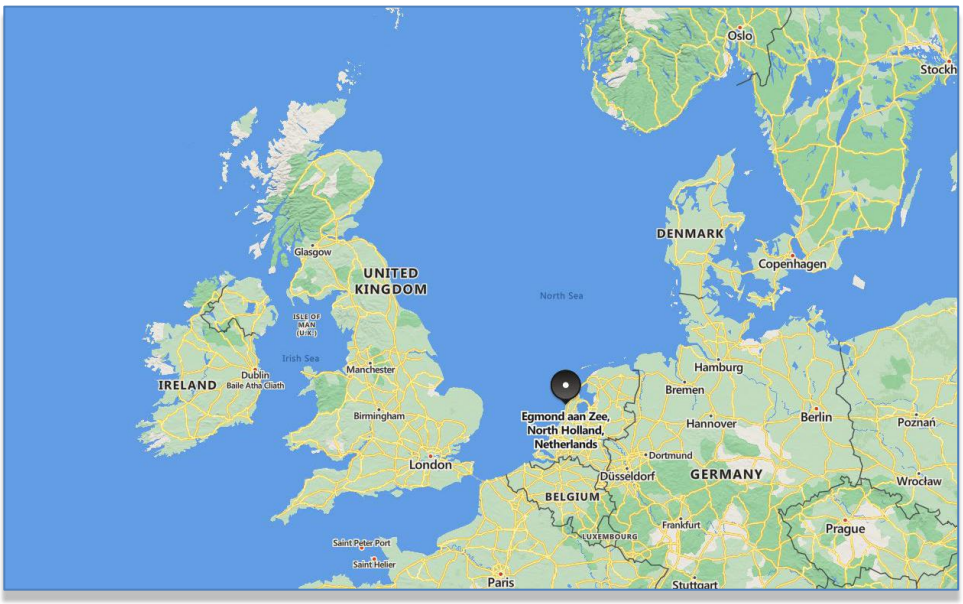


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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 located on coordinates E 590719.1, N 5841602.3 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.

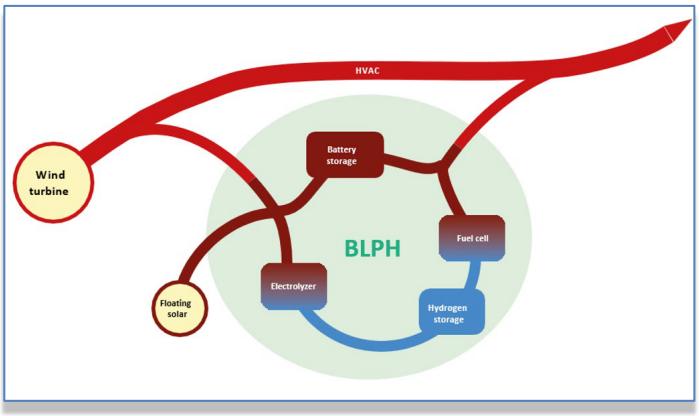


Figure 3 – BLPH Concept

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 s 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

This procedure aims to provide instructions for the correct execution and evaluation of the HYDROSTATIC PRESSURE TEST to carry out on the Hydrogen Vent

2.1 REFERENCES

The following procedure is in accordance with the codes below:

Dir 2014/68 EU All.1 par. 7.4

Consequently, it is applicable to devices designed and manufactured in accordance with such codes and rules.

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	CROSSWIND
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Table 1 - Definitions and Abbreviations

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3. HYDROSTATIC TEST PROCEDURE

3.1 The Quality Control Supervisor will oversee the HYDROSTATIC PRESSURE (STATIC) TEST and issue the related inspection report

3.2 Water must be used for the test. When hydro-stating stainless steel vessel, or stainless-steel cladded vessel, water with chloride content lower than 50 ppm is to be used.

3.3 Test start is effective when water in the system is considered stabilized (deaerated, clean, properly tightened, etc.).

3.4 Test pressure must be measured with calibrated manometer

3.5 The manometer to be used must be among those catalogued in the instrument registry, and they must fulfil the requirements for the service requested. In addition, the calibration and control validity terms must not have expired.

3.6 If it is not easily visible, an additional manometer must be mounted in a more accessible and visible position for the duration of the test.

3.7 The manometer used must have a scale in the range of 1.5 times (minimum) and 4 times (maximum) the test pressure.

3.8 During the HYDROSTATIC PRESSURE TEST, the water temperature must not be less than 5°C and not more than 40°C.

3.9 Before bringing the device to the test pressure, it is necessary to isolate or dismantle all the devices that must not undergo increases in pressure and isolate areas or sections of the devices that are not subject to pneumatic verification.

3.10 The test pressure must be maintained for one hour at least, in the presence of the inspector, so to analyze the status of the entire device and detect possible losses.

3.11 The pressure should be raised gradually and under control

3.12 No pressure drops shall be observed during the test duration to consider it valid and completed.

3.13 After the HYDROSTATIC PRESSURE TEST, the piping spools must be brought back to its initial conditions.

3.14 The HYDROSTATIC PRESSURE TEST must be performed before any surface treatment and before any functional tests.

3.15 After completion of fabrication and testing, the equipment shall be thoroughly drained of water, dried and cleaned thoroughly of all grease, loose scale, rust flux, welds spatter and so on

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4. HYDROSTATIC TEST PRESSURE

According to the Dir 2014/68 EU All.1 par. 7.4, the pressure for the TEST should be:
Pressure per PED = max (1.43*DP, 1.25*DP*ratio)
Pressure per the PED:
= max(1.43 * Design Pressure, 1.25 * Design Pressure * Stress ratio)
= max(1.43 * 350, 1.25 * 350 * 1)
= max(500.5, 437.5)
= 500.500 Kpa = 5.5Barg

5. ACCEPTABILITY CRITERIA

Hydraulic test is considered passed if the following is not revealed:
-indications of ruptures
-leakages, liquid drops and sweating in welds and in base metal
-pressure decrease as judged by a pressure gauge
-visible residual deformations
-leaks in flanged connections.

6. CORRECTIVE ACTION

6.1 Substitute the gaskets and re-establish the connections
6.2 Welding repair as agreed between the parties according to a specific procedure to be submitted if necessary

7. CERTIFICATION

HYDROSTATIC PRESSURE TEST completion certificates indicating the characteristics and results of the test will be drafted and issued by the Quality Control Department.
The certificate must be countersigned by the Quality Control Supervisor of the sub-supplier and by the inspector of the Client, if present at the test. Hydrostatic test report attached as sample.
The Authorized Inspector from Notified Body will witness the hydrostatic test.

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HYDROSTATIC PRESSURE TEST		
ENCORE THERMOENGINEERING S.r.l. ***MILANO - ITALY***	**HYDROSTATIC TEST REPORT**	**N° _____**
Item description :		
		Unit
Reference Drawing N°		
Test procedure N°		
Pressure gauge serial N°		
Pressure gauge rate		**Barg**
Test medium		
Design pressure		**Barg**
Design temperature		**°C**
Test pressure		**Barg**
Pressurization system		
Test temperature		**°C**
Holding time		**h**
Visual exam. under pressure		
Test result		
Notes :		
Inspector Signature	**Party stamp**	**Date**

1.4.2 Weld Procedure Specification, Weld location plan and qualifications records, weld operators list and welder qualifications record.

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

WELD PROCEDURE SPECIFICATION (WPS) WLED LOCATION PLAN (WLP) AND QUALIFICATIONS RECORDS (PQR), WELD OPERATORS LIST and WELDER QUALIFICATIONS RECORDS (WPQ)

Document Number: 1724000887-WEL-PRO-00011
Document Class: 2

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
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3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
DAVIDE CENACCHI	13/12/2024

03	10/12/2024	Accepted for Construction (AFC)	MD	RV	ADL
02	12/11/2024	Accepted for Construction (AFC)	MD	RV	ADL
01	18/10/2024	Issue for Review (IFR)	MD	RV	ADL
00	06/09/2024	Issue for Review (IFR)	MD	RV	ADL
Rev.	Date	Description	Prepared	Reviewed	Approved

THERMO ENGINEERING AN ENCORE COMBUSTION COMPANY

THERMO ENGINEERING ADVANCED COMBUSTION SYSTEMS

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Issue for Review (IFR)
02	Accepted for Construction (AFC)
03	Accepted for Construction (AFC)

HOLDS LIST

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The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

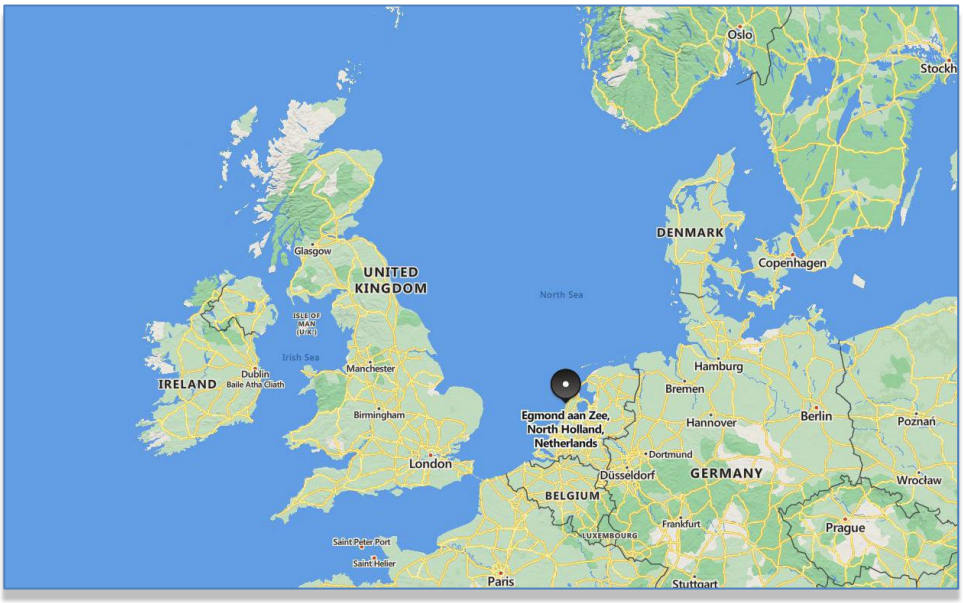


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



Figure 2 - Wind Park Details

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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.

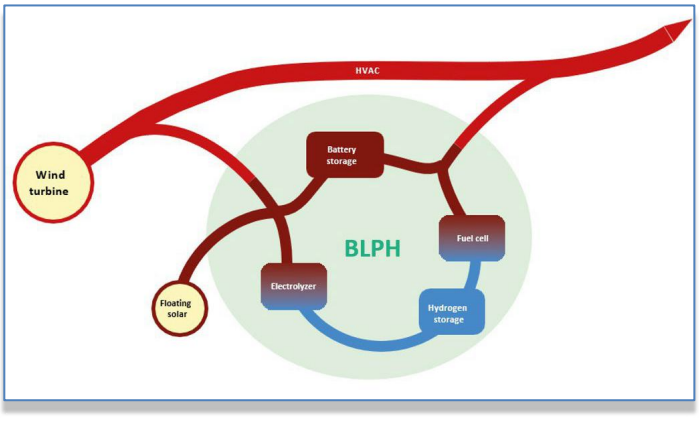


Figure 3 – BLPH Concept

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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. INTRODUCTION

This procedure aims to provide information about the welding duty of the project.

2.1 REFERENCES

The following procedure is in accordance with the codes and project specifications below:

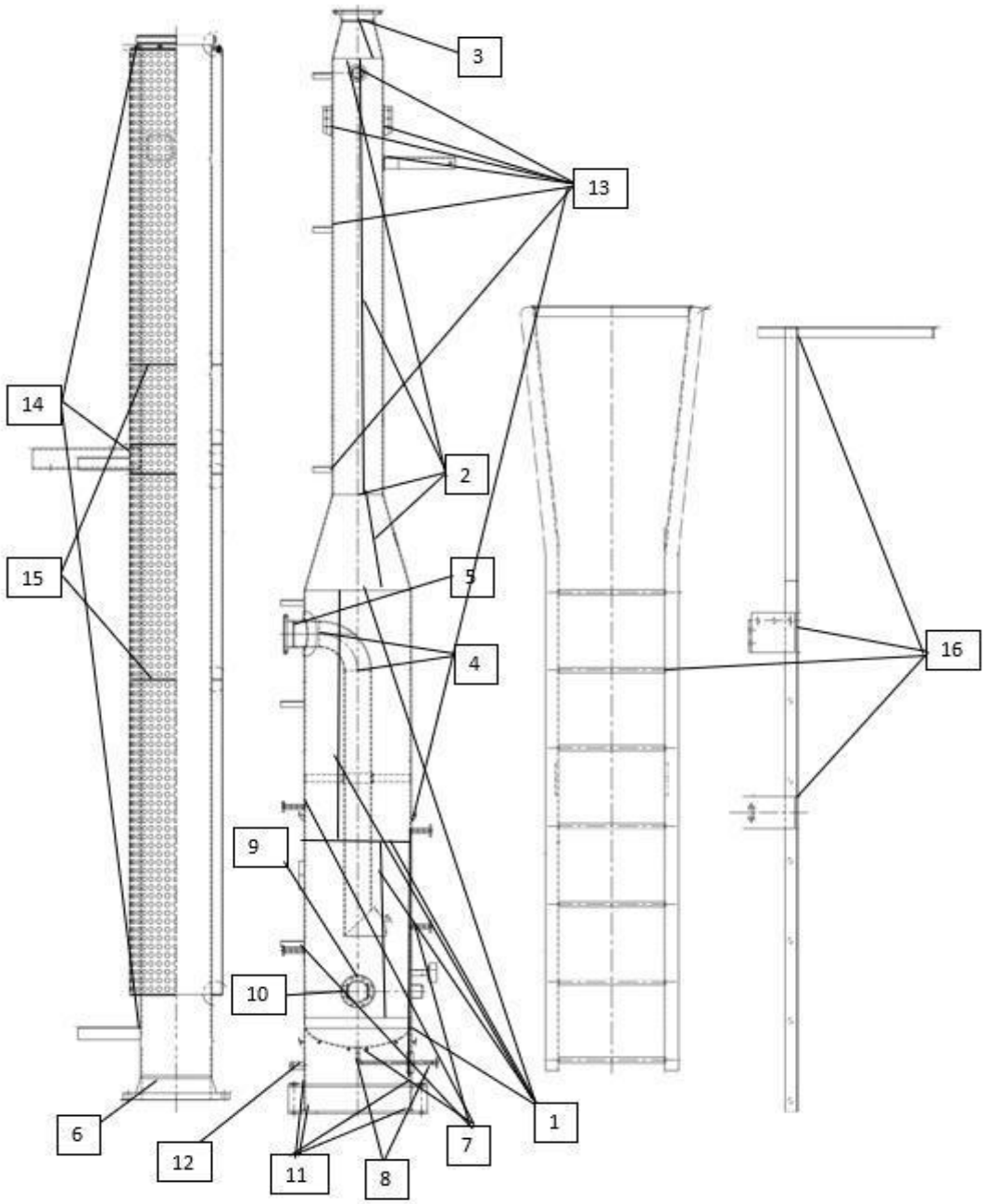
- **EN 15614-1**
- **ASME CODE SECTION IX**
- **123A90-DDL-MAC-SP-50043 - Technical Specification for Hydrogen Vent - U-43004**

2.2 DEFINITIONS AND ABBREVATIONS

COMPANY or CLIENT (CPY)	CROSSWIND
CONTRACTOR (CTR)	ROSETTI MARINO S.p.A.
PROJECT	HOLLANDSE KUST NOORD WIND PARK Project

Table 1 – Definitions And Abbreviations

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WELD MAP Rev.1 DATE: 08 October 2024

JOB : 23-0193	**HYDROGEN VENT**

Pag. 1 of 2

Note: joints subject to NDT are tracked from the records of those who performed the NDT

NOTE
Welds from 1 to 10 Welds on Pressure parts

Welds from 11 to 16 Welds on NON Pressure parts

JOINT	MATERIAL 1	MATERIAL 2	DIA.	THK.	WELDER	WPS	WPQR
16	S275J0	S275J0	---	---	RS	**23-0193-16**	**EN-R02/14**
15	1.4404	1.4404	420 mm	2 mm	RS	**23-0136-15**	**EN-R04/15**
14	1.4404	1.4404	---	---	RS	**23-0136-14**	**EN-R04/15**
13	P355JH	S275J0	---	---	RS	**23-0193-13**	**EN-R02/14**
12	P355JH	AISI 316L	---	---	DG	**23-0193-12**	**R05/00**
11	S275J0	S275J0	---	---	RS	**23-0193-11**	**EN-R02/14**
10	P265NL	P355QH1	8"	8,18 mm	RS	**23-0193-10**	**EN-R02/14**
9	P265NL	P355JH	8"	8,18 mm	RS	**23-0193-9**	**EN-R02/14**
8	P265NL	P265NL	1"	4,45 mm	RS	**23-0193-8**	**EN-R02/14**
7	P355JH	P355QH1	1"	4,45 mm	RS	**23-0193-7**	**EN-R02/14**
6	1.4404	1.4404	12"	6 mm	RS	**23-0136-6**	**EN-R04/15**
5	P265NL	P355QH1	10"	9,27 mm	RS	**23-0193-5**	**EN-R02/14**
4	P265NL	P265NL	10"	9,27 mm	RS	**23-0193-4**	**EN-R02/14**
3	P355QH1	P355JH	12"	10 mm	RS	**23-0193-3**	**EN-R02/14**
2	P355JH	P355JH	508 mm	10 mm	RS	**23-0193-2**	**EN-R02/14**
1	P355JH	P355JH	1066,8 mm	10 mm	RS	**23-0193-1**	**EN-R02/14** **EN-R07/15**

WELD MAP Rev.1 DATE: 08 October 2024

JOB : 23-0193

HYDROGEN VENT

Pag. 2 of 2

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-1 Rev. 1**

WPQR No.: **EN-R02/14 + EN-R07/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (135 + 121)**

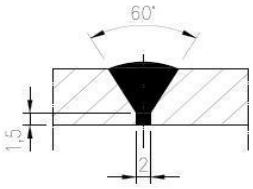
Parent Material Designation: **EN 15608 Gr. 1.2**

Material thickness (mm): **10**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1	**135**	**1**	**208-210**	**27-29**	**DCEP**	**130-330**	**6,6 – 6,7**	**0,73**
2-N	**121**	**2**	**399-401**	**29-31**	**DCEP**	**N.A.**	**18 – 19**	**0,69**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 14341-A G 42 4 M G3Si1 (135)**
EN ISO 14171-A S2Si (121)

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar + CO2 (135) nozzle 14 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **15 lt/min (135)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: N.A.**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-2 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141 + 135)**

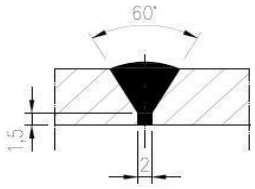
Parent Material Designation: **EN 15608 Gr. 1.2**

Material thickness (mm): **10**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**
2-N	**135**	**1**	**208-210**	**27-29**	**DCEP**	**130-330**	**6,6 – 6,7**	**0,73**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**
EN ISO 14341-A G 42 4 M G3Si1 (135)

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**
Ar + CO2 (135) nozzle 14 mm

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**
15 lt/min (135)

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-3 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141 + 135)**

Method of Preparation and Cleaning: **GRINDING, BRUSHING**

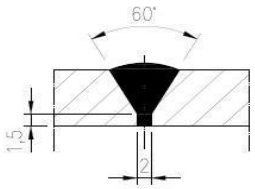
Parent Material Designation: **EN 15608 Gr. 1.2**

Material thickness (mm): **10**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**
2-N	**135**	**1**	**208-210**	**27-29**	**DCEP**	**130-330**	**6,6 – 6,7**	**0,73**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**
EN ISO 14341-A G 42 4 M G3Si1 (135)

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**
Ar + CO2 (135) nozzle 14 mm

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**
15 lt/min (135)

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-4 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141 + 135)**

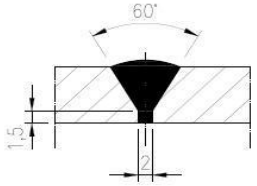
Parent Material Designation: **EN 15608 Gr. 1.1**

Material thickness (mm): **9,27**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**
2-N	**135**	**1**	**208-210**	**27-29**	**DCEP**	**130-330**	**6,6 – 6,7**	**0,69**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**
EN ISO 14341-A G 42 4 M G3Si1 (135)

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**
Ar + CO2 (135) nozzle 14 mm

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**
15 lt/min (135)

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-5 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141 + 135)**

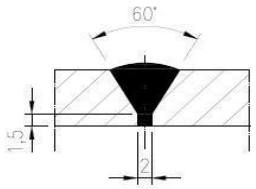
Parent Material Designation: **EN 15608 Gr. 1.1 + 1.2**

Material thickness (mm): **9,27**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**
2-N	**135**	**1**	**208-210**	**27-29**	**DCEP**	**130-330**	**6,6 – 6,7**	**0,73**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**
EN ISO 14341-A G 42 4 M G3Si1 (135)

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**
Ar + CO2 (135) nozzle 14 mm

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**
15 lt/min (135)

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-6 Rev. 1**

WPQR No.: **EN-R04/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141)**

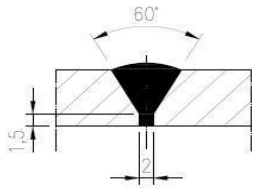
Parent Material Designation: **EN 15608 Gr. 8.1**

Material thickness (mm): **6**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**119-121**	**9-11**	**DCEN**	**N.A.**	**1,1 – 1,2**	**0,72**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 14343 25 20 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-7 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141)**

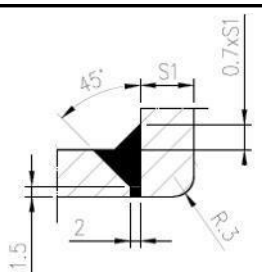
Parent Material Designation: **EN 15608 Gr. 1.2**

Material thickness (mm): **4,45**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-8 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141)**

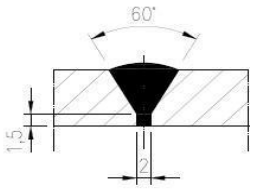
Parent Material Designation: **EN 15608 Gr. 1.1**

Material thickness (mm): **4,45**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**

Any Special Baking or Drying: **NONE**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

− Backing**:** **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

− Backing: **N.A.**

Weaving (maximum width of run): **N.A.**

Oscillation: amplitude, frequency, dwell time: **N.A.**

Pulse welding details: **N.A.**

Distance contact tube/work piece: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-9 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141)**

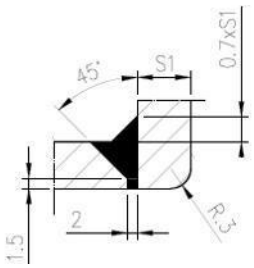
Parent Material Designation: **EN 15608 Gr. 1.1+1.2**

Material thickness (mm): **8,18**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-10 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW (141)**

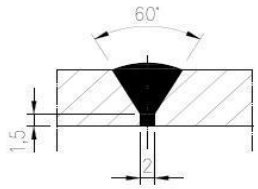
Parent Material Designation: **EN 15608 Gr. 1.1+1.2**

Material thickness (mm): **8,18**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-11 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **FW (141)**

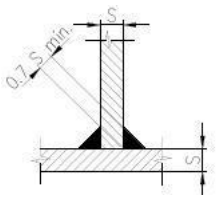
Parent Material Designation: **EN 15608 Gr. 1.2**

Material thickness (mm): **N.A.**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-12 Rev. 1**

WPQR No.: **R05/00**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **FW (141)**

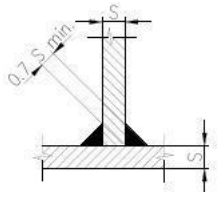
Parent Material Designation: **EN 15608 Gr. 8.2 + 1.1**

Material thickness (mm): **N.A.**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**110-120**	**14-16**	**DCEN**	**N.A.**	**0,8 – 1**	**1,32**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 14343 25 20 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-13 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **FW (141)**

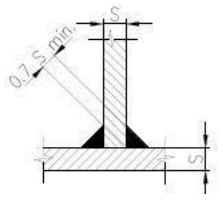
Parent Material Designation: **EN 15608 Gr. 1.2**

Material thickness (mm): **N.A.**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**144-146**	**11-13**	**DCEN**	**N.A.**	**0,7 – 0,8**	**1,62**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**

Any Special Baking or Drying: **NONE**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

− Backing**:** **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

− Backing: **N.A.**

Weaving (maximum width of run): **N.A.**

Oscillation: amplitude, frequency, dwell time: **N.A.**

Pulse welding details: **N.A.**

Distance contact tube/work piece: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-14 Rev. 1**

WPQR No.: **EN-R04/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **FW (141)**

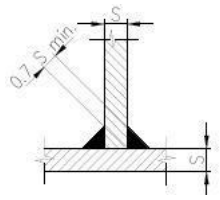
Parent Material Designation: **EN 15608 Gr. 8.1**

Material thickness (mm): **N.A.**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**119-121**	**9-11**	**DCEN**	**N.A.**	**1,1 – 1,2**	**0,72**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 14343 25 20 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-15 Rev. 1**

WPQR No.: **EN-R04/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **FW (141)**

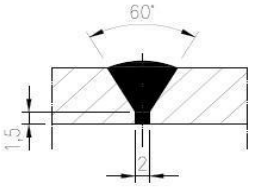
Parent Material Designation: **EN 15608 Gr. 8.1**

Material thickness (mm): **N.A.**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**141**	**2,4**	**119-121**	**9-11**	**DCEN**	**N.A.**	**1,1 – 1,2**	**0,72**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 14343 25 20 (141)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar (141) nozzle 8 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: EN26848 2,4 mmTbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

Welding Procedure Specification (WPS)
According EN 15614-1

Welding Procedure Specification: **23-0193-16 Rev. 1**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **FW (135)**

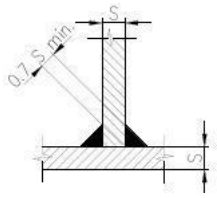
Parent Material Designation: **EN 15608 Gr. 1.2**

Material thickness (mm): **10**

Welding Position: **PA**

Weld Preparation Details (Sketch)

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input Max (EN 1011-1) (kJ/mm)
1-N	**135**	**1**	**208-210**	**27-29**	**DCEP**	**130-330**	**6,6 – 6,7**	**0,73**

Bevel cleaning method: **GRINDING**

Weld cleaning method: **BRUSHING, GRINDING**

Filler Material Designation and Make: **EN ISO 14341-A G 42 4 M G3Si1 (135)**

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: − Shielding: **Ar + CO2 (135) nozzle 14 mm**

Oscillation: amplitude, frequency, dwell time: **N.A.**

− Backing**:** **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate: − Shielding: **15 lt/min (135)**

Distance contact tube/work piece: **N.A.**

− Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size**: N.A.**

Torch angle: **75°**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature: **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

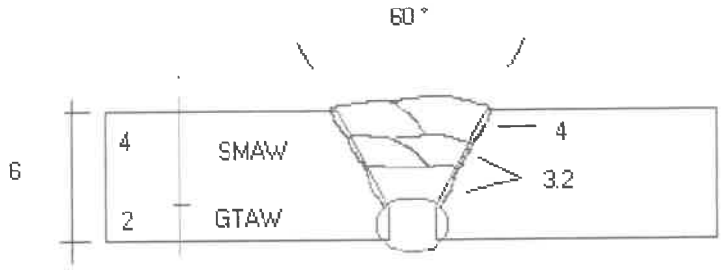
Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. VIANELLI A. Vianelli **TICI S.r.l.** **8 October 2024**

QW - 483	CERTIFICATO DI QUALIFICA DI PROCEDIMENTO *PROCEDURE QUALIFICATION REPORT*				
SOCIETA' *COMPANY NAME*	TICI S.R.L. - MONTODINE - (CR)				
CERTIF. DI QUALIFICA DI *ROCED.* *PROCEDURE QUALIFICATION REPORT*	PQR NR° R05/00	DATA *DATE*	05/09/00	WPS N° *WPS N°*	05-00
PROCEDIMENTO DI SALDATURA *WELDING PROCESS*	GTAW+SMAW	TIPO *TYPE*	MANUAL		

QW-402 - *JOINTS*



QW-403 - BASE METAL			QW-407 - POSTWELD HEAT TREATMENT			
SPECIFICA DEL MAT. *MATERIAL SPEC.*	A516	A240	TEMPERATURA *TEMPERATURE*	NONE		
TIPO E GRADO *TYPE AND GRADE*	70	TP310S	TEMPO *TIME*	NONE		
P N° 1 TO P N° 8 Gr. 2 *TO Gr.* 2			*ALTRO* *OTHER*	NONE		
ANALISI CHIMICA *CHEM. ANALYSIS*	C / Mn / Si / S / P / Cr / Ni / Mo		**QW-408 - GAS**	TYPE	% COMPOSIT.	Q.TY lt/min
			PROTEZIONE *SHIELDING*	ARGON	99.99	12
			AGGIUNTIVO *TRAILING*	NONE	NA	NA
SPESSORE *THICKNESS*	6	DIAMETRO *DIAMETER* NA	ROVESCIO *BACKING*	ARGON	99.99	11

QW-404 - FILLER METALS			QW-409 - ELECTRICAL CHARACTERISTICS	
SPECIFICA SFA *SFA SPECIFICATION*	5.9	5.4	CORRENTE *CURRENT*	DC
CLASSIFICAZIONE AWS *AWS CLASSIFICATION*	ER309L	E309MoL17	POLARITA' *POLARITY*	STRAIGHT + REVERSE
METALLO D'APPORTO *FILLER METAL - F Nr.*	6	5	AMPERE *AMPERES*	GTAW 120 - SMAW 115-150
ANALISI DELLA SALD. *WELD METAL ANALYSIS A N°*	8	8	VOLT *VOLT*	GTAW 15 - SMAW 24
DIAMETRO MATER. D'APPORTO *SIZE OF FILLER METAL*	2.4	3.2 - 4	DIMENS. ELETTR. AL TUNGSTENO *TUNGSTEN ELECTRODE SIZE*	EW Th 2 DIA 2.4
METALLO DI SALD. DEPOSITATO *WELD METAL THICKNESS*	2	4	**QW-410 - TECHNIQUE**	
QW-405 - POSITION			VELOCITA' DI LAVORO *TRAVEL SPEED*	GTAW 9 cm/min SMAW 24/55 - 29 cm/min
POSIZIONE DELLO SMUSSO *POSITIION OF GROOVE*	1G		PASS. STRETTA O LARGA *STRING OR WEAVE BEAD*	STRING
PROGRESS. DELLA SALD. *WELD PROGRESSION*	NA		OSCILLAZIONE-AMPIEZZA *OSCILLATION-AMPLITUDE*	NONE
QW-406 - PREHEAT			PASS. MULTIPLA/SINGOLA (PER LATO) *MULTIPLE /SINGLE PASS (FOR SIDE)*	MULTIPLE
TEMP. DI PRERISCALDO *PREHEAT TEMPERATURE*	20 °C		ELETTRODO MULTIPLO O SINGOLO *SINGLE OR MULTIPLE ELECTRODE*	SINGLE
TEMP. DI INTERPASS *INTERPASS TEMPERAT.*	150 °C		APPORTO TERMICO *HEAT INPUT*	GTAW - 12000 SMAW 3.2 - max 6900 SMAW 4 - 7448
ALTRO *OTHER*	NONE			

QW - 483 (BACK)	PQR N° R05/00

PROVA DI TRAZIONE
TENSILE TEST (QW-150)

NR. PROVINO *SPECIMEN NR.*	LARGH. *WIDTH mm*	SPESSORE *THK mm*	AREA *AREA mmq*	CARICO TOT. *ULT. TOT. LOAD*	*ULT. UNIT STRESS N/mmq*	CAR. FRATT. *CHARACT.OF FAIL*
258/1	18.8	5.8	109.04	63500	582	BM 516/70 SIDE
258/2	18.8	5.8	109.04	64000	587	BM 516/70 SIDE

PROVA DI PIEGA GUIDATA
GUIDED BEND TEST (QW-160)

NR. E TIPO DELLA PROVA *TYPE AND FIGURE NR. 462.3(a)*	RISULTATO *RESULT*
258/1 - ROOT	SATISFACTORY
258/2 - FACE	SATISFACTORY
258/3 - ROOT	SATISFACTORY
258/4 - FACE	SATISFACTORY

PROVE DI RESILIENZA
TOUGHNESS TESTS (QW-170)

NR. E TIPO DELLA PROVA *TYPE AND FIGURE NR. 462.3(a)*				RISULTATO *RESULT*				
NR. PROV. *SPECIM. NR.*	LOC. INTAGL. *NOTCH LOCAT.*	TIPO DI INT. *NOTCH TYPE*	T. DI PROVA *TEST TEMP.*	VAL. RESIL. *IMPACT VAL.*	*LATERAL EXPANSION* % SHEAR	mm	*DROP WEIGHT* BREAK	NO-BREAK
258/1-2	BM SS/CS	KV	-45 °C	72.3 / 25.4 J		1.75 (SS)		
258/1-2	BM SS/CS	KV	-45 °C	68.9 / 26.1		1.58		
258/1-2	BM SS/CS	KV	-45 °C	72.8 / 24.8		1.44		
258/3-4	HAZ SS/CS	KV	-45 °C	25.0 / 25.2		0.64		
258/3-4	HAZ SS/CS	KV	-45 °C	29.7 / 22.2		0.99		
258/3-4	HAZ SS/CS	KV	-45 °C	29.8 / 20.1		0.87		
258/5	WM	KV	-45 °C	28.1		0.92		
258/5	WM	KV	-45 °C	28.1		1.00		
258/5	WM	KV	-45 °C	28.1		0.97		

PROVE DI SALDATURA D'ANGOLO
FILLET WELD TEST (QW-180)

RISULTATO SODDISFACENTE: *RESULT SATISFACTORY:*	SI *YES*	NO *NO*	PENETR. NEL METALLO BASE: *PENETR. INTO PARENT METAL:*	SI *YES*	NO *NO*
RISULTATI MACRO *MACRO RESULTS*					

ALTRE PROVE
OTHER TESTS

TIPO DI PROVA *TYPE OF TEST*	HV10 : WM max 222 - HAZ/CS max 214 - HAZ/SS max 195 - BM/CS max 177 BM/SS max 171		
ANALISI DEL DEPOSITO *DEPOSIT ANALYSIS*			
NOME DEL SALDATORE *WELDER'S NAME*	DENTI GIOVANNI	NR. DI MATR. *CLOCK NR.*	NR. PUNZONE *STAMP NR.*
PROVE CONDOTTE DA *TESTS CONDUCTED BY*	BODYCOTE	NR. CERT. DI LABOR. *LABORATORY TEST NR.*	68538

SI CERTIFICA CHE QUANTO ESPOSTO NEL PRESENTE CERTIFICATO E' CORRETTO E CHE LA SALDATURA PREPARATA E' STATA PROVATA IN ACCORDO CON I REQUISIT DELLA SEZ. IX DEL CODICE ASME

WE CERTIFY THAT THE STATEMENTS IN THIS RECORD ARE CORRECT AND THAT THE TEST WELDS WERE PREPARED, WELDED AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF SECT. IX OF THE ASME CODE

T.I.C.I. S.r.l.

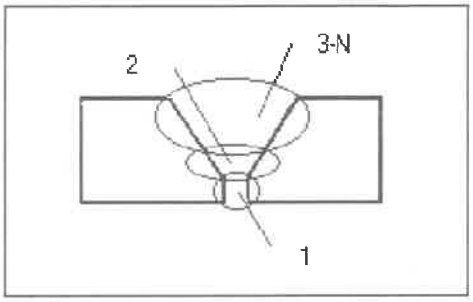
COSTRUTTORE MANUFACTURER	Via Garibaldi - Zona PIP 26010 MONTODINE (CR) Tel.+Fax 0373-242256
DATA *DATE* 05/09/00	DA BY

QW - 482	SPECIFICA DI SALDATURA *WELDING PROCEDURE SPECIFICATION* *According to ASME Code Sect. IX*	*W.P.S. N°* 05-00 Sh. 1 of 2

PER QUALIFICA / *FOR QUALIFICATION*

SOCIETA' COMPANY	TICI S.R.L. - MONTODINE - (CR)			COMP. *BY*	V. THEVENET
SPECIFICA PROC. SALDATURA *WELDING PROCEDURE SPECIF.*	05-00	DATA *DATE*	01/08/00	SUPPORTING PQR N°	R05-00
PROCEDIMENTO DI SALDATURA *WELDING PROCESS*	GTAW + SMAW	TIPO *TYPE*	MANUAL		

QW-402 - GIUNTI - *JOINTS*



DIS. DEL GIUNTO *JOINT DESIGN*	V - GROOVE	SUPPORTO *SUPPORT*	YES NO	SMAW GTAW	MATERIALE SUPP. *BACK MAT. TYPE*	WELD METAL	

QW-403 - METALLO BASE - *BASE METAL*

SPECIFICA DEL MAT. *MATERIAL SPEC.*	A516		A240	
TIPO E GRADO *TYPE AND GRADE*	70		TP310S	
P N°	1		8	
Gr.	2		2	
ANALISI CHIMICA CHEM. ANALYSIS	C Mn Si S P Cr Ni Mo		C Mn Si S P Cr Ni Mo	
GAMMA DI SPESSORI *THICKNESS RANGE*	GROOVE		FILLET	
METALLO BASE *BASE METAL*	6		NA	
DIA. TUBI - GAMMA SMUSSO *PIPE DIAM. - RANGE THK*	PLATE		NA	
ALTRO *OTHER*	NONE		NONE	

QW-404 - METALLO D'APPORTO - *FILLER METAL*

	GTAW	SMAW		
SPECIFICA SFA *SFA SPECIFICATION*	5.9	5.4		
CLASSIFICAZIONE AWS *AWS CLASSIFICATION*	ER309L	E309MoL-17		
METALLO D'APPORTO *FILLER METAL - F Nr.*	6	5		
ANALISI DELLA SALD. *WELD METAL ANALYSIS A N°*	8	8		
DIAMETRO MATER. D'APPORTO *SIZE OF FILLER METAL*	2.4	3.2 - 4		
METALLO DI SALD. DEPOSITATO *WELD METAL THICKNESS*				
GAMMA DI SPESSORI SALD. D'ANGOLO / *FILLET*	NA	NA		
THICKNESS RANGE SMUSSO / *GROOVE*	2	4		
FILO FLUSSO *ELECTRODE - FLUX (CLASS)*	NA	NA		
DENOMINAZIONE COMMERCIALE FLUSSO *FLUX TRADE NAME*	NA	NA		
INSERTO CONSUMABILE *CONSUMABLE INSERT*	NONE	NA		

QW - 482	SPECIFICA DI SALDATURA *WELDING PROCEDURE SPECIFICATION* *According to ASME Code Sect. IX*	*W.P.S. N°* **05-00** Sh. 2 of 2

PER QUALIFICA / *FOR QUALIFICATION*

QW-405 - POSIZIONE - ***POSITION***		**QW-407** - TRATT.TERMICO-***POSTWELD HEAT TREATM.***	
PROGRESSIONE SALD. (UP) (DOWN) *WELD PROGRESS*	NA	TEMPERATURA *TEMPERATURE*	NONE
POSIZIONE SMUSSO *GROOVE POSITIONS*	FLAT	TEMPO DI MANTENIMENTO *TIME RANGE*	NONE
POS. D'ANGOLO *FILLET POSITION(S)*	NA	ALTRO *OTHER*	NONE

QW-406 - PRERISCALDO - *PREHEAT*		**QW-408 - GAS**	*GAS TYPE*	%COMPOSIT.	Q.TY lt/min
TEMP. PRERISCALDO *PREHEAT TEMP. MIN.*	10 °C	PROTEZ. *SHIELDING*	ARGON	99.99	10 - 14
TEMP. INTERPASS. MAX. *INTERPASS. TEMP. MAX.*	150 °C	AGGIUNTIVO *TRAILING*	NONE	NA	NA
MANTENIMENTO *PREHEAT MAINTENANCE*		ROVESCIO *BACKING*	ARGON	99.99	9 - 13

QW-409 - CARATTERISTICHE ELETTRICHE - *ELECTRICAL CHARACTERISTICS*			
CORRENTE C.A. - C.C *CURRENT A.C. - D.C.*	D.C.	POLARITA' *POLARITY*	STRAIGHT + REVERSE
CAMPO *AMPS RANGE*	SEE TABLE	CAMPO VOLTS *VOLTS RANGE*	SEE TABLE
TIPO E DIAMETRO ELETTRODO AL TUNGSTENO *TUNGSTEN ELECTRODE SIZE(S) AND TYPE*	SFA 5.12 AWS EW Th2 DIA 2.4 2% THORIATED		
CARATT. DELL'ARCO PER GMAW *MODE OF METAL TRANSFER FOR GMAW*	NA		
GAMMA DI VELOCITA' ALIMENT. FILO *ELECTRODE WIRE SPEED RANGE*	NA		

QW-410 - PROCEDIMENTO - *TECHNIQUE*			
PASSATA STRETTA O LARGA *STRING OR WEAVE BEAD*	STRING		
DIMENSIONI UGELLO *ORIFICE OR GAS CUP SIZE*	8		
PULIZIA FRA LE PASSATE *INITIAL OR INTERPASS CLEANING*	BRUSHING - GRINDING		
METODO DI RIPRESA AL ROVESCIO *METHOD OF BACK GOUGING*	NONE		
OSCILLAZIONE *OSCILLATION*	NONE	FREQUENZA *FREQUENCY*	H.F. STARTING
DISTANZA UGELLO DI CONTATTO - PEZZO *CONTACT TUBE TO WORK DISTANCE*	NA		
PASSATA SINGOLA O MULTIPLA (PER LATO) *MULTIPLE OR SINGLE PASS (FOR SIDE)*	SINGLE GTAW - MULTIPLE SMAW		
ELETTRODO MULTIPLO O SINGOLO *MULTIPLE OR SINGLE ELECTRODE*	SINGLE		
CAMPO VELOCITA' SALDATURA *TRAVEL SPEED (RANGE)*			
MARTELLATURA *PEENING*	NONE		

STRATI DI SALDATURA *WELD LAYERS*	PROC. DI SALDATURA *WELDING PROCESS*	METALLO D'APPORTO *FILLER METAL* CLASSIFICAZIONE *CLASS*	 DIAMETRO *DIAMETER*	CORRENTE *CURRENT* POLARITA' *POLARITY*	 GAMMA AMP. *AMPS RANGE*	GAMMA VOLTAGGIO *VOLTS RANGE*	GAMMA DI LAVORO *TRAVEL SPEED RANGE. cm/min*	ALTRO *OTHER KJ/mm*
1	GTAW	ER309L	2.4	STRAIGHT	110-120	14-16	8-10	
2	SMAW	E309MoL17	3.2	REVERSE	110-130	22-25	20-60	
3-N	SMAW	E309MoL17	4	REVERSE	140-160	22-25	20-30	

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METAL TECHNOLOGY
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e-mail: bodycote@tin.it
web site: www.bodycote-mt.com

Report n. RPR N° 68538
issue Rev.0
according to EN 10204, type : 3.1C

T.I.C.I.SRL
Via Garibaldi - Zona PIP
26010 Montodine CR
Italy

Your ref.	Order n.	159	data	22/08/2000
Our ref.	Report n.	68538	data	05/09/2000
	Job n.	30768	data	22/08/2000

Remarks Welding Process : 1 GTAW ø 2.4 - 2÷4 SMAW ø 3.25 - 5÷6 SMAW ø 4
ER309L+E309MoL17

Standard ref. ASME IX ED.98 + 99 ADD - ASME B31.3

This Report is made of n° 6 **pages including this cover plus the following pages**

Test	Pag.	Test	Pag.
Macrographic examination	1	Tensile test	1
Hardness survey	1		
Bend test	1		
Impact test	1		

This Report (RPR) contains tests results on the following materials

Ref.	Identification	Material	DN / THK [mm]	Remarks
27258	Welded Coupon PQR R05-00	A240 Tp310S+A516 Gr.70	6.00	

Laboratory Manager | Customer | Customer | Inspector | Inspector

Bodycote MATERIALS TESTING S.r.l.

TCI

ÜTV 4

0 5 SET 2000

Condizioni generali:
1. Il committente si impegna a sottostare alle condizioni generali e tariffe stabilite dal Laboratorio per l'esecuzione delle prove.
2. I risultati delle prove verranno comunicati solo per mezzo di rapporto di prova , salvo diversi accordi contrattuali.
3. Il materiale residuato di prova verrà inviato a rottame dopo 10 giorni della stessa, salvo diversa richiesta scritta del Committente.
4. Il materiale giacente verrà inviato a rottame dopo 3 mesi dal ricevimento, salvo diversa richiesta scritta del Committente.
5. Il pagamento delle prove dovrà essere effettuato al ritiro del rapporto di prova , salvo diversi accordi contrattuali.

This test certificate may not be reproduced other than in full except with the prior written approval of the issuing laboratory

Mod. 06_ rev. 0 del 29/10/99

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Report n. RPR N° 68538

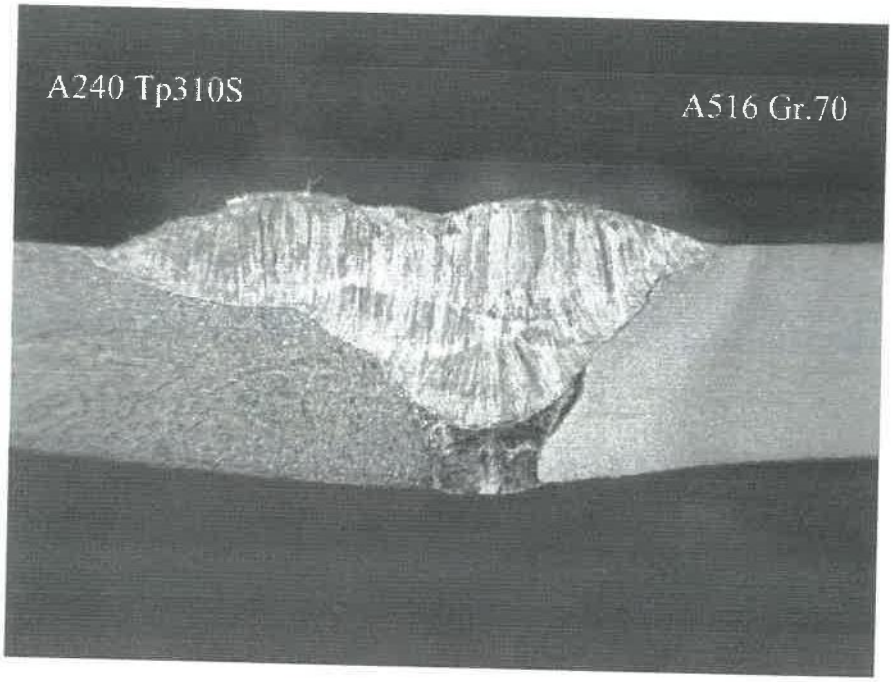
Equipment n.

PHOTOGRAPHIC DOCUMENTATION

Test Ref.	Laboratory	Client
258_1	1	R05-00

Etching : 75% HCl 25% HNO3

Magnification : x 5



R05-00

M1

Standard ref. ASME IX ED.98 + 99 ADD.

Remarks

Operator Customer Customer Inspector Inspector

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UTV 4

05 SET 2000

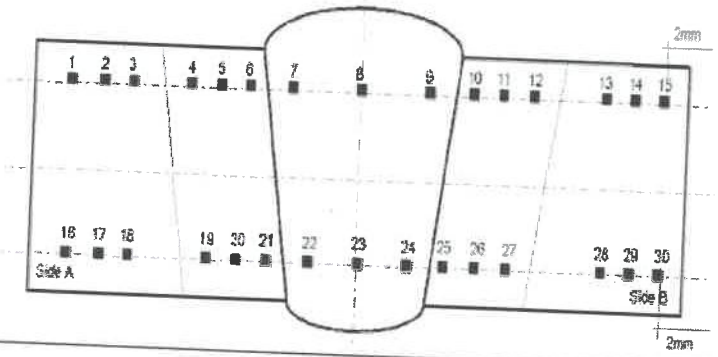
This page is binded to references n. 68538 (job 30768) whose details are indicated on the cover

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Report n. RPR N° 68538

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Equipment n.	HARDNESS TEST
8	



R05/00
M1

Method. Point #	HV 10 Value
258_1 #1	164.0
258_1 #2	169.0
258_1 #3	171.0
258_1 #4	188.0
258_1 #5	186.0
258_1 #6	187.0
258_1 #7	214.0
258_1 #8	222.0
258_1 #9	218.0
258_1 #10	214.0
258_1 #11	206.0
258_1 #12	202.0
258_1 #13	177.0
258_1 #14	176.0
258_1 #15	177.0
258_1 #16	164.0
258_1 #17	164.0
258_1 #18	161.0
258_1 #19	195.0
258_1 #20	194.0

Method. Point #	HV 10 Value
258_1 #21	191.0
258_1 #22	205.0
258_1 #23	196.0
258_1 #24	177.0
258_1 #25	209.0
258_1 #26	203.0
258_1 #27	182.0
258_1 #28	171.0
258_1 #29	166.0
258_1 #30	175.0

Method. Point #	- Value

Method. Point #	- Value

Method. Point #	- Value

Standard ref. ASME IX ED.98 + 99 ADD.

Remarks SIDE-A: SS
SIDE-B: CS

Operator | Customer | Customer | Inspector | Inspector

This page is binded to references n. 68538 (job 30768) *whose details are indicated on the cover*

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Report n. RPR N° 68538
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Equipment n. 0086/01

BEND TEST

Test Ref. Lab.	Test Ref. Client	T Test °C	Posizione Position	Dimensioni Dimensions mm			Mandrino Jig mm	α Deg.	Esito Results	Note Remarks	Rif. Ref.
268_1	PI1	R05-00	+20	Root Bend	38.00	x 6.00	4Thk.	180	OK		
268_2	PI1	R05-00	+20	Face Bend	38.00	x 6.00	4Thk.	180	OK		
268_3	PI1	R05-00	+20	Root Bend	38.00	x 6.00	4Thk.	180	OK		
268_4	PI1	R05-00	+20	Face Bend	38.00	x 6.00	4Thk.	180	OK		

Standard ref. ASME IX ED. 98 + 99 ADD.

Remarks

Operator | Customer | Customer | Inspector | Inspector

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Equipment n. 10

IMPACT TEST

Test Ref. Lab.	Test Ref. Client	T Test °C	Posizione Position	Dimensioni Dimensions mm			Intaglio Notch	Richiesti Required	A Single 8		>=0.38	B Single 8		>=0.38	C Single 8		>=0.38	10	
									Valore Value J	Shear %	Lateral E.	Valore Value J	Shear %	Lateral E.	Valore Value J	Shear %	Lateral E.	Media Average J	Rif. Ref.
268_1	R05-00	-45	BM (Side 310S)	10	x	5.00	KV		72.3		1.75	68.9		1.58	72.8		1.44	71.3	
268_2	R05-00	-45	BM (Side Gr.70)	10	x	5.00	KV		25.4		1.02	26.1		1.12	24.8		1.07	25.4	
268_3	R05-00	-45	HAZ (Side 310S)	10	x	5.00	KV		25.0		0.64	29.7		0.99	29.8		0.87	28.2	
268_4	R05-00	-45	HAZ (Side Gr.70)	10	x	5.00	KV		25.2		0.78	22.2		0.73	20.1		0.70	22.5	
268_5	R05-00	-45	WM	10	x	5.00	KV		28.1		0.92	28.1		1.00	28.1		0.97	28.1	

Standard ref. ASME IX ED.98 + 99 ADD. ASME B31.3

Remarks (REQUIRED FOR Dim. 10x10 Single = 16 J , Average = 20 J)

Operator | Customer | Customer | Inspector | Inspector

Bodycote MATERIALS TESTING S.r.l.

TIG

UTV 05 SET 2000

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Report n. RPR N° 68538
issue Rev.0

Equipment n. 2

TENSILE TEST

Test Ref. Lab.	Test Ref. Client	T Test °C	Posizione Position	Dimensioni Dimensions mm			Sezione Section mm²	Lo L1 mm	Lt L2 mm	Re N/mm²	Rp 0.2% N/mm²	Rp 0.5% N/mm²	Rp 1% N/mm²	E	Rm N/mm²	At %	Z %	Rif. Ref.
Richiesti Required		A516													>=515			
		A240													485÷620			
268_1	R05-00	+20	T	18.8	x	5.80	109.04			-	-	-	-		582	-		*
268_2	R05-00	+20	T	18.8	x	5.80	109.04			-	-	-	-		587	-		*

Standard ref. ASME IX ED.98 + 99 ADD.

Remarks Broken out of weld A516 Gr 70 side

Operator Customer Customer Inspector Inspector

Bodycote MATERIALS TESTING S.r.l.

This page is binded to references n. 68538 (job 30768) whose details are indicated on the cover

Welding Procedure Qualification Record Form (WPQR)

Welding procedure qualification - Test certificate

Manufacturer's WPQR No.:	**EN-R02/14**	Reference No.: **WPQR 14002** - File No.: **Z0492434**	
Manufacturer:	**TICI S.R.L.**	Examiner or examining body: **DNV-GL-B.A. ITALIA S.r.l.**	
Address:	**VIA DELL'ARTIGIANATO 6 MONTODINE (CR)**		
Code / Testing Standard:	**EN 15614-1**		
Date of Welding:	**03/07/2014**		

Range of qualification

Welding process(es):	**141 + 135 (ISO 4063)**
Type of joint and weld:	**BW, FW, ss, bs (141, 135) - nb, mb, sl (141) - mb, ml (135)**
Parent material group(s) and sub group(s):	**EN 15608 Gr. 1 - Covers the equal or lower specified yield strength steels of the same group**
Parent Material Tickness (mm) Butt Welds:	**7 ÷ 28**
Parent Material Tickness (mm) Fillet Welds:	**7 ÷ 16,8**
Weld Metal Thickness (mm) Butt Welds:	**1,4 ÷ 2,6 (141)** **3 ÷ 24 (135)**
Throat Thickness (mm):	**1,5 ÷ 3 (141)** **ALL (135)**
Single run / Multi run:	**SINGLE RUN (141)** **MULTI RUN (135)**
Outside Pipe Diameter (mm):	**> 150 mm (PA, PC ROTATED) - > 500 mm (OTHER POSITIONS)**
Filler Material Designation:	**EN ISO 636-A W42 4 W2Si1 (141)** **EN ISO 14341-A G 42 4 M G3Si1 (135)**
Filler Material Make:	**N.A.**
Filler Material Size:	**ALL, WITHIN HEAT INPUT LIMITS BELOW**
Designation of Shielding Gas / Flux:	**I1 (141) (ISO 14175)** **AR-CO2 M21 (135) (ISO 14175)**
Designation of Backing Gas:	**N.A.**
Type of Welding Current and Polarity:	**DCEN (141)** **DCEP (135)**
Mode of Metal Transfer:	**PULSED ARC**
Heat Input:	**MAX 2 kJ/mm WITH IMPACT TESTING (141)** **MIN 0,9 kJ/mm WITH HARDNESS TESTING (141)** **MAX 0,9 kJ/mm WITH IMPACT TESTING (135)** **MIN 0,5 kJ/mm WITH IMPACT TESTING (135)**
Welding Positions:	**ALL EXCEPT FOR PG AND J-L045**
Preheat Temperature:	**MIN 20 °C**
Interpass Temperature:	**MAX 150 °C**
Post-Heating:	**N.A.**
Post-Weld Heat-Treatment:	**N.A.**
Other Information:	**NONE**

Certified that test welds prepared, welded and tested satisfactorily in accordance with the requirements of the code / testing standard indicated above.

TICI S.R.L. - MONTODINE (CR)
Location

29/07/2014
Date of Issue

DET NORSKE VERITAS 1864
This document is accepted by DET NORSKE VERITAS ITALIA SRL Notified Body 0496 for 97/23/EC (PED)
Date: 29/7/14

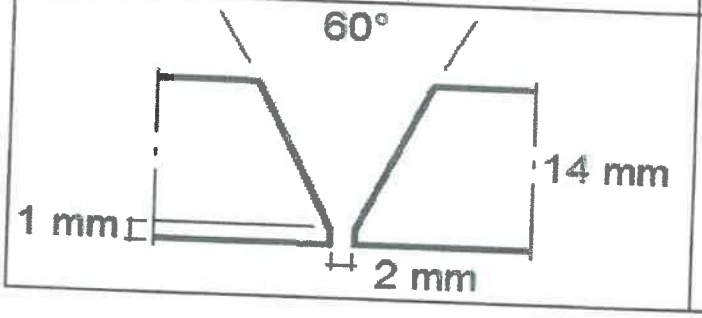
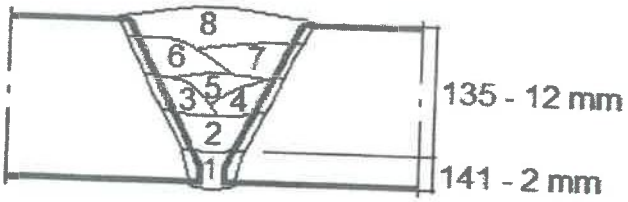
G. MASTANTUONO

Record of weld test

Location: **VIA DELL'ARTIGIANATO 6 MONTODINE (CR)**
Manufacturer's pWPS No.: **EN-02-14**
Manufacturer's WPQR No.: **EN-R02/14**
Manufacturer: **TICI S.R.L.**
Welder's Name: **BIANCHESSI OMAR - OB**
Mode of Metal Transfer: **PULSED SEMI-AUTOMATIC (135)**
Joint Type and Weld:
BW, P, ss (141, 135) - nb, sl (141) - mb, ml (135)

Examiner or examining body: **DNV-GL-B.A. ITALIA S.r.l.**
Reference No.: **WPQR 14002** - File No.: **Z0492434**
Method of Preparation and Cleaning: **BRUSHING GRINDING**
Parent Material Specification: **EN 15608 Gr.1.2 EN 10028-3 P275NH**
Material Thickness (mm): **14**
Outside Pipe Diameter (mm): **N.A.**
Welding Position: **PA**

Weld Preparation Details (Sketch):

Joint Design	Welding Sequences
	

Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input EN 1011-1 (kJ/mm) (*)	Metal transfer
1	141	2,4	144 - 146	11 - 13	DCEN	N.A.	0,7 - 0,8	1,2 - 1,6	N.A.
2 ÷ 8	135	1	208 - 210	27 - 29	DCEP	130 - 330	6,6 - 6,7	0,7	PULSED

(*) EN 1011-1 : $Q=k*(V*A/speed)*10^{-3}$ - k = 0,6 (141), 0,8 (135)

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 SIDERGAS (141)**
EN ISO 14341-A G 42 4 M G3Si1
SAF-FRO FILCORD-C (135)

Any Special Baking or Drying: **NONE**

Gas/Flux: Shielding: (ISO 14175) **I1 (141) nozzle 8 mm**
AR-CO2 M21 (135) nozzle 14 mm
Backing: **N.A.**

Gas Flow Rate: Shielding: **13 lt/min (141)**
15 lt/min (135)
Backing: **N.A.**

Tungsten Electrode Type/Size: **EN 26848 2,4 mm Tbi M3 WG-La15 (141)**

Details of Back Gouging/Backing: **N.A.**

Preheat Temperature: **20 °C**

Interpass Temperature: **150 °C**

Post-Heating: **N.A.**

Post-Weld Heat Treatment: **N.A.**

(Time, Temperature, Method : **N.A.**

Heating and Cooling Rates): **N.A.**

Other information, e.g.:
Weaving (maximum width of run): **N.A.**
Oscillation : amplitude, frequency, dwell time: **N.A.**
Pulse welding details: **SEMI-AUTOMATIC**
Distance contact tube/work piece: **N.A.**
Plasma welding details: **N.A.**
Torch angle: **75°**

A. MARZI - 29/07/2014
TICI S.R.L. - MONTODINE (CR)
Manufacturer
(name, signature, date)

This document is accepted by DET NORSKE VERITAS Notified Body 0496 for 97/23/EC (PED)
Det Norske Veritas
E. MASTANTUONO

Test results

Manufacturer's WPQR No.: **EN-R02/14**
Visual: **FBR CONTROL - VT 186/14B**
Penetrant: **FBR CONTROL - PT 285/14B**
Tensile Tests: **EXOVA - 180005**

Examiner or examining body: **DNV-GL-B.A. ITALIA S.r.l.**
Reference No.: **WPQR 14002** - File No.: **Z0492434**
Radiography: **FBR CONTROL - RT 260/14B**
Ultrasonic: **NONE**
Temperature: **20 °C**

Type/No.	Re N/mm²	Rm N/mm²	A % on	Z %	Fracture Location	Remarks
Requirement		415 ÷ 550				
223.TR1.01 / T		481			OUT OF WELD	
223.TR1.02 / T		483			OUT OF WELD	

Bend Tests — Former Diameter: **40 mm**

Type/No.	Bend Angle	Elongation	Results
223.PI1.01 / SIDE T	180°		NO DEFECT
223.PI1.02 / SIDE T	180°		NO DEFECT
223.PI1.03 / SIDE T	180°		NO DEFECT
223.PI1.04 / SIDE T	180°		NO DEFECT

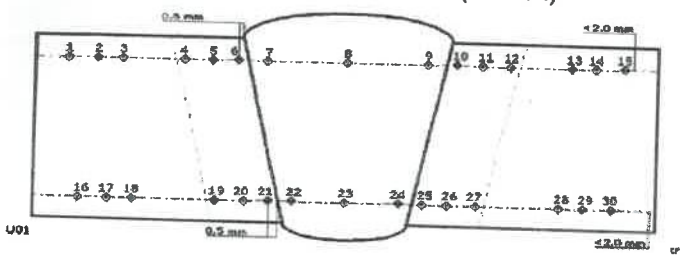
Macroscopic Examination: **EXOVA 180005**

Impact Test — Type: **KV2** — Size: **10 x 10 mm** — Requirement: **27 J**

Notch Location/Direction	Temp. °C	Values 1	2	3	Average	Remarks
223.RE2.01 / WM (1 mm CAP)	-20	143	155	129	142	
223.RE2.02 / HAZ (1 mm CAP)	-20	181	166	228	192	
223.RE2.03 / WM (1 mm ROOT)	-20	148	147	153	149	
223.RE2.04 / HAZ (1 mm ROOT)	-20	238	225	232	232	

Hardness Test (Type/Load): **MAX 380 HV 10**
Parent Metal: **142 - 141 - 144 - 139 - 147 - 146 - 145 - 149 - 146 - 144 - 140 - 142**
HAZ: **177 - 188 - 218 - 195 - 197 - 187 - 158 - 156 - 161 - 152 - 160 - 155**
Weld metal: **203 - 179 - 191 - 145 - 150 - 146**

Location of Measurements (Sketch)



Other Tests: **NONE**
Remarks: **NONE**
Tests Carried out in accordance with the requirements of: **EN 6892-1, EN 5173, EN 148-1, EN 6507-1**
Laboratory Report Reference No.: **EXOVA 180005**
Test results were **ACCEPTABLE**
Tests carried out in presence of: **E. MASTANTUONO NB 0496 DNV-GL - A. MARZI TICI S.R.L.**

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Welding Procedure Specification (Pwps/WPS)

Welding Procedure Specification: **EN-02-14**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **PULSED AUTOMATIC (135)**

Joint Type and Weld Type: **BW, P, ss (141, 135) - nb, sl (141) - mb, ml (135)**

Weld Preparation Details (Sketch)

Method of Preparation and Cleaning: **GRINDING BRUSHING**

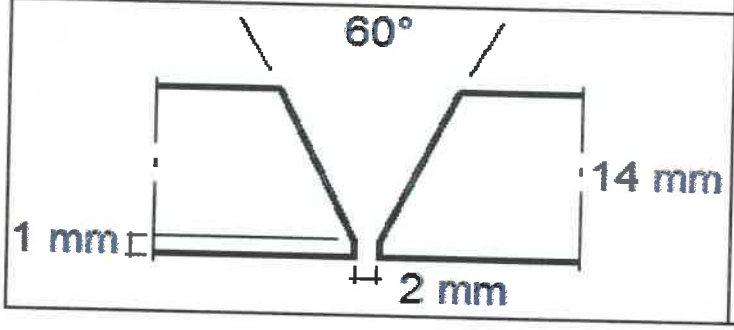
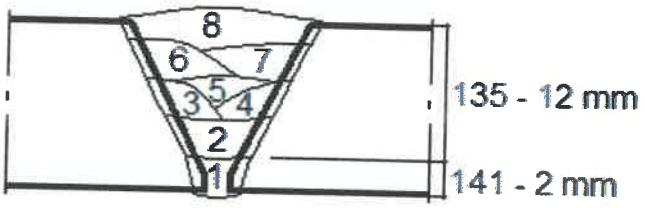
Parent Material Designation: **EN 15608 Gr. 1.1**

EN 10028-3 P275NH

Material thickness (mm): **14**

Outside Diameter (mm): **N.A.**

Welding Position: **PA**

Joint Design	Welding Sequences
	

Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input (EN 1011-1) (kJ/mm)
1	141	2,4	144 - 146	11 - 13	DCEN	N.A.	0,7 - 0,8	1,2 - 1,6
2 ÷ 8	135	1	208 - 210	27 - 29	DCEP	130 - 330	6,6 - 6,7	0,7

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 SIDERGAS (141)**
EN ISO 14341-A G 42 4 M G3Si1
SAF-FRO FILCORD-C (135)

Any Special Baking or Drying: **NONE**

Designation Gas/Flux: - Shielding: **I1 (141) nozzle 8 mm**
AR-CO2 M21 (135) nozzle 14 mm

- Backing: **N.A.**

Gas Flow Rate - Shielding: **13 lt/min (141)**
15 lt/min (135)

- Backing: **N.A.**

Tungsten Electrode Type/Size: (141) **EN 26848 2,4 mm Tbi M3 WG-La15**

Details of Back Gouging/Backing: **N.A.**

Preheat Temperature: **20 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

(Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

Other information, e.g.:

Weaving (maximum width of run): **N.A.**

Oscillation : amplitude, frequency, dwell time: **N.A.**

Pulse welding details: **SEMI-AUTOMATIC (135)**

Distance contact tube/work piece: **20 mm (135)**

Plasma welding details: **N.A.**

Torch angle: **75°**

A. MARZI - 03/07/2014
TICI S.R.L. - MONTODINE (CR)
Manufacturer
(Name, signature, date)

Exova Srl
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26013 Crema (CR)
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W: www.exova.com

Test report n° *EN 10204, type :* **180005** *3.2* **Rev.0**

Client
Cod. 1263

T.I.C.I. SRL
Via Dell 'Artigianato,6
26010 Montodine CR
Italy

Your ref.	Order n.	D.D.T. n.123	data	27/06/2014
Our ref.	Report n.	**180005**	data	**29/07/2014**
	Job n.	58023	data	07/07/2014

Remarks Welding procedure Qualification EN-R02/14
Welding Process : 141+135 - Welder : OB

Project

Client Reference	UNI EN ISO 15614-1:2012
Test standard	UNI EN ISO 6892-1:2009 - UNI EN ISO 5173:2012 - UNI EN ISO 148-1:2011 - UNI EN ISO 6507-1:2006

This Report is made of n° 6 pages including this cover plus the following pages

Test	Pag.
Macrographic examination	1
Hardness test	1
Tensile test	1
Impact test	1
Bend test	1

This Report (RPR) contains tests results on the following material:

Ref.	Identification		Material	DN / Thk [mm]	Remarks
128223	Weld Plate	EN-R02/14	ASTM A516 Gr.60	14.00	

Lab Manager | Customer | Inspector | Inspector

Exova s.r.l.
Luca Cantoni

29 JUL 2014

DNV Milan 29 JUL 2014

General conditions:
1. The Customer accepts general conditions and prices fixed by the laboratory to perform the tests.
2. Test results will be communicated only by means of test report except for different contractual agreement.
3. Tests sample will be destroyed 30 days after test except for different written Client request.
4. The spare will be destroyed 90 days after date of receipt for different written Client request.
5. The test results described in the following test report are referring only to the sample mentioned in it.
6. The date of material receivement is the same as the date of job opening. The date of testing is the same as the date of test report, except for different info.
7. The laboratory has examined the material sampled an supplied by the Client in compliance with standard request.

This test report may not be reproduced other than in full except with the prior written approval of the issuing laboratory

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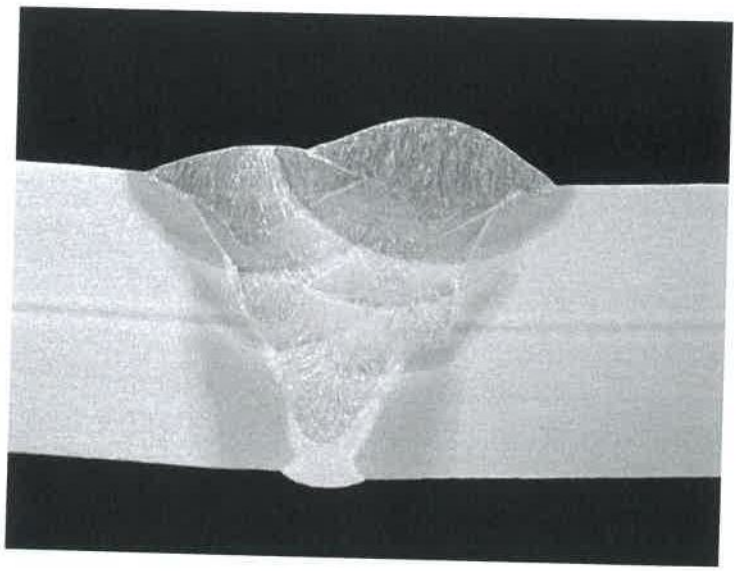
Test report n° 180005 Rev.0

Equipment n.	PHOTOGRAPHIC DOCUMENTATION	Pag. 1 of 1
1436		

Test Ref.	
Laboratory	Client
223.FO01.1	EN-R02/14

Etching : NITAL 3%

Magnification : x 2.5



EN-R02/14

M1

The macrographic examination at 25x of the weld relevant to the subject welding procedure test has shown no defects.

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 17639:2013

Remarks

Test performed in Crema Laboratory Via della Pierina 9/11

Operator	Customer	Inspector	Inspector
SPE Cristian Piloni			
Exova s.r.l.	29 JUL 2014		DNV Milan 29 JUL 2014

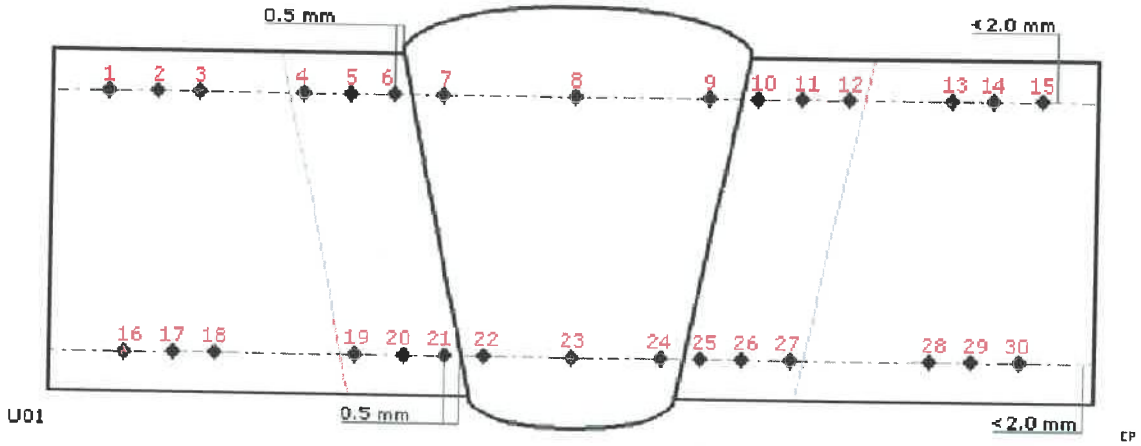
This page is binded to references n. *180005 (job 58023)* *whose details are indicated on the cover*

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Test report n° 180005 Rev.0

Equipment n.	HARDNESS TEST Internal procedure POI-07	Pag. 1 of 1
9		



EN-R02/14
M1

HV 10		HV 10		-		-		-	
Point #	Value	Point #	Value	Point #	Value	Point #	Value	Point #	Value
#1	142	#21	161	-	-	-	-	-	-
#2	141	#22	145	-	-	-	-	-	-
#3	144	#23	150	-	-	-	-	-	-
#4	177	#24	146	-	-	-	-	-	-
#5	188	#25	152	-	-	-	-	-	-
#6 Max	218	#26	160	-	-	-	-	-	-
#7	203	#27	155	-	-	-	-	-	-
#8	179	#28	144	-	-	-	-	-	-
#9	191	#29	140	-	-	-	-	-	-
#10	195	#30	142	-	-	-	-	-	-
#11	197	-	-	-	-	-	-	-	-
#12	187	-	-	-	-	-	-	-	-
#13	139	-	-	-	-	-	-	-	-
#14	147	-	-	-	-	-	-	-	-
#15	146	-	-	-	-	-	-	-	-
#16	145	-	-	-	-	-	-	-	-
#17	149	-	-	-	-	-	-	-	-
#18	146	-	-	-	-	-	-	-	-
#19	158	-	-	-	-	-	-	-	-
#20	156	-	-	-	-	-	-	-	-

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 6507-1:2006

Remarks Required : 380 HV10 Max

Test performed in Crema Laboratory Via della Pierina 9/11

Operator
SPE Cristian Pilon!
EXOVA S.r.l.

Customer
29 JUL 2014

Inspector

Inspector
Milan
29 JUL 2014

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Test report n° 180005 Rev.0

Equipment n. 1153

TENSILE TEST

Internal procedure POI-01

Richiesti *Required*														415÷550					

Test *Ref.* Lab.	Test *Ref.* Client	T *Test* °C	Posizione *Position*	Dimensioni *Dimensions* mm			Lo mm	Re N/mm²	Rp0.2% N/mm²	Rp0.5% N/mm²	Rt0.2% N/mm²	Rt0.35% N/mm²	Rt0.5% N/mm²	E	Rm N/mm²	A %	Z %	Rif. *Ref.*
223.TR1.01	EN-R02/14	+20	T Weld	25.00	x	13.60		-	-	-	-	-	-		481	-		#
223.TR1.02	EN-R02/14	+20	T Weld	25.00	x	13.10		-	-	-	-	-	-		483	-		#

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 6892-1:2009

Remarks X = Prismatic - # Broken out of weld

Rp% determined by offset method - A% = determined after fracture - Values rounded to the nearest

Test performed in Crema Laboratory Via della Pierina 9/11

Operator	Customer	Inspector	Inspector
SPE Luigi Vaiani Exova S.r.l.	TICI 29 JUL 2014		DNV Milan 29 JUL 2014

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Test report n° 180005 Rev.0

Equipment n. 814

IMPACT TEST

Internal procedure POI-02

Nominal machine energy : 450J

Test Ref. Lab.	Test Ref. Client	T Test °C	Posizione Position	Dimensioni Dimensions mm			Intaglio Notch	Richiesti Required	A Single 27 Valore Value J	A Single 27 Shear %	A Single 27 Lateral E.	B Single 27 Valore Value J	B Single 27 Shear %	B Single 27 Lateral E.	C Single 27 Valore Value J	C Single 27 Shear %	C Single 27 Lateral E.	Media Average J	Rif. Ref.
223.RE2.01	EN-R02/14	-20	WM(1mmCAP)	10	x	10.00	KV2		143			155			129			142	
223.RE2.02	EN-R02/14	-20	HAZ (1mmCAP)	10	x	10.00	KV2		181			166			228			192	
223.RE2.03	EN-R02/14	-20	WM(1mmroot)	10	x	10.00	KV2		148			147			153			149	
223.RE2.04	EN-R02/14	-20	HAZ (1mmroot)	10	x	10.00	KV2		238			225			232			232	

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 148-1:2011

Remarks

Test performed in Crema Laboratory Via della Pierina 9/11

Operator: Luigi Vailati, Exova s.r.l.

Customer: TICI, 29 JUL 2014

Inspector

Inspector: DNV Milan, 29 JUL 2014

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Test report n° 180005 Rev.0

Equipment n. 1123

BEND TEST

Internal procedure POI-03

Test Ref. Lab.	Test Ref. Client	T Test °C	Tipo Type	Dimensioni Dimensions mm			Mandrino Jig mm	Distanza rulli Distance rollers mm	Angolo angle °	Lo Lo mm	Allungamento Elongation %	Esito Results	Note Remarks	Rif. Ref.
223.PI1.01	EN-R02/14	+20	Side Bend T	10.0	x	14.0	40	66	180			No Defect		
223.PI1.02	EN-R02/14	+20	Side Bend T	10.0	x	14.0	40	66	180			No Defect		
223.PI1.03	EN-R02/14	+20	Side Bend T	10.0	x	14.0	40	66	180			No Defect		
223.PI1.04	EN-R02/14	+20	Side Bend T	10.0	x	14.0	40	66	180			No Defect		

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 5173:2012

Remarks Test method "FORMER"

Test performed in Crema Laboratory Via della Pierina 9/11

Operator: SPE Luigi Vailati, Exova S.r.l.

Customer: TICI, 29 JUL 2014

Inspector

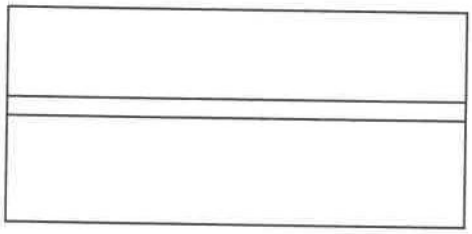
Inspector: DNV Milan, 29 JUL 2014

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FBR CONTROL TEL.02-9662740 fbrcontrol@gmail.com	CERTIFICATO CONTROLLO RADIOGRAFICO Radiographic Examination Record Page 1 of 2	RT N° 260/14B

CLIENTE – Client EXOVA		ORDINE – Order				COMMESSA – Job 58023	
DESCRIZIONE COMPONENTE ISPEZIONATO – Description of Inspected item QUALIFICA SALDATORE EN-R02/14 OB						IDENTIFICAZIONE - Identification MIF 128223	
MATERIALE – Material grade ASTM A A516°60		TRATTAMENTO T. – H.T. Condition N.A.				RANGE DI SPESSORI – Thk range 14 mm	
PROCED. D'ESAME – Examination Proc. EN ISO 15614-1		SPECIFIC / ACCETABILITY EN ISO 15614-1				MACCHIA FOCALE – Source size 1,5X1,5	
TIPO DI SORGENTE – Isotopo N.A.		TENSIONE – 300 MHF Di ENERGIA – 3mA				DENSITA' – Density 1,8÷4	
TIPO IQI – IQI Type	E.N. X	ASME	ASTM	TIPO DI PENETRAMETRO – Penetrameter type FILO – Wire X FORO – Hole			
PENOMBRA GEOMETRICA – Ug 0,042		POSIZIONE SORGENTE – Source position INTERNA – inside ESTERNA – Outside X				POSIZIONE FILM – Film position INTERNA – inside ESTERNA – Outside X	
POSIZIONE IQI - IQI Position		LATO SORGENTE - Source Side	X			LATO FILM - Film Side	
IDENTIFICAZ. IQI - Identification IQI 10 FE EN		SENSIBILITA' – Sensitività 2%				PELLICOLA – Film brand and designation D7 GEVARET	
DISTANZA SOEGENTE / PEZZO – Piece / Source Distance 700				CARICO CASSETTE- Cassette Loading SINGOLO FILM-Single film X DOPPIO FILM-Double film			
TEMPO DI ESPOSIZIONE – Exposure time 1 min.				TIPO E TEMPO DI SVILUPPO – Type & time of development G128-5 min.			
SCHERMO – Screen FRONT – Frontale 0,05 POSTERIORE – Back 0.10							
NOTE:							

MAPPATURA FILMS - Films Location Sketch



	FBR CONTROL Q.C. Inspector II Level	CLIENTE Client	Inspector
NOME - Name	LEVEL II SNT TC1 A UNI-EN 473 ISO 9712 UT RT MT PT VT	A. MARZI	
FIRMA - Signature			
DATA - Date	11/07/2014	29 JUL 2014	

FBR CONTROL TEL.02-9662740 fbrcontrol@gmail.com	CERTIFICATO CONTROLLO RADIOGRAFICO Radiographic Examination Record Page 2 of 2	RT N°260/14B

IDENTIFICAZIONE PELLICOLA Film Identification			Ø	Sp. Thk.	RADIATION THROUGHT 1 - Single W. 2 - Double W. 3 - Panoramic	X RAY Y RAY	DIFETTI Defects	GIUDIZIO Evaluation	OPERATOR Operatore
N° Serie Serial N°	GIUNTO N° Joint N°	Tratto Rad. Film Area							
MIF128223		0-1		14	1	X	P.	ACC.	OB
MIF128223		1-2		14	1	X	P.	ACC.	OB

FBR CONTROL Cogliate (MI)	NON DESTRUCTIVE TEST CERTIFICATE FOR VISUAL EXAMINATION	VT N°186/14B

CLIENTE/ Customer:**EXOVA**	COMMESSA/ Job:**58023**
DISEGNO/ Drawing:	ORDINE/ Order:
N°PROGRESSIVO/Progressiv N° :	MATERIALE/Material : **ASTM A516°60**

OBJECT/Oggetto : **QUALIFICA SALDATORE EN-R02/14 MIF128223 OB**

SURFACE CONDITIONS/Condizioni Superficie :**AS WELDED**

EXTENT OF SCANNING/Estensione del Controllo : **100% ON WELDING**

PROCEDURE/Procedura : **EN ISO 15614-1**

ACCEPT. STD./Criterio Accett. : **EN ISO 15614-1**

☐ ARTIFICIAL LIGHT/Luce Artificiale	☒ NATURAL LIGHT/Luce naturale	☐ ENDOSCOPE/Endoscopio

TECHNIQUE/Tecnica

☒ DIRETTO/Direct	☐ TRANSLUCENT/Traslucido	☐ REMOTE/Remoto

SKETCH

RESULTS/Risultati : **SATISFACTORY**

REMARKS/Note :

	OPERATOR - Operatore	CUSTOMER-Cliente	ISPECTOR
NAME-Nome:	GALLUCCI MASSIMO LEVEL II SNT TC1 A UNI EN 473 ISO 9712 UT RT MT PT VT	TM A. MARZI	
SIGNED-Firma:			
DATE-Data:	11/07/2014	29 JUL 2014	DNV Milan

FBR CONTROL TEL-02-9662740 fbrcontrol@gmail,com	N.D.E. CERTIFICATE DYE PENETRANT EXAMINATION	PT 285/14B

CUSTOMER/Cliente: EXOVA			P.O./Ordine:	
JOB N°/Commessa:58023			DRAWING:	
WORK INSTRUCTION:EN ISO 15614-1 Procedura di controllo:			ACCEPTANCE CRITERIA: EN ISO 15614 Criteri di Accettabilità	
EXAMINATION METHOD: Metodo d'esame	VISIBLE CONTRAST COLOR Contrasto di colore visivo	X	FLUORESCENT Fluorescente	
NATURAL LIGHTING: X Luce naturale: ≥ 1000 Lux	ARTIFICIAL LIGHT: Luce artificiale		WOOD LAMP/ lampada di wood:	
SURFACE CONDITION: ASWELDED Condizioni superficie			EXTENT OF INSPECTION: 100% ON WELDING Estensione del controllo	
EXAMINATION PRODUCT: Prodotti utilizzati	TYPE: Tipo		MANUFACTURER: Fabbricante	DESIGNATION: Designazione
CLEANER: PULIZIA	SOLVENT		NDT elite	BC1 BN-B1211127S
PENETRANT: Penetrante	LAVABILE CON ACQUA - Water Washable		NDT elite	K71 B2.P/PLUS BN-12118PS
PENETRANT REMOVER: Rimovente del penetrante	ACQUA - Water			
DEVELOPER: Rilevatore	UMIDO (solvente)- Wet(solvent)		NDT elite	D112A BN-10589WS
PENETRATING APPLICATION: Applicazione penetrante			BRUSH: Pennello	SPRAYING: X Spruzzatura
PENETRATION MIN TIME: 15 min Tempo di penetrazione			CLEANING: Lavaggio	WATER: Acqua X / SOLVENT: Solvente
DRYING: Asciugatura			NATURAL: Naturale	AIR: X Ad aria
DEVELOPER APPLICATION: Applicazione sviluppatore	SPRAYING Spruzzatura	X	MAX CHECKING TIME: : Tempo massimo di lettura:	10'÷30'

NOTE:

MATERIAL INSPECTED DESCRIPTION / Descrizione Materiale Ispezionato: QUALIFICA SALDATORE MIF 128223 EN-R02/14

MATERIAL:A516°60 OB

RESULT SATISFACTORY/ risultato soddisfacente

DATE OF EXAMINATION: 11/07/2014	THIRD PART	CUSTOMERS REPRESENTATIVES:
GALLUCCI MASSIMO LEVEL II SNT TC1 A UNI-EN 473 ISO 9712 UT RT MT PT VT	DNV Milan	29 JUL 2014

Welding Procedure Qualification Record Form (WPQR)

Welding procedure qualification - Test certificate

Manufacturer's WPQR No.:	**EN-R04/15**	Reference No.: **WPQR15008** - File No.: **Z0492434**
Manufacturer:	**TICI S.R.L.**	Examiner or examining body : **DNV-GL-B.A. ITALIA S.r.l.**
Address:	**VIA DELL'ARTIGIANATO 6 MONTODINE (CR)**	
Code / Testing Standard:	**EN 15614-1**	
Date of Welding:	**10/03/2015**	

Range of qualification

Welding process(es):	**141 + 111 (ISO 4063)**
Type of joint and weld:	**BW, FW, BRANCH CONNECTIONS WITH AN ANGLE ≥ 60°, ss, bs (141, 111) - nb, mb, ml (141) - mb, sl (111)**
Parent material group(s) and sub group(s):	**EN 15608 Gr. 8.2 to Gr. 8**
Parent Material Tickness (mm) Butt Welds:	**3 ÷ 12**
Parent Material Tickness (mm) Fillet Welds:	**3 ÷ 7,2**
Weld Metal Thickness (mm) Butt Welds:	**2,1 ÷ 6 (141)** **2,1 ÷ 3,9 (111)**
Throat Thickness (mm):	**ALL (141)** **2,25 ÷ 4,5 (111)**
Single run / Multi run:	**MULTI RUN (141)** **SINGLE RUN (111)**
Outside Pipe Diameter (mm):	**≥ 44,45**
Filler Material Designation:	**EN ISO 14343 25 20 (141)** **EN ISO 3581-A E 25 20 R (111)**
Filler Material Make:	**HAINEK (141) - VOESTALPINE BÖHLER WELDING AVESTA (111)**
Filler Material Size:	**ALL, WITHIN HEAT INPUT LIMITS BELOW**
Designation of Shielding Gas / Flux:	**I1 (141) (ISO 14175)**
Designation of Backing Gas:	**I1 (141) (ISO 14175)**
Type of Welding Current and Polarity:	**DCEN (141)** **DCEP (111)**
Mode of Metal Transfer:	**N.A.**
Heat Input:	**MAX 0,7 kJ/mm (141)** **MIN 0,4 kJ/mm WITH HARDNESS TESTING (141)** **MAX 0,7 kJ/mm (111)** **MIN 0,4 kJ/mm WITH HARDNESS TESTING (111)**
Welding Positions:	**ALL EXCEPT FOR PG AND J-L045**
Preheat Temperature:	**MIN 15 °C**
Interpass Temperature:	**MAX 150 °C**
Post-Heating:	**N.A.**
Post-Weld Heat-Treatment:	**N.A.**
Other Information:	**NONE**

Certified that test welds prepared, welded and tested satisfactorily in accordance with the requirements of the code / testing standard indicated above.

This document is accepted by DET NORSKE VERITAS ITALIA SRL Notified Body 0496 for 97/23/EC (PED)

TICI S.R.L. - MONTODINE (CR)	**02/04/2015**	**E. MASTANTUONO**
Location	Date of Issue	Examiner or examining body Name, date and signature

Record of weld test

Location: **VIA DELL'ARTIGIANATO 6 MONTODINE (CR)**

Manufacturer's pWPS No.: **EN-04-15**

Manufacturer's WPQR No.: **EN-R04/15**

Manufacturer: **TICI S.R.L.**

Welder's Name: **SOCCINI RICCARDO - RS**

Mode of Metal Transfer: **N.A.**

Joint Type and Weld: **BW, T, ss (141, 111) - nb, ml (141) - mb, sl (111)**

Weld Preparation Details (Sketch):

Examiner or examining body: **DNV-GL-GL-B.A. ITALIA S.r.L.**

Reference No.: **WPQR15008** - File No.: **Z0492434**

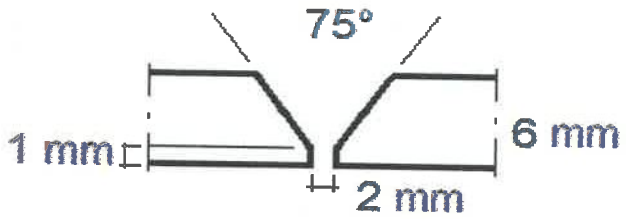
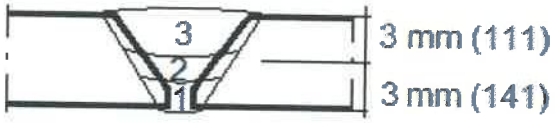
Method of Preparation and Cleaning: **BRUSHING, GRINDING**

Parent Material Specification: **EN 15608 Gr.8.2 - ASTM A240 310S**

Material Thickness (mm): **6**

Outside Pipe Diameter (mm): **88,9**

Welding Position: **PA**

Joint Design	Welding Sequences
	

Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input EN 1011-1 (kJ/mm) (*)	Metal transfer
1 - 2	141	2,4	119 - 121	9 - 11	DCEN	N.A.	1,1 - 1,2	0,5 - 0,7	N.A.
3	111	3,2	103 - 105	21 - 23	DCEP	N.A.	2,7 - 2,8	0,6 - 0,7	N.A.

(*) EN 1011-1 : $Q=k*(V*A/speed*10^{-3})$ - k = 0,6 (141), 0,8 (111)

Filler Material Designation and Make: **EN ISO 14343 25 20 HAINEK C216/24 (141)**
EN ISO 3581-A E 25 20 R VOESTALPINE
BÖHLER WELDING AVESTA 310 (111)

Any Special Baking or Drying: **NONE**

Gas/Flux: Shielding: **I1 (141) nozzle 8 mm**

Backing: **I1 (141)**

Gas Flow Rate: Shielding: **13 lt/min (141)**

Backing: **15 lt/min (141)**

Tungsten Electrode Type/Size: **(141) EN 26848 2,4 mm Tbi M3 WG-La15**

Details of Back Gouging/Backing: **N.A.**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **N.A.**

Post-Weld Heat Treatment: **N.A.**

(Time, Temperature, Method : **N.A.**

Heating and Cooling Rates): **N.A.**

Other information, e.g.:

Weaving (maximum width of run): **N.A.**

Oscillation : amplitude, frequency, dwell time: **N.A.**

Pulse welding details: **N.A.**

Distance contact tube/work piece: **N.A.**

Plasma welding details: **N.A.**

Torch angle: **75°**

A. MARZI - 02/04/2015

TICI S.R.L. - MONTODINE (CR)

Manufacturer

(Name, date and signature)

This document is accepted by DET NORSKE VERITAS ITALIA SRL Notified Body 0496 for 97/23/EC (PED)

E. MASTANTUONO

Examiner or examining body

Name, date and signature

Welding Procedure Specification (pWPS/WPS)

Welding Procedure Specification: **EN-04-15**

WPQR No.: **EN-R04/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW, T, ss (141, 111) - nb, ml (141) - mb, ml (111)**

Weld Preparation Details (Sketch)

Method of Preparation and Cleaning: **GRINDING, BRUSHING**

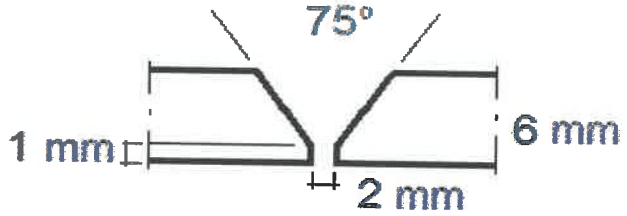
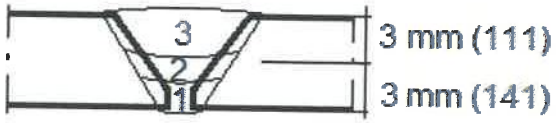
Parent Material Designation: **EN 15608 Gr. 8.2**

ASTM A240 310S

Material thickness (mm): **6**

Outside Diameter (mm): **88,9**

Welding Position: **PA**

Joint Design	Welding Sequences
	

Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input (EN 1011-1) (kJ/mm)
1 - 2	141	2,4	119 - 121	9 - 11	DCEN	N.A.	1,1 - 1,2	0,5 - 0,7
3	111	3,2	103 - 105	21 - 23	DCEP	N.A.	2,7 - 2,8	0,6 - 0,7

Filler Material Designation and Make: **EN ISO 14343 25 20 HAINEK C216/24 (141)**
EN ISO 3581-A E 25 20 R VOESTALPINE
BÖHLER WELDING AVESTA 310 (111)

Other information, e.g.:

Any Special Baking or Drying: **NONE**

Designation Gas/Flux: - Shielding: **I1 (141) nozzle 8 mm**

- Backing: **I1 (141)**

Gas Flow Rate - Shielding: **13 lt/min (141)**

- Backing: **15 lt/min (141)**

Tungsten Electrode Type/Size: **(141) EN 26848 2,4 mm Tbi M3 WG-La15**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

(Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

Weaving (maximum width of run): **N.A.**

Oscillation : amplitude, frequency, dwell time: **N.A.**

Pulse welding details: **N.A.**

Distance contact tube/work piece: **N.A.**

Plasma welding details: **N.A.**

Torch angle: **75°**

A. MARZI - 10/03/2015
TICI S.R.L. - MONTODINE (CR)
Manufacturer
(Name, signature, date)

DET NORSKE VERITAS 1864
This document is accepted by
DET NORSKE VERITAS ITALIA SRL
Notified Body 0496 for 97/23/EC (PED)
Date: 10/3/15 Sign:

Test results

Manufacturer's WPQR No.: **EN-R04/15**
Visual: **IRTEC SRL - 6457/15**
Penetrant: **IRTEC SRL - 6458/15**
Tensile Tests: **EXOVA - 183850**

Examiner or examining body: **DNV-GL-GL-B.A. ITALIA S.r.L.**
Reference No.: **WPQR15008** - File No.: **Z0492434**
Radiography: **IRTEC SRL - 6456/15**
Ultrasonic: **NONE**
Temperature: **20 °C**

Type/No.	Re N/mm²	Rm N/mm²	A % on	Z %	Fracture Location	Remarks
Requirement		**≥ 515**				
847.TR1.01		**568**			**IN WELD**	
847.TR1.02		**553**			**IN WELD**	

Bend Tests — Former Diameter: **25 mm**

Type/No.	Bend Angle	Elongation	Results
847.PI1.01 FACE	**180°**		**NO DEFECT**
847.PI1.02 FACE	**180°**		**NO DEFECT**
847.PI1.03 ROOT	**180°**		**NO DEFECT**
847.PI1.04 ROOT	**180°**		**NO DEFECT**

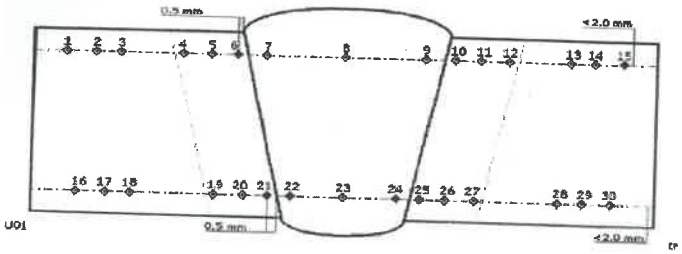
Macroscopic Examination: **EXOVA 183850**

Impact Test — Type: — Size: — Requirement:

Notch Location/Direction	Temp. °C	Values 1	2	3	Average	Remarks

Hardness Test (Type/Load): **HV10**
Parent Metal: **177 - 170 - 174 - 177 - 172 - 174 - 183 - 185 - 181 - 172 - 177 - 180**
HAZ: **165 - 157 - 150 - 150 - 149 - 162 - 162 - 164 - 159 - 168 - 170 - 167**
Weld metal: **172 - 167 - 174 - 156 - 150 - 164**

Location of Measurements (Sketch)



Other Tests: **NONE**
Remarks: **NONE**
Tests Carried out in accordance with the requirements of:
Laboratory Report Reference No.: **EXOVA 183850**
Test results were **ACCEPTABLE**
Tests carried out in presence of: **E. MASTANTUONO NB 0496 DNV-GL - A. MARZI TICI S.R.L.**

This document is accepted by DET NORSKE VERITAS ITALIA SRL Notified Body 0496 for 97/23/EC (PED)

E. MASTANTUONO
Examiner or examining body
Name, date and signature

Acciai Speciali Terni S.p.A. con Unico Socio

Viale B. Brin, 218 - 05100 Terni - Italia

AZIENDA CON SISTEMA DI GESTIONE CERTIFICATO DA IGQ SECONDO ISO 9001

11070092

SPECIFICA:
SPECIFICATION:
ANFORDERUNGEN: ASTM A 240

CERTIFICATO DI COLLAUDO EN 10204/3.1
INSPECTION CERTIFICATE
CERTIFICATE DE RECEPTION
ABNAHMEPRÜFZEUGNIS N°

1423973

ORDINE CLIENTE N°:
CUSTOMER ORDER N°:
COMMANDE DU CLIENT N°:
BESTELLUNG Nr: ORDINE 08/07/

CLIENTE:
CUSTOMER:
CLIENT:
BESTELLER: F.LLI PINATO S.N.C DI MARINA E PATR
VIALE LOMBARDIA 51/53
BRUGHERIO
20861 MB ITALIA

ORDINE INTERNO N°:
INTERNAL ORDER N°:
COMMANDE INT. N
WERKS Nr: 8X130556

C.P.C. INOX SPA
VIA MONZA 1-ZONA INDUSTRIALE
GESSATE
20060 MI ITALIA

AVV. DI SPEDIZ. N°:
SHIPPING NOTICE N°:
AVIS D'EXPEDITION N°:
VERSANDANZEIGE Nr: BP089097

PRODOTTO:
PRODUCT
PRODUIT:
PRUFGEGENSTAND: STAINLESS STEEL COILS

TIPO D'ACCIAIO:
STEEL TYPE:
TYPE D'ACIER:
MARKENBEZEICHNUNG: 310S

N° ROTOLO COIL N° N° BOBINE BAND Nr.	N° COLATA HEAT N° N° COULÉE SCHMELZE Nr.	COMPOSIZIONE CHIMICA / CHEMICAL COMPOSITION / COMPOSITION CHIMIQUE / CHEMISCHE ZUSAMMENSETZUNG												
		% C	% Mn	% Si	% P	% S	% Cr	% Ni	% Mo	% N	% Ti	Cu	Co	%
651860	0439938	.048	1.03	.510	.025	.001	24.09	19.08	.2 0	.024		.240	.190	

TIMBRO DEL PRODUTTORE:
PRODUCER TRADE MARK:
MARQUE DU PRODUCTEUR:
ZEICHEN DES LIEFERWERKS: Acciai Speciali Terni S.p.A con unico Socio

TIMBRO DEL RESPONSABILE INCARICATO:
INSPECTOR STAMP:
MARQUE DU RESPONSABLE CHARGE:
STEMPEL DES WERKSSACHVERSTÄNDIGEN:

TRATT. TERMICO - RICOTTURA DI SOLUBILIZZ.: 1100^C ARIA - ACQUA NEBULIZZATA - ACQUA
HEAT TRATMENT - ANNEALING: AIR - WATER SPRAY - WATER COOLING
TRAITEMENT - THERMIQUE - HYPERTREMPE: AIR - EAU ATOMISEE - EAU
WARMEBEHANDLUNG - ABSCHRECKEN: °C/LUFT - SPRÜHWASSER - WASSER

PROCESSO DI ELABORAZIONE: E + AOD + CC
STEELMAKING PROCESS
PROCEDE D'ELABORATION
ERSCHMELZUNGSART

IL MATERIALE È RESISTENTE ALLA CORROSIONE INTERGRANULARE SECONDO: ASTM A262 E
THE MATERIAL IS RESISTANT TO INTERCRYSTALLINE CORROSION IN DACCORDANCE WITH:
LE MATERIEL EST RESISTANT A LA CORROSION INTERGRANULAIR SELON:
DIE OBENGENANNTE SCHMELZE IST BESTÄNDIG GEGEN INTERKRISTALLINE KORROSION GEMÄSS:

RISULTATI DELLE PROVE / TEST RESULTS / RESULTATS DES ESSAIS / ERGEBNIS DER PRÜFUNGEN (1 N/mm² = 1 MPa)

N° COLLO PACKAGE N° N° COLIS KISTEN Nr.	N° ROTOLO COIL N° N° BOBINE BAND Nr.	DIMENSIONI DIMENSIONS ABMESSUNGEN mm	N° PEZZI PIECES N° N° PIECES STÜCKZAHL	FINITURA FINISH FINITION AUSFÜHRG	PESO WEIGHT POIDS GEWICHT Kg.	PRELIEVO (1)	SENSO (2)	TRAZIONE / TENSILE / TRACTION / ZUGVERSUCH Rp 0.2% N/mm²	Rp 1% N/mm²	Rm N/mm²	A % Lo = 2"	A % Lo = 80	A % Lo = A5	DUREZZA HARDNESS DURETE HÄRTE HR B	PIEGA BEND PLIAGE FALTVERSUCH a= 180°	GRANA GRAIN KORN Scala
CARATTERISTICHE RICHIESTE - REQUIRED CHARACTERISTICS - CARACTERISTIQUES REQUISES - ANFORDERUNGEN								≥ 205	≥	>515	≥ 40	≥	≥	≤ 95	≤	
C84939	651860	6.00X1020.0	1	1NAC	17750	T	T	2[illegible]2		590	49.5			80.0		
C84939						C	T	2[illegible]5		597	49.1			80.0		

COPIA CONFORME ALL'ORIGINALE
F.lli PINATO
Patrizia

COMPLIES WITH PD 2000/53/EC

MOD. 2114 - 3a855190

* XXXXX XXXXXXXX XXX XXXXX XXXXXXX

HAINEK

HAINEK S.r.l. - Via Del Commercio, 7 - 26013
Crema (CR) - ITALY - Tel. +39 0373 250112
e-mail: info@hainek.com Fax +39 0373 204382

www.hainek.com

P.IVA 01222970194 R.E.A. Cremona n° 152814
Cap. Sociale i.v. € 25500,00

TEST CERTIFICATE

ISPECTION CERTIFICATE
EN 10204
CHEMICAL ANALYSIS ACCORDING TO EN 10204 - 3.1

CUSTOMER
T.I.C.I. S.R.L.
VIA DELL'ARTIGIANATO, 6
26010 MONTODINE

CERTIFICATE N.
20150205/05

DATE
2015/02/05

PRODUCT
HAINEK C216/24
BACCHETTA 310 DIAM. 2,4

BATCH N.
431079

CLASSIFICATION
ASME SECT. II PART C SFA 5.9
EDITION 2013 AWS A 5.9 ER 310
EN ISO 14343:25 20

RIF. NS. DOC. DI TRASPORTO
DDT 525 DEL 04/02/15

CHEMICAL ANALYSIS

C	Mn	Si	S	P	Cr	Ni	Mo	Al	Cu
0,107	1,703	0,401	0,0009	0,016	25,788	20,652	0,086		0,104

Zr	N	Ti	Nb	Cu con riv	V	B	Co	As	Fe
	0,026		0,006				0,051		

I DATI RIPORTATI SONO RICAVATI DA DOCUMENTI DEL PRODUTTORE IN NOSTRO POSSESSO

HAINEK S.R.L.
Quality dep.

DET NORSKE VERITAS 1864
This document is accepted by
DET NORSKE VERITAS ITALIA SRL
Notified Body 0496 for 97/23/EC (PED)
Date: Sig.

NOLEGGIO E VENDITA IMPIANTI PER SALDATURA E POSIZIONATORI - GAS TECNICI - MATERIALI E MACCHINE PER SALDATURA E TAGLIO - POSIZIONATORI A RULLI E A TAVOLA ROTANTE
TORCE E RICAMBI - ASPIRATORI PER FUMI DI SALDATURA - ABRASIVI - ELETTROUTENSILI - PRODOTTI CHIMICI - ANTINFORTUNISTICA - ASSISTENZA E CONSULENZA TECNICA

AIR LIQUIDE LORCH Hypertherm CEPRO KOBELCO TRANSLAS Red-D-Arc Weld Automation LINCOLN ELECTRIC

voestalpine Böhler Welding

voestalpine Böhler Welding Italia S.p.A.
Via Palizzi, 90
I - 20157 MILANO MI
T. +39 02 39017.1
F. +39 02 39017.244
www.voestalpine.com/welding

Certificato 2.2
Test Report 2.2

secondo / as per : EN 10204
No. : No. : 2014-2014185843-900001-003
Rev. 0 Page / Page : 1 / 1

MAINARDI DANILO & C. SRL

S.S.415 KM. 45,955
26012 CASTELLEONE
Italia

Ordine N°	PO no.		del / of	06.05.2014
Ordine N°	Order no.	1014166818		
Bolla di consegna/Pos./Splitt.	Delivery note/pos./splitt	2014185843/000010/900001	del / of	09.05.2014
Oggetto test	Product	elettrodo rivestito / covered electrode		
Denominazione commerciale	Trade name	**AVESTA 310**		
Classificazione norma	Standard designation	AWS A5.4 E310-17		
		EN ISO 3581-A E 25 20 R		
Dimensione	Dimension	SMAW 3,2 x 350 mm		
Colata	Serial no.	05032		
Quantità fornita	Quantity	12,3 KG		

249958
73417
ASFAA02E
0140

Composizione chimica in % del deposito — **Chemical composition in % of the weld metal**

C	Si	Mn	P	S	Cr	Mo	Ni	Cu						
0,103	0,72	2,3	0,015	0,007	26,3	0,08	21,7	0,04						

proprietà meccaniche — **Mechanical properties**

Prova di trazione — Tensile test

T	ReL / Rp 0,2 MPa	Rp 1,0 MPa	Rm MPa	A (Lo = 5d) %	Z %	WBH PWHT	Note Remarks
20°C	444		587	30			typical values

Prova di resilienza — Impact test

T	Energia di impatto Impact energy KV / J	Medio Average KV / J	Espansione lat. Lateral expansion mm	Frattura cristalliina Shear fracture %	WBH PWHT	Note Remarks
20°C		52				typical values

Questo certificate è stato emesso con sistema automatizzato e non richiede firma
This certificate was issued by DP-equipment and does not require signature.

Centro / Town: Milano
Data / Date: 13.05.2014

This document is accepted by
DET NORSKE VERITAS ITALIA SRL
Notified Body 0496 for 97/23/EC (PED)
Date 8/8/15 Sign Bonalumi

Coordinate bancarie
Unicredit S.p.A., Fil. OP.MI
BBAN: CIN: L-ABI 02008 | CAB 09432
c/c 000005518634
IBAN IT 32 L 02008 09432 000005518634

Deutsche Bank S.p.A., Fil. G Milano
BBAN: CIN: G-ABI 03104 | CAB 01607
c/c 000000021490
IBAN IT 86 G 03104 01607 000000021490

Società soggetta alla Direzione e Coordinamento delle voestalpine Böhler Welding Group GmbH di Düsseldorf (Germania)
Capitale sociale Euro 1.702.800,00 i.v. | R.E.A. 990 454
Reg. Imprese n. 04193840156 | Cod. Fisc. e Part. IVA: IT 04193840156

voestalpine
ONE STEP AHEAD.

IR TEC SRL
SISTEMA DI QUALITÀ CERTIFICATO ISO 9001:2008

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F.SANTI, 3
Tel. 02.90.96.15.41 • 2 - Fax 02.90.96.32.92
E-mail : info@irtecsrl.com Web : www.irtecsrl.com

CERTIFICATO No. CERTIFICATE	6456/15
RIF. REF.	2089/15
DATA DATE	2015-03-26
FOGLIO SHEET	1 DI OF 1

RT TESTING **CONTROLLO RT**

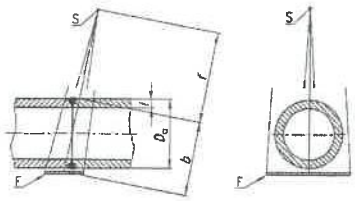
CLIENTE CUSTOMER: T.I.C.I. S.r.l. – Via DELL'ARTIGIANATO,6 – 26010 MONTODINE (CR)	**ENTE DI COLLAUDO :** INSPECTION AGENCY
COMMESSA JOB: ---	
OGGETTO SUBJECT: Radiographic examination of the butt welded test coupon for welder performance and welding procedure qualification Test coupon as per WPS – EN – R04/15/3 – Weldings procedures/process: 141 + 111 BASE MATERIALS : N°.: 1 TUBE A240 310S – HEAT: 0439938 WELDER'S NAME : RICCARDO SOCCINI – STAMP: RS	

STADIO DI LAVORAZIONE WORKING STEP: AFTER WELDING COMPLETION	**SUPERFICIE** SURFACE: AS WELDED
SPECIFICA SPECIFICATION: EN ISO 17636 -1 Cl. B - EN ISO 5817 level B EN ISO 15614 -1 – EN ISO 9606 - 1	**DIMENSIONI** DIMENSIONS
APPARECCHIO EQUIPMENT: **RX** ☑ GILARDONI 300 — 130 **Kv** — 3 **mA**	**Rγ (Ir 192)** ☐ — **Ci**
DIST. FUOCO-FILM SOURCE-FILM DIST.: 800 mm — **DIMENS. FUOCO** SOURCE SIZE: 3 mm	**ESPOSIZIONE** EXPOSURE TIME: 2 **MINUTI** MINUTES --- **sec.**
SPESSORE NOMINALE SALDATURA NOMINAL WELD THICKNESS: 6 mm	**SPESSORE TOTALE SALDATURA** ACTUAL WELD THICKNESS: 6 mm
DISTANZA OGGETTO (LATO SORGENTE) – FILM SOURCE SIDE OF OBJECT – FILM DISTANCE: 88.9 mm	**DIST. FUOCO-OGGETTO** SOURCE-OBJECT DISTANCE: 711.1 mm ≥ mm
INCERTEZZA GEOMETRICA GEOMETRIC UNSHARPNESS: // mm ≤ //	**SPESSORE ATTRAVERSATO** CROSSED THICKNESS: 12 mm
PELLICOLE FILM TYPE: AGFA D7 ☐ D5 ☐ D4 ☐ — KODAK AA 400 ☐ T200 ☐ MX 125 ☑	**SCHERMI Pb** LEAD SCREENS: **ANT.** FRONT 0.05 mm **POST.** BACK 0.10 mm
PENETRAMETRO PENETRAMETER: W 13 FE ☑ W 6 FE ☐ ASTM 1A ☐	**LATO SORGENTE** SOURCE SIDE ☑ **LATO FILM** FILM SIDE ☐
ESPOSIZIONE EXPOSURE: **FILM SINGOLO** SINGLE FILM ☑ **FILM DOPPIO** DOUBLE FILM ☐	**DENSITÀ** DENSITY: 2,3 ÷ 2,7 — **SENSIBILITÀ** SENSITIVITY: W14
TECNICA DI SVILUPPO FILM PROCESSING: **MANUALE** MANUAL ☐ **AUTOMATICA** AUTOMATIC ☑	**DENS. RICH.** DENS. REQ.: ≥ 2,3 — **SENS. RICH.** SENS. REQ.: W14

6.1.6 Tecnica ellittica (vedere figura 11)

figura 11 Disposizione di ripresa radiografica per esposizione a doppia parete-doppia immagine di pezzi curvi per la valutazione di ambedue le pareti (sorgente e pellicola esterni al pezzo)

Legenda
S Sorgente di radiazioni
F Pellicola



SIGLA MARK	POSIZ. POSIT.	DIFETTI DEFECTS	ESITO RESULT
R04/15/3	A	//	OK
R04/15/3	B	//	OK

LEGENDA OK = BUONO – Good RRX = RIPARARE – Repair NX = RIPETERE FILM – Repeat the exposure

1	Cricche	Cracks	10	Eccesso di penetrazione	Eccess Penetration
2	Cricche di Cratere	Crater Cracks	11	Eccesso localizzato	Local protrusion
3	Pori e Porosità	Porosity	12	Colpi d'arco e spruzzi	Arc strikes and spatters
4	Tarli	Wormholes	13	Slivellamento	Misalignement
5	Inclusioni solide e cavità allungate	Solid inclusions and elongated cavities	14	Insellamento	Root concavity
			15	Sgocciolamento	Burn Through
6	Inclusioni di Rame	Copper Inclusions	16		
7	Incollature	Lack of Fusion	17		
8	Mancanza di penetrazione	Lack of Penetration	18	Difetto film	Process or film defect
9	Incisioni Marginali	Undercuts	/	Nessun difetto	No defect

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customer inspector	IL COLLAUDATORE The inspector
F. MENZELLA NDT LEV II SNT - TC - 1A PT: 13/BO/MMA/mp/0200C MT: 13/BO/MMA/mp/0211C RT: 13/BO/MR/mp/0211C UNI EN ISO 9712:12 65 RX3 REV. 2	SANTARCANGELO VINCENZO EN 473 2° liv. RT-UT-PT-MT CICPND 2° Liv. RT-UT-PT-MT	02/04/15	1864 DNV Milan

IR TEC SRL
SISTEMA QUALITÀ CERTIFICATO ISO 9001:2008

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F.SANTI, 3
Tel. 02.90.96.15.41 • 2 - Fax 02.90.96.32.92
E-mail : info@ irtecsrl.com Web:www.irtecsrl.com

CERTIFICATO No. CERTIFICATE	6458/15
RIF. REF.	2089/15
DATA DATE	2015-03-26
FOGLIO SHEET	1 DI OF 1

PT TESTING **CONTROLLO PT**

CLIENTE CUSTOMER: T.I.C.I. S.r.l. – Via DELL'ARTIGIANATO,6 – 26010 MONTODINE (CR)	**ENTE DI COLLAUDO:** INSPECTION AGENCY
OGGETTO SUBJECT: PENETRANT EXAMINATION OF THE WELD OF TEST COUPON FOR PIPE BUTT WELDER PERFORMANCE AND WELDING PROCEDURE QUALIFICATION AS PER **WPS** – EN – R04/15/3 THK 6 Weldings procedures/process: 141 + 111 – WELDER'S NAME : RICCARDO SOCCINI – STAMP: RS BASE MATERIALS : N°.: 1 TUBE A240 310S	
MATERIALE MATERIAL: HEAT: 0439938	**DIMENSIONI** DIMENSION
STADIO DI LAVORAZIONE WORKING STEP: AFTER WELDING COMPLETION	**SUPERFICIE** SURFACE: AS WELDED
SPECIFICA SPECIFICATION: EN ISO 3452-1 - EN ISO 5817 level B & C EN ISO 15614-1 – EN ISO 9606-1	**DESIGN. PRODOTTI** PRODUCTS DESIGNATION: ISO 3452-2 II A e Livello2

PULITORE CLEANER	CGM VELNET	**LOTTO** BATCH	317.13 11/2015
PENETRANTE PENETRANT	CGM RED W	**LOTTO** BATCH	S.129.13 05/2015
RIVELATORE DEVELOPER	CGM ROTRIVEL U	**LOTTO** BATCH	S.155.13 06/2015

FLUORESCENTE ☐ FLUORESCENT	**CONTRASTO DI COLORE** ☑ COLOUR CONTRAST
TEMPERATURA SUPERFICIE SURFACE TEMPERATURE	12°C
PULITURA DELLA SUPERFICIE SURFACE CLEANING	SOLVENT
TEMPO ASCIUGATURA (≥ 5 minuti) DRYING TIME	8 MINUTES
APPLICAZIONE PENETRANTE PENETRANT APPLICATION	SPRAY
TEMPO DI PENETRAZIONE PENETRATION TIME	20 MINUTES
ASPORTAZIONE PENETRANTE PENETRANT REMOVAL	WATER & CLOTHES
TEMPO ASCIUGATURA (≤ 30 minuti) DRYING TIME	10 MINUTES
APPLICAZIONE RIVELATORE DEVELOPER APPLICATION	SPRAY
TEMPO DI SVILUPPO DEVELOPING TIME	10 ÷ 30 MINUTES
ILLUMINAZIONE ILLUMINATION	>1000 lux

NOTE REMARKS

ESITO RESULT: THE EXAMINED WELD SATISFY THE REQUIREMENTS OF THE CODE

68 LP1 REV. 2

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customer inspector	IL COLLAUDATORE The inspector
F. MENZELLA NDT LEV II SNT - TC - 1A PT: 13/BO/MA/mp/0200C MT: 13/BO/MA/mp/0211C RT: 13/BO/MR/mp/0211C UNI EN ISO 9712:12	SANTARCANGELO VINCENZO EN 473 2° LIV. RT-UT-PT-MT CICPND 2° LIV. RT-UT-PT-MT	02/04/15	0496

IR TEC SRL
SISTEMA QUALITÀ CERTIFICATO ISO 9001:2008

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F.SANTI, 3
Tel. 02.90.96.15.41 • 2 - Fax 02.90.96.32.92
E-mail : info@ irtecsrl.com Web:www.irtecsrl.com

CERTIFICATO No. CERTIFICATE	6457/15
RIF. REF.	2089/15
DATA DATE	2015-03-26
FOGLIO SHEET	1 DI OF 1

VISUAL EXAMINATION **ESAME VISIVO**

CLIENTE CUSTOMER	T.I.C.I. S.r.l. – Via DELL'ARTIGIANATO,6 – 26010 MONTODINE (CR)
ENTE DI COLLAUDO : INSPECTION AGENCY	
COMMESSA JOB	---
OGGETTO OBJECT	VISUAL EXAMINATION OF THE WELD OF TEST COUPON FOR PIPE BUTT WELDER PERFORMANCE AND WELDING PROCEDURE QUALIFICATION AS PER **WPS** – EN – R04/15/3 THK 6 Weldings procedures/process: 141 + 111 BASE MATERIALS : N°.: 1 TUBE A240 310S – HEAT: 0439938 WELDER'S NAME : RICCARDO SOCCINI – STAMP: RS
STADIO DI LAVORAZIONE WORKING STEP	AFTER WELDING COMPLETION.
SPECIFICA SPECIFICATION	EN ISO 17637 – EN ISO 15614 - 1 - EN ISO 9606 - 1
ACCETTABILITÀ ACCEPTANCE STANDARD	EN ISO 5817 LEVEL B & C

SUPERFICIE SURFACE

GREZZA ROUGTH	☐	**MOLATA** GROUND	☐
LAVORATA MACHINED	☐	**SPAZZOLATA** BRUSHED	☑
SALDATA WELDED	☐	**LAMINATA** ROLLED	☐
SABBIATA SANDBLASTED	☐	**DECAPATA** PICKLED	☐

ILLUMINAZIONE LIGHTING ≥ 1000 lx

NATURALE DAYLIGHT	☑	**ARTIFICIALE** ARTIFICIAL	☐

NOTE REMARKS		
ESITO RESULT	**SODDISFACENTE** ☑ SATISFACTORY	**NON CONFORME** ☐ NOT CONFORM

74 VT1 REV. 0

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customer inspector	IL COLLAUDATORE The inspector
SANTARCANGELO VINCENZO EN 473 2° LIV. RT-UT-PT-MT CICPND 2° LIV. RT-UT-PT-MT	SANTARCANGELO VINCENZO EN 473 2° LIV. RT-UT-PT-MT CICPND 2° LIV. RT-UT-PT-MT	02/04/15	

Exova Srl
Via della Pierina 9/11
26013 Crema (CR)
Italy

T: +39 0373 8972 1
F: +39 0373 8972 00
E: info@exova.com
W: www.exova.com

Test report n° 183850 **Rev.0**
EN 10204, type : 3.2

Client
Cod. 1263

T.I.C.I. SRL
Via Dell 'Artigianato,6
26010 Montodine CR
Italy

Your ref.	Order n.	D.D.T. n. 46	data 17/03/2015
Our ref.	Report n.	**183850**	data **02/04/2015**
	Job n.	59240	data 20/03/2015

Remarks Weld Plate EN-R04/15
Process : 141+111
Welder : RS

Project

Client Reference UNI EN ISO 15614-1:2012
Test standard UNI EN ISO 6892-1:2009 - UNI EN ISO 5173:2012 - UNI EN ISO 6507-1:2006

This Report is made of n° 5 pages including this cover plus the following page:

Test	Pag.
Macrographic examination	1
Hardness test	1
Tensile test at room temperature	1
Bend test	1

This Report (RPR) contains tests results on the following material:

Ref.	Identification	Material	DN / Thk [mm]	Remarks
132847	EN-R04/15	ASTM A240 310S (INOX 310S)		

Lab Manager	Customer	Inspector	Inspector
Exova s.r.l. Luca Cantoni	02/04/15		N°0826 049C DNV Milan

General conditions:
1. The Customer accepts general conditions and prices fixed by the laboratory to perform the tests.
2. Test results will be communicated only by means of test report except for different contractual agreement.
3. Tests sample will be destroyed 30 days after test except for different written Client request.
4. The spare will be destroyed 90 days after date of receipt for different written Client request.
5. The test results described in the following test report are referring only to the sample mentioned in it.
6. The date of material receivement is the same as the date of job opening. The date of testing is the same as the date of test report, except for different info.
7. The laboratory has examined the material sampled an supplied by the Client in compliance with standard request.

This test report may not be reproduced other than in full except with the prior written approval of the issuing laboratory

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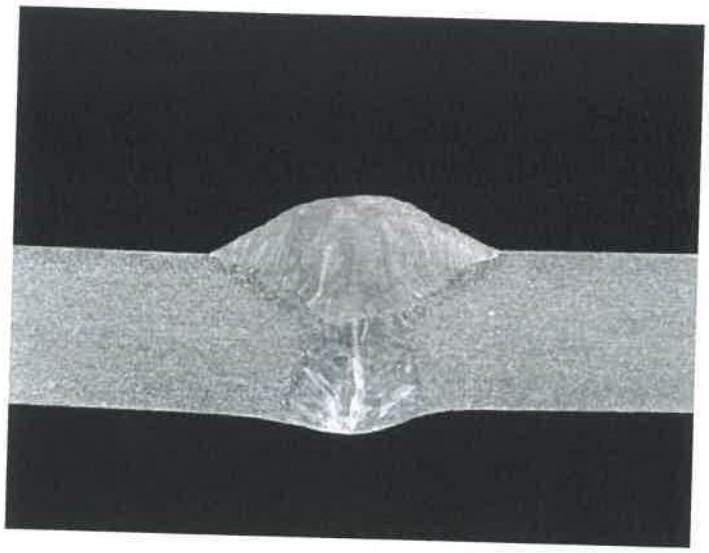
Test report n° 183850 Rev.0

Equipment n.	PHOTOGRAPHIC DOCUMENTATION	Pag. 1 of 1
1871		

Test Ref.	
Laboratory	Client
847.FO01.1	EN-R04/15

Etching : 75% HCl 25% HNO3

Magnification : x 3.5



EN-R04/15

M1 h6

Comments Test specimen has been examined at low magnification (25x) with and without etching.
According to UNI EN ISO 5817:2014, level B and C, the results of this exam don't showed the presence of imperfections or defects in weld metal.

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 17639:2013

Remarks

Operator	Customer	Inspector	Inspector
EXOVA S.r.l. SPE Cristian Pironi	02/04/15		

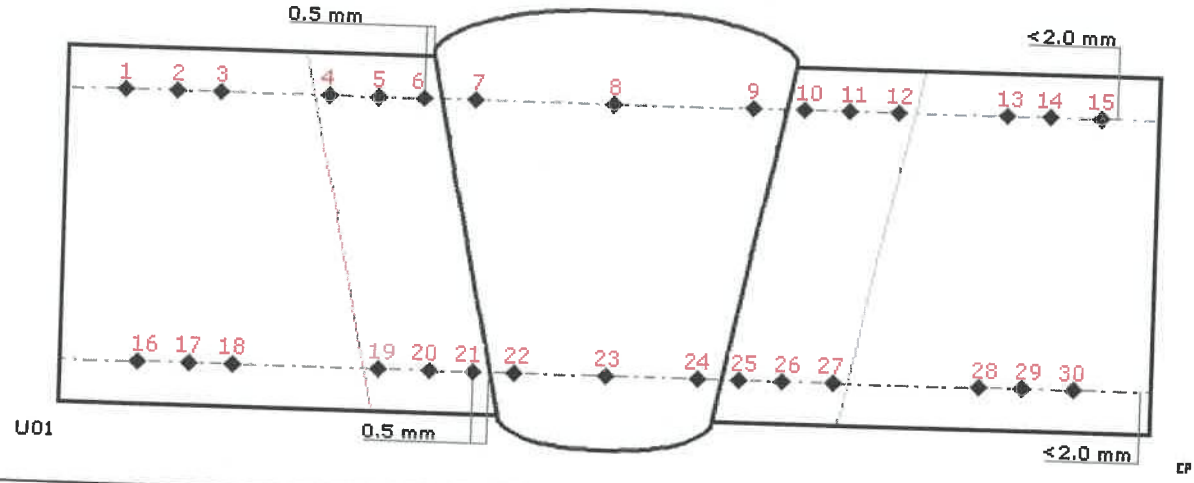
This page is binded to references n. 183850 (job 59240) *whose details are indicated on the cover*

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Test report n° 183850 Rev.0

Equipment n.	HARDNESS TEST	Pag. 1 of 1
9	Internal procedure POI-07	



EN-R04/15
T M1 h6

HV 10	
Point #	Value
#1	177
#2	170
#3	174
#4	165
#5	157
#6	150
#7	172
#8	167
#9	174
#10	150
#11	149
#12	162
#13	177
#14	172
#15	174
#16	183
#17 Max	185
#18	181
#19	162
#20	164

HV 10	
Point #	Value
#21	159
#22	156
#23	150
#24	164
#25	168
#26	170
#27	167
#28	172
#29	177
#30	180

-	
Point #	Value

-	
Point #	Value

-	
Point #	Value

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 6507-1:2006

Remarks

Operator	Customer	Inspector	Inspector
SPE Cristian Rioni	TIG		
Exova S.r.l.	02/04/15		RO 80496

This page is binded to references n. *183850 (job 59240)* *whose details are indicated on the cover*

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Test report n° 183850 Rev.0

Exova

Equipment n. 1153

TENSILE TEST

Internal procedure POI-01

Richiesti *Required*												>=515			

Test *Ref.* Lab.	Client	T *Test* °C	Posizione *Position*	Dimensioni *Dimensions* mm			Lo mm	Re N/mm²	Rp0.2% N/mm²	Rp0.5% N/mm²	Rt0.2% N/mm²	Rt0.35% N/mm²	Rt0.5% N/mm²	E	Rm N/mm²	A %	Z %	Rif. *Ref.*
847.TR1.01	EN-R04/15	+20	T Weld h2	12.00	x	5.80		-	-	-	-	-	-		568	-		#
847.TR1.02	EN-R04/15	+20	T Weld h4	12.00	x	5.70		-	-	-	-	-	-		553	-		#

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 6892-1:2009

Remarks X = Prismatic - # Broken in weld

Speed of testing in elastic field ref. method B : R=15MPa/s - after elastic field <= 0.008 Lc/s

Test performed in Crema Laboratory Via della Pierina 9/11

Operator: SPE Luigi Vallati — Exova S.r.l.

Customer: TCI 02/04/15

Inspector

Inspector: 100600496

This page is binded to references n. *183850 (job 59240)* *whose details are indicated on the cover*

DNV Milan

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Test report n° 183850 Rev.0

Equipment n. 1123

BEND TEST

Internal procedure POI-03

Test Ref. Lab.	Test Ref. Client	T Test °C	Tipo Type	Dimensioni Dimensions mm			Mandrino Jig mm	Distanza rulli Distance rollers mm	Angolo angle °	Lo Lo mm	Allungamento Elongation %	Esito Results	Note Remarks	Rif. Ref.
847.PI1.01	EN-R04/15	+20	Face Bend T	20.0	x	6.0	25	40	180			No Defect	h2	
847.PI1.02	EN-R04/15	+20	Face Bend T	20.0	x	6.0	25	40	180			No Defect	h4	
847.PI1.03	EN-R04/15	+20	Root Bend T	20.0	x	6.0	25	40	180			No Defect	h2	
847.PI1.04	EN-R04/15	+20	Root Bend T	20.0	x	6.0	25	40	180			No Defect	h4	

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 5173:2012

Remarks Test Method "FORMER"

Test performed in Crema Laboratory Via della Pierina 9/11

Operator	Customer	Inspector	Inspector
Luigi Vallati Exova s.r.l.	02/04/15		

This page is binded to references n. *183850 (job 59240)* *whose details are indicated on the cover*

Welding Procedure Qualification Record Form (WPQR)

Welding procedure qualification - Test certificate

Manufacturer's WPQR No.:	**EN-R07/15**	Reference No.: **WPQR15010** - File No.: **Z0492434**
Manufacturer:	**TICI S.R.L.**	Examiner or examining body : **DNV-GL-B.A. ITALIA S.r.l.**
Address:	**VIA DELL'ARTIGIANATO 6 MONTODINE (CR)**	
Code / Testing Standard:	**EN 15614-1**	
Date of Welding:	**10/03/2015**	

Range of qualification

Welding process(es):	**121 (ISO 4063)**
Type of joint and weld:	**BW - ss, mb, sl, ml - bs, sl, ml**
Parent material group(s) and sub group(s):	**EN 15608 Gr. 11.1 - Covers the equal or lower specified yield strength steels of the same group**
Parent Material Tickness (mm) Butt Welds:	**7,5 ÷ 30**
Parent Material Tickness (mm) Fillet Welds:	**N.A.**
Weld Metal Thickness (mm) Butt Welds:	**7,5 ÷ 16,5 (1ST SIDE)** **7,5 ÷ 30 (2ND SIDE)**
Throat Thickness (mm):	**N.A.**
Single run / Multi run:	**SINGLE RUN (1ST SIDE) / MULTI RUN (2ND SIDE)**
Outside Pipe Diameter (mm):	**> 150 (PA ROTATED)**
Filler Material Designation:	**EN ISO 14171-A S2Si**
Filler Material Make:	**SIDERGAS**
Filler Material Size:	**ALL, WITHIN HEAT INPUT LIMITS BELOW**
Designation of Shielding Gas / Flux:	**ISO 14174 S A AB 1 56 AC H5**
Designation of Backing Gas:	**N.A.**
Type of Welding Current and Polarity:	**DCEP**
Mode of Metal Transfer:	**N.A.**
Heat Input:	**MAX 0,9 kJ/mm WITH IMPACT TESTING** **MIN 0,4 kJ/mm WITH HARDNESS TESTING**
Welding Positions:	**PA, PA ROTATED**
Preheat Temperature:	**MIN 15 °C**
Interpass Temperature:	**MAX 150 °C**
Post-Heating:	**N.A.**
Post-Weld Heat-Treatment:	**N.A.**
Other Information:	**NONE**

Certified that test welds prepared, welded and tested satisfactorily in accordance with the requirements of the code / testing standard indicated above.

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TICI S.R.L. - MONTODINE (CR)
Location

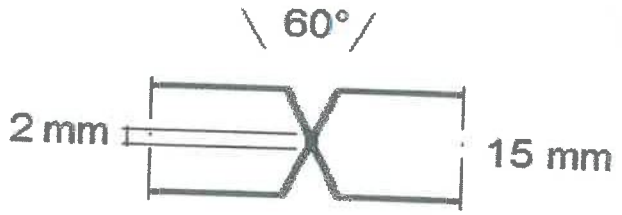
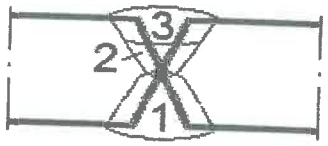
02/04/2015
Date of Issue

E. MASTANTUONO
Examiner or examining body
Name, date and signature

Record of weld test

Location: **VIA DELL'ARTIGIANATO 6 MONTODINE (CR)**
Manufacturer's pWPS No.: **EN-07-15**
Manufacturer's WPQR No.: **EN-R07/15**
Manufacturer: **TICI S.R.L.**
Welder's Name: **FUSAR BASSINI SIMONE - SF**
Mode of Metal Transfer: **N.A.**
Joint Type and Weld: **BW, P, bs, sl, ml**
Weld Preparation Details (Sketch):

Examiner or examining body: **DNV-GL-GL-B.A. ITALIA S.r.L.**
Reference No.: **WPQR15010** - File No.: **Z0492434**
Method of Preparation and Cleaning: **BRUSHING, GRINDING**
Parent Material Specification: **EN 15608 Gr.11.1/2**
ASME SA 516 GR.70
Material Thickness (mm): **15**
Outside Pipe Diameter (mm): **N.A.**
Welding Position: **PA**

Joint Design	Welding Sequences
	

Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input EN 1011-1 (kJ/mm) (*)	Metal transfer
1	121	2	399 - 401	29 - 31	DCEP	N.A.	18 - 19	0,6 - 0,7	N.A.
2	121	2	399 - 401	29 - 31	DCEP	N.A.	15 - 16	0,6- 0,7	N.A.
3	121	2	399 - 401	29 - 31	DCEP	N.A.	18 - 19	0,6- 0,7	N.A.

(*) EN 1011-1 : $Q=k*(V*A/speed*10^{-3})$ - k = 1 (121)

Filler Material Designation and Make: **EN ISO 14171-A S2Si SIDERGAS S2Si SAW**

Any Special Baking or Drying: **NONE**
Gas/Flux: Shielding: **ISO 14174 S A AB 1 56 AC H5 FL61-4-25VCI FLUX LINCOLN**
Backing: **N.A.**
Gas Flow Rate Shielding: **N.A.**
Backing: **N.A.**
Tungsten Electrode Type/Size: **N.A.**
Details of Back Gouging/Backing: **BY GRINDING**
Preheat Temperature: **15 °C**
Interpass Temperature: **150 °C**
Post-Heating: **N.A.**
Post-Weld Heat Treatment: **N.A.**
(Time, Temperature, Method : **N.A.**
Heating and Cooling Rates): **N.A.**

Other information, e.g.:
Weaving (maximum width of run): **N.A.**
Oscillation : amplitude, frequency, dwell time: **N.A.**
Pulse welding details: **N.A.**
Distance contact tube/work piece: **N.A.**
Plasma welding details: **N.A.**
Torch angle: **N.A.**

A. MARZI - 02/04/2015
TICI S.R.L. - MONTODINE (CR)
Manufacturer
(name, signature and date)

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E. MASTANTUONO
Examiner or examining body
Name, date and signature

Welding Procedure Specification (pWPS/WPS)

Welding Procedure Specification: **EN-07-15**

WPQR No.: **EN-R07/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW, P, bs, sl,ml**

Weld Preparation Details (Sketch)

Method of Preparation and Cleaning: **GRINDING, BRUSHING**

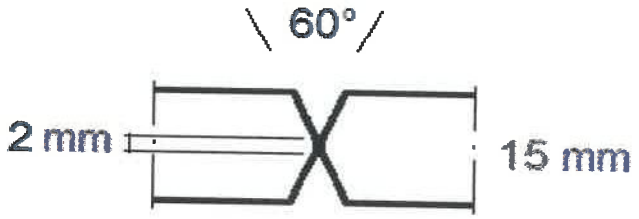
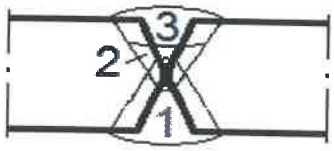
Parent Material Designation: **EN 15608 Gr. 11.1**

ASME SA516 GR. 70

Material thickness (mm): **15**

Outside Diameter (mm): **N.A.**

Welding Position: **PA**

Joint Design	Welding Sequences
	

Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input (EN 1011-1) (kJ/mm)
1	121	2	399 - 401	29 - 31	DCEP	N.A.	18 - 19	0,6 - 0,7
2	121	2	399 - 401	29 - 31	DCEP	N.A.	15 - 16	0,6- 0,7
3	121	2	399 - 401	29 - 31	DCEP	N.A.	18 - 19	0,6- 0,7

Filler Material Designation and Make: **EN ISO 14171-A S2Si SIDERGAS S2Si SAW**

Other information, e.g.:

Any Special Baking or Drying: **NONE**

Designation Gas/Flux: **ISO 14174 SAAB156ACH5 FL61-4-25VCI FLUX LINCOLN**

Gas Flow Rate – Backing: **N.A.**

– Shielding: **N.A.**

– Backing: **N.A.**

Tungsten Electrode Type/Size: **N.A.**

Details of Back Gouging/Backing: **BY GRINDING**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

(Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

Weaving (maximum width of run): **N.A.**

Oscillation : amplitude, frequency, dwell time: **N.A.**

Pulse welding details: **N.A.**

Distance contact tube/work piece: **N.A.**

Plasma welding details: **N.A.**

Torch angle: **N.A.**

A. MARZI - 10/03/2015
TICI S.R.L. - MONTODINE (CR)
(Name, signature, date)

This document is accepted by DET NORSKE VERITAS ITALIA SRL Notified Body 0496 for 97/23/EC (PED) Date 10/3/15 Sign:

Test results

Manufacturer's WPQR No.: **EN-R07/15**
Visual: **IRTEC SRL - 6464/15**
Penetrant: **IRTEC SRL - 6463/15**
Tensile Tests: **EXOVA - 183852**

Examiner or examining body: **DNV-GL-GL-B.A. ITALIA S.r.L.**
Reference No.: **WPQR15010** - File No.: **Z0492434**
Radiography: **IRTEC SRL - 6462/15**
Ultrasonic: **NONE**
Temperature: **20 °C**

Type/No.	Re N/mm²	Rm N/mm²	A % on	Z %	Fracture Location	Remarks
Requirement		**485 ÷ 620**				
849.TR1.01		**499**			**OUT OF WELD**	
849.TR1.02		**501**			**OUT OF WELD**	

Bend Tests — Former Diameter: **40 mm**

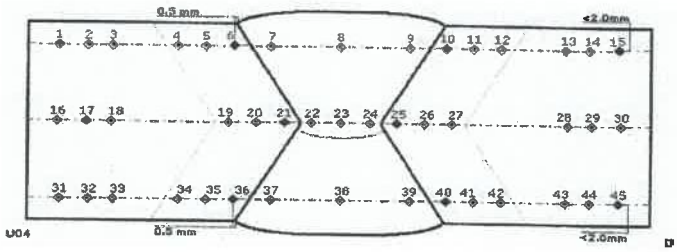
Type/No.	Bend Angle	Elongation	Results
849.PI1.01 SIDE	**180°**		**NO DEFECT**
849.PI1.02 SIDE	**180°**		**NO DEFECT**
849.PI1.03 SIDE	**180°**		**NO DEFECT**
849.PI1.04 SIDE	**180°**		**NO DEFECT**

Macroscopic Examination: **EXOVA 183852**

Impact Test — Type: **KV2** — Size: **10 x 10 mm** — Requirement: **27 J**

Notch Location/Direction	Temp. °C	Values 1	2	3	Average	Remarks
849.RE2.01 / VHT0/2	**-20**	**96**	**65**	**43**	**68**	
849.RE2.02 / VHT1/2	**-20**	**175**	**170**	**160**	**168**	

Location of Measurements (Sketch)



Hardness Test (Type/Load): **HV10**

Parent Metal: **150 - 151 - 149 - 148 - 151 - 153 - 147 - 150 - 151 - 158 - 155 - 156 - 165 - 157 - 159 - 160 - 158 - 157**

HAZ: **173 - 182 - 183 - 185 - 172 - 164 - 173 - 178 - 181 - 173 - 169 - 167 - 169 - 183 - 186 - 191 - 181 - 174**

Weld metal: **186 - 178 - 177 - 169 - 158 - 167 - 190 - 183 - 185**

Other Tests: **NONE**
Remarks: **NONE**
Tests Carried out in accordance with the requirements of:
Laboratory Report Reference No.: **EXOVA 183852**
Test results were **ACCEPTABLE**
Tests carried out in presence of: **E. MASTANTUONO NB 0496 DNV-GL - A. MARZI TICI S.R.L.**

This document is accepted by DET NORSKE VERITAS ITALIA SRL Notified Body 0496 for 97/23/EC (PED)

E. MASTANTUONO
Examiner or examining body
Name, date and signature

Corus UK Limited
Corus Construction & Industrial
P.O. Box 1, Scunthorpe,
North Lincolnshire, DN16 1BP
Telephone: 01724 404040
Fax: 402353 Telex: 52601

INSPECTION CERTIFICATE

In Accordance with: DIN.50049/EN10204 3.1B

Date: 26/10/01
Cert No.: SPLA/01/00491668/1

Customer

MANNI SIDERURGICA SPA

VIA AUGUSTO RIGHI 7 (ZAI)
37135 VERONA
VERONA ITALY

Inspection: ROYAL & SUNALLIANCE ENG

Corus Ref. No.: 62078/ 5
Works Order/Item No.: 50/ 129/ 5
Customers Order No.: AM1B000598

Specification/Product:
ASME 98/ ASTM 9C (S)A516/M-90 70/485(A20/S5)

Plate 10000 X 2500 X 15.00mm Piece Weight 2943.8Kg
"N"- Normalised

B6A10 DIMS/AM1B000598/ MANNI 3 REV 0/70/485/ FE510.2KW/P355NH MOZZECANE

L=Longitudinal T=Transverse Z=Through Thickness S=Sub-Surface M=Mid-Thickness Q=Quarter-Thickness TH=Third-Thickness BS=Bottom Surface A=Supply Condition N=Normalised SR=Stress Relieved SA=Strain Aged

Quantity	Cast/Heat No	Piece No	Test Piece No.	Test Condition	Yield Stress Re N/MM2	Tensile Strength Rm	Re/Rm %	Elong% A Lo= 200	Charpy Impact E23 10x10x2mmV Units Joules	Test Condition	Steelmaking Process: B.O.S.
		Specification Min			262	485		17	20 Av/ 16 Ind @ -46C		
		Max				620					
*	69275	FM758/ 2		T	372	530		25	L -46C 82 113 108 101	O	
				T	373	530		25	L -46C 106 102 95 101	O	

ANALYSIS %		C	Si	Mn	P	S	Cr	Mo	Ni	Al	Cu	Nb	N	Sn	Ti	V	Cr+Mo+Ni+Cu	CEV
Specification	Min		.15	0.85						.020								
	Max	.27	.40	1.20	.035	.035	0.200	.120	.400		.400	.020				.030		
Cast/Heat		.19	.37	1.16	.010	.006	0.014	.002	.020	.032	.009	.017	.006	.001	.002	.002	1.000	
Specification	Min																0.045	.39
	Max																	

Plate(s) and tests normalised at 890-930 deg.C for a minimum of 1.5 minutes per millimetre of thickness.
Surface Inspected.

This document is accepted by DET NORSKE VERITAS ITALIA SRL Notified Body 0496 for 97/23/EC (PED)
Date 10/5/... Sign

On behalf of Corus UK Limited, the manufacturer
These results are certified by Corus UK Limited and comply with the requirements of the Product Description

M.D.Haylett

M.D.Houghton, Test House Manager, Scunthorpe

Authentic Inspection Certificates issued by Corus UK Limited will: continue to be accepted as equivalent to, or in conjunction with a Corus UK Limited Works Inspection Certificate; and will continue to be issued without a hand written signature or wet embossing should ensure that the supplier retains a true and accurate reproduction of the original.

FILO (FE)

SIDERGAS SPA.
Cap. Soc. 1.000.000 € i.v. - C.F. e P. IVA IT00226230233 www.sidergas.com - e-mail: info@sidergas.com
SEDE LEGALE/CORPORATE: Viale Rimembranza, 17 - 37015 S. AMBROGIO VALP.LLA (VR) - ITALY
SEDE OPERATIVA/PLANT: Via Tombelolo, 82/A - 37020 DOLCE' (VR) - ITALY

certified Quality Management System complying with the requirements of UNI EN ISO 9001:2008.

PRODUCT CERTIFICATE (conforms to EN 10204)
Certificato di Prodotto/Certificat de Produit

NrLotto/Release N° 15/00041 Data Ord./Order Date 09/01/2015	N° DDT/ Deliv. Note No. 000114/D Date DDT/Deliv.Note Date 19/01/2015	NrFattura/Invoice N° DataFattura/Invoice Date	RQC Marco Martinelli	Nr. Cert./Cert. No. 000117	Data Cert./Cert. Date 19/01/2015
Nr. Ordine Acq. / P.O. No. 10-22-70 DEL 09.01.15	Nr. Container/Container No.		Cliente/Purchaser HAINEK SRL		
Nr. Sigillo Vettore/Seal N°	Nr. Sigillo/Seal N° Sidergas		Destinatario/Consignee Via del Commercio, 7 26013 CREMA (CR)		SIDERGAS S.P.A. CE 0036 - 06 0036 - CPR - S019 EN ISO 13479:2004
Vettore/Shipping Agent: VENTURINI ALFREDO & C. S.N.C.					
Nave/Vessel:	Data Spedizione/Shipping date: 19/01/2015				

ANALISI CHIMICA DEL FILO/CHEMICAL COMPOSITION OF THE WIRE
in accordo a/according to EN 10204 3.1

Nr.Colata/ Batch No.	Normativa/ Standard:	Classificazione/ Classification:	Codice/P. Number Des.ne/Description	Analisi Chimica/Chemical analysis: % p/p/wt.-%						
230614	AWS A5.17 EN ISO 14171-A	EM12K S2Si	Codice: OCASIRS20K0250 Cod. cliente: Tipo filo: SIDERGAS S2SI SAW Diam. (mm): 2.00 Peso (Kg): 25 Finitura: RAMATO Imballo: K-415 Avvolgimento: SSS	C	Mn	Si	S	P	Cu*	Mo
				0,0910	1,0030	0,2780	0,0050	0,0110	0,0230	0,0070
				Ni	Cr	N	Ti	V	Al	Zr
				0,0120	0,0200	0,0041	0,0000	0,0020	0,0020	0,0000
				B	As	Sn	Ca			
				0,0000	0,0015	0,0020	0,0000			

Note/Remarks:

Cu*: Cu di colata/Cu of heat. A questo valore deve essere addizionato l'eventuale rivestimento in rame del filo compreso tipicamente tra 0,5 e 0,15%.
To this value has to be added the copper coating on the wire, if present, typically within the range 0,05 - 0,15%.

CARATTERISTICHE MECCANICHE DEL METALLO SALDATO / MECHANICAL PROPERTIES OF ALL-WELD METAL
in accordo a/according to EN 10204 2.2

Resistenza a trazione / Tensile Strength:		Snervamento (0,2%)/ Yeld Strength (0,2%)		Allungamento / Elongation:	Resilienza / IMPACT TEST (KV)		
					Temperatura/Temp.	media (J) / average (Lb x Ft.)	
500	(MPa)	420	(MPa)	22,00 (%)	-40°C -40°F	90	67
72.465	(PSI)	60.871	(PSI)		-51°C -59°F	60	44
					-73°C -99°F	47	35

Note/Remarks:

Additional Information: Il valore tipico per HDM per il filo SIDERGAS S2SI SAW è < 5ml / 100g.
Comb. Filo e Flusso/Wire and Flux Combinatio Valori tipici ottenuti in combinazione con il flusso EN ISO 14171 SA AB 1 67 AC H5.

Note Certificato / Certificate Remarks:

DET NORSKE VERITAS 1864
This document is accepted by
DET NORSKE VERITAS ITALIA SRL
Notified Body 0496 for 97/23/EC (PED)
Date: 20/1/15 Signature:

- This certificate is produced elecrtonically and is valid without segnature
- We certify that the filler is made in Italy by SIDERGAS SPA according to above nomatives and to order prescriptions, and in compliance with a certified ISO 9001 Quality Assurance System

FLUSSO (FE)

Inspection Certificate 3.1

LINCOLN ELECTRIC
THE WELDING EXPERTS®

Product	860
Item (Flux)	FX860-25
Lot/batch	F1FX140239
Customer	HAINEK SRL VIA DEL COMMERCIO, 7 26013 CREMA Italy
Product Line	Flux
Item (Wire)	FL61-4-25VCI
Lot/Batch	F1SW14O272
Classification	AWS A5.17/A5.17M :F6A2-EL12 F7A4-EM12K F7A2-EA1/EA2-A2 ISO 14174 : S A AB 1 56 AC H5

Chemical analysis (%) — According to EN10204:2004 3.1

	C	Si	Mn	P	S
Weld Metal:	0.05	0.29	1.24	0.03	0.01
Wire:	0.12	0.23	1.02	0.01	0.01

Mechanical tests, all weld metal — According to EN10204:2004

Additional information
Other tests — According to EN10204:2004

Remarks

DET NORSKE VERITAS * INBA *
This document is accepted by
DET NORSKE VERITAS ITALIA SRL
Notified Body 0496 for 97/23/EC (PED)

The product identified above has been manufactured, tested and supplied in compliance with a certified ISO 9001 Quality Assurance Programme.

Company	Printed by	Function	Date	Cert. No.
LINCOLN ELECTRIC ITALIA srl	**A. Barone**	**PM consumables**	**22/10/2014**	**99120882**
Registered office: *VIA F.LLI CANEPA 8* *16010 SERRA RICCO', GE* *Italy*	*Telephone:* 010/754111	*Fax:* 010/7541150		

certificateV10.0

IRTEC SRL
SISTEMA DI QUALITÀ CERTIFICATO ISO 9001:2008

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

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E-mail : info@irtecsrl.com Web : www.irtecsrl.com

CERTIFICATO No. CERTIFICATE	6462/15
RIF. REF.	2089/15
DATA DATE	2015-03-26
FOGLIO SHEET	1 DI OF 1

RT TESTING **CONTROLLO RT**

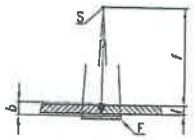
CLIENTE CUSTOMER	T.I.C.I. S.r.l. – Via DELL'ARTIGIANATO,6 – 26010 MONTODINE (CR)
ENTE DI COLLAUDO : INSPECTION AGENCY	
COMMESSA JOB	—
OGGETTO SUBJECT	Radiographic examination of the butt welded test coupon for welder performance and welding procedure qualification Test coupon as per WPS – EN – R07/15 N°.: 1 – Weldings procedures/process: 121 BASE MATERIALS : PLATE A516 Gr.70 – HEAT: G9275 WELDER'S NAME : SIMONE FUSAR BASSINI – STAMP: SF

STADIO DI LAVORAZIONE WORKING STEP: AFTER WELDING COMPLETION	**SUPERFICIE** SURFACE: AS WELDED
SPECIFICA SPECIFICATION: EN ISO 17636 -1 Cl. B - EN ISO 5817 level B EN ISO 15614 -1 – EN ISO 9606 - 1	**DIMENSIONI** DIMENSIONS
APPARECCHIO EQUIPMENT: **RX** ☑ GILARDONI 300 — 130 **Kv** — 3 **mA**	**Rγ (Ir 192)** ☐ — **Ci**
DIST. FUOCO-FILM SOURCE-FILM DIST.: 800 mm — **DIMENS. FUOCO** SOURCE SIZE: 3 mm	**ESPOSIZIONE** EXPOSURE TIME: 2 **MINUTI** MINUTES — --- **sec.**
SPESSORE NOMINALE SALDATURA NOMINAL WELD THICKNESS: 15 mm	**SPESSORE TOTALE SALDATURA** ACTUAL WELD THICKNESS: 15 mm
DISTANZA OGGETTO (LATO SORGENTE) – FILM SOURCE SIDE OF OBJECT – FILM DISTANCE: 15 mm	**DIST. FUOCO-OGGETTO** SOURCE-OBJECT DISTANCE: 785 mm ≥ mm
INCERTEZZA GEOMETRICA GEOMETRIC UNSHARPNESS: // mm — ≤ //	**SPESSORE ATTRAVERSATO** CROSSED THICKNESS: 15 mm
PELLICOLE FILM TYPE: AGFA D7 ☐ D5 ☐ D4 ☐ — KODAK AA 400 ☐ T200 ☐ MX 125 ☑	**SCHERMI Pb** LEAD SCREENS: **ANT.** FRONT 0.05 mm — **POST.** BACK 0.10 mm
PENETRAMETRO PENETRAMETER: W 10 FE ☑ W 6 FE ☐ ASTM 1A ☐	**LATO SORGENTE** SOURCE SIDE ☑ — **LATO FILM** FILM SIDE ☐
ESPOSIZIONE EXPOSURE: **FILM SINGOLO** SINGLE FILM ☑ — **FILM DOPPIO** DOUBLE FILM ☐	**DENSITÀ** DENSITY: 2,3 ÷ 2,7 — **SENSIBILITÀ** SENSITIVITY: W13
TECNICA DI SVILUPPO FILM PROCESSING: **MANUALE** MANUAL ☐ — **AUTOMATICA** AUTOMATIC ☑	**DENS. RICH.** DENS. REQ.: ≥ 2,3 — **SENS. RICH.** SENS. REQ.: W13

6.1.2 Sorgente di radiazioni posta di fronte al pezzo e pellicola posta dal lato opposto (vedere figura 1)

figura 1 Disposizione di ripresa radiografica per pezzi piani ed esposizione a parete singola (vedere 3 per *l*, *b*, *f*)

Legenda
S Sorgente di radiazioni
F Pellicola



SIGLA MARK	POSIZ. POSIT.	DIFETTI DEFECTS	ESITO RESULT
R07/15/1	1 – 2	//	OK

LEGENDA OK = BUONO – Good RRX = RIPARARE – Repair NX = RIPETERE FILM – Repeat the exposure

1	Cricche	Cracks	10	Eccesso di penetrazione	Eccess Penetration
2	Cricche di Cratere	Crater Cracks	11	Eccesso localizzato	Local protrusion
3	Pori e Porosità	Porosity	12	Colpi d'arco e spruzzi	Arc strikes and spatters
4	Tarli	Wormholes	13	Slivellamento	Misalignement
5	Inclusioni solide e cavità allungate	Solid inclusions and elongated cavities	14	Insellamento	Root concavity
			15	Sgocciolamento	Burn Through
6	Inclusioni di Rame	Copper Inclusions	16		
7	Incollature	Lack of Fusion	17		
8	Mancanza di penetrazione	Lack of Penetration	18	Difetto film	Process or film defect
9	Incisioni Marginali	Undercuts	/	Nessun difetto	No defect

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customer inspector	IL COLLAUDATORE The inspector
F. MENZELLA NDT LEV II SNT - TC - 1A PT: 13/BQ/MMA/mp/0200C MT: 13/BQ/MMA/mp/0211C RT: 13/BQ/MR/mp/0211C UNI EN ISO 9712:12	SANTARCANGELO VINCENZO EN 473 2° LIV. RT-UT-PT-MT CICPND 2° LIV. RT-UT-PT-MT	TIG 02/04/15	

69 RX3 REV. 2

IR TEC SRL
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E-mail : info@ irtecsrl.com Web:www.irtecsrl.com

CERTIFICATO No. CERTIFICATE	6463/15
RIF. REF.	2089/15
DATA DATE	2015-03-25
FOGLIO SHEET	1 DI OF 1

PT TESTING **CONTROLLO PT**

CLIENTE CUSTOMER: T.I.C.I. S.r.l. – Via DELL'ARTIGIANATO,6 – 26010 MONTODINE (CR)	**ENTE DI COLLAUDO:** INSPECTION AGENCY

OGGETTO SUBJECT: PENETRANT EXAMINATION OF THE WELD OF TEST COUPON FOR PLATE BUTT WELDER PERFORMANCE
AND WELDING PROCEDURE QUALIFICATION AS PER **WPS** – EN – R07/15
Weldings procedures/process: 121 – WELDER'S NAME : SIMONE FUSAR BASSINI – STAMP: SF
BASE MATERIALS : PLATE A516 Gr.70 – HEAT: G9275

MATERIALE MATERIAL	HEAT: G9275			**DIMENSIONI** DIMENSION
STADIO DI LAVORAZIONE WORKING STEP	AFTER WELDING COMPLETION			**SUPERFICIE** SURFACE: AS WELDED
SPECIFICA SPECIFICATION	EN ISO 3452-1 - EN ISO 5817 level B & C EN ISO 15614-1 – EN ISO 9606-1			**DESIGN. PRODOTTI** PRODUCTS DESIGNATION: ISO 3452-2 II A e Livello2
PULITORE CLEANER	CGM VELNET	**LOTTO** BATCH	317.13 11/2015	
PENETRANTE PENETRANT	CGM RED W	**LOTTO** BATCH	S.129.13 05/2015	
RIVELATORE DEVELOPER	CGM ROTRIVEL U	**LOTTO** BATCH	S.155.13 06/2015	

FLUORESCENTE ☐ FLUORESCENT	**CONTRASTO DI COLORE** ☑ COLOUR CONTRAST
TEMPERATURA SUPERFICIE SURFACE TEMPERATURE	12°C
PULITURA DELLA SUPERFICIE SURFACE CLEANING	SOLVENT
TEMPO ASCIUGATURA (≥ 5 minuti) DRYING TIME	8 MINUTES
APPLICAZIONE PENETRANTE PENETRANT APPLICATION	SPRAY
TEMPO DI PENETRAZIONE PENETRATION TIME	20 MINUTES
ASPORTAZIONE PENETRANTE PENETRANT REMOVAL	WATER & CLOTHES
TEMPO ASCIUGATURA (≤ 30 minuti) DRYING TIME	10 MINUTES
APPLICAZIONE RIVELATORE DEVELOPER APPLICATION	SPRAY
TEMPO DI SVILUPPO DEVELOPING TIME	10 ÷ 30 MINUTES
ILLUMINAZIONE ILLUMINATION	>1000 lux

NOTE REMARKS: WELDER'S NAME :

ESITO RESULT: THE EXAMINED WELD SATISFY THE REQUIREMENTS OF THE CODE

68 LP1 REV. 2

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customer inspector	IL COLLAUDATORE The inspector
F. MENZELLA NDT LEV II SNT - TC - 1A PT: 13/BO/MMA/mp/0200C MT: 13/BO/MMA/mp/0211C RT: 13/BO/MR/mp/0211C UNI EN ISO 9712:12	SANTARCANGELO LORENZO EN 473 2° Liv. RT-UT-PT-MT CICPND 2° Liv. RT-UT-PT-MT	02/04/15	No 864 DNV Milan

IR TEC SRL
SISTEMA QUALITÀ CERTIFICATO ISO 9001:2008

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

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CERTIFICATO No. CERTIFICATE	6464/15
RIF. REF.	2089/15
DATA DATE	2015-03-25
FOGLIO SHEET	1 DI OF 1

VISUAL EXAMINATION ESAME VISIVO

CLIENTE CUSTOMER	T.I.C.I. S.r.l. – Via DELL'ARTIGIANATO,6 – 26010 MONTODINE (CR)
ENTE DI COLLAUDO : INSPECTION AGENCY	
COMMESSA JOB	---
OGGETTO OBJECT	VISUAL EXAMINATION OF THE WELD OF TEST COUPON FOR PLATE BUTT WELDER PERFORMANCE AND WELDING PROCEDURE QUALIFICATION AS PER WPS – EN – R07/15 Weldings procedures/process: 121 BASE MATERIALS : PLATE A516 Gr.70 – HEAT: G9275 WELDER'S NAME : SIMONE FUSAR BASSINI – STAMP: SF
STADIO DI LAVORAZIONE WORKING STEP	AFTER WELDING COMPLETION.
SPECIFICA SPECIFICATION	EN ISO 17637 – EN ISO 15614 - 1 - EN ISO 9606 - 1
ACCETTABILITÀ ACCEPTANCE STANDARD	EN ISO 5817 LEVEL B & C

SUPERFICIE SURFACE

GREZZA ROUGTH	☐	**MOLATA** GROUND	☐
LAVORATA MACHINED	☐	**SPAZZOLATA** BRUSHED	☑
SALDATA WELDED	☐	**LAMINATA** ROLLED	☐
SABBIATA SANDBLASTED	☐	**DECAPATA** PICKLED	☐

ILLUMINAZIONE LIGHTING ≥ 1000 lx

NATURALE DAYLIGHT	☑	**ARTIFICIALE** ARTIFICIAL	☐

NOTE REMARKS		
ESITO RESULT	**SODDISFACENTE** ☑ SATISFACTORY	**NON CONFORME** ☐ NOT CONFORM

74 VT1 REV. 0

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customer inspector	IL COLLAUDATORE The inspector
SANTARCANGELO VINCENZO EN 473 2° Liv. RT-UT-PT-MT CICPND 2° Liv. RT-UT-PT-MT	SANTARCANGELO VINCENZO EN 473 2° Liv. RT-UT-PT-MT CICPND 2° Liv. RT-UT-PT-MT	TIG 02/04/15	DNV 86 Milan

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26013 Crema (CR)
Italy

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E: info@exova.com
W: www.exova.com

Test report n° 183852 **Rev.0**
EN 10204, type : 3.2

Client
Cod. 1263

T.I.C.I. SRL
Via Dell 'Artigianato,6
26010 Montodine CR
Italy

Your ref.	Order n.	D.D.T. n. 46	data	17/03/2015
Our ref.	Report n.	**183852**	data	**02/04/2015**
	Job n.	59240	data	20/03/2015

Remarks Weld Plate EN-R07/15
Process : 121
Welder : SF

Project

Client Reference	UNI EN ISO 15614-1:2012
Test standard	UNI EN ISO 6892-1:2009 - UNI EN ISO 5173:2012 - UNI EN ISO 148-1:2011 - UNI EN ISO 6507-1:2006

This Report is made of n° 6 pages including this cover plus the following page:

Test	Pag.
Macrographic examination	1
Hardness test	1
Tensile test at room temperature	1
Impact test	1
Bend test	1

This Report (RPR) contains tests results on the following material:

Ref.	Identification	Material	DN / Thk [mm]	Remarks
132849	EN-R07/15	ASTM A516 Gr.70		

Lab Manager	Customer	Inspector	Inspector
Exova S.r.l. Luca Cantoni	TICI 02/04/15		N° 0496 DNV Milan

General conditions:
1. The Customer accepts general conditions and prices fixed by the laboratory to perform the tests.
2. Test results will be communicated only by means of test report except for different contractual agreement.
3. Tests sample will be destroyed 30 days after test except for different written Client request.
4. The spare will be destroyed 90 days after date of receipt for different written Client request.
5. The test results described in the following test report are referring only to the sample mentioned in it.
6. The date of material receivement is the same as the date of job opening. The date of testing is the same as the date of test report, except for different info.
7. The laboratory has examined the material sampled an supplied by the Client in compliance with standard request.

This test report may not be reproduced other than in full except with the prior written approval of the issuing laboratory

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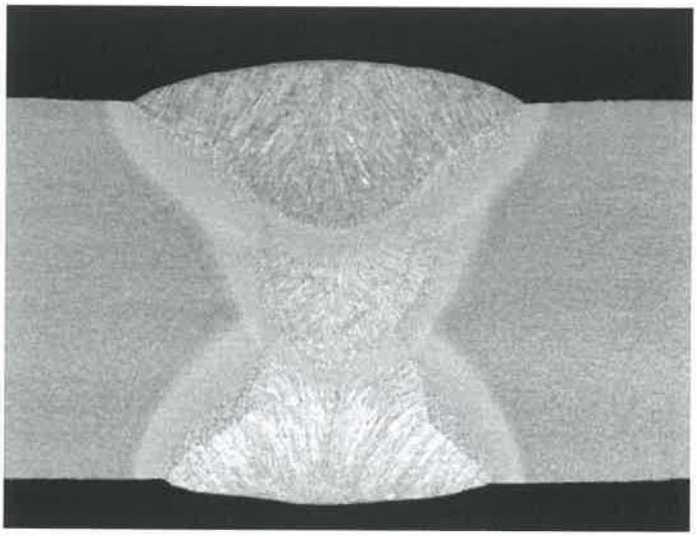
Test report n° 183852 Rev.0

Equipment n.	PHOTOGRAPHIC DOCUMENTATION	Pag. 1 of 1
1871		

Test Ref.	
Laboratory	Client
849.FO01.1	EN-R07/15

Etching : NITAL 3%

Magnification : x 3



EN-R07/15

M1

Comments Test specimen has been examined at low magnification (25x) with and without etching.
According to UNI EN ISO 5817:2014, level B and C, the results of this exam don't showed the presence of imperfections or defects in weld metal.

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 17639:2013

Remarks

Test performed in Crema Laboratory Via della Pierina 9/11

Operator	Customer	Inspector	Inspector
EXOVA S.r.l. SPE Cristian Pilosi	02/04/15		Nolo 0486

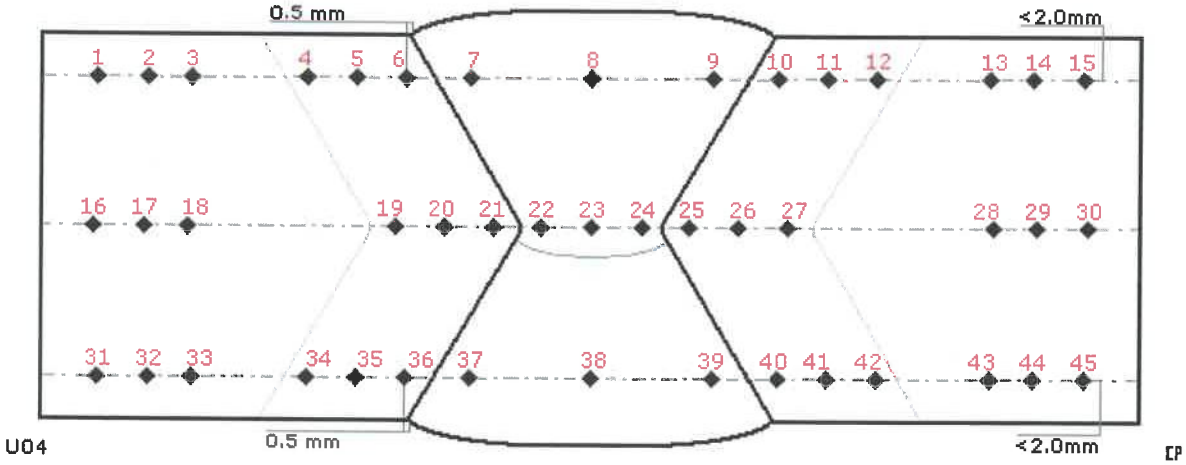
This page is binded to references n. *183852 (job 59240)* *whose details are indicated on the cover*

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Test report n° 183852 Rev.0

Equipment n.	HARDNESS TEST	Pag. 1 of 1
9	Internal procedure POI-07	



EN-R07/15
M1

HV 10		HV 10		HV 10		-		-	
Point #	Value	Point #	Value	Point #	Value	Point #	Value	Point #	Value
#1	150	#21	181	#41	181	-	-	-	-
#2	151	#22	169	#42	174	-	-	-	-
#3	149	#23	158	#43	160	-	-	-	-
#4	173	#24	167	#44	158	-	-	-	-
#5	182	#25	173	#45	157	-	-	-	-
#6	185	#26	169	-	-	-	-	-	-
#7	186	#27	167	-	-	-	-	-	-
#8	178	#28	158	-	-	-	-	-	-
#9	177	#29	155	-	-	-	-	-	-
#10	185	#30	156	-	-	-	-	-	-
#11	172	#31	165	-	-	-	-	-	-
#12	164	#32	157	-	-	-	-	-	-
#13	148	#33	159	-	-	-	-	-	-
#14	151	#34	169	-	-	-	-	-	-
#15	153	#35	183	-	-	-	-	-	-
#16	147	#36	186	-	-	-	-	-	-
#17	150	#37	190	-	-	-	-	-	-
#18	151	#38	183	-	-	-	-	-	-
#19	173	#39	185	-	-	-	-	-	-
#20	178	#40 Max	191	-	-	-	-	-	-

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 6507-1:2006

Remarks

Test performed in Crema Laboratory Via della Pierina 9/11

Operator	Customer	Inspector	Inspector
SPE Cristian Pisoni Exova S.r.l.	TIG 02/04/15		Milano 04/06

This page is binded to references n. *183852 (job 59240)* *whose details are indicated on the cover*

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Test report n° 183852 Rev.0

Equipment n. 1153

TENSILE TEST

Internal procedure POI-01

	Re	Rp0.2%	Rp0.5%	Rt0.2%	Rt0.35%	Rt0.5%	E	Rm	A	Z	
Richiesti *Required*								485÷620			

Test Ref. Lab.	Test Ref. Client	T Test °C	Posizione Position	Dimensioni Dimensions mm			Lo mm	Re N/mm²	Rp0.2% N/mm²	Rp0.5% N/mm²	Rt0.2% N/mm²	Rt0.35% N/mm²	Rt0.5% N/mm²	E	Rm N/mm²	A %	Z %	Rif. Ref.
849.TR1.01	EN-R07/15	+20	T Weld	25.00	x	15.00		-	-	-	-	-	-		499	-		#
849.TR1.02	EN-R07/15	+20	T Weld	25.00	x	15.20		-	-	-	-	-	-		501	-		#

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 6892-1:2009

Remarks X = Prismatic - # Broken out of weld

Speed of testing in elastic field ref. method B : R=15MPa/s - after elastic field <= 0.008 Lc/s

Test performed in Crema Laboratory Via della Pierina 9/11

Operator	Customer	Inspector	Inspector
SPE Luigi Vallati Exova s.r.l.	02/04/15		

This page is binded to references n. *183852 (job 59240)* *whose details are indicated on the cover*

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Test report n° 183852 Rev.0

Equipment n. 814

IMPACT TEST

Internal procedure POI-02

Nominal machine energy : 450J

Test Ref. Lab.	Test Ref. Client	T Test °C	Posizione Position	Dimensioni Dimensions mm			Intaglio Notch	Richiesti Required	A Single Valore Value J	A Single Shear %	A Single Lateral E.	B Single Valore Value J	B Single Shear %	B Single Lateral E.	C Single Valore Value J	C Single Shear %	C Single Lateral E.	Media Average J	Rif. Ref.
																		27	
849.RE2.01	EN-R07/15	-20	VWT0/2	10	x	10.00	KV2		96			65			43			68	
849.RE2.02	EN-R07/15	-20	VHT1/2	10	x	10.00	KV2		175			170			160			168	

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 148-1:2011

Remarks

Test performed in Crema Laboratory Via della Pierina 9/11

Operator: ing. Luigi Vallati — Exova S.r.l.

Customer: TCR 02/04/15

Inspector

Inspector: Nobili 0436 — DNV Milan

This page is binded to references n. 183852 (job 59240) whose details are indicated on the cover

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Test report n° 183852 Rev.0

Equipment n. 1123

BEND TEST

Internal procedure POI-03

Test Ref. Lab.	Test Ref. Client	T Test °C	Tipo Type	Dimensioni Dimensions mm				Mandrino Jig mm	Distanza rulli Distance rollers mm	Angolo angle °	Lo Lo mm	Allungamento Elongation %	Esito Results	Note Remarks	Rif. Ref.
849.PI1.01	EN-R07/15	+20	Side Bend T		10.0	x	15.0	40	66	180			No Defect		
849.PI1.02	EN-R07/15	+20	Side Bend T		10.0	x	15.0	40	66	180			No Defect		
849.PI1.03	EN-R07/15	+20	Side Bend T		10.0	x	15.0	40	66	180			No Defect		
849.PI1.04	EN-R07/15	+20	Side Bend T		10.0	x	15.0	40	66	180			No Defect		

Standard ref. UNI EN ISO 15614-1:2012 - UNI EN ISO 5173:2012

Remarks Test method "FORMER"

Test performed in Crema Laboratory Via della Pierina 9/11

Operator	Customer	Inspector	Inspector
Exova S.r.l.	02/04/15		04/06/2015

This page is binded to references n. *183852 (job 59240)* *whose details are indicated on the cover*

T.I.C.I. S.r.l. Via Garibaldi - Zona PIP 26010 Montodine (CR)	WELDING OPERATOR PERFORMANCE QUALIFICATIONS (WPQ)	QUALITY CONTROL SERVICE
(See QW-301, Section IX, ASME Boiler and Pressure Vessel Code)		

Welders name	Denti Giovanni	Stamp No.	
Welding process used	GTAW + SMAW	Type	MANUAL
Identification of WPS followed by welder during welding of test coupon			05-00
Base material(s) welded	A516 Gr.70 + A240 TP310S	Thickness	6 mm

Manual or Semiautomatic Variables for Each Process (QW-350)	Actual value	Range Qualified
Backing (metal, weld metal, welded from both sides, flux, etc.)(QW-402)	Weld metal for SMAW	Same
	None for GTAW	None/Yes
ASME P-No. To ASME P-No. (QW-403)	1 to 8	Same
■ Plate ☐ Pipe (enter diameter pipe)		2.5" & over
Filler metal specification (SFA) - Classification (QW-404)		
Filler metal F-No.	6 + 5	Same
Consumable insert for GTAW or PAW	None	Same
Weld deposit thickness for each welding process	2 + 4 mm	4+8 mm
Welding position (1G, 5G, etc.)(QW-405)	1G	Flat
Progression (uphill / downhill)	NA	NA
Backing gas for GTAW, PAW, or GMAW ; Fuel gas for OFW (QW-408)	Yes	Same
GMAW transfer mode (QW-409)	NA	NA
GTAW welding current type / polarity	Direct/Straight	Same
Machine Welding Variables for the Process Used (QW-360)		
Direct / Remote control		
Automatic voltage control (GTAW)		
Automatic joint tracking		
Weld position (1G, 5G, etc.)		
Consumable insert		
Backing (metal, weld metal, welded from both sides, flux, etc.)		

Guided Bend Test Result

Guided Bend Test Type	☐ QW-462.2 (side) Results	☒ QW-462.3(a) (Trans R & F) Type	☐ QW-462.3(b)(Long R & F) Results
ROOT		SATISFACTORY	
FACE		SATISFACTORY	

Visual examination results (QW-302.4)					SATISFACTORY		
Radiographic test results (QW-304 and QW-305)							
(For alternative qualification of groove welds by radiography)							
Fillet weld - Fracture test				Lenght and percent of defects			in.
Macro test fusion		Fillet leg size		in. X		in.	in.
Welding test conducted by					TICI S.r.l.		
Mechanical test conducted by	BODYCOTE			Laboratory test No.		66538	

We certify that the statements in this record are correct andthat the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of ASME Code.

Organization	T.I.C.I. S.r.l. Via Garibaldi - Zona PIP 26010 MONTODINE (CR) Tel.+Fax 0373-242255
Date : 05/09/00	By :

ICIM

CERTIFICATO PROVA DI QUALIFICAZIONE OPERATORE DI SALDATURA
WELDER OPERATOR APPROVAL TEST CERTIFICATE – WAC14732 - UNI EN 14732

ACCREDIA
PRS N° 082 C

Certificato n° *Certificate No.*	**ICIM – WACo – 026696 – 00**
Fabbricante *Manufacturer*	T.I.C.I. S.r.l.
Indirizzo *Address*	Via Dell'Artigianato, 6 - 26010 - MONTODINE (CR)
Procedura di Saldatura del Fabbricante n° *Manufacturer Welding Procedure WPS n°*	EN-01-20
Nome dell'Operatore di Saldatura *Welding Operator's Name*	**SOCCINI Riccardo**
Metodo di Identificazione *Identification method*	C. I. AT 6715537 Stamp. N. RS
Data e luogo di nascita *Date and Place of Birth*	07/09/1979 Treviglio (BG) / Italia
Datore di lavoro *Employer*	T.I.C.I. S.R.L.
Codice/Norma di esame *Code/Testing Standard*	UNI EN ISO 14732:2013 ☒ ICIM S.p.A. è ON per Direttiva 2014/68/UE – No. Bo. 0425. La presente qualifica soddisfa la direttiva 2014/68/UE- All. I - 3.1.2

Foto
Photograph

Conoscenze tecniche
Job Knowledge

☐ Accettabile / *Accettable*
☒ Non sottoposta a prova /*Not Tested*

Variabili ***Variables***	**Dettagli della prova** ***Welding test details***	**Campo di validità** ***Range of approval***
Processo di saldatura *Welding Process*	121	121
Apparecchiatura di saldatura *Welding equipment*	ESAB LAH 630	Same equipment
Unità di saldatura *Welding machine*		
Dettagli per la saldatura meccanizzata ***Details for mechanized welding***	**Dettagli della prova** ***Welding test details***	**Campo di validità** ***Range of approval***
Controllo visivo/controllo visivo in remoto *Visual control/remote visual control*	Direct	Direct
Controllo automatico della lunghezza dell'arco *Automatic control of arc length*	Without	With & Without
Inseguimento automatico del giunto *Automatic traking of joint*	Without	With & Without
Posizione di saldatura *Welding position*	PA	PA
Passata singola/passata multipla *Single run/Multirun*	Multiple	Single & Multiple
Materiale a supporto *Back-up material*	With	With
Inserto fusibile *Fusible insert*	Without	With & Without

0252CM_06_IT

ACCREDIA
PRS N° 082 C

Certificato n°
Certificate No. **ICIM – WACo – 026696 – 00**

Dettagli per la saldatura automatica *Details for automatic welding*	Dettagli della prova *Welding test details*	Campo di validità *Range of approval*
Sensore del giunto *Joint sensor*	---	---
Sensore di controllo dell'arco *Sensor for arc welding control*	---	---
Tecnica a passata Singola/Multipla *Single run/Multirun technique*	---	---
Tipo unità di saldatura *Type of welding machine*	---	---
Altro *Other*	---	---

Approval based on *Qualificazione basata su*		Tests result documentation *Documentazione del risultato delle prove*
Prova di procedura di saldatura secondo il punto 4.1 a *Test of welding procedure according to 4.1 a (UNI EN ISO 15614-1, UNI EN ISO 15614-2)*	☒	ACCEPTABLE IRTEC S.r.l. Report no. RC-0292/23
Prova di saldatura di pre-produzione o di produzione secondo il punto 4.1 b *Test of pre-production welding or production welding according to 4.1 b (UNI EN ISO 15613)*	☐	
Prova di saldatura in conformità alla ISO 9606 secondo il punto 4.1 c *Test of welding as per ISO 9606 requirements according to 4.1 c*	☐	
Prova di produzione o di campionamento della produzione secondo il punto 4.1 d *Test of sample of the production according to 4.1 d*	☐	

Si certifica che l'operatore di saldatura sopra indicato, usando la procedura di saldatura indicata nel presente modulo, ha soddisfatto I requisiti descritti dalle norme applicate.

We certify that the welding operator identified above, using the welding procedure given in the present form, has satisfied the requirements described from the applied standards.

Data di saldatura *Date of welding*	Validità della qualificazione fino al *Validity of qualification until*	Esaminatore *Examiner*
24/03/2023	23/03/2029	LAZZARIN MARCO – ICIM Welding Inspector

Data di delibera *Date of approval*	**Approvatore** *Manager*
26/05/2023	*Vincenzo De'acqua* Rappresentante Direzione / Management Representative ICIM S.p.A.

Conferma della validità da parte del Fabbricante (semestrale)
Confirmation of the validity by Manufacturer (6 month)

Posizione/Titolo *Position/title*	Firma *Signature*	Data *Date*
RGQ/CQ		25.09.2023
RGQ/CQ		18.03.2024
RGQ/CQ		18.09.2024

Posizione/Titolo *Position/title*	Firma *Signature*	Data *Date*

Riconvalida della qualificazione da parte dell'Esaminatore (triennale)
Revalidation for qualification by Examiner (every 3 years)

Posizione/Titolo *Position/title*	Firma *Signature*	Data *Date*

Posizione/Titolo *Position/title*	Firma *Signature*	Data *Date*

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Welding Procedure Specification (pWPS/WPS)

Welding Procedure Specification: **EN-01-20**

WPQR No.: **EN-R01/14 + EN-R07/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW, P, ss (141, 111, 121) - nb, sl (141) - mb, ml (111)**

Weld Preparation Details (Sketch)

Method of Preparation and Cleaning: **GRINDING BRUSHING**

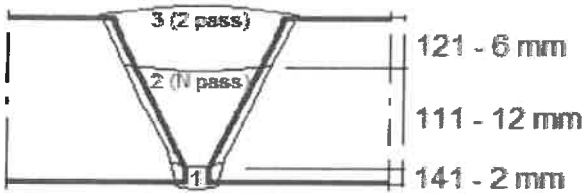
Parent Material Designation: **EN 15608 Gr. 1**

Material thickness (mm): **20**

Outside Diameter (mm): **N.A.**

Welding Position: **PA**

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input (EN 1011-1) (kJ/mm)
1	141	2,4	144 - 146	11 - 13	DCEN	N.A.	0,7 - 0,8	1,2 - 1,6
2 (N pass)	111	3,25	111 - 113	23 - 25	DCEP	N.A.	2,4 - 2,5	0,8 - 0,9
		4	146 - 148	22 - 24	DCEP	N.A.	3,0 - 3,1	0,8 - 0,9
3 (2 pass)	121	2	399 - 401	29 - 31	DCEP	N.A.	15 - 16	0,6- 0,7
			399 - 401	29 - 31	DCEP	N.A.	18 - 19	0,6- 0,7

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**
EN ISO 2560-A E 42 5 B 32 H5 (111)
EN ISO 14171-A S2Si

Other information, e.g.:

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: - Shielding: **I1 (141) nozzle 8 mm ISO 14174 SAAB156ACH5 (121)**

Oscillation : amplitude, frequency, dwell time: **N.A.**

- Backing: **N.A.**

Pulse welding details: **N.A.**

Gas Flow Rate - Shielding: **10-13 lt/min (141)**

Distance contact tube/work piece: **N.A.**

- Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size: **(141) EN 26848 2,4 mm Tbi M3 WG-La15**

Torch angle: **75°**

Details of Back Gouging/Backing: **N.A.**

Preheat Temperature: **20 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

(Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. MARZI - 25/09/2020
TICI S.R.L. - MONTODINE (CR)

T.I.C.I. S.R.L.
Via dell'Artigianato,6 - 26010 Montodine - CR
Tel: 0373 - 242256 Fax: 0373 - 655280
ticisrl1@virgilio.it – www.ticisrl.com
P. IVA IT 00962060190

CERTIFICATO PROVA DI QUALIFICAZIONE DEL SALDATORE
WELDER APPROVAL TEST CERTIFICATE - UNI EN ISO 9606-1

PRS N° 062 C

Certificato n° / *Certificate No.*	**ICIM – WAC – 026683 – 00**
Fabbricante / *Manufacturer*	T.I.C.I. S.r.l.
Indirizzo / *Address*	Via Dell'Artigianato, 6 - 26010 - MONTODINE (CR)
Procedura di Saldatura del Fabbricante n° / *Manufacturer Welding Procedure WPS n°*	EN-02-20
Nome del Saldatore / *Welder's Name*	**SOCCINI Riccardo**
Metodo di Identificazione / *Identification method*	C. I. AT 6715537 Stamp. N. RS
Data e luogo di nascita / *Date and Place of Birth*	07/09/1979 Treviglio (BG) / Italia
Datore di lavoro / *Employer*	T.I.C.I. S.R.L.
Codice/Norma di esame / *Code/Testing Standard*	UNI EN ISO 9606-1:2017; Schema ICIM 0248CS; ☒ ICIM S.p.A. è ON per Direttiva 2014/68/UE – No. Bo. 0425. La presente qualifica soddisfa la direttiva 2014/68/UE- All. I - 3.1.2

Prova supplementare di saldatura ad angolo / *Supplementary fillet weld test* ☐ Sì/*Yes* ☒ No

Conoscenze tecniche / *Job Knowledge* ☐ Accettabile / *Acceptable* ☒ Non sottoposta a prova / *Not Tested*

Variabili / ***Variables***	**Dettagli della prova** / ***Welding test details***	**Campo di validità** / ***Range of approval***
Processo di saldatura / *Welding Process*	141 135	141, 142, 143, 145 135, 138
Modalità di trasferimento / *Transfer Mode*	Spray Arc	All, excluded Short Arc
Tipo di prodotto / *Product Type – Plate (P) or Pipe (T)*	P	P – T
Tipo di saldatura / *Type of weld*	BW	BW
Gruppo del materiale base e sottogruppo / *Parent Material Group(s) and Sub Group(s)*	1 / 1.1	—
Materiale d'apporto designazione / *Filler material designation*	141= ISO 636-A: W 42 4 2Si 135=EN ISO 14341-A: G 46 4 M21 4Si1	S, M
Gruppo materiale d'apporto / *Filler material group*	FM1	FM1, FM2
Gas di protezione / *Shielding gas*	141=ISO 14175 I1 (Ar 99,99%) 135=ISO 14175 M21 (Ar 82% + CO_2 18%)	—
Ausiliari / *Auxiliaries (e.g. backing gas)*	—	—
Tipologia di corrente e polarità / *Type of Current and Polarity*	DCEN DCEP	—
Spess. del materiale (mm) / *Material Thickness (mm)*	14	—
Spessore del materiale depositato (mm) / *Deposited Thickness (mm)*	141 = 2 135 = 12	2 to 4 3 to 24
Diametro esterno del tubo (mm) / *Pipe outside diameter (mm)*	—	≥ 500 in fixed position ≥ 75 in rotating position
Posizione di saldatura / *Welding positions*	PA	PA
Dettagli della saldatura / *Weld details*	141= ss nb 135= ss mb	ss nb – ss mb – bs – ss gb – ss fb ss mb – bs
Strati multipli/strato singolo / *Multy-layer / single layer*	ml	—
Altro / *Other*	—	—

0251CM_09_IT

ICIM

CERTIFICATO PROVA DI QUALIFICAZIONE DEL SALDATORE
WELDER APPROVAL TEST CERTIFICATE - UNI EN ISO 9606-1

ACCREDIA

PRS N° 082 C

Certificato n°
Certificate No. **ICIM – WAC – 026683 – 00**

Tipo di test ***Type of test***	**Eseguite e Accettate** ***Performed and Acceptable***	**Non testate** ***Not tested***
Esame visivo *Visual testing (UNI EN ISO 17637)*	ACCEPTABLE ELEMENT MATERIALS TECHNOLOGY MILAN S.r.l. Report no. RPR288-1E1R1A23	
Esame radiografico *Radiographic testing (UNI EN ISO 17636)* o, se applicabile / *or, if applicable* **Esame ultrasonoro** *Ultrasonic testing (UNI EN ISO 17640)*		X X
Prova di piegatura *Bend test (UNI EN ISO 5173)* o, se applicabile / *or, if applicable* **Prova di trazione con intaglio** *Notch tensile test*	ACCEPTABLE ELEMENT MATERIALS TECHNOLOGY MILAN S.r.l. Report no. RPR288-1E1R1A23	 X
Prova di frattura *Fracture test (UNI EN ISO 9017)* o, se applicabile / *or, if applicable* **Esame macrografico** *Macroscopic examination (UNI EN ISO 17639)* o, se applicabile / *or, if applicable*		X X

Si certifica che il saldatore sopra indicato, usando la procedura di saldatura indicata nel presente modulo, ha soddisfatto i requisiti descritti dalle norme applicate con la seguente Designazione:
We certify that the welder identified above, using the welding procedure given in the present form, has satisfied the requirements described from the applied standards with the following Designation:

UNI EN ISO 9606-1:2017 – 141 – P – BW – FM1 – S – s2 – PA – ss nb – ml
UNI EN ISO 9606-1:2017 – 135 – S – P – BW – FM1 – S – s12 – PA – ss mb – ml

Luogo di saldatura *Place of welding*	Data di saldatura *Date of welding*	Esaminatore *Examiner*
Montodine (CR)	24/03/2023	LAZZARIN Marco – Welding Inspector

Data di delibera ***Date of approval***	**Approvatore** ***Manager***
26/05/2023	*Vincenzo Delacqua* Rappresentante Direzione / Management Representative ICIM S.p.A.

Rivalidazione dopo 3 anni *Revalidation after 3 years*	Valido fino al *Valid until*	Rivalidazione dopo 2 anni *Revalidation after 2 years*	Valido fino al *Valid until*	Rivalidazione dopo 6 mesi *Revalidation after 6 months*	Valido fino al *Valid until*
9.3 a)	23/03/2026	**9.3 b)**		**9.3 c)**	

Applicabile esclusivamente per rivalidazione secondo paragrafi 9.3 b) oppure paragrafo 9.3 c)
Applicable for Revalidation according to sub-clause 9.3 b) or sub-clause 9.3 c)
Per la rivalidazione della qualifica da parte dell'ente di esame, per i successivi 2 anni si prega di fare riferimento all'allegato 0085CM
For the revalidation of the qualification by examining body for the following 2 years please refer to the attachment 0085CM
Conferma della validità da parte del datore di lavoro/coordinatore della saldatura/ente di esame, per i successivi 6 mesi
Confirmation of the validity by employer/welding coordinator/examining body for the following 6 months

Data *Date*	Firma *Signature*	Posizione o Titolo *Position or Title*
25.09.2023	Nestor Dan	RAQ/QC
18.03.2024	Nestor Dan	RAQ/QC
18.09.2024	Nestor Dan	RAQ/QC

0251CM_09_IT

Welding Procedure Specification (pWPS/WPS)

Welding Procedure Specification: **EN-02-20**

WPQR No.: **EN-R02/14**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **PULSED AUTOMATIC (135)**

Joint Type and Weld Type: **BW, P, ss (141, 135) - nb, sl (141) - mb, ml (135)**

Weld Preparation Details (Sketch)

Method of Preparation and Cleaning: **GRINDING BRUSHING**

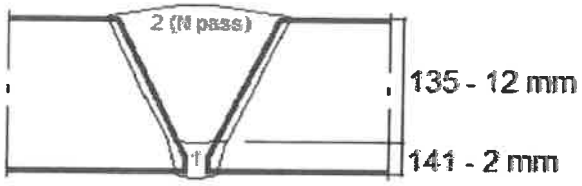
Parent Material Designation: **EN 15608 Gr. 1**

Material thickness (mm): **14**

Outside Diameter (mm): **N.A.**

Welding Position: **PA**

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input (EN 1011-1) (kJ/mm)
1	141	2,4	144 - 146	11 - 13	DCEN	N.A.	0,7 - 0,8	1,2 - 1,6
2 (N pass)	135	1	208 - 210	27 - 29	DCEP	130 - 330	6,6 - 6,7	0,7

Filler Material Designation and Make: **EN ISO 636-A W42 4 W2Si1 (141)**
EN ISO 14341-A G 42 4 M G3Si1 (135)

Other information, e.g.:

Any Special Baking or Drying: **NONE**

Weaving (maximum width of run): **N.A.**

Designation Gas/Flux: - Shielding: **I1 (141) nozzle 8 mm**
AR-CO2 M21 (135) nozzle 14 mm

Oscillation : amplitude, frequency, dwell time: **N.A.**

- Backing: **N.A.**

Pulse welding details: **SEMI-AUTOMATIC (135)**

Gas Flow Rate - Shielding: **10-13 lt/min (141)**
10-15 lt/min (135)

Distance contact tube/work piece: **20 mm (135)**

- Backing: **N.A.**

Plasma welding details: **N.A.**

Tungsten Electrode Type/Size: **(141)** **EN 26848 2,4 mm Tbi M3 WG-La15** Torch angle: **75°**

Details of Back Gouging/Backing: **N.A.**

Preheat Temperature: **20 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

(Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

A. MARZI - 25/09/2020
TICI S.R.L. - MONTODINE (CR)

CERTIFICATO PROVA DI QUALIFICAZIONE DEL SALDATORE
WELDER APPROVAL TEST CERTIFICATE - UNI EN ISO 9606-1

ACCREDIA
PRS N° 082 C

Certificato n° / Certificate No.	**ICIM – WAC – 026692 - 00**
Fabbricante / *Manufacturer*	T.I.C.I. S.r.l.
Indirizzo / *Address*	Via Dell'Artigianato, 6 - 26010 - MONTODINE (CR)
Procedura di Saldatura del Fabbricante n° / *Manufacturer Welding Procedure WPS n°*	EN-08-20
Nome del Saldatore / *Welder's Name*	**SOCCINI Riccardo**
Metodo di Identificazione / *Identification method*	C. I. AT 6715537 Stamp. N. RS
Data e luogo di nascita / *Date and Place of Birth*	07/09/1979 Treviglio (BG) / Italia
Datore di lavoro / *Employer*	T.I.C.I. S.R.L.
Codice/Norma di esame / *Code/Testing Standard*	UNI EN ISO 9606-1:2017; Schema ICIM 0248CS; ☒ ICIM S.p.A. è ON per Direttiva 2014/68/UE – No. Bo. 0425. La presente qualifica soddisfa la direttiva 2014/68/UE- All. I - 3.1.2

Prova supplementare di saldatura ad angolo / *Supplementary fillet weld test* ☐ Sì/*Yes* ☒ No

Conoscenze tecniche / *Job Knowledge* ☐ Accettabile / *Acceptable* ☒ Non sottoposta a prova / *Not Tested*

Variabili / ***Variables***	**Dettagli della prova** / ***Welding test details***	**Campo di validità** / ***Range of approval***
Processo di saldatura / *Welding Process*	141 111	**141, 142, 143, 145** 111
Modalità di trasferimento / *Transfer Mode*	N.A.	---
Tipo di prodotto / *Product Type – Plate (P) or Pipe (T)*	T	P – T – Branch Connection ≥ 60°
Tipo di saldatura / *Type of weld*	BW	BW
Gruppo del materiale base e sottogruppo / *Parent Material Group(s) and Sub Group(s)*	8 / 8.1	---
Materiale d'apporto designazione / *Filler material designation*	141= EN ISO 14343-A: W 19 12 3 L Si 111= EN ISO 3581-A: E 19 12 3 L R 3 2	S, M A, RA, RB, RC, RR, R
Gruppo materiale d'apporto / *Filler material group*	FM5	FM5
Gas di protezione / *Shielding gas*	ISO 14175 I1 Ar 99,99%	---
Ausiliari / *Auxiliaries (e.g. backing gas)*	ISO 14175 I1 Ar 99,99%	---
Tipologia di corrente e polarità / *Type of Current and Polarity*	141 = DCEN 111 = DCEP	---
Spess. del materiale (mm) / *Material Thickness (mm)*	5,54	---
Spessore del materiale depositato (mm) / *Deposited Thickness (mm)*	141 = 2 111 = 3,54	2 to 4 3 to 7,08
Diametro esterno del tubo (mm) / *Pipe outside diameter (mm)*	60,3	≥ 30,15
Posizione di saldatura / *Welding positions*	PA	PA
Dettagli della saldatura / *Weld details*	141 = ss gb 111 = ss mb	ss mb – bs – ss gb ss mb, bs
Strati multipli/strato singolo / *Multy-layer / single layer*	ml	---
Altro / *Other*	---	---

0251CM_09_IT

Certificato n°
Certificate No. **ICIM – WAC – 026692 - 00**

Tipo di test ***Type of test***	**Eseguite e Accettate** ***Performed and Acceptable***	**Non testate** ***Not tested***
Esame visivo *Visual testing (UNI EN ISO 17637)*	ACCEPTABLE IRTEC S.r.l. Report no. RC-0095/23	
Esame radiografico *Radiographic testing (UNI EN ISO 17636)* o, se applicabile / *or, if applicable* **Esame ultrasonoro** *Ultrasonic testing (UNI EN ISO 17640)*	ACCEPTABLE IRTEC S.r.l. Report no. RC-0300/23	X
Prova di piegatura *Bend test (UNI EN ISO 5173)* o, se applicabile / *or, if applicable* **Prova di trazione con intaglio** *Notch tensile test*		X
Prova di frattura *Fracture test (UNI EN ISO 9017)* o, se applicabile / *or, if applicable* **Esame macrografico** *Macroscopic examination (UNI EN ISO 17639)* o, se applicabile / *or, if applicable*		X

Si certifica che il saldatore sopra indicato, usando la procedura di saldatura indicata nel presente modulo, ha soddisfatto i requisiti descritti dalle norme applicate con la seguente Designazione:

We certify that the welder identified above, using the welding procedure given in the present form, has satisfied the requirements described from the applied standards with the following Designation:

1) UNI EN ISO 9606-1: 2017 – 141 – T – BW – FM5 – S – D60,3 – s2 – PA – ss gb – ml
2) UNI EN ISO 9606-1: 2017 – 111 – T – BW – FM5 – R – D60,3 – s3,54 – PA – ss mb – ml

Luogo di saldatura *Place of welding*	Data di saldatura *Date of welding*	Esaminatore *Examiner*
Montodine (CR)	24/03/2023	LAZZARIN MARCO - Welding Inspector

Data di delibera ***Date of approval***	**Approvatore** ***Manager***
26/05/2026	*Vincenzo De Acqua* Rappresentante Direzione / Management Representative **ICIM S.p.A.**

Rivalidazione dopo 3 anni *Revalidation after 3 years*	Valido fino al *Valid until*	Rivalidazione dopo 2 anni *Revalidation after 2 years*	Valido fino al *Valid until*	Rivalidazione dopo 6 mesi *Revalidation after 6 months*	Valido fino al *Valid until*
9.3 a)	23/03/2026	**9.3 b)**		**9.3 c)**	

Applicabile esclusivamente per rivalidazione secondo paragrafi 9.3 b) oppure paragrafo 9.3 c)

Applicable for Revalidation according to sub-clause 9.3 b) or sub-clause 9.3 c)

Per la rivalidazione della qualifica da parte dell'ente di esame, per i successivi 2 anni si prega di fare riferimento all'allegato XXXXX

For the revalidation of the qualification by examining body for the following 2 years please refer to the attachment XXXX

Conferma della validità da parte del datore di lavoro/coordinatore della saldatura/ente di esame, per i successivi 6 mesi

Confirmation of the validity by employer/welding coordinator/examining body for the following 6 months

Data *Date*	Firma *Signature*	Posizione o Titolo *Position or Title*
25.09.2023	Nora Dai	RGQ/CQ
18.03.2024	Nora Dai	RGQ/CQ
18.09.2024	Nora Dai	RGQ/CQ

0251CM_09_IT

Welding Procedure Specification (pWPS/WPS)

Welding Procedure Specification: **EN-08-20**

WPQR No.: **EN-R04/15**

Manufacturer: **TICI S.R.L. - MONTODINE (CR)**

Mode of metal transfer: **N.A.**

Joint Type and Weld Type: **BW, T, ss (141, 111) - nb, ml (141) - mb, ml (111)**

Weld Preparation Details (Sketch)

Method of Preparation and Cleaning: **GRINDING, BRUSHING**

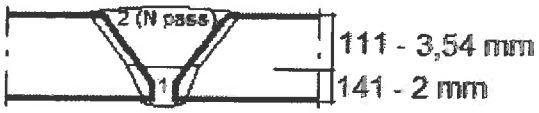
Parent Material Designation: **EN 15608 Gr. 8**

Material thickness (mm): **5,54**

Outside Diameter (mm): **60,3**

Welding Position: **PA**

Joint Design



Welding Details

Run	Welding Process	Size of Filler Material (mm)	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed (mm/sec)	Run out length/Travel Speed (mm/sec)	Heat input (EN 1011-1) (kJ/mm)
1	141	2,4	119 - 121	9 - 11	DCEN	N.A.	1,1 - 1,2	0,5 - 0,7
2 (N pass)	111	3,2	103 - 105	21 - 23	DCEP	N.A.	2,7 - 2,8	0,6 - 0,7

Filler Material Designation and Make: **EN ISO 14343-A 19 9 L**
EN ISO 3581-A E 19 9 L R 1 2

Other information, e.g.:

Any Special Baking or Drying: **NONE**

Designation Gas/Flux: - Shielding: **I1 (141) nozzle 8 mm**

- Backing: **I1 (141)**

Gas Flow Rate - Shielding: **10-13 lt/min (141)**

- Backing: **10-15 lt/min (141)**

Tungsten Electrode Type/Size: **(141) EN 26848 2,4 mm Tbi M3 WG-La15**

Details of Back Gouging/Backing: **NONE**

Preheat Temperature: **15 °C**

Interpass Temperature: **150 °C**

Post-Heating: **NONE**

Pre-heat maintenance temperature **NONE**

Post-Weld Heat-Treatment and/or Ageing: **NONE**

(Time, Temperature, Method: **N.A.**

Heating and Cooling Rates): **N.A.**

Weaving (maximum width of run): **N.A.**

Oscillation : amplitude, frequency, dwell time: **N.A.**

Pulse welding details: **N.A.**

Distance contact tube/work piece: **N.A.**

Plasma welding details: **N.A.**

Torch angle: **75°**

A. MARZI - 25/09/2020
TICI S.R.L. - MONTODINE (CR)

T.I.C.I. S.R.L.
Via dell'Artigianato, 8 - 26010 Montodine - CR
Tel: 0373 - 242256 Fax: 0373 - 966290
ticiarl1@virgilio.it - www.ticiarl.com
P.I./C.F. IT 00982060190

1.4.3 Non-Destructive examinations Procedures and operators list and qualifications

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

NON-DESTRUCTIVE EXAMINATIONS PROCEDURES (NDE) AND OPERATORS LIST AND QUALIFICATIONS

Document Number: 1724000887-NDT-PRO-00008
Document Class: 2

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Comandini Massimo Level III NDT EN - ISO9712 WI CSWIP 3.1	23-01-2025

Rev.	Date	Description	Prepared	Reviewed	Approved
03	22/01/2025	Acceptance for Construction (AFC)	MD	RV	ADL
02	12/12/2024	Acceptance for Construction (AFC)	MD	RV	ADL
01	10/10/2024	Acceptance for Construction (AFC)	MD	RV	ADL
00	06/09/2024	Issue for Review (IFR)	MD	RV	ADL

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THERMO ENGINEERING ADVANCED COMBUSTION SYSTEMS

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Acceptance for Constrcution (AFC)
02	Acceptance for Construction (AFC)
03	Acceptance for Constrcution (AFC)

HOLDS LIST

No.	Description
1	
2	
3	
4	

List of Attachments

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- Attachment 2 - VISUAL EXAMINATION PROCEDURE.....24
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RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

I.R.T.E.C. s.r.l.

RADIOGRAPHIC TESTING PROCEDURE

IR TEC SRL
SISTEMA DI QUALITA'
CERTIFICATO ISO 9001:2008

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

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4. SYMBOLS AND ABBREVIATED TERMS
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6. GENERAL PREPARATIONS AND REQUIREMENTS
7. RECOMMENDED TECHNIQUES
8. ACCEPTANCE CRITERIA
9. TEST REPORT

By signature and date on the front sheet of this Procedure by the relevant persons, the signature on each page of this Procedure are waived

1	3	2024/10/02	Revised according with comments
1	2	2017/09/01	GE Films added
1	1	2015/11/25	Revised according to comments
1	0	2014/07/31	Prima emissione – First issue
Em.	**Rev.**	**Data –Date**	**Descrizione – Description**
REVISIONI – REVISIONS			

Emessa da:
Issued by :

ISTITUTO DI RICERCHE TECNOLOGIE E COLLAUDI

Verificata/Approvata da:
Verified/Approved by :
Level 3 ISO 9712

dott. Ing. G. GROSSI

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

1. SCOPE AND APPLICABILITY

1.1. This procedure describes the method used for X-Ray or γ-Ray examination of butt welds in plates, shells, flat and formed heads, structural shapes, tubes and pipes.

1.2. In the case of examination of T-joints and branch connections the test arrangement shall be agreed between the contracting parties.

1.3. This procedure is applicable to ferrous and non ferrous alloys for the following maximum thicknesses (equivalent in steel):

1.3.1. 50 mm for X-Rays exposures (300 kV)

1.3.2. 90 mm for Ir 192 exposures

1.4. For what not specified here, the requirements of UNI EN 17636-1 shall be considered as requirements that integrate the present procedure.

1.5. The need of the radiographic examination, when required by the design, shall be indicated in the drawing of vessel or other item to be tested. Shall also clearly indicated the required extension of examination.

2. NORMATIVE REFERENCES

2.1. UNI EN ISO 17636-1

2.2. UNI EN ISO 9712

2.3. UNI EN ISO 11699-1

2.4. UNI EN ISO 11699-2

2.5. UNI EN ISO 5579

2.6. UNI EN ISO 10675-1

2.7 Specification K559-2254-MT-SPE-001 Structural fabrication specification

3. TERMS AND DEFINITIONS

3.1. Nominal thickness **t** - Nominal thickness of the parent material (manufacturing tolerances do not have to be taken in account)

3.2. Penetrated thickness **w** – Thickness of material in the direction of the radiation beam calculated on the basis of the nominal thicknesses of all penetrated walls

3.3. Object to film distance **b** – Distance between the radiation side of the radiographed part of the test object and the film surface measured along the central axis of the radiation beam.

3.4. Source size **d** – the maximum projected dimension of the radiating source (or effective focal spot) in the plane perpendicular to the distance from the weld or object being radiographed. See paragraph 7.6.3.

3.5. Source to film distance **SFD** – Distance between the source of radiation and the film measured in the direction of the beam.

3.6. Source to object distance **f** – distance between the source of radiation and the source side of the test object measured along the central axis of the radiation beam.

3.7. External diameter $\mathbf{D_e}$ – nominal external diameter of the pipe.

3.8. Panoramic exposure . Exposure with radiation source centrally located inside the object and with the film outside (see figure 3).

4. SYMBOLS AND ABBREVIATED TERMS

4.1. SWE – Single wall exposure

4.2. DWE – Double wall exposure

4.3. SWV – Single wall viewing

4.4. DWV – Double wall viewing

4.5. IQI - Image quality indicator

5. CLASSIFICATION OF RADIOGRAPHIC TECHNIQUES

5.1. The radiographic techniques are divided into two classes:

5.1.1. Class A: basic techniques

5.1.2. Class B: improved techniques

5.2. Unless otherwise required the class B techniques shall be used.

5.3. If, for technical or industrial reasons, it is not possible to meet **one** of the following conditions specified for class B:

5.3.1. Type of radiation source

5.3.2. Source to object distance

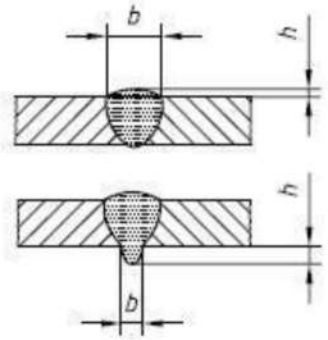
It may be agreed by contracting parties that the **condition selected** may be that specified for class A. The loss of sensitivity shall be compensated by an increase of minimum density to 3.0 or by selection of a better film system class with a minimum density of 2.6.
The other conditions for class B remain unchanged, especially the image quality achieved.
This does not apply if the special SFD reduction as described in 7.6 are used (panoramic and SWE-SWV with source in the concave side of the object).

6. GENERAL PREPARATIONS AND REQUIREMENTS

6.1. **Protection against ionizing radiation** – National safety precautions shall be strictly applied.

6.2. **Surface preparation and stage of manufacture** - The weld ripples or weld surface irregularities on both the inside (where accessible) and outside shall be removed by any suitable process to such a degree that the images of surface irregularities cannot mask or be confused with the image of any discontinuity on the resulting radiograph. The finished surface of all butt-welded joints may be flush with the base material or may have reasonably uniform crowns, with reinforcement not to exceed that specified in the referencing Code Section.
According to UNI EN ISO 5817 the maximum allowed excess weld metal and penetration shall be :

Quality level UNI EN ISO 5817	Maximum excess weld metal (mm)	Maximum Penetration (mm)
C	0.15 b + 1 – max. 7	0.6 b + 1 – max. 4
B	0.1 b + 1 – max. 5	0.2 b + 1 – max. 3



Unless otherwise specified, radiography shall be carried out after the final stage of manufacture, e.g. after heat treatment.

6.3. **Location of the weld in the radiographs** – Where the radiograph does not show the weld, lead markers shall be placed on either side of the weld.

6.4. **Identification of radiographs and location markers** – Lead symbols shall be affixed to each section of the object being radiographed.
The images of these symbols shall appear in the radiograph outside the area of interest where possible and shall assure unambiguous identification of the section and permitting the area of interest on a radiograph to be accurately traceable to its location on the part.
In all exposure techniques except the techniques in the figures 8 and 9 the location markers indicate the start and the end of the radiographed length.
In the case of the exposure techniques in figures 8 and 9 (DWE-DWV) one location marker in the middle of the examined length shall be used.

6.5. **Marking** – Permanent markings on the object to be examined shall be made **by the manufacturer** in the positions of the location markers which have been indelibly marked by the personnel performing radiography .
When inaccessibility or other limitations prevent the placement of markers as stipulated in 6.4 a dimensioned map of the actual marker placement shall accompany the radiographs to show that full coverage has been obtained.

6.6. **Overlap of films** – When radiographing an area with two or more separate films, the films shall overlap sufficiently to ensure the complete coverage of the region of interest. This is verified by the location markers which are to appear on each film.
In every case the minimum distance between the location marker and the end of the film shall be 20 mm.

6.7. **Types and positions of image quality indicators** – The quality of image shall be verified by use of wire image quality indicators (IQI) in accordance with UNI EN ISO 19232-1. In the following table are listed the materials of which the wires are made and the materials :

Wire material	Suitable for testing of the following materials
CU - Copper	Copper, Zinc, Tin and their alloys
FE - Steel	Ferrous materials
TI - Titanium	Titanium, titanium alloy
AL - Aluminium	Aluminium, aluminium alloys

6.7.1. The IQI shall be placed **source side at the center of each radiographed length**. The identification numbers and, when used the lead letter F, shall not be in the area of interest, except when geometric configuration makes it impractical. The IQI shall be in close contact with the surface of the object. Its location shall be made in a section of uniform thickness characterized by a uniform optical density on the film.
The following points shall also be considered:

- The wires of the IQI shall be directed perpendicular to the weld and its location shall ensure that at least 10 mm of wire shows in the parent metal adjacent to the weld.
- For elliptic and perpendicular exposures (DWE-DWV figures 8 and 9) the IQI may be placed **either on the source or on the film side.**
- Where inaccessibility prevents hand placing the IQI on the source side, the IQI shall be placed on the film side in contact with the part being examined.
  A lead letter "F" shall be placed adjacent to or on the IQI(s).
  In this case shall be visible the smaller wire adjacent to that required for the source side position (see paragraph 6.9).
- For panoramic exposures of pipes and shells with diameter 200 mm and above at least three IQIs should be placed equally spaced at the circumference.

6.8. **Evaluation of image quality** - Viewing facilities shall provide subdued background lighting of an intensity that will not cause reflections, shadows, or glare on the radiograph that interfere with the interpretation process.
Equipment used to view radiographs for interpretation shall provide a variable light source sufficient for designated wire to be visible for the density of 4.0.
The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretation.

6.9. **Minimum image quality values** – Tables 1 ÷ 6 show the minimum quality values required for class A and B radiographic technique.
In the case where Ir 192 sources are used, IQI values worse than the ones listed in tables 1 ÷ 6 may be accepted by agreement of contracting parties as allowed in UNI EN ISO 17636-1 paragraph 6.9.

6.10. **Personnel qualification** – Personnel performing non destructive examination shall be qualified in accordance with ISO 9712 to the appropriate level.

7. RECOMMENDED TECHNIQUES

7.1. Test arrangements

7.1.1. A single wall exposure technique shall be used for radiography whenever practical. When it is not practical to use a single wall technique a double wall technique shall be used. An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained. In any case films shall be placed as close to the object as possible.
Multi-film techniques shall not be used to reduce exposure times on uniform sections.
Multi-film technique may be agreed by the contracting parties when it is useful for reasons such as the geometry of the piece or differences in material thickness (e.g. butt weld between plates of different thicknesses).

7.1.2. **Single wall technique** - In the single wall technique, the radiation passes through only one wall of the weld which is viewed for acceptance on the radiograph. See in figures 1 ÷ 4 the test arrangements.

7.1.3. **Double-Wall Technique** - When it is not practical to use a single-wall technique, one of the following double-wall techniques shall be used:

7.1.3.1. **Single-Wall Viewing** - For welds in components, a technique may be used in which the radiation passes through two walls and only the weld (material) on the film-side wall is viewed for acceptance on the radiograph. When complete coverage is required for circumferential welds, a minimum of three exposures taken 120 deg to each other shall be made. See in figure 5 ÷ 7 the test arrangements.

7.1.3.2. **Double-Wall Viewing**

7.1.3.2.1. **Elliptic technique -** For welds in pipes and tubes a technique may be used in which the radiation passes through two walls and the weld in both walls is viewed for acceptance on the same radiograph
The radiation beam shall be offset from the plane of the weld at an angle sufficient to separate the images of the source-side and film-side portions of the weld so that there is no overlap of the areas to be interpreted. The distance between the two projected weld images shall be about one weld width.

The elliptic technique **should not** be used if :

- $D_e > 100$ mm
- $t > 8$ mm
- Weld width > De/4

Two 90° displaced images are sufficient if t/De < 0.12; otherwise three exposures 120° or 60° apart are required. See in figure 8 the test arrangement

7.1.3.2.2. **Perpendicular technique** - When it is difficult to carry out an elliptic examination at De ≤ 100 mm, the perpendicular technique may be used. The weld may be radiographed with the radiation beam positioned so that the images of both walls are superimposed. When complete coverage is required, a minimum of three exposures taken at either 60° or 120° to each other shall be made for each joint. See in figure 9 the test arrangement.

7.2. **Choice of tube voltage and radiation source**

7.2.1. **X-ray devices up to 300 kV** - To maintain a good flaw sensitivity, the X-ray tube voltage should be as low as possible. The maximum values of X-ray tube voltage versus thickness are given in figure 10.
For some applications where there is a thickness change across the area of the object being radiographed, a slightly higher voltage may be used :

Copper and nickel alloys	60 kV
Steel	50 kV
Titanium and alloys	40 kV
Aluminium and alloys	30 kV

7.2.2. **Iridium 192 sources** – The allowable ranges of penetrated thickness for steel, copper and nickel base alloys are listed in the following table:

Penetrated thickness, w (mm)	
Class A	Class B
$20 \leq w \leq 100$	$20 \leq w \leq 90$

The travel time to position the source shall not exceed 10% of the total exposure time.

7.2.3. **For certain applications, wider wall thickness ranges may be permitted, if sufficient image quality can be achieved.**

7.3. Film systems and lead screens

7.3.1. In table 7 are listed the minimum film system classes (according to UNI EN 160 11699-1) to be used for the radiography of steels, copper and nickel based alloys.
In table 8 are listed the minimum film system classes (according to UNI EN 160 11699-1) to be used for the radiography of aluminium, titanium and their alloys.

7.3.2. When using metal screens, good contact between film and screens is absolutely required.
Other screen thicknesses may also be agreed between the contracting parties, provided the required image quality is achieved.

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

7.4. Alignment of beam

7.4.1. The beam of radiation shall be directed to the centre of the area being examined and should be perpendicular to the object surface at that point. Other arrangements may be agreed between the contracting parties.

7.5. Reduction of scattered radiation

7.5.1. The presence of excessive scattered radiation prevents to obtain the required sensitivity.

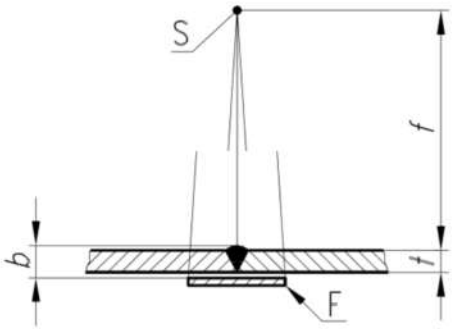
7.5.2. In order to reduce the effect of backscattered radiation, direct radiation shall be collimated to the section under examination and the film shall be shielded, if necessary by a sheet of lead of a convenient thickness (e.g. 1 ÷ 5mm) placed behind the film-screen combination.
May be, also, necessary to intercept edge scatter by lead sheets of convenient thickness (e.g. 1 ÷ 5mm).

7.5.3. If necessary, the presence of excessive backscattered radiation shall be checked by means of a lead letter B (with a minimum height of 12.7 mm and a minimum thickness of 1.5 mm) placed behind the cassette.
If a light image of the "B" appears on a darker background, protection from back scatter is insufficient and the radiograph shall be considered unacceptable . No image or a dark image of the "B" on a lighter background is not cause for rejection.

7.6. Source to object distance

7.6.1. The **minimum source to object distance f_{min}** depends on the source size **d** and on the object to film distance **b** and shall be:

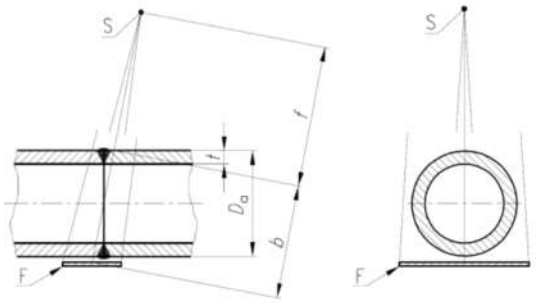
Class A	Class B
$f_{min} \geq d*7.5*b^{2/3}$	$f_{min} \geq d*15*b^{2/3}$

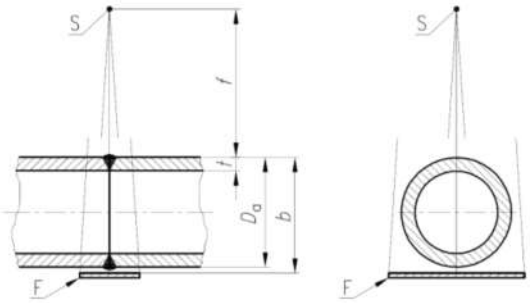


7.6.2. Source size - The equipment manufacturer's or supplier's publications, such as technical manuals, decay curves, or written statements documenting the actual or maximum source size or focal spot, shall be
acceptable as source size verification.

7.6.3. When the source size or focal spot size is defined by two dimensions, the larger shall be used.

- The focal spot of a radiographic tube has an elliptic, rectangular or trapezoidal shape; the focal spot dimension is the major axis of the ellipse, the longer side of the rectangle and the larger base of the trapezium.
- An Ir 192 source has a cylindrical shape; the dimension is the greater between the diameter and the length.





7.6.4. If the dimension **b** (total weld thickness) is less than 1.2*t it may be
replaced by the nominal thickness **t**.

7.6.5. For determination of the source to object f_{min}, the nomogram in figure 11 may be used.

7.6.6. When using the elliptic or perpendicular technique (figures 8 and 9) the dimension **b** shall be replaced by the external diameter $\mathbf{D_e}$ of the pipe.

7.6.7. When using the technique in figure 4 (source inside the object), the minimum source to object distance **f** may be reduced up to 20%.

7.6.8. When using the technique in figure 3 (panoramic exposure) and provided that the IQI requirements are met, the minimum source to object distance **f** may be reduced up to 50%.
A further reduction can be agreed by the contracting parties provided that the IQI requirements are met.

7.7. Maximum area for a single exposure

7.7.1. The number of radiographs for a complete examination of welds shall be specified in accordance with the following technical requirements:

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

7.7.1.1. The ratio of the penetrated thickness at the outer edge of an evaluated area of uniform thickness to that at the centre beam shall not be more than 1.1 for class B and 1.2 for class A :

7.7.1.2. The densities resulting from any variation of penetrated thickness should not be lower or higher than those indicated in 7.8.

7.7.1.3. The size of the area to be examined includes the weld and the heat affected zones. In general, about 10 mm of parent metal shall be examined on each side of the weld.

7.7.2. Recommendations for the number of radiographs are indicated in Annex A of UNI EN ISO 17636-1which gives an acceptable examination of a circumferential butt weld.

7.8. Density of radiograph

7.8.1. Exposure conditions should be such that the optical density of the radiograph in the area examined satisfies the requirements of the following table

Class	Optical density	
	Required	Admitted (special agreement)
A	2.0 ÷ 4.0	1.5 ÷ 4.0
B	2.3 ÷ 4.0	2.0 ÷ 4.0
A measuring tolerance of ± 0.1 is permitted		

7.8.2. For composite viewing of multiple film exposures, each film of the composite set shall have a minimum density of 1.3. The maximum density shall be 4.0 for either single or composite viewing.

7.8.3. The fog density shall not exceed 0.3.
Fog density is defined the total density (emulsion and base) of a processed, unexposed film.

7.9. Processing

7.9.1. Films are automatically processed with :
Carestream M37 Filmprocessor using :

- G 135 Developer
- G 335 Fixe

in accordance with the conditions recommended by the film and chemical manufacturer to obtain the selected film system class (cycle 8 minutes temperature 28°C)

7.9.2. The radiographs should be free from defects due to processing or other causes which would interfere with interpretation.

7.10. Film viewing conditions

7.10.1. Viewing facilities shall provide subdued background lighting of an intensity that will not cause reflections, shadows, or glare on the radiograph that interfere with the interpretation process. Equipment used to view radiographs for interpretation shall provide a variable light source in accordance with EN 25580 sufficient for the designated wire to be visible for the specified density range. The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretation.

8. ACCEPTANCE CRITERIA

8.1. Before radiographic testing the welds must have successfully passed the visual examination.

8.2. Acceptance criteria shall be in accordance with ISO 10675-1 Level 1

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

9. TEST REPORT

9.1. The test report shall include the following information :

- 9.1.1. Name of examination body
- 9.1.2. Object
- 9.1.3. Material
- 9.1.4. Heat treatment
- 9.1.5. Material thickness
- 9.1.6. Specification of examination including requirements for acceptance
- 9.1.7. Radiographic technique and class, required sensitivity
- 9.1.8. Test arrangement
- 9.1.9. Radiation source, size of focal spot and identification of equipment
- 9.1.10. Film type and system, screens and filters
- 9.1.11. Tube voltage used and current or source type and activity
- 9.1.12. Source to film distance and time of exposure
- 9.1.13. Processing technique : manual or automatic
- 9.1.14. Type and position of IQIs
- 9.1.15. Data on film density, IQI readings
- 9.1.16. Results of examination
- 9.1.17. Any deviation by special agreement from this procedure
- 9.1.18. Geometry of the weld
- 9.1.19. System of marking used
- 9.1.20. Film position plan
- 9.1.21. Welding process

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

TABLE 1 – CLASS "A" – SINGLE WALL				
	Source side IQI			
Nominal thickness t (mm)	Wire type	Wire diameter (mm)	IQI Denomination and thinnest visible wire	Sensitivity (%)
t ≤ 1.2	W18	0.063	6th wire of 13 XX EN	≥ 5.25
1.2 < t ≤ 2.0	W17	0.080	5th wire of 13 XX EN	4.0 ÷ 6.67
2.0 < t ≤ 3.5	W16	0.100	4th wire of 13 XX EN (7th wire of 10 XX EN)	2.86 ÷ 5.0
3.5 < t ≤ 5.0	W15	0.125	3rd wire of 13 XX EN 6th wire of 10 XX EN	2.5 ÷ 3.57
5.0 < t ≤ 7	W14	0.16	2nd wire of 13 XX EN 5th wire of 10 XX EN	2.29 ÷ 3.2
7 < t ≤ 10	W13	0.20	(1st wire of 13 XX EN) 4th wire of 10 XX EN	2.0 ÷ 2.86
10 < t ≤ 15	W12	0.25	3rd wire of 10 XX EN (7thwire of 6 XX EN)	1.67 ÷ 2.5
15 < t ≤ 25	W11	0.32	2nd wire of 10 XX EN 6thwire of 6 XX EN	1.28 ÷ 2.13
25 < t ≤ 32	W10	0.40	(1st wire of 10 XX EN) 5th wire of 6 XX EN	1.25 ÷ 1.6
32 < t ≤ 40	W9	0.50	4th wire of 6 XX EN	1.25 ÷ 1.56
40 < t ≤ 55	W8	0.63	3rd wire of 6 XX EN	1.15 ÷ 1.58
55 < t ≤ 85	W7	0.80	2nd wire of 6 XX EN (7th wire of 1 XX EN)	0.94 ÷ 1.45
85 < t ≤ 150	W6	1.00	(1st wire of 6 XX EN) 6th wire of 1 XX EN	0.67 ÷ 1.18
150 < t ≤ 250	W5	1.25	5th wire of 1 XX EN	0.5 ÷ 0.83
250 < t	W4	1.60	4th wire of 1 XX EN	<. 0.64

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

TABLE 2 – CLASS "B" – SINGLE WALL				
	Source side IQI			
Nominal thickness t (mm)	**Wire type**	**Wire diameter (mm)**	**IQI Denomination and thinnest visible wire (*)**	**Sensitivity (%)**
$t \leq 1.5$	W19	0.05	7th wire of 13 XX EN	≥ 3.33
$1.5 < t \leq 2.5$	W18	0.063	6th wire of 13 XX EN	2.52 ÷ 4.2
$2.5 < t \leq 4$	W17	0.080	5th wire of 13 XX EN	2.0 ÷ 3.2
$4 < t \leq 6$	W16	0.100	4th wire of 13 XX EN 7th wire of 10 XX EN	1.67 ÷ 2.5
$6.0 < t \leq 8$	W15	0.125	3th wire of 13 XX EN 6th wire of 10 XX EN	1.56 ÷ 2.08
$8 < t \leq 12$	W14	0.16	2nd wire of 13 XX EN 5th wire of 10 XX EN	1.33 ÷ 2.0
$12 < t \leq 20$	W13	0.20	(1st wire of 13 XX EN) 4th wire of 10 XX EN	1.0 ÷ 1.67
$20 < t \leq 30$	W12	0.25	3rd wire of 10 XX EN (7th wire of 6 XX EN)	0.83 ÷ 1.25
$30 < t \leq 35$	W11	0.32	2nd wire of 10 XX EN 6th wire of 6 XX EN	0.91 ÷ 1.07
$35 < t \leq 45$	W10	0.40	(1st wire of 10 XX EN) 5th wire of 6 XX EN	0.89 ÷ 1.14
$45 < t \leq 65$	W9	0.50	4th wire of 6 XX EN	0.77 ÷ 1.11
$65 < t \leq 120$	W8	0.63	3th wire of 6 XX EN	0.53 ÷ 0.97
$120 < t \leq 200$	W7	0.80	2th wire of 6 XX EN (7th wire of XX EN)	094 ÷ 0.67
$200 < t \leq 350$	W6	1.00	(1st wire of 6 XX EN) 6th wire of 1 XX EN	0.29 ÷ 0.5
$350 < t$	W5	1.25	5th wire of 1 XX EN	< 0.36

(*) If possible do not use the IQI in brackets

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

TABLE 3 – CLASS "A" – DOUBLE WALL EXPOSURE – DOUBLE WALL VIEWING				
	Source side IQI			
Penetrated thickness w (mm)	**Wire type**	**Wire diameter (mm)**	**IQI Denomination and thinnest visible wire (*)**	**Sensitivity (%)**
w ≤ 1.2	W18	0.063	6th wire of 13 XX EN	≥ 10,5
1.2 < w ≤ 2.0	W17	0.080	5th wire of 13 XX EN	8.0 ÷ 13.33
2.0 < w ≤ 3.5	W16	0.100	4th wire of 13 XX EN (7th wire of 10 XX EN)	5.71 ÷ 10.0
3.5 < w ≤ 5.0	W15	0.125	3th wire of 13 XX EN 6th wire of 10 XX EN	5.0 ÷ 7.14
5.0 < w ≤ 7	W14	0.16	2nd wire of 13 XX EN 5th wire of 10 XX EN	4.57 ÷ 6.4
7 < w ≤ 12	W13	0.20	(1st wire of 13 XX EN) 4th wire of 10 XX EN	3.33 ÷ 5.71
12 < w ≤ 18	W12	0.25	3th wire of 10 XX EN 7th wire of 6 XX EN	2.78 ÷ 4.17
18 < w ≤ 30	W11	0.32	2nd wire of 10 XX EN 6th wire of 6 XX EN	2.13 ÷ 3.56
30 < w ≤ 40	W10	0.40	(1th wire of 10 XX EN) 5th wire of 6 XX EN	2.0 ÷ 2.67
40 < w ≤ 50	W9	0.50	4th wire of 6 XX EN	2.0 ÷ 2.5
50 < w ≤ 60	W8	0.63	3rd wire of 6 XX EN	2.1 ÷ 2.52
60 < w ≤ 85	W7	0.80	2th wire of 6 XX EN (7th wire of 1 XX EN)	1.88 ÷ 2.67
85 < w ≤ 120	W6	1.00	(1st wire of 6 XX EN) 6th wire of 1 XX EN	1.67 ÷ 2.35
120 < w ≤ 220	W5	1.25	5th wire of 1 XX EN	1.14 ÷ 2.08
220 < w ≤ 380	W4	1.60	4th wire of 1 XX EN	0.84 ÷ 1.45
380 < w	W3	2.00	3rd wire of 1 XX EN	<. 1.05

(*) If possible do not use the IQI in brackets

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

TABLE 4 – CLASS "B" – DOUBLE WALL EXPOSURE – DOUBLE WALL VIEWING				
	Source side			
Penetrated thickness w (mm)	**Wire type**	**Wire diameter (mm)**	**IQI Denomination and thinnest visible wire (*)**	**Sensitivity (%)**
w ≤ 1.5	W19	0.05	7th wire of 13 XX EN	≥ 6.66
1.5 < w ≤ 2.5	W18	0.063	6th wire of 13 XX EN	5.04 ÷ 8.4
2.5 < t ≤ 4	W17	0.080	5th wire of 13 XX EN	4.0 ÷ 6.4
4 < w ≤ 6	W16	0.100	4th wire of 13 XX EN 7th wire of 10 XX EN	3.33 ÷ 5.0
6.0 < w ≤ 8	W15	0.125	3rd wire of 13 XX EN 6th wire of 10 XX EN	3.13 ÷ 4.17
8 < w ≤ 15	W14	0.16	2nd wire of 13 XX EN 5th wire of 10 XX EN	2.13 ÷ 4.0
15 < w ≤ 25	W13	0.20	(1st wire of 13 XX EN) 4th wire of 10 XX EN	1.6 ÷ 2.67
25 < w ≤ 38	W12	0.25	3rd wire of 10 XX EN 7th wire of 6 XX EN	1.32 ÷ 2.0
38 < w ≤ 45	W11	0.32	2nd wire of 10 XX EN 6thfilodi 6 XX EN	1.42 ÷ 1.68
45 < w ≤ 55	W10	0.40	(1st wire of 10 XX EN) 5th wire of 6 XX EN	1.45 ÷ 1.78
55 < w ≤ 70	W9	0.50	4th wire of 6 XX EN	1.43 ÷ 1.82
70 < w ≤ 100	W8	0.63	3rd wire of 6 XX EN	1.26 ÷ 1.8
100 < w ≤ 170	W7	0.80	2th wire of 6 XX EN 7th wire of XX EN	0.94 ÷ 1.6
170 < w ≤ 250	W6	1.00	(1st wire of 6 XX EN) 6th wire of 1 XX EN	0.8 ÷ 1.18
250 < w	W5	1.25	5th wire of 1 XX EN	< 1.0

(*) If possible do not use the IQI in brackets

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

TABLE 5 – CLASS "A" – DOUBLE WALL EXPOSURE – SINGLE OR DOUBLE WALL VIEWING				
	Film side IQI			
Penetrated thickness w (mm)	**Wire type**	**Wire diameter (mm)**	**IQI Denomination and thinnest visible wire (*)**	**Sensitivity (%)**
$w \leq 1.2$	W18	0.063	6th wire of 13 XX EN	≥ 10,5
$1.2 < w \leq 2.0$	W17	0.080	5th wire of 13 XX EN	8.0 ÷ 13.33
$2.0 < w \leq 3.5$	W16	0.100	4th wire of 13 XX EN (7th wire of 10 XX EN)	5.71 ÷ 10.0
$3.5 < w \leq 5.0$	W15	0.125	3rd wire of 13 XX EN 6th wire of 10 XX EN	5.0 ÷ 7.14
$5.0 < w \leq 10$	W14	0.16	2nd wire of 13 XX EN 5th wire of 10 XX EN	3.2 ÷ 6.4
$10 < w \leq 15$	W13	0.20	(1st wire of 13 XX EN) 4th wire of 10 XX EN	2.67 ÷ 4.0
$15 < w \leq 22$	W12	0.25	3rd wire of 10 XX EN (7th wire of 6 XX EN)	2.27 ÷ 3.44
$22 < w \leq 38$	W11	0.32	2nd wire of 10 XX EN 6th wire of 6 XX EN	1.68 ÷ 2.91
$38 < w \leq 48$	W10	0.40	(1st wire of 10 XX EN) 5th wire of 6 XX EN	1.67 ÷ 2.11
$48 < w \leq 60$	W9	0.50	4th wire of 6 XX EN	1.67 ÷ 2.08
$60 < w \leq 85$	W8	0.63	3rd wire of 6 XX EN	1.48 ÷ 2.1
$85 < w \leq 125$	W7	0.80	2nd wire of 6 XX EN (7th wire of XX EN)	1.28 ÷ 1.88
$125 < w \leq 225$	W6	1.00	(1st wire of 6 XX EN) 6th wire of 1 XX EN	0.89 ÷ 1.6
$225 < w \leq 375$	W5	1.25	5th wire of 1 XX EN	0.67 ÷ 1.11
$375 < w$	W4	1.60	4th wire of 1 XX EN	< 0.85

(*) If possible do not use the IQI in brackets

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

TABLE 6 – CLASS "B" – DOUBLE WALL EXPOSURE – SINGLE OR DOUBLE WALL VIEWING				
	Film side			
Penetrated thickness w (mm)	**Wire type**	**Wire diameter (mm)**	**IQI Denomination and thinnest visible wire (*)**	**Sensitivity (%)**
$w \leq 1.5$	W19	0.05	7th wire of 13 XX EN	≥ 6.67
$1.5 < w \leq 2.5$	W18	0.063	6th wire of 13 XX EN	5.04 ÷ 8.4
$2.5 < w \leq 4$	W17	0.080	5th wire of 13 XX EN	4.0 ÷ 6.4
$4 < w \leq 6$	W16	0.100	4th wire of 13 XX EN (7th wire of 10 XX EN)	3.33 ÷ 5.0
$6.0 < w \leq 12$	W15	0.125	3rd wire of 13 XX EN 6th wire of 10 XX EN	2.08 ÷ 4.17
$12 < w \leq 18$	W14	0.16	2nd wire of 13 XX EN 5th wire of 10 XX EN	1.78 ÷ 2.67
$18 < w \leq 30$	W13	0.20	1st wire of 13 XX EN 4th wire of 10 XX EN	1.33 ÷ 2.22
$30 < w \leq 45$	W12	0.25	3rd wire of 10 XX EN (7th wire of 6 XX EN)	1.11 ÷ 1.67
$45 < w \leq 55$	W11	0.32	2nd wire of 10 XX EN 6th wire of 6 XX EN	1.16 ÷ 1.42
$55 < w \leq 70$	W10	0.40	(1st wire of 10 XX EN) 5th wire of 6 XX EN	1.14 ÷ 1.45
$70 < w \leq 100$	W9	0.50	4th wire of 6 XX EN	1.0 ÷ 1.43
$100 < w \leq 180$	W8	0.63	3rd wire of 6 XX EN	0.7 ÷ 1.26
$180 < w \leq 300$	W7	0.80	2nd wire of 6 XX EN (7th wire of XX EN)	0.53 ÷ 0.89
$300 < w$	W6	1.00	(1st wire of 6 XX EN) 6th wire of 1 XX EN	≤ 0.67

(*) If possible do not use the IQI in brackets

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION

TABLE 7 – Film system classes and metal screens for the radiography of steels, copper and nickel based alloys					
Radiation source	**Penetrated thickness, w (mm)**	**Film system class (*) (***)**		**Thickness of lead screens (mm)**	
		Class A	Class B	Front screen	Back screen
≤ 100 kV	Any	C5	C3	None or ≤ 0.03	None or ≤ 0.03
100 < kV ≤ 150	Any	C5	C3	0.03 ÷ 0.15	0.03 ÷ 0.15
150 < kV ≤ 250	Any	C5	C4	0.03 ÷ 0.15	0.03 ÷ 0.15
250 < kV ≤ 500	≤ 50	C5	C4	0.03 ÷ 0.2	0.03 ÷ 0.2
250 < kV ≤ 500	> 50	C5	C5	0.1 ÷ 0.2 (**)	0.02 ÷ 0.2
Ir 192	Any			Class A	
		C5	C4	0.02 ÷ 0.2	0.02 ÷ 0.2
				Class B	
		C5	C4	0.1 ÷ 0.2 (**)	0.02 ÷ 0.2

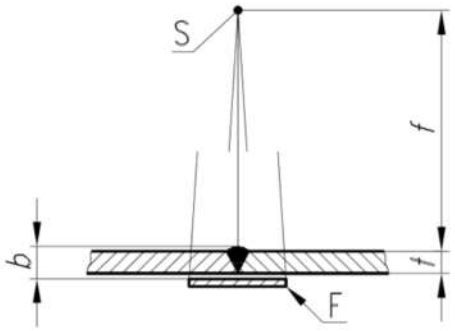
TABLE 8 – Film system classes and metal screens for the radiography of aluminium and titanium				
Radiation source	**Film system class (*) (***)**		**Thickness of lead screens (mm)**	
	Class A	Class B	Front screen	Back screen
kV ≤ 125	C5	C3	None	None
125 < kV ≤ 150	C5	C3	≤ 0.03	0.03 ÷ 0.15
150 < kV ≤ 250	C5	C3	0.03 ÷ 0.15	0.03 ÷ 0.15
250 < kV ≤ 300	C5	C3	0.1 ÷ 0.2	0.1 ÷ 0.2

(*) Better film system classes may also be used.

(**) Films with front and back lead screens 0.03 mm may be used if an additional lead screen of 0.1 mm is placed between the object and the film.

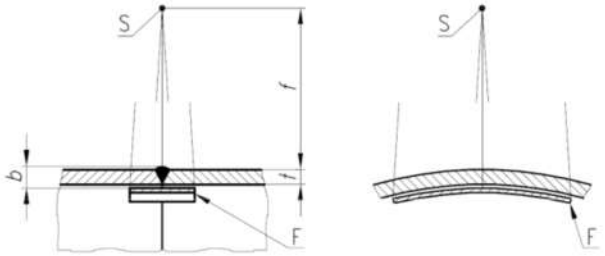
(***) C3 = GE STRUCTURIX D4
C4 = GE STRUCTURIX D5
C5 = GE STRUCTURIX D7

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION



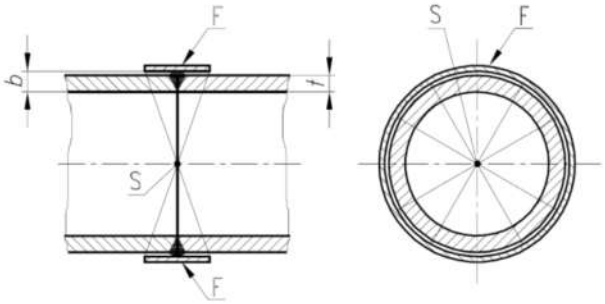
Weld in a flat plate or long. weld in a shell
SWE-SWV

FIGURE 1



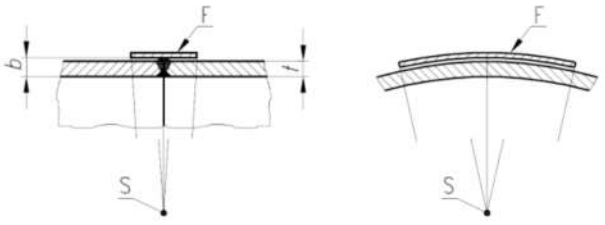
Circumferential weld
Outside source - SWE-SWV

FIGURE 2



Circumferential weld
Panoramic exposure - SWE-SWV

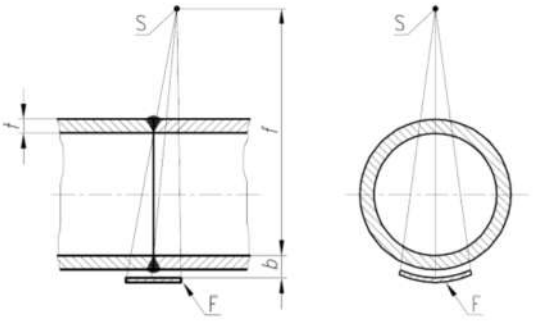
FIGURE 3



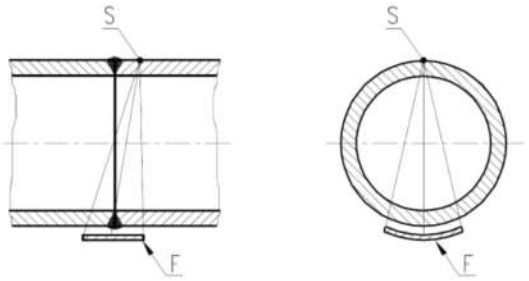
Circumferential weld
Inside source - SWE-SWV

FIGURE 4

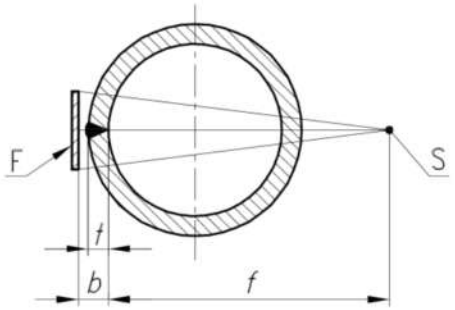
RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION



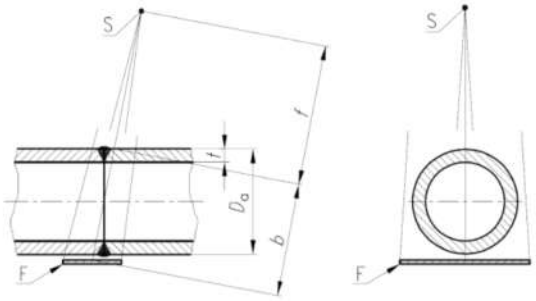
Circumferential weld FIGURE 5
DWE – SWV. The source to object distance shall be kept as small as possible while respecting the requirements of paragraph 7.6..



Circumferential weld FIGURE 6
DWE-SWV

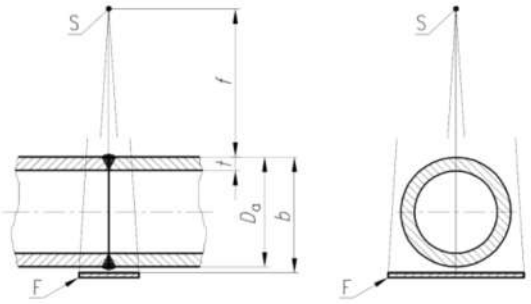


Longitudinal weld FIGURE 7
DWE-SWV



Circumferential weld FIGURE 8
Elliptic exposure - DWE-SWV

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION



Circumferential weld
Perpendicular exposure - DWE-DWV

FIGURE 9

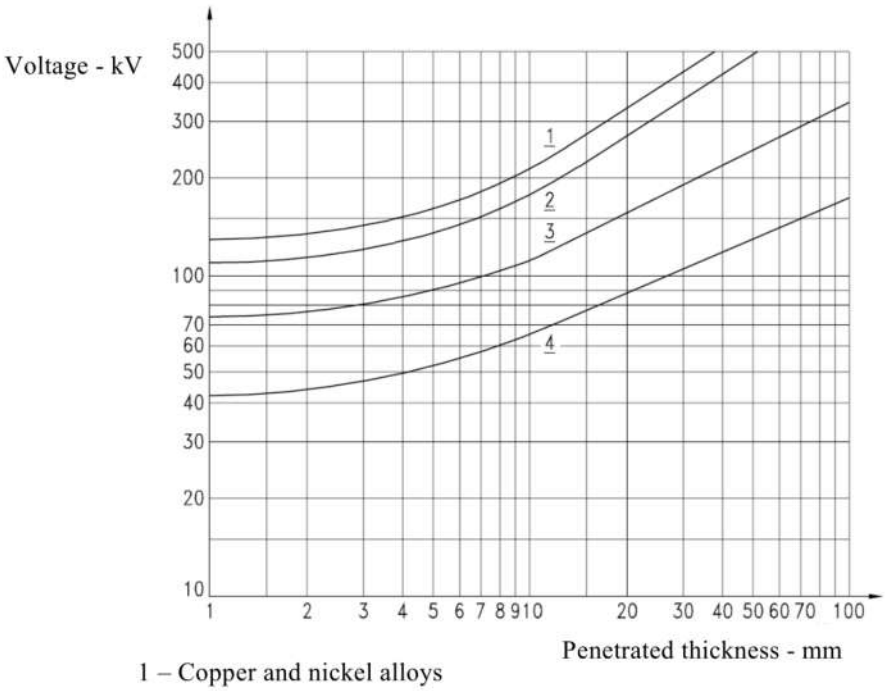
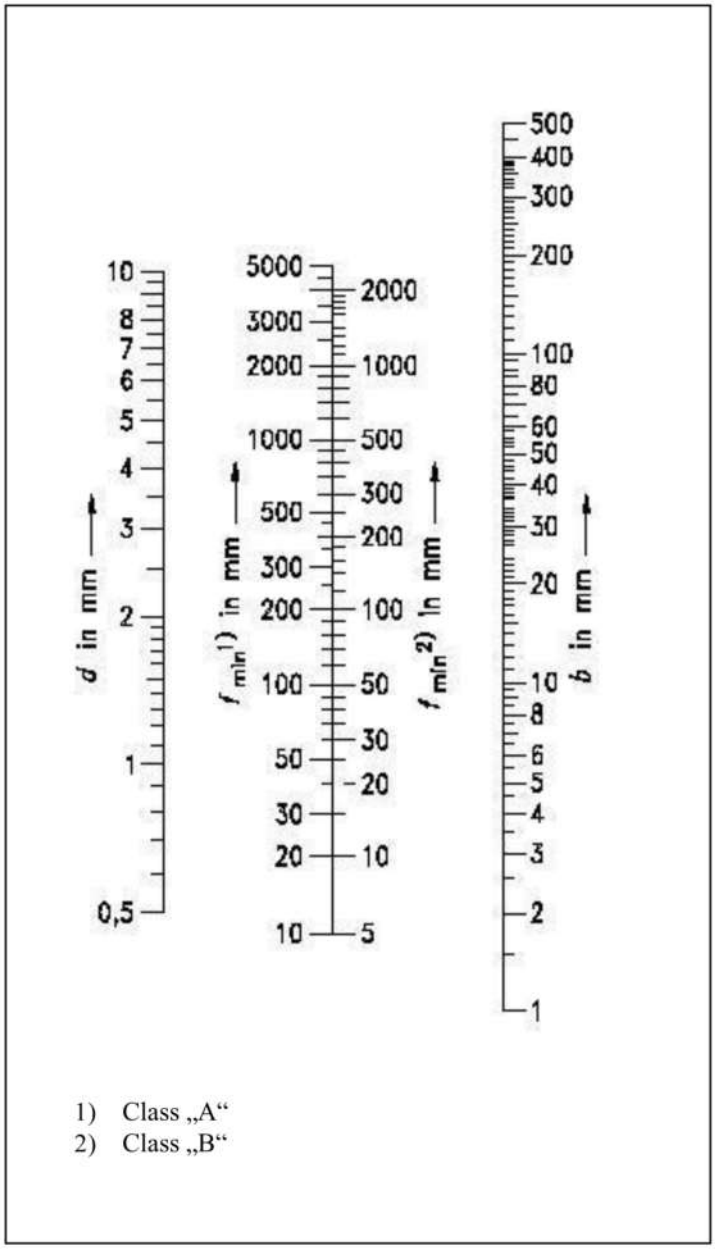


FIGURE 10

1 – Copper and nickel alloys
2 – Steel
3 – Titanium and alloys
4 - Aluminium and alloys

RADIOGRAPHIC EXAMINATION OF WELDS BY MEANS OF X RAYS AND γ RAYS ACCORDING TO UNI EN ISO 17636-1 SPECIFICATION



1) Class „A“
2) Class „B“

FIGURE 11

VISUAL EXAMINATION OF WELDS

Irtec s.r.l.

VISUAL EXAMINATION PROCEDURE

IR TEC SRL
SISTEMA DI QUALITA'
CERTIFICATO ISO 9001:2015

VISUAL EXAMINATION OF WELDS

INDEX

1. **SCOPE AND APPLICABILITY**
2. **REFERENCE DOCUMENTS**
3. **EXAMINATION CONDITIONS AND EQUIPMENT**
4. **PERSONNEL**
5. **GENERAL**
6. **VISUAL EXAMINATION OF JOINT PREPARATION**
7. **VISUAL EXAMINATION DURING WELDING**
8. **VISUAL EXAMINATION OF THE FINISHED WELD**
9. **VISUAL EXAMINATION OF REPAIRED WELDS**
10. **ACCEPTANCE CRITERIA**
11. **EXAMINATION RECORDS**

APPENDIX A

By signature and date on the front sheet of this Procedure by the relevant persons, the signature on each page of this Procedure are waived

1	3	2024/12/16	Revised according to comments
1	2	2018/05/11	Revised according to comments
1	1	2015/04/06	Revised according to ISO 17637: 2011
1	0	2006/03/24	Prima emissione – First issue
Em.	**Rev.**	**Data –Date**	**Descrizione - Description**
REVISIONI - REVISIONS			

Emessa da:
Issued by :
Technical Manager
Dott. Ing G. Grossi

Verificata/Approvata da:
Verified/Approved by :
Technical Manager
dott. Ing. G. GROSSI

VISUAL EXAMINATION OF WELDS

1. SCOPE AND APPLICABILITY

1.1. This procedure describes the method to be followed for visual examination of the following :

1.1.1. Weld preparations.

1.1.2. Surface of fillet and groove steel welds.

1.2. The test shall be conducted in the operative steps as specified by the construction Code :

1.2.1. Tackwelds to be left in place shall be examined visually for defects, and if found to be defective shall be removed.

1.2.2. Finished longitudinal, circumferential, shell to nozzle and fillet welds.

1.2.3. All the joints and connections shall be inspected for leaks during hydrostatic test

2. REFERENCE DOCUMENTS

2.1. EN 17637

2.2. EN 17635

2.3. EN 5817

3. EXAMINATION CONDITIONS AND EQUIPMENT

3.1. The luminance at the surface shall be a minimum of 350 lux.

3.2. For performance of direct inspection, the access shall be sufficient to place the eye within 600 mm of the surface and at an angle not less than approximately 30°. See figure 1

3.3. If required to obtain a good contrast and relief effect between imperfections and background, an additional light source should be used.

4. PERSONNEL

4.1. Personnel performing visual examination shall have an annual visual examination to assure natural or corrected near distance acuity such that they are capable of reading standard J-1 letters on standard Jaeger test type chart and be approved by the Employer.

4.2. If required personnel shall be certified level 2 according to ISO 9712.

5. GENERAL

5.1. The extent of examination shall be defined in advance by an application standard or by agreement between the contracting parties.

5.2. Welds shall, generally, examined in the as welded conditions.

6. VISUAL EXAMINATION OF JOINT PREPARATION

6.1. When visual examination is required prior to welding, the bevels shall be examined to check that :

6.1.1. the shape and dimensions of the weld preparation meet the specified requirements given in the welding procedure specification.

6.1.2. the fusion faces and adjacent surfaces are cleaned.

6.1.3. the parts to be joined by welding are fixed in relation to each other according to drawings or instructíons.

7. VISUAL EXAMINATION DURING WELDING

7.1. When required, the weld shall be examined during the welding process to check that :

7.1.1. Each run or layer of weld metal is cleaned before it is covered by a further run, particular attention being paid to the junctions between the weld metal and the fusion face.

7.1.2. There are no visible imperfections, e.g. cracks or cavities; if such imperfections are observed, they shall be reported so that remedial action can be taken before the deposition of further weld metal.

7.1.3. The transition between the runs and between the weld and the parent metal has such a shape that satisfactory melting can be accomplished when welding the next run.

7.1.4. The depth and shape of gouging is in accordance with the WPS or compared with the original groove shape in order to assure complete removal of the weld metal as specified.

8. VISUAL EXAMINATION OF THE FINISHED WELD

8.1. General

8.1.1. The finished weld shall be examined to determine whether it meets the agreed acceptance standard. If not specifically included within the requirements of an application standard or by agreement between the contracting parties, the items detailed in 8.2 to 8.5 shall be checked.

8.2. Cleaning and dressing

8.2.1. The weld shall be examined to check that :

8.2.1.1. All slag has been removed by manual or mechanical means. This is to avoid imperfections from being obscured.

8.2.1.2. There are no tool impressions or blow marks.

8.2.1.3. When weld dressing is required, overheating of the joint due to grinding is avoided and that grinding marks and an uneven finish are also avoided.

8.2.1.4. For fillet welds and butt welds to be dressed flush, the joint merges smoothly with the parent metal without under flushing.

8.3. Profile and dimensions

8.3.1. The weld shall be examined to check that :

8.3.1.1. The profile of the weld face and the height of any excess weld metal meet the requirements of the acceptance standard.

8.3.1.2. The surface of the weld is regular, the pattern and the pitch of weave marks present an even and satisfactory visual appearance. The distance between the last layer and the parent metal or the position of runs has been measured where required by the WPS.

8.3.1.3. The weld width is consistent over the whole of the joint and that it meets the requirements given in the weld drawing or acceptance standard. In the case of butt welds, it shall be checked that the weld preparation has been completely filled.

8.4. Weld root and surfaces

8.4.1. The visually accessible parts of the weld, i.e. the weld root for a single-sided butt weld and the weld surfaces, shall be examined for deviations from the acceptance standard.

8.4.2. The weld shall be examined to check that :

8.4.2.1. In the case of single-sided butt welds, the penetration, root concavity and any burn-through or shrinkage grooves are within the limits specified in the acceptance standard over the whole of the joint.

8.4.2.2. Any undercut is within the acceptance standard.

8.4.2.3. Any imperfections such as cracks or porosity detected, using optical aids when necessary, or the weld surface or heat affected zones comply with the appropriate acceptance criteria.

8.4.2.4. Any attachments temporarily welded to the object to facilitate production or assembly which are prejudicial to the function of the object or the ability to be examined, are removed so that the object is not damaged. The area where the attachment was fixed shall be checked to ensure freedom of cracks.

8.5. Post-weld heat treatment.

8.5.1. Further examination may be required after post-weld heat treatment.

9. VISUAL EXAMINATION OF REPAIRED WELDS

9.1. General

9.1.1. When welds fail to comply wholly or in part with the acceptance criteria and repair is necessary, the checks detailed in 9.2 and 9.3 shall be made during repair operation.

9.2. Partially removed weld.

9.2.1. It shall be checked that the excavation is sufficiently deep and long to remove all imperfections. It shall also be ensured that there is a gradual taper from the base of the cut to the surface of the weld metal at the ends and sides of the cut, the width and profile of the cut being such that there is adequate access for re-welding.

9.3. Completely removed weld.

9.3.1. It shall be checked that, when a cut has been made through a faulty weld and there has been no serious loss of material, or when a section of materials containing a faulty weld has been removed and a new section is to be inserted, the shape and dimensions of the weld preparation meet the specified requirements.

9.4. Examination

9.4.1. Every repaired weld shall be examined to the same requirements as the original weld, as specified in clause 8.

10. ACCEPTANCE CRITERIA

10.1. **Materials**

10.1.1. All surface and edge examination shall be evaluated in terms of the material specification.

10.1.2. Indications parallel to rolled surfaces on the edges of a plate cut during fabrication or weld preparation shall be removed and weld repaired if the depth is over 3 mm.

10.2. **Welds**

10.2.1. If not otherwise specified the welds shall be evaluated and accepted according to the required acceptance class of EN ISO 5817 (see appendix A for butt welds).

11. EXAMINATION RECORDS

11.1. It is not always necessary to keep a record of the examination. However, when specified, a record should be kept to show that every relevant item of the visual examination at each stage has been checked. The following lists the information that should be included in the report :

11.1.1. Name of the component manufacturer

11.1.2. Name of the examining body

11.1.3. Identification of the object examined

11.1.4. Material (if not included in other documents)

11.1.5. Type of joint

11.1.6. Material thickness

11.1.7. Welding process (if not included in other documents)

11.1.8. Acceptance criteria

11.1.9. Imperfections exceeding the acceptance criteria and their location

11.1.10. The extent of examination with reference to drawings as appropriate

11.1.11. Examination devices used

11.1.12. Result of examination with reference to acceptance criteria

11.1.13. Name of examiner and date of examination

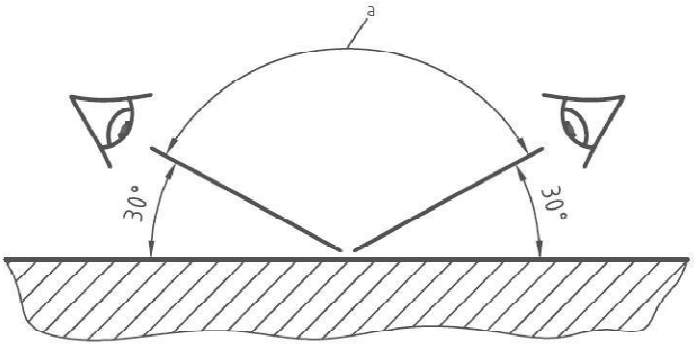
11.2. Where required, welds that have been examined and approved should be suitably marked or identified. When it is required to have a permanent visual record of a weld as examined, photographs or accurate sketches or both should be made with any imperfections clearly indicated.

VISUAL EXAMINATION OF WELDS

APPENDIX A

ACCEPTANCE CRITERIA FOR VISUAL INSPECTION OF BUTT WELDS ACCORDING TO EN 5817

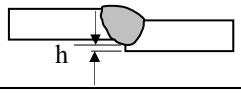
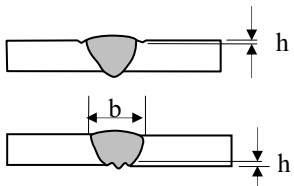
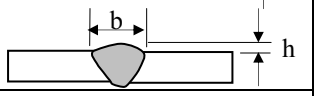
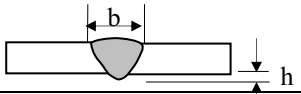
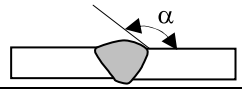
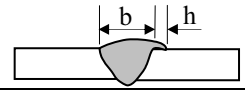
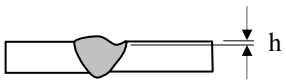
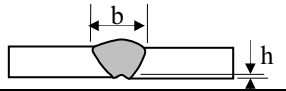
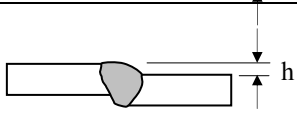
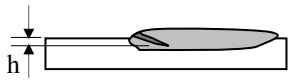
1. Alignment tolerance for butt welds.
   1.1. Alignment of sections at butt welded edges shall be such that the maximum offset is not greater than the applicable amount for the welded joint category given in table A1. The section thickness “t” is the nominal thickness of the thinner section at the joint.
   1.2. Any offset within the allowable tolerance shall be faired at a three to one taper over the width of the finished weld or, if necessary, by adding additional weld metal beyond the edge of the weld.
2. Finished longitudinal and circumferential joints.
   2.1. Butt welded joints shall have complete penetration and full fusion (see the exception in table A1 for joint category D). The surface of the weld shall be left “as welded” provided the weld is free of coarse ripples, grooves, overlaps, abrupt ridges or valleys.
   2.2. A reduction in thickness due to the welding process is acceptable provided the following conditions are met :
      2.2.1. No sharp notch is present.
      2.2.2. The reduction in thickness does not exceed the amount listed in table A1.
   2.3. The thickness of the weld reinforcement on each face or excess penetration shall not exceed the amount listed in table A1.
   2.4. Concavity due to the welding process on the root side of a single welded circumferential butt weld is permitted provided no sharp notch is present and the thickness of the weld is at least equal to the thickness of the thinner member.
   2.5. No overlap is admitted for C and B joint category.
3. Fillet welds
   3.1. Fillet welds shall have complete penetration and full fusion. The surface of the weld shall be left “as welded” provided the weld is free of coarse ripples, grooves, overlaps, abrupt ridges or valleys.
   3.2. The reduction of the thickness of the base metal due to the welding process shall meet the same requirements as for butt welds.
   3.3. The design section of the weld shall result wholly inscribed in the actual section.



[a] Range

Figure 1 — Access for testing

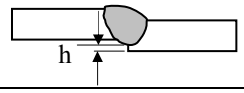
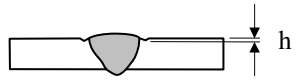
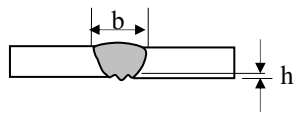
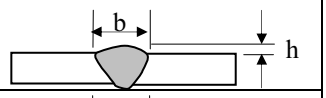
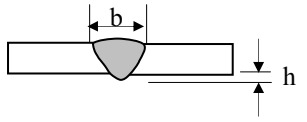
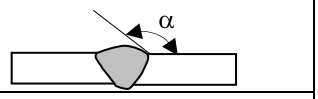
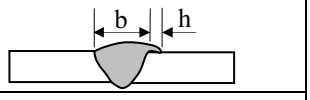
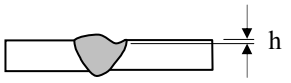
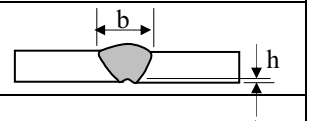
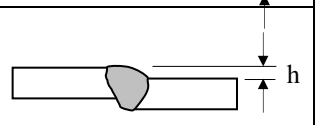
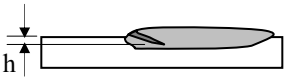
VISUAL EXAMINATION OF WELDS

TABLE A1 (t > 3 mm)				
Defect	**Joint Category**			
	D	**C**	**B**	
Crack	Not permitted	Not permitted	Not permitted	
Lack of fusion	Not permitted	Not permitted	Not permitted	
Stray arc	Depends upon material	Not permitted	Not permitted	
Spatter	Depends upon application	Depends upon application	Depends upon application	
Lack of penetration Single side welds	Short imperfections h ≤ 0.2 t max 2 mm	Not permitted	Not permitted	
Undercut	h ≤ 0.2 t max 1 mm	h ≤ 0.1 t max 0.5 mm	h ≤ 0.05 t max 0.5 mm	
	Short imperfections			
Shrinkage groove	h ≤ 0.2 t max 2 mm	h ≤ 0.1 t max 1 mm	h ≤ 0.05 t max 0.5 mm	
Weld reinforcement	h ≤ 1 + 0.25 b max 10 mm	h ≤ 1 + 0.15 b max 7 mm	h ≤ 1 + 0.1 b max 5 mm	
Excess penetration	h ≤ 1 + 1.0 b max 5 mm	h ≤ 1 + 0.6 b max 4 mm	h ≤ 1 ÷ 0.2 b max 3 mm	
Incorrect weld toe	α ≥ 90°	α ≥ 110°	α ≥ 150°	
Overlap	h ≤ 0.2 b	Not permitted	Not permitted	
Reduction in thickness	Short imperfections h ≤ 0.25 t max 2 mm	h ≤ 0.1 t max 1 mm	h ≤ 0.05 t max 0.5 mm	
Root concavity	Short imperfections h ≤ 0.2 t max 2 mm	h ≤ 0.1 t max 1 mm	h ≤ 0.05 t max 0.5 mm	
Offset of the edges Longitudinal welds and plates	h ≤ 0.25 t max 5 mm	h ≤ 0.15 t max 4 mm	h ≤ 0.1 t max 3 mm	
Offset of the edges Circumferential welds	h ≤ 0.5 t max 4 mm	h ≤ 0.5 t max 3 mm	h ≤ 0.5 t max 2 mm	
End crater pipe	h ≤ 0.2 t max 2 mm	h ≤ 0.1 t max 1 mm	Not permitted	

Short imperfections :

- Weld less than 100 mm long : imperfections whose total length is not greater than 25% of the length of the weld.
- Weld 100 mm long or longer : imperfections whose total length is not greater than 25 mm in the 100 mm of the weld which contains the greatest number of imperfections.

VISUAL EXAMINATION OF WELDS

TABLE A2 (0.5 ≤ t ≤ 3 mm)				
Defect	**Joint Category**			
	D	**C**	**B**	
Crack	Not permitted	Not permitted	Not permitted	
Lack of fusion	Not permitted	Not permitted	Not permitted	
Stray arc	Depends upon material	Not permitted	Not permitted	
Spatter	Depends upon application	Depends upon application	Depends upon application	
Lack of penetration Single side welds	Short imperfections h ≤ 0.2 t max 2 mm	Not permitted	Not permitted	
Undercut	Short imperfections h ≤ 0.2 t	Short imperfections h ≤ 0.1 t max 0.5 mm	Not permitted	
Shrinkage groove	h ≤ 0.2 mm+0.1 t	Short imperfections h ≤ 0.1 t max 1 mm	Short imperfections h ≤ 0.05 t max 0.5 mm	
Weld reinforcement	h ≤ 1 + 0.25 b max 10 mm	h ≤ 1 + 0.15 b max 7 mm	h ≤ 1 + 0.1 b max 5 mm	
Excess penetration	h ≤ 1 + 0.6 b	h ≤ 1 + 0.3 b	h ≤ 1 + 0.1 b	
Incorrect weld toe	α ≥ 90°	α ≥ 110°	α ≥ 150°	
Overlap	h ≤ 0.2 b	Not permitted	Not permitted	
Reduction in thickness	Short imperfections h ≤ 0.25 t	Short imperfections h ≤ 0.1 t	Not permitted	
Root concavity	h ≤ 0.2 mm + 0.1 t	h ≤ 0.1 t	h ≤ 0.05 t	
Offset of the edges Longitudinal welds and plates	h ≤ 0.2 mm+0.25 t	h ≤ 0.2 mm+0.15 t	h ≤ 0.2 mm+0.1 t	
Offset of the edges Circumferential welds	h ≤ 0.5 t max 4 mm	h ≤ 0.5 t max 3 mm	h ≤ 0.5 t max 2 mm	
End crater pipe	h ≤ 0.2 t	Not permitted	Not permitted	

DELTA FERRITE CHECK
AUSTENITIC AND DUPLEX MATERIALS

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10. NUMBER OF READINGS
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12. REPORT

By signature and date on the front sheet of this Procedure by the relevant persons, the signature on each page of this Procedure are waived

1	0h	2019/04/08	First issue
Em.	**Rev.**	**Date**	**Description**

REVISIONS

Emessa da:

ISTITUTO DI RICERCHE TECNOLOGIE E COLLAUDI

Verificata/Approvata da:
Technical Manager
dott. Ing. G. GROSSI

DELTA FERRITE CHECK
AUSTENITIC AND DUPLEX MATERIALS

1. PURPOSE

1.1. This document details the procedure to verify the ferrite content (Fe % or FN) of austenitic and duplex stainless steels.

2. APPLICABILITY

2.1. This procedure is applicable to verify :

2.1.1. Materials
2.1.2. Welds
2.1.3. Weld metal overlays

3. EQUIPMENT

3.1. A FISCHER FERITSCOPE FMP30 with a FGAB1.3-Fe type probe shall be used.
3.2. A FISCHER calibration standard set N-0589 shall be used with the following calibration standards :

- Base
- 0.53 FN - 0.52 Fe%
- 1.61 FN – 1.74 Fe%
- 10.2 FN – 11.3 Fe%
- 39.9 FN – 35.0 Fe%
- 123.5 FN – 85.6 Fe%

4. REFERENCE DOCUMENTS

4.1. This document is based and satisfies the requirements of the instruction manual of the apparatus used to perform the examination.
4.2. ASTM A 799 paragraph 5.2 allows using this instrument according to the manufacturer's instructions for calibration.
4.3. NYS B9.10
4.4. AWS A4.2

5. PERSONNEL

5.1. Personnel shall complete sufficient organized training to become familiar with the principles and practices of the method.
5.2. Personnel shall be approved by the technical responsible of IRTEC.

6. SURFACE PREPARATION

6.1. The surface to be checked shall be clean from any dirt, grease, oil, paint, slag. If necessary shall be mechanically brushed using a stainless steel brush and degreased using clean acetone.

7. CALIBRATION

7.1. The instrument shall be calibrated according to the procedure in the user's manual (matrix calibration).

8. CALIBRATION VERIFICATION

8.1. The calibration of the instrument shall be verified before the measurements using two standards near the maximum and the minimum of the required range.
8.2. Verify that the used standards are not damaged.

Calibration Standard		Ferrite		Acceptable readings	
		Ferrite %	FN	% (*)	FN
1	//	Ferrit base	//	//	//
6	58675	85.6%	123.5	83.9 ÷ 87.3	122.5 ÷ 124.5
5	58674	35.0%	39.9	34.5 ÷ 35.5	38.9 ÷ 40.9
4	58673	11.3%	10.2	10.9 ÷ 11.7	9.5 ÷ 10.9
3	58672	1.74%	1.61	1.34 ÷ 2.14	1.21 ÷ 2.01
2	58671	0.52%	0.53	0.12 ÷ 0.92	0.13 ÷ 0.93

(*) Processed by means of the relationship between FN and Ferrite % given by Helmut Fischer GMBH according to ANSI/AWS A4.2-91 table 6 (see the figure 6 in this procedure)

8.2.1. Verification will be regarded as positive where the reading of each calibration standard (average of three readings) is within the guaranteed error limit.

9. MEASUREMENT

9.1. Place the probe perpendicular to the surface and read the ferrite % or the FN.
9.2. Lift the probe at least 25 mm from the surface before taking the following measurement.
9.3. Do not scan the surface to avoid the early wear of the tip of the probe.
9.4. After the measurements apply, if necessary, the correction factors for the curvature and the thickness of the sample, the distance from the edge of the sample and the thickness of the plating (see the figures 1 ÷ 5).
9.5. These corrections are, generally, necessary if :

9.5.1.	Convex curvature radius	< 25 mm
9.5.2.	Concave curvature radius	< 40 mm
9.5.3.	Thickness of the sample	< 2 mm
9.5.4.	Thickness of the plating	< 3 mm
9.5.5.	Edge distance	< 2 mm

10. NUMBER OF READINGS

10.1. If not specified, at least two readings shall be taken in each weld joint.

11. ACCEPTANCE CRITERIA

11.1. Testing shall be carried out before PWHT. Percentage of ferrite shall be btween 3 ÷ 12, and for items thickness over 19 mm and PWHT done shall be 3 ÷ 9.

12. REPORT

12.1. The following data shall be reported on the certificate to be dated and signed by the operator :

12.1.1. Reference to this procedure
12.1.2. Instrument and probe used
12.1.3. Item identification
12.1.4. Material
12.1.5. Heat treatment condition
12.1.6. Surface status
12.1.7. Position of readings
12.1.8. Results

DELTA FERRITE CHECK
AUSTENITIC AND DUPLEX MATERIALS

CORRECTION FACTORS

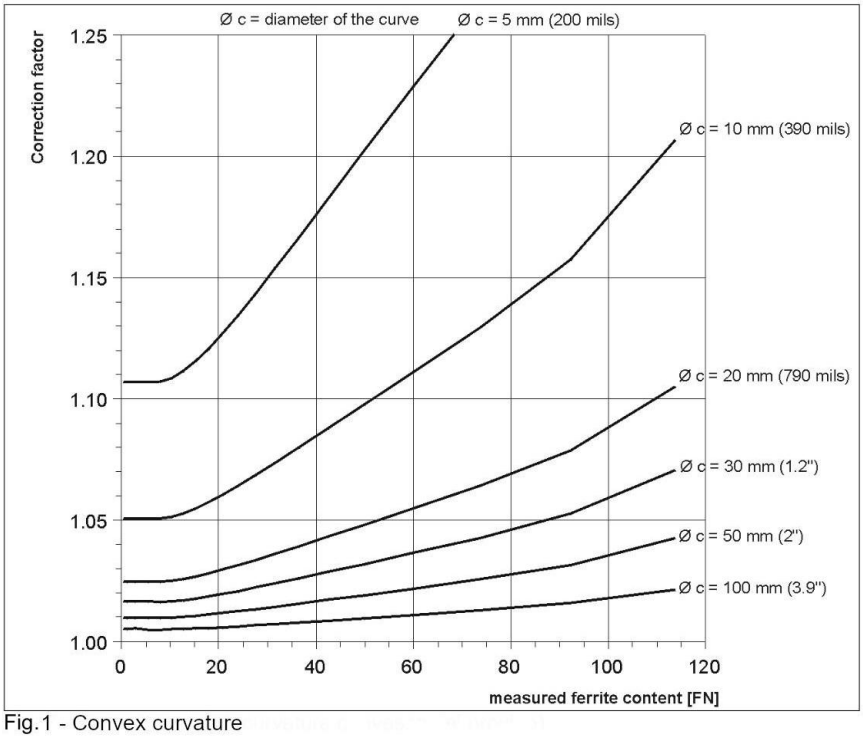


Fig.1 - Convex curvature

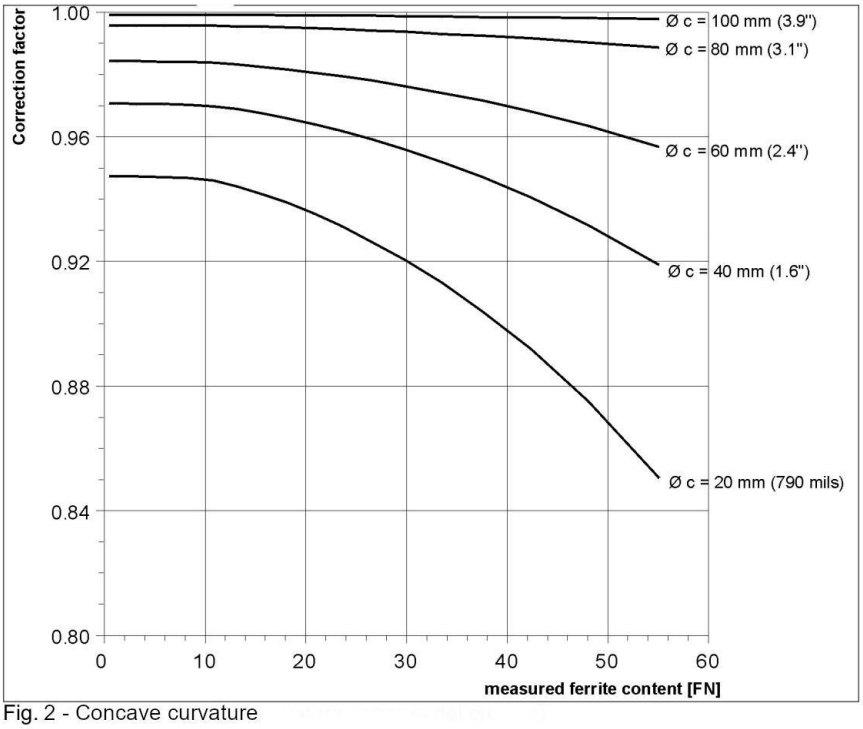


Fig. 2 - Concave curvature

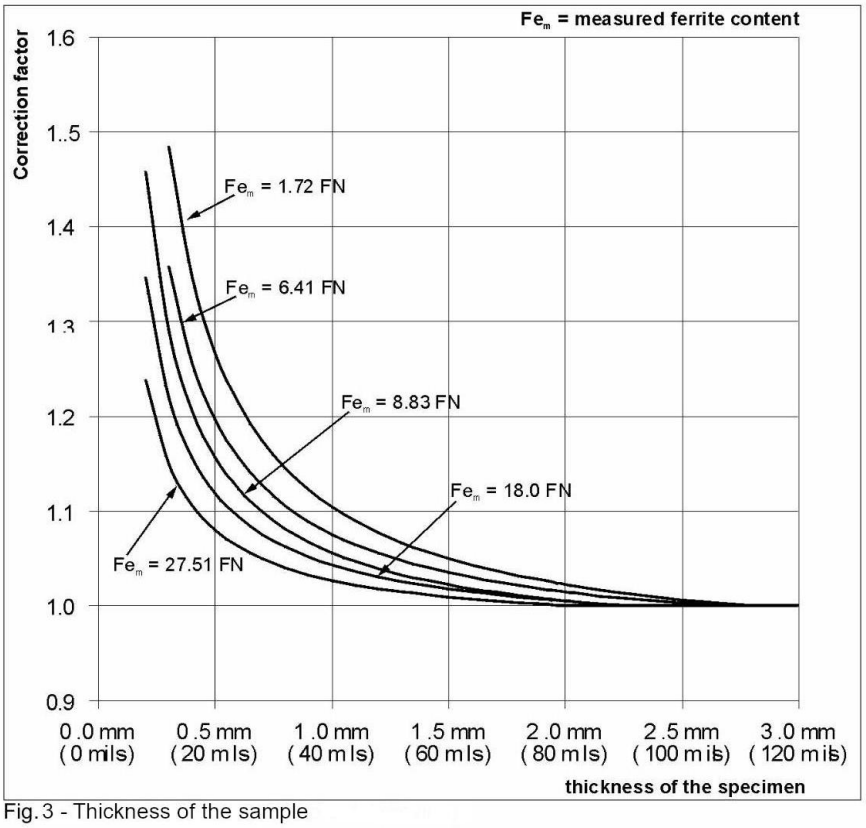


Fig.3 - Thickness of the sample

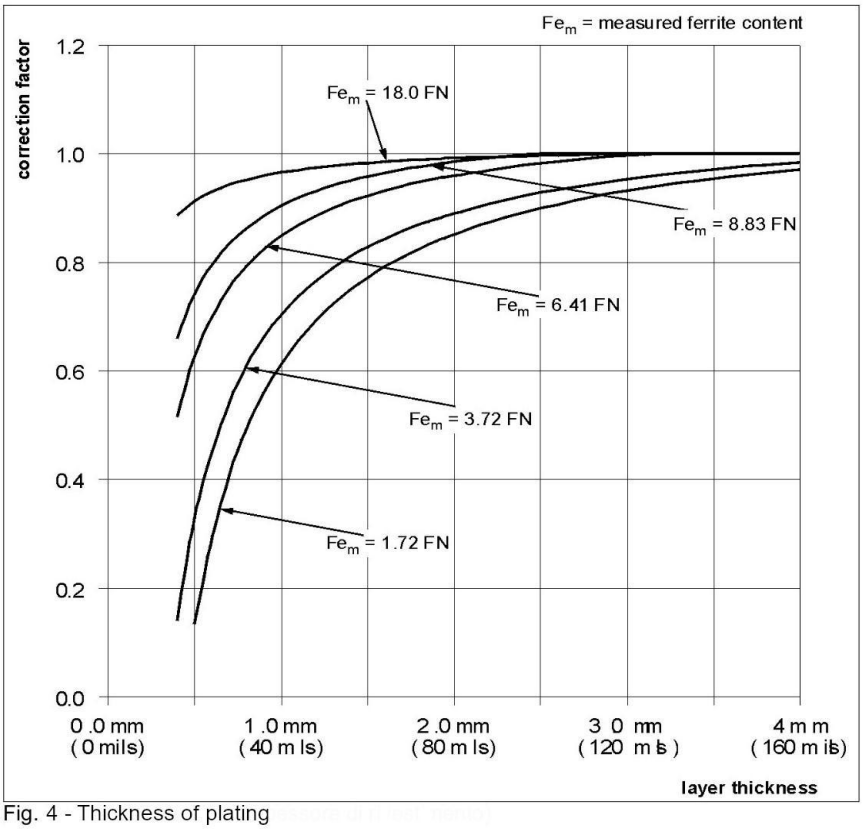


Fig. 4 - Thickness of plating

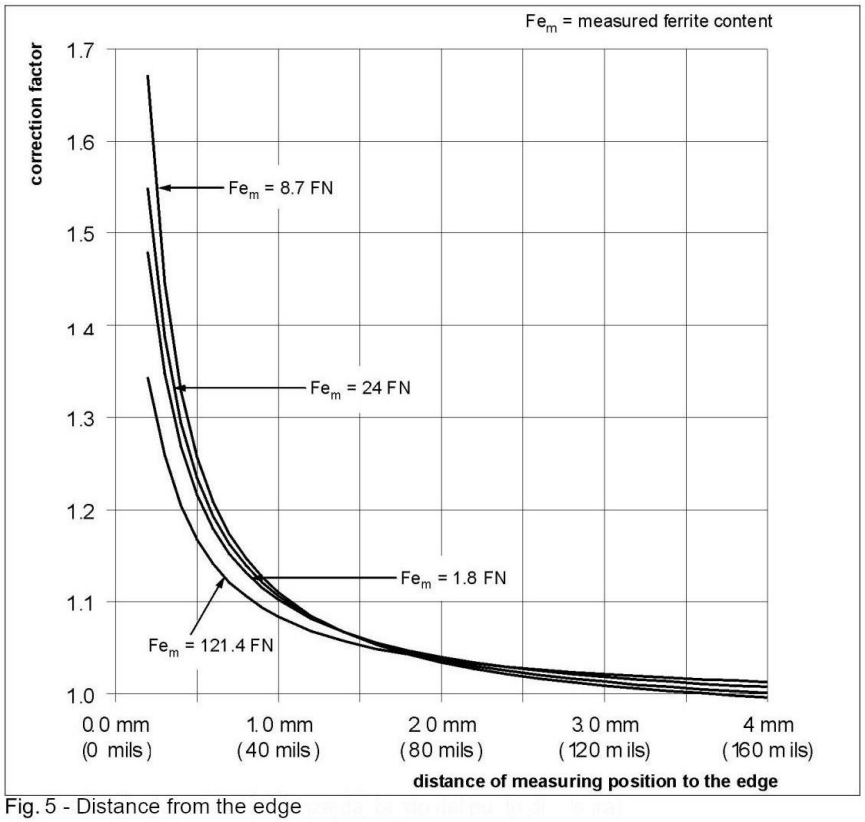
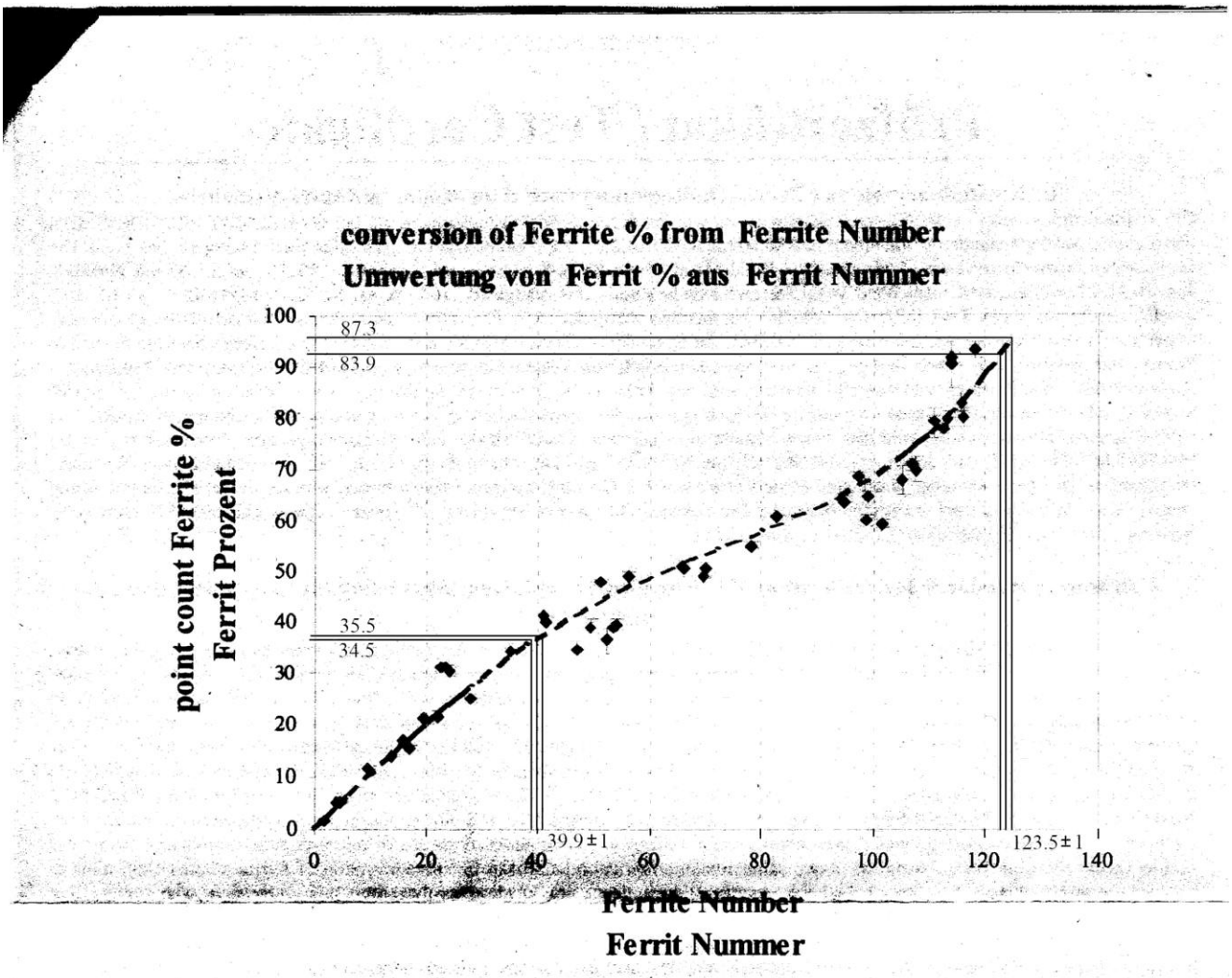


Fig. 5 - Distance from the edge

DELTA FERRITE CHECK
AUSTENITIC AND DUPLEX MATERIALS



Gewährleistung: Unsere Garantie für die gelieferten Kalibriernormale bezüglich herstellungsbedingter Mängel gilt für einen Zeitraum von 12 Monaten, gerechnet ab dem Datum der Lieferung bzw. Rechnungsdatum.
Unsere Gewährleistung umfasst nur den kostenlosen Umtausch beanstandeter Einstellnormale.
Prüfmittelüberwachung: die Festlegung des Überprüfungsintervalls hängt ab von der Häufigkeit und der Art und Weise der Benutzung des Einstellnormales und obliegt daher dem Anwender.
Hinweis: Vor jeder Benutzung sollten die Einstellnormale visuell auf äußerlich erkennbare mechanische Beschädigungen wie Eindrücke, Korrosion oder Oberflächenverschmutzung überprüft werden. Einstellnormale sollten ersetzt werden, sobald diese sichtbare Gebrauchspuren aufweisen.

Note:

Warranty: The guarantee for the stated accuracy of the standards in respect to productional defects lasts 12 months from the time of shipment or invoice.
Our warranty only covers the even exchange of faulty calibration standards free of charge.
Verification of measuring: the frequency of verification of this standard is determined by the user, based upon the number of uses and the severity of use.
Remark: Prior to each use inspect the standards for obvious mechanical defects, such as deep scratches, gouges, corrosion, contamination or other defects. Any standards showing mechanical defects should be replaced promptly.

Zertifikatsrücken Ferrit Seite 2 von 2 Erstellt: 05.09.95 Geändert: 10.10.2005

As regards the NDT-VT-01 E1 R0h procedure – Delta ferrite check Austenitic and Duplex Materials, we confirm that it can also be applied to welding overlays as in point 2.1.3.

Thickness of the overlay ≥ 2 mm

End of document

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customer inspector	IL COLLAUDATORE The inspector
	dott. Ing. G. GROSSI		

I.R.T.E.C. s.r.l.

LIQUID PENETRANT TESTING PROCEDURE

IR TEC SRL
SISTEMA DI QUALITA'
CERTIFICATO ISO 9001:2008

LIQUID PENETRANT EXAMINATION OF WELDS ACCORDING TO EN ISO

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7. EXAMINATION
8. EVALUATION
9. DOCUMENTATION/RECORDS
10. REPAIR REQUIREMENTS
11. PERSONNEL

By signature and date on the front sheet of this Procedure by the relevant persons, the signature on each page of this Procedure are waived

2	2	2024/03/06	Verified according with EN ISO 3452-1:2021
2	1	2015/11/26	Revised according to comments
2	0	2014/10/14	First issue
Em.	**Rev.**	**Data - Date**	**Descrizione - Description**

REVISIONS

Issued by :

IRTEC SRL ISTITUTO DI RICERCHE TECNOLOGIE E COLLAUDI

Checked/Approved by :
NDE LEVEL 3 ISO 9712
dott. Ing. G. GROSSI

LIQUID PENETRANT EXAMINATION OF WELDS ACCORDING TO EN ISO

1. SCOPE

1.1. This procedure describes the method to be followed for water washable visible and solvent removable liquid penetrant examination of welds.

2. REFERENCE DOCUMENTS

2.1. This procedure satisfies the requirements of the following specifications :

2.2. UNI EN ISO 3452-1:2021

2.3. UNI EN ISO 23277:2015

3. APPLICABILITY

3.1. This procedure is applicable to :

3.2. Butt and fillet welds

3.3. Weld overlays

3.4. This procedure is applicable to parts of any size.

4. EQUIPMENT

4.1. Penetrant materials
The term “penetrant materials” is intended to include all penetrants, solvents or cleaning agents, developers, etc., used in the examination process.

5. MISCELLANEOUS REQUIREMENTS

5.1. **Control of Contaminants** - All the penetrant materials shall be certified to satisfy the control of contaminants. These certifications shall include the penetrant manufacturers’ batch numbers and the test results obtained in accordance with the requirements of table B.

5.2. **Expiration date** - Make sure to use the penetrant materials before the expiration date

5.3. **Surface preparation**

5.3.1. In general, satisfactory results may be obtained when the surfaces of the part is in the as-welded, as-rolled, as-cast or as-forged condition. Surface preparation by grinding, machining, or other methods may be necessary where surface irregularities could mask indications.

5.3.2. Prior to each liquid penetrant examination, the surface to be examined and all adjacent areas within at least 25 mm shall be dry and free of all dirt, grease, lint, scale, welding flux, weld spatter, paint, oil and other extraneous matter that could obscure surface openings or otherwise interfere with the examination.

5.3.3. Typical cleaning agents which may be used are organic solvents.

5.3.4. Cleaning solvents shall meet the requirements of 5.1. The cleaning method employed is an important part of the examination process.

5.3.5. Solvent cleaning after machining is a correct method of cleaning.

5.3.6. Grinding is a correct method of cleaning.

5.3.7. Is also correct perform examination after welding (it is only necessary to remove the slag and grind where necessary).

5.4. **Drying After Preparation**

5.4.1. After cleaning, drying of the surface to be examined shall be accomplished in the following way :

5.4.1.1. Solvent cleaning – dry cloths and/or normal evaporation

5.4.1.2. Minimum evaporation time shall be 2 minutes.

6. TECHNIQUE

6.1. Techniques

6.1.1. A color contrast (daylight visible) penetrant shall be used (the penetrant materials to be used are listed in Table A).
The penetrant shall be used with one of the following penetrant processes :

6.1.1.1. Water washable

6.1.1.2. Solvent Removable

6.1.2. The materials to be used is listed in Table A.

6.1.3. When solvent cleaning or excess penetrant removal is required, the solvents in Table A shall be used.

6.2. Techniques for Standard Temperatures

6.2.1. As a standard technique, the ambient temperature and the surface of the part to be processed shall not be below 10°C nor above 50°C throughout the examination period.

6.2.2. Where is not practical to comply with these temperature limitations, other temperatures and times may be used, provided the procedures are qualified as specified in UNI EN ISO 3452-5 or 3452-6 as applicable.

7. EXAMINATION

7.1. Penetrant Application

7.1.1. The penetrant will be applied by a pressurized spray can, by brushing or by dipping.

7.2. Penetration time

7.2.1. Penetration time is critical. The minimum penetration time shall be 15 minutes.

7.3. Excess penetrant removal

7.3.1. **Water-Washable Penetrants** – Excess water-washable penetrant shall be removed by wiping with a dry cloth repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by lightly wiping the surface with a water spry and/or wet cloths. The water pressure shall not exceed 3.5 bar. The water temperature shall not exceed 43°C.

7.3.2. **Solvent removable penetrants** - Excess solvent removable penetrants shall be removed by wiping with a dry cloth, repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by lightly wiping the surface with cloth moistened with solvent. To minimize removal of penetrant from discontinuities, care shall be taken to avoid the use of excess solvent.
Flushing the surface with solvent, following the application of the penetrant and prior to developing, is prohibited.

7.3.3. **Excess penetrant removal check –** The final cleaning shall be performed with a clear cloth that shall remain clean.

7.4. Drying After Excess Penetrant Removal

7.4.1. For the water washable technique, the surfaces may be dried by blotting with clean cloths and/or by using circulating air, provided the temperature of the surface is not raised above 52°C.

7.4.2. For the solvent removable technique, the surfaces may be dried by normal evaporation (minimum 2 minutes), blotting, wiping, or forced air.

7.5. Developing

7.5.1. The developer shall be applied by spraying as soon as possible after penetrant removal. In every case the time interval after drying shall not exceed 10 minutes.

7.5.2. Wet Developer Application – Prior to applying solvent suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

7.5.3. Developer shall be applied only to a dry surface. It shall be applied by a pressurized spry can. Drying shall be by normal evaporation.

7.5.4. The developer shall be applied only to a dry surface in a thin and uniform layer.

7.5.5. The developer shall not be applied over a dry layer of developer.

7.5.6. Developing time begins when the developer coating is dry.

7.6. **Interpretation**

7.6.1. **Final interpretation** - Final interpretation shall be made within 10 to 30 minutes of developing time (see 7.5.6). If bleed out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed or established time, the examination shall be performed in increments.

7.6.2. **Characterizing indication(s)** – The type of discontinuities are difficult to evaluate if the penetrant diffuses excessively into the developer. If this condition occurs, close observation of the formation of indication(s) during application of the developer may assist in characterizing and determining the extent of the indication(s).
The type and size of the indication is the basis for acceptance evaluation.

7.6.2.1. A linear indication is one having a length greater than three times the width

7.6.2.2. A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width

7.6.3. **Color Contrast Penetrants** – With a color contrast penetrant, the developer forms a reasonably uniform white coating. Surface discontinuities are indicated by bleed-out of penetrant which is normally a deep red color that stains the developer. Indications with a light pink color may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult.

7.6.3.1. A minimum light intensity of 500 lx is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications. This light intensity may be obtained by an incandescence bulb lamp 220V 100W transparent glass at a distance not greater than 400 mm

7.6.3.2. Lighting has been actually measured by means of a calibrated luxmeter.

7.6.4. **Post-Examination Cleaning** – When post-examination cleaning is required, it should be conducted as soon as practical after examination and documentation. Cleaning shall be performed by brushing and dry cloths.

8. EVALUATION

8.1. All indications shall be evaluated in term of the acceptance standards of the referencing Code Section.

8.1.1. Acceptance criteria for welds (all materials), if not otherwise specified, shall be in accordance with Tables D and E of this procedure.

8.2. Broad areas of pigmentation which could mask indications of discontinuities are unacceptable. Such areas shall be cleaned and reexamined using the same type of penetrant.

8.3. Discontinuities at the surface will be indicated by bleed-out of penetrant; however, localized surface irregularities due to machining marks or other surface conditions may produce false indications.

8.4. Any indication which is believed non relevant shall be regarded as an imperfection unless it is shown by reexamination by the same method or by the use of other nondestructive methods or by surface conditioning that no unacceptable imperfection is present.

9. DOCUMENTATION/RECORDS

9.1. **Recording of Indications**

9.1.1. **Nonrejectable Indications** – Nonrejectable indications shall be recorded as specified by the referencing Code Section.

9.1.2. **Rejectable Indications** - Rejectable indications shall be recorded. As minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

9.1.3. **Examination Records**

9.1.4. For each examination, the following information shall be recorded (see Annex) :

9.1.4.1. Information on the part tested :

a) Identification of part/weld (part number/weld seam number)

b) Dimensions

c) Material

d) Surface conditions

e) Production stage

9.1.4.2. procedure identification and revision

9.1.4.3. Designation of the penetrant system used

a) RED WW : II-a-e-Level 1

b) AVIO B : II-c Class 2-e-Level 2

9.1.4.4. map or record of indications per 9.1

9.1.4.5. lighting equipment

9.1.4.6. examination personnel identity, qualification level and signature

9.1.4.7. date of examination

10. REPAIR REQUIREMENTS

10.1. Whenever a defect is removed and subsequent welding is not required because the removed material does not reduce the wall thickness below the drawing requirements, the affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners.

10.2. If the welding is required, prior to weld repair the excavated area shall be examined again by this specification. The weld repair shall be performed, if necessary, by applicable welding specification and shall be authorized, if necessary, by Quality Control Department. In any case, after repair, the surface shall be examined by the methods required by this procedure with the same acceptance criteria.

11. PERSONNEL

11.1. Personnel performing liquid penetrant examination shall be qualified to NDE Level 2 according to EN ISO 9712.

LIQUID PENETRANT EXAMINATION OF WELDS ACCORDING TO EN ISO

TABLE A	
PENETRANT MATERIALS	**NDT ITALIANA**
SOLVENT (For cleaning and penetrant removal)	Elite BC1
PENETRANT	Elite K71B2p (sensitivity level 2
DEVELOPER	Elite D112A

TABLE B		
CONTROL OF CONTAMINANTS		
TEST	METHOD	RESULT
Corrosive properties	UNI EN ISO 3452-2	According to standard
Halogens (Cl+F)	SE 165-02	≤ 1%
Sulfur	SE 165-02	≤ 1%

TABLE C			
MINIMUM DWELL TIMES (minutes)			
Material	Form	Type of discontinuity	Penetrant
Aluminum, Magnesium, Steel, Brass, Bronze, Titanium, High temperature alloys	Castings and welds	Cold shuts, porosity, lack of fusion, cracks	5
	Wrought materials, ex-trusions, forgings, plates	Laps, cracks	10

TABLE D			
Type of indicationj	Acceptance level (a)		
	1	2	3
Linear indication	L ≤ 2	L ≤ 4	L ≤ 8
Non linear indication	d ≤ 4	d ≤ 6	d ≤ 8
(a) Acceptance levels 2 and 3 may be specified with suffix “X” which denotes that all linear indications detected shall be evaluated to level 1.			

TABLE E	
ACCEPTANCE STANDARDS FOR WELDS (All materials)	
Quality level according to EN ISO 5817 EN ISO 10042	Acceptance levels According to EN ISO 23277
B	2X
C	2X
D	3X

MAGNETIC PARTICLE EXAMINATION OF WELDS ACCORDING TO EN ISO STANDARD
(Yoke technique, Black wet particles)

I.R.T.E.C. S.R.L.

MAGNETIC PARTICLE TESTING PROCEDURE

IR TEC SRL
SISTEMA DI QUALITA'
CERTIFICATO ISO 9001:2008

MAGNETIC PARTICLE EXAMINATION OF WELDS ACCORDING TO EN ISO STANDARD
(Yoke technique, Black wet particles)

SUMMARY

1. SCOPE
2. GENERAL
2.2. This procedure is applicable to welds and parts with any dimensions compatibly with the characteristics of the equipment and the technique of magnetization
3. REFERENCE DOCUMENTS
4. EQUIPMENT
5. MISCELLANEOUS REQUIREMENTS
6. TECHNIQUE
7. CALIBRATION
8. EXAMINATION
9. EVALUATION
10. DOCUMENTATION
11. ACCEPTANCE CRITERIA
12. REPAIR
13. PERSONNEL

Non è stata trovata alcuna voce d'indice.

2	2i	2024/10/04	Revised according with comments
2	1	2017/07/23	Verified according to EN ISO 17638:2016
2	0	2014/10/14	First Issue
Em.	**Rev.**	**Data**	**Descrizione - Description**

REVISIONI - REVISIONS

By signature and date on the front sheet of this Procedure by the relevant persons, the signature on each page of this Procedure are waived

Emessa da:

IRTEC SRL ISTITUTO DI RICERCHE TECNOLOGIE E COLLAUDI

Verificata/Approvata da:
NDE Level 3 ISO 9712

dott. Ing. G. GROSSI

MAGNETIC PARTICLE EXAMINATION OF WELDS ACCORDING TO EN ISO STANDARD (Yoke technique, Black wet particles)

1. SCOPE

1.1. When specified by the referencing Code Section, the magnetic particle examination techniques described in this procedure shall be used. This procedure is in conformance with ISO 17638 Non-destructive testing of welds — Magnetic particle testing. This document provides details that have been considered in this procedure.

1.2. This procedure is applicable for magnetic particle examination of the following :

1.2.1. Ferromagnetic groove and fillet welds

1.2.2. This procedure is applicable to parts of any dimension.

2. GENERAL

2.1. The magnetic particle examination method may be applied to detect cracks and other discontinuities on or near the surfaces of ferromagnetic materials. The sensitivity is greatest for surface discontinuities and diminishes rapidly with increasing depth of subsurface discontinuities below the surface.
Typical types of discontinuities that can be detected by this method are cracks, laps, seams, cold shuts, and laminations.
In principle, this method involves magnetizing an area to be examined, and applying ferromagnetic particles (the examination's medium) to the surface. The particles will form patterns on the surface where cracks and other discontinuities cause distortions in the normal magnetic field. These patterns are usually characteristic of the type of discontinuity that is detected.
Whichever technique is used to produce the magnetic flux in the part, maximum sensitivity will be to linear discontinuities oriented perpendicular to the lines of flux. For optimum effectiveness in detecting all types of discontinuities, each area is to be examined at least twice, with the lines of flux during one examination approximately perpendicular to the lines of flux during the other.

2.2. This procedure is applicable to welds and parts with any dimensions compatibly with the characteristics of the equipment and the technique of magnetization

2.3. The test shall be conducted in the operative steps as specified by the contract.

3. REFERENCE DOCUMENTS

3.1. EN ISO 17638

3.2. EN ISO 23278

4. EQUIPMENT

AC yokes shall be used for producing the necessary magnetic flux in the weldt.

4.1. Examination Medium

4.1.1. **Particle Types**. - Black wet ferromagnetic particles in water or oil suspension shall be used. The materials listed in table 1 shall be used.

4.1.2. **Particles**. - Wet particles concentration shall be in accordance with the recommendation in table 1.

4.1.3. **Temperature Limitations**. - Particles shall be used within the following temperature range: 5 ÷ 50°C

5. MISCELLANEOUS REQUIREMENTS

5.1. Surface Conditioning

5.1.1. Satisfactory results are usually obtained when the surfaces are in the as-welded, as-rolled, as-cast, or as forged conditions. However, surface preparation by grinding or machining may be necessary where surface irregularities could mask indications due to discontinuities.

5.1.2. Prior to magnetic particle examination, the surface to be examined and all adjacent areas within at least 25 mm shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, oil, or other extraneous matter that could interfere with the examination.

5.1.3. Cleaning may be accomplished using, organic solvents, paint removers, sand or grit blasting, grinding.

5.2. Nonmagnetic Surface Contrast Enhancement

5.2.1. Non magnetic surface contrasts may be applied by the examiner to uncoated surfaces, only in amounts sufficient to enhance particle contrast. Demonstration by means of the pie-shaped field indicator of the field strength shows the adequacy of the technique used.
The field indicator shall be coated with the same amount of contrast.

MAGNETIC PARTICLE EXAMINATION OF WELDS ACCORDING TO EN ISO STANDARD (Yoke technique, Black wet particles)

6. TECHNIQUE

6.1. The AC magnetizing technique shall be used.

6.1.1. AC yoke method shall only be applied to detect discontinuities that are open to the surface of the part.

6.1.2. Permanent magnet yoke magnetizing technique shall be used only if explicitly requested

7. CALIBRATION

7.1. Frequency of Calibration

7.1.1. **Light Meters** – Visible light meters shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

7.1.2. **Lifting Power of Yokes**

Prior to use, the magnetizing power of electromagnetic yokes shall have been checked within the past year. The magnetizing power of all yokes shall be checked whenever the yoke has been damaged or re paired.

Each alternating current electromagnetic yoke shall have a lifting power of at least 4.5 kg at the maximum pole spacing that will be used.

Each weight shall be weighed with a scale from a reputable manufacturer or measured with a calibrated calliper and the weight calculated using a density for steel of 7.8 kg/dm3 and stenciled with the applicable nominal weight prior to first use. A weight need only be verified again if damaged in a manner that could have caused potential loss of material.

7.2. Magnetic Field Adequacy and Direction

7.2.1. **Magnetic Field Adequacy** - The applied magnetic field shall have sufficient strength to produce satisfactory indications, but shall not be so strong that it causes masking of relevant indications by nonrelevant accumulations of magnetic particles.

Factors that influence the required field strength include the size, shape, and material permeability of the part; the technique of magnetization; coatings; the method of particle application; and the type and location of discontinuities to be detected.

When it is necessary to verify the adequacy of magnetic field strength, it shall be verified by using the following method.

7.2.1.1. **Pie-Shaped Magnetic Particle Field Indicator-** The indicator, shown in Fig. 1, shall be positioned on the surface to be examined, such that the copper-plated side is away from the inspected surface. A suitable field strength is indicated when a clearly defined line (or lines) of magnetic particles form(s) across the copper face of the indicator when the magnetic particles are applied simultaneously with the magnetizing force. When a clearly defined line of particles is not formed, the magnetizing technique shall be changed as needed.

8. EXAMINATION

8.1. Preliminary Examination

Before the magnetic particle examination is conducted, a check of the examination surface shall be conducted to locate any discontinuity surface openings which may not attract and hold magnetic particles because of their width.

8.2. Direction of Magnetization

At least two separate examinations shall be performed on each area. During the second examination, the lines of magnetic flux shall be approximately perpendicular to those used during the first examination.

8.3. Method of Examination

The ferromagnetic particles used in an examination medium shall be wet and visible. Examination(s) shall be done by the continuous method.

The magnetizing current shall be turned on after the particles have been applied by flowing or spraying with a pressurized can. Flow of particles shall stop with the application of current. Wet particles applied from aerosol spray cans may be applied before and/or after magnetizing current is applied. Wet particles may be applied during the application of magnetizing current if they are not applied directly to the examination area and are allowed to flow over the examination area or are applied directly to the examination area with low velocities insufficient to remove accumulated particles.

8.4. Examination Coverage

All examinations shall be conducted with sufficient field overlap to ensure 100% coverage at the required sensitivity.

See in the figure 2 the effective testing area (shaded) for magnetizing with yokes..

8.5. Interpretation

The interpretation shall identify if an indication as false, nonrelevant, or relevant. False and nonrelevant indications shall be proven as false or nonrelevant. Interpretation shall be carried out to identify the locations of indications and the character of the indication.

8.5.1. **Visible (Color Contrast) Magnetic Particles** - Surface discontinuities are indicated by accumulations of magnetic particles which should contrast with the examination surface. The color of the magnetic particles shall be sufficiently different than the color of the examination surface. A minimum light intensity of 1000 Lx is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications. The calibration of the lux-meter shall be verified every 12 months.

8.5.2. Demagnetization

When residual magnetism in the part could interfere with subsequent processing or usage, the part shall be demagnetized any time after completion of the examination.

8.5.3. Post-examination Cleaning

When post-examination cleaning is required, it should be conducted as soon as practical using a process that does not adversely affect the part.

9. EVALUATION

9.1. All indications shall be evaluated in terms of the acceptance standards of EN ISO 23278

9.2. When using a contrast enhancement coating; if an indication greater than 50% of the maximum allowable flaw size is detected, the coating in the area of the indication shall be removed and the examinationrepeated.

9.3. Discontinuities on or near the surface are indicated by retention of the examination medium. However, localized surface irregularities due to machining marks or other surface conditions may produce false indications.

9.4. Broad areas of particle accumulation, which might mask indications from discontinuities, are prohibited, and such areas shall be cleaned and reexamined.

10. DOCUMENTATION

10.1. Recording of Indications

10.1.1. **Rejectable Indications** - Rejectable indications shall be recorded. As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

10.1.2. A complete set of records for each part shall be retained by the Manufacturer until the Manufacturer's Data report has been signed By the Inspector

10.2. Examination Records

For each examination, the following information shall be recorded :

a) procedure identification and revision
b) magnetic particle equipment and type of current
c) magnetic particles (visible or fluorescent, wet or dry)
d) examination personnel identity and qualification level
e) map or record of indications per 10.1
f) material and thickness
g) lighting equipment
h) date and time examinations were performed

11. ACCEPTANCE CRITERIA

11.1. Acceptance criteria shall be in accordance with EN ISO 23278. See appendix A.

12. REPAIR

12.1. Whenever a defect is removed and subsequent welding is not required because the removed material does not reduce the wall thickness below the drawing requirements, the affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners.

12.2. If the welding is required, prior to weld repair the excavated area shall be examined again by this specification. The weld repair shall be performed by applicable welding specification and shall be authorized by Quality Control Department. In any case, after repair, the surface shall be examined by the methods required by this specification for the item involved.

MAGNETIC PARTICLE EXAMINATION OF WELDS ACCORDING TO EN ISO STANDARD (Yoke technique, Black wet particles)

13. PERSONNEL

13.1. Personnel performing magnetic particle examination shall be qualified to NDT Level 2 according to ISO 9712 standard.

TABLE 1	
MATERIALS	**NDT ITALIANA**
Solvent (for cleaning)	BIO REMOVE5R
Black magnetic particles in oil suspension (spray can)	BW2 SP
Contrast lacquer	WBL5 SP

MAGNETIC PARTICLE EXAMINATION OF WELDS ACCORDING TO EN ISO STANDARD
(Yoke technique, Black wet particles)

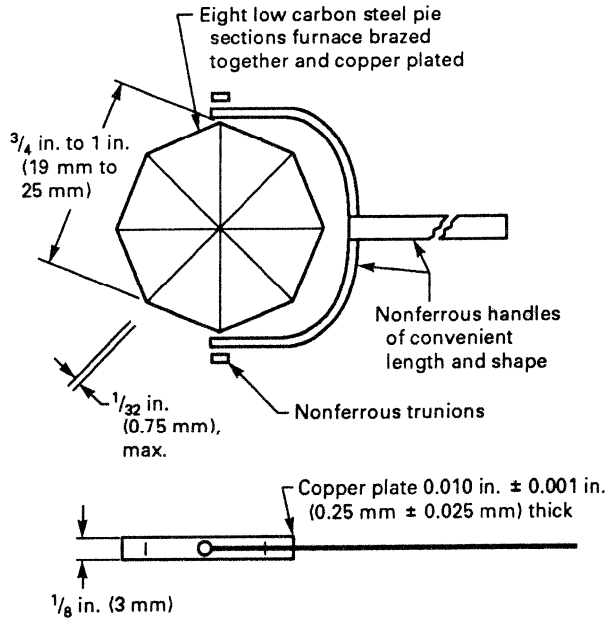


FIG. 1 - PIE-SHAPED MAGNETIC PARTICLE FIELD INDICATOR

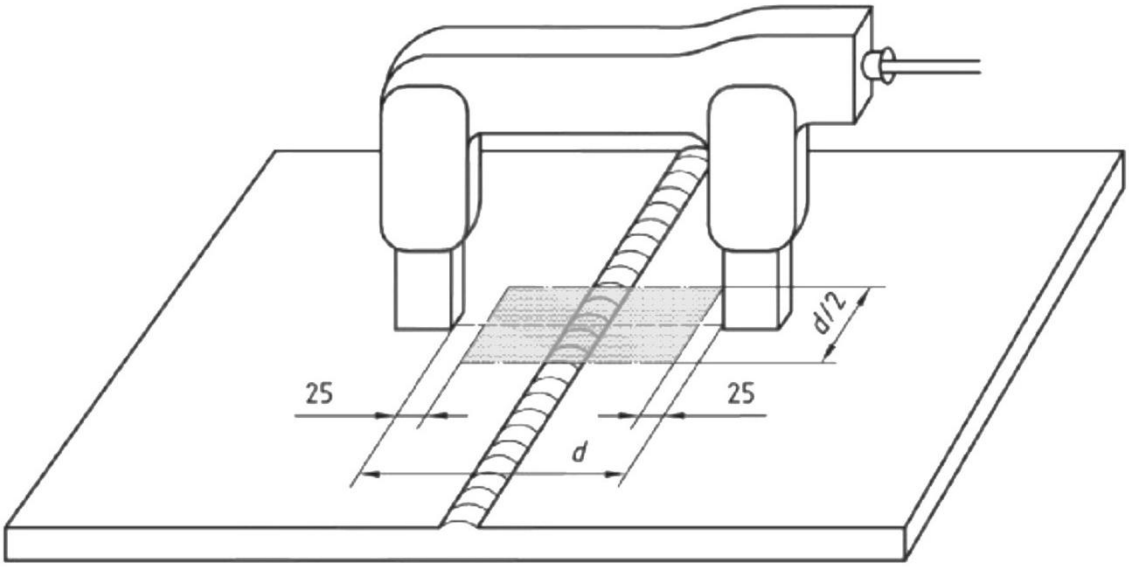


FIGURE 2

MAGNETIC PARTICLE EXAMINATION OF WELDS ACCORDING TO EN ISO STANDARD
(Yoke technique, Black wet particles)

APPENDIX A

EVALUATION OF INDICATIONS REVEALED BY MAGNETIC PARTICLE EXAMINATION (ACCORDING TO EN ISO 23278

1. EVALUATION OF INDICATIONS

1.1. Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such at the edge of heat affected zone), etc., may produce similar indications.

1.2. An indication is the evidence of a mechanical imperfection.

1.3. A linear indication is one having a length greater than three times its width.

1.4. A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

1.5. Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

2. ACCEPTANCE STANDARDS

2.1. Acceptance criteria for welds (all materials), if not otherwise specified, shall be in accordance with Table A1. Table A2 connects the acceptance level with the quality level of the weld according with EN ISO 5817.

TABLE A1

Type of indicationj	Acceptance level (a)		
	1	2	3
Linear indication	$L \leq 1.5$	$L \leq 3$	$L \leq 6$
Non linear indication	$d \leq 2$	$d \leq 3$	$d \leq 4$

(a) Acceptance levels 2 and 3 may be specified with suffix “X” which denotes that all linear indications detected shall be evaluated to level 1.

TABLE A2

ACCEPTANCE STANDARDS FOR WELDS

Quality level according to EN ISO 5817	Acceptance levels According to EN ISO 23278
B	2X
C	2X
D	3X

ULTRASONIC TESTING OF WELDS
ISO 17640

APPENDIX A
APPENDIX B
APPENDIX C
APPENDIX D

1	0	2024/10/01	First issue
Em.	**Rev.**	**Data**	**Descrizione**

1.1 INDICE DELLE REVISIONI

Emessa da:

ISTITUTO DI RICERCHE TECNOLOGIE E COLLAUDI

Verificata/Approvata da:
NDT LEVEL 3 ISO 9712

ULTRASONIC TESTING OF WELDS
ISO 17640

1. SCOPE

1.1. This document specifies techniques for the manual ultrasonic testing of fusion-welded joints in metallic materials of thickness ≥ 8 mm which exhibit low ultrasonic attenuation.
It is intended for use on full penetration welded joints where both the welded and parent material are ferritic.

1.2. This document specifies two testing levels, each corresponding to a different probability of detection of imperfections. Guidance on the selection of testing levels A, B is given in the following table.

Quality Level of the Weld UNI EN ISO 5817	Testing Level UNI EN ISO 17640	Acceptance Level UNI EN ISO 11666
C	A	3
B	B	2

1.3. This document can be used for the assessment of discontinuities, for acceptance purposes, the following technique:

- Evaluation based on length and echo amplitude of the discontinuity;

2. NORMATIVE REFERENCES

ISO 9712, Non-destructive testing — Qualification and certification of NDT personnel
ISO 11666, Non-destructive testing of welds — Ultrasonic testing— Acceptance levels
ISO 16811, Non-destructive testing — Ultrasonic testing — Sensitivity and range setting
IS0 17635, Non-destructive testing of welds — General rules for metallic materials
EN 12668 (all parts), Non-destructive testing — Characterization and verification of ultrasonic examination equipment

3. Terms and definitions

3.1. For the purposes of this document, the terms and definitions given in ISO 5577 and ISO 17635 apply.

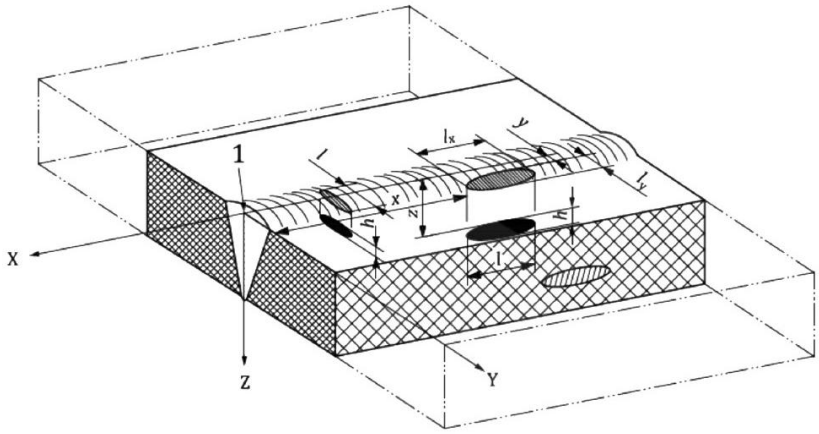
4. Symbols

4.1. The symbols in Table 1 apply.

Table 1 — Symbols

Symbol	Definition	Unit
AL	acceptance level	—
D_{DSR}	diameter of the disk-shaped reflector (flat-bottomed hole)	mm
h	extension of the discontinuity in depth direction	mm
l	length of the discontinuity	mm
l_x	projected length of the discontinuity in the x-direction	mm
l_y	projected length of the discontinuity in the y-direction	mm
p	full skip distance	mm
t	thickness of parent material[a]	mm
x	position of the discontinuity in the longitudinal direction	mm
y	position of the discontinuity in the transverse direction	mm
z	position of the discontinuity in the depth direction	mm
[a] If the joined parts are not of equal thickness, t represents the smallest thickness.		

4.2. Indications shall be considered to be originating from either longitudinal or transverse discontinuities, depending on the direction of their major dimension with respect to the weld axis x, in accordance with figure 1.



Key
1 origin

Figure 1 — Coordinate system for defining the location of discontinuities

5. General

5.1. The purpose of this document is to describe general techniques of ultrasonic weld testing, using standard criteria, for the most commonly used welded joints.
The specific requirements of this document cover the test equipment, preparation, performance of testing, and reporting. The parameters specified, in particular those for the probes, are compatible with the requirements of 1SO 11666 and 1SO 23279.

5.2. If the joined parts are not of equal thickness, the smallest thickness shall be considered.

6. Information required prior to testing

6.1. Items to be specified:
- a) method for setting the reference level;
- b) method to be used for the evaluation of discontinuities;
- c) acceptance levels;
- d) testing level;
- e) manufacturing and operation stage(s) at which the testing is to be carried out;
- f) qualification of personnel;
- g) type(s) of parent material and product form (i.e. cast, forged, rolled);
- h) manufacturing or operation stage at which testing is to be made, including heat treatment, if any;
- i) time and extent of any post-weld heat treatment;
- j) joint preparation and dimensions;
- k) requirements for surface conditions;
- l) welding procedure or relevant information on the welding process;
- m) extent of testing;

7. Requirements for personnel and equipment

7.1. Personnel qualifications

7.1.1. Personnel performing testing in accordance with this document shall be qualified to an appropriate level in ultrasonic testing in accordance with ISO 9712 or equivalent in the relevant industrial sector.

7.2. Test equipment

7.2.1. Any equipment used for testing in conjunction with this document shall comply with the requirements of EN 12668.

7.3. Probe parameters

7.3.1. Test frequency

7.3.1.1. The frequency shall be within the range 2 MHz to 5 MHz.

7.3.2. Angles of incidence

7.3.2.1. When testing is carried out with transverse waves and techniques that require the ultrasonic beam to be reflected from an opposite surface, care shall be taken to ensure that the angle between the beam and the normal to the opposite reflecting surface is between 35° and 70°.

7.3.2.2. Where more than one beam angle is used, at least one of the angle-beam probes used shall conform to this requirement. incidence.

7.3.2.3. When the use of two or more beam angles is specified, the difference between the nominal beam angles shall be 10° or greater.

7.3.3. Transducer size

7.3.3.1. The transducer size shall be chosen according to the ultrasonic path to be used and the frequency. The smaller the transducer, the smaller the length and width of the near field, and the larger the beam spread in the far field at a given frequency.
Small probes having 8x9 mm crystal dimensions are therefore most useful when working at short sound paths.
For longer sound paths, i.e. greater than 100 mm 14x14 mm crystal dimensions may be used and 20x 22 mm crystal dimensions are more suitable for greater than 200 mm sound paths.

7.3.4. Adaptation of probes to curved scanning surfaces

7.3.4.1. The gap, g, between test surface and bottom of the probe shall not be greater than 0,5 mm.
If a value for g larger than 0,5 mm results, the probe shall be adapted to the surface and the sensitivity shall be set accordingly.

7.3.5. Coupling media

7.3.5.1. As coupling medium shall be used the NDT FYP gel. The coupling medium used for range and sensitivity setting and for the test shall be the same.

8. Testing volume

8.1. The testing volume is defined as the zone which includes weld and the width of the heat-affected zone on each side of the weld or at least 10 mm if the width of the heat-affected zone is not known.
In all cases, scanning shall cover the whole testing volume. If individual sections of this volume cannot be covered in at least one scanning direction, or if the angles of incidence with the opposite surface do not meet the requirements of 7.3.2, alternative or supplementary ultrasonic techniques shall be agreed upon. This may, in some cases, require removal of the weld reinforcement.

9. Preparation of scanning surfaces

9.1. Scanning surfaces shall be wide enough to permit the testing volume (see Figure 2) to be fully covered. Alternatively, the width of the scanning surfaces may be smaller if equivalent coverage of the testing volume can be achieved by scanning from both the upper and the lower surface of the joint.

9.2. Scanning surfaces shall be even and free from foreign matter likely to interfere with probe coupling (e.g. rust, loose scale, weld spatter, notches, grooves). Waviness of the test surface shall not result in a gap between the probe and test surfaces greater than 0,5 mm. These requirements shall be ensured by dressing, if necessary.

10. Parent metal testing

10.1. The parent metal, in the scanning zone area (see Figure 2), shall be tested with straight-beam probes prior to or after welding.
Where imperfections are found, their influence on the proposed angle-beam testing shall be assessed and, if necessary, the techniques adjusted correspondingly

11. Range and sensitivity setting

11.1. General

11.1.1. Setting of range and sensitivity shall be carried out prior to each testing in accordance with this document. The temperature difference during range and sensitivity setting and during the test shall be within +15 °C.

11.1.2. Checks to confirm these settings shall be performed at least every 4 h and upon completion of the testing.

11.1.3. Checks shall also be carried out whenever a system parameter is changed or changes in the equivalent settings are suspected.

11.2. Reference for sensitivity setting

11.2.1. One of the following techniques for setting the reference shall be used.

11.2.1.1. Technique 1: the reference is a distance-amplitude curve (DAC) for side-drilled holes of diameter
3 mm
11.2.1.2. Technique 3: the reference notch shall be rectangular, 1 mm wide with a depth of 1 mm. This technique applies only for the thickness range 8 mm < t < 15 mm and only for beam angles ≥ 70°.
11.2.1.3. See in appendix D the block to be used for various weld thicknesses. See also the minimum calculated depth of the side drilled hole for various transducers and path lengths.
11.2.2. The length of the side-drilled holes and notches shall be at least 38 mm.

11.3. Evaluation levels

11.3.1. All indications equal to or exceeding the levels in Appendix C of this document (1SO 11666:2018).shall be evaluated.

11.4. Transfer correction

11.4.1. When separate blocks are used for establishing reference levels, a measurement shall be made of the transfer differences, between test object and reference block, at a representative number of locations.
11.4.2. Suitable techniques are described in Appendix B of this document (ISO 16811).
11.4.3. If the differences are less than or equal to 2 dB, correction is not required.
If the differences are greater than 2 dB but smaller than or equal to 12 dB, they shall be compensated for.
If transfer losses exceed 12 dB, the reason shall be considered and further preparation of the scanning surfaces shall be carried out.

11.5. Signal-to-noise ratio

11.5.1. During testing of the weld, the noise level, excluding spurious surface indications, shall remain at least 12 dB below the evaluation level. This requirement may be relaxed subject to specification.

12. Testing levels

12.1. This document specifies two testing levels (A, B) related to quality levels of welds.

Testing Level	Quality Level UNI EN ISO 5817
A	C
B	B

13. Testing techniques

13.1. General

13.1.1. Ultrasonic testing of welds shall be performed by contact manual pulse-echo scanning to find longitudinal indications.
Transversal indications will also be sought if required.
See in appendix A the scanning positions.

13.2. Manual scanning

13.2.1. During angle-beam scanning, a slight swivelling movement up to an angle of approximately 10° on either side of the nominal beam direction shall be applied to the probe.

13.3. The tandem technique will only be used if expressly requested.

13.4. **Location of discontinuities**

13.4.1. The location of discontinuities shall be defined by reference to a coordinate system, e.g. as shown in Figure 1. A point on the testing surface shall be selected as the origin for these measurements.

13.5. Evaluation of indications

13.5.1. **General**

13.5.1.1. All relevant indications above the evaluation level shall be assessed in accordance with 13.5.2 to 13.5.4.

13.5.2. **Maximum echo amplitude.**

13.5.2.1. The echo amplitude shall be maximized by probe movement and recorded in relation to the reference level.

13.5.3. **Discontinuity length**

13.5.3.1. The length of a discontinuity, shall, be determined by the drop of the echo to the evaluation level. See the Appendix B of this document

13.5.4. **Discontinuity height**

13.5.4.1. The height of a discontinuity shall be determined only if required.

13.5.5. **Characterization of discontinuities**

13.5.5.1. Discontinuities are characterized by the height of the echo and their length (13.5.3.1).

14. ACCEPTANCE STANDARD

14.1. See in appendix C the acceptance standard for isolated indications.

15. Test report

15.1. The test report shall include at least the following information:

a) an identification of the object under test:
b) the material and product form;
c) the dimensions;
d) the location of tested weld/welded joint, sketch showing geometrical configuration (if necessary);
e) a reference to the welding procedure, specification and heat treatment;
f) the state of manufacture;
g) the surface conditions;
h) contract requirements, e.g. specifications, guidelines, special agreements;
i) the place and date of testing;
j) an identification of test organizations and identification and certification of operator;
k) the maker and type of the ultrasonic instrument with identification number;
l) the maker, type, nominal frequency, size of transducer and actual angle of incidence of probes used
m) an identification of reference blocks used with a sketch, if necessary;
n) the coupling medium;
o) the testing level(s) and reference to this procedure
p) the extent of testing;
q) the location of the scanning areas;
r) the reference points and details of the coordinate system used as specified in 13.4
s) an identification of probe positions, by use of a sketch;
t) the range setting;
u) the method and values used for sensitivity setting (gain setting for reference levels and values used for transfer corrections);
v) the reference levels;
w) the result of the parent material test;
x) the standards for acceptance levels;
y) the deviations from this document or contract requirements;
z) the coordinates of the discontinuities, as specified in 13.4, with details of associated probes and corresponding probe positions;
aa) the maximum echo amplitudes as specified in 13.5.2
bb) the lengths of discontinuities as specified in 13.5.3;
cc) the results of evaluation according to specified acceptance levels;

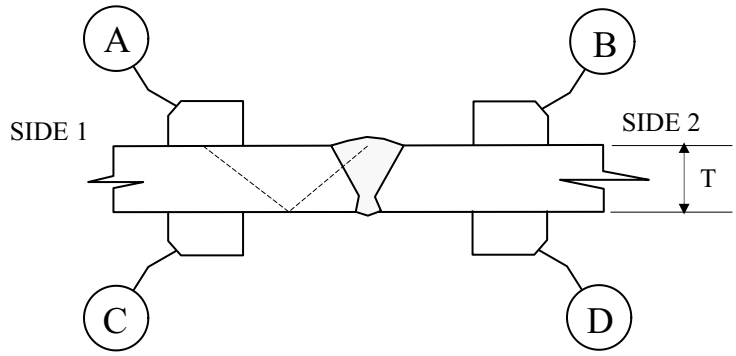
ULTRASONIC TESTING OF WELDS
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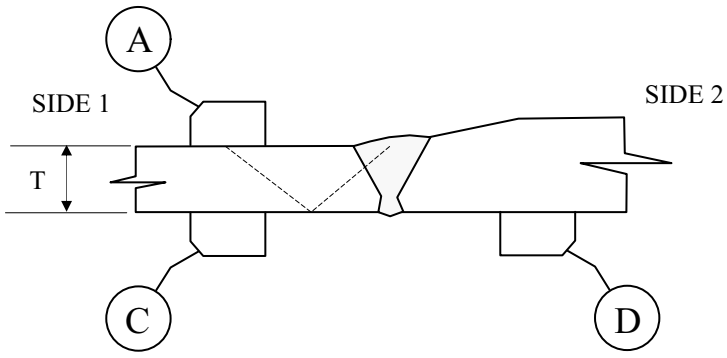
APPENDIX A

BUTT WELDS OF PLATES AND TUBES

Testing Level	THICKNESS (mm)	ANGLES OF BEAM	SCANNING POSITIONS	BEAM TYPE	No. OF SCANS	NOTE
A	8 ≤ T< 15	1	A or B	reflected	2	/
	15 ≤ T< 40	1	A or B	reflected	2	/
B	8 ≤ T< 15	70°	A e B oppure C e D	reflected	2	2
	15 ≤ T< 40	60 e 70°	A e B oppure C e D	reflected	4	1, 2
	40 ≤ T< 60	45 e 60°	A e B oppure C e D	reflected	4	/
	60 ≤ T< 100	45 e 60°	A e B oppure C e D	reflected	4	/
	100 ≤ T< 300	45 e 60°	A e B e C e D	direct	8	3

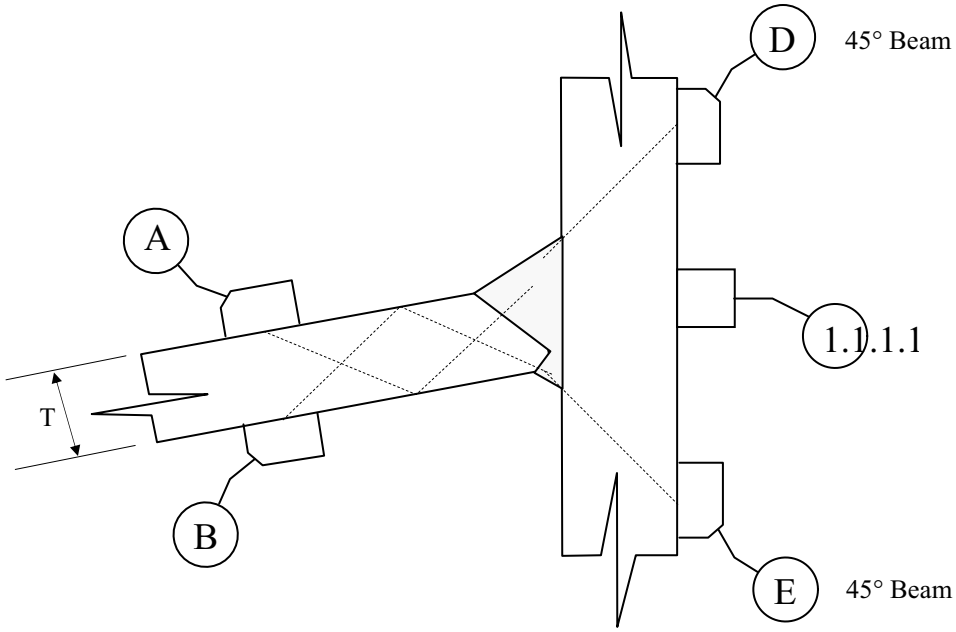
NOTE 1) In the thickness range 15 < T ≤ 25 mm if the probe frequency is < 3 MHz one beam angle is sufficient
2) If the weld is only accessible from one side 1 or 2, two beam angles shall be used
3) The 60° beam will be used to reach the root of the weld





WELD OF SET-IN NOZZLES

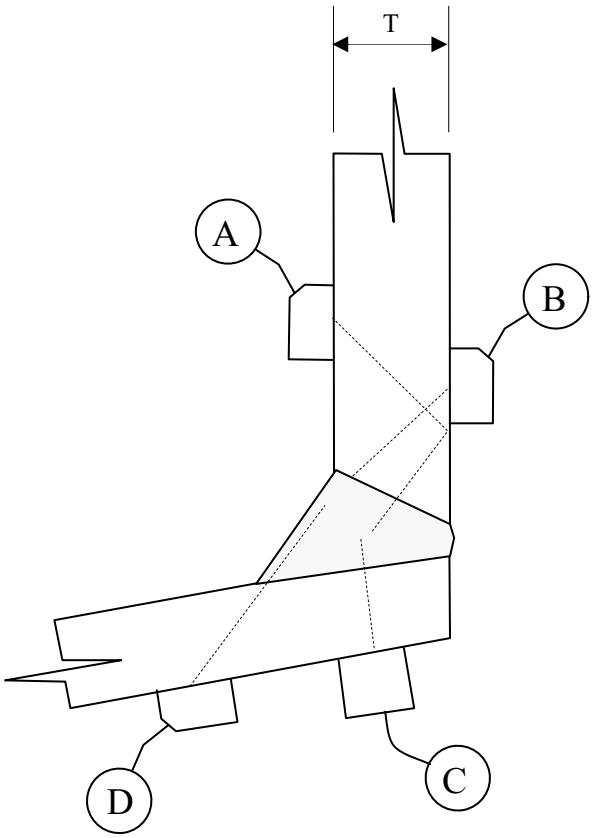
Testing Level	THICKNESS (mm)	Angles of beam	SCANNING POSITIONS	BEAM TYPE	No. OF SCANS
A	8 ≤ T< 15	1 (70° for A – 45° for D)	A or D or C	reflectedfor A direct for D and C	1
	15 ≤ T< 40	1 (60° for A – 45° for D)	A+C or A+D	reflectedfor A direct for D and C	2
B	8 ≤ T< 15	1 (70° for A – 45° for D)	A o D + C	reflectedfor A	2
	15 ≤ T< 40	1 (60° for A – 45° for D e E)	A o (D+E) + C	Reflected for A	2 o 3
	40 ≤ T< 60	1 (60° for A – 45° for D e E)	(A o B)+(D+E)+C	Reflected for A and B	4
	60 ≤ T≤ 300	2 for A and B (45° and 60°) 1 for D and E (45°)	A+B+D+E+C	direct	7



NOTA If the nozzle has a reinforcing plate, the test will be carried out before welding the reinforcing plate.

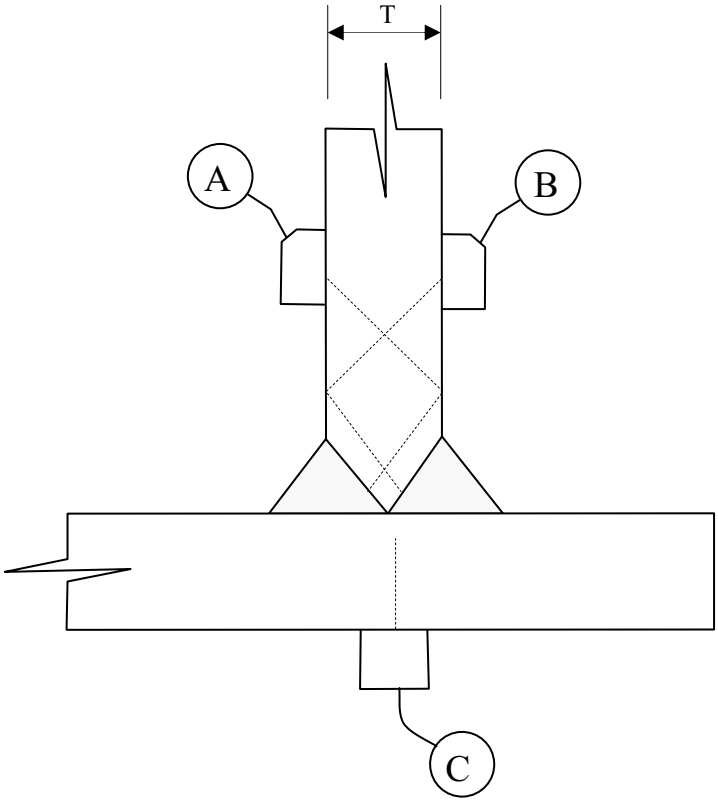
WELD OF SET-ON NOZZLES

Testing Level	THICKNESS (mm)	BEAM ANGLES	SCANNING POSITIONS		BEAM TYPE	No. of SCANS
A	8 ≤ T< 15	70°	A or B		Reflected for A, direct for B	1
	15 ≤ T< 40	60°	A or B	C	Reflected for A, direct for B	2
B	8 ≤ T< 15	2 (60° e 70°) per A o B	A o B	/	Reflected for A, direct for B	2
	15 ≤ T< 40	2 (60° e 70°) per A o B	A o B	C	Reflected for A, direct for B	3
	40 ≤ T< 60	2 (45° e 60°) per A e B	A e (B o D)	C	Reflected for A, direct for B and D	5
	60 ≤ T< 100	2 per A e B (45° e 60°), 1 per D (45°)	A e (B o D)	C	Reflected for A, direct for B and D	5
	100 ≤ 300	2 per A e B (45° e 60°), 1 per D (45°)	A e (B o D)	C	Direct for A, B, e D	4 o 5



TEE WELDS

Testing level	THICKNESS (mm)	BEAM ANGLES	POSIZIONI DI SCANSIONE		FASCIO UTILIZZATO	No. DI SCANSIONI
A	8 ≤ T< 15	70°	A or B		Reflected for A e B	1
	15 ≤ T< 40	60°			Reflected for A e B	2
B	8 ≤ T< 15	1 (70°) for A or B	A or B	C	Reflected for A e B, direct for C	2
	15 ≤ T< 40	1 (70°) for A and B	A and B	C	Reflected for A e B, direct for C	3
	40 ≤ T< 300	2 (45° e 60°) for A and B	A and B	C	Direct for A and B and C	5



APPENDIX B

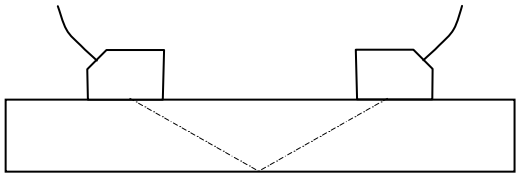
EVALUATION OF THE TRANSFER LOSS

Straight beam
Place the probe on block V1 and bring the background echo to 80% of the screen. Note the amplification (Vt,t).
Rest the probe on the work piece base material and bring the background echo to 80% of the screen. Note down the amplification (Vt,r).
Note on the DGS diagram of the probe used, on the curve of the large reflector (∞), the theoretical difference in amplification for the paths in the calibration block and the test piece (ΔVS).
Calculate ΔVt = Vt,r - Vtr - ΔVS.
This is the correction to be applied to the amplification to account for transfer losses.
This correction will only be applied if positive and > 2 dB

Angle beam
Calibration block V1 is used.
Use 2 (identical) probes of the type to be used for control; one will be used as a transmitter and the other as a receiver.

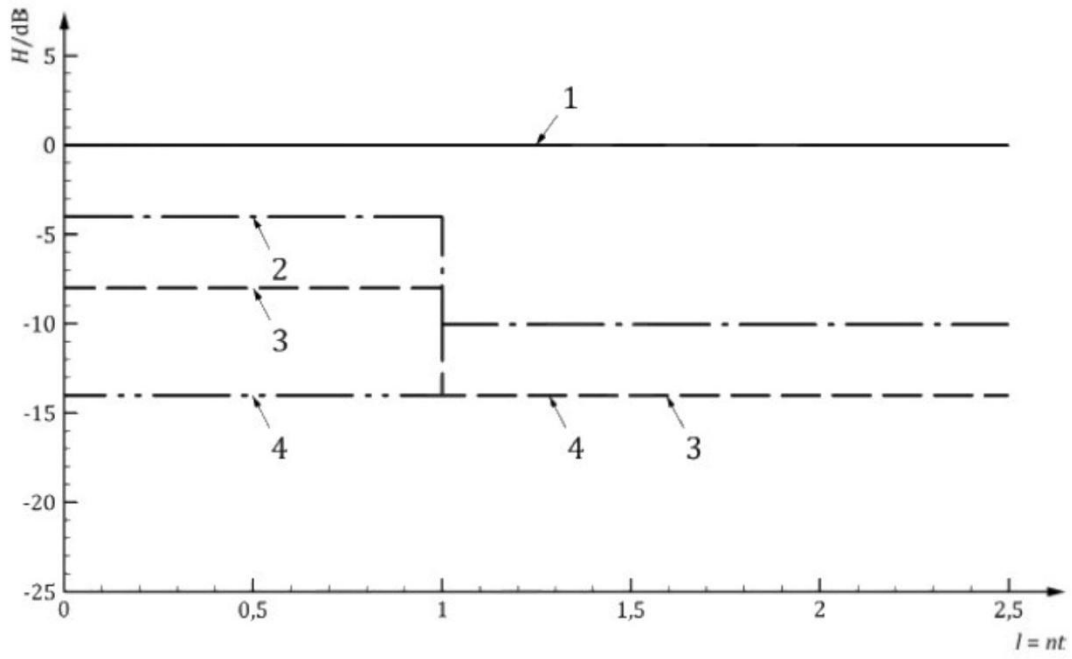
Place the two probes on the same face of the V1 block (see sketch at the bottom of the page) and bring the signal to 80% of the screen.
Note the amplification of the instrument (Vt,t).
Note down the ultrasonic path in the calibration block (ST)
Note on the DGS diagram of the probe used, on the curve of the large reflector (∞), the theoretical difference in amplification for the paths in the calibration block and in the work piece (ΔVS).
Place the two probes in the same way on the work piece base material.
Record the amplification of the instrument (Vt,r).
Note down the ultrasonic path in the work piece to be checked (SR)

Calculate ΔVt = Vt,t - Vt,r - ΔVS.
This is the correction to be applied to the amplification to account for transfer losses.
This correction will only be applied if positive and > 2 dB



Determination of transfer loss for control by angle probe

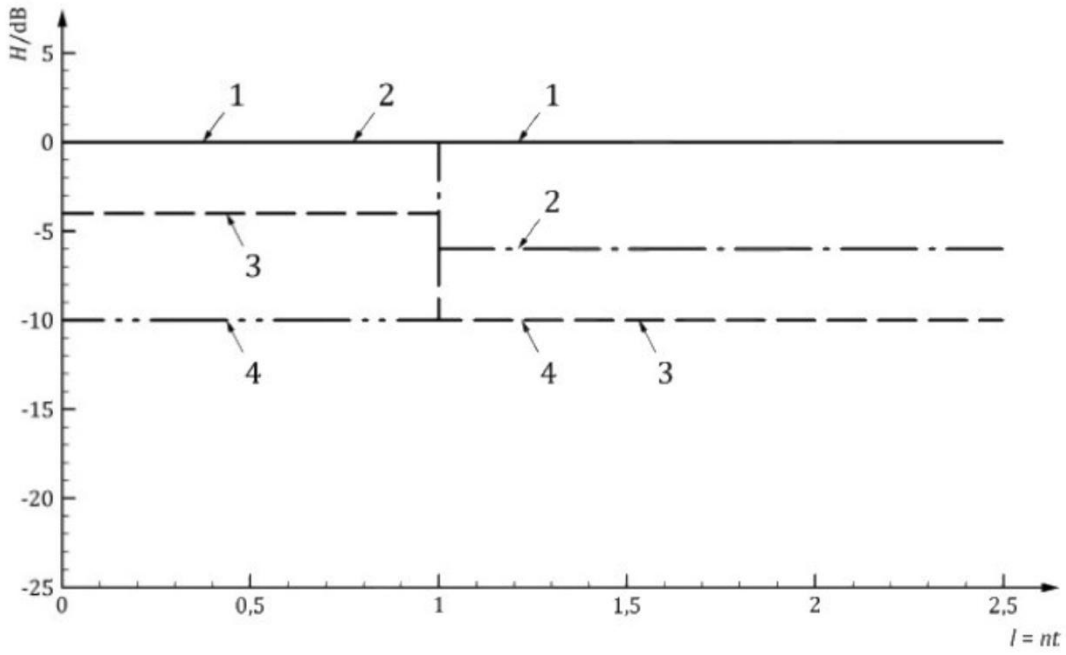
APPENDIX C



Key

1	reference level
2	acceptance level 2
3	recording level
4	evaluation level
H	amplitude
l	length of discontinuities
n	multiplier of t
t	thickness

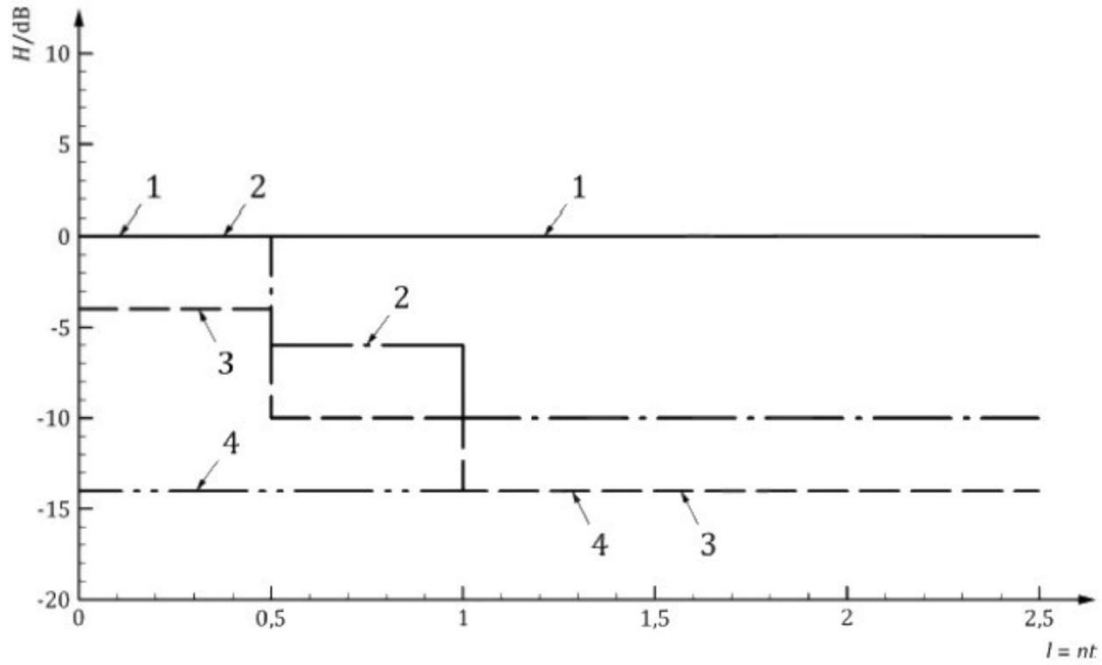
Figure A.1 — Levels for techniques 1 and 3 for thicknesses 8 mm to 15 mm — Acceptance level 2



Key

1	reference level
2	acceptance level 3
3	recording level
4	evaluation level
H	amplitude
l	length of discontinuities
n	multiplier of *t*
t	thickness

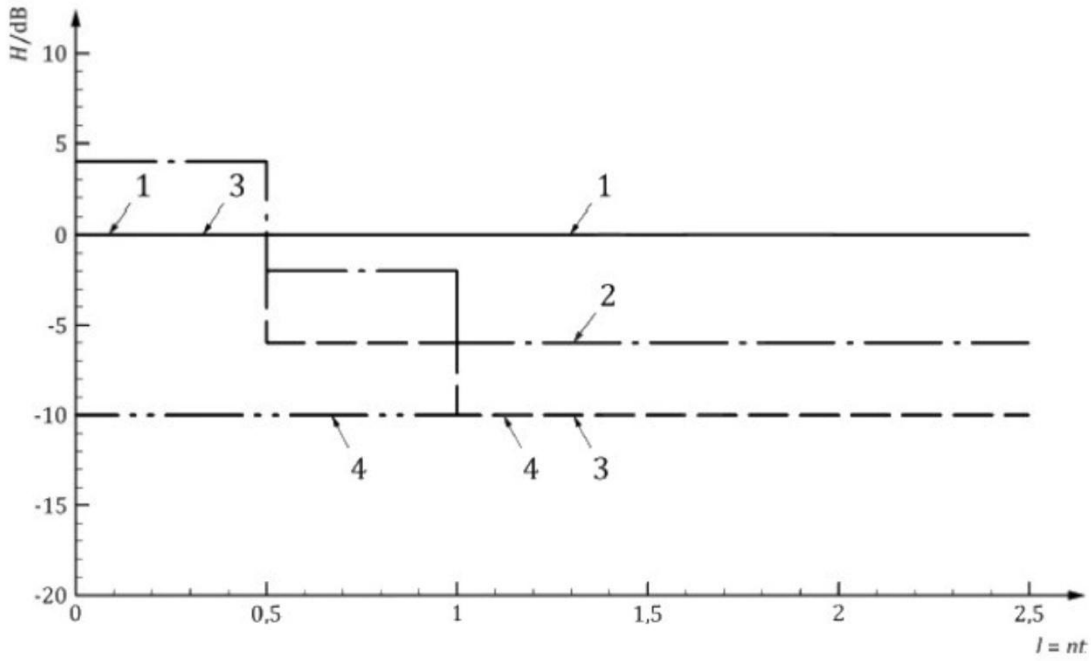
Figure A.2 — Levels for techniques 1 and 3 for thicknesses 8 mm to 15 mm — Acceptance level 3



Key

1	reference level
2	acceptance level 2
3	recording level
4	evaluation level
H	amplitude
l	length of discontinuities
n	multiplier of *t*
t	thickness

Figure A.3 — Levels for technique 1 for thicknesses 15 mm to 100 mm — Acceptance level 2

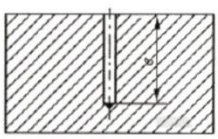
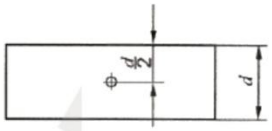
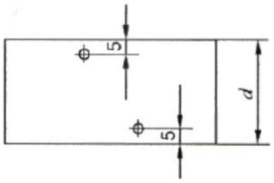
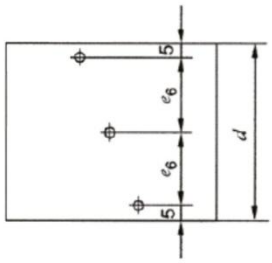
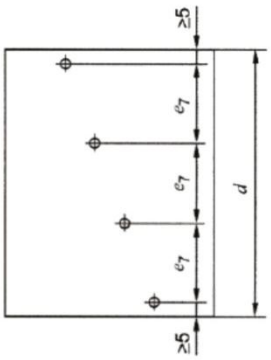


Key

1	reference level
2	acceptance level 3
3	recording level
4	evaluation level
H	amplitude
l	length of discontinuities
n	multiplier of *t*
t	thickness

Figure A.4 — Levels for technique 1 for thicknesses 15 mm to 100 mm — Acceptance level 3

APPENDIX D

Spessore della parete, *d*, in mm	Blocchi di riferimento e riflettori di riferimento	Condizioni
		
$10 \le d \le 15$		
$15 < d \le 20$		$e > \frac{2\lambda s}{D_{eff}}$
$20 < d \le 40$		$D_{SDH} \ge 1{,}5\ \lambda$ $e_6 = \frac{d-10}{2}$
$d > 40$		$e_7 \le \frac{d-10}{2}$

Probe	Frequency	Path length	e ≥	
8x9	4 MHz	100	32 mm	
14x14	2 MHz	150	31 mm	
20x22	2 Mhz	200	27 mm	

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CERTIFICATO DI LIVELLO 3
LEVEL 3 CERTIFICATE

N° 34832/PND/C

Si certifica la qualificazione per esami in Prove Non Distruttive al **LIVELLO 3**

*This is to certify qualification by examinations in Non-Destructive Testing at the **LEVEL 3***

di / of

Grossi Giuseppe

nato a / *born in* **Domodossola (VB)**

il / *on* **10 novembre 1941**

per i metodi seguenti / *for the following methods:*

RT (Radiografia) - UT (Ultrasuoni) - MT (Magnetoscopia) - PT

(Liquidi Penetranti)

Il presente certificato viene rilasciato in conformità alla Norma UNI EN ISO 9712.
This certificate is issued according to UNI EN ISO 9712.

Il Presidente del Comitato Tecnico
The President of Technical Committee

P. I. E. Tuberosa

L'Amministratore Unico
The Administrator

Dr. Ing. M. Crepaldi

Data Delibera: 23/12/2020
Approval Date

Data Scadenza: 23/12/2025 C
Expiry Date

AIPnD



PRS N°0076

PROVE NON DISTRUTTIVE: Certificato di Qualifica Operatore

NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-24-02015-C

Si certifica la qualifica in Prove Non Distruttive al Livello 3

It certifies the qualification for Non-Destructive Testing at the level 3

Titolare del certificato / *Certificate holder*

Vincenzo Santarcangelo (ID # 4044)

Nato a / *born in*: Matera (MT) Italy

Il / *on*: 25 Apr 1960

Per il metodo-tecnica / F*or the method-tecnique:*

Radiographic Testing / Film interpretation (RT/F-I)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)

APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / F*or the sectors*:

Pre- and in-service testing which includes manufacturing (s)

(composed by product sector c-f-w-t-wp-m)

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Emesso / *Issued:* 5 Jun 2024

Valido dal / *Validity start date*: 6 Jun 2024

Data ultima revisione / *Date last revision:* ----------

Scadenza / *Expiry date*: 5 Jun 2029

Responsabile Tecnico di Schema

NDT Scheme Chief

Luca Rossi

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Vincenzo Santarcangelo (ID # 4044)

Nato a / *born in*: Matera (MT) Italy

Il / *on*: 25 Apr 1960

Per il metodo-tecnica / F*or the method-tecnique:*

Penetrant Testing (PT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)

APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / F*or the sectors*:

Pre- and in-service testing which includes manufacturing (s)

(composed by product sector c-f-w-t-wp-m)

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Emesso / *Issued:* 5 Jun 2024

Valido dal / *Validity start date*: 6 Jun 2024

Data ultima revisione / *Date last revision:* ----------

Scadenza / *Expiry date*: 5 Jun 2029

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NDT Scheme Chief

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NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-21-02198-C

Si certifica la qualifica in Prove Non Distruttive al Livello 2
It certifies the qualification for Non Destructive Testing at the level 2

Titolare del certificato / *Certificate holder*
Lorefice Nicolò (ID # 7066)

Nato a / *born in*: Gela (CL) Il / *on*: 11 Nov 1993

Per il metodo / *for the method:*
Penetrant Testing (PT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)
APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / *for the sectors*:
Pre- and in-service testing which includes manufacturing

Il presente certificato viene rilasciato in conformità alla Norma UNI EN ISO 9712:2012 e Regolamento Bureau Veritas IT-IND-REG-01_NDT.IND
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Data ultima revisione / *Date last revision*: ----------

Emesso / *issued*: 28 Jul 2021 Scadenza / *Expiry date*: 27 Jul 2026

Autorizzazione del datore di lavoro
Employer authorizing

Responsabile Tecnico di Schema
NDT Scheme Chief
Luca Rossi

Firma titolare del certificato
Signature of certificate holder

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NDT OPERATOR QUALIFICATION CERTIFICATE

No. **20VE00144PN1**

Operator	**CAVALLO ANDREA**		
Born in	**GROTTAGLIE (TA)**	on	**02/04/1995**
Employed by	**CAVALLO ANDREA**		
Located in	**Fragagnano (TA)**		

THIS IS TO CERTIFY that the non destructive test operator is qualified by examinations at the LEVEL 2 according to UNI EN ISO 9712:2012 standard and to RINA Rule RC/C 14

in the method:

MAGNETIC PARTICLE

for the sectors:

Pre-service and in service testing of equipment, plants and structures

This certificate is valid from	**14 February 2020**	to	**13 February 2025**
Issued at	**GENOVA**	on	**14 February 2020**

Filippo Lago
(Italy Welding & Pressure Equipment Certification Head)

Operator

RINA Services S.p.A.
Via Corsica 12 - 16128 Genova

This certificate consist of 1 page

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NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-20-01877-C

Si certifica la qualifica in Prove Non Distruttive al Livello 2
It certifies the qualification for Non Destructive Testing at the level 2

Titolare del certificato / *Certificate holder*
Cavallo Andrea (ID # 6449)

Nato a / *born in*: Grottaglie (TA) Il / *on*: 2 Apr 1995

Per il metodo / *for the method:*
Penetrant Testing (PT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)
APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

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Data ultima revisione / *Date last revision*: ----------

Emesso / *issued*: 21 Sep 2020 Scadenza / *Expiry date*: 20 Sep 2025

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Employer authorizing

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Signature of certificate holder

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NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

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It certifies the qualification for Non Destructive Testing at the level 2

Titolare del certificato / *Certificate holder*
Cavallo Andrea (ID # 6449)

Nato a / *born in*: Grottaglie (TA) Il / *on*: 2 Apr 1995

Per il metodo / *for the method:*
Radiographic Testing / Radiographic Interpretation (RT/RI)

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APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

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Pre- and in-service testing which includes manufacturing

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Data ultima revisione / *Date last revision*: ----------

Emesso / *issued*: 2 Feb 2022 Scadenza / *Expiry date*: 1 Feb 2027

Autorizzazione del datore di lavoro
Employer authorizing

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di Marchetti L. & F.
Via Attilio Mo[illegible] - 48100 RAVENNA
Partita I.V.A. 01 203 960 396
Codice Fiscale 00 174 550 400

Responsabile Tecnico di Schema
NDT Scheme Chief
Luca Rossi

Firma titolare del certificato
Signature of certificate holder



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NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-23-02424-C

Si certifica la qualifica in Prove Non Distruttive al Livello 2
It certifies the qualification for Non-Destructive Testing at the level 2

Titolare del certificato / *Certificate holder*
Nicolò Lorefice (ID # 7066)

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Il / *on*: 11 Nov 1993

Per il metodo / *For the method*
Magnetic Testing (MT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)
APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / *For the sectors*
Pre- and in-service testing which includes manufacturing

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Data ultima revisione / *Date last revision*: ----------

Emesso / *Issued*: 23 Jul 2023

Valido dal / *Valid from*: 23 Jul 2023

Scadenza / *Expiry date*: 22 Jul 2028

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NDT Scheme Chief
Luca Rossi

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1.4.4 Painting Procedures

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

PAINTING PROCEDURE – HYDROGEN VENT

Document Number: 1724000887-MAT-PRO-00010
Document Class: 2

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Michele Sacchi	13-11-2024

Rev.	Date	Description	Prepared	Reviewed	Approved
02	12/11/2024	Accepted for Constrcution (AFC)	MD	RV	ADL
01	25/10/2024	Issue for Review (IFR)	MD	RV	ADL
00	28/09/2024	Issue for Review (IFR)	MD	RV	ADL

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THERMO ENGINEERING ADVANCED COMBUSTION SYSTEMS

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Issue for Review (IFR)
02	Accepted for Construction (AFC)

HOLDS LIST

No.	Description
1	
2	
3	
4	

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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.

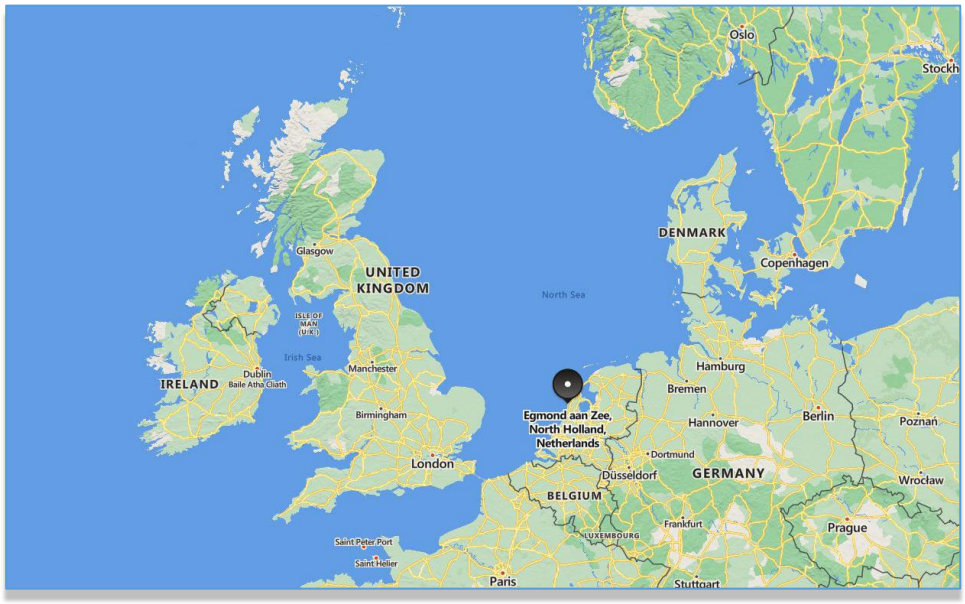


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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 located on coordinates E 590719.1, N 5841602.3 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.

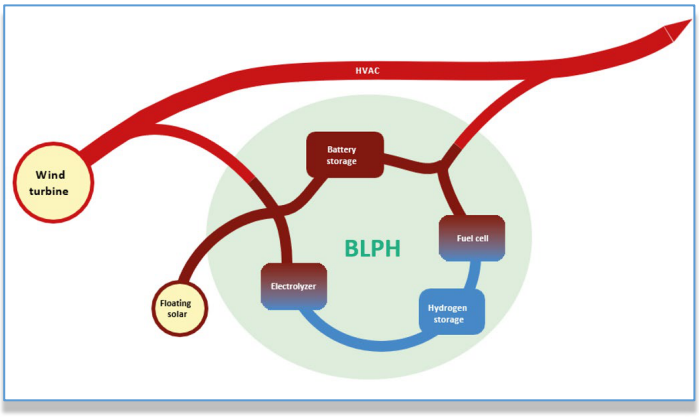


Figure 3 – BLPH Concept

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 s 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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HOLLANDSE KUST NOORD WIND PARK

RISER – TIP – WATER SEAL – WIND TIP

Blue words _ Rev.2

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5. Climatic condition
6. Surface preparation
7. Paint system and application
8. Painting cycles
9. Quality control plan
10. Coating repair
11. Painting report
12. Attachment (Technical Data sheet, Test report sample,)

1. REFERENCE

CLIENT	TICI
PROJECT	HOLLANDSE KUST NOORD
CLIENT JOB NUMBER	393
DOCUMENT REFERENCE	123A90DDLMATSP60006 REV 01

2. SCOPE

This document describes the working procedure on, carbon steel and S.S: parts for surface preparation application painting application and inspection of external parts of Risers, windshield, water seal stair / handrails.

3. STANDARD

- **ASTM D 4285 - 2006**: Standard test method for indicating oil or water in compressed air.
- **ISO 4624**:**2016** Paints and Varnishes - Pull-off test for adhesion.
- **SSPC SP 16**:**2020** Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
- **ISO 8501-3:2006** Part 3: Preparation grades of welds, edges and other areas with surface imperfections
- **ISO 8502-3**:**2017** Preparation of steel substrates before application of paints and related products - Test for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure sensitive tape method).
- **ISO 8502-4**:**2012** Preparation of steel substrates before application of paint and related products - Test for the assessment of surface cleanliness - Part 4: Guidance on the estimation of the probability of condensation prior to paint application.
- **ISO 8502-6:2020** Preparation of steel substrates before application of paint and related products - Test for the assessment of surface cleanliness - Part 6: Extraction of soluble contaminants for analysis – The Bresle method.

- **ISO 8502-9**:**2020** Preparation of steel substrates before application of paint and related products - Test for the assessment of surface cleanliness – Part 9: Field method for the conduct metric determination of water-soluble salts.
  - **ISO 8503-1:2012** Preparation of steel substrates before application of paint and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive
  - **ISO 8503-2:2012** Preparation of steel substrates before application of paint and related products
    Surface roughness characteristics of blast-cleaned steel substrates – Part 2: Comparator procedure.
  - **SSPC-SP 1**:**2004** Solvent cleaning.
  - **ISO 19840:2012** Measurement of dry film thickness

4. PRE – SURFACE INSPECTION & TREATMENT

Prior to surface preparation, substrate surfaces shall be free from dust, dirty and debris And cleaning as per SSPC SP1.

The metallic surface to be protected by paint shall comply with ISO 8501-3 grade P3.

5. CLIMATIC CONDITION & TREATMENT

The painting shall be carried out only at the following conditions:

- Air temperature: from 5 to 40 °C or as indicated in Technical Data Sheet.
- Air relative humidity: max 85%. or as indicated in Technical Data Sheet..
- Steel temperature: at least 3 °C above the dew point temperature of the surrounding air.

Temperature and humidity shall be monitored Before start of each shift and minimum twice per shift.

6. SURFACE PREPARATION

Sharp edges, fillets, corners and welds shall be rounded or smoothened by grinding to grade P3 as defined in ISO 8501-3, minimum radius 2 mm (performed by TICI)

The surfaces shall be free from any foreign matter such as weld flux, residue, slivers, oil, grease, salt etc. prior to blast cleaning.

All surfaces should be washed with clean fresh water prior to blast cleaning.

All machined parts shall be cleaned with a solvent liquid suitable to remove any machining fluids.

Any oil and grease contamination shall be removed in accordance with ISO 12944-4, prior to blasting operations.

The external surfaces in stainless steel shall be blast-cleaned with WHITE CORUNDUM in accordance to the visual standard, SSPC SP16 before painting.

Blast abrasives shall be free from oil, grease, or moisture.

The maximum total allowable level of soluble salts on a prepared surface is 20 mg/m². The salt level shall be assessed in accordance with

ISO 8502-6 and ISO 8502-9The dust level on the blast-cleaned surface at the time of coating shall not exceed Rating 2 in accordance with ISO 8502-3. Checks on dust levels shall be made at once per item.

7. PAINTING CYCLES - REPAIRS

Application will be performed by conventional spray

Before all spray application a suitable stripe coat will Be performed

COATING SYSTEM 1B – CARBON STEEL PARTS

RISER + STAIRS AND HANDRAILS

(SEE NOTE FOR TEST PLATE QUALIFICATION)

- **SA 2½ – MEDIUM G**
- **AVANTGUARD 750 – 60µm**
- **HEMPAPRIME MULTI 500 - 180µm**
- **HEMPATHANE 55610 – 60µm –**
- **TOT DFT: 300µm**

RISER RAL 9002 – STAIRS AND HANDRAIL RAL 1023

COATING SYSTEM 6A – STAINLESS STEEL PARTS

WINDSHIELD and TIP

- **SSPC SP16 –**
- **HEMPADUR 15570 – 50µm**
- **HEMPAPRIME MULTI 500 - 100µm**
- **HEMPEL PRO ACRYLIC 5588 – 75µm – RAL 9002**
- **TOT DFT: 225µm**

All inspections, from surface preparation to adhesion test shall be followed by Unoprima's Frosio NS 476 Inspector, level III.

TEST QUALIFICATION PLATE FOR SYSTEM 1B

Before starting the work a qualification test plate (Norsok plate) will be worked for qualified system 1B.

All phases of working on plate's will be followed and certified By NS 476 Frosio Inspector level III.

REPAIRS

REPAIR OF DEFECTS

Any repair shall be performed according to the instructions listed in the PDS published by Paint Manufacturer. Failing or for better explain the instructions, the criteria reported in the following sections shall apply.

All damages occurred to previous coats shall be repaired before application of the next one and before the final acceptance of the Company.

Surface preparation activities shall be performed with materials and tools compatible with the metal support, e.g. SS compatible abrasives/tools on SS.

Inadequate coating thickness

In case an inadequate coating thickness is detected, investigation shall start in order to define which of the layers is faulty. If the primer is defective, the total coating shall be removed and reapplied. In case the failure is in the intermediate or finishing layers, all areas with inadequate coating thickness shall be thoroughly cleaned, if necessary, abraded and additional compatible coats applied until they meet the specified thickness.

These additional coats shall not be visible on the final coating and on adjoining areas.

Contaminated Surfaces

Surfaces to be over-coated, which have become contaminated by grease, oil, fatty materials and any other foreign material shall be cleaned and degreased according to the standard SSPC-SP 1.

Coating damages not exposing bare steel

The coating around the damaged area shall be feathered using sandpapering or rotary disking. The re-cleaning shall be extended, not less than 50 mm, to undamaged surrounding surfaces in order to assure film continuity. The complete specified paint system shall be applied on the cleaned area.

Coating damage exposing bare steel

Damaged areas shall be cleaned by abrasive blasting or power tooling as required by the original grade of cleaning.

Damage of small dimension

Any damaged areas less than 200 x 200 mm shall be cleaned at least by power tooling according to standard SSPC-SP 11 and coated with the original specified paint system.

Surface preparation shall be extended not less than 50 mm to the surrounding sound coating and the edges properly fathered.

Damage of medium dimension

Any damaged areas less than 1 m2 shall be cleaned by abrasive blasting according to standard SSPC-SP 10 and coated with the original specified paint system.

Surface preparation shall be extended not less than 50 mm to the surrounding sound coating and the edges properly fathered.

Extensive damage

The damaged areas shall be considered extensive in the following instances:

1. When the surface affected by damages is greater than 1 m2,
2. When the extension of the damages of small and/or medium dimension, is greater than 5% scattered or greater than 10% localized of the coated area.

In this circumstances the complete areas shall be re-blasted and re-coated as originally provided by the Specification.

8. QUALITY CONTROL PLAN

ITEM	INSPECTION TEST ON ITEM	FREQUENCY	ACCEPTANCE STANDARD	REPORT FORM	CONSEQUENCE
1.	INSPECTION ON SURFACE CONDITION / STEEL PREPARATION	ALL SURFACE	SURFACE SHALL BE DRY AND FREE FROM BURS, WELDS, DIRT AND OIL. CLEANING AS PER SSPC SP1. GRADE OF STEEL PREPARATION SHALL BE PER ISO 8501-3 GRADE P3	UNOPRIMA	DEFECT TO BE REPAIRED BY ALFA LAVAL. SOLVENT CLEANING AS PER SSPC – SP1
2.	CLIMATIC CONDITION	BEFORE START OF EACH SHIFT - MINIMUM TWICE PER SHIFT.	ISO 8502 – 4 SURFACE TEMP. 3°C ABOVE DEW POINT, HUMIDITY MAX 85%, AMBIENT TEMPERATURE MIN 5°C OR AS PER TDS	UNOPRIMA	USE HEATER AND / OR DEHUMIDIFICATOR
3.	ABRASIVES QUALITY	BEFORE BLASTING	CONDUCIVITY LESS THAN 150 µS/cm – ISO 11127 – ISO 8502/6-9	UNOPRIMA	CHANGE ABRASIVES OR RETEST
4.	ABRASIVE BLASTING	ALL SURFACE	STAINLESS STEEL PARTS SSPC SP16 CARBON STEEL PARTS SA 2½	UNOPRIMA	RE - BLASTING
5.	SURFACE PROFILE	ONE SHOT PER ITEM	ISO 8503-4 or ISO 8503-5 MEDIUM “G” FOR C.S. FINE “G” FOR S.S.	UNOPRIMA	RE - BLASTING
6.	CLEANING SURFACE / DUST TEST	ALL SURFACE	ISO 8502 – 3 CLASS 2 RATING 2	UNOPRIMA	RE – BLOWING AND TESTING
7.	SALT TEST	ONE EVERY LOT OF BLASTING	ISO 8502 – 06/09 – MAX ACC. VALUE 20mg/m²	UNOPRIMA	CLEAN ITEM WITH FRESH WATER AND RE-TEST
8.	COATING MATERIAL RECEIPT	ALL PRODUCT	Coating material traceability Legible labels clearly -Product name -Batch number -Storage instructions -Date of manufacturer	UNOPRIMA	NEW PRODUCT TO BE PROVIDED
9.	WFT	DURING PAINT APPLICATION	ISO 2808 1A	UNOPRIMA	INCREASE THICKNESS IF IS NOT ENAUGHT
10.	DFT	ISO 19840	ISO 19840	UNOPRIMA	APPLY ANOTHER COAT AS PER TDS
11.	ADHESION TEST	ISO 16276-1	MINIMUM ACCEPTANCE VALUE 5MPa	UNOPRIMA	TEST TO BE REPEATED
12.	VISUAL CHECK TO DETERMINE CURING, CONTAMINATION, SOLVENT RETENTION, PINHOLE/POPPING, RUNS SAGGING AND SURFACE DEFECT	100% ALL SURFACE	NO DEFECT	UNOPRIMA	REMOVAL AND REPAIR DEFECT

10. REPORT PAINTING

unoprima	RAPPORTO DI VERNICIATURA - Painting report Data / Date	Nr.	
CLIENTE Customer	COMMITTENTE FINALE Final costumer	COMM. CLIENTE FINALE Final Costumer Job	
OGGETTO Object	PROGETTO Project	CICLO VERNICIATURA Painting System	

PREPARAZIONE DELLA SUPERFICIE - Surface preparation				
Cleaning degree - *ISO 8501-1*	Anchor profile - ISO 8503 - 2	Salt test - *ISO 8502 -6&9*	Dust test - *ISO 8502 -3*	DATA - Date
TEMP. AMBIENTE - Air temperature	UMID. REL - Relative umidity	P.d.R - Dew point	TEMP SUPPORTO - Surf. temp	

VERNICIATURA - Painting				
STRATO - Coat	1st	2nd	3rd	4th
METODO DI APPLICAZIONE Application method				
DATA - Date *TIME - From _ To _*				
TEMPERATURA AMBIENTE Air temperature				
UMIDITA' RELATIVA Relative Humidity		FAC - SIMILE		
PUNTO DI RUGIADA Dew point				
TEMPERATURA SUPPORTO Surface temperature				
PRODOTTO VERNICIANTE Paint product lot/ batch number				
COLORE Color				
CONTROLLO FILM UMIDO µm Wet film thickness check				
CONTROLLO MEK - Mek test - ASTM D 4752-03				
D.F.T. REQUIRED µm				
D.F.T. AVERAGE µm - MIN _ MAX				
TEST DI ADESIONE Adhesion Test ASTM D3359 Meth "A" or ISO 4624				
TEST DIEL. - Holiday test ASTM D5162 Method A WET SPOUNGE TEST 90 V				

NOTE Remarks		
ISPETTORE UNOPRIMA Unoprima Inspector DATA - Date	ISPETTORE CLIENTE Customer Inspector DATA - Date	ISPETTORE COMMITTENTE FINALE Final customer Inspector DATA - Date

Rapporto vern. Rev. 1 - 18.01.10

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						12 of 40
		2	07/11/24	I.S.	A.M.	A.M	
		1	25/10/24	I.S.	A.M.	A.M	
Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	
		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

11.ATTACHMENT

UNOPRIMA DAILY LOG — DATE

1 — ENVIROMENTAL CONDITION - ISO 8502 / 4

TIME	AIR T°	HUMIDITY %	SURF. T°	DEW POINT	UNOPRIMA'S JOB	CHECKED

2 — INDICATING OIL or WATER IN COMPRESSED AIR - ASTM D4285

TIME	PLANT POSITION	RESULT	UNOPRIMA'S JOB	CHECKED

3 — DETERMINATION OF SOLUBLE SALTS ON SURFACE - ISO 8502 - 6 / 9

TIME	FIND VALUE	ZERO SET	RESULTS	UNOPRIMA'S JOB	CHECKED

4 — SURFACE ROUGHNESS CHECK - ISO 8503 - 1 / 5

TIME	ISO 8503 - 1 COMPARATOR	ISO 8503 - 5 STYLUS	UNOPRIMA'S JOB	CHECKED

5 — VISUAL CLEANLINESS - ISO 8501 / 1

TIME	REQUEST	FIND	UNOPRIMA'S JOB	CHECKED

6 — ASSESSMENT OF DUST ON STEEL SURFACE - ISO 8502 / 3

TIME	DUST SIZE CLASS FIND	UNOPRIMA'S JOB	CHECKED

7 — NOTE

REV. 1 - 24/01/2022



TECHMA

Technical data sheet
High carbon steel grit

Description:	High carbon steel grit
Size specification:	SPEC J444 All pass on 1.70 mm 30% max on 1.40 mm 85% min on 1.00 mm 97% min on 0.85 mm
Hardness:	Type GP 480 ÷ 550 HV (47 ÷ 52 HRC) Type GL 570 ÷ 650 HV (54 ÷ 58 HRC) Type GH > 840 HV (> 65 HRC)
Bulk Density:	> 7 Kg / dm^3
Chemical composition:	C 0,80 ÷ 1,2 Mn 0,35 ÷ 1,2% Si ≥ 0,40% S ≤ 0,05% P ≤ 0,05%
Microstructure:	uniform martensite

Lecco, 09.01.14

Techma Srl

Via alla Spiaggia, 19 I – 23900 LECCO
Tel +39 0341 288035 Fax +39 0341 220347
www.techmasrl.com info@techmasrl.com

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						
		2	07/11/24	I.S.	A.M.	A.M	**14** of
		1	25/10/24	I.S.	A.M.	A.M	
Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	**40**
		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

TECHMA

Technical data sheet
White Alumina Oxide

Description:	White Alumina Oxide			
Form:	angular			
Size and symbols:	BB16	1,18	÷ 1,4 mm	(1230 micron)
	BB20	1,0	÷ 1,18 mm	(1040 micron)
	BB24	0,71	÷ 0,85 mm	(745 micron)
	BB30	0,60	÷ 0,71 mm	(625 micron)
	BB36	0,50	÷ 0,60 mm	(525 micron)
	BB40	0,425	÷ 0,50 mm	(438 micron)
	BB46	0,355	÷ 0,425 mm	(370 micron)
	BB60	0,25	÷ 0,30 mm	(260 micron)
	BB80	0,18	÷ 0,212 mm	(185 micron)
	BB100	0,125	÷ 0,15 mm	(129 micron)
	BB120	0,106	÷ 0,125 mm	(109 micron)
	BB150	0,075	÷ 0,106 mm	(82 micron)
	BB180	0,053	÷ 0,09 mm	(69 micron)
	BB220	0,045	÷ 0,075 mm	(58 micron)
Hardness:	2050 kN/mm^2			
Specific gravity:	3,98 g/cm^3			
Bulk density:	1,61 Kg/dm^3			
Chemical analysis:	Al_2O_3	> 99%		
	TiO_2	≈0,006%		
	SiO_2	≈0,023%		
	Fe_2O_3	≈0,035%		
	CaO	≈0,01%		
	Na_2O	≈0,15%		

Lecco, 11.02.2014

Techma Srl

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Product Data Sheet

HEMPEL
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Hempadur 15553

Product characteristics

Description
Hempadur 15553 is a two-component epoxy paint. It cures to a flexible, well adhering coating with good abrasion and impact resistance. Contains zinc phosphate. Cures down to -10°C/14°F. Complies with EU Directive 2004/42/EC, The Paints Directive on the limitation of volatile organic compounds: subcategory j.

Recommended use
Hempadur 15553 is recommended as a primer for systems on hot dipped galvanized steel, aluminium, mild steel and stainless steel surfaces in moderately to severely corrosive environments. Hempadur 15553 is also suited in moderate corrosive environments when roughening of the surface is not possible. Please see surface preparation overleaf.

Service temperature:
- Maximum, dry exposure only: 140°C [284°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.
- Complies with the European Fire Standard EN 13501-1, reaction to fire classification, when used as part of a predefined paint system. B-s1, d0.

Product safety

Flash point 30°C [86°F]

VOC content mixed product

Legislation	Value	5% thinning, by volume	Limit value, phase II (2010)*
EU	388 g/L [3.24 lb/US gal]	411 g/L [3.43 lb/US gal]	500 g/L [4.17 lb/US gal]
US (coatings)	388 g/L [3.24 lb/US gal]	-	-
US (regulatory)	388 g/L [3.24 lb/US gal]	-	-
China	388 g/L [3.24 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. *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
15553

Product components
Base 15557
Curing Agent 98021

Standard shade* / code
Pebble Grey 11320

Gloss
Flat

Volume solids
55 ± 2%

* Other shades are available, please contact your local Hempel representative.

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		1	25/10/24	I.S.	A.M.	A.M	
Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	40
		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

Product Data Sheet

HEMPEL
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Hempadur 15553

Specific gravity
1.5 kg/L [13 lb/US gal]

Reference dry film thickness
50 micron [2.0 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).
- Stainless steel, aluminium and other non ferric metals and alloys: use non-metallic blast media (corundum, garnet, etc.). Sweep blasting to a uniform dense sharp profile, without blank spots.
- Remove dust, blast media and loose materials.
- In some cases, roughening of the surface is not required for galvanized and stainless steel. Consult Hempel for advice.

Maintenance and Repair
- Abrasive blasting to min. Sa 2 (ISO 8501-1) / SP 6 (SSPC).
- Stainless steel, aluminium and other non ferric metals and alloys: use non-metallic blast media (corundum, garnet, etc.). Sweep blasting to a uniform dense sharp profile, without blank spots.
- Feather edges to sound surrounding coating.
- Remove dust, blast media and loose materials.
- In some cases, roughening of the surface is not required for galvanized and stainless steel. Consult Hempel for advice.

Roughness
- Surface profile Medium (G) (ISO 8503-2).

Consult Hempel's separate Surface Preparation Guidelines for more details.

Application

Mixing ratio
Base 15557 : Curing Agent 98021
(3 : 1 by volume)

Stir well before use.

Thinner
Hempel's Thinner 08450

Cleaner
Hempel's Tool Cleaner 99610

Pot life

Product temperature	20°C [68°F]
Pot life	2 hours

Application method

Tool	Thinning max vol.	Application parameters
Airless spray	5%	Nozzle pressure: 175 bar [2500 psi] Nozzle orifice: 0.017-0.019"

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	50 micron [2.0 mils]	80 micron [3.1 mils]	50 micron [2.0 mils]
Wet film thickness	90 micron [3.5 mils]	150 micron [6 mils]	90 micron [3.5 mils]
Theoretical spreading rate	11 m²/L [450 sq ft/US gal]	6.9 m²/L [280 sq ft/US gal]	11 m²/L [450 sq ft/US gal]

For best performance, avoid excessive film thickness.

Product Data Sheet

HEMPEL
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Hempadur 15553

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.
- Optimal paint temperature for proper mixing, pumping and spraying is: 15-25°C [59-77°F].

Application remarks
- Flash-coat technique is recommended when overcoating porous substrates.

Drying and overcoating

Product compatibility
- Previous coat: None.
- Subsequent coat: According to Hempel's Specification. Recommended products are: Hempadur, Hempathane, Hempatex

Drying time

Surface temperature		20°C [68°F]
Touch dry	min	18
Hard dry	min	90
Fully cured	days	7

Determined for dry film thickness 50 micron [2.0 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 [14°F]	0°C [32°F]	20°C [68°F]
Atmospheric medium				
Hempadur 15553	Min	27 h	14 h	3 h
	Max	Ext*	Ext	Ext
Hempathane HS 55610	Min	27 h	14 h	3 h
	Max	90 d	45 d	10 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.

Other remarks
- Epoxy coatings have an inherent tendency of chalking, fading and discolouring. This does not affect the performance of the coating
- Hempel's Specification supersedes any recommendations given in the Product Data Sheets.

Storage

Shelf life

Ambient temperature	25°C [77°F]	35°C [95°F]
Base	9 months	9 months
Curing Agent	36 months	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.

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Product Data Sheet

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Hempadur 15553

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.
- General Application Guidelines

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.

Hempel shall not be liable for defects where the application of the Product has not been made fully in accordance with the recommendations and requirements set out in the relevant PDS and the Additional Documents. The information and terms of this disclaimer apply to this PDS, the Additional documents and any other documents supplied by Hempel in respect of the Product. In addition, the Product is supplied and all technical assistance is given subject to Hempel's General Conditions of Sale, Delivery and Service, unless otherwise expressly agreed in writing.

Product Data Sheet

HEMPEL
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Hempadur 15570

Product characteristics

Description
Hempadur 15570 is a two component, polyamide-adduct cured epoxy paint, which cures to a strong and highly corrosion resistant coating, at temperatures down to -10°C/14°F. The Micaceous Iron Oxide pigmented reddish grey 12430 shade is also well suited for application under humid conditions, on damp steel surfaces, and may be applied on moist surfaces. The greyish yellow 21780 and the grey 11320 shades contains zinc phosphate.
Complies with EU Directive 2004/42/EC, The Paints Directive on the limitation of volatile organic compounds: subcategory j.

Recommended use
As a maintenance and repair primer, intermediate, and/or finishing coat in Hempadur systems in severely corrosive environment. As a finishing coat where a cosmetic appearance is of less importance. As a low temperature curing epoxy primer, intermediate, and/or finishing coat in paint systems according to specification. Well suited as a (blast) primer in epoxy systems.
Mist coat on Galvosil.

Service temperature:
- Maximum, dry exposure only: 140°C [284°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.
- Complies with the European Fire Standard EN 13501-1, reaction to fire classification, when used as part of a predefined paint system. B-s1, d0.

Product safety

Flash point 25°C [77°F]

VOC content mixed product

Legislation	Value	15% thinning, by volume	Limit value, phase II (2010)[a]
EU	412 g/L [3.44 lb/US gal]	478 g/L [3.99 lb/US gal]	500 g/L [4.17 lb/US gal]
US (coatings)	412 g/L [3.44 lb/US gal]	-	-
US (regulatory)	412 g/L [3.44 lb/US gal]	-	-
China	412 g/L [3.44 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.

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
15570

Product components
Base 15579
Curing agent 95570

Standard shade* / code
Brownish red 50630

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						20 of 40
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Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	
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Product Data Sheet

HEMPEL
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Hempadur 15570

Specific gravity
1.3 kg/L [11 lb/US gal]

Reference dry film thickness
100 micron [3.9 mils]

Micaceous iron oxide (MIO) shade / code
Metallic grey 12430

Gloss
Flat

Volume solids
54 ± 2%

Specific gravity
1.4 kg/L [12 lb/US gal]

Reference dry film thickness
100 micron [3.9 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.
- All damage of shopprimer and contamination from storage and fabrication should be thoroughly mechanically/chemically cleaned prior to final painting.

New build:
- Abrasive blasting to min. Sa 2½ (ISO 8501-1) / SP 10 (SSPC).
- Remove dust, blast media and loose materials.

Maintenance and Repair
- Remove dust, blast media and loose materials.
- Flash rust degree of maximum FR M (ISO 8501-4).
- Spot abrasive blasting to min. PSa 2 (ISO 8501-2) / SP 6 (SSPC).
- Water jetting to min. Wa 2 (ISO 8501-4).
- Minor areas can be cleaned by power tool to St 3 provided the surface is roughened and not polished.

Roughness
- Surface profile Medium (G) (ISO 8503-2).

Consult Hempel's separate Surface Preparation Guidelines for more details.

Application

Mixing ratio
Base 15579 : Curing agent 95570
(3 : 1 by volume)

Stir well before use.

Thinner
Hempel's Thinner 08450

Cleaner
Hempel's Tool Cleaner 99610

Pot life

Product temperature	20°C [68°F]
Pot life	2 hours

Application method

Tool	Thinning max vol.	Application parameters
Airless spray	5%	Nozzle pressure: 175 bar [2500 psi] Nozzle orifice: 0.019-0.021"
Air spray	15%	Not Applicable.
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].

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		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

Product Data Sheet

HEMPEL
Trust is earned

Hempadur 15570

Film thickness

Specification range	Low	High	Recommended
Dry film thickness	50 micron [2.0 mils]	125 micron [4.9 mils]	100 micron [3.9 mils]
Wet film thickness	90 micron [3.5 mils]	230 micron [9 mils]	190 micron [7 mils]
Theoretical spreading rate	11 m²/L [450 sq ft/US gal]	4.3 m²/L [180 sq ft/US gal]	5.4 m²/L [220 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
- 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.
- Temperature of product must be above 15°C [59°F] during application.

Relative Humidity:
- Relative humidity must be below 85% during application.
- Relative humidity must be below 85% during curing.

Drying and overcoating

Product compatibility
- Previous coat: None or according to Hempel's specification.
- Subsequent coat: According to Hempel's Specification. Recommended products are: Hempadur, Hempathane, Hempatex

Drying time

Surface temperature		20°C [68°F]
Touch dry	min	60
Hard dry	hours	5
Fully cured	days	7

Determined for dry film thickness 100 micron [3.9 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		20°C [68°F]
Atmospheric medium		
Hempadur 15570	Min Max	4 h Ext
Hempathane HS 55610	Min Max	4 h Ext
Hempatex Enamel 56360	Min Max	120 min 8 h
Immersion		
Hempadur 15570	Min Max	8 h 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.

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.

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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Product Data Sheet

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Hempadur 15570

Storage

Shelf life

Ambient temperature	25°C [77°F]	35°C [95°F]
Base	36 months	24 months
Curing agent	36 months	24 months

Shelf life from date of production, when stored in original, unopened containers. Thereafter, the product quality must be re-inspected. Always check the best before date or expiry date on the label.

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.

Additional documents

Additional information is available at the Hempel website hempel.com or at your local Hempel website:

- Explanatory Notes explaining the fields in this Product Data Sheet.
- Surface Preparation Guidelines.
- Application Guidelines for different application methods.
- General Application Guidelines

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

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Hempel shall not be liable for defects where the application of the Product has not been made fully in accordance with the recommendations and requirements set out in the relevant PDS and the Additional Documents. The information and terms of this disclaimer apply to this PDS, the Additional documents and any other documents supplied by Hempel in respect of the Product. In addition, the Product is supplied and all technical assistance is given subject to Hempel's General Conditions of Sale, Delivery and Service, unless otherwise expressly agreed in writing.

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Product Data Sheet

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Hempaprime Multi 500

Product characteristics

Description
Hempaprime Multi 500 is a fast drying, high solids epoxy paint. It provides hard wearing and long lasting barrier protection in coating systems for severe corrosive environments. The product meets the requirements of ISO 12944 Part 5, 2019 when used as part of a predefined paint system.

Recommended use
Hempaprime Multi 500 is recommended as a high-build, intermediate coat in high performance coating systems where fast handling and short overcoating times are required. Due to its fast drying - up to twice as fast as comparable products - the product is excellent for projects where fast throughput is key. The product can also be used as a self-priming, surface tolerant coat and a finishing coat in heavy-duty coating systems. Suited for application down to 10°C [50°F]. The product is available in several MIO shades such as 18021 and 18061; both with 80% MIO content. The volume solids % for MIO shades is 82 ± 2.

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, Im2; Part 9, CX.
- 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
- Fast overcoating.
- Crack resistant in high film thickness.
- Low VOC.
- Ready to use - optimised application properties.
- Surface tolerant.

Product safety

Flash point 25°C [77°F]

VOC content mixed product

Legislation	Value
EU	196 g/L [1.64 lb/US gal]
US (coatings)	196 g/L [1.64 lb/US gal]
US (regulatory)	196 g/L [1.64 lb/US gal]
China	196 g/L [1.64 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
45950

Product components
Base 45959
Curing Agent 95090

Standard shade / code
Brownish red 50630 *

Wide range of colours is available via Hempel's tinting system.

Gloss
Semi-gloss

* Slight discolouration may occur. This does not affect the performance of the coating.

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Product Data Sheet

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Hempaprime Multi 500

Volume solids
85 ± 2%

Specific gravity
1.4 kg/L [12 lb/US gal]

Reference dry film thickness
150 micron [6.0 mils]

Aluminium shade / code
Aluminium grey 19002

Gloss
Please consult Hempel's Guideline on aluminium pigmented coatings.

Volume solids
78 ± 2%

Specific gravity
1.3 kg/L [11 lb/US gal]

Reference dry film thickness
150 micron [6.0 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).
- Stainless steel, aluminium and other non ferric metals and alloys: use non-metallic blast media (corundum, garnet, etc.). Sweep blasting to a uniform dense sharp profile, without blank spots.
- Remove dust, blast media and loose materials.

Maintenance and Repair
- Spot abrasive blasting to min. PSa 2 (ISO 8501-2) / SP 6 (SSPC).
- Minor areas may be hand or power tool cleaned instead of abrasive blasting.
- Water jetting to min. Wa 2 (ISO 8501-4).
- Flash rust degree of maximum FR M (ISO 8501-4).
- Stainless steel, aluminium and other non ferric metals and alloys: use non-metallic blast media (corundum, garnet, etc.). Sweep blasting to a uniform dense sharp profile, without blank spots.
- Feather edges to sound surrounding coating.
- 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 45959 : Curing Agent 95090
(4 : 1 by volume)

Stir well before use.

Thinner
Hempel's Thinner 08450

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Product Data Sheet

Hempaprime Multi 500

Cleaner
Hempel's Tool Cleaner 99610
Hempel's Thinner 08450

Pot life

Product temperature	10°C [50°F]	20°C [68°F]	30°C [86°F]	40°C [104°F]
Pot life	2½ hours	1 hour	¾ hours	½ hours
Pot life (brush)	-	60 min	-	-

Application method

Tool	Thinning max vol.	Application parameters
Airless spray	5%	Nozzle pressure: 225 bar [3300 psi] Nozzle orifice: 0.019-0.023"
Brush/Roller	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	118 micron [4.7 mils]	295 micron [12 mils]	177 micron [7.1 mils]
Theoretical spreading rate	8.5 m²/L [346 sq ft/US gal]	3.4 m²/L [139 sq ft/US gal]	5.6 m²/L [228 sq ft/US gal]

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. For best performance, avoid excessive film thickness.

Application conditions
- Optimal paint temperature for proper mixing, pumping and spraying is: 20°C [68°F].
- 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 [50°F] during application and curing.

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.
- Metallised surfaces should be overcoated before exposure to open air conditions.
- Flash-coat technique is recommended when overcoating porous substrates.

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, Hempaprime, Hempathane

Drying time

Surface temperature		10°C [50°F]	20°C [68°F]	30°C [86°F]	40°C [104°F]
Touch dry	hours	2½	1	⅔	⅓
Surface dry	hours	5½	2½	1	½
Hard dry	hours	8	3½	1½	¾
Fully cured	days	-	7	-	-

Determined for dry film thickness 150 micron [6.0 mils] at standard conditions, see Hempel's Explanatory Notes for details.

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Product Data Sheet

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Hempaprime Multi 500

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					
Hempaprime Multi 500	Min	7 h	3 h	2 h	90 min
	Max	Ext*	Ext	Ext	Ext
Hempathane HS 55610	Min	7 h	3 h	2 h	90 min
	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.
- According to Hempel's Specification.

Overcoating details

- If the maximum overcoating interval is exceeded, roughening of the surface is necessary to ensure intercoat adhesion.
- 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.

Storage

Shelf life

Ambient temperature	25°C [77°F]
Base	24 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.

Carbon Footprint

Dry film thickness	1 µm	1 mil
GWP (Global Warming Potential)	5.5 g CO_2e/m^2	0.028 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.

Product Data Sheet

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Hempaprime Multi 500

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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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

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Product Data Sheet

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Hempel's Pro Acrylic

Product characteristics

Description
Hempel's Pro Acrylic 55883 is a two-component, isocyanate-free, acrylic finishing coat with good gloss and colour retention. It is resistant to water and spillage of aliphatic hydrocarbons.
Minimum curing temperature is 0°C/32°F.

Recommended use
Hempel's Pro Acrylic is recommended as a finishing coat for protection of structural steel in severely corrosive environment, where light-fastness and gloss retention are required.
The product may be specified as a one-coat direct-to-metal system in corrosive environments classified as C2 and C3.

Service temperature:
- Maximum, dry exposure only: 120°C [248°F].

Certificates / Approvals
- Meets requirements to NORSOK M-501 when used as part of a predefined paint system. Edition 6, System 1.

Product safety

Flash point 32°C [90°F]

VOC content mixed product

Legislation	Value
EU	362 g/L [3.02 lb/US gal]
US (coatings)	432 g/L [3.61 lb/US gal]
US (regulatory)	432 g/L [3.61 lb/US gal]
China	432 g/L [3.61 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
55883

Product components
Base 55889
Curing Agent 97883

Standard shade* / code
White 10000 **

Gloss
Glossy

Volume solids
58 ± 2%

Specific gravity
1.3 kg/L [11 lb/US gal]

Reference dry film thickness
50 micron [2.0 mils]

Aluminium shade* / code**
Aluminium grey 19000 ****

Gloss
Please consult Hempel's Guideline on aluminium pigmented coatings.

* Wide range of colours is available via Hempel's Multi-Tinting system.
** Colour stability may be affected by exposure to chemicals, elevated temperatures, low light conditions and/ or inadequate ventilation.
*** Other shades are available, please contact your local Hempel representative.
**** Appearance of the aluminium pigmented coats will depend on application method, drying conditions, handling etc. Please see the Guideline on Aluminium pigmented coatings at hempel.com or at your local Hempel website.

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Product Data Sheet

HEMPEL
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Hempel's Pro Acrylic

Volume solids
52 ± 2%

Specific gravity
1.1 kg/L [9 lb/US gal]

Reference dry film thickness
50 micron [2.0 mils]

Surface preparation

Cleanliness
- According to Hempel's Specification.

Consult Hempel's separate Surface Preparation Guidelines for more details.

Application

Mixing ratio
Base 55889 : Curing Agent 97883
(7 : 1 by volume)

Stir well before use.

Thinner
Hempel's Thinner 08450

Cleaner
Hempel's Thinner 08450

Pot life

Product temperature	20°C [68°F]
Pot life	4 hours

Application method

Tool	Thinning max vol.	Application parameters
Airless spray	5%	Nozzle pressure: 150 bar [2200 psi] Nozzle orifice: 0.017-0.019"

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	50 micron [2.0 mils]	120 micron [4.7 mils]	50 micron [2.0 mils]
Wet film thickness	90 micron [3.5 mils]	210 micron [8 mils]	90 micron [3.5 mils]
Theoretical spreading rate	12 m²/L [490 sq ft/US gal]	4.8 m²/L [200 sq ft/US gal]	12 m²/L [490 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 0°C [32°F] during application and curing.

Application remarks
- Two coats of the topcoat may be necessary to obtain full hiding power.

Drying and overcoating

Product compatibility
- Previous coat: According to Hempel's Specification. Recommended products are: Hempadur Mastic 4588W, Hempadur 45141/45143
- Subsequent coat: None.

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Hempel's Pro Acrylic

Drying time

Surface temperature		20°C [68°F]
Surface dry	hours	4½
Hard dry	hours	10
Fully cured	days	7

Determined for dry film thickness 50 micron [2.0 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		0°C [32°F]	10°C [50°F]	20°C [68°F]
Atmospheric medium				
Hempel's Pro Acrylic	Min	18 h	9 h	6 h
	Max	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.

Storage

Shelf life

Ambient temperature	25°C [77°F]
Base	36 months
Curing Agent	18 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

- 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)	11.4 g CO_2e/m^2	0.059 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.

Product Data Sheet

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Hempel's Pro Acrylic

Additional documents

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https://www.hempel.com/service-and-support/technical-guidelines
or at your local Hempel website:

- Explanatory Notes for Product Data Sheet.
- Application methods.
- General Application Guidelines

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Product Data Sheet

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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)*
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. *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

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						33 of 40
		2	07/11/24	I.S.	A.M.	A.M	
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Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	
		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

Product Data Sheet

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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.

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						34 of 40
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		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

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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.

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						35 of 40
		2	07/11/24	I.S.	A.M.	A.M	
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Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	
		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

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.

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.

Hempel shall not be liable for defects where the application of the Product has not been made fully in accordance with the recommendations and requirements set out in the relevant PDS and the Additional Documents. The information and terms of this disclaimer apply to this PDS, the Additional documents and any other documents supplied by Hempel in respect of the Product. In addition, the Product is supplied and all technical assistance is given subject to Hempel's General Conditions of Sale, Delivery and Service, unless otherwise expressly agreed in writing.

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		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

Product Data Sheet

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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)*
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. *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%

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						
		2	07/11/24	I.S.	A.M.	A.M	37 of
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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 continuously stirred during application. This is especially important in case of heavy thinning.

Thinner
Below 20°C [68°F] Hempel's Thinner 08960
Above 20°C [68°F] Hempel's Thinner 08450

Cleaner
Hempel's Tool Cleaner 99610

Pot life

Product temperature	0°C [32°F]	0°C [32°F]	20°C [68°F]
Pot life	5 hours	5 hours	4 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	62 micron [2.5 mils]	154 micron [6.2 mils]	92 micron [3.7 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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		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

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.

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						39 of 40
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Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	
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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.

Hempel shall not be liable for defects where the application of the Product has not been made fully in accordance with the recommendations and requirements set out in the relevant PDS and the Additional Documents. The information and terms of this disclaimer apply to this PDS, the Additional documents and any other documents supplied by Hempel in respect of the Product. In addition, the Product is supplied and all technical assistance is given subject to Hempel's General Conditions of Sale, Delivery and Service, unless otherwise expressly agreed in writing.

Unoprima Customer: TICI	Final customer: ROSETTI MARINO						
		2	07/11/24	I.S.	A.M.	A.M	40 of
		1	25/10/24	I.S.	A.M.	A.M	
Customer Job: 393	Project: HOLLANDESE KUST	0	26/09/24	I.S.	A.M.	A.M	40
		REV.	ISSUE DATE	PREPARED BY	CHECKED BY	APPROVED BY	

1.4.5 Packing, Shipping handling and Storage procedures

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

PACKING, SHIPPING HANDLING AND STORAGE PROCEDURES
HYDROGEN VENT

Document Number: 1724000887-QC-PRO-00018

Document Class: 3

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
M. Bl	13/11/2024

02	12/11/2024	Issue for Information (IFI)	SB	RV	ADL
01	25/10/2024	Issue for Information (IFI)	SB	RV	ADL
00	19/09/2024	Issue for Information (IFI)	SB	RV	ADL
Rev.	Date	Description	Prepared	Reviewed	Approved

THERMO ENGINEERING AN ENCORE COMBUSTION COMPANY

THERMO ENGINEERING ADVANCED COMBUSTION SYSTEMS

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Revision / Change Log

Rev.	Description
00	Issue for Information (IFI)
01	Issue for Information (IFI)
02	Issue for Information (IFI)

HOLDS LIST

No.	Description
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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.

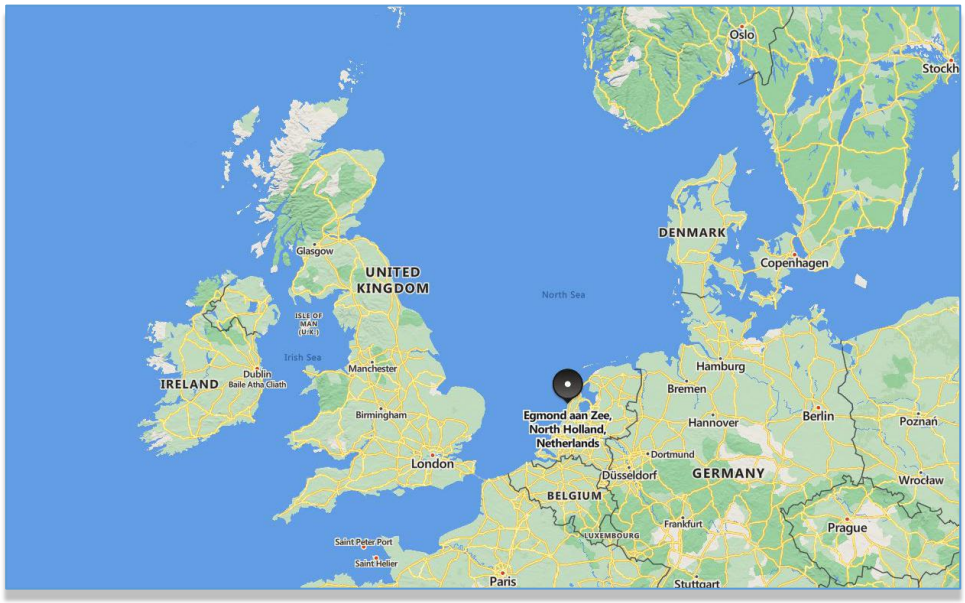


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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 located on coordinates E 590719.1, N 5841602.3 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.

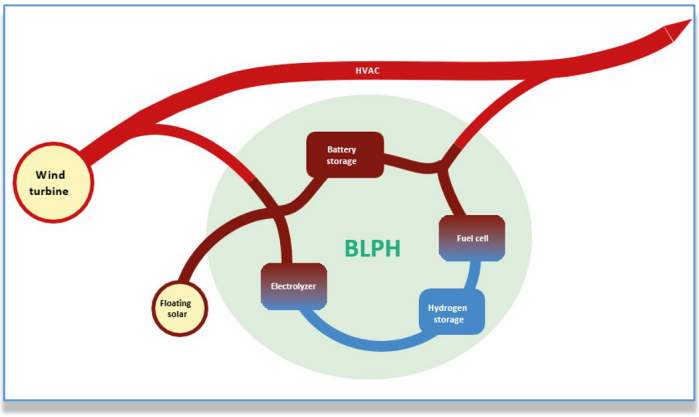


Figure 3 – BLPH Concept

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 s 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

This Document describe in detail the packing, shipping and storage specifications to be followed during the project execution.

2.1 REFERENCES

See chapter 3.3

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	CROSSWIND
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Table 1 - Definitions and Abbreviations

3 INTRODUCTION

This specification provides an exhaustive and complete general information concerning the packing of industrial equipment and parts composing the supplies produced by Encore Thermoengineering S.r.l. Main purpose of packing is to ensure content to reach the final destination in condition of perfect integrity and efficiency.

In particular, packages must be suitable for:

- Allow their lifting, handling and transportation in safe conditions for the encharged persons;
- Neutralize on packages content all effects deriving from the expectable mechanical, chemical and environmental actions during their handling, transportation and storage, including heavy rain, thermal excursions, , high humidity, sprays of spruzzi di saltiness, sand and dust, as well as long stay on ship decks, barges and transit areas.

3.1 ADDRESSEES

Addressees of the specification contained in the present document are:

- Packing Companies (directly encharged by Encore Thermoengineering S.r.l.);
- Sub-vendors (if encharged by Encore Thermoengineering S.r.l. to deliver items already packed);
- Clients of Encore Thermoengineering S.r.l.

Subvendors, if encharged by Encore Thermoengineering S.r.l. to deliver items already packed, are also, towards Encore Thermoengineering srl, suppliers of the package.

3.2 RESPONSIBILITY OF PACKING SUPPLIER

Packing supplier is responsible for:

- Timely notification of eventual damages to goods detected when taking them in charge or by himself accidentally caused;
- Integrity and conservation of the goods delivered to him;
- Their correct handling;
- Compliance of packings with applicable General and Particular specifications;
- Suitable use of protections (barrier bag, dehydrating salts, etc.);
- Necessary measures to avoid undesired intrusion inside the packages or leak of their content;
- Proper excution of the package, its structural suitability, as well as of the storage of woodden materials and relevant accessories;
- **Conformity of packages to the selected shipping mode (road / sea etc.) including compliance with particular requirements in force in the destination contry of the goods**

If package is to be prepared at a subvendor workshop, subvendors is normally responsible for handling and transportation activity necessary to allow the packing activity.

As a general rule goods to be packed must be stored indoor, in protected areas from atmospheric agents and served by suitable lifting and transportation means.

All possible precautions must be adopted to avoid thefts.

Encore Thermoengineering srl reserves the right to evaluate and approve goods partition between the various package sas well as the foreseen type of package.

In his proposal subvendor can offer alternate solutions to the present specifications if considered, based on his experience more efficient or economical. This alternate proposals must be in anycase approved in writing by Encore Thermoengineering srl.

3.3 REFERENCE CODES

The present document constitutes a guideline for the preparation of the suitable package, but the indication herein contained do not release packing supplier from the correct structual and protection design (sections of beams and frames, type and quantity of anticorrosion products etc.): in fact said design needs to be carried out case by case. Therefore the compliance with the present specification is for packing supplier necessary but not sufficient to grant a safe and suitable packing as far as his responsibility is concerned.

For further and more detailed technical specifications (in particular for design of structural elements), please refer to following norms:

- UNI 10858 – special wooden packages for content between 300 and 10000 kg and maximum dimensions (600 x 250 x 250) cm;
- UNI 9151 - wooden packages for content over 300 kg.
- HPE (Holzpackmittel Paletten Exportverpackung) - PACKAGING GUIDELINES
- DIN 4074 – wooden materials
- CSA0151 / MI978 / DIN 68705 – phenolic plywood elements
- MIL-B131-F – barrier bags
- MIL-D-3464-D AMERICAN STANDARD / DIN 55473 – silicagel
- ISPM 15 – antiparasitic treatments
- IMCO – hazardous goods transportation

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4 SELECTION OF PACKING TYPE

Generally, packages are made of:

- One rigid container or support (i.e. case cage /platform)
- Flexible accessory protections (like polythene/ barrier bag/ anticorrosion oils etc.).

Here below are described selection criteria for packing type, rigid and flexible. With a reasonable choice of the packing type, as well as its correct design, the material optimization can be pursued, together with the maxium possible safetyfor the delivery of the goods at the final destination.

4.1 SELECTION CRITERIA

The type of packing and protection are selected based on the following information:

1 Nature of the contained goods

2 Selected transportation mode

3 Storage duration and conditions

4 Eventual particular requirements

4.2 PRODUCTS

For shipment, equiment supplied by Encore Thermoengineering srl are normally grouped as follows:

- Machinery and equipment (fans, ignition skids, bottles skid, winches, dampers etc.)
- Piping (or piping elements: pipes, flanges, valves, fittings etc.)
- Instrumentation (like pressure/temperature gauges, thermocouples, legel gauges etc.)
- Electrical items (motors, boards, cables, computer, monitor, printers etc.)
- Refractories (bricks etc)
- Insulating materials (insulating panels).
- Steelworks (ladders and stairs, walkways, templates, frames, davit, tip, riser, KO drum and water seal, air ducts, profiled steel bars, stud bolts, supports etc.)

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4.2.1 Shipping mode

Shipping mode is determined by destination place and packages size. In general the choice is between 4 differente shipping modes

Road (trucking) Railway(rail) Seafreight Airfreight



There are the following possible cases:

- Packing is the shipment unit;
- Packing is into a container;
- (unfrequently) goods are shipped loose (without packing).

For Encore Thermoengineering srl projects normal selection is for seafreight (direct packing or containerised) whilts arirfreight is used mainly for partial shipment (like single items or spares ecc.) o urgent parts.

In any case, shipping mode selection is on Encore Thermoengineering srl that informs packing supplier accordingly.

Shipping mode contributes in the selction of the packing type.

4.2.2 Storage

Information about duration and conditions of the evntual storage period are very useful to select, beyond the main packing type, the most suitable protections (like barrier bags, coatings, anticorrosion oils, etc.).

4.2.3 Special requirements

In the packing type definition it is necessary to consider all the possible special requirements available like for instance:

- Size constraints or limitation for the packages,
- Special requirements of stackability[1-2],
- Number of transhipments,
- Availability of one way containers[3] ecc.

that may influence both the selction of packing and internal protectioN

1. Capacity to support a distributed load on the sides
2. Capacity to support a distributed load on the cover.

container "one way" require generally a limited handling of the goods and this allows to prepare less expensive packings.

4.2.4 Rigid packing – selection table

The following table guide to rigid packing selection based on content, shipping mode and storage information.

MACHINERY AND EQUIPMENT

Seafreight/railway (container)	Case – cage – platform - loose
Road	Case – cage – platform - loose
Airfreight	Case

PIPING

Seafreight/railway (container)	Cage – saddles – bundle - loose
Road	Cage – saddles – bundle
Airfreight	Cage

INSTRUMENTATION

Seafreight/railway (container)	Case
Road	Case - Cage
Airfreight	Case

ELECTRICAL ITEMS

Seafreight/railway (container)	Case
Road	Case - Cage
Airfreight	Case

REFRACTORIES

Seafreight/railway (container)	Cage - platform
Road	Cage - platform
Airfreight	Cage

INSULATING MATERIALS

Seafreight/railway (container)	Case
Road	Case

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Airfreight	Case

STEELWORKS

Seafreight/railway (container)	Cage – saddles – bundle - loose
Road	Cage – saddles – bundle
Airfreight	Cage

4.2.5 Rigid packing – execution versions

The following table lists the various versions of rigid packing, with the relavnt indication of applicability. In fact there is the possibility– for instance cases and cages – of different versions as far as execution or size are concerned (i.e cage small/ standard).

N	PACKING	CONSTRAINTS/SUITABLE FOR:
1	Cage, small, plywood/OSB	Volume upto 3m^3 Net weight upto 500 kg
2	Case, small, wood	Volume upto 3m3 Net weight upto 500 kg
3	Case, standard, plywood/ OSB	None
4	Cage, small	Volume upto 3m3 Net weight upto 500 kg
5	Cage, reduced	Maximum dimensions upto 800 x 250 x 250 cm Net weight upto 5.000 kg
6	Cage, standard	·None
7	Platform	Loose items
8	Saddle	Equipments or pipes. big diameter
9	Saddle on roller	·Equipments or pipes. big diameter * Frontal containerisation
10	Bundle	Grouped rigid parts (selfsupporting)

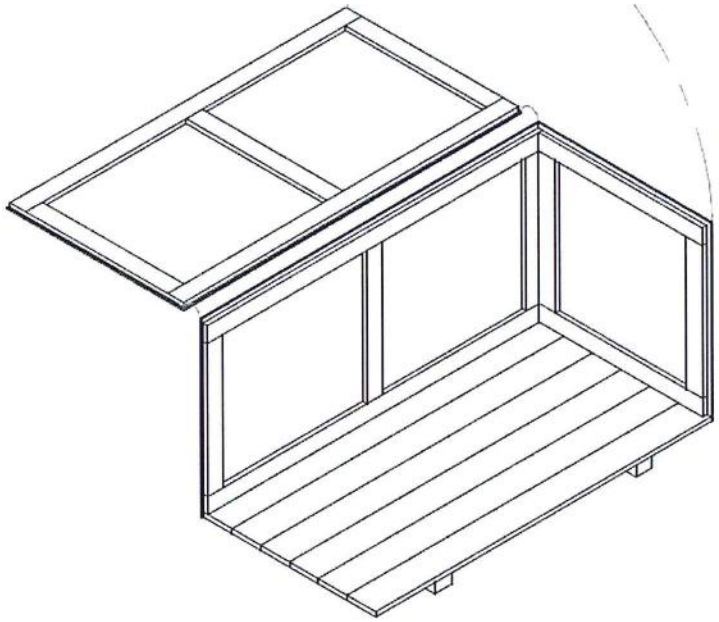
In the next chapter will be described in the detail the different execution versions for rigid packing.

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CONSTRUCTION SPECIFICATIONS

4.3 SMALL CASES, PLYWOOD/ OSB



Constraints:

- Volume upto 3 m3
- Netweight upto 500 kg

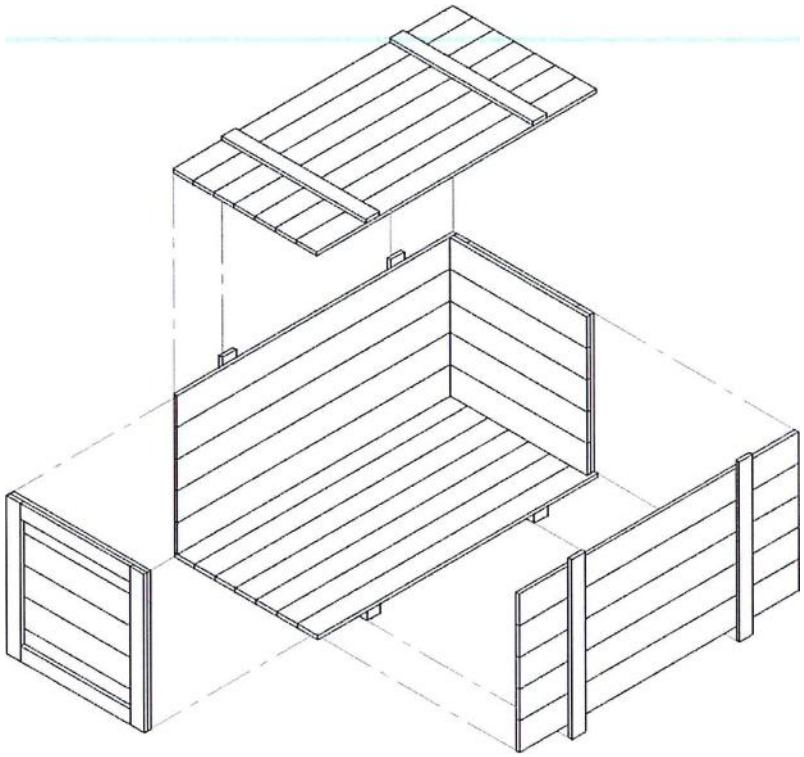
Suitable as main packing or as pre-packing (for instances small items or accessories) before stowing them in bigger packings. Due to lightness, are partcularly suitable for airfreight, the cost of which is essentially based on the weight.

Bottom is made by longitudinal juxtaposed beams, connected by rivetting to two or more transversal sub-beams; Sides and cover are made by an internal frameand by and external casing (see figure in the page). External casing is made by panels wood-based (phenolic plywood or OSB type3) juxtaposed

Cover is waterproofed by means of a poliethyliene film layer (minimum thickness 0,1 mm) put inbetween the frame and the casing. Bottom, on the contrary, must not be waterproofed so to allow and facilitate the drainage of evental liquids and or condensates.

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4.4 SMALL WOODEN CASES



Constraints:

- Volume upto 3 m3
- Netweight upto 500 kg

Suitable as main packing or as pre-packing (for instances small items or accessories) before stowing them in bigger packings. Especially for airfreight, is preferable to use Small cases, plywood/ OSB (see 3.1) so to reduce the overall weight of the packing and consequently the transportation cost.

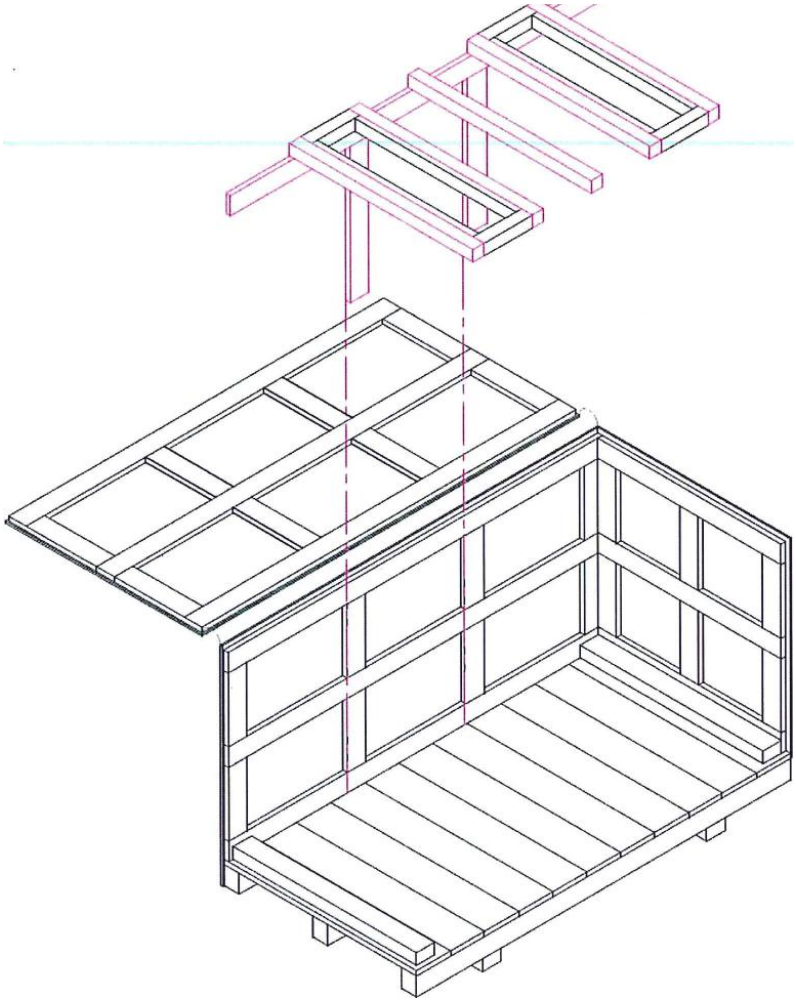
Bottom is made by longitudinal juxtaposed beams, connected by rivetting to two or more transversal sub-beams; Sides and cover are made by external transversal beams rivetted to an internal casing (see figure in the page) made by beams lingitudinally juxtaposed.

Cover is waterproofed by means of a poliethyliene film layer (minimum thickness 0,1 mm) put in between the frame and the casing. Waterproofing layers are only applied on the internal sides.Bottom, on the contrary, must not be waterproofed so to allow and facilitate the drainage of evental liquids and or condensates.

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4.5 STANDARD CASES, PLYWOOD/ OSB



Constraints:

- None

BOTTOM

Bottom is made by juxtaposed wooden beams, transversally fixed to two or more underneath longitudinal beams.

Under the longitudinal beams are installed adequate under-beams, longitudinal or transversal, and fixed to them by riveting. The under-beams, spacing the bottom from ground, allow the passage and the posizioning of the lifting ropes or forks.

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In necessary, the bottom is strenghtened through two transversal head-beams, fixed by riveting (maximum thickness upto 6 cm) or bolting (higher thicknesses).

Further possible elements of transversal reinforcement of the bottom are the dispatchers and the distributors of load: the dispatchers of load locally strengthen the base of the box in correspondence of the two lifting points; the distributors of load divide the load of support on the longitudinal beams.

The section of the possible dispatchers of load must be calculated considering the solicitation produced in the base during lifting.

SIDES AND COVER

The walls (sides and headings) and the cover are made by an inside framework and an external covering. The framework of the walls is made by horizontal transversal beams and vertical beams; the framework of the cover is made by longitudinal transversal beams and clips. The covering, both of the walls and of the cover, is made by juxtaposed panels, multilayer phenolic plywood or OSB type 3 (see figure in the previous page).

Inside the sides an auxiliary structure must be applied, composed by an upper horizontal transversal beam and from vertical beams; this structure has the purpose to strengthen the walls with the purpose to confer to the box a suitable stackability.

UNDERCOVER BEAMS AND REINFORCEMENTS ("TIES")

All cases must be provided with undercover beams, transversally installed, riveted to the sides and supported to the auxiliary structure. These structural elements play a double role:

- in collaboration with the cover and with the possible ties they bear the hold of the ropes during lifting ;
- they give to the box a suitable stackability and walkability;

If necessary finally the boxes must be equipped of additional structures in wood ("ties") suitable to bear the hold of the ropes during lifting.

Every tie consists in a frame inserted among two beams of undercover (see figure in the previous page).

WATERPROOFING

The cover is waterproofed through an intermediate layer of polyethilene film (minimum thickness 0,1 mm) between the frame and the covering. When, because of dimensions, the case cannot be

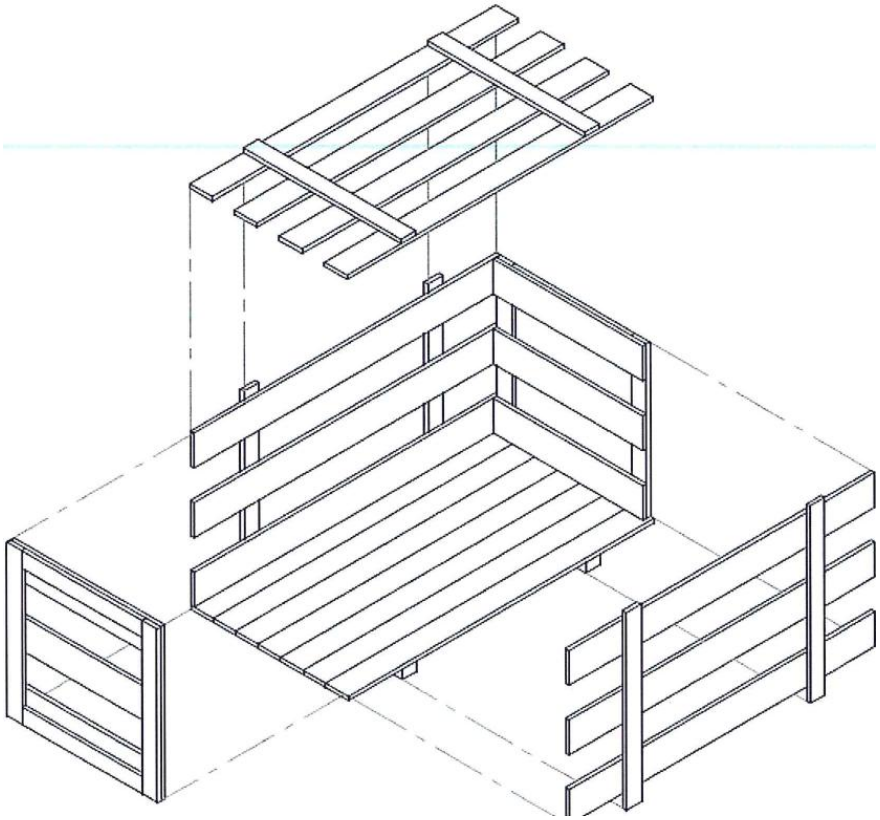
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protected against the atmospheric agents during the transportation,an additonal layer in COEX is to be added on the top side being COEX a waterproof material resistant to UV rays.

Same COEX additional layer is necessary when known the case to remain for long periods exposed to the atmosferic agentsbefore being unpacked.

Bottom, on the contrary, must not be waterproofed so to allow and facilitate the drainage of evental liquids and or condensates

4.6 CAGES



Constraints:

- Volume upto 3 m3
- Netweight upto 500 kg

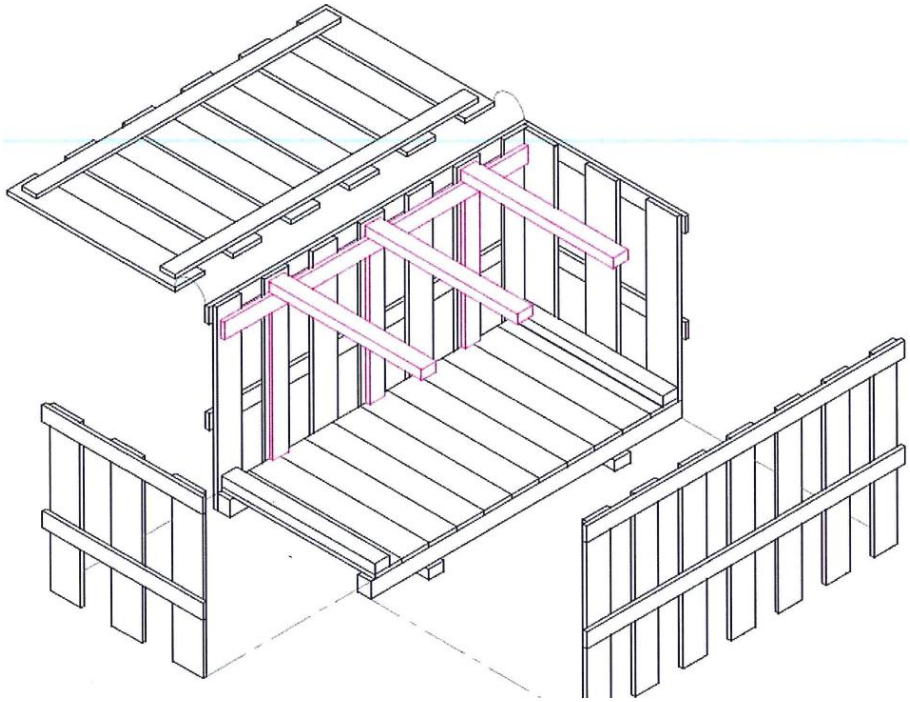
Bottom is made by longitudinal juxtaposed or spaced beams, connected by rivetting to two or more transversal sub-beams; Sides and cover are made by external beams riveted to an internal casing made by wooden beams installed longitudinally and spaced between them (see figure).

Beams of internal casing must generate a full surface not less than 33% of the total; when allowed by the nature of the content, also the bottom could be spaced (cage type) with a full surface not less than 50%.

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4.7 REDUCED CAGES



Constraints

- Maximum dimensions upto 800 x 250 x 250 cm
- Net weight upto 5.000 kg

BOTTOM

Bottom is made by longitudinal juxtaposed wooden beams, connected by rivetting to two or more transversal sub-beams; when allowed by the nature of the content, also the bottom could be spaced (cage type) with a full surface not less than 60% of the total.

Under the longitudinal beams are positioned some under-beams, transversal or longitudinal, fixed to the longitudinal beams through riveting. The under-beams, spacing the bottom from ground, allow the passage and the posizioning of the lifting ropes or forks.

The bottom is normally strengthened by two transversal head-beams riveted to the boards.

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Further possible transversal reinforcement elements for the bottom are the dispatchers and the distributors of load: the dispatchers of load locally strengthen the base of the cage in correspondence of the two lifting points; the distributors of load divide the load of support on the longitudinal beams.

SIDES AND COVER

The walls (sides and headings) and the cover are an inside covering made by wooden vertical beams spaced between them, and by external transversal connecting beams installed horizontally.

The covering is made by and external covering of transversally juxtaposed wooden beams , and by internal transversal connecting beams installed longitudinally.

Boards must have a constant width between 12 and 18 cm, they must have a full surface not less that 45% of the total

Inside the sides an auxiliary structure must be applied, composed by an upper horizontal transversal beam and from vertical beams; this structure has the purpose to strengthen the walls with the purpose to confer to the box a suitable stackability.

In case of stowing of loose parts with size less that the casing boards spacing, header must have full surface.

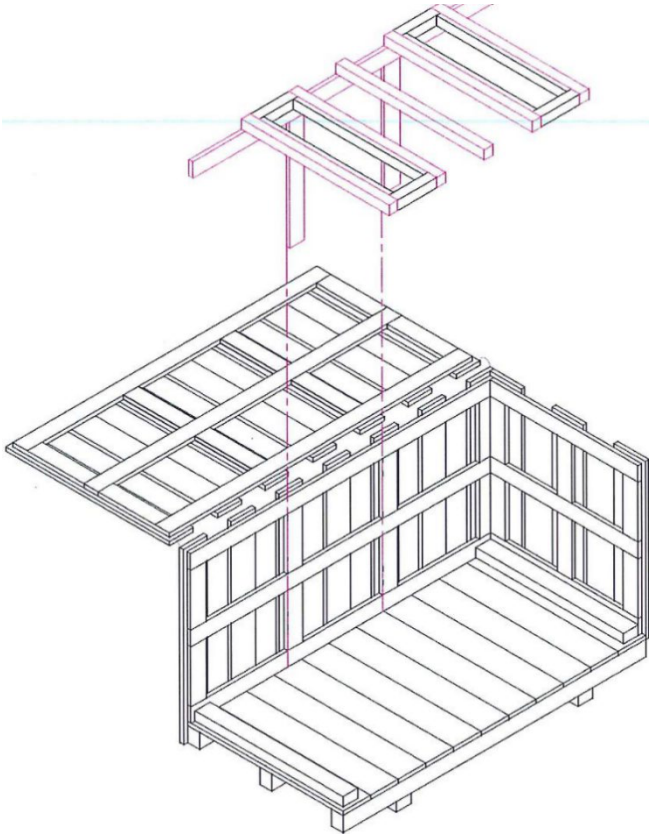
UNDERCOVER BEAMS

All cases must be provided with undercover beams, transversally installed, riveted to the top part of the sides and supported to the auxiliary structure. These structural elements play a double role:

- in collaboration with the cover and with the possible ties they bear the hold of the ropes during lifting ;
- they give to the box a suitable stackability and walkability;

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4.8 STANDARD CAGES



Constraints:

- None

BOTTOM

Bottom is made by longitudinal juxtaposed wooden beams, connected by rivetting to two or more transversal sub-beams; when allowed by the nature of the content, also the bottom could be spaced (cage type) with a full surface not less than 60% of the total.

Under the longitudinal beams are positioned some under-beams, transversal or longitudinal, fixed to the longitudinal beams through riveting. The under-beams, spacing the bottom from ground, allow the passage and the posizioning of the lifting ropes or forks.

The bottom is normally strengthened by two transversal head-beams riveted (maximum thickness 6 cm) or bolted (higher thicknesses) to the boards

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Further possible transversal reinforcement elements for the bottom are the dispatchers and the distributors of load: the dispatchers of load locally strengthen the base of the cage in correspondence of the two lifting points; the distributors of load divide the load of support on the longitudinal beams.

The section of the possible dispatchers of load must be calculated considering the solicitation produced in the base during lifting.

SIDES AND COVER

The walls (sides and headings) and the cover are made by The walls (sides and headings) and the cover are made by an inside framework and an external covering. The framework of the walls is made by horizontal transversal beams and vertical beams; the framework of the cover is made by longitudinal transversal beams and clips. The covering, both of the walls and of the cover, is made by spaced panels (see figure). Boards must have a constant width between 12 and 18 cm, they must have a full surface not less than 45% of the total

Inside the sides an auxiliary structure must be applied, composed by an upper horizontal transversal beam and from vertical beams; this structure has the purpose to strengthen the walls with the purpose to confer to the box a suitable stackability.

In case of stowing of loose parts with size less that the casing boards spacing, header must have full surface.

UNDERCOVER BEAMS AND REINFORCEMENTS ("TIES")

All cases must be provided with undercover beams, transversally installed, riveted to the top part of the sides and supported to the auxiliary structure. These structural elements play a double role:

· in collaboration with the cover and with the possible ties they bear the hold of the ropes during lifting ;

· they give to the box a suitable stackability and walkability;

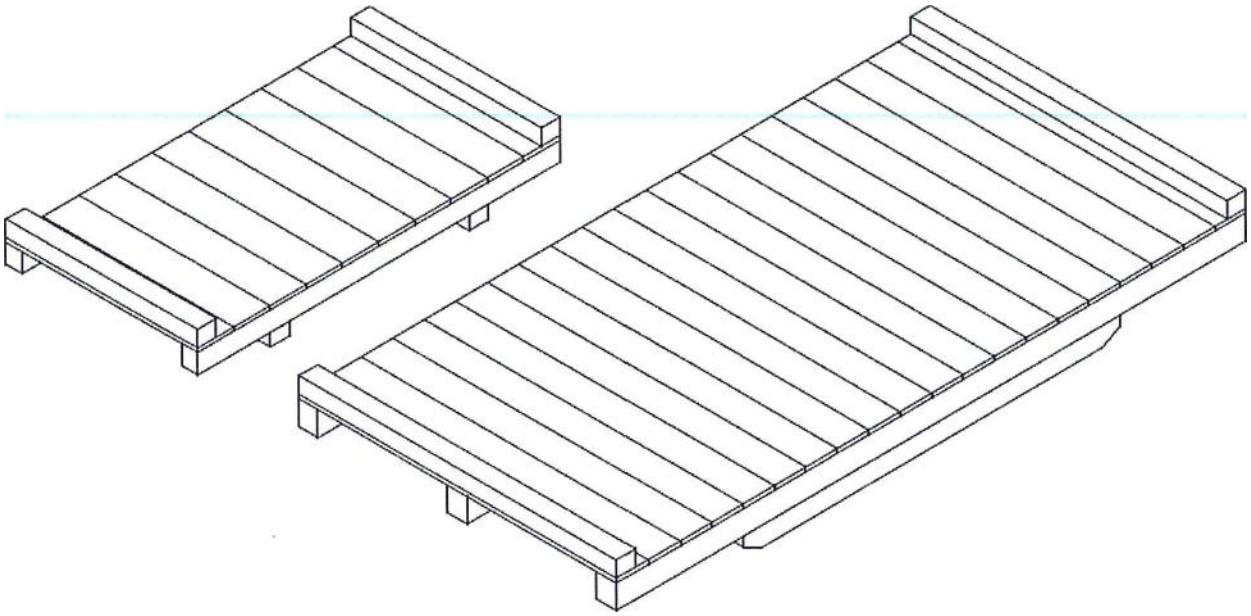
If necessary finally the boxes must be equipped of additional structures in wood ("ties") suitable to bear the hold of the ropes during lifting.

Every tie consists in a frame inserted among two beams of undercover (see figure in the previous page).

Longitudinal clips, solicited to bending, have same section of under-covers; the transversal fillets, riveted to the under-covers and solicited to compression, can be of iminor (not less than half of the under-covers) section

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4.9 PLATFORMS



Suitable for:

- Loose parts

The platforms are wood bases conceived for the stowage and the transportation of goods that require either a distributed support (loose parts) or however a separation from ground but don't require particular mechanical protections. From the constructive point of view can be considered cases without walls and cover.

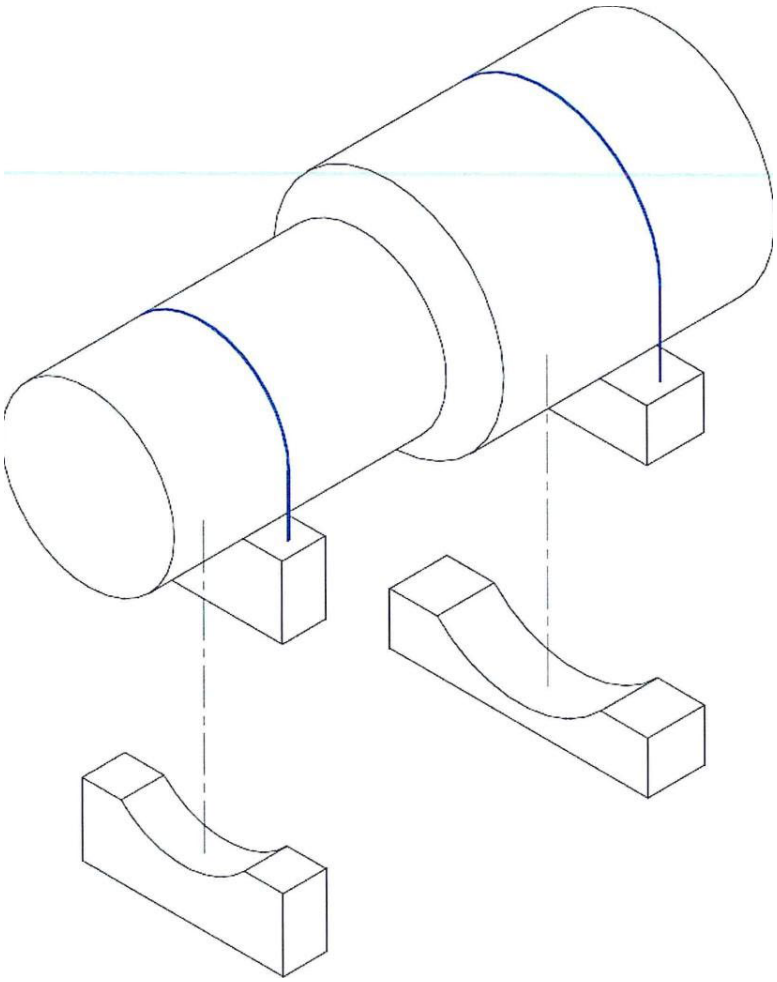
The platform is - if necessary - strengthened by two head-beams, transversal, fixed on the boards through riveting (for thicknesses up to 6 cms) or bolting (for higher thicknesses).

Further possible transversal reinforcement elements for the bottom are the dispatchers and the distributors of load: the dispatchers of load locally strengthen the base of the cage in correspondence of the two lifting points; the distributors of load divide the load of support on the longitudinal beams.

All goods must be adequately tied up among them and fixed to the platform through strapping and - if necessary - wrapped with extensible film or barrier bag.

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4.10 SADDLE



Suitable for:

- · Equipments or pipes. big diameter

Saddles are shaped structures, normally concave, wood or steel made fixed to the equipment to pack; they play a simple role of support to ground, but they don't ensure other types of protection (against shocks, dust, humidity etc.).

Saddles are suitable to pack equipment self-supporting, metallic - without instrumentation or insulation - and non metallic - provided that transportation mode is nor air or conventional seafreight.

If instead the equipment is already complete with proper structures of support, it will be enough complete them with thicknesser in wood (supports) fixed through bolts or threaded bars.

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Construction notes:

The indicative minimum length of the saddles must be at least equal to the external diameter of the equipment (D) to allow the fixing of the saddles to the equipment itself.

The following table recommends the width of the saddles; the supports are normally of the same length and width of the plates to which they are fixed length and width coincident with the plates to which they are fixed.

WIDTH OF THE SADDLES	
NET WEIGHT [kg]	WIDHT [cm]
Upto 2.000	15
From 2.001 to 6.000	20
From 6.001 to 10.000	30
From 10.001 to 20.000	40
Over 20.000	50

The depth of the cradle (or of the shaped part) - measured in vertical one - must be at least equal to the 15% of the diameter D.

For instance for equipment of 2 m diameter, the depth of the cradle must be than at least 30 cms (200 x 015). To be noticeds that to such minimum depth corresponds to an arc of support of around 90°, normally enough to ensure the stability of the equipment.

The elevation of the equipment on saddles must be the minimum possible, maintaining the strenght of the saddles themselves and the passage of the lifting ropes (unless a different lifting is anticipated i.e. through lugs etc.).

The number of saddles to be provided (2, 3 or more) must be determined based on the technical information by the Manufacturer. Specifically the number will depend on the weight and the rigidity of the equipment; furthermore, the transportation mode must be considered, to assure a correct division of the weight on the plan of load.

The combination of the measures of length and width, the number of the saddles or the supports and the overall (equipment + saddles) weight must generate a maximum pressure of support on ground not exceeding 10.000 kg / m

For instance 2 saddles 200 x 50 cm are suitable to support a maximum overall weight of 20.000 kg (2 x 0,5 x 2 x 10.000).

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The saddles are built with one wooden beam or overlapping more layers of beams; in this second case must be maintained in one piece the full- length beams (from the base up to the lowest point of the cradle) not to compromise the strength of the saddles themselves.

Saddles must be firmly anchored to the equipment, alternatively through:

- steel ropes, of suitable section, sheated with protective rubber;
- bands with buckles correctly sized and certified.

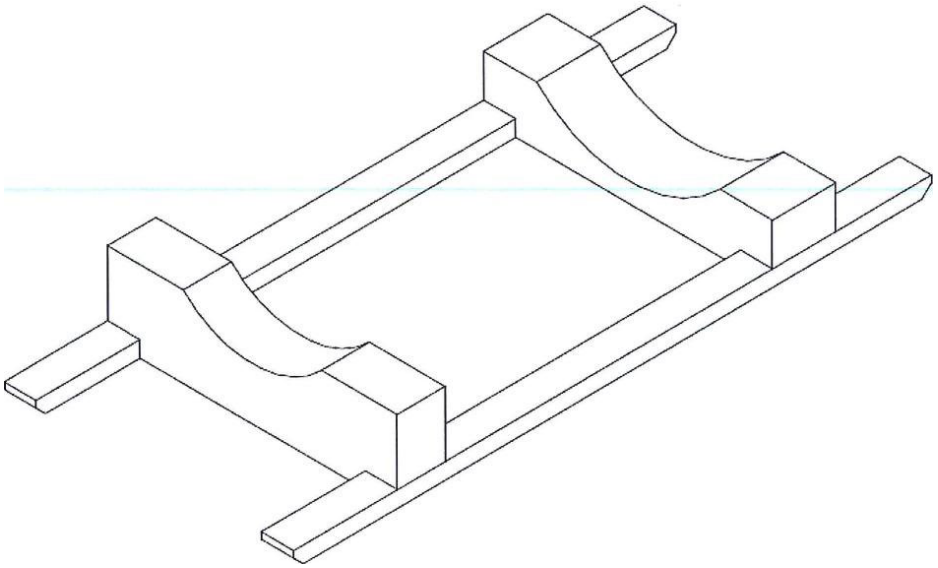
In case of rope anchorage, the connection with the saddle can be realized through threaded bars and lugs or through screwed head-plate, always interposing a tension regulating device with closed eyelet.

In case of anchorage to framework, the connection with the saddle is realized through passing threaded bars that acts on a bracket placed at every extremity of the framework; the regulation of the torque to made through the coupling nut-counter nut.

The supplier propose steel saddles. In such case, they must be equipped of:

- intermediate rubber spacer

4.11 SADDLE ON ROLLERS



Suitable for:

- Equipments or pipes. big diameter
- Frontal containerisation

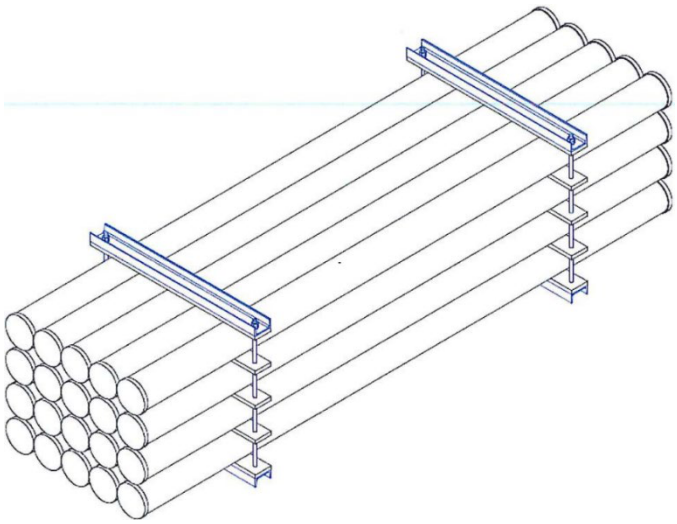
Saddles on rollers are normal saddles, as already described above, connected by longitudinal boards (roller - see figure). The roller facilitate the frontal containerisation.

For this type of packing the construction notes are same as for saddles, exception made for the pressure on ground, that in this case, can be higher;

Regarding the rollers, they must be made in one piece and have a bevel to facilitate the slipping inside the container.

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4.12 BUNDLE



Suitable for:

- Grouped rigid parts (self-supporting)

Bundles are grouped rigid parts (self-supporting) stacked and fixed between them through suitable fixings or binding (see figure They are typically used for the packing of pipes, of parts of heavy steelworks and you easily stackable supports.

The bundles are suitable to pack pipes of diameter from DN80 to 250 mm (or even more, if convenient in terms of handling or marking), while the pipes of greater dimensions are normally packed individually on saddles.

The number of the fixings essentially depends on the length of the bundle. Indicatively must be foreseen :

- · for bundles of length 5_ 6 ms: two fixings;
- · for bundles of length > 6 ms: three or more fixings.

In case of road transport without intermediate storage and gross weight up to 1.500 kg, the bundles can be tied up with simple metallic straps, of suitable section; the distance among two following bindings must not exceed the measure of 1,5 m

If in the formation of the bundles some void areas are detected in correspondence of the points of fixing, originated from the different size of the stacked elements, such voids must be filled with wood thicknesser, to ensure a suitable torque of the fixings.

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The fixings can be realized with bands and certified buckles or using wood beams connected among them through connecting rods.The profiles used for the realization of the fixings must be galvanized or painted with rust protection coat to avoid dirtying the transported material.

The extremities of the pipes must be covered as described in the paragraph 4.1.

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5 PROTECTIONS

5.1 CAPPING

If not otherwise specified, nozzles, pipes ends or openings must be properly be covered.

The nozzles must be covered with gasket in rubber + disk in plywood, completed by a suitable number of bolts.

The extremities of the pipes packed in bundles must be covered:

- individually, through plastic caps, fixed to the pipe through linen ribbon
- altogether, through double layer of polyethylene film (minimumt thickness 0,1 mm) fixed to the bundle through linen ribbon.

The ends of pipes shipped individually must be covered:

- through plastic caps, fixed to the pipe through linen ribbon;
- if - for big diameters - the aforesaid plastic caps are not available, through suitable plywood caps fixed to the pipe.

Openings on goods packed in boxes or in cages must always be covered with caps in plastics or disks in plywood, fixed with linen ribbon.

5.2 WATERPROOFING OF THE PACKAGES

The cover of boxes and cages must always be waterproofed, through film in polyethylene of suitable thickness (minimum 0,1 mm). The waterproofing layers must be applied inside the panels (or of the boards) of the casing.

Same is for the waterproofing of the walls of wooden boxes, while the walls of plywood boxes can also be waterproofed sealing the escapes among the panels of covering through special adhesive (type Vinavil).

Bottom, on the contrary, must not be waterproofed so to allow and facilitate the drainage of evental liquids and or condensates.

5.3 WATER PROOFING OF THE CONTENT

5.3.1 VCI protections

All oxidable parts

- machined surfaces,
- shatfs,
- hubs,
- supports,

- electrical equipment etc.

must be protected through covers or antioxidants.

In fact many products identified as VCI (Vapor Corrosion Inhibitor) are available on the market and they release protective agents with rustproof action.

The products VCIs are available in various forms, as

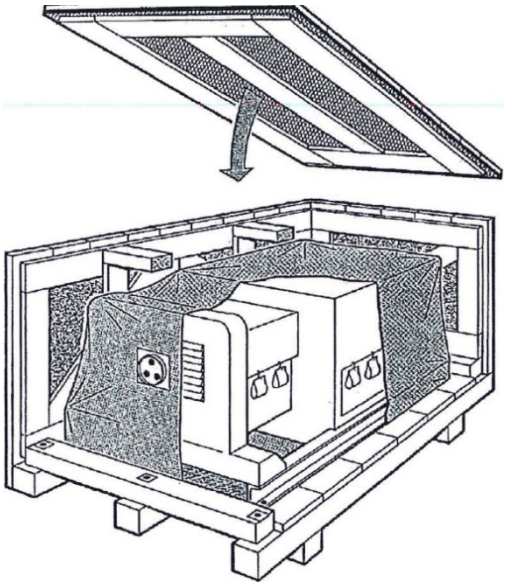
- powders,
- papers,
- sponges,
- oils,
- emitter,
- sackets,
- film,

suitable for the more various applications.

Before applying VCI all parts to be protected must be adequately cleaned, so that not to compromise the effectiveness and the duration of the adopted treatments.

Different indications excepted it is asked for a protection that has a validity of at least 6 months beginning from the date of closing of the I pack.

5.3.2 Barrier bag



An integral protection of the transported goods can be achieved containing them in a special barrier bag - MIL B131 E Class 1 - that, with a suitable quantity of dehydrating salt, it is able to maintain a low humidity for a long period. The barrier bag is effective only if intact. For this reasons it is not recommended with cages and road transport (the bag risks to tear because of the wind); it is typically used for protecting goods packed in cases.

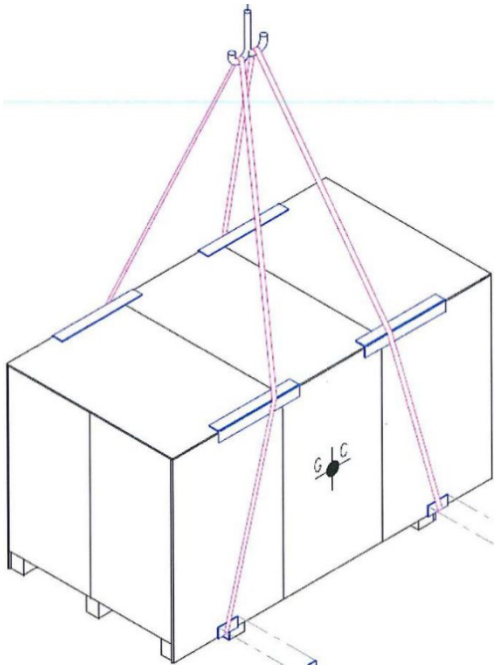
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It can be employed in alternative or additionally to the protections VCI.

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6 MISCELLANEA

6.1 REINFORCEMENTS



Over the 1.000 kg of gross weight, boxes and cages must be equipped with stirrups and angular reinforcement in steel, respectively fixed to the base and the upper edges of the sides in correspondence of the ropes passing points and sized so that to avoid abrasions and damages provoked by the action of the ropes or chains during lifting

6.2 MARKING

The marking of the packages must allow a sure identification (ID, reference packing list, place of destination etc.), net and gross weights, dimensions (length, width and height) and to provide the necessary instructions to correctly perform the operations of lifting, transport and storage (slinging points, dimensions, weights, etc.).

Marking must be clear, permanent, water-resistant and proportioned to packeg size. It can be made with

- plasticized poster compiled with black fonts on white background, or
- directly on the package with black fonts on clear background.

On every package 2 positions must be marked(one on a side and one on a head)

Marking to make always:

- top, vertical arrows on each one of the 4 walls of the package;

- protect from rain, umbrella;
- ·fragile, glass
- Forking or slinging points (cases and cages), chain;
- Center of gravity, on heads and sides - viewfinder.
- For cages marking to be put on dedicated rigid panel.
- Marking always to be in accordance with international standard sas per following table.

6.2.1 International symbology

SYMBOL	DESCRIPTION	NOTES
	ATTENTION! FRAGILE	AT LEAST ON ONE SIDE ON TOP (PREFERABLY ON ALL SIDES)
	TOP	ON TOP PART OF THE 4 SIDES OF PACKAGE
	SLING HERE	ON THE SLINGING POINT DEPENDING ON CENTER OF GRAVITY
	PROTECT FROM RAIN	ON ALL SIDES
	CENTER OF GRAVITY	ON SIDES
	DON'T USE HOOKS	TO MEAN THAT USE OF HOOKS IS PROHIBITED FOR LIFTING
	KEEP AWAY FROM HEAT SOURCES	TO MEAN THAT PACKAGE MUST BE KEPT FAR AWAY FROM HEAT SOURCES
	DON'T USE FORKLIFT	TO MEAN THAT USE OF FORKLIFT IS PROHIBITED FOR LIFTING

6.3 PACKING LIST

Every shipment must be carefully documented through a summary "packing list" that contains all the useful information to a general management of the shipment itself, particularly:

- Purcahse order number, ID of the single package;
- Type of package (case/ cage/ platform, ecc.);
- Adopted protection type;
- Gross and net weight;
- Dimensions and volume;
- Content description;
- Total number of packages;
- Total net and gross weight;
- Total volume.

A copy of the general packing list must be iput in a transparent envelope and fixed to the outside of every package covered by a metallic plaquette.

6.4 STOWAGE

Goods must be firmly fixed to the package, so to avoid falls or displacements, dangerous especially during lifting and transportation.

Normally package content must be fixed directly to the base bu bolting, threaded bars , stirrups or brackets or other suitable fixings.

Fixings to the walls can eventually be predisposed either with auxiliary function (to contribute to hold up the loads produced by the manouvres of lifting and transport) or to stop light material.

In the following table the main dynamic loads, to which the package might be subjected during the manouvres of transport, are listed:

TRANSPORTATIONNN	MANOUVRES	DYNAMIC LOADS
Road	Rough braking Turns routing Uphill or downhill	inertia centrifugal force imbalance
Railway	Rough braking Crash on bumpers during manouvre	inertia concussive force

Seafreight	roll (transversal oscillation) pitch (longitudinal oscillation)	imbalance imbalance
Airfreight	take off landing	imbalance inertia

Where possible, it is preferable to place the heaviest parts in the bottom part of the package, so to increase the stability. Small items should be pre-packed in wood cases or cardboard and put into the main package.In case of transport in container, are in charge to the supplier containerization and fixing of packages inside it.

6.4.1 Maxium sizes of packages

For road and rail transportation, normally are in force the following size limits:

TRASPORTATION	SIZES - W. x H. x L. [mm]
ROAD	2.500 x 2.500 x 13.600
RAILWAY	3.100 x 2.100 x 14.000

For the maximum sizes allowed in the foreign Countries of transit and destination of the packages, reference must be done to possible specific regulations in force

6.4.2 Containers

Listed in the following table are the sizes of containers box type (frontal opening) - in carbon steel by 20 and 40 feet (the most commonly used). Inner sizes are particularly useful to prepare the loading lay out:

SIZES [mm]	20 ft	40 ft
OUTER W. x H. x L	2.500 x 2.500 x 6.000	2.500 x 2.500 x 12.000
INNER W. x H. x L	2.300 x 2.300 x 5.900	2.300 x 2.300 x 11.900
OPENING W. x H. x L	2.250 x 2.280	2.250 x 2.280

The stowage within containers must have operated in the respect of the following dispositions:

- The heaviest goods must be possibly stowed in the low part and you uniformly distributed;
- Load must have placed close to the walls of the container;
- Goods must be fixed on the base of the container through the use of bands, beams, wedges etc.

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The containers must be watertight and in good conditions of maintenance and painting. In case of use of second-hand containers, countersign and number of the previous owner must be cancelled.

6.4.3 Testing

Encore Thermoengineering the right reserves him to check the suitability of the packages, of the stowage, of the marking and of the documentation. If any detail will be in deviation from the present specification, the supplier will be binded to completion, remake, partial or total, of the involved packing activity, at his own care and expenses and in useful time for the respect of the date of required delivery

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7 STORAGE AND PRESERVATION

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7.1 SCOPE

This section covers the minimum requirements to be applied for check activities and preservation against corrosion of all shop manufactured/assembled equipment and materials at ETE workshop during the storage period before site installation and ensure therefore their preservation.

7.2 DEFINITIONS AND TERMS

For the purpose of this specification, the following definitions and abbreviations shall apply:

CRA: Corrosion resistant alloy, an alloy with minimum content of chromium of 12% (such as stainless steel AISI 300 series, duplex stainless steels), Ni alloys, titanium alloys, etc.

EQUIPMENT: includes Machinery and Static items like vessels, heat exchangers, tanks, etc. The equipment, depending on dimensions and transportability, can be shop or site fabricated / assembled

FERRITIC STEEL: means carbon steel, low temperature carbon steel, low alloy steel with max content of chromium of 12-30%

INITIAL PRESERVATION: means the application of specified preservatives and fitting of specified protection to any material/system by uncasing or installation at site, to maintain the equipment/system unimpaired

MACHINERY: includes Rotary machines (such as pumps and compressors), packages (skid or site assembled), blowers etc

MISCELLANEOUS: includes instruments valves, instrumentation, electrical and electronic equipment, bulk material etc

ETE: Encore Thermoenginering S.r.l.

7.3 REFERENCE DOCUMENTS

- This document

7.4 SUBJECT

Details for check activities on goods upon receipt at site and during the period at site before goods are put in any kind of operation.

7.5 GENERALITIES

The following instructions cover storage phases.

Additional to detailed instructions, the following site activities shall be carried out after uncasing/installation

Part / item	Preservation by
Door hinges, grease nipples and fasteners	To be lubricated
Threaded openings	To have metal plugs compatible with the metallurgy of the component being capped or plugged. If IP rating is maintained, plastic plugs are acceptable for non-hydraulic/pneumatic systems
Gaskets of door covers	To apply thin layer of non-acid vaseline
Ball valves	To be locked in open position
Exposed valve spindles	To be protected with denso tape
Flexible hoses	Open sides must be plugged
Bearings	To be greased or oiled
Insulation	Where the insulation can be exposed to damage during storage or installation, the insulation shall be protected with 10 mm plywood sheets.
Vent holes	After testing they must be filled with stiff grease or equivalent material not capable to sustain pressure.
Partially fabricated vessels	To be suitably braced to prevent deformation. Open ends shall be covered to prevent ingress of dirt and

	foreign matter during shipment. Shipment drawings shall be submitted prior to shipment for approval.
Instrument or panel glasses	To apply 6 mm plywood
Panel fronts	Apply wooden frame (or another effective device/s) for corners protection
Various instrumentation, JB, buttons	Envelope them in aluminium sheeted glass fibre cloth, if necessary
Flanges	To be fitted with protective covers.
Straight pipe spools	To be fitted with water resistant medium density fibreboard blanks using a minimum of 4xM6 bolts.
Pressure & temperature gauges,controllers, panels, and junction boxes, temp. Instruments, telecom. equipment, detectors, transmitters, heaters, pushbutton stands and connection boxes	Aluminium sheeted glass fibre cloth, min. 0,3 kg per m^2, shall be used to envelope. Or Shock absorber,

Moreover:

•Preservation labels shall be attached to equipment, clearly visible, as soon as the Initial preservation is carried out.

•For all supplied spare parts ETE shall specify required preservation instructions.

Tie-on labels can be used. Stick-on type labels can be used on non-waxed equipment if required and sustainable for long time without getting damage

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7.6 PRESERVATION FOR EQUIPMENT

Equipment shall be preserved as follows:

Equipment in ferritic steel	Preservation by
Equipment (e.g.: pressure vessels, heat exchangers, etc.)	Preservative coating, VCI fogging/ emitter, along with Silica Gel bags. The min quantity of silica gel shall be 0.5 kg/m3 and able to keep the relative humidity below 50% (design factor)
Machined surfaces (e. g.: flanges)	Application of a temporary protection having expected durability in outdoor exposure not less than 6 months.

All flanged openings Shall be sealed. Metallic covers shall be 6 mm min thickness. The external side of the metallic covers shall be painted with a primer. Wood or plastic flanges are not allowed.

Nozzles with non-permanent blind flanges and/or gaskets shall be labeled on the exterior surface with the following marking: "TEMPORARY GASKET - REPLACE BEFORE OPERATION".

7.7 PRESERVATION FOR MACHINERY

Machinery shall be preserved as follows:

Machinery in ferritic steel	Preservation by
Packaged machinery	As minimum: Closed box with a barrier bag and silica gel. The min quantity of silica gel shall be 0.5 kg/m3 of barrier bag volume and able to keep the relative humidity below 50% (design factor). Soft materials shall be added for mechanical protection of instrumentation.
Machined surfaces	Application of a temporary protection having expected durability in outdoor exposure not less than 6 months.

Threaded orifices shall be protected with metal plugs. The plugs that have to be eliminated prior to commissioning shall be painted with a different color to the rest of the equipment. Cast iron plugs are not allowed.

External shafts, stems, gears, grips, skids and sliders, other than anticorrosive treatment, shall be protected with waterproof paper or plastic sheet well fastened with adhesive tape. For CRA material adhesive tape and plastic sheet shall be chloride free.

Dry silica gel bags may be placed also inside the rotating parts of the machine.

7.8 PROCEDURE FOR PIPING

Piping has been divided in the following categories:

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Ferritic steel (bulk material):

Piping shall be coated with a temporary protection free from low melting point metal having min 6 months of expected durability in outdoor environment. The external surface of piping shall be free from exogenous compounds such as rust, debris and metal particles.

Ferritic steel already coated (i.e.: immersion or underground installation, spools, etc.)

The coating shall be applied as per contractual specification.

The pipe fittings shall be supplied only with temporary protection free from low melting point metal having min 6 months of expected durability in outdoor environment.

Flanges

Coating damaging shall be avoided: no chains or metallic cords shall be used for handling these materials.

CRA:

Superficial iron contamination is forbidden: no chains or metallic cords shall be used for handling these materials, storing in separated area from ferritic steel piping is mandatory. These materials shall be preserved internally and externally until_installation has been completed and any precaution shall be taken for avoiding surface contamination.

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7.9 PRESERVATION FOR PIPING

Piping shall be preserved as follow

Piping	Preservation by
Pipes, regardless material of construction	Plastic caps, placed at the ends of pipes, when pipes are not packaged inside a closed box.
Pipes (threaded ends); Flanges (coupling surfaces, threaded parts)	Plastic caps, placed at the ends of pipes, when pipes are not packaged inside a closed box. Flanges shall be packaged in closed box with barrier bag. The threaded surface shall be temporary protected by oil or grease free from low melting point metal having expected durability in outdoor exposure not less than 6 months.
Coated piping	Plastic caps, placed at the ends of pipes, when pipes are not packaged inside a closed box.
Additional requirements for CRA	The packaging shall be chloride free and stored in a separated area from carbon steel piping in order to avoid surface contamination

7.10 PROCEDURE FOR MISCELLANEOUS ITEMS

All electrical and electronic equipment exposed to humidity shall be protected with silica gel or vapour corrosion inhibitor VCI (Cortec VCI 100 or equivalent

All openings in hydraulic/pneumatic tubing shall be provided with steel caps or solid shank steel plugs compatible with the metallurgy of the component being capped or plugged. Non-metallic plugs shall not be used.

Gaskets/O-rings on instrument equipment to be greased with acid free Vaseline.

Hydraulic-Pneumatic tubing: All openings provided with steel caps or solid shank steel plugs (metallurgy compatible with the capped/plugged part)

Gasket/O-Ring: To be greased with non-acid Vaseline.

7.11 SITE INSPECTION

Site person in charge shall record the initial preservation status

A detail record of preservation activities, preserved parts, preservatives used and date shall be prepared and content will be as follows:

- date of preservation;

- grade of preservation material;

- interior packaging option;

- storage conditions;

- protection term without preservation;

- preservation term;

- depreservation methods.

7.12 CHECK LIST AFTER ARRIVAL AT SITE STORAGE

Visual check of packages and goods integrity with a thorough attention to the goods packed on saddles and bundles

EXTERNAL PAINTING

- Any damages on painting shall be immediately repaired
- For this scope, please refer to the Painting Procedure.

CLEANING

- Verify that all the stainless steel parts (flare tips, service piping and ignition panels) do not show

oxidations and/or contaminated areas.

- In case of oxidation and/or contaminated areas, is necessary clean accurately using:

Inox brush, Detergents & Degreasing cleaner polishing based degreasing solvents (for eg. E-NOX Clean INOX-CLEAN - @ bio-chem Surface Technology) and surfactants (for eg. STAR 100 Metal STAR - @ bio-chem Surface Technology) in polishing effect rapid evaporation for cleaning and polishing of stainless steel surfaces.

7.13 MAINTENANCE & PRESERVATION DURING STORAGE & LONG TERM STORAGE (6 MONTHS MIN.)

During the storage period before the equipment installation, the user shall carry out the following tests:

#	Action	Periodic Check
1	Visual check of packages and goods integrity with a thorough attention to the goods packed or saddles and bundles. In case of damages on packages, please carry out any necessary repairing actions immediately	Every month
2	Visual check of the painting integrity. In case of damages, please carry out any necessary repairing actions immediately.	Every month
3	Visual check of stainless steel parts. In case of oxidation and/or contaminated areas, is necessary clean accurately using: Inox brush, Detergents & Degreasing cleaner polishing based degreasing solvents (for eg. E-NOX Clean INOX-CLEAN - @ bio-chem Surface Technology) and surfactants (for eg. STAR 100 Meta STAR - @ bio-chem Surface Technology) in polishing effect rapid evaporation for cleaning an polishing of stainless steel surfaces.	Every month
4	Access to the storage area of non authorized personnel must be limited	Always

1.5 CACULATION NOTES

1.5.1 Mechanical Calculation

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

MECHANICAL CALCULATION
HYDROGEN VENT

Document Number: 1724000887-MAC-CA-00004

Document Class: 2

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	16/01/25

Rev.	Date	Description	Prepared	Reviewed	Approved
05	10/12/2024	Accepted for Construction (AFC)			
04	04/12/2024	Accepted for Construction (AFC)	DB	RV	AL
03	14/10/2024	Accepted for Construction (AFC)	DB	RV	AL
02	03/09/2024	Accepted for Construction (AFC)	DB	RV	AL
01	26/07/2024	Issue for Review (IFR)	DB	RV	AL
00	12/06/2024	Issue for Review (IFR)	DB	GP	AL

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Issue for Review (IFR)
02	Accepted for Costruction AFC)
03	Accepted for Costruction AFC)
04	Accepted for Construction (AFC)
05	Accepted for Construction (AFC)

HOLDS LIST

No.	Description
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3	
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REVISED TEXT AND PART IN BLU COLOR

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.

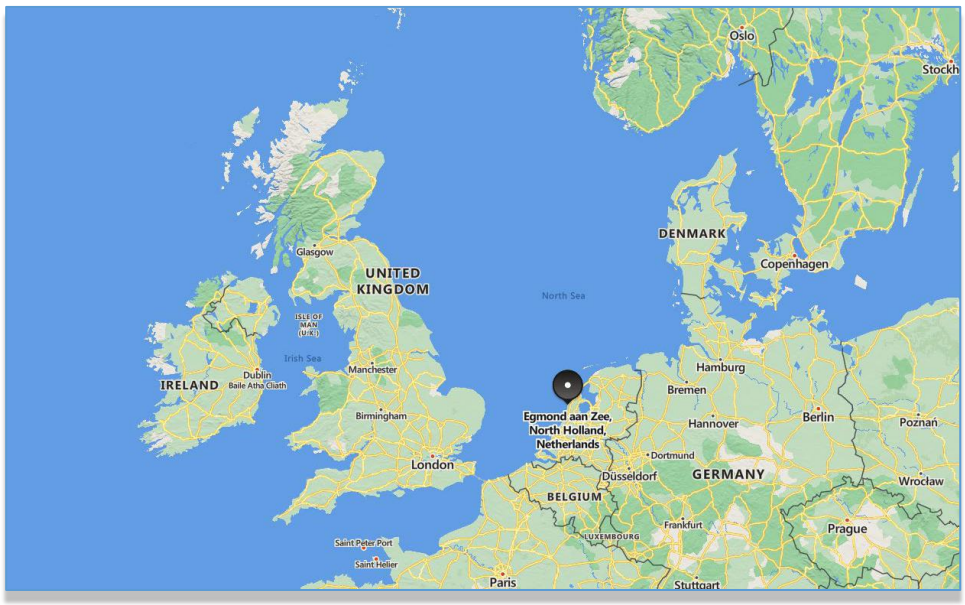


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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 located on coordinates E 590719.1, N 5841602.3 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.

1.1.2Project 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.

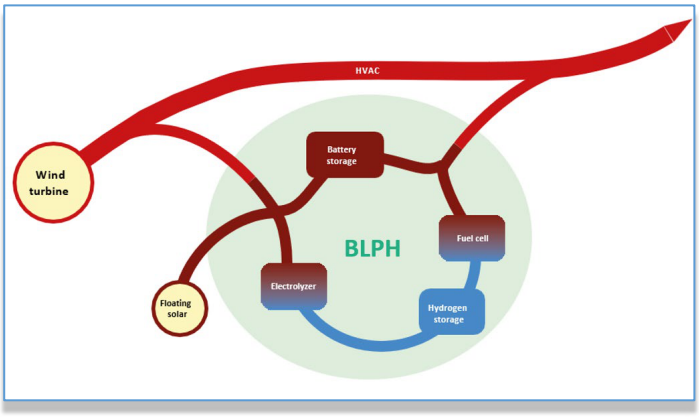


Figure 3 – BLPH Concept

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 s 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 aim of this document is to show the mechanical calculation for the hydrogen vent stack

2.1 References

Doc. No.	Description
1724000887-MAC-DA-00003	GENERAL ARRANGEMENT DRAWINGS, INCLUDING FOUNDATION LOADS-HYDROGEN VENT

Table 1 - Reference Documents

2.2 Definitions and Abbreviations

COMPANY - CPY	CrossWind
CONTRACTOR - CTR	ROSETTI MARINO S.p.A. -
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
ETE	Encore Thermoengineering srl
ASME	American Society of Mechanical Engineers
HKN	Hollandse Kust Noord
BLPH	Base Load Power Hub
B.O.P.	Bottom of Baseplate
BESS	Battery Energy Storage System
COG	Center of Gravity
DNV	Det Norske Veritas (notified body)
EDMS	Electronic Document Management System
HW	Hydrotest
ID	Inside Diameter
PV	Pressure Vessel
LRFD	Load and Resistance Factor Design

MAWP	Maximum allowable working Pressure
MDMT	Minimum Design Metal Temperature
MSL	Mean Sea Level
NP	No Pressure
OD	Outside Diameter
PP	Plot Plans
PVP	Pressure Vessel and Piping
SP	Specification
ST	Structural
THK	Thickness
TP	Transport Protocol
VooW	Van Oord Offshore Wind
W	Wind
Wt	Weight

Table 2 - Definitions and Abbreviations

2.3 Code and Rules

Doc. No.	Description
/1/ BS EN ISO 19900	General requirements for offshore structures - 2019
/2/ BS EN ISO 19901-1	Specific requirements for offshore structures - Part 1: Metocean design and operating considerations - 2015
/3/ BS EN ISO 19901-2	Seismic design procedures and criteria
/4/ BS EN ISO 19901-3	Specific requirements for offshore structures – Part 3: Topsides structure - 2014
/5/ BS EN ISO 19901-5	Specific requirements for offshore structures – Part 5: Weight Management - 2021
/6/ BS EN ISO 19901-6	Specific requirements for offshore structures – Part 6: Marine Operations – 2009

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/7/ BS EN ISO 19902	Petroleum and natural gas industries - Fixed steel offshore structures – 2020
/8/ ISO 19906:2019	Petroleum and natural gas industries – Arctic offshore structures
/9/ ANSI / AISC 360-16	Specification for Structural Steel Buildings - July 2016
/10/ API RP 2A-WSD	Recommended practice for planning, designing and constructing fixed offshore platforms – Working stress design – 22nd edition – 2014
/11/ DNVGL-ST-N001	DNV GL - Marine operation and marine warranty - 2021
/12/ EN 1991-1-3:2003 & A1:2015	EN, Eurocode 1 – Actions on Structures – Part 1-3: General actions – Snow loads - Incorporating corrigenda December 2004 and March 2009, December 2015.
/13/ DNV-ST-0145	DNV, Offshore substations
/14/ DNV-RP-C201	DNV, Buckling Strength of Plated Structures, October 2010.
/15/ DNVGL-RP-C203	DNV GL, Fatigue design of offshore steel structures, September 2019 and Amendment January 2020
/16/ DNVGL-RP-C204	DNVGL-RP-C204 Design against accidental loads – 2019
/17/ DNVGL-RP-C205	DNV GL - Environmental conditions and environmental loads - September 2019, amended September 2021.
/18/ DNV-OS-C101	Design of offshore steel structures, general- LRFD method, 2021
/19/ DNV-OS-B101	Metallic materials, 2021
/20/ DNVGL-ST-0126	Support structures for wind turbine, 2018

2.4 Company Specifications

Doc. No.	Description
/21/ DEP 37.19.00.12	Gen - Offshore Topsides Structures
/22/ DEP 37.19.00.30	Gen - Fixed Steel Offshore Structures (Adoption of IOGP S-631-11, Amendments / Supplements to ISO 19902:2020).

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/23/ DEP 37.81.10.19	Gen - Marine Operations Requirements – Loadout, Transportation and Installation of Offshore Structures (Amendments / Supplements to ISO 19901-6)
/24/ DEP 37.91.10.11	Mobile Mooring Systems (Amendments / Supplements to API RP 2SK, API RP 2SM AND API RP 2I)

2.5 Project Documents

Doc. No.	Description
/25/ 123A90-DDL-MD-RE-01006	Weight Control Report
/26/ 123A90-PML-MD-PRO-01002	Weight Control Procedure
/27/ 123A90-DDL-PP-DS-70070	Plot Plans
/28/ Pending	Handling Philosophy Report
/29/ 123A90-DDL-ST-SP-90018	Structural Material Specification for Topside
/30/ Pending	Structural Material Specification for Transition Piece
/31/ 123A90-DDL-ST-SP-90019	Structural Fabrication Specification
/32/ 123A90-DDL-TI-SP-99014	Specification for TP, Topside and Caissons Transportation and Installation

2.6 Other Documents

Doc. No.	Description
/33/ K559–2254-ST-PHI-001	BLPH Structural Topsides Design & Installation Philosophy, Rev.1, 09 December 2022
/34/ K559–2254-ST-REP-001	BLPH Structural Topsides and Transition Piece Design and Analysis Report, Rev.0, 27 February 2023
/35/ 144671-VOOW-TF-ENG-REP-1011	Design Basis Part C, Re.4, 05-07-2021

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/36/ SR.20.01165 (not received)	Meteocean criteria for Hollandse Kust Noord Wind Farm zone (shell), Rev A03, 05-02-2021
/37/ K559–2254-WC-REP-001	BLPH Weight Control Report, Rev.2, 17 March 2023
/38/ 144671-VOOW-TF-ENG-REP-1051	Design Basis Part C for BLPH, Rev. 3, 28 June 2022
/39/ 144671-VOOW-TF-ENG-REP-1052	Wave Loads and Effects for BLPH, Rev. 0, 16 December 2021
/40/ 144671-VOOW-TF-ENG-REP-1016	Wave Run-up Study, Rev.2, 29 November 2021
/41/ 144671-VOOW-TF-ENG-REP-1103	Wave Impact Analysis, Rev.1, 7 May 2021
/42/ 144671-VOOW-TF-ENG-REP-1053	Axial Pile Capacity Assessment for BLPH, Rev.3, 07 July 2022
/43/ 144671-VOOW-TF-ENG-REP-1054	Foundation Load Document for BLPH, Rev.1, 07 April 2022
/44/ 144671-VOOW-TF-ENG-REP-1055	Design Verification Primary Steel for BLPH, Rev.1, 13 April 2022
/45/ 144671-VOOW-TF-ENG-REP-1056	Ship Impact for BLPH, Rev.0, 07 March 2022
/46/ 144671-VOOW-TF-ENG-REP-1502	Main Access Platform – Wave Run-up Braces
/47/ 144671-VOOW-GEN-SUR-REP-0074	Foundation As-built Survey CW70 HNA6
/48/ K559-2254-PM-PLN-003	Basic Design Engineering Package, Rev2, 06 July 2023

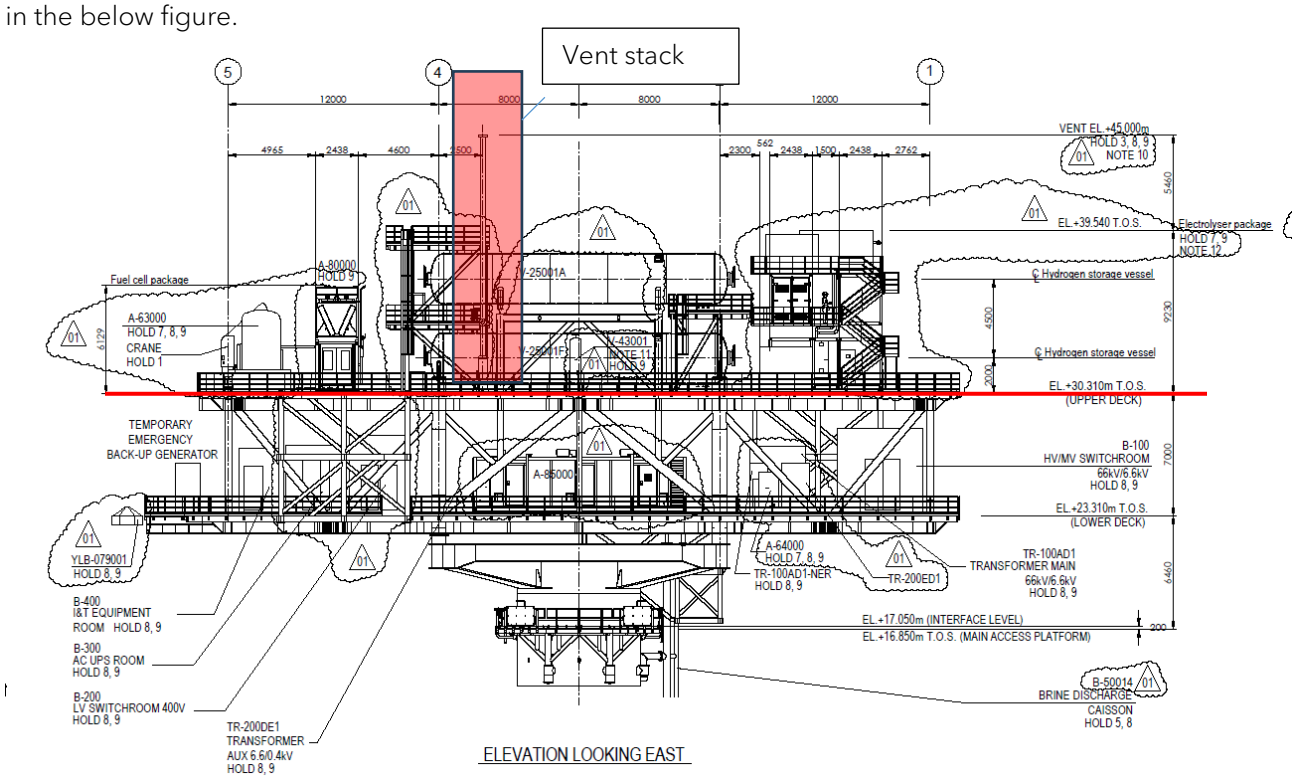
2.7 Code for Calculation of Equipment Under Pressure

This design of the bottom adheres to the guidelines and standards set forth by ASME Section VIII, Division 1, which governs the construction of pressure vessels. ASME (American Society of Mechanical Engineers) Section VIII, Division 1, is an internationally recognized code that provides detailed criteria for the design, fabrication, inspection, and testing of pressure vessels, thereby ensuring the safety, reliability, and efficiency of the equipment under pressure.

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3. SYSTEM DESCRIPTION

The bottom of the vent stack is located on the topside at el. 30.310 m B.O.P. (Bottom of baseplate) as shown in the below figure.



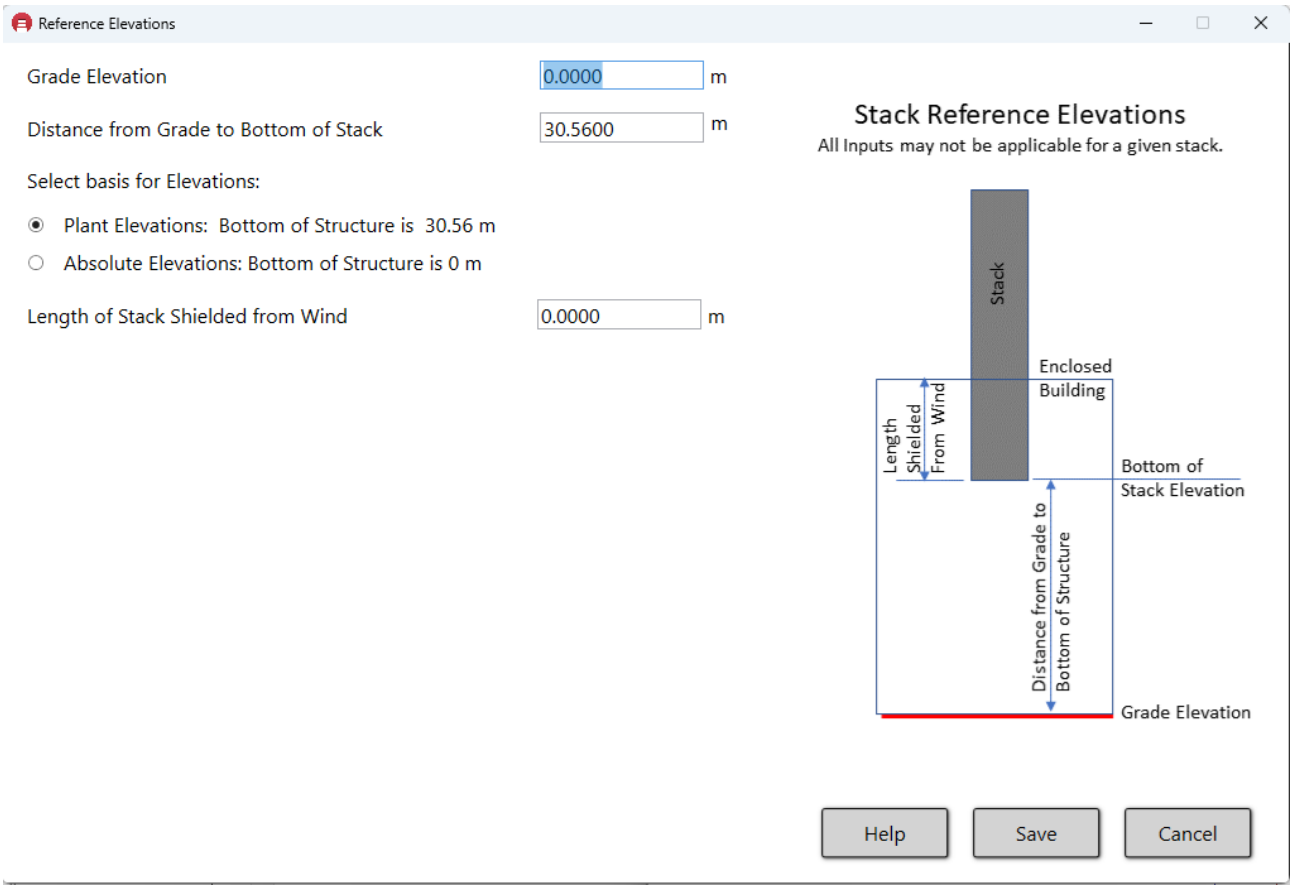
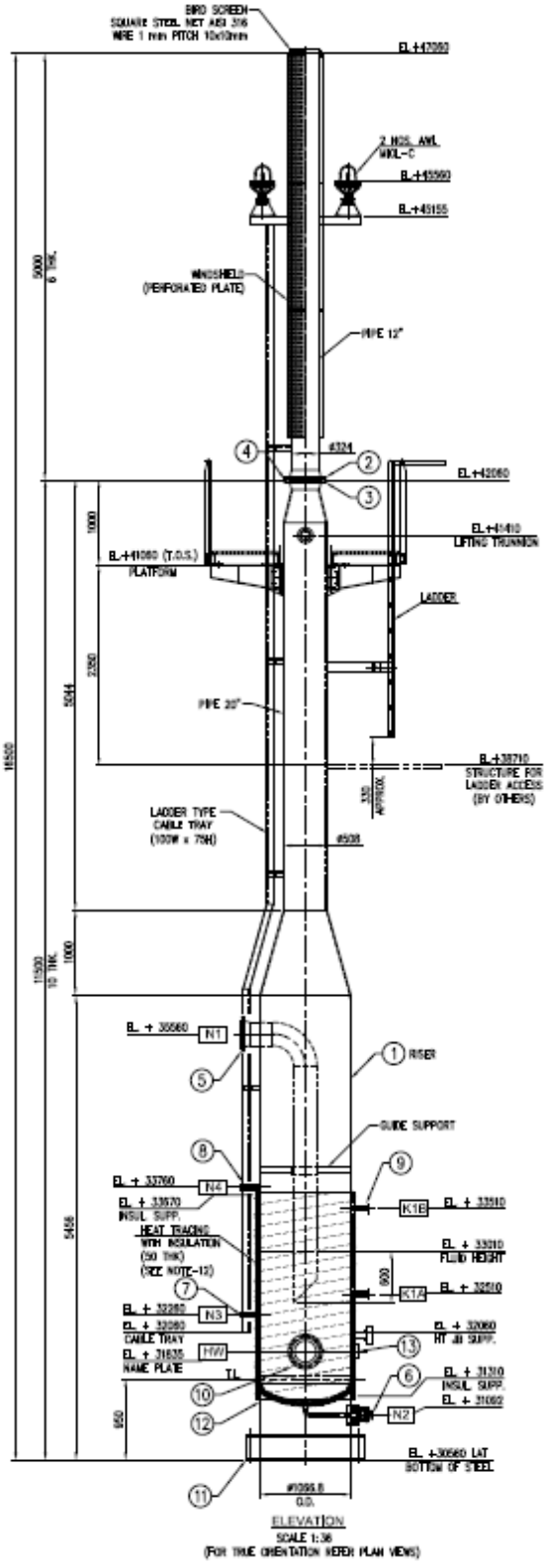
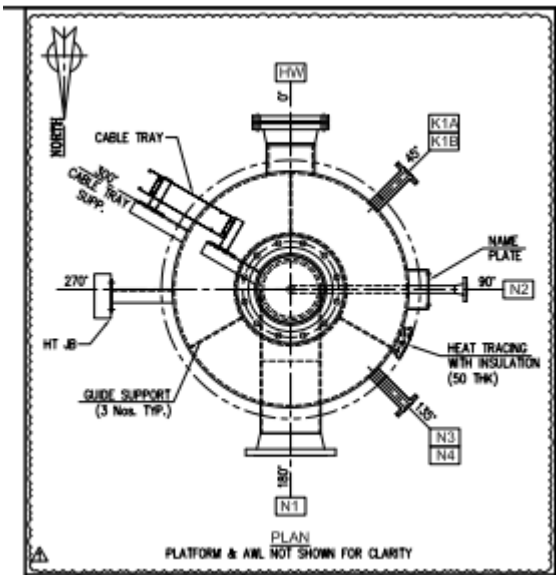


Figure 4 Elevation of the vent stack

The geometry of the vent stack is depicted in the document 1724000887-MAC-DA-00003 and shown hereafter for a quick reference.





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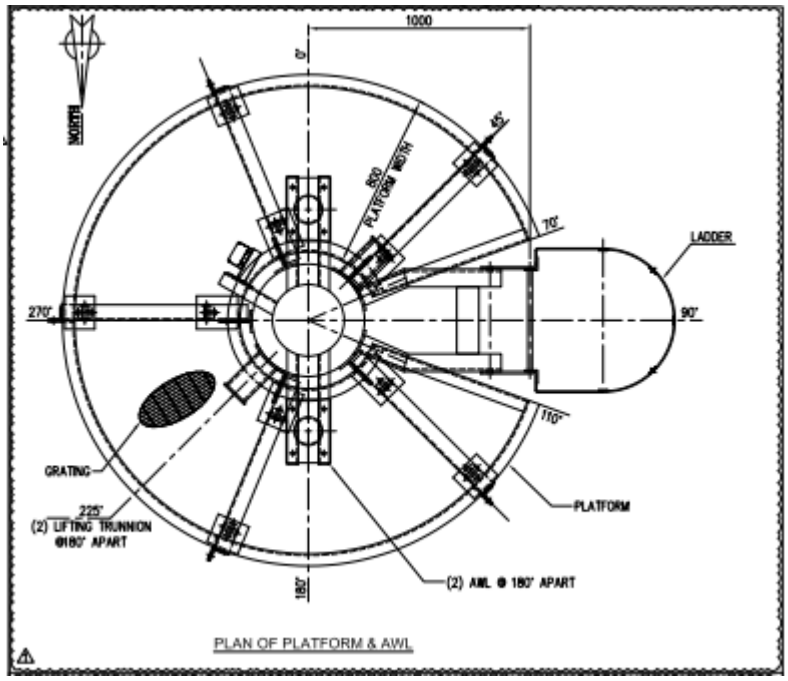


Figure 5 General Arrangment

The structure has a vortex disrupter device at the top, which is covered by a perforated shield to prevent the occurrence of vibrations caused by vortices.

4. LOADS

4.1 DEAD LOADS

The dead loads of the structural element are calculated according to the specific weight of the materials and the involved volumes.

The dead loads which is not parts of the resisting system has been inputted manually in the calculation.

4.2 DEAD LOAD OF EQUIPMENT CONTENT WEIGHT

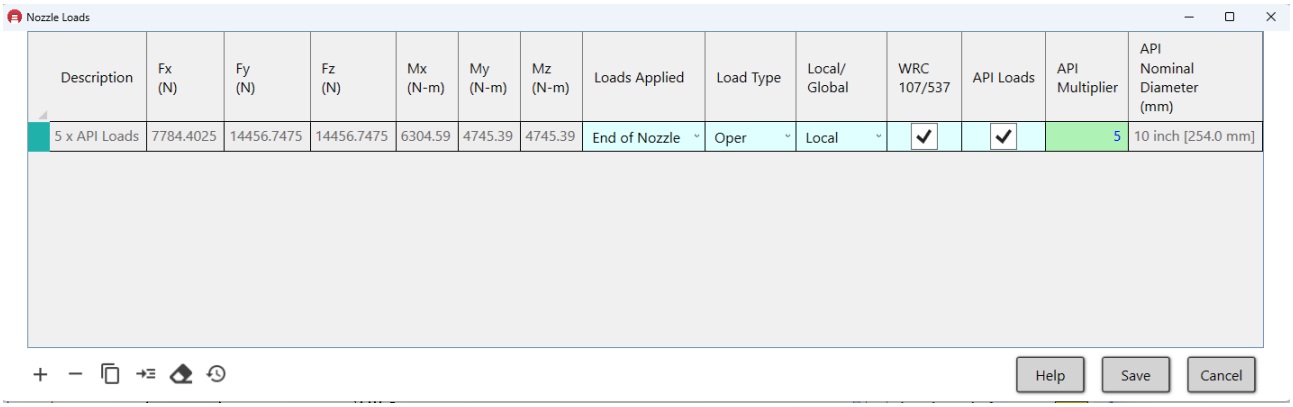
The dead load of the equipment content weight is coming from a water level up to 2.45 m inside of the stack from the elliptical bottom head.

4.3 LOADS ON PLATFORM

Not applicable

4.4 NOZZLE LOADS

Nozzle 1N's loads have been calculated with a factor of 5 times the value from API 537.



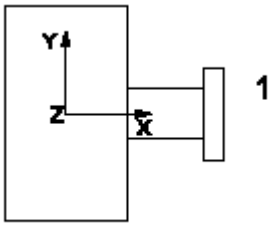


Figure 6 Nozzle 1N loads

4.5 WIND LOADS

For the pourpose of the calculation the desing wind load is considered according to 100 -years period of return (extreme environmental condition) according to the data K559-2254-PM-PLN-003 - Basic Design Engineering Package_rev2 §6.1.3.

6.1.3 Wind Speed Data

Omni-Directional wind data is to be used as shown in Table 6.6

Table 6.6 - Omni-Directional Extreme Values at 125 m MSL

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

Figure 6.6 Omni direction Extreme value of wind loads at 125 MSL

As the calculation is performed using the Eurocode the input shall be the design wind loads at 10 m and 10 min average. At the same time the structural verification following Eurocode procedure are performed consider 3s gust in conformity with the requirement of ISO 19901-3 (2014) .

A 10 min average wind speed of 42.9 m/s at 125 msl for a category II terrain is derived from a basic wind speed of 28 m/s. The latter is used for the calculations.

The following image is showing the detail of the porous shroud.

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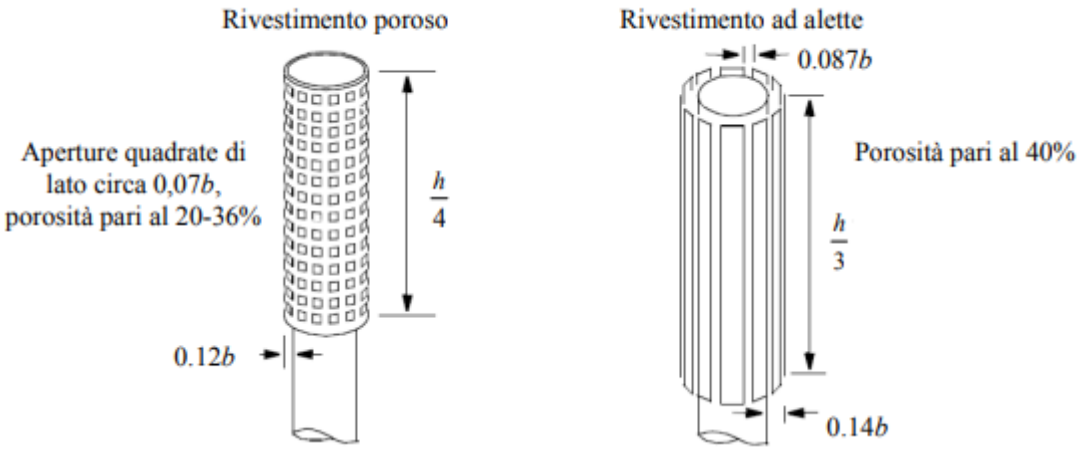


Figure 7 Porous shroud information

4.6 WAVE AND CURRENT LOADS

According to the structural design basis the table below reported applied to the case to evaluate the inertia forces.

Case	Location	Elevation (LAT) [m]	Sea State	Max acceleration [m/s2]
Operational	Topsides CoG	28	Normal	0.67
Extreme	Topsides CoG	28	Extreme	1.61

Figure 8 Topsides acceleration to evaluate inertia forces

According to the table an horizontal and vertical acceleration of $\frac{1.61}{9.806}g = 0.164$ is applied on the structure.

4.7 SEISMIC LOADS

Not applied

Transportation Loads

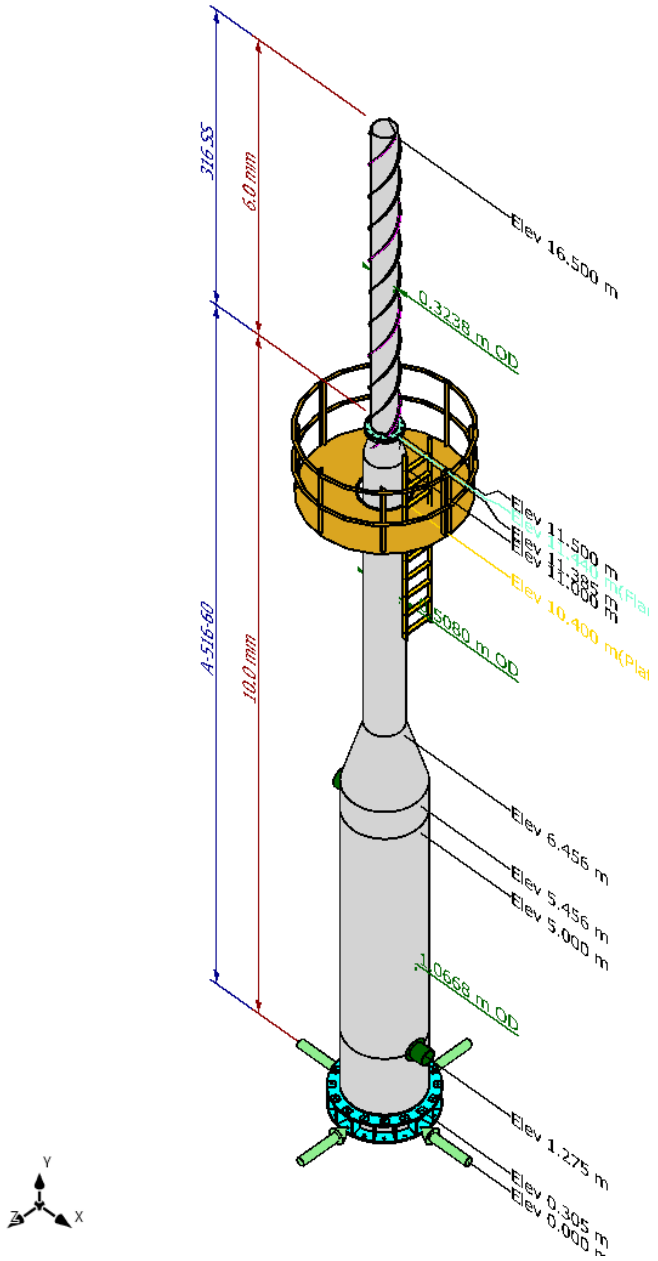
An horizontal load of 0.7 g us applied at the vent center of gravity to cater for the acceleration during the transportation

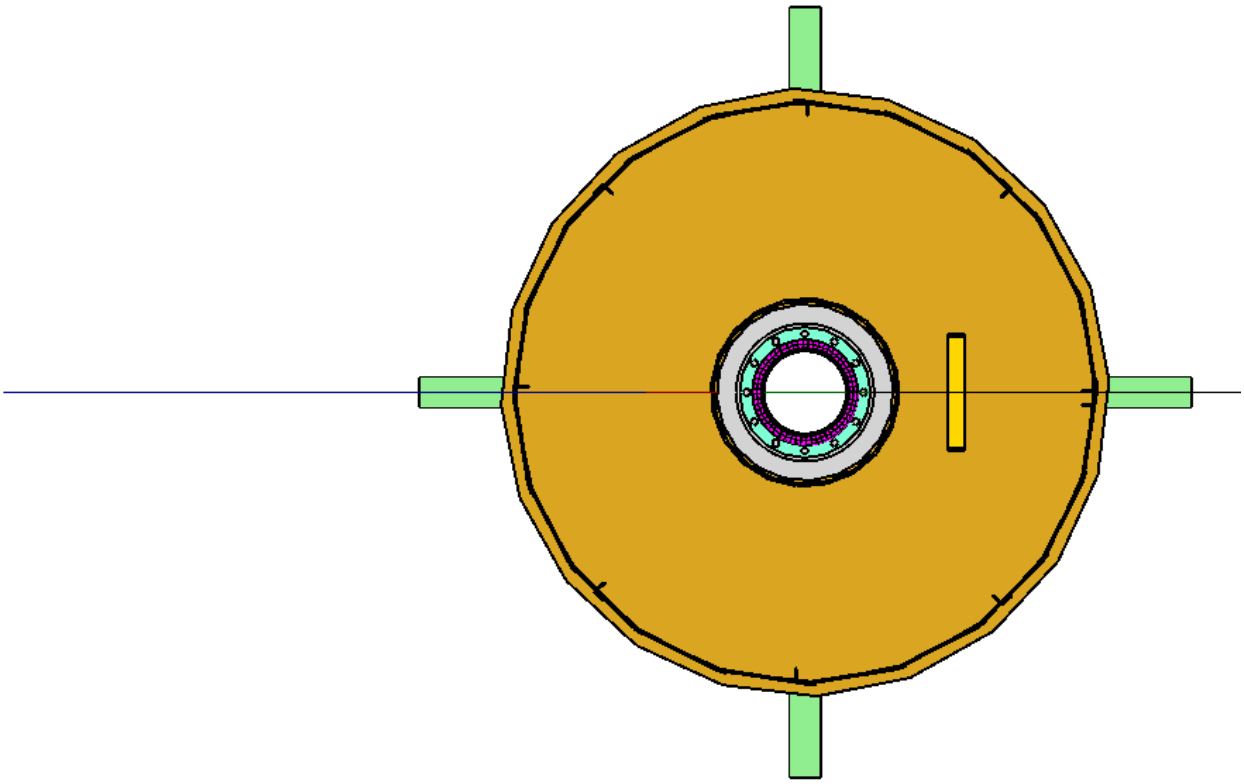
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5 STRUCTURAL CALCULATIONS

The calculation is performed using Mecastack one of the most reliable software in this field.

The Mecastack software is a specialized tool for the design and analysis of steel piles subjected to axial, transverse and moment loads. The software allows to check the strength, stability and deformability of the stacks according to international standards. In particular the calculation has been performed according to Eurocode standards.







Note:

1- We use helical strakes in the calculation instead of the porous shroud. The results are not affected because we only need to consider a large wind area. We size the porous shroud based on reliable literature and previous experience.

2- A dummy high damping ratio of 10% has been added to the calculation to make the software ignore the vortex shedding (which is not important because of the shroud).

3- The loads case named "seismic" are referring to the maximum between transportation loads and case "wave and current loads" as shown above in this document. This is required because the software can handle only one seismic loads during the analysis.

MecaStack v5630

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Calculations Prepared by:
Date: Dec 04, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Vent Cross wind-20241204-00.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height = 16.50 m Top of Stack Elevation = 47.06 m
Grade Elevation = 0.00 m Bottom of Stack = 30.56 m

All elevations are entered based upon the bottom of the structure being at Elevation 30.56 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
47.06	0.3238	47.06	6.0	47.06	0.0
41.945	0.3238	42.06	10.0	42.06	3.0
41.56	0.5080			30.865	0.0
37.016	0.5080				
36.016	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
47.06	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		-10.00	206.84	195121	1.53E-05	137.89	8000	517.11
42.06	A-516-60	80.00	204.66	199333	1.20E-05	117.90	7849	413.68
		-10.00	220.63	202705	1.15E-05	117.90	7849	413.68
31.006	S275J0	80.00	239.00	207692	1.20E-05	101.79	7849	356.33

```
                -10.00 275.00   210000 1.20E-05     117.14    7849  410.03
```

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
40.960	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
42.060	38.960	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	33.010	31.510	0.0000	758.00	Oper
External insulation	33.660	30.910	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	31.510	0.000	200.0	Dead

Nozzles:

Num	Description	Elevation m	Nominal Diameter	Schedule	Outer Diameter mm	Thickness mm	Tilt Deg	Orien-tation Deg	Proj-ection mm
1	1N	35.560	10 inch [254.0 mm]	Std	273.1	9.3	0.0	180.0	200.0
2	HW	31.835	8 inch [203.2 mm]	Std	219.1	8.2	0.0	0.0	200.0

Num	Description	Repad Width mm	Repad Thickness mm	Flange Spec	Flange Radial Width mm	Flange Thickness mm	Nozzle Loads
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx	Fy	Fz	Mx	My	Mz	Local/ Global	Load Applied	Load Type	Check WRC 107

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		KN	KN	KN	KN-m	KN-m	KN-m				
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC KN	FyC KN	FzC KN	MxC KN-m	MyC KN-m	MzC KN-m		Ver KN	Shear KN	Mom KN-m	Mbase KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	|	14.46	16.42	7.89	89.99

Equivalent Nozzle Loads Applied on Stack:
Ver = Stack Vertical Load considered at Nozzle Elev: Fy
Shear = Stack Shear Load considered at Nozzle Elev: [Fx^2+Fz^2]^0.5
Mom = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
Mbase = Est Mom at base if no Support: Mom + Shear*Elev
Provided only to evaluate the impact of the load on overall stack

Helical Strakes: (3 Vanes 120 deg apart assumed)

ElTop	= Top Strake Elevation	= 47.06 m
ElBot	= Bottom Strake Elevation	= 41.56 m
Pitch	= Strake Pitch (One complete wrap)	= 1.6190 m
Width	= Strake Width	= 32.4 mm
Thick	= Strake Thickness	= 3.2 mm
OD	= Outer Diameter of Stack and Insulation (If Applicable)	= 323.8 mm
ShapeFac	= Strake Shape Factor (Applied to bare stack shell)	= 1.40
SO	= Stand-off from OD of shell to strake	= 0.0 mm
Len	= Pitch Length: [(PI*(OD+2*SO+2*Width))^2+(Pitch^2)]^0.5	= 32.588 m
Area	= Total Painted Area (3 vanes): (2*Width*Len*3*Wraps)	= 92.932 sq cm
Wraps	= Total Number of Wraps (Top elev - Bot elev)/ Pitch	= 3.40
WtUni	= Estimated Linear Weight of Strakes and Clips: Wt/(ElTop-ElBot)	= 4.54 kg/m
Wt	= Estimated total Wt of Strakes and Clips: 1.5*(Area/2)*Thick*Dens	= 25.0 kg

Type	= Type of Baseplate	= Chair Continuous Plate
SupType	= Type of Support	= Rigid Steel Base
Friction	= Coefficient of Friction for Support	= 0.300
BasisBolt	= Basis for Bolt Design	= Brownell & Young
Nbolt	= Number of Bolts	= 16
Dbolt	= Nominal Bolt Diameter	= 27.0 mm
Dbh	= Bolt Hole Diameter	= 36.0 mm
CAbolt	= Corrosion Allowance on Bolt	= 3.0 mm
CAplt	= Corrosion Allowance on Plates	= 0.0 mm
ID	= Inside Diameter of Baseplate	= 820.0 mm
BCD	= Bolt Circle Diameter of Baseplate	= 1270.0 mm
OD	= Outer Diameter of Baseplate	= 1385.0 mm
Tb	= Thickness of Bottom Plate	= 25.0 mm
Tt	= Thickness of Top Plate	= 25.0 mm
Fw	= Fillet Weld Size	= 5.0 mm

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Fwu       = Weld Ultimate Tensile Strength                          = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                              = 1
Hg        = Height of Anchor Chair                                  = 305.0 mm
Tg        = Thickness of Gusset                                     = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                  = S275J0
Dens      = Material Density                                        = 7849 Kg/m^3
Temp      = Design Temperature                                      = 21.11 Deg C
Fy        = Minimum Yield Stress                                    = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                 = 410030.5
KPa
Sa        = Allowable Tensile Stress                                = 117141.7
KPa
E         = Modulus of Elasticity                                   = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                        = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                               = False
Matl      = Bolt Material Specification                             = Gr. 8.8
Fu        = Ultimate Tensile Stress                                 = 800548.8
KPa
Fy        = Yield Stress                                            = 640440.4
KPa
Fproof    = Proof Stress                                            = 544374.4
KPa
Eb        = Modulus of Elasticity                                   = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile            = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                            = 800.55 MPa
PreStress = Pretension Stress on Bolt                               = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                = Rectangular
Pt        = Plate Washer Thickness                                  = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                  = 90.0 mm
Pl        = Length of Washer Parallel to Shell                      = 100.0 mm
Pdh       = Bolt Hole Diameter                                      = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 42.0 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                 = 323.8 mm
Do        = Outside Diameter of Flange                              = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange            = 25.4 mm
Dbc       = Bolt Circle Diameter                                    = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle             = 54.0 mm
Tf        = Thickness of Flange                                     = 31.8 mm
Tw        = Fillet Weld Size                                        = 6.0 mm
Gus       = Gussets                                                 = False
Db        = Nominal Bolt Diameter                                   = 22.2 mm
Nb        = Number of Bolts                                         = 12
BMatl     = Bolt Material                                           = Gr 8 (US)
```

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```
Fu        = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
FMatl     = Flange Material                                               = A-36
Fyf       = Yield Stress of Flange                                        = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                               = 193742.33
MPa
```

Design Codes

Comprehensive Design Standard:

Stress Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

```
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)     = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters       = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset              = False
```

Wind Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'

```
Vbo       = Basic Wind Velocity (10 minute mean)                          = 28.00 m/s
Cdir      = Directional Factor per Para 4.2                               = 1.000
Cseason   = Season factor per Para 4.2                                    = 1.000
Ki        = Turbulence Factor per Para 4.3.2                              = 1.000
K         = Equivalent Surface Roughness per Table 7.13                   = 0.0200 mm
Terrain   = Terrain Category Per Table 4.1                                = 0
Alt       = Altitude of the site above sea level                          = 0.0000 m
```

Vortex Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'

```
Arrange   = Stack Arrangement                                             = Single
Simplified= Use the simplified method found in Para E.1.5.3 'Approach 2'  = False
Modes     = Number of Modes to consider in Vortex Shedding Analysis       = 1
```

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

```
Life      = Fatigue Life Of Stack In Years                                = 50.0 Years
GMf       = Partial Safety Factor for Fatigue Strength                    = 1.35
GFf       = Partial Safety Factor for Equiv Const Amplitude Stress Range  = 1.00
```

Fatigue Categories: Euro

Elev m	Cat
47.060	69

Seismic Criteria: Manually Specify Seismic Loading

```
Spec      = What is the basis for the loads being entered                 =
Ft        = Load applied at the top of the stack (0 if none)              = 0 N
RatioShear= Ratio of Base Shear to Dead Weight (g-force)                  = 0.700
RatioVer  = Ratio of Base Vertical Load to Dead Weight (g-force)          = 0.700
Method    = Method used to apply the loads to the structure               = ASCE 7-10
Fac_Live  = Factor to apply to Live loads to be treated as Mass           = 0.000
```

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```
Fac_Oper  = Factor to apply to operating loads to be treated as Masses      = 1.000
```

Deflection Criteria:

```
Deflection Criteria for Static Loading:
MaxDefl   = Limitation based upon Stack Ht: Stack_Ht / 133                  = 124.1 mm

Deflection Criteria for Vortex Loading:
DeflLimit = Limitation based upon a % of Top OD: Stack_Top_OD x 0.05        = 16.2 mm
```

Damping Criteria:

```
Structural Damping Criteria:
     Criteria:      ASME STS-1-2021
     Stack Type:   UnLined
     Support:      ELASTIC
```

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

```
   Log Decrement Damping = 2 * PI * Bs

Aerodynamic Damping Criteria:
     (Only used in Along wind analysis, Not considered for vortex shedding)

     Criteria:   EN 1994-1-4
```

Weight Summary (Live)

Component	Elev COG m	Weight kg	Weight N
Platforms (Live, Fac = 1)	40.960	1360.1	13338
Total	40.960	1360.1	13338

Platforms (Live Load)

Platform Elevation m	Platform Total Angle Deg	Platform Width m	Platform Area sq m	Live Load Pressure kPa	Live Load Force kg
40.960	360.0	0.7500	2.964	4.500	1360.1
Total	0.0	0.0000	0.000	0.000	1360.1

Weight Summary (Oper)

Component	Elev COG	Weight	Weight

	m	kg	N
General Attachment Uniform (Oper, Fac = 1)	32.260	1137.0	11150
Nozzle(s)	35.560	-1474.2	-14457
Total	46.688	-337.2	-3307

General Attach Uniform Wt (Oper, Factor = 1): (Wt = 1137.0 kg, El COG = 32.260 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
Water	33.010	31.510	32.260	758.00	1137.0
Total	30.560	30.560	32.260		1137.0

Nozzle Wt (Oper): (Wt = -1474.2 kg, El COG = 35.560 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	35.560	273.1	0.00	0.00	0.00	0.00	-1474.18	35.560	-1474.18
Total		0.0	0.00	0.00	0.00	0.00	-1474.18	35.560	-1474.18

Weight Summary (Dead)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	36.164	2458.5	24110
Ladders	40.510	69.2	679
Platforms	40.960	319.3	3132
Helical Strakes	44.310	25.0	245
Baseplate	30.687	389.0	3815
Structural Flange(s)	42.000	58.0	569
Nozzle(s)	34.097	53.2	521
General Attachment Uniform)	32.285	82.5	809
General Attachment Concentrated	31.510	200.0	1961
Total	35.859	3654.7	35841

Cylindrical Shells Wt: (Wt = 2458.5 kg, El COG = 36.164 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
47.060	42.060	44.560	0.3238	6.0	8000	239.6	47.92	239.6
42.060	41.945	42.003	0.3238	10.0	7849	6.3	77.38	8.9
41.945	41.560	41.753	0.4159	10.0	7849	27.2	100.09	38.5
41.560	37.016	39.288	0.5080	10.0	7849	393.0	122.80	558.0
37.016	36.016	36.516	0.7874	10.0	7849	134.7	191.69	191.7
36.016	31.006	33.511	1.0668	10.0	7849	916.5	260.59	1305.6
31.006	30.865	30.936	1.0668	10.0	7849	25.8	260.59	36.7
30.865	30.560	30.713	1.0668	10.0	7849	79.5	260.59	79.5

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Total	36.164					1822.5		2458.5

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 40.510 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	42.060	38.960	40.510	22.32	69.2
Total			40.510		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 40.960 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
40.960	0.0	360.0	0.7500	0.5080	40.960	319.3
Total					40.960	319.3

Helical Strakes Wt: (Wt = 25.0 kg, El COG = 44.310 m)

El Top m	El Bot m	El COG m	Lin Wt kg/m	TOt Wt kg
47.060	41.560	44.310	4.54	25.0
Total		44.310		25.0

Baseplate Wt: (Wt = 389.0 kg, El COG = 30.687 m)

Description	Elevation COG m	Weight kg
Bottom Plate	30.573	192.0
Top Plate	30.853	120.2
Gussets	30.713	61.1
Washers	30.713	15.6
Total	30.687	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 42.000 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
42.000	482.6	31.8	0.0	0.0	0.0	25.1	7.9	42.000	2	58.0
Total					0.0	25.1	7.9	42.000		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

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Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 34.097 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	35.560	273.1	-3.99	12.06	7.36	16.85	0.00	35.560	32.27
2	31.835	219.1	-2.53	8.51	2.65	12.26	0.00	31.835	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	34.097	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 32.285 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	33.660	30.910	32.285	30.00	82.5
Total	30.560	30.560	32.285		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 31.510 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	31.510	0.000	200.0
Total	31.510		200.0

Weights of Each Lifting Section
Assumes each section with a flange or field weld is a lifting section

Lift Section Number	Elev Bottom m	Elev Top m	Section Length m	Elev Center of Gravity m	Weight kg
1	30.560	42.000	11.4400	35.099	3357.1
2	42.000	47.060	5.0600	44.257	297.6
Total	30.560	47.060	16.5000	35.845	3654.7

Lifting Weight Detailed Breakdown

Component	Lift # 1 kg	Lift # 2 kg	Total kg
Stack	2214.3	244.2	2458.5
Ladder(s)	67.9	1.3	69.2
Platform(s)	319.3	0.0	319.3
Helical Strakes	2.0	23.0	25.0
Baseplate	389.0	0.0	389.0
Structural Flange(s)	29.0	29.0	58.0
Nozzle(s)	53.2	0.0	53.2
Gen Attach Uniform	82.5	0.0	82.5
Gen Attach Concentrated	200.0	0.0	200.0
Total	3357.1	297.6	3654.7

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Wind Area Summary

Elev m	Shape Fac Riser	Riser Area m^2/m	Ladder Area m^2/m	Platform Area m^2/m	Piping Area m^2/m	Attach Area m^2/m	Tot Uni Area m^2/m	Total Area sq m
47.060	1.400	0.453	0.000	0.000	0.000	0.000	0.453	1.360
44.060	1.400	0.453	0.000	0.000	0.000	0.000	0.453	0.907
42.060	1.400	0.453	0.305	0.000	0.000	0.000	0.758	0.025
42.027	1.400	0.453	0.305	1.824	0.000	0.000	2.582	0.211
41.945	1.400	0.453	0.305	1.824	0.000	0.000	2.582	0.331
41.817	1.400	0.539	0.305	1.885	0.000	0.000	2.729	0.350
41.688	1.400	0.625	0.305	1.947	0.000	0.000	2.877	0.369
41.560	0.512	0.260	0.305	2.008	0.000	0.000	2.573	1.544
40.960	0.511	0.260	0.305	0.000	0.000	0.000	0.565	1.129
38.960	0.510	0.259	0.000	0.000	0.000	0.000	0.259	0.504
37.016	0.508	0.258	0.000	0.000	0.000	0.000	0.258	0.086
36.683	0.509	0.353	0.000	0.000	0.000	0.000	0.353	0.118
36.349	0.507	0.446	0.000	0.000	0.000	0.000	0.446	0.149
36.016	0.504	0.538	0.000	0.000	0.000	0.000	0.538	0.172
35.697	0.504	0.537	0.000	0.000	0.000	0.000	0.537	0.073
35.560	0.504	0.537	0.000	0.000	0.000	0.000	0.537	0.073
35.423	0.503	0.537	0.000	0.000	0.000	0.000	0.537	0.947
33.660	0.501	0.534	0.000	0.000	0.000	0.000	0.534	0.347
33.010	0.499	0.533	0.000	0.000	0.000	0.000	0.533	0.567
31.945	0.495	0.528	0.000	0.000	0.000	0.000	0.528	0.058
31.835	0.495	0.528	0.000	0.000	0.000	0.000	0.528	0.058
31.725	0.494	0.527	0.000	0.000	0.000	0.000	0.527	0.114
31.510	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.265
31.006	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.050
30.910	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.024
30.865	0.493	0.526	0.000	0.000	0.000	2.244	2.770	0.845
Total (m^2/m)								10.676

1. Total Riser Wind Area = 6.967 sq m (65.26 % of Total Area)
2. Total Ladder Wind Area = 0.945 sq m (8.85 % of Total Area)
3. Total Platform Wind Area = 2.080 sq m (19.48 % of Total Area)
4. Total Piping Wind Area = 0.000 sq m (0.00 % of Total Area)
5. Total Attachment Wind Area = 0.684 sq m (6.41 % of Total Area)

Wind Area: Ladders

Elev Bot m	Elev Top m	Shape Factor	Overlap	Wind Area m^2/m
42.027	42.060	2.000	No	0.305
41.945	42.027	2.000	No	0.305
41.817	41.945	2.000	No	0.305
41.688	41.817	2.000	No	0.305
41.560	41.688	2.000	No	0.305
40.960	41.560	2.000	No	0.305
38.960	40.960	2.000	No	0.305

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Overlap : When 2 ladders overlap only 25% of one ladder is considered due to shielding.

Wind Area: Platforms

Elev Top m	Elev Bot m	Shape Factor	Wind Area m^2/m	Tot Wind Area sq m
42.027	40.960	2.000	2.008	2.142

Wind Area: General Attachment (Uniform)

Elev Top m	Elev Bot m	Wind Area m^2/m
33.010	31.510	0.000
33.660	30.910	0.000

Wind Area: General Attachment (Concentrated)
Shape factor is accounted for manually by the user in the wind areas entered

Wind Area: General Attachment (Concentrated)

Elev Top m	Elev Bot m	Wind Area m^2/m
31.725	31.510	0.000

Wind Area: Baseplate

OD = Outer diameter of baseplate = 1.3850 m
StackOD = Outer Diameter of Stack = 1.0668 m
Cf_Riser = Wind Shape Factor for Riser = 0.493
Cf_LandP = Wind Shape Factor for Ladders & Platforms = 2.000
Wind Area = OD * Cf_LandP - StackOD * Cf_Riser = 2.244 m^2/m
The Baseplate wind area is included in the 'Attachment' category.

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
47.060	44.060	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
44.060	42.060	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
42.060	42.027	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
42.027	41.945	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
41.945	41.817	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
41.817	41.688	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
41.688	41.560	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
41.560	40.960	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
40.960	38.960	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal

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38.960	37.016	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
37.016	36.683	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
36.683	36.349	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
36.349	36.016	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
36.016	35.697	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
35.697	35.560	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
35.560	35.423	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
35.423	33.660	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
33.660	33.010	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
33.010	31.945	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.945	31.835	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
31.835	31.725	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
31.725	31.510	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.510	31.006	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.006	30.910	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
30.910	30.865	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
30.865	30.560	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5

Section Props - If a number is shown, then the section contains something unusual (Breach, nozzle, stiffeners, etc..) and so the properties were calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Thermal Expansion of Stack
+ values are in the +Y (up) direction and - values are in the -Y (Down)

Elev m	Installation Temperature Deg C	Hot Temperature Deg C	Hot Expansion mm	Cold Temperature Deg C	Cold Expansion mm
47.060	21.11	200.00	23.4	-10.00	-6.5
44.060	21.11	200.00	14.2	-10.00	-5.1
42.060	21.11	80.00	8.1	-10.00	-4.1
42.027	21.11	80.00	8.1	-10.00	-4.1
41.945	21.11	80.00	8.0	-10.00	-4.1
41.817	21.11	80.00	7.9	-10.00	-4.0
41.688	21.11	80.00	7.8	-10.00	-4.0
41.560	21.11	80.00	7.8	-10.00	-3.9
40.960	21.11	80.00	7.3	-10.00	-3.7
38.960	21.11	80.00	5.9	-10.00	-3.0
37.016	21.11	80.00	4.6	-10.00	-2.3
36.683	21.11	80.00	4.3	-10.00	-2.2
36.349	21.11	80.00	4.1	-10.00	-2.1

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36.016	21.11	80.00	3.8	-10.00	-2.0
35.697	21.11	80.00	3.6	-10.00	-1.8
35.560	21.11	80.00	3.5	-10.00	-1.8
35.423	21.11	80.00	3.4	-10.00	-1.7
33.660	21.11	80.00	2.2	-10.00	-1.1
33.010	21.11	80.00	1.7	-10.00	-0.9
31.945	21.11	80.00	1.0	-10.00	-0.5
31.835	21.11	80.00	0.9	-10.00	-0.5
31.725	21.11	80.00	0.8	-10.00	-0.4
31.510	21.11	80.00	0.7	-10.00	-0.3
31.006	21.11	80.00	0.3	-10.00	-0.2
30.910	21.11	80.00	0.2	-10.00	-0.1
30.865	21.11	80.00	0.2	-10.00	-0.1
30.560	21.11	80.00	0.0	-10.00	0.0

1. Elevation for Y restraint = 30.56 m

Frequency Summary

Description	Direction Deg	Mode # 1 Hz	Mode # 2 Hz	Mode # 3 Hz
Hot & Corroded	0.0	3.822	11.290	26.499
Hot & UnCorroded	0.0	4.472	12.368	29.949
Cold & Corroded	0.0	3.860	11.502	26.899
Cold & Uncorroded	0.0	4.518	12.625	30.382

Mode Shape (Hot & Corroded)

Elevation m	Mode # 1 (3.822 Hz) Normalized	Mode # 2 (11.290 Hz) Normalized	Mode # 3 (26.499 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.620	0.111	-0.430
42.060	0.404	-0.224	-0.487
42.027	0.401	-0.226	-0.479
41.945	0.394	-0.231	-0.460
41.817	0.383	-0.237	-0.426
41.688	0.372	-0.242	-0.391
41.560	0.361	-0.247	-0.354
40.960	0.312	-0.260	-0.175
38.960	0.168	-0.240	0.370
37.016	0.077	-0.161	0.535
36.683	0.068	-0.147	0.514
36.349	0.061	-0.134	0.483
36.016	0.054	-0.121	0.448
35.697	0.049	-0.109	0.414
35.560	0.046	-0.105	0.399
35.423	0.044	-0.100	0.384
33.660	0.018	-0.044	0.186
33.010	0.011	-0.027	0.121
31.945	0.003	-0.008	0.037

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31.835	0.003	-0.007	0.031
31.725	0.002	-0.005	0.025
31.510	0.001	-0.003	0.016
31.006	0.000	0.000	0.002
30.910	0.000	0.000	0.001
30.865	0.000	0.000	0.001

Mode Shape (Hot & UnCorroded)

Elevation m	Mode # 1 (4.472 Hz) Normalized	Mode # 2 (12.368 Hz) Normalized	Mode # 3 (29.949 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.597	0.073	-0.510
42.060	0.380	-0.245	-0.485
42.027	0.377	-0.246	-0.476
41.945	0.370	-0.249	-0.452
41.817	0.360	-0.252	-0.414
41.688	0.350	-0.255	-0.375
41.560	0.339	-0.257	-0.334
40.960	0.293	-0.260	-0.143
38.960	0.158	-0.221	0.403
37.016	0.072	-0.143	0.547
36.683	0.064	-0.130	0.524
36.349	0.057	-0.118	0.492
36.016	0.051	-0.107	0.456
35.697	0.046	-0.097	0.421
35.560	0.044	-0.092	0.405
35.423	0.041	-0.088	0.390
33.660	0.017	-0.039	0.189
33.010	0.011	-0.024	0.124
31.945	0.003	-0.007	0.039
31.835	0.003	-0.006	0.033
31.725	0.002	-0.005	0.027
31.510	0.001	-0.003	0.017
31.006	0.000	-0.001	0.003
30.910	0.000	0.000	0.002
30.865	0.000	0.000	0.001

Mode Shape (Cold & Corroded)

Elevation m	Mode # 1 (3.860 Hz) Normalized	Mode # 2 (11.502 Hz) Normalized	Mode # 3 (26.899 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.623	0.117	-0.418
42.060	0.408	-0.221	-0.487
42.027	0.405	-0.223	-0.480
41.945	0.397	-0.228	-0.461
41.817	0.386	-0.235	-0.428
41.688	0.375	-0.240	-0.393
41.560	0.364	-0.245	-0.357
40.960	0.314	-0.260	-0.180

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38.960	0.169	-0.243	0.364
37.016	0.078	-0.164	0.533
36.683	0.069	-0.150	0.512
36.349	0.061	-0.137	0.482
36.016	0.055	-0.124	0.447
35.697	0.049	-0.112	0.413
35.560	0.047	-0.107	0.398
35.423	0.044	-0.102	0.383
33.660	0.018	-0.044	0.186
33.010	0.011	-0.028	0.121
31.945	0.003	-0.008	0.038
31.835	0.003	-0.007	0.031
31.725	0.002	-0.006	0.026
31.510	0.001	-0.003	0.016
31.006	0.000	0.000	0.002
30.910	0.000	0.000	0.001
30.865	0.000	0.000	0.001

Mode Shape (Cold & Uncorroded)

Elevation m	Mode # 1 (4.518 Hz) Normalized	Mode # 2 (12.625 Hz) Normalized	Mode # 3 (30.382 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.601	0.078	-0.497
42.060	0.384	-0.241	-0.486
42.027	0.381	-0.243	-0.477
41.945	0.374	-0.246	-0.454
41.817	0.364	-0.250	-0.416
41.688	0.353	-0.253	-0.377
41.560	0.343	-0.255	-0.338
40.960	0.296	-0.260	-0.148
38.960	0.160	-0.224	0.397
37.016	0.073	-0.145	0.545
36.683	0.065	-0.132	0.522
36.349	0.058	-0.121	0.490
36.016	0.052	-0.109	0.455
35.697	0.046	-0.099	0.420
35.560	0.044	-0.094	0.404
35.423	0.042	-0.090	0.389
33.660	0.017	-0.039	0.189
33.010	0.011	-0.025	0.124
31.945	0.003	-0.008	0.039
31.835	0.003	-0.006	0.033
31.725	0.002	-0.005	0.027
31.510	0.001	-0.003	0.017
31.006	0.000	-0.001	0.003
30.910	0.000	0.000	0.002
30.865	0.000	0.000	0.001

Wind Loads per Eurocode - EN 1991-1-4:2005(E)

Wind Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'
Vbo = Basic Wind Velocity (10 minute mean) = 28.00 m/s
Cdir = Directional Factor per Para 4.2 = 1.000

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Cseason   = Season factor per Para 4.2                                  = 1.000
Ki        = Turbulence Factor per Para 4.3.2                           = 1.000
K         = Equivalent Surface Roughness per Table 7.13                = 0.0200 mm
Terrain   = Terrain Category Per Table 4.1                             = 0
Alt       = Altitude of the site above sea level                       = 0.0000 m
```

Orography Factors {Ref Para 4.3.1}

Elev m	Co
47.060	1.000

```
H         = Distance from Bottom of Stack to Top of Stack              = 16.5000 m
zbase     = Distance from Grade to Bottom of Stack                     = 30.5600 m
b         = Average Wind OD for entire Stack                           = 0.6441 m
Zs        = 0.6*H + zbase  {Fig 6.1}                                   = 40.4600 m
Calt      = 1 + 0.001 * Alt * (10/Zs)^0.2   {Since z > 10 m NA.2b}     = 1.000
Vb        = Basic Wind Velocity: Vbo * Cdir * Calt * Cseason {Eqn 4.1} = 28.00 m/s
Zo        = Terrain Categories and parameters (Table 4.1)              = 0.0030 m
Zmin      = Terrain Categories and parameters (Table 4.1)              = 1.0000 m
Kr        = 0.19 * (Zo / 0.05)^0.07   {Eqn 4.5}                        = 0.156
Sy        = Wind Turbulence: Kr * Vb * Ki {Eqn 4.6}                    = 4.37

Zs        = 0.6*H + zbase  {Fig 6.1}                                   = 40.4600 m
Zt        = Reference height provided in Annex B.1                     = 200.00
Lt        = Reference length scale provided in Annex B.1               = 300.00
Alpha     = 0.67 + 0.05 * Ln(Zo)  {Eqn B.1}                            = 0.380
Lzs       = Lt * (Zs / Zt)^Alpha   {Eqn B.1}                           = 163.575
Cr(Zs)    = Roughness Factor: Kr * ln(Zs/Zo)   {Eqn 4.4}               = 1.484
Co        = Orography factor based upon user entered data @ Elev = 71.020 m = 1.00
Vm(Zs)    = Cr(Zs) * Co(Zs) * Vb  {Eqn 4.3}                            = 41.55 m/s
n         = Natural Frequency                                          = 3.822 Hz
Fl(Zs)    = n * L(Zs) / Vm(Zs)  {Eqn B.2}                              = 15.049
Sl(Zs)    = Spectral - 6.8*Fl(Zs) / (1+10.2*fl(Zs))^(5/3)  {Eqn B.2}   = 0.023

d         = Diameter used for Reynolds Number Calculation              = 0.6441 m
V         = V used for Reynolds Number Calculation                     = 54.74 m/s
Re        = Reynolds Number: d * V / 0.000015  {Eqn 7.15}               = 2.35E+06
Cfo       = Force Coeff for Cylinder without Free End flow per Fig 7.28 = 0.650
Lambda    = Effective Slenderness Ratio per Table 7.16                 = 25.288
Pl        = Lookup value based upon Lambda from Fig 7.16               = 0.801
me        = Equivalent mass per unit length   {F.14}                   = 74.71 kg/m
Ba        = Aero Log Decrement Damping:  Cf*Rho*b*Vm(Zs)/(2*n*me)  [F.18] = 0.0299
Bs        = Structural Log Damping                                     = 0.6283
Bt        = Total Logarithmic Damping: (Bs+Ba)*2*PI  {Eqn B.6}         = 0.658
B2        = Background: 1/(1+0.9*((b+h)/L(Zs))^0.63)  {Eqn B.3}        = 0.821
Nh        = 4.6 * h * fl(Zs) / L(Zs)  {Eqn B.8}                        = 6.983
Nh        = 4.6 * b * fl(Zs) / L(Zs)  {Eqn B.8}                        = 0.273
Rh        = 1/Nh - (1-e^(-2*Nh))/(2*Nh^2)  {Eqn B.7}                   = 0.133
Rb        = 1/Nb - (1-e^(-2*Nb))/(2*Nb^2)  {Eqn B.8}                   = 0.841
Rt        = ((PI^2) / (2*Del)) * Sl * Rh * Rb   {Eqn B.6}              = 0.019
v         = n * (R2 / (B2 + R2))^0.5   {Eqn B.5}                       = 0.579
kp        = (2 * ln(v * 600))^0.5 + 0.6 / (2 * ln(v*600))^0.5  {Eqn B4} = 3.596
Iv(Zs)    = Sv / Vm(Zs)    {Eqn B.7}                                   = 0.105
CsCd      = (1 + 2*kp*Iv(Zs) * (B2+R2)^0.5) / (1 + 7*Iv(Zs))  {Eqn 6.1} = 0.975
Cs        = (1 + 7 * Iv(Zs) * B2^0.5) / (1 + 7 * Iv(Zs))  {Eqn 6.2}    = 0.960
```

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```
Cd        = (1 + 2*kp*Iv(Zs)*((B2+R2)^0.5))/(1+7*Iv(Zs)*B2^0.5)   {Eqn 6.3} = 1.016
Rho       = Air Density                                                      = 1.225
Kg/m^3
qb        = 0.5 * Rho * Vb^2  {Eqn 4.10}                                     = 480.357 kPa
```

Calculate Riser Shape Factors

Z m	D m	V m/s	Re	Lambda	Pl	Cfo	Cf
47.060	0.32	56.06	1.21E+06	50.302	0.88	0.589	0.515
44.060	0.32	55.15	1.19E+06	50.302	0.88	0.587	0.514
42.060	0.32	54.43	1.17E+06	50.302	0.88	0.586	0.513
42.027	0.32	54.41	1.17E+06	50.302	0.88	0.586	0.513
41.945	0.32	54.38	1.17E+06	50.302	0.88	0.586	0.513
41.817	0.39	54.33	1.40E+06	42.284	0.86	0.603	0.517
41.688	0.45	54.28	1.62E+06	36.471	0.84	0.617	0.519
41.560	0.51	54.22	1.84E+06	32.063	0.83	0.629	0.520
40.960	0.51	53.97	1.83E+06	32.063	0.83	0.628	0.519
38.960	0.51	53.00	1.79E+06	32.063	0.83	0.627	0.518
37.016	0.51	51.80	1.75E+06	32.063	0.83	0.625	0.516
36.683	0.69	51.56	2.39E+06	23.460	0.79	0.651	0.516
36.349	0.88	51.30	3.01E+06	18.498	0.77	0.670	0.514
36.016	1.07	51.03	3.63E+06	15.268	0.75	0.684	0.510
35.697	1.07	50.76	3.61E+06	15.268	0.75	0.684	0.510
35.560	1.07	50.64	3.60E+06	15.268	0.75	0.684	0.510
35.423	1.07	50.51	3.59E+06	15.268	0.75	0.683	0.510
33.660	1.07	48.45	3.45E+06	15.268	0.75	0.680	0.507
33.010	1.07	47.37	3.37E+06	15.268	0.75	0.679	0.506
31.945	1.07	44.74	3.18E+06	15.268	0.75	0.674	0.503
31.835	1.07	44.36	3.16E+06	15.268	0.75	0.674	0.502
31.725	1.07	43.95	3.13E+06	15.268	0.75	0.673	0.502
31.510	1.07	43.00	3.06E+06	15.268	0.75	0.671	0.501
31.006	1.07	39.48	2.81E+06	15.268	0.75	0.665	0.496
30.910	1.07	38.34	2.73E+06	15.268	0.75	0.662	0.494
30.865	1.07	37.69	2.68E+06	15.268	0.75	0.661	0.493

```
   Re     = Reynolds Num: D*V / v {Eqn 7.15}          | v  = Air Viscosity: 15*10^-6 m^2/s
   Lambda = Eff Slenderness Ratio {Table 7.16}        | Pl = End Effect Factor {Fig 7.36}
   Cfo    = Force coeff w/o Free-end Flow {Fig 7.28} | Cf = Force coefficient {Eqn 7.19}
```

Wind Pressures and Forces

Z m	Z ft	Cr	Co	Vm m/s	Iv	Ce	Linear Area m^2/m	Total Area sq m	qp kPa	Fw lb	Fw N
47.060	154.396	1.507	1.000	42.21	0.104	3.919	0.453	1.360	1.882	561	2497
44.060	144.553	1.497	1.000	41.92	0.104	3.877	0.453	0.907	1.862	370	1647
42.060	137.992	1.490	1.000	41.72	0.105	3.847	0.758	0.025	1.848	10	45
42.027	137.883	1.490	1.000	41.71	0.105	3.847	2.582	0.211	1.848	86	381
41.945	137.614	1.489	1.000	41.70	0.105	3.845	2.582	0.331	1.847	134	597
41.817	137.193	1.489	1.000	41.69	0.105	3.843	2.729	0.350	1.846	142	631
41.688	136.772	1.488	1.000	41.68	0.105	3.841	2.877	0.369	1.845	149	664
41.560	136.351	1.488	1.000	41.66	0.105	3.839	2.573	1.544	1.844	624	2777
40.960	134.383	1.486	1.000	41.60	0.105	3.830	0.565	1.129	1.840	456	2027

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38.960	127.821	1.478	1.000	41.38	0.106	3.799	0.259	0.504	1.825	201	896
37.016	121.443	1.470	1.000	41.16	0.106	3.766	0.258	0.086	1.809	34	152
36.683	120.350	1.469	1.000	41.12	0.106	3.761	0.353	0.118	1.806	47	208
36.349	119.256	1.467	1.000	41.08	0.106	3.755	0.446	0.149	1.804	59	262
36.016	118.162	1.466	1.000	41.04	0.106	3.749	0.538	0.172	1.801	68	302
35.697	117.114	1.464	1.000	41.00	0.107	3.743	0.537	0.073	1.798	29	129
35.560	116.666	1.464	1.000	40.98	0.107	3.741	0.537	0.073	1.797	29	129
35.423	116.218	1.463	1.000	40.97	0.107	3.739	0.537	0.947	1.796	373	1659
33.660	110.433	1.455	1.000	40.74	0.107	3.707	0.534	0.347	1.781	136	603
33.010	108.300	1.452	1.000	40.66	0.107	3.694	0.533	0.567	1.775	221	982
31.945	104.805	1.447	1.000	40.51	0.108	3.674	0.528	0.058	1.765	22	100
31.835	104.445	1.446	1.000	40.50	0.108	3.672	0.528	0.058	1.764	22	99
31.725	104.086	1.446	1.000	40.48	0.108	3.670	0.527	0.114	1.763	44	195
31.510	103.379	1.445	1.000	40.45	0.108	3.666	0.526	0.265	1.761	102	455
31.006	101.725	1.442	1.000	40.38	0.108	3.656	0.526	0.050	1.756	19	86
30.910	101.410	1.442	1.000	40.37	0.108	3.654	0.526	0.024	1.755	9	41
30.865	101.263	1.442	1.000	40.36	0.108	3.653	2.770	0.845	1.755	325	1446
Total								10.676		4273	19009

Cr = Roughness: kr * ln(z/zo) {Eqn 4.4} | Co = Orography factor {Sec 4.3.1}
Vm = Mean Velocity: Cr(z)*Co(z)*Vb {Eqn 4.3} | Iv = Turbulence: Sv/Vm(z) {Eqn 4.7}
Ce = Exposure: qp(z) / qb {Eqn 4.9} | qp = Peak Vel Press: Ce(z)*qb {Eqn 4.8}
Fw = Force: qp*CsCd*(Total Area) {Eqn 5.3}

Wind Loads Applied to the Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	832.4	2497
44.060	42.060	823.4	1647
42.060	42.027	1366.5	45
42.027	41.945	4653.4	381
41.945	41.817	4651.9	597
41.817	41.688	4914.9	631
41.688	41.560	5177.7	664
41.560	40.960	4628.5	2777
40.960	38.960	1013.3	2027
38.960	37.016	461.0	896
37.016	36.683	455.3	152
36.683	36.349	622.5	208
36.349	36.016	785.5	262
36.016	35.697	944.6	302
35.697	35.560	942.5	129
35.560	35.423	941.6	129
35.423	33.660	940.7	1659
33.660	33.010	927.7	603
33.010	31.945	921.9	982
31.945	31.835	909.7	100
31.835	31.725	908.1	99
31.725	31.510	906.4	195
31.510	31.006	903.3	455

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31.006	30.910	900.8	86
30.910	30.865	900.4	41
30.865	30.560	4740.9	1446
Total			19009

Weight Summary (Seismic)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	36.164	2458.5	24110
Ladders	40.510	69.2	679
Platforms	40.960	319.3	3132
Helical Strakes	44.310	25.0	245
Baseplate	30.687	389.0	3815
Structural Flange(s)	42.000	58.0	569
Nozzle(s)	34.097	53.2	521
General Attachment Uniform)	32.285	82.5	809
General Attachment Uniform (Oper, Fac = 1)	32.260	1137.0	11150
General Attachment Concentrated	31.510	200.0	1961
Nozzle(s)	35.560	-1474.2	-14457
Platforms (Live, Fac = 0)	30.560	0.0	0
Total	34.758	3317.6	32534

Seismic Loads Entered by User are Based upon

Seismic Criteria: Manually Specify Seismic Loading

Spec	= What is the basis for the loads being entered	=
Ft	= Load applied at the top of the stack (0 if none)	= 0 N
RatioShear	= Ratio of Base Shear to Dead Weight (g-force)	= 0.700
RatioVer	= Ratio of Base Vertical Load to Dead Weight (g-force)	= 0.700
Method	= Method used to apply the loads to the structure	= ASCE 7-10
Fac_Live	= Factor to apply to Live loads to be treated as Mass	= 0.000
Fac_Oper	= Factor to apply to operating loads to be treated as Masses	= 1.000
T	= Period of Structure	= 0.221 s
Wt	= Weight of stack	= 3317.6 kg
Wt	= Weight of stack	= 32534 N
Base_Shear	= Seismic Base Shear (RatioShear * Wt)	= 22774 N
Base_Ver	= Seismic Base Vertical Load (RatioVer * Wt)	= 22774 N
Kfac	= Exponent based upon Period per ASCE 7-10 Eqn 12.8-12	= 1.000

Elev m	hx m	wx N	wx*hx^k	Cvx	Shear N	Ver N
45.560	15.0000	1544	23161.8	0.171	3893	1080
43.060	12.5000	1029	12867.7	0.095	2163	720
42.043	11.4834	319	3659.2	0.027	615	223
41.986	11.4259	368	4208.9	0.031	707	258
41.881	11.3208	160	1809.5	0.013	304	112
41.753	11.1925	160	1789.0	0.013	301	112
41.624	11.0642	160	1768.5	0.013	297	112
41.260	10.7000	2420	25900.7	0.191	4353	1694

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39.960	9.4000	4412	41490.0	0.306	6973	3088
37.988	7.4280	2341	17396.3	0.128	2924	1639
36.849	6.2893	627	3942.6	0.029	663	439
36.516	5.9560	627	3733.7	0.028	628	439
36.183	5.6227	627	3524.7	0.026	592	439
35.856	5.2963	816	4325.7	0.032	727	571
35.628	5.0683	-6721	-34078.4	-0.252	-5728	-4705
35.492	4.9317	-6721	-33160.4	-0.245	-5573	-4705
34.542	3.9817	4507	17951.1	0.132	3017	3155
33.335	2.7750	1852	5142.2	0.038	864	1297
32.477	1.9173	10956	21014.5	0.155	3532	7669
31.890	1.3298	1229	1634.7	0.012	275	860
31.780	1.2202	1229	1500.0	0.011	252	860
31.618	1.0577	3196	3382.2	0.025	568	2237
31.258	0.6980	2417	1687.7	0.012	284	1692
30.958	0.3980	274	108.9	0.001	18	192
30.888	0.3275	115	37.7	0.000	6	80
30.713	0.1525	4594	700.9	0.005	118	3216
Total	0.0000	32534	135499.2	1.000	22774	22774

hx = Distance from Bottom of Stack
Elev = Elevation above grade
Denom = Summation(wx*hx^k) = 135499
Cvx = % of Total Base Shear: wx*hx^k / Denom
Ver = RatioVer * wx

Seismic Loads Applied to Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	1297.6	3893
44.060	42.060	1081.4	2163
42.060	42.027	18526.7	615
42.027	41.945	8647.6	707
41.945	41.817	2369.8	304
41.817	41.688	2343.0	301
41.688	41.560	2316.1	297
41.560	40.960	7255.4	4353
40.960	38.960	3486.7	6973
38.960	37.016	1504.0	2924
37.016	36.683	1988.0	663
36.683	36.349	1882.6	628
36.349	36.016	1777.2	592
36.016	35.697	2275.7	727
35.697	35.560	-41953.3	-5728
35.560	35.423	-40823.2	-5573
35.423	33.660	1710.9	3017
33.660	33.010	1329.6	864
33.010	31.945	3315.0	3532
31.945	31.835	2508.2	275
31.835	31.725	2301.6	252
31.725	31.510	2638.3	568
31.510	31.006	562.8	284

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31.006	30.910	190.7	18
30.910	30.865	140.7	6
30.865	30.560	386.2	118
------	------	--------	-----
Total			22774

Vortex Shedding Summary

Mode Num	Configuration	Frequency Hz	Crit Wind Speed m/s	Reduced Mass kg	Defl Max m	Defl Limit m	Defl Ratio	Comment
1	Hot & Corroded	3.822	6.88	208	0.0007	0.0162	0.041	PASS
1	Hot & UnCorroded	4.472	8.05	194	0.0007	0.0162	0.043	PASS
1	Cold & Corroded	3.860	6.95	210	0.0007	0.0162	0.041	PASS
1	Cold & Uncorroded	4.518	8.13	196	0.0007	0.0162	0.043	PASS

1. Defl Ratio = Defl Max / Defl Limit

Vortex Shedding Analysis per Eurocode: EN 1991-1-4:2005+A1:2010
Ref Para E.1.5.2 Approach 1 for calculation of cross wind amplitudes

Zcr	= (5/6) * Stack Ht + Dist from Grade To Base Of Stack	= 74.870 m
Co	= Orography factor based upon user entered data @ Elev = 74.870 m	= 1.00
Vm	= Mean Wind Velocity: Cr * Co * Vb {Eqn 4.3}	= 41.94 m/s
Bs	= Structural Log Decrement Damping	= 0.6283
St	= Strouhal number for a single stack	= 0.180
Vc	= Critical Wind Speed: b * n / S	= 8.13 m/s
b	= Diameter at Turbulence Zone (Mode # 1)	= 0.3238 m
n	= Natural Frequency of Mode # 1	= 4.518 Hz
me	= Equivalent mass per unit length	= 73.40 kg/m
Nodes	= Number of Nodes	= 1
AntiNodes	= Number of AntiNodes	= 1

Summary of Nodes and Antinodes

Num	Node Elevation m	Anti-Node Elevation m
1	30.560	47.060

Nodes are where the lateral deflection is zero
Anti-Nodes are the points between nodes where the deflection is maximum

Correlation Length # 1:		
b1	= Average Diameter for Correction Length # 1	= 0.3238 m
yf/b1	= Ratio of yf / b1	= 0.00
L1	= Since Yf/b < 0.1: 6 * b	= 1.9428 m
L1_Top	= Top Elevation for Correlation Length # 1	= 47.060 m
L1_Bot	= Bot Elevation for Correlation Length # 1	= 45.117 m
Clat Calculation for Correlation Length # 1:		
b1	= Average diameter for correlation length # 1	= 0.3238 m

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```
Vm1       = Mean wind speed for Correlation Length # 1 {Eqn 4.3}            = 37.63 m/s
Vcrit1    = Critical Wind Speed:  b1 * n / St  {Eqn E.2}                    = 8.13 m/s
Re1       = Reynolds Number:  b1 * Vcrit1 / (15*10^-6 m^2/2)   {Eqn E.5}    = 1.75E+05
Ratio1    = Ratio:  Vcrit1 / Vm1  {Ref Table E.3}                           = 0.216
Clat01    = Basic lateral force coeffic for circular cylinders {Fig E.2}    = 0.700
Clat1     = Since Ratio <= 0.83: Clat0 {Table E.3}                          = 0.700

Clat      = Maximum value of Clat from all considered correlation lengths   = 0.700

Check to Determine if Strakes Adequate to Meet EN 1993-3-2:2006 Sec B.2(3):
b         = Average Wind OD in Strake Region                                = 0.3281 m
h         = Stack Height                                                    = 16.5000 m
P         = Strake Pitch                                                    = 1.6190 m
Pmin      = Minimum Acceptable Pitch: 4.5*b                                 = 1.4764 m
Pmax      = Maximum Acceptable Pitch: 5*b                                   = 1.6405 m
Chk1      = Pitch in Acceptable Range:  Pmin <= P <= Pmax                   = True

T         = Strake Depth                                                    = 32.4 mm
Tmin      = Minimum Acceptable Strake Depth: 0.1*b                          = 32.8 mm
Tmax      = Maximum Acceptable Strake Depth: 0.12*b                         = 39.4 mm
Chk2      = Depth in Acceptable Range:  Tmin <= T <= Tmax                   = False

Ls        = Length of Straked Region                                        = 5.5000 m
Lmin      = Minimum Req'd Strake Length: 0.3*h                              = 4.9500 m
Lmax      = Maximum Req'd Strake Length: 0.5*h                              = 8.2500 m
Chk3      = Length in Acceptable Range:  Lmin <= L <= Lmax                  = True

Lu        = Length of Unstraked Portion at top of Stack                     = 0.0000 m
Lu_Max    = Max Allowed Unstraked Length: b                                 = 0.3281 m
Chk4      = Unstraked Length @ Top Acceptable: Lu <= Lu_max                 = True

Sc        = Scruton Number: 2 * me * Bs / (Rho * D1^2)                      = 699.25
Chk5      = Scruton Number is Larger than 8                                 = True

Straked?  = Are all strake criteria from EN 1993-3-2 Section B.2(3) Met?    = False

Kw        = Effective Correlation length Factor Kw {Eqn E.8}                = 0.522
K         = Mode shape factor K                                             = 0.137

Calculate yf for Correlation Length # 1:
b1        = Average Outer Diameter at correlation length # 1                = 0.3238 m
St        = Strouhal number for a single stack                              = 0.180
Sc        = Scruton Number: 2 * me * Bs / (Rho * D1^2)                      = 717.94
yf1       = (1/St^2) * (1/Sc) * K * Kw * clat * b     {Eqn E.7}             = 0.0007 m

yf        = Maximum yf from all correlation lengths considered  {Eqn E.7}   = 0.0007 m

Eo        = Bandwidth factor:  0.3    {Eqn E.10}                            = 0.300
Number of cycles calculations based upon EN 1991-1-4 Section E.1.5.2.6:
Vcrit     = Critical Wind Speed corresponding to Clat calculation           = 8.13 m/s
Vm        = Mean Wind Speed corresponding to Clat calculation               = 41.94 m/s
Vo        = Weibull probability distribution * (2)^0.5: 0.2*Vm  {Eqn E.10}  = 8.39 m/s
Tyrs      = Life of Structure in Years                                      = 50.0 Years
T         = Life of Structure in Seconds: 3.2*10^7 * T                      = 1.60E+09
N         = Num Cycles: 2*T*n*Eo*(Vcrit/Vo)^2*Exp(-(Vcrit/Vo)^2) {Eqn E.10} = 1.593E+09

 Elev      Elev     mtot         m        Phi       Ht        Fw         Fw       Fw
```

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m	ft	kg	kg/m		m	Uniform N/m	Total lb	Total N
77.620	254.658	157.4	52.46	1.000	3.0000	29.5	20	88
74.620	244.815	104.9	52.46	0.601	2.0000	17.7	8	35
72.620	238.254	3.5	104.24	0.384	0.0332	22.5	0	1
72.587	238.145	37.5	459.00	0.381	0.0818	98.3	2	8
72.505	237.877	16.3	126.96	0.374	0.1283	26.7	1	3
72.377	237.455	16.3	126.96	0.364	0.1283	25.9	1	3
72.248	237.034	16.3	126.96	0.353	0.1283	25.2	1	3
72.120	236.613	246.7	411.23	0.343	0.6000	79.2	11	48
71.520	234.645	449.9	224.95	0.296	2.0000	37.4	17	75
69.520	228.083	238.7	122.80	0.160	1.9440	11.0	5	21
67.576	221.705	63.9	191.69	0.073	0.3333	7.9	1	3
67.243	220.612	63.9	191.69	0.065	0.3333	7.0	1	2
66.909	219.518	63.9	191.69	0.058	0.3333	6.3	0	2
66.576	218.424	83.3	260.59	0.052	0.3195	7.6	1	2
66.257	217.376	-685.4	-5020.12	0.046	0.1365	-130.8	-4	-18
66.120	216.928	-685.4	-5020.12	0.044	0.1365	-124.3	-4	-17
65.983	216.481	459.5	260.59	0.042	1.7635	6.1	2	11
64.220	210.695	188.9	290.59	0.017	0.6500	2.8	0	2
63.570	208.562	1117.2	1048.59	0.011	1.0655	6.3	2	7
62.505	205.067	125.3	1143.92	0.003	0.1095	2.0	0	0
62.395	204.707	125.3	1143.92	0.003	0.1095	1.7	0	0
62.285	204.348	325.9	1512.71	0.002	0.2155	1.8	0	0
62.070	203.641	246.5	489.00	0.001	0.5040	0.4	0	0
61.566	201.988	27.9	290.59	0.000	0.0960	0.0	0	0
61.470	201.673	11.7	260.59	0.000	0.0450	0.0	0	0
61.425	201.525	468.5	1536.00	0.000	0.3050	0.1	0	0
Total		3288.5					63	281

Fw = m * (2*PI*n)^2 * Phi * yf {Eqn E.6} m = Uniform mass

Vortex Shedding Loads Applied to Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	29.5	88
44.060	42.060	17.7	35
42.060	42.027	22.5	1
42.027	41.945	98.3	8
41.945	41.817	26.7	3
41.817	41.688	25.9	3
41.688	41.560	25.2	3
41.560	40.960	79.2	48
40.960	38.960	37.4	75
38.960	37.016	11.0	21
37.016	36.683	7.9	3
36.683	36.349	7.0	2
36.349	36.016	6.3	2
36.016	35.697	7.6	2
35.697	35.560	-130.8	-18
35.560	35.423	-124.3	-17

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35.423	33.660	6.1	11
33.660	33.010	2.8	2
33.010	31.945	6.3	7
31.945	31.835	2.0	0
31.835	31.725	1.7	0
31.725	31.510	1.8	0
31.510	31.006	0.4	0
31.006	30.910	0.0	0
30.910	30.865	0.0	0
30.865	30.560	0.1	0
------	------	-------	-----
Total			281

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Live	L
3	Operating	O
4	Thermal Hot	TH
5	Wind	W
6	Seismic Hor	Eh
7	Seismic Ver	Ev
8	Vortex Across	V

Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	L	O	TH	W	Eh	Ev	V
9	A: 0.9*D 0 Deg	X		1.100	0	0.9							
10	A: 1.1*D+1.5*W+0.9*L+0.9*O 0 D	X		1.100	0	1.1	0.9	0.9		1.5			
11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0	X		1.100	0	1.35	0.9	0.9		1.5			
12	B: 1.0*D 0 Deg	X		1.100	0	1.0							
13	C: 1.0*D+1.3*W+0.78*L+0.78*O 0	X		1.100	0	1.0	0.78	0.78		1.3			
14	Serviceability: 1.0*D+1.0*W 0		X	1.100	0	1.0				1.0			
15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	X		1.100	0	1.0	1.0	1.0			1.0		
16	1.0*D+1.0*S 0 Deg	X		1.100	0	1.0					1.0		
17	Serviceability: 1.0*D+1.0*S 0		X	1.100	0	1.0					1.0		
18	D+O+P 0 Deg	X		1.000	0	1.0		1.0					

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated
Stress Criteria: EN 1993-3-2 (Limit States)
Wind Criteria: EN 1991-1-4 (Ultimate)
Seismic Criteria: MANUAL (N/A)
Wind Combinations:
Service wind loads specified, use combos per EN 1990 Appendix A

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Seismic Combinations:
Seismic code is based upon ultimate loads, and so are the EN 1990 Table A1.3 combinations,
so we use the factors from that table

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
27	Fixed	0.0000	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed

Riser Stiffening Ring Property Summary
All stiffening rings as well as other components that behave as stiffening rings

ID	Country	Shape	Size	Config	Material	Inside Stack?

The material properties for the shell/ring section are based upon the shell.
Software does not evaluate any problems that could arise if the riser is a different material than the stiffening rings.

Ring Num	Elev m	Stiff Ring	Eff Shell Width mm	Shell Thickness mm	Ls m	Area sq cm	Mom of Inertia cm^4	Section Modulus cm^3	Xc mm
1	42.000	Flange	65.6	7.0	10.6275	55.014	343.67	79.4	36.1
2	30.865	Baseplate Top	493.3	10.0	5.7200	89.110	2417.41	191.3	32.7
3	30.560	Baseplate Bot	493.3	10.0	0.1525	119.960	10913.54	541.9	81.1

Properties are for the combined stiffener and effective shell (Corroded)
Ls = Ring spacing, 1/2 of shell on each side of ring.
Xc = Centroid of combined section from OD of stack shell
Effective Shell Width Each Side of Stiff = 0.975*(0.5*D*Shell_Thk)^0.4 [EN 1993-1-6 Sec B3.1]

Stiffening Ring: [1] Flange
El 42.0 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	79.4	63.5	39.7	0.0	50.419	264.88	271.45
Shell Above	7.0	32.8	-3.5	16.4	2.298	0.09	36.11
Shell Below	7.0	32.8	-3.5	-16.4	2.298	0.09	36.11
Total			36.1	0.0	55.014		343.67

X & Y axis are local used for this calculation & may not correspond to global X & Y.

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Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 79.4 cm^3

Stiffening Ring: [2] Baseplate Top
El 30.865 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	159.1	25.0	79.6	0.0	39.775	839.04	1710.61
Shell Above	10.0	246.7	-5.0	123.3	24.667	2.06	353.40
Shell Below	10.0	246.7	-5.0	-123.3	24.667	2.06	353.40
Total			32.7	0.0	89.110		2417.41

X & Y axis are local used for this calculation & may not correspond to global X & Y.
Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 191.3 cm^3

Stiffening Ring: [3] Baseplate Bot
El 30.56 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	282.5	25.0	141.3	0.0	70.625	4696.93	7251.88
Shell Above	10.0	246.7	-5.0	123.3	24.667	2.06	1830.83
Shell Below	10.0	246.7	-5.0	-123.3	24.667	2.06	1830.83
Total			81.1	0.0	119.960		10913.54

X & Y axis are local used for this calculation & may not correspond to global X & Y.
Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 541.9 cm^3

Summary of Stiffening Ring Check for Static Ovalling
Are Stiff Rings are Adequate to consider riser 'Stiffened'

Ring Num	Elev m	d m	t mm	rm m	we kPa	Ls m	My N-m	Sact cm^3	Sreqd cm^3	Unity Sreqd/Sact
1	72.560	0.3238	7.0	0.1584	1.848	10.6275	246.3	79.4	1.3	0.017
2	61.425	1.0668	10.0	0.5284	1.755	5.7200	1401.1	191.3	6.4	0.034
3	61.120	1.0668	10.0	0.5284	1.755	0.1525	37.4	541.9	0.2	0.000

d = Outer Diameter of Stack
Ls = 1/2 of dist each side of stiff
My = Moment: 0.5*rm^2*we*Ls
t = Corroded Thickness of shell
Sact = Act Sec Modulus of Ring+Shell
we = Wind Press at Elevation

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Sreqd = My / (Fy / 1.1)

Verify that Beam Theory can be Used per EN 1993-3-2 [5.1]

Since the Chimney is considered to be Stiffend then Beam Theory can be used.

Fatigue Analysis Vortex Shedding per Eurocode
Ref EN 1993-2 Sect 9.2 and EN 1993-1-9

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

Life = Fatigue Life Of Stack In Years = 50.0 Years
GMf = Partial Safety Factor for Fatigue Strength = 1.35
GFf = Partial Safety Factor for Equiv Const Amplitude Stress Range = 1.00

Fatigue Categories: Euro

Elev m	Cat
47.060	69

Number of cycles calculations based upon EN 1991-1-4 Section E.1.5.2.6:
Vcrit = Critical Wind Speed corresponding to Clat calculation = 8.13 m/s
Vm = Mean Wind Speed corresponding to Clat calculation = 41.94 m/s
Vo = Weibull probability distribution * (2)^0.5: 0.2*Vm {Eqn E.10} = 8.39 m/s
Tyrs = Life of Structure in Years = 50.0 Years
T = Life of Structure in Seconds: 3.2*10^7 * T = 1.60E+09
N = Num Cycles: 2*T*n*Eo*(Vcrit/Vo)^2*Exp(-(Vcrit/Vo)^2) {Eqn E.10} = 1.593E+09
m = Slope of S-N curve per EN 1993-1-9 Figure 7.1 = 0.000
Since N > 1E08 then the S-N curve Is flat And m = 0

Lambda = Equivalence Factor (N / 2E6)^(1/m) [EN 1993-3-2 9.2] = 2.187
Since N > 1E8 then use N = 1e8 And m = 5 for Lamda calculation

Fatigue Analysis Vortex Shedding for Load # 8 - Vortex Across
Fatigue Analysis per Eurocode EN 1993-1-9

Top El m	Bot El m	Moment KN-m	DSE MPa	DSE2 MPa	DSc MPa	Ratio
47.060	44.060	0.13	0.57	1.24	69.00	0.024
44.060	42.060	0.34	1.48	3.23	69.00	0.063
42.060	42.027	0.35	1.29	2.83	69.00	0.055
42.027	41.945	0.36	1.33	2.91	69.00	0.057
41.945	41.817	0.38	1.39	3.05	69.00	0.060
41.817	41.688	0.39	1.02	2.23	69.00	0.044
41.688	41.560	0.41	0.79	1.72	69.00	0.034
41.560	40.960	0.51	0.75	1.65	69.00	0.032
40.960	38.960	0.97	1.42	3.11	69.00	0.061
38.960	37.016	1.50	2.21	4.83	69.00	0.094
37.016	36.683	1.60	2.35	5.14	69.00	0.101
36.683	36.349	1.70	1.32	2.88	69.00	0.056
36.349	36.016	1.79	0.86	1.88	69.00	0.037
36.016	35.697	1.89	0.62	1.35	69.00	0.026

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35.697	35.560	1.93	0.62	1.36	69.00	0.027
35.560	35.423	1.96	0.66	1.45	69.00	0.028
35.423	33.660	2.43	0.79	1.73	69.00	0.034
33.660	33.010	2.61	0.85	1.86	69.00	0.036
33.010	31.945	2.91	0.95	2.07	69.00	0.041
31.945	31.835	2.94	0.96	2.09	69.00	0.041
31.835	31.725	2.97	1.03	2.26	69.00	0.044
31.725	31.510	3.03	0.99	2.16	69.00	0.042
31.510	31.006	3.17	1.03	2.26	69.00	0.044
31.006	30.910	3.20	1.04	2.28	69.00	0.045
30.910	30.865	3.21	1.05	2.29	69.00	0.045
30.865	30.560	3.29	0.44	0.96	69.00	0.019

DSE = 2 x Bending Stress DSE2 = DSE * Lambda [EN 1993-3-2 9.1]
DSc = Fatigue Strength Category Ratio: GFf*DSE2 / (DSc / GMf) [EN 1993-1-9 8.2]

Fatigue Analysis Along Wind per Eurocode
Ref EN 1993-2 Sect 9.2.1, EN 1993-3-1 9.2.1 and EN 1993-1-9

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

Life = Fatigue Life Of Stack In Years = 50.0 Years
GMf = Partial Safety Factor for Fatigue Strength = 1.35
GFf = Partial Safety Factor for Equiv Const Amplitude Stress Range = 1.00

Fatigue Categories: Euro

Elev m	Cat
47.060	69

N = Number of cycles: EN 1993-3-1 Eqn 9.1: 10^5*Tyrs/50 = 1.000E+05
m = Slope of S-N curve per EN 1993-1-9 Figure 7.1 = 3.000
Lambda = Equivalence Factor [EN 1993-3-2 9.2] = 0.368
qp = (1 + 7 * Iv(Z) * 0.5 * Rho * Vm(Z) {Eqn 4.10} = 1572.585 kPa
Rho = Air Density = 1.225 Kg/m^3
qb = 0.5 * Rho * Vb^2 {Eqn 4.10} = 480.357 kPa
Ce = qp(Z) / qb {Eqn 4.9} = 3.274
G = Gust Response Factor: ce*cs*cd-1 {EN 1993-3-1 Eqn 9.1} = 2.193

Fatigue Analysis Along Wind for Load # 5 - Wind
Fatigue Analysis per Eurocode EN 1993-1-9

Top El m	Bot El m	Moment KN-m	SR MPa	DSE MPa	DSE2 MPa	DSc MPa	Ratio
47.060	44.060	3.75	16.03	7.96	2.93	69.00	0.057
44.060	42.060	10.39	44.45	22.09	8.14	69.00	0.159
42.060	42.027	10.52	38.97	19.36	7.13	69.00	0.140
42.027	41.945	10.88	40.30	20.02	7.38	69.00	0.144
41.945	41.817	11.51	42.61	21.17	7.80	69.00	0.153
41.817	41.688	12.21	31.62	15.71	5.79	69.00	0.113

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41.688	41.560	13.00	24.85	12.35	4.55	69.00	0.089
41.560	40.960	17.71	26.02	12.93	4.76	69.00	0.093
40.960	38.960	38.21	56.15	27.89	10.28	69.00	0.201
38.960	37.016	60.99	89.60	44.52	16.40	69.00	0.321
37.016	36.683	65.06	95.60	47.50	17.50	69.00	0.342
36.683	36.349	69.20	53.84	26.75	9.85	69.00	0.193
36.349	36.016	73.42	35.28	17.53	6.46	69.00	0.126
36.016	35.697	77.55	25.28	12.56	4.63	69.00	0.091
35.697	35.560	79.35	25.70	12.77	4.70	69.00	0.092
35.560	35.423	81.16	27.39	13.61	5.01	69.00	0.098
35.423	33.660	106.15	34.61	17.19	6.33	69.00	0.124
33.660	33.010	116.10	37.85	18.80	6.93	69.00	0.136
33.010	31.945	133.25	43.44	21.58	7.95	69.00	0.156
31.945	31.835	135.07	43.98	21.85	8.05	69.00	0.157
31.835	31.725	136.90	47.60	23.65	8.71	69.00	0.170
31.725	31.510	140.54	45.82	22.76	8.39	69.00	0.164
31.510	31.006	149.21	48.65	24.17	8.90	69.00	0.174
31.006	30.910	150.89	49.19	24.44	9.00	69.00	0.176
30.910	30.865	151.68	49.45	24.57	9.05	69.00	0.177
30.865	30.560	157.26	20.93	10.40	3.83	69.00	0.075

Moment = Moment due to 1.0 x Wind Loads (10 minute mean wind speed)
SR = Full Stress Range due to 10 minute Mean wind speed: Moment / Sec Mod
DSE = 1.1*(SR-(G/r)*SR) [EN 1993-3-1 9.1] DSE2 = DSE * Lambda [EN 1993-3-2 9.1]
DSc = Fatigue Strength Category Ratio: GFf*DSE2 / (DSc / GMf) [EN 1993-1-9 8.2]

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
47.060	44.060	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.097	PASS
44.060	42.060	16	1.0*D+1.0*S 0 Deg	Buckling	0.261	PASS
42.060	42.027	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.168	PASS
42.027	41.945	16	1.0*D+1.0*S 0 Deg	Buckling	0.174	PASS
41.945	41.817	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.184	PASS
41.817	41.688	16	1.0*D+1.0*S 0 Deg	Buckling	0.139	PASS
41.688	41.560	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.111	PASS
41.560	40.960	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.118	PASS
40.960	38.960	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.263	PASS
38.960	37.016	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.442	PASS
37.016	36.683	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.476	PASS
36.683	36.349	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.249	PASS
36.349	36.016	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.171	PASS
36.016	35.697	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.129	PASS
35.697	35.560	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.131	PASS
35.560	35.423	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.145	PASS
35.423	33.660	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.193	PASS
33.660	33.010	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.214	PASS
33.010	31.945	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.252	PASS
31.945	31.835	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.257	PASS
31.835	31.725	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.279	PASS
31.725	31.510	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.271	PASS

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31.510	31.006	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.291	PASS
31.006	30.910	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.258	PASS
30.910	30.865	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.260	PASS
30.865	30.560	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.103	PASS

STACK COMPRESSIVE STRESSES PER EN 1991-1-6, Worst Case
Highest Unity ratios for each member and the load case that produces it.

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio	Load Case
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097	15
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261	16
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168	15
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174	16
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184	15
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139	16
41.560	19.50	4.94	0.51	18.64	19.15	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111	11
40.960	26.56	5.62	0.51	19.51	20.02	0.04	169.82	18.98	1.935	1.327	0.118	0.016	0.118	11
38.960	58.10	22.49	2.04	42.68	44.73	0.04	169.82	18.98	1.935	1.327	0.263	0.076	0.263	15
37.016	99.06	25.08	2.28	72.77	75.05	0.04	169.82	18.98	1.935	1.327	0.442	0.206	0.442	15
36.683	106.68	26.56	2.41	78.37	80.78	0.04	169.82	18.98	1.935	1.327	0.476	0.238	0.476	15
36.349	114.52	27.19	1.80	44.54	46.34	0.06	186.06	10.34	2.000	1.292	0.249	0.063	0.249	15
36.016	122.56	27.82	1.45	29.45	30.89	0.07	180.23	6.85	1.977	1.278	0.171	0.034	0.171	15
35.697	130.47	28.54	1.22	21.27	22.49	0.09	173.90	5.47	1.951	1.272	0.129	0.024	0.129	15
35.560	133.51	29.12	1.13	21.62	22.75	0.09	174.04	5.47	1.952	1.272	0.131	0.024	0.131	15
35.423	145.91	15.33	0.67	24.62	25.28	0.09	174.71	5.47	1.954	1.272	0.145	0.028	0.145	15
33.660	201.93	17.76	0.76	32.92	33.68	0.09	174.82	5.47	1.955	1.272	0.193	0.045	0.193	15
33.010	223.84	20.94	0.90	36.49	37.39	0.09	174.78	5.47	1.955	1.272	0.214	0.054	0.214	15
31.945	260.40	35.63	1.53	42.45	43.98	0.09	174.47	5.47	1.953	1.272	0.252	0.073	0.252	11
31.835	264.75	41.82	1.69	43.10	44.79	0.09	174.38	5.47	1.953	1.272	0.257	0.075	0.257	11

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```
31.725 269.12 43.25  1.91 46.78 48.69  0.09 174.34   5.47 1.953 1.272 0.279 0.088 0.279
11
31.510 277.76 44.96  1.93 45.28 47.21  0.09 174.29   5.47 1.953 1.272 0.271 0.083 0.271
11
31.006 298.22 49.72  2.13 48.61 50.74  0.09 174.26   5.47 1.952 1.272 0.291 0.095 0.291
11
30.910 302.15 50.87  2.18 49.25 51.44  0.09 199.09   5.70 1.937 1.270 0.258 0.078 0.258
11
30.865 304.00 51.13  2.19 49.55 51.75  0.09 199.09   5.70 1.937 1.270 0.260 0.078 0.260
11
30.560 316.88 57.41  0.90 21.09 21.99  0.08 212.95 217.27 1.985 2.000 0.103 0.011 0.103
11

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Buckling Summary Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.69	0.12	0.00	0.12	0.03	130.79	31.32	1.976	1.424	0.001	0.000	0.001
42.060	0.00	1.85	0.31	0.00	0.31	0.03	130.79	31.32	1.976	1.424	0.002	0.000	0.002
42.027	0.00	2.33	0.33	0.00	0.33	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.945	0.00	2.90	0.42	0.00	0.42	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.817	0.00	3.01	0.43	0.00	0.43	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.688	0.00	3.15	0.38	0.00	0.38	0.03	175.79	32.93	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.29	0.34	0.00	0.34	0.04	172.76	24.52	1.946	1.349	0.002	0.000	0.002
40.960	0.00	3.75	0.34	0.00	0.34	0.04	169.82	18.98	1.935	1.327	0.002	0.000	0.002
38.960	0.00	8.23	0.75	0.00	0.75	0.04	169.82	18.98	1.935	1.327	0.004	0.000	0.004
37.016	0.00	10.57	0.96	0.00	0.96	0.04	169.82	18.98	1.935	1.327	0.006	0.000	0.006
36.683	0.00	11.90	1.08	0.00	1.08	0.04	169.82	18.98	1.935	1.327	0.006	0.000	0.006
36.349	0.00	12.47	0.82	0.00	0.82	0.06	161.35	10.34	1.900	1.292	0.006	0.001	0.006
36.016	0.00	13.03	0.68	0.00	0.68	0.07	153.32	6.85	1.868	1.278	0.011	0.003	0.011
35.697	0.00	13.68	0.59	0.00	0.59	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
35.560	0.00	14.20	0.55	0.00	0.55	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
35.423	0.00	14.80	0.64	0.00	0.64	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
33.660	0.00	16.99	0.73	0.00	0.73	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
33.010	0.00	19.85	0.85	0.00	0.85	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.945	0.00	22.05	0.95	0.00	0.95	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.835	0.00	23.56	0.95	0.00	0.95	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.725	0.00	24.02	1.06	0.00	1.06	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.510	0.00	24.44	1.05	0.00	1.05	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.006	0.00	27.13	1.16	0.00	1.16	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
30.910	0.00	27.90	1.20	0.00	1.20	0.09	165.11	5.70	1.820	1.270	0.015	0.005	0.015
30.865	0.00	28.07	1.20	0.00	1.20	0.09	165.11	5.70	1.820	1.270	0.015	0.005	0.015

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30.560   0.00 32.26  0.51  0.00  0.51  0.08 197.44 217.27 1.932 2.000 0.003 0.000 0.003

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 9
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 32.26 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	w m	l m	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.60	3.1	0.391	204.66	0.200	0.989	0.375	0.867	1459.11	177.49	161.35

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36.016 191.4 10.6275 1.0 0.60 3.5 0.366 204.66 0.200 0.956 0.422 0.824 1150.45 168.65
153.32
35.697 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.560 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.423 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.660 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.010 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.945 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.835 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.725 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.510 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.006 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
30.910 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.865 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.200 0.979 0.319 0.909 2355.72 217.18
197.44

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98

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37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.62	0.85	0.14	12.02	12.17	0.03	130.79	31.32	1.976	1.424	0.093	0.009	0.093
42.060	15.58	2.26	0.38	33.34	33.72	0.03	130.79	31.32	1.976	1.424	0.258	0.069	0.258
42.027	15.79	2.85	0.41	29.23	29.64	0.03	178.95	46.59	1.971	1.438	0.166	0.029	0.166
41.945	16.32	3.54	0.51	30.22	30.73	0.03	178.95	46.59	1.971	1.438	0.172	0.031	0.172
41.817	17.26	3.67	0.53	31.96	32.49	0.03	178.95	46.59	1.971	1.438	0.182	0.035	0.182
41.688	18.32	3.85	0.46	23.72	24.18	0.03	175.79	32.93	1.959	1.383	0.138	0.021	0.138
41.560	19.50	4.02	0.42	18.64	19.06	0.04	172.76	24.52	1.946	1.349	0.110	0.014	0.110
40.960	26.56	4.58	0.42	19.51	19.93	0.04	169.82	18.98	1.935	1.327	0.117	0.016	0.117
38.960	57.32	22.07	2.00	42.11	44.11	0.04	169.82	18.98	1.935	1.327	0.260	0.074	0.260
37.016	91.48	24.92	2.26	67.20	69.46	0.04	169.82	18.98	1.935	1.327	0.409	0.178	0.409
36.683	97.60	26.55	2.41	71.70	74.11	0.04	169.82	18.98	1.935	1.327	0.436	0.201	0.436
36.349	103.81	27.24	1.80	40.38	42.18	0.06	186.06	10.34	2.000	1.292	0.227	0.053	0.227
36.016	110.13	27.93	1.45	26.46	27.91	0.07	180.09	6.85	1.976	1.278	0.155	0.028	0.155
35.697	116.33	28.72	1.23	18.96	20.19	0.09	173.71	5.47	1.950	1.272	0.116	0.020	0.116
35.560	119.02	29.36	1.13	19.27	20.41	0.09	173.87	5.47	1.951	1.272	0.117	0.021	0.117
35.423	130.86	17.09	0.74	22.08	22.82	0.09	174.53	5.47	1.954	1.272	0.131	0.024	0.131
33.660	194.41	19.76	0.85	31.69	32.54	0.09	174.72	5.47	1.954	1.272	0.186	0.043	0.186
33.010	218.93	23.25	1.00	35.69	36.68	0.09	174.68	5.47	1.954	1.272	0.210	0.053	0.210
31.945	260.40	29.51	1.27	42.45	43.71	0.09	174.63	5.47	1.954	1.272	0.250	0.072	0.250
31.835	264.75	35.28	1.42	43.10	44.52	0.09	174.55	5.47	1.954	1.272	0.255	0.075	0.255

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31.725 269.12 36.58  1.62 46.78 48.40  0.09 174.51   5.47 1.953 1.272 0.277 0.087 0.277
31.510 277.76 38.18  1.64 45.28 46.91  0.09 174.46   5.47 1.953 1.272 0.269 0.082 0.269
31.006 298.22 42.18  1.81 48.61 50.42  0.09 174.43   5.47 1.953 1.272 0.289 0.094 0.289
30.910 302.15 43.12  1.85 49.25 51.10  0.09 199.30   5.70 1.938 1.270 0.256 0.076 0.256
30.865 304.00 43.34  1.86 49.55 51.41  0.09 199.31   5.70 1.938 1.270 0.258 0.077 0.258
30.560 316.88 48.45  0.76 21.09 21.85  0.08 213.07 217.27 1.985 2.000 0.103 0.011 0.103

   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 10
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 48.45 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82

```
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.296 0.989 0.293 1.000 2390.29 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.295 0.956 0.330 0.968 1877.48 198.10
180.09
35.697 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1544.00 191.08
173.71
35.560 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1547.44 191.25
173.87
35.423 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.06 191.99
174.53
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.361 0.939 1566.14 192.19
174.72
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1565.42 192.15
174.68
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1564.30 192.10
174.63
31.835 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.42 192.00
174.55
31.725 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.48 191.96
174.51
31.510 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.53 191.91
174.46
31.006 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.938 1559.91 191.88
174.43
30.910 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.12 219.23
199.30
30.865 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.15 219.24
199.31
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.297 0.979 0.319 0.981 2355.72 234.38
213.07

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59

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41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.62	1.04	0.17	12.02	12.20	0.03	130.79	31.32	1.976	1.424	0.093	0.009	0.093
42.060	15.58	2.78	0.46	33.34	33.80	0.03	130.79	31.32	1.976	1.424	0.258	0.069	0.258
42.027	15.79	3.50	0.50	29.23	29.73	0.03	178.95	46.59	1.971	1.438	0.166	0.029	0.166
41.945	16.32	4.34	0.62	30.22	30.85	0.03	178.95	46.59	1.971	1.438	0.172	0.031	0.172
41.817	17.26	4.51	0.65	31.96	32.61	0.03	178.95	46.59	1.971	1.438	0.182	0.035	0.182
41.688	18.32	4.72	0.57	23.72	24.28	0.03	175.79	32.93	1.959	1.383	0.138	0.021	0.138
41.560	19.50	4.94	0.51	18.64	19.15	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	26.56	5.62	0.51	19.51	20.02	0.04	169.82	18.98	1.935	1.327	0.118	0.016	0.118
38.960	57.32	24.35	2.21	42.11	44.32	0.04	169.82	18.98	1.935	1.327	0.261	0.075	0.261
37.016	91.48	27.85	2.53	67.20	69.73	0.04	169.82	18.98	1.935	1.327	0.411	0.179	0.411
36.683	97.60	29.86	2.71	71.70	74.41	0.04	169.82	18.98	1.935	1.327	0.438	0.203	0.438
36.349	103.81	30.70	2.03	40.38	42.41	0.06	186.06	10.34	2.000	1.292	0.228	0.053	0.228
36.016	110.13	31.55	1.64	26.46	28.10	0.07	179.91	6.85	1.975	1.278	0.156	0.029	0.156
35.697	116.33	32.52	1.40	18.96	20.36	0.09	173.49	5.47	1.949	1.272	0.117	0.021	0.117

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```
35.560 119.02 33.31  1.29 19.27 20.56  0.09 173.66   5.47 1.950 1.272 0.118 0.021 0.118
35.423 130.86 21.20  0.92 22.08 23.00  0.09 174.32   5.47 1.953 1.272 0.132 0.024 0.132
33.660 194.41 24.48  1.05 31.69 32.74  0.09 174.54   5.47 1.954 1.272 0.188 0.043 0.188
33.010 218.93 28.77  1.23 35.69 36.92  0.09 174.51   5.47 1.953 1.272 0.212 0.053 0.212
31.945 260.40 35.63  1.53 42.45 43.98  0.09 174.47   5.47 1.953 1.272 0.252 0.073 0.252
31.835 264.75 41.82  1.69 43.10 44.79  0.09 174.38   5.47 1.953 1.272 0.257 0.075 0.257
31.725 269.12 43.25  1.91 46.78 48.69  0.09 174.34   5.47 1.953 1.272 0.279 0.088 0.279
31.510 277.76 44.96  1.93 45.28 47.21  0.09 174.29   5.47 1.953 1.272 0.271 0.083 0.271
31.006 298.22 49.72  2.13 48.61 50.74  0.09 174.26   5.47 1.952 1.272 0.291 0.095 0.291
30.910 302.15 50.87  2.18 49.25 51.44  0.09 199.09   5.70 1.937 1.270 0.258 0.078 0.258
30.865 304.00 51.13  2.19 49.55 51.75  0.09 199.09   5.70 1.937 1.270 0.260 0.078 0.260
30.560 316.88 57.41  0.90 21.09 21.99  0.08 212.95 217.27 1.985 2.000 0.103 0.011 0.103

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 11
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 57.41 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                                 MPa     MPa
MPa
------ ------ ------- --- ---- --- ----- ------ ----- ----- ----- ----- ----- ------- ------ ---
---
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
```

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```
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.295 0.989 0.293 1.000 2385.26 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.294 0.956 0.331 0.967 1872.60 197.90
179.91
35.697 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.293 0.928 0.365 0.932 1539.24 190.84
173.49
35.560 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.294 0.928 0.364 0.933 1543.00 191.03
173.66
35.423 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1557.31 191.75
174.32
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.33 192.00
174.54
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.47 191.96
174.51
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.63 191.91
174.47
31.835 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1558.81 191.82
174.38
31.725 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1557.77 191.77
174.34
31.510 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1556.76 191.72
174.29
31.006 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1556.02 191.68
174.26
30.910 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.916 1621.01 219.00
199.09
30.865 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.916 1621.04 219.00
199.09
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.980 2355.72 234.25
212.95

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

```
  Bot   Cq  Cqs    aq    Lq   Lpq    Kw  qw_max  qeq    Xq   f_qEd s_qRcr  s_qRk  s_qRd
```

Elev m							kPa	kPa		MPa	MPa	MPa	MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.77	0.13	0.00	0.13	0.03	130.79	31.32	1.976	1.424	0.001	0.000	0.001
42.060	0.00	2.06	0.34	0.00	0.34	0.03	130.79	31.32	1.976	1.424	0.003	0.000	0.003
42.027	0.00	2.59	0.37	0.00	0.37	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.945	0.00	3.22	0.46	0.00	0.46	0.03	178.95	46.59	1.971	1.438	0.003	0.000	0.003
41.817	0.00	3.34	0.48	0.00	0.48	0.03	178.95	46.59	1.971	1.438	0.003	0.000	0.003
41.688	0.00	3.50	0.42	0.00	0.42	0.03	175.79	32.93	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.66	0.38	0.00	0.38	0.04	172.76	24.52	1.946	1.349	0.002	0.000	0.002
40.960	0.00	4.17	0.38	0.00	0.38	0.04	169.82	18.98	1.935	1.327	0.002	0.000	0.002

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38.960   0.00  9.15  0.83  0.00  0.83  0.04 169.82  18.98 1.935 1.327 0.005 0.000 0.005
37.016   0.00 11.74  1.07  0.00  1.07  0.04 169.82  18.98 1.935 1.327 0.006 0.000 0.006
36.683   0.00 13.22  1.20  0.00  1.20  0.04 169.82  18.98 1.935 1.327 0.007 0.000 0.007
36.349   0.00 13.85  0.92  0.00  0.92  0.06 161.35  10.34 1.900 1.292 0.006 0.001 0.006
36.016   0.00 14.48  0.75  0.00  0.75  0.07 153.32   6.85 1.868 1.278 0.011 0.003 0.011
35.697   0.00 15.20  0.65  0.00  0.65  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
35.560   0.00 15.78  0.61  0.00  0.61  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
35.423   0.00 16.45  0.71  0.00  0.71  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
33.660   0.00 18.88  0.81  0.00  0.81  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
33.010   0.00 22.05  0.95  0.00  0.95  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.945   0.00 24.50  1.05  0.00  1.05  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.835   0.00 26.17  1.06  0.00  1.06  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.725   0.00 26.69  1.18  0.00  1.18  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.510   0.00 27.15  1.17  0.00  1.17  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.006   0.00 30.14  1.29  0.00  1.29  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
30.910   0.00 30.99  1.33  0.00  1.33  0.09 165.11   5.70 1.820 1.270 0.015 0.005 0.015
30.865   0.00 31.19  1.34  0.00  1.34  0.09 165.11   5.70 1.820 1.270 0.015 0.005 0.015
30.560   0.00 35.84  0.56  0.00  0.56  0.08 197.44 217.27 1.932 2.000 0.003 0.000 0.003

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 12
Per EN 1993-3-2: Para 5.2.3

```
Nb      = Design Value of Total Vertical Load at Base [5.5]                = 35.84 KN
Ncrit   = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio  = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                              MPa     MPa
MPa
------ ------ -------- --- ---- --- ------ ------ ------ ------ ------ ------ ------- ------ ---
---
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
```

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```
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.60 3.1 0.391 204.66 0.200 0.989 0.375 0.867 1459.11 177.49
161.35
36.016 191.4 10.6275 1.0 0.60 3.5 0.366 204.66 0.200 0.956 0.422 0.824 1150.45 168.65
153.32
35.697 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.560 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.423 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.660 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.010 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.945 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.835 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.725 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.510 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.006 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
30.910 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.865 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.200 0.979 0.319 0.909 2355.72 217.18
197.44

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	4.87	0.77	0.13	10.42	10.55	0.03	130.79	31.32	1.976	1.424	0.081	0.007	0.081

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```
42.060  13.50  2.06  0.34 28.90 29.24  0.03 130.79  31.32 1.976 1.424 0.224 0.052 0.224
42.027  13.68  2.59  0.37 25.33 25.70  0.03 178.95  46.59 1.971 1.438 0.144 0.022 0.144
41.945  14.15  3.22  0.46 26.19 26.66  0.03 178.95  46.59 1.971 1.438 0.149 0.023 0.149
41.817  14.96  3.34  0.48 27.70 28.18  0.03 178.95  46.59 1.971 1.438 0.157 0.026 0.157
41.688  15.87  3.50  0.42 20.55 20.97  0.03 175.79  32.93 1.959 1.383 0.119 0.016 0.119
41.560  16.90  3.66  0.38 16.15 16.53  0.04 172.76  24.52 1.946 1.349 0.096 0.011 0.096
40.960  23.02  4.17  0.38 16.91 17.29  0.04 169.82  18.98 1.935 1.327 0.102 0.012 0.102
38.960  49.68 19.55  1.77 36.50 38.27  0.04 169.82  18.98 1.935 1.327 0.225 0.056 0.225
37.016  79.28 22.14  2.01 58.24 60.25  0.04 169.82  18.98 1.935 1.327 0.355 0.135 0.355
36.683  84.58 23.63  2.14 62.14 64.28  0.04 169.82  18.98 1.935 1.327 0.379 0.153 0.379
36.349  89.96 24.26  1.60 34.99 36.60  0.06 186.06  10.34 2.000 1.292 0.197 0.040 0.197
36.016  95.45 24.88  1.30 22.93 24.23  0.07 180.05   6.85 1.976 1.278 0.135 0.022 0.135
35.697 100.82 25.60  1.10 16.43 17.53  0.09 173.66   5.47 1.950 1.272 0.101 0.017 0.101
35.560 103.15 26.19  1.01 16.70 17.72  0.09 173.82   5.47 1.951 1.272 0.102 0.017 0.102
35.423 113.41 15.58  0.68 19.13 19.81  0.09 174.49   5.47 1.953 1.272 0.114 0.020 0.114
33.660 168.49 18.00  0.77 27.46 28.24  0.09 174.68   5.47 1.954 1.272 0.162 0.034 0.162
33.010 189.74 21.18  0.91 30.93 31.84  0.09 174.65   5.47 1.954 1.272 0.182 0.041 0.182
31.945 225.68 26.72  1.15 36.79 37.93  0.09 174.60   5.47 1.954 1.272 0.217 0.056 0.217
31.835 229.45 31.80  1.28 37.35 38.64  0.09 174.51   5.47 1.953 1.272 0.221 0.058 0.221
31.725 233.24 32.95  1.46 40.54 42.00  0.09 174.47   5.47 1.953 1.272 0.241 0.067 0.241
31.510 240.73 34.35  1.47 39.24 40.71  0.09 174.43   5.47 1.953 1.272 0.233 0.064 0.233
31.006 258.46 37.96  1.63 42.13 43.76  0.09 174.40   5.47 1.953 1.272 0.251 0.072 0.251
30.910 261.87 38.82  1.67 42.69 44.35  0.09 199.26   5.70 1.938 1.270 0.223 0.059 0.223
30.865 263.47 39.01  1.67 42.95 44.62  0.09 199.26   5.70 1.938 1.270 0.224 0.060 0.224
30.560 274.63 43.67  0.68 18.28 18.96  0.08 213.04 217.27 1.985 2.000 0.089 0.008 0.089

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 13
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 43.67 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000

          Since Nratio <= 0.1 then Secondary Moments need not be considered.
```

Meridional Buckling Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx    Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m             mm           MPa                            MPa     MPa
MPa
------ ------ -------- --- ---- --- ------ ------ ------ ------ ------ ------ ------- ------ ---
---
```

```
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.296 0.989 0.293 1.000 2389.20 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.295 0.956 0.330 0.968 1876.42 198.05
180.05
35.697 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.294 0.928 0.364 0.933 1542.97 191.03
173.66
35.560 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1546.47 191.21
173.82
35.423 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.03 191.93
174.49
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1565.32 192.15
174.68
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1564.57 192.11
174.65
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1563.51 192.06
174.60
31.835 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.63 191.96
174.51
31.725 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.68 191.92
174.47
31.510 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1559.72 191.87
174.43
31.006 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1559.07 191.84
174.40
30.910 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.917 1624.23 219.18
199.26
30.865 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.917 1624.26 219.19
199.26
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.981 2355.72 234.35
213.04

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
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   Lpx   = (ax / (1-B))^0.5  [8.16]          Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17] s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                  s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]    fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

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Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139
41.560	19.59	3.66	0.38	18.73	19.10	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	25.86	4.17	0.38	19.00	19.38	0.04	169.82	18.98	1.935	1.327	0.114	0.015	0.114
38.960	58.10	22.49	2.04	42.68	44.73	0.04	169.82	18.98	1.935	1.327	0.263	0.076	0.263
37.016	99.06	25.08	2.28	72.77	75.05	0.04	169.82	18.98	1.935	1.327	0.442	0.206	0.442
36.683	106.68	26.56	2.41	78.37	80.78	0.04	169.82	18.98	1.935	1.327	0.476	0.238	0.476
36.349	114.52	27.19	1.80	44.54	46.34	0.06	186.06	10.34	2.000	1.292	0.249	0.063	0.249
36.016	122.56	27.82	1.45	29.45	30.89	0.07	180.23	6.85	1.977	1.278	0.171	0.034	0.171
35.697	130.47	28.54	1.22	21.27	22.49	0.09	173.90	5.47	1.951	1.272	0.129	0.024	0.129
35.560	133.51	29.12	1.13	21.62	22.75	0.09	174.04	5.47	1.952	1.272	0.131	0.024	0.131
35.423	145.91	15.33	0.67	24.62	25.28	0.09	174.71	5.47	1.954	1.272	0.145	0.028	0.145
33.660	201.93	17.76	0.76	32.92	33.68	0.09	174.82	5.47	1.955	1.272	0.193	0.045	0.193
33.010	223.84	20.94	0.90	36.49	37.39	0.09	174.78	5.47	1.955	1.272	0.214	0.054	0.214
31.945	262.10	27.34	1.17	42.72	43.90	0.09	174.70	5.47	1.954	1.272	0.251	0.072	0.251
31.835	266.24	33.38	1.35	43.34	44.69	0.09	174.60	5.47	1.954	1.272	0.256	0.075	0.256
31.725	270.41	34.71	1.54	47.01	48.54	0.09	174.56	5.47	1.954	1.272	0.278	0.087	0.278
31.510	278.70	36.38	1.56	45.43	46.99	0.09	174.51	5.47	1.953	1.272	0.269	0.082	0.269
31.006	298.31	40.17	1.72	48.63	50.35	0.09	174.48	5.47	1.953	1.272	0.289	0.093	0.289
30.910	302.06	41.03	1.76	49.24	51.00	0.09	199.36	5.70	1.938	1.270	0.256	0.076	0.256
30.865	303.82	41.22	1.77	49.52	51.29	0.09	199.36	5.70	1.938	1.270	0.257	0.077	0.257
30.560	315.76	45.87	0.72	21.01	21.73	0.08	213.10	217.27	1.986	2.000	0.102	0.011	0.102

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 15
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 45.87 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

Bot	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd

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Elev m	m	mm	MPa					MPa	MPa	MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.98	3.1	0.391	204.66	0.296	0.989	0.292	1.000	2394.09	204.66	186.06
36.016	191.4	10.6275	1.0	0.98	3.5	0.366	204.66	0.295	0.956	0.330	0.969	1881.48	198.25	180.23
35.697	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.364	0.935	1548.17	191.29	173.90
35.560	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.935	1551.31	191.45	174.04
35.423	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.98	192.18	174.71
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.298	0.928	0.361	0.940	1568.32	192.30	174.82
33.010	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.298	0.928	0.361	0.939	1567.43	192.25	174.78
31.945	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.72	192.17	174.70
31.835	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.57	192.06	174.60
31.725	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.62	192.01	174.56
31.510	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.61	191.96	174.51
31.006	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1560.97	191.93	174.48
30.910	173.9	10.6275	1.0	0.99	3.8	0.345	239.00	0.297	0.928	0.383	0.918	1626.24	219.30	199.36
30.865	173.9	10.6275	1.0	0.99	3.8	0.345	239.00	0.297	0.928	0.383	0.918	1626.26	219.30	199.36
30.560	2.1	0.1525	1.0	1.00	4.6	0.383	239.00	0.297	0.979	0.319	0.981	2355.72	234.41	213.10

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   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139
41.560	19.59	3.66	0.38	18.73	19.10	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	25.86	4.17	0.38	19.00	19.38	0.04	169.82	18.98	1.935	1.327	0.114	0.015	0.114
38.960	58.10	9.15	0.83	42.68	43.51	0.04	169.82	18.98	1.935	1.327	0.256	0.072	0.256
37.016	99.06	11.74	1.07	72.77	73.84	0.04	169.82	18.98	1.935	1.327	0.435	0.200	0.435
36.683	106.68	13.22	1.20	78.37	79.57	0.04	169.82	18.98	1.935	1.327	0.469	0.231	0.469
36.349	114.52	13.85	0.92	44.54	45.46	0.06	186.06	10.34	2.000	1.292	0.244	0.061	0.244
36.016	122.56	14.48	0.75	29.45	30.20	0.07	180.83	6.85	1.979	1.278	0.167	0.032	0.167
35.697	130.47	15.20	0.65	21.27	21.92	0.09	174.61	5.47	1.954	1.272	0.126	0.023	0.126
35.560	133.51	15.78	0.61	21.62	22.23	0.09	174.68	5.47	1.954	1.272	0.127	0.023	0.127
35.423	135.78	16.45	0.71	22.91	23.62	0.09	174.60	5.47	1.954	1.272	0.135	0.025	0.135
33.660	162.85	18.88	0.81	26.55	27.35	0.09	174.62	5.47	1.954	1.272	0.157	0.032	0.157
33.010	174.08	22.05	0.95	28.38	29.32	0.09	174.54	5.47	1.954	1.272	0.168	0.036	0.168
31.945	194.85	24.50	1.05	31.76	32.81	0.09	174.55	5.47	1.954	1.272	0.188	0.043	0.188
31.835	197.19	26.17	1.06	32.10	33.16	0.09	174.55	5.47	1.954	1.272	0.190	0.044	0.190
31.725	199.56	26.69	1.18	34.69	35.87	0.09	174.52	5.47	1.953	1.272	0.206	0.051	0.206
31.510	204.32	27.15	1.17	33.30	34.47	0.09	174.49	5.47	1.953	1.272	0.198	0.047	0.198
31.006	215.65	30.14	1.29	35.15	36.45	0.09	174.45	5.47	1.953	1.272	0.209	0.052	0.209
30.910	217.82	30.99	1.33	35.51	36.84	0.09	199.31	5.70	1.938	1.270	0.185	0.043	0.185
30.865	218.84	31.19	1.34	35.67	37.01	0.09	199.31	5.70	1.938	1.270	0.186	0.043	0.186
30.560	225.77	35.84	0.56	15.03	15.59	0.08	213.05	217.27	1.985	2.000	0.073	0.006	0.073

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 16
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 35.84 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

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Meridional Buckling Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.99	3.1	0.391	204.66	0.298	0.989	0.291	1.000	2412.24	204.66	186.06
36.016	191.4	10.6275	1.0	0.99	3.5	0.366	204.66	0.298	0.956	0.328	0.972	1898.28	198.91	180.83
35.697	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.80	192.07	174.61
35.560	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.27	192.15	174.68
35.423	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.51	192.06	174.60
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.89	192.08	174.62
33.010	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.21	191.99	174.54
31.945	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.36	192.00	174.55
31.835	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.49	192.01	174.55
31.725	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.81	191.97	174.52
31.510	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.24	191.94	174.49
31.006	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.296	0.928	0.362	0.938	1560.17	191.89	174.45

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30.910 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.19 219.24
199.31
30.865 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.15 219.24
199.31
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.981 2355.72 234.35
213.05

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
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s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.77	0.13	0.00	0.13	0.03	143.87	34.45	1.976	1.424	0.001	0.000	0.001
42.060	0.00	2.06	0.34	0.00	0.34	0.03	143.87	34.45	1.976	1.424	0.002	0.000	0.002
42.027	0.00	2.59	0.37	0.00	0.37	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.945	0.00	3.22	0.46	0.00	0.46	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.817	0.00	3.34	0.48	0.00	0.48	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.688	0.00	3.50	0.42	0.00	0.42	0.03	193.37	36.23	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.66	0.38	0.00	0.38	0.04	190.03	26.97	1.946	1.349	0.002	0.000	0.002
40.960	0.00	4.17	0.38	0.00	0.38	0.04	186.80	20.88	1.935	1.327	0.002	0.000	0.002
38.960	0.00	9.15	0.83	0.00	0.83	0.04	186.80	20.88	1.935	1.327	0.004	0.000	0.004
37.016	0.00	11.74	1.07	0.00	1.07	0.04	186.80	20.88	1.935	1.327	0.006	0.000	0.006
36.683	0.00	13.22	1.20	0.00	1.20	0.04	186.80	20.88	1.935	1.327	0.006	0.000	0.006
36.349	0.00	13.85	0.92	0.00	0.92	0.06	177.49	11.38	1.900	1.292	0.005	0.001	0.005
36.016	0.00	14.48	0.75	0.00	0.75	0.07	168.65	7.53	1.868	1.278	0.010	0.003	0.010
35.697	0.00	15.20	0.65	0.00	0.65	0.09	160.12	6.02	1.837	1.272	0.015	0.005	0.015
35.560	0.00	15.78	0.61	0.00	0.61	0.09	160.12	6.02	1.837	1.272	0.015	0.005	0.015
35.423	10.13	1.99	0.09	1.71	1.80	0.09	191.49	6.02	1.952	1.272	0.015	0.005	0.015
33.660	39.09	4.42	0.19	6.37	6.56	0.09	192.10	6.02	1.954	1.272	0.034	0.006	0.034
33.010	49.76	7.60	0.33	8.11	8.44	0.09	191.79	6.02	1.953	1.272	0.044	0.007	0.044
31.945	67.25	14.00	0.60	10.96	11.56	0.09	191.37	6.02	1.951	1.272	0.060	0.009	0.060
31.835	69.05	20.04	0.81	11.24	12.05	0.09	190.89	6.02	1.950	1.272	0.063	0.009	0.063
31.725	70.85	21.37	0.95	12.32	13.26	0.09	190.76	6.02	1.949	1.272	0.070	0.010	0.070
31.510	74.39	23.05	0.99	12.13	13.11	0.09	190.63	6.02	1.949	1.272	0.069	0.010	0.069
31.006	82.66	26.83	1.15	13.47	14.63	0.09	190.52	6.02	1.948	1.272	0.077	0.011	0.077
30.910	84.24	27.69	1.19	13.73	14.92	0.09	217.62	6.27	1.933	1.270	0.069	0.010	0.069
30.865	84.98	27.88	1.20	13.85	15.05	0.09	217.62	6.27	1.933	1.270	0.069	0.010	0.069
30.560	89.99	32.53	0.51	5.99	6.50	0.08	233.49	239.00	1.983	2.000	0.028	0.001	0.028

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 18
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 32.53 KN

Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	143.87
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	143.87
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	193.37
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	190.03
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
36.349	215.6	10.6275	1.0	0.60	3.1	0.391	204.66	0.200	0.989	0.375	0.867	1459.11	177.49	177.49
36.016	191.4	10.6275	1.0	0.60	3.5	0.366	204.66	0.200	0.956	0.422	0.824	1150.45	168.65	168.65
35.697	173.9	10.6275	1.0	0.60	3.8	0.345	204.66	0.200	0.928	0.464	0.782	949.58	160.12	160.12
35.560	173.9	10.6275	1.0	0.60	3.8	0.345	204.66	0.200	0.928	0.464	0.782	949.58	160.12	160.12
35.423	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.936	1552.18	191.49	191.49
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1564.34	192.10	192.10
33.010	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.296	0.928	0.362	0.937	1558.18	191.79	191.79
31.945	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.935	1549.75	191.37	191.37
31.835	173.9	10.6275	1.0	0.97	3.8	0.345	204.66	0.293	0.928	0.365	0.933	1540.19	190.89	190.89

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31.725 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.293 0.928 0.365 0.932 1537.51 190.76
190.76
31.510 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.292 0.928 0.365 0.931 1534.91 190.63
190.63
31.006 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.292 0.928 0.365 0.931 1532.80 190.52
190.52
30.910 173.9 10.6275 1.0 0.97 3.8 0.345 239.00 0.292 0.928 0.387 0.911 1596.48 217.62
217.62
30.865 173.9 10.6275 1.0 0.97 3.8 0.345 239.00 0.292 0.928 0.387 0.911 1596.57 217.62
217.62
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.292 0.979 0.319 0.977 2355.72 233.49
233.49

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	34.45
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	34.45
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	51.25
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	51.25
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	51.25
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	36.23
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	26.97
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	20.88
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	20.88
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	20.88
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	20.88
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	11.38
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	7.53
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	6.02
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	6.02
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	6.02
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	6.02
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	6.02
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	6.02
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	6.02
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	6.02
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	6.02
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	6.02
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	6.27
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	6.27

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30.560 1.00 2.11 0.500 0.257 1.118 0.818 1.755 1.435 1.0000 0.08 3620.51 239.00 239.00

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Summary of Maximum Stack Deflection
A summary of the worst lateral deflections for the stack and the load case the produced them.

Elev m	Load #	Load Case	Defl Max mm	Defl Limit mm	Unity	Result
47.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	67.4	124.1	0.543	Pass
44.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	42.9	101.5	0.422	Pass
42.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.7	86.5	0.332	Pass
42.027	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.5	86.2	0.331	Pass
41.945	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.0	85.6	0.327	Pass
41.817	17	Serviceability: 1.0*D+1.0*S 0 Deg	27.2	84.6	0.322	Pass
41.688	17	Serviceability: 1.0*D+1.0*S 0 Deg	26.5	83.7	0.316	Pass
41.560	17	Serviceability: 1.0*D+1.0*S 0 Deg	25.7	82.7	0.311	Pass
40.960	17	Serviceability: 1.0*D+1.0*S 0 Deg	22.3	78.2	0.285	Pass
38.960	17	Serviceability: 1.0*D+1.0*S 0 Deg	12.1	63.2	0.192	Pass
37.016	17	Serviceability: 1.0*D+1.0*S 0 Deg	5.6	48.5	0.114	Pass
36.683	17	Serviceability: 1.0*D+1.0*S 0 Deg	4.9	46.0	0.107	Pass
36.349	17	Serviceability: 1.0*D+1.0*S 0 Deg	4.4	43.5	0.101	Pass
36.016	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.9	41.0	0.095	Pass
35.697	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.5	38.6	0.090	Pass
35.560	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.3	37.6	0.088	Pass
35.423	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.1	36.6	0.086	Pass
33.660	17	Serviceability: 1.0*D+1.0*S 0 Deg	1.3	23.3	0.055	Pass
33.010	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.8	18.4	0.043	Pass
31.945	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	10.4	0.022	Pass
31.835	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	9.6	0.019	Pass
31.725	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	8.8	0.017	Pass
31.510	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.1	7.1	0.013	Pass
31.006	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	3.4	0.004	Pass
30.910	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	2.6	0.002	Pass
30.865	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	2.3	0.002	Pass
30.865	14	Serviceability: 1.0*D+1.0*W 0 Deg	0.0	NaN	0.000	Pass

Ratio = Defl Max / Defl Limit

Stack Deflection Load # 14
Load Combination Serviceability: 1.0*D+1.0*W 0 Deg

Elev	Dx	Dy	Dz	Dres	Limit	Ratio	Rresult

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m	mm	mm	mm	mm	mm		
47.060	43.4	-0.1	0.0	43.4	124.1	0.350	Pass
44.060	27.6	-0.1	0.0	27.6	101.5	0.272	Pass
42.060	18.5	-0.1	0.0	18.5	86.5	0.214	Pass
42.027	18.3	-0.1	0.0	18.3	86.2	0.213	Pass
41.945	18.0	-0.1	0.0	18.0	85.6	0.211	Pass
41.817	17.5	-0.1	0.0	17.5	84.6	0.207	Pass
41.688	17.0	-0.1	0.0	17.0	83.7	0.204	Pass
41.560	16.6	0.0	0.0	16.6	82.7	0.200	Pass
40.960	14.4	0.0	0.0	14.4	78.2	0.184	Pass
38.960	7.9	0.0	0.0	7.9	63.2	0.125	Pass
37.016	3.7	0.0	0.0	3.7	48.5	0.076	Pass
36.683	3.3	0.0	0.0	3.3	46.0	0.071	Pass
36.349	2.9	0.0	0.0	2.9	43.5	0.068	Pass
36.016	2.6	0.0	0.0	2.6	41.0	0.064	Pass
35.697	2.3	0.0	0.0	2.3	38.6	0.061	Pass
35.560	2.2	0.0	0.0	2.2	37.6	0.059	Pass
35.423	2.1	0.0	0.0	2.1	36.6	0.058	Pass
33.660	0.9	0.0	0.0	0.9	23.3	0.038	Pass
33.010	0.5	0.0	0.0	0.5	18.4	0.029	Pass
31.945	0.2	0.0	0.0	0.2	10.4	0.015	Pass
31.835	0.1	0.0	0.0	0.1	9.6	0.013	Pass
31.725	0.1	0.0	0.0	0.1	8.8	0.012	Pass
31.510	0.1	0.0	0.0	0.1	7.1	0.009	Pass
31.006	0.0	0.0	0.0	0.0	3.4	0.003	Pass
30.910	0.0	0.0	0.0	0.0	2.6	0.002	Pass
30.865	0.0	0.0	0.0	0.0	2.3	0.001	Pass
30.560	0.0	0.0	0.0	0.0	NaN	0.000	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dz^2)
Ratio = Dres / Limit

Stack Deflection Load # 17
Load Combination Serviceability: 1.0*D+1.0*S 0 Deg

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
47.060	67.4	-0.1	0.0	67.4	124.1	0.543	Pass
44.060	42.9	-0.1	0.0	42.9	101.5	0.422	Pass
42.060	28.7	-0.1	0.0	28.7	86.5	0.332	Pass
42.027	28.5	-0.1	0.0	28.5	86.2	0.331	Pass
41.945	28.0	-0.1	0.0	28.0	85.6	0.327	Pass
41.817	27.2	-0.1	0.0	27.2	84.6	0.322	Pass
41.688	26.5	-0.1	0.0	26.5	83.7	0.316	Pass
41.560	25.7	0.0	0.0	25.7	82.7	0.311	Pass
40.960	22.3	0.0	0.0	22.3	78.2	0.285	Pass
38.960	12.1	0.0	0.0	12.1	63.2	0.192	Pass
37.016	5.6	0.0	0.0	5.6	48.5	0.114	Pass
36.683	4.9	0.0	0.0	4.9	46.0	0.107	Pass
36.349	4.4	0.0	0.0	4.4	43.5	0.101	Pass
36.016	3.9	0.0	0.0	3.9	41.0	0.095	Pass
35.697	3.5	0.0	0.0	3.5	38.6	0.090	Pass
35.560	3.3	0.0	0.0	3.3	37.6	0.088	Pass

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35.423	3.1	0.0	0.0	3.1	36.6	0.086	Pass
33.660	1.3	0.0	0.0	1.3	23.3	0.055	Pass
33.010	0.8	0.0	0.0	0.8	18.4	0.043	Pass
31.945	0.2	0.0	0.0	0.2	10.4	0.022	Pass
31.835	0.2	0.0	0.0	0.2	9.6	0.019	Pass
31.725	0.2	0.0	0.0	0.2	8.8	0.017	Pass
31.510	0.1	0.0	0.0	0.1	7.1	0.013	Pass
31.006	0.0	0.0	0.0	0.0	3.4	0.004	Pass
30.910	0.0	0.0	0.0	0.0	2.6	0.002	Pass
30.865	0.0	0.0	0.0	0.0	2.3	0.002	Pass
30.560	0.0	0.0	0.0	0.0	NaN	0.000	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dz^2)
Ratio = Dres / Limit

Conical Transition Analysis

Cone Analysis per API RP 2A-WSD: Elev 41.945 m to 41.560 m
Load Combination # 10, A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	7.0	7.0	7.0
Fys:	Yield Stress (MPa)	204.66	204.66	204.66
E:	Modulus of Elasticity (MPa)	199333.14	199333.14	199333.14
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	618.98	618.98	618.98
M:	Overturning Moment (KN-m)	16.32	0.00	19.50
V:	Vertical Axial Loading (KN)	3.54	0.00	4.02
Sx:	Section Modulus (cm^3)	540.1	540.1	1361.2
Ax:	Cross Sectional Area (sq cm)	69.668	69.668	110.176
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.51	0.52	0.37
fb:	Bending Strss - M/Sx (MPa)	30.22	31.08	14.32
fb':	Localized Bending Stress (MPa)	42.43	42.43	25.40
fh':	Hoop Stress (MPa)	22.50	0.00	13.47

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Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1723.70	1723.70
1098.69			
Fhc:	Hoop Comp - Fys (MPa)	307.00	307.00
300.96			
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	153.50	153.50
150.48			
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2585.54	2585.54
1648.03			
Fxc:	Crit Lcl Bklng (MPa)	204.66	204.66
198.26			
Stot:	Total Stress Check 1: fa + fb (MPa)	30.73	31.60
14.69			
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	73.16	74.03
40.09			
Fb:	Allow Bend (LRFD): .9*Fxc (MPa)	184.20	184.20
178.43			
Fh:	Min(Fb, 0.5*Fhc) (MPa)	153.50	153.50
150.48			

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.167	PASS	0.172	PASS	0.082	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.120	PASS	0.065	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.090	PASS
Stiff Ring Req'd?	0.167	Not Req'd	0.172	Cone OK	0.090	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 37.016 m to 36.016 m
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	
0.0				
OD:	Outer Diameter (mm)	508.0	0.0	
1066.8				
T:	Thickness (mm)	7.0	7.0	
7.0				
Fys:	Yield Stress (MPa)	204.66	204.66	
204.66				
E:	Modulus of Elasticity (MPa)	199333.14	199333.14	
199333.14				
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	
117.90				
Ft:	Tensile Stress (MPa)	618.98	618.98	
618.98				
M:	Overturning Moment (KN-m)	99.06	0.00	
122.56				
V:	Vertical Axial Loading (KN)	25.08	0.00	
27.82				
Sx:	Section Modulus (cm^3)	1361.2	1361.2	
6134.7				

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```
Ax:    Cross Sectional Area (sq cm)                    110.176     110.176
233.061

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         2.28        2.36
1.19
fb:    Bending Strss - M/Sx (MPa)                       72.77       75.56
19.98
fb':   Localized Bending Stress (MPa)                  151.57      151.57
61.96
fh':   Hoop Stress (MPa)                                80.38        0.00
32.86
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1098.69     1098.69
523.19
Fhc:   Hoop Comp - Fys (MPa)                           300.96      300.96
260.94
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    150.48      150.48
130.47
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   1648.03     1648.03
784.78
Fxc:   Crit Lcl Bklng  (MPa)                           198.26      199.54
170.26
Stot:  Total Stress Check 1: fa + fb (MPa)              75.05       77.92
21.17
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       226.62      229.50
83.13
Fb:    Allow Bend (LRFD): .9*Fxc (MPa)                 178.43      179.59
153.23
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          150.48      150.48
130.47
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.421	PASS	0.434	PASS	0.138	PASS
Check 2: Stot1 / Ft	0.366	PASS	0.371	PASS	0.134	PASS
Check 3: fh' < Fh	0.534	PASS	0.000	PASS	0.252	PASS
Stiff Ring Req'd?	0.534	Not Req'd	0.434	Cone OK	0.252	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Structural Flange Analysis

Structural Flange # 1: Elev 42.000 m, Load # 9
Load Combination # 9, A: 0.9*D 0 Deg
Controlling: Max Bolt Spacing

```
M         = Moment on Flange                                          = 0.0 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -2331 N
S         = Shear Load on Flange                                      = 0 N

Ds        = Outer Diameter of Shell                                   = 323.8 mm
Do        = Outside Diameter of Flange                                = 482.6 mm
Dbc       = Bolt Circle Diameter                                      = 431.8 mm
Tf        = Thickness of Flange                                       = 31.8 mm
Tw        = Fillet Weld Size                                          = 6.0 mm
```

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```
Db        = Nominal Bolt Diameter                                    = 22.2 mm
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (LRFD) 0.56*Fu            = 579.16 MPa
Fv        = Allowable Bolt Tensile Stress: (LRFD) 0.34*Fy            = 351.63 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (LRFD) 1.35*Fy             = 291.34 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 0 N
Fact      = Actual force on bolt                                     = 134811 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 224684 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.856

Sh        = Shear on Bolt                                            = 0 N
Sallow    = Allowable Shear on Bolt                                  = 136415 N
Ratio     = Sh / Sallow                                              = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
```

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```
Aw        = Area of Weld                                              = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                        = 270.0 KPa
Sw        = Allowable Fillet Weld Stress: (LRFD) 0.45*Fuw             = 186.16 MPa
Ratio     = Fba / Sw                                                  = 0.001

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                              = 87.6 mm
Lg        = Gross Flange area for each bolt                           = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                 = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                          = 54.0 mm
A         = Distance from Bolt CL to Flange OD                        = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                = 42.9 mm
Rho       = Calculated Parameter                                      = 3.377
Beta      = Calulcated Parameter                                      = 0
Alpha'    = Alpha where treq'd is minimum                             = 0
Tc        = Required thickness to develop load w/no prying            = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                          = 0
Q         = Prying Force per bolt                                     = 0 N
Treq'd    = Required Flange Thickness                                 = 0.0 mm
Ratio     = Treqd / Tf                                                = 0.000
```

Structural Flange # 1: Elev 42.000 m, Load # 15
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg

Controlling: Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                          = 15999.1 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -2589 N
S         = Shear Load on Flange                                      = 6363 N

Ds        = Outer Diameter of Shell                                   = 323.8 mm
Do        = Outside Diameter of Flange                                = 482.6 mm
Dbc       = Bolt Circle Diameter                                      = 431.8 mm
Tf        = Thickness of Flange                                       = 31.8 mm
Tw        = Fillet Weld Size                                          = 6.0 mm

Db        = Nominal Bolt Diameter                                     = 22.2 mm
Nb        = Number of Bolts                                           = 12
Fu        = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (LRFD) 0.56*Fu             = 579.16 MPa
Fv        = Allowable Bolt Tensile Stress: (LRFD) 0.34*Fy             = 351.63 MPa
Fp        = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb        = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys       = Yield Stress of Shell                                     = 215.81 MPa
Fw        = Tensile Stress of Weld                                    = 413.68 MPa
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (LRFD) 1.35*Fy              = 291.34 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt            = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters          = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                           = 222.3 mm
```

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```
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 12135 N
Ab        = Nominal Area of Bolt                                          = 3.879 sq cm
Km        = Stiffness of Material                                         = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                             = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby       = Bolt Yield Stress                                             = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 11040 N
Fact      = Actual force on bolt                                          = 134811 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.082

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 125757 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 224684 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144436 N
Ratio     = Fb / Fbcomb                                                   = 0.871

Sh        = Shear on Bolt                                                 = 530 N
Sallow    = Allowable Shear on Bolt                                       = 136415 N
Ratio     = Sh / Sallow                                                   = 0.004

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw        = Area of Weld                                                  = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                            = 23200.7 KPa
Sw        = Allowable Fillet Weld Stress: (LRFD) 0.45*Fuw                 = 186.16 MPa
Ratio     = Fba / Sw                                                      = 0.125

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                  = 87.6 mm
Lg        = Gross Flange area for each bolt                               = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                    = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                     = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                              = 54.0 mm
A         = Distance from Bolt CL to Flange OD                            = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                    = 42.9 mm
Rho       = Calculated Parameter                                          = 3.377
Beta      = Calulcated Parameter                                          = 5.1868
Alpha'    = Alpha where treq'd is minimum                                 = 1
Tc        = Required thickness to develop load w/no prying                = 13.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                              = 0
Q         = Prying Force per bolt                                         = 0 N
Treq'd    = Required Flange Thickness                                     = 8.4 mm
```

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Ratio = Treqd / Tf = 0.266

Breach # 1: Elev 35.560 m, Load # 15
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg
Controlling: Shell Buckling Capacity w/ Breach

Breach Analysis based upon 'Tubular Steel Structures' by M.S. Troitsky
Analysis assumes that this is the only breach and doesn't consider interaction with other openings.

This breach opening is due to a nozzle and was automatically generated by the MecaStack.

Elev = Elevation Where Breach Ctr Line Intersects Stack Ctr Line = 35.56 m

ElTop = Elevation at Top of Breach = 35.697 m
ElBot = Elevation at Bottom of Breach = 35.423 m
Wid = Width of Ducting = 273.1 mm
Ht = Height of Ducting = 273.1 mm
Ht1 = Vertical Height of Breach Opening at Shell = 273.1 mm
Tilt = Tilt of Duct relative to grade (0 is Horizontal) = 0.0 Deg
OD = Outer Diameter at Elevation = 1066.8 mm
ThkUnc = Uncorroded Thickness of Stack = 10.0 mm
ThkCor = Corroded Thickness of Stack = 7.0 mm

Loads Acting @ Breach (Take worst of loads at Top, Mid and Bot of Breach):
Moment is for a perfect cylinder and won't match stress summary if eccentric moments are included.
V = Vertical Load = 15.33 KN
M = Moment due to Lateral Loads = 145.91 KN-m

Yc = Distance from Centerline to Elastic Neutral Axis = 60.2 mm
r = Radius to Outside of Stack = 533.4 mm
r1 = Radius to Inside of Stack = 20.7 mm
Dm = Mean Diameter: 2*(r+r1)/2 = 41.7 mm
Alpha = Half Angle of Opening: ArcSin(Wid/OD) = 0.2588 rads
Beta = Angle to Neutral Axis: ArcSin(Yc/r) = 0.1132 rads
Gamma1 = (PI/2 - Alpha + Beta)/2 = 0.7126 rads
Gamma2 = (PI/2 - Alpha - Beta)/2 = 0.5994 rads
Sc = Statical Moment Under Compression = 3536.6 cm^3
St = Statical Moment Under Tension = 198.6 cm^3
Ic = Moment of Inertia of Wall Under Compression = 3597.78 cm^4
It = Moment of Inertia of Wall Under Tension = 2892.11 cm^4
Phi = (Mom + Ver*Yc) / (Ic + It) = 200.2527
N = Phi * (Sc-St) = 3.45 KN

Breach # 1 Ld 15 Cylinder Buckling Capacity:
This checks the reduced buckling capacity for the cylinder considering that it is weakened by the breach cutout. Reduction is based upon Troitsky Fig 5-24 for Effect of Rect Cutout on Cylindrical Buckling Capacity.

fclassic = Classic Buckling Stress for Cylinder: 0.6*E*ThkCor/r = 1569.56 MPa
FS = Factor of Safety for Compression = 0.900
rbar = Non-dimensional parameter: (Wid+Ht) / (4*((OD/2)*ThkCor)^0.5) = 2.234
P/Pcl = Actual / Classical Buckling Capacity {Fig 5-23}; Max=0.2 = 0.200

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```
fmax      = Max Comp Stress: (Phi/2)*(2*Yc+(r+r1)*COS(Alpha))              = 4.51 MPa
fallow    = Allowable Reduced Buckling Stress: (P/Pcl)*fclassic*FS          = 282.52 MPa
UR_sb     = Shell Buckling Unity Ratio: fmax/fallow                         = 0.110
```

Breach # 2: Elev 31.835 m, Load # 11
Load Combination # 11, B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg
Controlling: Shell Buckling Capacity w/ Breach

Breach Analysis based upon 'Tubular Steel Structures' by M.S. Troitsky
Analysis assumes that this is the only breach and doesn't consider interaction with other openings.

This breach opening is due to a nozzle and was automatically generated by the MecaStack.

```
Elev      = Elevation Where Breach Ctr Line Intersects Stack Ctr Line       = 31.835 m

ElTop     = Elevation at Top of Breach                                      = 31.945 m
ElBot     = Elevation at Bottom of Breach                                   = 31.725 m
Wid       = Width of Ducting                                                = 219.1 mm
Ht        = Height of Ducting                                               = 219.1 mm
Ht1       = Vertical Height of Breach Opening at Shell                      = 219.1 mm
Tilt      = Tilt of Duct relative to grade (0 is Horizontal)                = 0.0 Deg
OD        = Outer Diameter at Elevation                                     = 1066.8 mm
ThkUnc    = Uncorroded Thickness of Stack                                   = 10.0 mm
ThkCor    = Corroded Thickness of Stack                                     = 7.0 mm

Loads Acting @ Breach (Take worst of loads at Top, Mid and Bot of Breach):
Moment is for a perfect cylinder and won't match stress summary if eccentric moments are
included.
V         = Vertical Load                                                   = 43.25 KN
M         = Moment due to Lateral Loads                                     = 269.12 KN-m

Yc        = Distance from Centerline to Elastic Neutral Axis                = 57.8 mm
r         = Radius to Outside of Stack                                      = 533.4 mm
r1        = Radius to Inside of Stack                                       = 20.7 mm
Dm        = Mean Diameter: 2*(r+r1)/2                                       = 41.7 mm
Alpha     = Half Angle of Opening:  ArcSin(Wid/OD)                          = 0.2068 rads
Beta      = Angle to Neutral Axis:  ArcSin(Yc/r)                            = 0.1085 rads
Gamma1    = (PI/2 - Alpha + Beta)/2                                         = 0.7362 rads
Gamma2    = (PI/2 - Alpha - Beta)/2                                         = 0.6277 rads
Sc        = Statical Moment Under Compression                               = 3731.6 cm^3
St        = Statical Moment Under Tension                                   = 200.2 cm^3
Ic        = Moment of Inertia of Wall Under Compression                     = 3860.45
cm^4
It        = Moment of Inertia of Wall Under Tension                         = 2931.06
cm^4
Phi       = (Mom + Ver*Yc) / (Ic + It)                                      = 353.9735
N         = Phi * (Sc-St)                                                   = 9.72 KN
```

Breach # 2 Ld 11 Cylinder Buckling Capacity:
This checks the reduced buckling capacity for the cylinder considering that it is weakened by
the breach cutout. Reduction is based upon Troitsky Fig 5-24 for Effect of Rect Cutout on Cylindrical Buckling Capacity.

```
fclassic  = Classic Buckling Stress for Cylinder: 0.6*E*ThkCor/r            = 1569.56 MPa
FS        = Factor of Safety for Compression                                = 0.900
```

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```
rbar      = Non-dimensional parameter: (Wid+Ht) / (4*((OD/2)*ThkCor)^0.5)    = 1.793
P/Pcl     = Actual / Classical Buckling Capacity {Fig 5-23}; Max=0.2         = 0.200
fmax      = Max Comp Stress: (Phi/2)*(2*Yc+(r+r1)*COS(Alpha))                = 8.03 MPa
fallow    = Allowable Reduced Buckling Stress: (P/Pcl)*fclassic*FS           = 282.52 MPa
UR_sb     = Shell Buckling Unity Ratio: fmax/fallow                          = 0.196
```

Nozle # 1: Check Nozzle Loads Per WRC 107/537
Description: 1N

```
Elev      = Elev of Ctr of Nozzle to Ctr of Stack Intersection               = 35.56 m
OD        = Outer Diameter of Nozzle                                         = 273.1 mm
Thk       = Thickness of Nozzle                                              = 9.3 mm
Proj      = Radial Projection from OD of Stack to end of Nozzle/Flange       = 200.0 mm
RW        = Radial Width of Repad from OD of Nozzle ot OD of Repad           = 100.0 mm
RT        = Repad Thickness                                                  = 8.0 mm
Tilt      = Tilt Relative to Horizonal (0 is Horizzontal, + is down)         = 0.0 Deg
Orien     = Orientation of Nozzle in the Plan View                           = 180.0 Deg
FW        = Flange Width                                                     = 66.7 mm
FT        = Flange Thickness                                                 = 30.2 mm
```

Nozzle # 1 Nozzle WRC Load Summary

Load Num	Description	Fx KN	Fy KN	Fz KN	Mx KN-m	My KN-m	Mz KN-m	Local/ Global	Load Applied	Load Type	Max Ratio	Worst Case
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	0.475	*

* is the worst case loading

Nozzle # 1 WRC Load Summary of Transformed Loads
Transformation of Loads to Global Coordinates and at Nozzle to Shell Intersection

Load Num	Description	Fxt [P] KN	Fyt [Vl] KN	Fzt [Vc] KN	Mxt [Mt] KN-m	Myt [Mc] KN-m	Mzt [Ml] KN-m	Load Type	Max Ratio	Worst Case
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Oper	0.475	*

* WRC 107 Analysis is based upon loads being at the Nozzle to Shell Interface
* Values in [] represent those values that are used in WRC 537 stress analysis

Nozzle # 1 Nozzle Load Detailed Calculations for Load Producing Highest Stress Ratio:
Load #'s Refer to the Load # for the Nozzle Loads Only

```
Ds        = Outer Diameter of Stack @ Nozzle                                 = 1066.8 mm
Ts        = Corroded thickness of Stack @ Nozzle                             = 7.0 mm
Rw        = Repad Width                                                      = 3.9 mm
Rt        = Repad Thickness                                                  = 0.3 mm
Teff      = Effective Thickness: (Ts^2+Rt^2)^0.5                             = 0.4 mm
Rcyl      = Mean Cylinder Radius: [(Ds+2*Rt) + (Ds-2*Ts)]/4                  = 21.0 mm
Sallow    = Allowable Local Stress: 2 * Fy                                   = 409.33 MPa
```

Nozzle # 1 Local Stress per WRC 537: Cylinder to Repad

```
P         = Radial Force                                                     = 7.78 KN
```

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```
Mc        = Circumferential Moment                                    = 474.54 KN-
cm
Ml        = Longitudinal Moment                                       = 474.54 KN-
cm
Mt        = Torsional Moment                                          = 630.46 KN-
cm
Vc        = Shear in Circumferential Direction                        = 14.46 KN
Vl        = Shear in Longitudinal Direction                           = 14.46 KN
```

Parameter	Cylinder	Cylinder	Round Attachment	Round Attachment
		mm		mm
Outer Diameter	Do	1082.8	do	273.1
Mean Diameter	Dm	1067.8	dm	263.8
Inside Diameter	Di	1052.8	di	254.5
Mean Radius	Rm	533.9	rm	131.9
Thickness	T	15.0	t	9.3

Parameter	Expected Range	Actual Value	Status
Gamma = Rm/T	5 <= Gamma <= 300	35.593	OK
Beta = 0.875*ro/Rm	Beta <= 0.5	0.224	OK
di/Di	di/Di <= 0.6	0.242	OK
t/T	t/T >= 1	0.618	Warning
Lambda = (dm/Dm)*(Dm/T)^0.5	Lambda <= 2.8	2.084	OK

One ore more criteria was not met so please use the results with caution.
It is recommended to verify the local stress using Finite Element Analysis
When checking FEA it is recommended to use the Loads x Nd to apply the appropriate safety factor

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Circumferential Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.224	-4.77	-4.77	-4.77	-4.77	-2.91	-2.91	-2.91	-2.91
P	Bending	0.224	-6.43	6.43	-6.43	6.43	-12.52	12.52	-12.52	12.52
Mc	Membrane	0.224	0.00	0.00	0.00	0.00	-7.55	-7.55	7.55	7.55
Mc	Bending	0.224	0.00	0.00	0.00	0.00	-81.97	81.97	81.97	-81.97
Ml	Membrane	0.224	-17.88	-17.88	17.88	17.88	0.00	0.00	0.00	0.00

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Ml	Bending	0.224	-25.19	25.19	25.19	-25.19	0.00	0.00	0.00	0.00
TOTAL	Circumferential		-54.27	8.96	31.87	-5.65	-104.96	84.03	74.09	-64.81

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Longitudinal Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.224	-2.91	-2.91	-2.91	-2.91	-4.77	-4.77	-4.77	-4.77
P	Bending	0.224	-12.75	12.75	-12.75	12.75	-6.40	6.40	-6.40	6.40
Mc	Membrane	0.224	0.00	0.00	0.00	0.00	-14.64	-14.64	14.64	14.64
Mc	Bending	0.224	0.00	0.00	0.00	0.00	-38.06	38.06	38.06	-38.06
Ml	Membrane	0.224	-7.50	-7.50	7.50	7.50	0.00	0.00	0.00	0.00
Ml	Bending	0.224	-42.63	42.63	42.63	-42.63	0.00	0.00	0.00	0.00
TOTAL	Longitudinal		-65.79	44.96	34.48	-25.30	-63.87	25.05	41.53	-21.80

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Shear Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Vc	Shear	0.000	2.25	2.25	-2.25	-2.25	0.00	0.00	0.00	0.00
Vl	Shear	0.000	0.00	0.00	0.00	0.00	-2.25	-2.25	2.25	2.25
Mt	Shear	0.000	3.59	3.59	3.59	3.59	3.59	3.59	3.59	3.59
TOTAL	Shear		5.84	5.84	1.34	1.34	1.34	1.34	5.84	5.84

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Combined Stress Intensity

Description	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Total Circumferential (Sc)	-54.27	8.96	31.87	-5.65	-104.96	84.03	74.09	-64.81
Total Longitudinal (Sl)	-65.79	44.96	34.48	-25.30	-63.87	25.05	41.53	-21.80

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Total Shear (Ss)	5.84	5.84	1.34	1.34	1.34	1.34	5.84	5.84
Combined Intensity	16.40	45.88	35.04	19.83	41.18	84.06	75.11	44.57

When Sc & Sl have like signs: S = 0.5*(Sc+Sl +/- [(Sc-Sl)^2 + 4*Ss^2]^0.5
or S = [(Sc-Sl)^2+4*Ss^2]^0.5
When Ss=0: S = Max of [Abs(Sc), Abs(Sl) or Abs(Sc-Sl)]
When Sc & Sl have unlike Signs: S = [(Sc-Sl)^2+4*Ss^2]^0.5

SI_Max = Maximum Combined Stress Intensity = 84.06 MPa
Sallow = Allowable Local Stress: 2 * Fy = 409.33 MPa
UR = Unity Stress Ratio: SI_Max / Allow = 0.205

Nozzle # 1 Local Stress per WRC 537: Repad to Shell

P = Radial Force = 7.78 KN
Mc = Circumferential Moment = 474.54 KN-cm
Ml = Longitudinal Moment = 474.54 KN-cm
Mt = Torsional Moment = 630.46 KN-cm
Vc = Shear in Circumferential Direction = 14.46 KN
Vl = Shear in Longitudinal Direction = 14.46 KN

Parameter	Cylinder	Cylinder mm	Round Attachment	Round Attachment mm
Outer Diameter	Do	1066.8	do	487.1
Mean Diameter	Dm	1059.8	dm	480.1
Inside Diameter	Di	1052.8	di	473.1
Mean Radius	Rm	529.9	rm	240.0
Thickness	T	7.0	t	7.0

Parameter	Expected Range	Actual Value	Status
Gamma = Rm/T	5 <= Gamma <= 300	75.700	OK
Beta = 0.875*ro/Rm	Beta <= 0.5	0.402	OK
di/Di	di/Di <= 0.6	0.449	OK
t/T	t/T >= 1	1.000	OK
Lambda = (dm/Dm)*(Dm/T)^0.5	Lambda <= 2.8	5.573	Warning

One ore more criteria was not met so please use the results with caution.
It is recommended to verify the local stress using Finite Element Analysis

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When checking FEA it is recommended to use the Loads x Nd to apply the appropriate safety factor

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Circumferential Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.391	-10.78	-10.78	-10.78	-10.78	-3.51	-3.51	-3.51	-3.51
P	Bending	0.391	-4.73	4.73	-4.73	4.73	-47.66	47.66	-47.66	47.66
Mc	Membrane	0.391	0.00	0.00	0.00	0.00	-9.40	-9.40	9.40	9.40
Mc	Bending	0.391	0.00	0.00	0.00	0.00	-159.53	159.53	159.53	-159.53
Ml	Membrane	0.391	-17.68	-17.68	17.68	17.68	0.00	0.00	0.00	0.00
Ml	Bending	0.391	-19.14	19.14	19.14	-19.14	0.00	0.00	0.00	0.00
TOTAL	Circumferential		-52.34	-4.59	21.31	-7.51	-220.09	194.28	117.76	-105.98

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Longitudinal Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.391	-3.51	-3.51	-3.51	-3.51	-10.78	-10.78	-10.78	-10.78
P	Bending	0.391	-13.32	13.32	-13.32	13.32	-19.06	19.06	-19.06	19.06
Mc	Membrane	0.391	0.00	0.00	0.00	0.00	-40.97	-40.97	40.97	40.97
Mc	Bending	0.391	0.00	0.00	0.00	0.00	-60.13	60.13	60.13	-60.13
Ml	Membrane	0.391	-9.74	-9.74	9.74	9.74	0.00	0.00	0.00	0.00
Ml	Bending	0.391	-40.79	40.79	40.79	-40.79	0.00	0.00	0.00	0.00
TOTAL	Longitudinal		-67.36	40.86	33.71	-21.24	-130.96	27.44	71.26	-10.88

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Shear Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa

Vc	Shear	0.000	2.78	2.78	-2.78	-2.78	0.00	0.00	0.00	0.00
Vl	Shear	0.000	0.00	0.00	0.00	0.00	-2.78	-2.78	2.78	2.78
Mt	Shear	0.000	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56
TOTAL	Shear		5.34	5.34	-0.22	-0.22	-0.22	-0.22	5.34	5.34

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Combined Stress Intensity

Description	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Total Circumferential (Sc)	-52.34	-4.59	21.31	-7.51	-220.09	194.28	117.76	-105.98
Total Longitudinal (Sl)	-67.36	40.86	33.71	-21.24	-130.96	27.44	71.26	-10.88
Total Shear (Ss)	5.34	5.34	-0.22	-0.22	-0.22	-0.22	5.34	5.34
Combined Intensity	18.43	46.69	33.72	13.73	89.14	194.28	118.36	95.70

When Sc & Sl have like signs: S = 0.5*(Sc+Sl +/- [(Sc-Sl)^2 + 4*Ss^2]^0.5
or S = [(Sc-Sl)^2+4*Ss^2]^0.5
When Ss=0: S = Max of [Abs(Sc), Abs(Sl) or Abs(Sc-Sl)]
When Sc & Sl have unlike Signs: S = [(Sc-Sl)^2+4*Ss^2]^0.5

SI_Max = Maximum Combined Stress Intensity = 194.28 MPa
Sallow = Allowable Local Stress: 2 * Fy = 409.33 MPa
UR = Unity Stress Ratio: SI_Max / Allow = 0.475

Baseplate Analysis, Worst Case Load # 10 - A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg
Based Upon 'Process Equipment Design' by Brownell & Young

The following components are Controlled by this Load Case:
Bolt Tension, Top Plate, Gussets, Local, Weld

M = Moment on Baseplate = 316.88 KN-m
V = Vertical Load on Baseplate (+ is compression / - is tension) = 48.45 KN
S = Shear Load on Baseplate = 43.29 KN
Ds = Outer Diameter of Stack at Base = 1066.8 mm
Type = Type of Baseplate = Chair Continuous Plate
SupType = Type of Support = Rigid Steel Base
Friction = Coefficient of Friction for Support = 0.300
BasisBolt = Basis for Bolt Design = Brownell & Young

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```
Nbolt     = Number of Bolts                                          = 16
Dbolt     = Nominal Bolt Diameter                                    = 27.0 mm
Dbh       = Bolt Hole Diameter                                       = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                              = 3.0 mm
CAplt     = Corrosion Allowance on Plates                            = 0.0 mm
ID        = Inside Diameter of Baseplate                             = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                        = 1270.0 mm
OD        = Outer Diameter of Baseplate                              = 1385.0 mm
Tb        = Thickness of Bottom Plate                                = 25.0 mm
Tt        = Thickness of Top Plate                                   = 25.0 mm
Fw        = Fillet Weld Size                                         = 5.0 mm
Fwu       = Weld Ultimate Tensile Strength                           = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                               = 1
Hg        = Height of Anchor Chair                                   = 305.0 mm
Tg        = Thickness of Gusset                                      = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                   = S275J0
Dens      = Material Density                                         = 7849 Kg/m^3
Temp      = Design Temperature                                       = 21.11 Deg C
Fy        = Minimum Yield Stress                                     = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                  = 410030.5
KPa
Sa        = Allowable Tensile Stress                                 = 117141.7
KPa
E         = Modulus of Elasticity                                    = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                         = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                                = False
Matl      = Bolt Material Specification                              = Gr. 8.8
Fu        = Ultimate Tensile Stress                                  = 800548.8
KPa
Fy        = Yield Stress                                             = 640440.4
KPa
Fproof    = Proof Stress                                             = 544374.4
KPa
Eb        = Modulus of Elasticity                                    = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile             = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                             = 800.55 MPa
PreStress = Pretension Stress on Bolt                                = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                 = Rectangular
Pt        = Plate Washer Thickness                                   = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                   = 90.0 mm
Pl        = Length of Washer Parallel to Shell                       = 100.0 mm
Pdh       = Bolt Hole Diameter                                       = 30.0 mm
Bolt Properties:
P         = Thread Pitch                                             = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                     = 19.3 mm
```

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```
Aroot     = Bolt Minor Area:  (PI/4)*Dminor^2                                  = 2.921 sq cm

Bolt Tensile Strength per 'Process Equipment Design' by Brownell and Young:
Fu        = Bolt Ultimate Tensile Stress                                       = 800.55 MPa
Dbolt     = Diameter of Bolt                                                   = 27.0 mm
Cor Allow = Bolt Corrosion Allowance                                           = 3.0 mm
Dboltc    = Bolt Diameter Corroded:  Dbolt - Cor Allow                         = 24.0 mm
P         = Thread Pitch                                                       = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                               = 19.3 mm
Abolt     = Bolt Minor Area:  (PI/4)*Dminor^2                                  = 2.921 sq cm
Phi       = Factor for LRFD:   0.33*1.5                                        = 0.50
Pallow    = Bolt Tensile Strength: Phi*Fu*Abolt                                = 116.94 KN

Stack Shell Properties: (Uses Stack Hot Properties at the Baseplate Location)
Fys       = Yield Stress of Shell Material                                     = 239.00 MPa
Fb_shell  = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                       = 322.65 MPa

Baseplate Stress Limits: (Uses Baseplate Material Properties)
Fb        = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                       = 371.25 MPa
Fbs       = Allowable Plate Strong Bending: (LRFD) 0.9*Fy                      = 247.50 MPa

BASEPLATE COMPRESSIVE STRESS:
fcmax     = [4*M/(PI*Ds^2) + V/(PI*Ds)] / [(OD-ID)*0.5]                        = 1306.1 KPa

BOLT LOADING:
Pbolt     = Max Bolt Load: 4*M/(N*Dbc) - V / N                                 = 59349 N
Pallow    = Allowable Bolt Tensile Load                                        = 116936 N
Ratio     = Unity Ratio: Pbolt / Pallow                                        = 0.508


Bottom (Bearing) Plate: ('Pressure Vessel Design Manual' 3rd Edition by Dennis Moss)
Tension Case Between Gussets where gussets attempt to Lift up Bottom Plate
b         = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg           = 237.4 mm
bs        = Gusset Inside Spacing Outside Gussets: b                           = 237.4 mm
Mo        = Moment due to Tension: Pbolt*b/8                                   = 107456.3
KPa
w         = Radial Width of Bottom Plate: 0.5*(OD-ID)                          = 282.5 mm
tbt       = Thickness Req'd for Tension: (6*Mo/((w-Dbh)*Fb)^0.5+CAplt          = 10.7 mm
Compression Case where concrete bearing is applied to Bottom Plate
bmax      = Controlling Inside Gusset Spacing: Max(b, bs)                      = 237.4 mm
l         = Radial bending width of baseplate: 0.5*(OD-Ds)                     = 159.1 mm
l/bmax    = Ratio used for Moment Calculation: l/b                             = 0.670
cc1       = Moment coefficient taken from Table 3-36 using l/b                 = 0.0563
cc2       = Moment coefficient taken from Table 3-36 using l/b                 = 0.2256
Mx        = Moment in x dir: cc1 * fcmax * b^2 {Units Force*Length/Length}     = 4.15 KN
My        = Moment in y dir: cc2 * fcmax * L^2 {Units Force*Length/Length}     = 7.46 KN
Mmax      = Maximum Moment: Max(Mx, My) {Units Force*Length/Length}            = 7.46 KN
tbc       = Thickness req'd for Compression: (6*Mmax/Fb)^.5+CAplt              = 11.0 mm
tb_reqd   = Thickness req'd for Bottom Plate: Max(tbc, tbt)                    = 11.0 mm
Ratio     = Unity Ratio: tb_reqd / Tb                                          = 0.439

TOP PLATE: ('Process Equipment Design' by Brownell & Young)
bt        = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg           = 237.4 mm
Lt        = Radial distance:  (Do-Dbc)/2                                       = 159.1 mm
bl        = bt / Lt                                                            = 1.492
ly        = Distance in x direction: lt                                        = 159.1 mm
at        = (Dbc - Ds) / 2                                                     = 101.6 mm
```

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```
G1        = Gamma1 Value from Table 10.6                                    = 0.171
G2        = Gamma 1 Value from Table 10.6                                   = 0.072
e         = 1/2 Distance across flats of Bolting Nut                        = 21.8 mm
Term1     = Pbolt / (4*PI)                                                  = 1061.7268
Term2     = [2*ly*Sin(PI*at1/ly)]/(PI*e)                                    = 4.2055
Mx        = Term1 * ((1 + U) * Log(Term2) + 1) - (1 - U - G2t) [Eqn 10.39]  = 0.27 KN-m
My        = Term1 * ((1 + U) * Log(Term2) + 1) - (G1t * Term1) [Eqn 10.38]  = 0.32 KN-m
tt_reqd   = Req'd Thickness: (6*Mmax / Fb)^0.5 + CAplt                      = 14.3 mm
Ratio     = Unity Ratio tt_reqd / Tt                                        = 0.574


GUSSET: (AISC 15th Edition for Column Buckling)
Gusset: Nominal Compressive Strength per AISC 360-16 Sec E3:
Lc        = Effective Length of Member                                      = 255.0 mm
r         = Minimum of Radius of gyration:  Min(rx, ry)                     = 3.5 mm
Lc/r      = Slenderness Ratio                                               = 73.612
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                           = 130.143
Fe        = Elastic Buckling Stress:  PI^2*E / (Lc/r)^2   {E3-4}            = 382.41 MPa
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                           = 130.143
Fcr       = Critical Stress: [0.658^(Fy/Fe)]*Fy   {E3-2}                    = 203.52 MPa
Ag        = Gross Cross Sectional Area of Member                            = 19.092 sq
cm
Pn        = Flexural Buckling Strength:  Fcr*Ag {E3-1}                      = 388.57 KN
Pc        = Design Compressive Strength: Pn*0.9 (LRFD)                      = 349.71 KN
Pg        = Bolt load per gusset:  Pbolt / Ngus                             = 59.35 KN
Ratio     = Unity Ratio: Pg / Pc                                            = 0.170

SHELL LOCAL STRESS: ('Process Equipment Design' by Brownell & Young)
a         = Radial Dist to Bolts:  (BCD-Ds)/2                               = 101.6 mm
m         = PI * BCD / Nbolt                                                = 249.4 mm
Fb_shell  = Allowable bending stress of shell                               = 322.65 MPa
ts        = 1.76*(Pbolt*a/(m*hg*Fb_shell))^0.6667 * [Ds/2]^0.333 [Eqn 10.59]= 5.6 mm
Ratio     = Unity Ratio ts / Ts                                             = 0.560

WELD STRESS: (Per AISC 15th ed)
m         = PI * Ds / Nbolt                                                 = 209.5 mm
Aw        = Weld Area per Bolt: Lw*Fw/1.414                                 = 14.814 sq
cm
Lw        = Weld Length per Bolt: 2*m                                       = 418.9 mm
Abm       = Area of Base Metal (Assumes Ts is thinnest): Ts*Lw              = 41.893 sq
cm
Fnw       = Nominal Stress of Weld Material:  0.6*Fwu {Table J2.5}          = 289579.3
KPa
Rnw       = Design Weld Strength (LRFD): Fnw*Aw*0.75 {Eqn J2-2}             = 321731 N
Rnpy      = Design Base Metal Strength (LRFD): 0.6*Fy*Abm {Eqn J4-3}        = 600743 N
Rnpr      = Allowable Base Rupture (ASD):  0.6*Fu*Abm*0.75 {Eqn J4-5}       = 671758 N
Pnw       = Minimum of Rnw, Rnpy, and Rnpr                                  = 321731 N
Ratio     = Unity Ratio:  Pbolt / Pnw                                       = 0.184
```

Baseplate Analysis, Worst Case Load # 11 - B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg
Based Upon 'Process Equipment Design' by Brownell & Young

```
The following components are Controlled by this Load Case:
Bottom Plate

M         = Moment on Baseplate                                             = 316.88 KN-m
V         = Vertical Load on Baseplate (+ is compression / - is tension)    = 57.41 KN
```

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```
S          = Shear Load on Baseplate                                  = 43.29 KN
Ds         = Outer Diameter of Stack at Base                          = 1066.8 mm
Type       = Type of Baseplate                                        = Chair
                                                                        Continuous

Plate
SupType    = Type of Support                                          = Rigid Steel
Base
Friction   = Coefficient of Friction for Support                      = 0.300
BasisBolt  = Basis for Bolt Design                                    = Brownell &
Young
Nbolt      = Number of Bolts                                          = 16
Dbolt      = Nominal Bolt Diameter                                    = 27.0 mm
Dbh        = Bolt Hole Diameter                                       = 36.0 mm
CAbolt     = Corrosion Allowance on Bolt                              = 3.0 mm
CAplt      = Corrosion Allowance on Plates                            = 0.0 mm
ID         = Inside Diameter of Baseplate                             = 820.0 mm
BCD        = Bolt Circle Diameter of Baseplate                        = 1270.0 mm
OD         = Outer Diameter of Baseplate                              = 1385.0 mm
Tb         = Thickness of Bottom Plate                                = 25.0 mm
Tt         = Thickness of Top Plate                                   = 25.0 mm
Fw         = Fillet Weld Size                                         = 5.0 mm
Fwu        = Weld Ultimate Tensile Strength                           = 482632.1
KPa
Ngus       = Number of Gussets per Bolt                               = 1
Hg         = Height of Anchor Chair                                   = 305.0 mm
Tg         = Thickness of Gusset                                      = 12.0 mm
Material: (Properties looked up from database)
Spec       = Material Specification                                   = S275J0
Dens       = Material Density                                         = 7849 Kg/m^3
Temp       = Design Temperature                                       = 21.11 Deg C
Fy         = Minimum Yield Stress                                     = 274996.9
KPa
Fu         = Ultimate Tensile Stress                                  = 410030.5
KPa
Sa         = Allowable Tensile Stress                                 = 117141.7
KPa
E          = Modulus of Elasticity                                    = 209957162.5
KPa
A          = Coefficient of Thermal Expansion                         = 1.20E-05
mm/mm/C


Bolt Material:
Override   = Manually Specify Material                                = False
Matl       = Bolt Material Specification                              = Gr. 8.8
Fu         = Ultimate Tensile Stress                                  = 800548.8
KPa
Fy         = Yield Stress                                             = 640440.4
KPa
Fproof     = Proof Stress                                             = 544374.4
KPa
Eb         = Modulus of Elasticity                                    = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile              = 60.00 %
Fult       = Bolt Ultimate Tensile Stress                             = 800.55 MPa
PreStress  = Pretension Stress on Bolt                                = 480.33 MPa
```

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```
Plate Washer:
Ptype     = The Type of Plate Washer                                    = Rectangular
Pt        = Plate Washer Thickness                                      = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                      = 90.0 mm
Pl        = Length of Washer Parallel to Shell                          = 100.0 mm
Pdh       = Bolt Hole Diameter                                          = 30.0 mm
Bolt Properties:
P         = Thread Pitch                                                = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                        = 19.3 mm
Aroot     = Bolt Minor Area:  (PI/4)*Dminor^2                           = 2.921 sq cm

Bolt Tensile Strength per 'Process Equipment Design' by Brownell and Young:
Fu        = Bolt Ultimate Tensile Stress                                = 800.55 MPa
Dbolt     = Diameter of Bolt                                            = 27.0 mm
Cor Allow = Bolt Corrosion Allowance                                    = 3.0 mm
Dboltc    = Bolt Diameter Corroded:  Dbolt - Cor Allow                  = 24.0 mm
P         = Thread Pitch                                                = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                        = 19.3 mm
Abolt     = Bolt Minor Area:  (PI/4)*Dminor^2                           = 2.921 sq cm
Phi       = Factor for LRFD:   0.33*1.5                                 = 0.50
Pallow    = Bolt Tensile Strength: Phi*Fu*Abolt                         = 116.94 KN

Stack Shell Properties: (Uses Stack Hot Properties at the Baseplate Location)
Fys       = Yield Stress of Shell Material                              = 239.00 MPa
Fb_shell  = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                = 322.65 MPa

Baseplate Stress Limits: (Uses Baseplate Material Properties)
Fb        = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                = 371.25 MPa
Fbs       = Allowable Plate Strong Bending: (LRFD) 0.9*Fy               = 247.50 MPa

BASEPLATE COMPRESSIVE STRESS:
fcmax     = [4*M/(PI*Ds^2) + V/(PI*Ds)] / [(OD-ID)*0.5]                 = 1315.6 KPa

BOLT LOADING:
Pbolt     = Max Bolt Load: 4*M/(N*Dbc) - V / N                          = 58789 N
Pallow    = Allowable Bolt Tensile Load                                 = 116936 N
Ratio     = Unity Ratio: Pbolt / Pallow                                 = 0.503


Bottom (Bearing) Plate: ('Pressure Vessel Design Manual' 3rd Edition by Dennis Moss)
Tension Case Between Gussets where gussets attempt to Lift up Bottom Plate
b         = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg     = 237.4 mm
bs        = Gusset Inside Spacing Outside Gussets: b                    = 237.4 mm
Mo        = Moment due to Tension: Pbolt*b/8                            = 106442.3
KPa
w         = Radial Width of Bottom Plate: 0.5*(OD-ID)                   = 282.5 mm
tbt       = Thickness Req'd for Tension: (6*Mo/((w-Dbh)*Fb)^0.5+CAplt   = 10.7 mm
Compression Case where concrete bearing is applied to Bottom Plate
bmax      = Controlling Inside Gusset Spacing: Max(b, bs)               = 237.4 mm
l         = Radial bending width of baseplate: 0.5*(OD-Ds)              = 159.1 mm
l/bmax    = Ratio used for Moment Calculation: l/b                      = 0.670
cc1       = Moment coefficient taken from Table 3-36 using l/b          = 0.0563
cc2       = Moment coefficient taken from Table 3-36 using l/b          = 0.2256
Mx        = Moment in x dir: cc1 * fcmax * b^2 {Units Force*Length/Length}  = 4.18 KN
My        = Moment in y dir: cc2 * fcmax * L^2 {Units Force*Length/Length}  = 7.51 KN
Mmax      = Maximum Moment: Max(Mx, My) {Units Force*Length/Length}     = 7.51 KN
```

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```
tbc       = Thickness req'd for Compression: (6*Mmax/Fb)^.5+CAplt          = 11.0 mm
tb_reqd   = Thickness req'd for Bottom Plate: Max(tbc, tbt)                = 11.0 mm
Ratio     = Unity Ratio: tb_reqd / Tb                                      = 0.441

TOP PLATE: ('Process Equipment Design' by Brownell & Young)
bt        = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg       = 237.4 mm
Lt        = Radial distance:  (Do-Dbc)/2                                   = 159.1 mm
bl        = bt / Lt                                                        = 1.492
ly        = Distance in x direction: lt                                    = 159.1 mm
at        = (Dbc - Ds) / 2                                                 = 101.6 mm
G1        = Gamma1 Value from Table 10.6                                   = 0.171
G2        = Gamma 1 Value from Table 10.6                                  = 0.072
e         = 1/2 Distance across flats of Bolting Nut                       = 21.8 mm
Term1     = Pbolt / (4*PI)                                                 = 1051.7084
Term2     = [2*ly*Sin(PI*at1/ly)]/(PI*e)                                   = 4.2055
Mx        = Term1 * ((1 + U) * Log(Term2) + 1) - (1 - U - G2t) [Eqn 10.39] = 0.27 KN-m
My        = Term1 * ((1 + U) * Log(Term2) + 1) - (G1t * Term1) [Eqn 10.38] = 0.32 KN-m
tt_reqd   = Req'd Thickness: (6*Mmax / Fb)^0.5 + CAplt                     = 14.3 mm
Ratio     = Unity Ratio tt_reqd / Tt                                       = 0.571


GUSSET: (AISC 15th Edition for Column Buckling)
Gusset: Nominal Compressive Strength per AISC 360-16 Sec E3:
Lc        = Effective Length of Member                                     = 255.0 mm
r         = Minimum of Radius of gyration:  Min(rx, ry)                    = 3.5 mm
Lc/r      = Slenderness Ratio                                              = 73.612
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                          = 130.143
Fe        = Elastic Buckling Stress:  PI^2*E / (Lc/r)^2   {E3-4}           = 382.41 MPa
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                          = 130.143
Fcr       = Critical Stress: [0.658^(Fy/Fe)]*Fy   {E3-2}                   = 203.52 MPa
Ag        = Gross Cross Sectional Area of Member                           = 19.092 sq
cm
Pn        = Flexural Buckling Strength:  Fcr*Ag {E3-1}                     = 388.57 KN
Pc        = Design Compressive Strength: Pn*0.9 (LRFD)                     = 349.71 KN
Pg        = Bolt load per gusset:  Pbolt / Ngus                            = 58.79 KN
Ratio     = Unity Ratio: Pg / Pc                                           = 0.168

SHELL LOCAL STRESS: ('Process Equipment Design' by Brownell & Young)
a         = Radial Dist to Bolts:  (BCD-Ds)/2                              = 101.6 mm
m         = PI * BCD / Nbolt                                               = 249.4 mm
Fb_shell  = Allowable bending stress of shell                              = 322.65 MPa
ts        = 1.76*(Pbolt*a/(m*hg*Fb_shell))^0.6667 * [Ds/2]^0.333 [Eqn 10.59]= 5.6 mm
Ratio     = Unity Ratio ts / Ts                                            = 0.556

WELD STRESS: (Per AISC 15th ed)
m         = PI * Ds / Nbolt                                                = 209.5 mm
Aw        = Weld Area per Bolt: Lw*Fw/1.414                                = 14.814 sq
cm
Lw        = Weld Length per Bolt: 2*m                                      = 418.9 mm
Abm       = Area of Base Metal (Assumes Ts is thinnest): Ts*Lw             = 41.893 sq
cm
Fnw       = Nominal Stress of Weld Material:  0.6*Fwu {Table J2.5}         = 289579.3
KPa
Rnw       = Design Weld Strength (LRFD): Fnw*Aw*0.75 {Eqn J2-2}            = 321731 N
Rnpy      = Design Base Metal Strength (LRFD): 0.6*Fy*Abm {Eqn J4-3}       = 600743 N
Rnpr      = Allowable Base Rupture (ASD):  0.6*Fu*Abm*0.75 {Eqn J4-5}      = 671758 N
Pnw       = Minimum of Rnw, Rnpy, and Rnpr                                 = 321731 N
```

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Ratio = Unity Ratio: Pbolt / Pnw = 0.183

Static Summation of Forces
Total sum of all loads acting on system, Shear = (Fx^2+Fz^2)^0.5

Ld	Load Case (P)=Primary, (C)=Combination	Dir	Fx	Fy	Fz	Shear
		Deg	KN	KN	KN	KN
1	(P)Dead	0	0.00	-35.84	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	16.42
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00
5	(P)Wind	0	19.01	0.00	0.00	19.01
6	(P)Seismic Hor	0	22.77	0.00	0.00	22.77
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	0.28
9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O	0	43.29	-48.45	0.00	43.29
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O	0	43.29	-57.41	0.00	43.29
12	(C)B: 1.0*D 0 Deg	0	0.00	-35.84	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*	0	37.52	-43.67	0.00	37.52
14	(C)Serviceability: 1.0*D+1.0*W	0	19.01	-35.84	0.00	19.01
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 D	0	39.19	-45.87	0.00	39.19
16	(C)1.0*D+1.0*S 0 Deg	0	22.77	-35.84	0.00	22.77
17	(C)Serviceability: 1.0*D+1.0*S	0	22.77	-35.84	0.00	22.77
18	(C)D+O+P 0 Deg	0	16.42	-32.53	0.00	16.42

Support Loading Notes
These notes apply to the support loading data which follows

1) Joint = Joint Number, Load = Load Number, Type = P(Primary) Or C(Combination)
2) Dir= Direction Of Lateral Loads (Wind/Seismic/Vortex), 0 Deg=+X axis, 90 Deg=+Z Axis
3) Fx/Fy/Fz = Forces In X/Y/Z directions, Mx/My/Mz = Moments about X/Y/Z Axis
4) Y Is the vertical direction, And + loads are acting up, And - Is acting down.

Detailed Support Loads: Fixed @ El 30.56 m
Loads acting on the support points (+Y is Vertical and Upward)

Load	Load Case (P)=Primary,(C)=Combo	Dir	Fx	Fy	Fz	Mx	My	Mz
		Deg	KN	KN	KN	KN-m	KN-m	KN-m
1	(P)Dead	0	0.00	-35.84	0.00	0.00	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	0.00	0.00	-89.99
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00	0.00	0.00
5	(P)Wind	0	19.01	0.00	0.00	0.00	0.00	-157.26
6	(P)Seismic Hor	0	22.77	0.00	0.00	0.00	0.00	-225.77
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	3.29	0.00	0.00
9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg	0	43.29	-48.45	0.00	0.00	0.00	-316.88
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O 0 De	0	43.29	-57.41	0.00	0.00	0.00	-316.88

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12	(C)B: 1.0*D 0 Deg	0	0.00	-35.84	0.00	0.00	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*O 0 D	0	37.52	-43.67	0.00	0.00	0.00	-274.63
14	(C)Serviceability: 1.0*D+1.0*W 0 De	0	19.01	-35.84	0.00	0.00	0.00	-157.26
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	0	39.19	-45.87	0.00	0.00	0.00	-315.76
16	(C)1.0*D+1.0*S 0 Deg	0	22.77	-35.84	0.00	0.00	0.00	-225.77
17	(C)Serviceability: 1.0*D+1.0*S 0 De	0	22.77	-35.84	0.00	0.00	0.00	-225.77
18	(C)D+O+P 0 Deg	0	16.42	-32.53	0.00	0.00	0.00	-89.99

Load	Load Case (P)=Primary,(C)=Combo	Vertical KN	Shear KN	Moment KN-m
1	(P)Dead	-35.84	0.00	0.00
2	(P)Live	-13.34	0.00	0.00
3	(P)Operating	3.31	16.42	89.99
4	(P)Thermal Hot	0.00	0.00	0.00
5	(P)Wind	0.00	19.01	157.26
6	(P)Seismic Hor	0.00	22.77	225.77
7	(P)Seismic Ver	-22.77	0.00	0.00
8	(P)Vortex Across	0.00	0.28	3.29
9	(C)A: 0.9*D 0 Deg	-32.26	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg	-48.45	43.29	316.88
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O 0 De	-57.41	43.29	316.88
12	(C)B: 1.0*D 0 Deg	-35.84	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*O 0 D	-43.67	37.52	274.63
14	(C)Serviceability: 1.0*D+1.0*W 0 De	-35.84	19.01	157.26
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	-45.87	39.19	315.76
16	(C)1.0*D+1.0*S 0 Deg	-35.84	22.77	225.77
17	(C)Serviceability: 1.0*D+1.0*S 0 De	-35.84	22.77	225.77
18	(C)D+O+P 0 Deg	-32.53	16.42	89.99

These are the resultant forces and the shear and moment can occur in any direction
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Mom: (Mx^2 + Mz^2)^0.5
Vertical load is the Fy force.

Maximum Support Loads for All Load Combinations
Maximum loading for each restraint, but loads may not necessarily occur at the same time

Restraint Description	Vertical KN	Uplift KN	Shear KN	Moment KN-m	Torsion KN-m
Fixed	-57.41	0.00	43.29	316.88	0.00

Vertical = Max downward acting Fy (Largest negative Fy value)
Uplift = Max upward acting Fy (Largest postive Fy value)
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Overturning Moment: (Mx^2 + Mz^2)^0.5
Torsion = Maximum magnitude of My

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6. MAIN RESULTS

Stack Stress Worst Case Summary

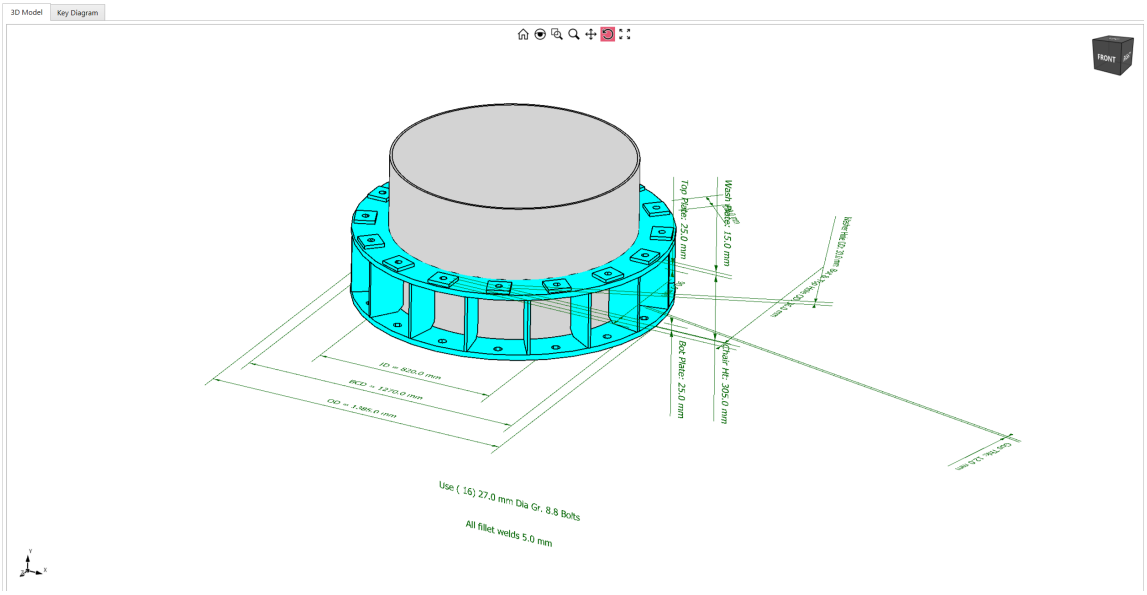
Summary of the load and highest stress ratios for each stack element

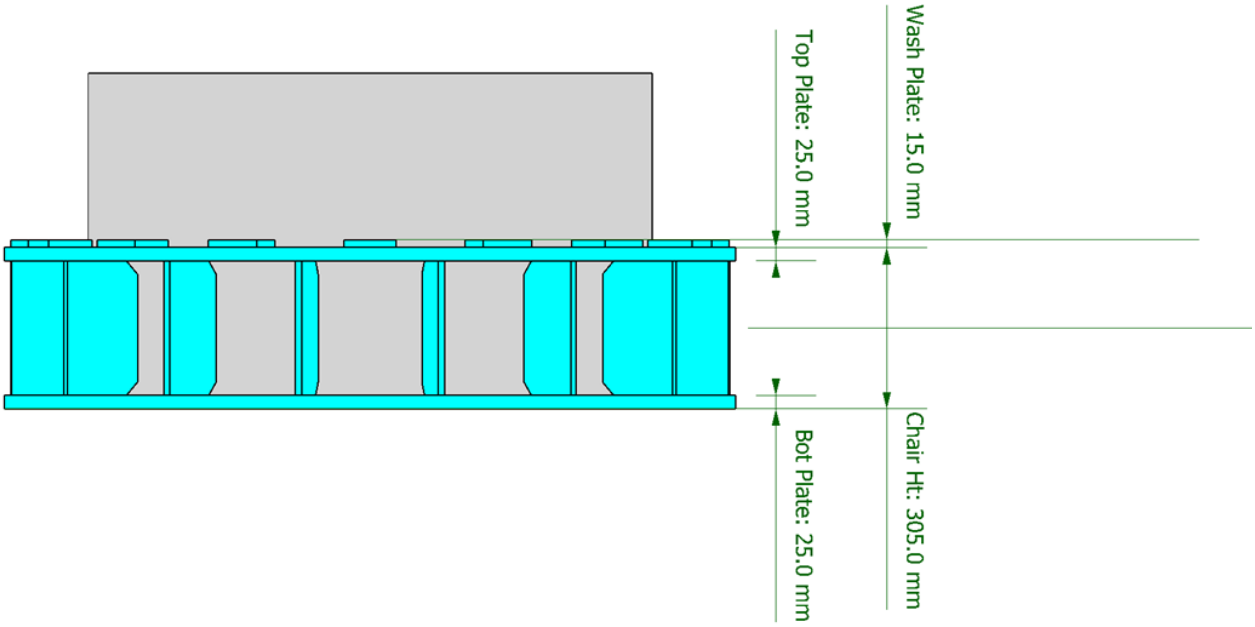
Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
16.500	13.500	16	1.0*D+1.0*S 0 Deg	Buckling	0.097	PASS
13.500	11.500	16	1.0*D+1.0*S 0 Deg	Buckling	0.263	PASS
11.500	11.467	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.174	PASS
11.467	11.385	16	1.0*D+1.0*S 0 Deg	Buckling	0.181	PASS
11.385	11.257	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.191	PASS
11.257	11.128	16	1.0*D+1.0*S 0 Deg	Buckling	0.144	PASS
11.128	11.000	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.115	PASS
11.000	10.400	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.121	PASS
10.400	8.400	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.273	PASS
8.400	6.456	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.458	PASS
6.456	6.123	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.493	PASS
6.123	5.789	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.259	PASS
5.789	5.456	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.178	PASS
5.456	5.137	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.134	PASS
5.137	5.000	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.135	PASS
5.000	4.863	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.150	PASS
4.863	3.100	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.199	PASS
3.100	2.450	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.221	PASS
2.450	1.385	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.260	PASS
1.385	1.275	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.265	PASS
1.275	1.165	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.287	PASS
1.165	0.950	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.278	PASS
0.950	0.350	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.302	PASS
0.350	0.305	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.304	PASS
0.305	0.000	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.122	PASS

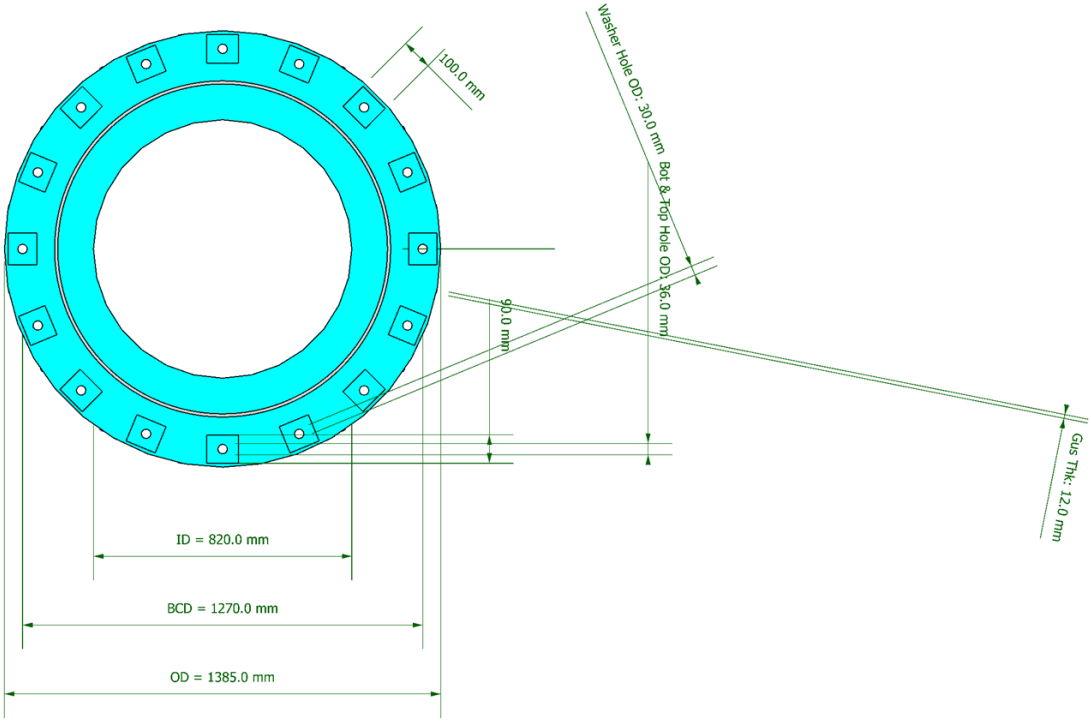
The maximum ratio of demand/capacity for the shell is lower than 1 showing a good structural behavior of the structure which has enough safety margin. All the verification are passed.

7. LOADS AT THE BASE

7.2 BASE PLATE

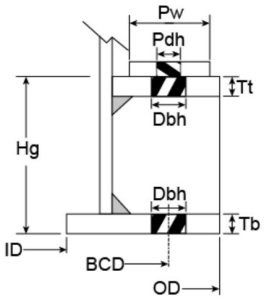


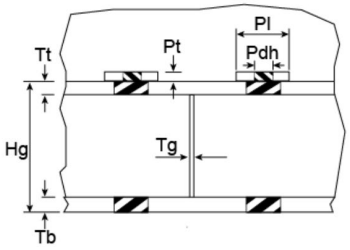




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Parameters	Description	Value	Units
Type	Type of Baseplate	Chair Continuous Plate	
Standard	Populate with Standard Dimensions	Get Standard Dimensions	
SupType	Type of Support	Rigid Steel Base	
Friction	Coefficient of Friction for Support	0.3	
Bolt	Bolt Material	Gr. 8.8	
BasisBolt	Basis for Bolt Design	Brownell & Young	
Pretension	Anchor Bolt Pretension	60.00 % of Ult / 480.33 MPa	
Nbolt	Number of Bolts	16	
Dbolt	Nominal Bolt Diameter	27	mm
Dbh	Bolt Hole Diameter	36	mm
CAbolt	Corrosion Allowance on Bolt	3	mm
Matl	Baseplate Material	S275J0	
CAplt	Corrosion Allowance on Plates	0	mm
ID	Inside Diameter of Baseplate	820	mm
BCD	Bolt Circle Diameter of Baseplate	1270	mm
OD	Outer Diameter of Baseplate	1385	mm
Tb	Thickness of Bottom Plate	25	mm
Tt	Thickness of Top Plate	25	mm
Fw	Fillet Weld Size	5	mm
Fwu	Weld Ultimate Tensile Strength	482632.1	KPa
Ngus	Number of Gussets per Bolt	1	
Hg	Height of Anchor Chair	305	mm
Tg	Thickness of Gusset	12	mm
Washer	Plate Washer	100.0 x 90.0 x 15.0 mm	





7.3Resultant Actions

The Case 6 below is representing the Transportation loads which provides the highest reactions effect among the horizontal acceleration applied with the load cases "transportation Loads" and " Wave and current Loads"

Detailed Support Loads: Fixed @ El 0.0 m

Loads acting on the support points (+Y is Vertical and Upward)

Load	Load Case (P)=Primary, (C)=Combo	Dir	Fx	Fy	Fz	Mx	My	Mz
		Deg	KN	KN	KN	KN-m	KN-m	KN-m
1	(P)Dead	0	0.00	-35.84	0.00	0.00	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	0.00	0.00	-89.99
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00	0.00	0.00
5	(P)Wind	0	18.99	0.00	0.00	0.00	0.00	-157.10
6	(P)Seismic Hor	0	22.77	0.00	0.00	0.00	0.00	-227.63
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	3.29	0.00	0.00

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9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00	0.00

Load	Load Case (P)=Primary,(C)=Combo	Vertical KN	Shear KN	Moment KN-m
1	(P)Dead	-35.84	0.00	0.00
2	(P)Live	-13.34	0.00	0.00
3	(P)Operating	3.31	16.42	89.99
4	(P)Thermal Hot	0.00	0.00	0.00
5	(P)Wind	0.00	18.99	157.10
6	(P)Seismic Hor	0.00	22.77	227.63
7	(P)Seismic Ver	-22.77	0.00	0.00
8	(P)Vortex Across	0.00	0.28	3.29

These are the resultant forces and the shear and moment can occur in any direction
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Mom: (Mx^2 + Mz^2)^0.5
Vertical load is the Fy force.

Maximum Support Loads for All Load Combinations

Maximum loading for each restraint, but loads may not necessarily occur at the same time

Restraint Description	Vertical KN	Uplift KN	Shear KN	Moment KN-m	Torsion KN-m
Fixed	-57.41	0.00	43.26	317.61	0.00

Vertical = Max downward acting Fy (Largest negative Fy value)
Uplift = Max upward acting Fy (Largest postive Fy value)
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Overturning Moment: (Mx^2 + Mz^2)^0.5
Torsion = Maximum magnitude of My

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8. LIST OF ATTACHMENT

A- ASME VIII PRESSURE CALCULATION OF BOTTOM KOD

B- LIFTING ANALYSIS CONFIGURATION WITHOUT TIP

C- LIFTING ANALYSIS CONFIGURATION WITH TIP

D- LIFTING LUG CALCULATION

E- MISCELLANUES CALCULATION

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9. CONCLUSIONS

Based on the results of the analysis, the following conclusions can be drawn:

- All the load cases have been considered and checked for the stability of the structure.
- The resultant stresses are within the allowable limits for all the load cases.
- The structure is stable and safe under the applied loads.

A – PRESSURE CALCULATION ACCORDING TO ASME VIII div.1

The calculation is performed using PV ELITE one of the most reliable software in this field.

PV Elite is a comprehensive software tool used for the design and analysis of pressure vessels and heat exchangers. It offers capabilities such as finite element analysis, wind and seismic analysis, and the ability to model various types of vessel components.

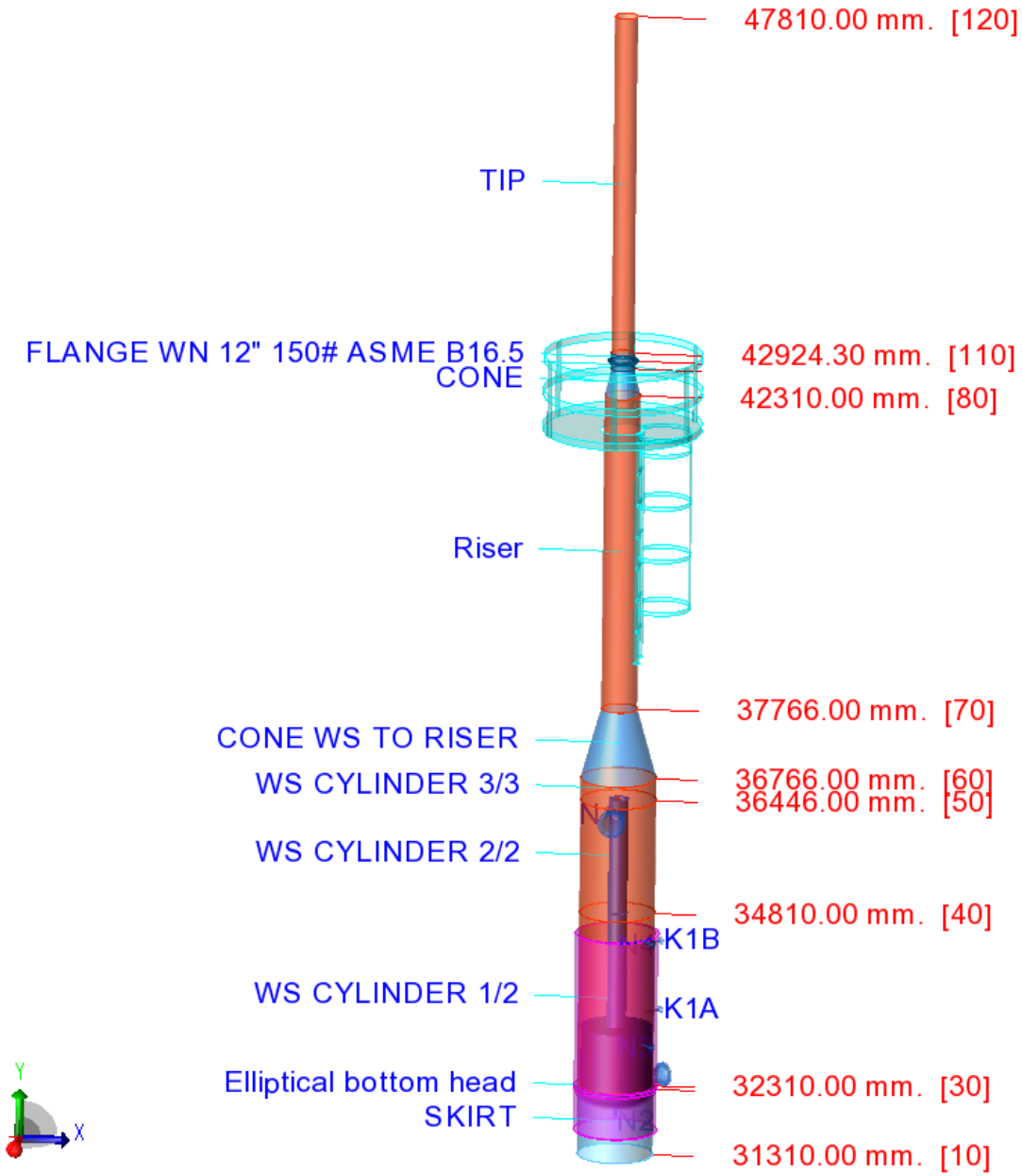
Note:

1- Base Plate analysis is not included. For details refers to the structural calculation in this document.

2- The loads case named "seismic" are referring to the maximum between transportation loads and case "wave and current loads" as shown above in this document. This is required because the software can handle only one seismic loads during the analysis.

3- The skirt is modeled with a dummy material of SA516-60 but for its verification , as it is not an element under pressure, please refer to the structural analysis where S75J0 has been used.

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47810.00 mm. [120]
TIP
FLANGE WN 12" 150# ASME B16.5
CONE
42924.30 mm. [110]
42310.00 mm. [80]
Riser
37766.00 mm. [70]
CONE WS TO RISER
WS CYLINDER 3/3
36766.00 mm. [60]
36446.00 mm. [50]
WS CYLINDER 2/2
34810.00 mm. [40]
K1B
WS CYLINDER 1/2
K1A
Elliptical bottom head
SKIRT
32310.00 mm. [30]
31310.00 mm. [10]
Y
X

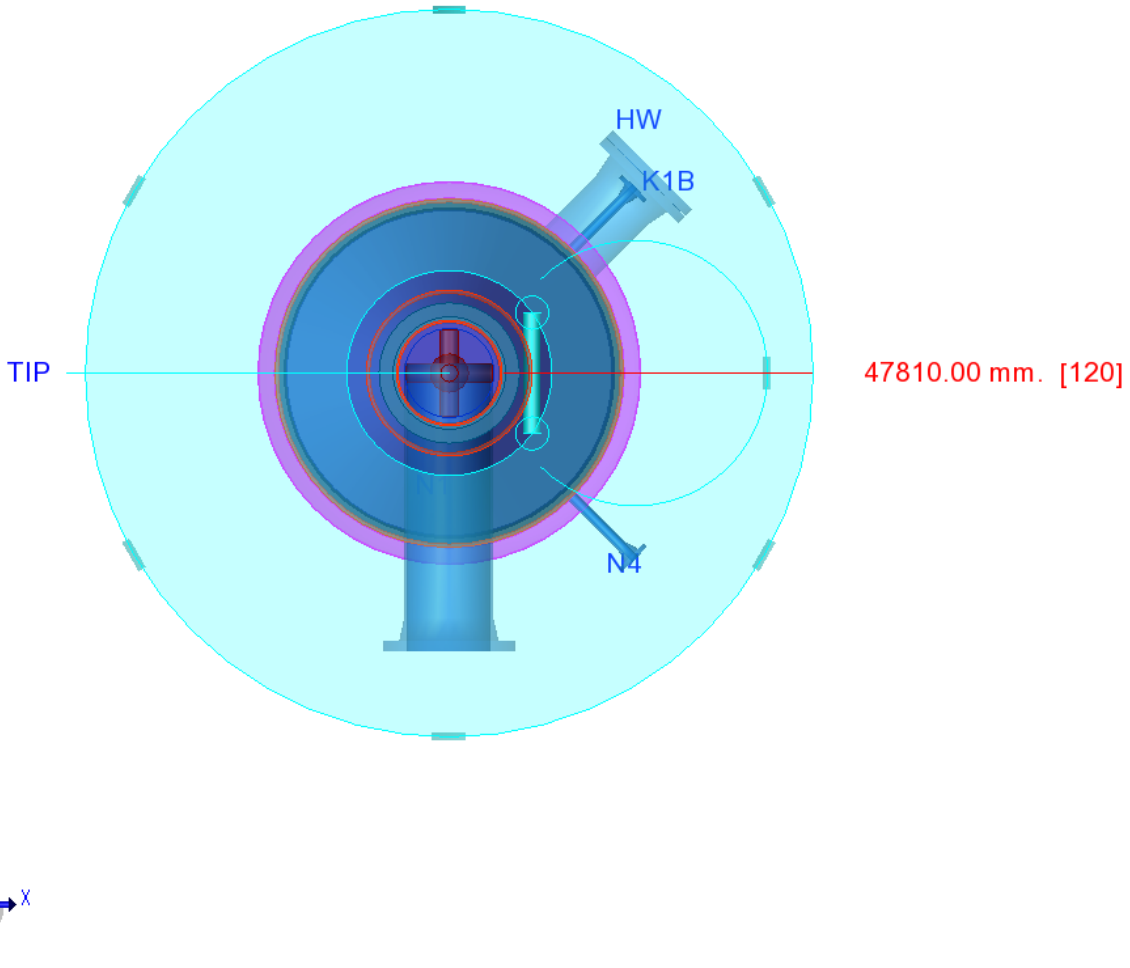

HW
K1B
TIP
47810.00 mm. [120]
N4
Y
X
Z

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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

```
ASME Code Version      : 2023

Analysis Performed by : Ing.Diego Bruciafreddo

Job File              : W:\1.COMMESSE\DB-ENCORE-C16-23-0193-ROSETTI MARI

Date of Analysis      : Dec 4,2024    9:40pm
```

Note:
PV Elite performs all calculations internally in Imperial Units
to remain compliant with the ASME Code and any built in assumptions
in the ASME Code formulas. The finalized results are reflected to show
the user's set of selected units.

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PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	350	kPa
Design Internal Temperature	80.0	°C
Type of Hydrotest	1.43 * MAWP (PED)	
Hydrotest Position	Vertical	
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-10.0	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-2	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	N	

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS

Load Case 9	EP+OW+WI+FW+BW	
Load Case 10	EP+OW+EQ+FS+BS	
Load Case 11	HP+HW+HI	
Load Case 12	HP+HW+HE	
Load Case 13	IP+WE+EW	
Load Case 14	IP+WF+CW	
Load Case 15	IP+VO+OW	
Load Case 16	IP+VE+EW	
Load Case 17	NP+VO+OW	
Load Case 18	FS+BS+IP+OW	
Load Case 19	FS+BS+EP+OW	
Wind Design Code	EN 1991-1-4:2005+A1:2010	
Fundamental Wind Velocity [Vb,0]	100.8	Km/hr
Direction Factor [Cdir]	1.0	
Seasonal Factor [CSeason]	1.0	
Force Coefficient [Cf]	0.69999999	
Structural Factor [CsCd]	1.0	
Terrain Category	0 - Sea or Costal Area	
Seismic Design Code	G Loading	
Seismic Importance Factor	1.000	
G Loading Coefficient Gx	0.700	
G Loading Coefficient Gz	0.700	
G Loading Coefficient Gy	0.700	
Percent Seismic for Hydrotest	0.000	
Design Pressure + Static Head	Y	
Consider MAP New and Cold in Noz. Design	N	
Consider External Loads for Nozzle Des.	Y	
Use ASME VIII-1 Appendix 1-9	N	
Material Database Year	1997	

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	No
Shell Head Joints are Tapered	No
Compute "K" in corroded condition	No
Use Code Case 2286	No
Use the MAWP to compute the MDMT	No
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes
Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT calcs. (Div. 1)	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Skirt Sup.	
Description	SKIRT	
Distance "FROM" to "TO"	950	mm

Skirt Outside Diameter	1066.8	mm
Diameter of Skirt at Base	1066.8	mm
Skirt Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Temperature Internal Pressure	80	°C
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA/EN 10028-2	
Allowable Stress, Ambient	134.5	N/mm^2
Allowable Stress, Operating	134.5	N/mm^2
Allowable Stress, Hydrotest	174.8	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	266.6	N/mm^2
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number		
Class / Thickness / Grade P355GH:: 6	< t <= 10	
Product Form	Plate	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Head-to-Skirt or Circ. Seam	0.85	
Weld is pre-Heated	No	
Element From Node	10	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	350	mm
Height/Length of Insulation	600	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3

Element From Node	20	
Element To Node	30	
Element Type	Elliptical	
Description	Elliptical bottom head	
Distance "FROM" to "TO"	50	mm
Element Outside Diameter	1066.8	mm
Element Thickness	6.35	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Allowable Stress, Ambient	117.9	N/mm^2
Allowable Stress, Operating	117.9	N/mm^2
Allowable Stress, Hydrotest	153.3	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	204.7	N/mm^2

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UCS-66 Chart Curve Designation	C	
External Pressure Chart Name	CS-2	
UNS Number	K02100	
Product Form	Plate	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Liquid	
Detail ID	WS LIQUID 1/2	
Dist. from "FROM" Node / Offset dist	-263.52	mm
Height/Length of Liquid	313.52	mm
Liquid Density	0.0009996	kg/cm^3
Element From Node	20	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	-266.7	mm
Height/Length of Insulation	316.7	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	2	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	5.3838	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Element To Node	40	
Element Type	Cylinder	
Description	WS CYLINDER 1/2	
Distance "FROM" to "TO"	2500	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	

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Weld is pre-Heated	No	
Element From Node	30	
Detail Type	Liquid	
Detail ID	WS Liquid 2/2	
Dist. from "FROM" Node / Offset dist	0	mm
Height/Length of Liquid	850	mm
Liquid Density	0.0009996	kg/cm^3
Element From Node	30	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	0	mm
Height/Length of Insulation	2200	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3
Element From Node	30	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	700	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	135.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	
Detail Type	Nozzle	
Detail ID	N4	
Dist. from "FROM" Node / Offset dist	2200	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	135.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	
Detail Type	Nozzle	
Detail ID	K1A	
Dist. from "FROM" Node / Offset dist	950	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	

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Detail Type	Nozzle	
Detail ID	K1B	
Dist. from "FROM" Node / Offset dist	1950	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Detail Type	Nozzle	
Detail ID	HW	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	8	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	49.044	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Detail Type	Weight	
Detail ID	WGHT:[1 OF 1]	
Dist. from "FROM" Node / Offset dist	850	mm
Miscellaneous Weight	87.271	kgf
Offset from Element Centerline	0	mm

Element From Node	40	
Element To Node	50	
Element Type	Cylinder	
Description	WS CYLINDER 2/2	
Distance "FROM" to "TO"	1636	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Nozzle	
Detail ID	N1	

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Dist. from "FROM" Node / Offset dist	1500	mm
Nozzle Diameter	10	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	71.383	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	40	
Detail Type	Weight	
Detail ID	N1-INNER1OF2	
Dist. from "FROM" Node / Offset dist	0	mm
Miscellaneous Weight	103.46	kgf
Offset from Element Centerline	0	mm

Element From Node	40	
Detail Type	For./Mom.	
Detail ID	N10 Nozle Laod	
Dist. from "FROM" Node / Offset dist	1500	mm
Force in X Direction	1445	kgf
Force in Y Direction	1445	kgf
Force in Z Direction	-778	kgf
Moment about X Axis	474	kgf-m
Moment about Y Axis	0	kgf-m
Moment about Z Axis	631	kgf-m
Force/Moment Combination Method	SRSS	

Element From Node	50	
Element To Node	60	
Element Type	Cylinder	
Description	WS CYLINDER 3/3	
Distance "FROM" to "TO"	320	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	60	
Element To Node	70	
Element Type	Conical	
Description	CONE WS TO RISER	

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Distance "FROM" to "TO"	1000	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Cone Diameter at "To" End	508	mm
Design Length of Cone	1000	mm
Half Apex Angle of Cone	15.61036	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	70	
Element To Node	80	
Element Type	Cylinder	
Description	Riser	
Distance "FROM" to "TO"	4544	mm
Element Outside Diameter	508	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	70	
Detail Type	Platform	
Detail ID	PLT 1	
Dist. from "FROM" Node / Offset dist	4044	mm
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	360.0	
Platform Wind Area	14080	cm^2
Platform Weight	181.4	kgf
Platform Railing Weight	0.03	kgf/mm
Platform Grating Weight	0.003026	kg/cm^2
Platform Width	800	mm
Platform Height	1100	mm
Platform Clearance or End Offset	60	mm
Platform Force Coefficient	1.6	
Ladder Layout Angle	90.0	

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Ladder Start Elevation	39865	mm
Ladder End Elevation	43200	mm
Unit Weight of Ladder	0.04	kgf/mm
Platform Length (top head platform)	0	mm

Element From Node	80	
Element To Node	90	
Element Type	Conical	
Description	CONE	
Distance "FROM" to "TO"	385.7	mm
Element Outside Diameter	508	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Cone Diameter at "To" End	323.9	mm
Design Length of Cone	385.7	mm
Half Apex Angle of Cone	13.422951	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	90	
Element To Node	100	
Element Type	Flange	
Description	FLANGE WN 12" 150# ASME B16.5	
Distance "FROM" to "TO"	114.3	mm
Flange Inside Diameter	323.9	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-350 LF2 [Impact Tested]	
Allowable Stress, Ambient	137.9	N/mm^2
Allowable Stress, Operating	137.9	N/mm^2
Allowable Stress, Hydrotest	179.3	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	230.2	N/mm^2
UCS-66 Chart Curve Designation	Impact Tested	
External Pressure Chart Name	CS-2	

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UNS Number	K03011	
Class / Thickness / Grade 1::		
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0	kgf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Weld is pre-Heated	No	

Element From Node	100	
Element To Node	110	
Element Type	Flange	
Description	FLANGE WN 12" 150# ASME B16.5	
Distance "FROM" to "TO"	114.3	mm
Flange Inside Diameter	323.9	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-182 F316L	
Allowable Stress, Ambient	115.1	N/mm^2
Allowable Stress, Operating	115.1	N/mm^2
Allowable Stress, Hydrotest	149.7	N/mm^2
Material Density	0.008027	kg/cm^3
P Number Thickness	0	mm
Yield Stress, Operating	151.5	N/mm^2
External Pressure Chart Name	HA-4	
UNS Number	S31603	
Class / Thickness / Grade :: > 5		
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0	kgf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Weld is pre-Heated	No	

Element From Node	110	
Element To Node	120	
Element Type	Cylinder	
Description	TIP	
Distance "FROM" to "TO"	4885.7	mm
Element Outside Diameter	323.9	mm
Element Thickness	6	mm
Internal Corrosion Allowance	0	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C

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Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-213 TP316	
Allowable Stress, Ambient	137.9	N/mm^2
Allowable Stress, Operating	123.8	N/mm^2
Allowable Stress, Hydrotest	179.3	N/mm^2
Material Density	0.008027	kg/cm^3
P Number Thickness	0	mm
Yield Stress, Operating	183.5	N/mm^2
External Pressure Chart Name	HA-2	
UNS Number	S31600	
Product Form	Smls. tube	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

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XY Coordinate Calculations:

From	To	X (Horiz.) mm	Y (Vert.) mm	DX (Horiz.) mm	DY (Vert.) mm
SKIRT		...	950	...	950
Elliptical bott		...	1000	...	50
WS CYLINDER 1/2		...	3500	...	2500
WS CYLINDER 2/2		...	5136	...	1636
WS CYLINDER 3/3		...	5456	...	320
CONE WS TO RISE		...	6456	...	1000
Riser		...	11000	...	4544
CONE		...	11385.7	...	385.7
FLANGE WN 12" 1		...	11500	...	114.3
FLANGE WN 12" 1		...	11623.8	...	114.3
TIP		...	16509.5	...	4885.7

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Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd kPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) N/mm^2
SKIRT		...	...	3	1066.8	...
Elliptical botto		361.4	...	3	1066.8	100.22
WS CYLINDER 1/2		358.33	...	3	1066.8	100.22
WS CYLINDER 2/2		350	...	3	1066.8	100.22
WS CYLINDER 3/3		350	...	3	1066.8	100.22
CONE WS TO RISER		350	...	3	1066.8	100.22
Riser		350	...	3	508	100.22
CONE		350	...	3	508	100.22
FLANGE WN 12" 15		350	...	3	323.9	137.9
FLANGE WN 12" 15		350	...	3	323.9	115.1
TIP		350	...	...	323.9	123.8

Element Required Thickness and MAWP :

From	To	Design Pressure kPa	M.A.W.P. Corroded kPa	M.A.P. New & Cold kPa	Minimum Thickness mm	Required Thickness mm
SKIRT		...	No Calc	No Calc	10	No Calc
Elliptical botto		350	621.533	1205.89	6.35	4.91749
WS CYLINDER 1/2		350	1313.69	1892.88	10	4.90463
WS CYLINDER 2/2		350	1322.02	1892.88	10	4.8604
WS CYLINDER 3/3		350	1322.02	1892.88	10	4.8604
CONE WS TO RISER		350	1273.01	1822.55	10	4.93166
Riser		350	2792.45	4008.37	10	4.5875
CONE		350	2715.34	3897.17	10	4.5875
FLANGE WN 12" 15		350	1833.99	1964.96	10	No Calc
FLANGE WN 12" 15		350	1833.99	1964.96	10	No Calc
TIP		350	4655.32	5185.53	6	1.5875
Minimum			621.533	1205.880		

MAWP: 621.533 kPa, limited by: Elliptical bottom head.

Internal Pressure Calculation Results :

ASME Code, Section VIII Division 1, 2023

Elliptical Head From 20 To 30 SA-516 60 , UCS-66 Crv. C at 80 °C

Elliptical bottom head

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
= (P*Do*K)/(2*S*E+2*P*(K-0.1)) per Appendix 1-4 (c)
= (361.4*1067*1)/(2*117.9*0.85+2*361.4*(1-0.1))
= 1.9175 + 3.0000 = 4.9175 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 11.405 kPa
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*3.35)/(1*1067-2*3.35*(1-0.1))
= 632.938 - 11.405 = 621.533 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.35)/(1*1067-2*6.35*(1-0.1))
= 1205.887 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(K*Do-2*t*(K-0.1)))/(2*E*t)
= (361.4*(1*1067-2*3.35*(1-0.1)))/(2*0.85*3.35)
= 67.320 N/mm^2

Straight Flange Required Thickness:

```
  = (P*Ro)/(S*E+0.4*P) + ca   per Appendix 1-1 (a)(1)
  = (361.4*533.4)/(117.9*0.85+0.4*361.4)+3
  = 4.921 mm
```

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 8.822 kPa

```
  = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
  = (117.9 * 0.85 * 3.35 )/(533.4 - 0.4 * 3.35 )
  = 630.945 - 8.822 = 622.123  kPa
```

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 2.611 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 6.35, tr = 1.917, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
```

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 6.35, tr = 1.921, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
```

Cylindrical Shell From 30 To 40 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 1/2

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:

```
  = (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (358.3*533.4)/(117.9*0.85+0.4*358.3)
  = 1.9046 + 3.0000 = 4.9046 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 8.332 kPa

```
  = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
  = (117.9*0.85*7)/(533.4-0.4*7)
  = 1322.021 - 8.332 = 1313.689  kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
  = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
  = (117.9*0.85*10)/(533.4-0.4*10)
  = 1892.882 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
  = (P*(Ro-0.4*t))/(E*t)
  = (358.3*((533.4-0.4*7))/(0.85*7)
  = 31.957 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 4.012, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -48 °C
```

Cylindrical Shell From 40 To 50 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 2/2

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*533.4)/(117.9*0.85+0.4*350)
= 1.8604 + 3.0000 = 4.8604 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
= (P*(Ro-0.4*t))/(E*t)
= (350*((533.4-0.4*7))/(0.85*7)
= 31.214 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 2.574, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.313, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Cylindrical Shell From 50 To 60 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 3/3

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*533.4)/(117.9*0.85+0.4*350)
= 1.8604 + 3.0000 = 4.8604 mm
```

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Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (350*((533.4-0.4*7))/(0.85*7)
= 31.214 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 1.86, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.226, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C	-44 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Conical Section From 60 To 70 SA-516 60 , UCS-66 Crv. C at 80 °C

CONE WS TO RISER

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
= (P*Do)/(2*cos(a)*(S*E+0.4*P)) per Appendix 1-4 (e)
= (350*1067)/(2*0.963*(117.9*0.85+0.4*350))
= 1.9317 + 3.0000 = 4.9317 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4 (e)(5)
= (2*117.9*0.85*(7)*0.963)/(1067-0.8*(7)*0.963)
= 1273.009 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4(e)
= (2*117.9*0.85*10*0.963)/(1067-0.8*10*0.963)
= 1822.553 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(D-0.8*t*cos(a)))/(2*E*t*cos(a))
= (350*(1067-0.8*(7)*0.963))/(2*0.85*(7)*0.963)
= 32.415 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.010 %

Minimum Design Metal Temperature Results:

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Govrn. thk, tg = 10, tr = 1.932, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.235, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Cylindrical Shell From 70 To 80 SA-516 60 , UCS-66 Crv. C at 80 °C

Riser

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*254)/(117.9*0.85+0.4*350)
= 0.8859 + 3.0000 = 3.8859 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(254-0.4*7)
= 2792.454 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(254-0.4*10)
= 4008.367 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
= (P*(Ro-0.4*t))/(E*t)
= (350*((254-0.4*7))/(0.85*7)
= 14.777 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.008 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 2.643, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.321, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Conical Section From 80 To 90 SA-516 60 , UCS-66 Crv. C at 80 °C

CONE

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Do)/(2*cos(a)*(S*E+0.4*P)) per Appendix 1-4 (e)
```

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```
= (350*508)/(2*0.973*(117.9*0.85+0.4*350))
= 0.9108 + 3.0000 = 3.9108 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4 (e)(5)
= (2*117.9*0.85*(7)*0.973)/(508-0.8*(7)*0.973)
= 2715.345 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4(e)
= (2*117.9*0.85*10*0.973)/(508-0.8*10*0.973)
= 3897.167 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(D-0.8*t*cos(a)))/(2*E*t*cos(a))
= (350*(508-0.8*(7)*0.973))/(2*0.85*(7)*0.973)
= 15.197 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 3.189 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 1.587, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.193, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C          -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C
```

Cylindrical Shell From 110 To 120 SA-213 TP316 at 80 °C

TIP

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:

```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*161.9)/(123.8*1+0.4*350)
= 0.4574 + 0.0000 = 0.4574 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (123.8*1*6)/(161.9-0.4*6)
= 4655.324 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*1*6)/(161.9-0.4*6)
= 5185.534 kPa
```

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Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(Ro-0.4*t))/(E*t)
= (350*((161.9-0.4*6))/(1*6)
= 9.308 N/mm^2
```

SA-213 TP316, Min Metal Temp without impact per UHA-51: -196 °C

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

```
Pressure per UG99b     = 1.30 * M.A.W.P. * Sa/S        807.993  kPa
Pressure per UG99b[36] = 1.30 * Design Pres * Sa/S      455.000  kPa
Pressure per UG99c     = 1.30 * M.A.P. - Head(Hyd)    1412.639  kPa
Pressure per UG100     = 1.10 * M.A.W.P. * Sa/S        683.686  kPa
Pressure per PED       = max(1.43*DP, 1.25*DP*ratio)   500.500  kPa
Pressure per App 27-4  = M.A.W.P.                      621.533  kPa
```

Pressure per the PED:
= max(1.43 * Design Pressure, 1.25 * Design Pressure * Stress ratio)
= max(1.43 * 350, 1.25 * 350 * 1)
= max(500.5, 437.5)
= 500.500 kPa

Vertical Test performed per: PED

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (N/mm^2 & kPa):

From To	Stress	Allowable	Ratio	Pressure
Elliptical bottom he	64.1	153.3	0.418	655.50
WS CYLINDER 1/2	40.6	153.3	0.265	652.43
WS CYLINDER 2/2	39.1	153.3	0.255	627.93
WS CYLINDER 3/3	38.1	153.3	0.249	611.89
CONE WS TO RISER	39.4	153.3	0.257	608.75
Riser	17.6	153.3	0.115	598.95
CONE	16.8	153.3	0.109	554.41
TIP	14.6	179.3	0.081	548.39

Stress ratios for Nozzle and Pad Materials (N/mm^2):

Description	Pad/Nozzle	Ambient	Operating	Ratio
N2	Nozzle	117.90	117.90	1.000
N2	Pad	117.90	117.90	1.000
N3	Nozzle	117.90	117.90	1.000
N4	Nozzle	117.90	117.90	1.000
K1A	Nozzle	117.90	117.90	1.000
K1B	Nozzle	117.90	117.90	1.000
HW	Nozzle	117.90	117.90	1.000
HW	Pad	137.90	137.90	1.000

N1	Nozzle	117.90	117.90	1.000
N1	Pad	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (N/mm^2):

Description	Ambient	Operating	Ratio
Elliptical bottom he	117.90	117.90	1.000
WS CYLINDER 1/2	117.90	117.90	1.000
WS CYLINDER 2/2	117.90	117.90	1.000
WS CYLINDER 3/3	117.90	117.90	1.000
CONE WS TO RISER	117.90	117.90	1.000
Riser	117.90	117.90	1.000
CONE	117.90	117.90	1.000
FLANGE WN 12" 150# A	137.90	137.90	1.000
FLANGE WN 12" 150# A	115.10	115.10	1.000
TIP	137.90	123.80	1.114
Minimum			1.000

Hoop Stress in Nozzle Wall during Pressure Test (N/mm^2):

Description	Ambient	Operating	Ratio
N2	3.31	153.28	0.022
N3	2.11	153.28	0.014
N4	2.07	153.28	0.013
K1A	2.11	153.28	0.014
K1B	2.07	153.28	0.014
HW	8.48	153.28	0.055
N1	8.79	153.28	0.057

Elements Suitable for Internal Pressure.

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External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm	Outside Diameter mm	Corroded Thickness mm	Factor A	Factor B N/mm^2
10	20	950	...	...	No Calc	No Calc
20	30	No Calc	1066.8	3.35	0.00043614	43.6045
30	40	4593.84	1066.8	7	0.00016183	16.1796
40	50	4593.84	1066.8	7	0.00016183	16.1796
50	60	4593.84	1066.8	7	0.00016183	16.1796
60	70	737.907	1066.8	7	0.00099569	85.1672
70	80	4544	508	7	0.00023648	23.6426
80	90	315.734	508	7	0.0035425	114.682
90	100	No Calc	...	7	No Calc	No Calc
100	110	No Calc	...	7	No Calc	No Calc

110	120	4885.7	323.9	6	0.00037746	35.7443

External Pressure Calculations:

From	To	External Actual T. mm	External Required T. mm	External Design Pressure kPa	External M.A.W.P. kPa
10	20	...	No Calc	...	No Calc
20	30	6.35	4.5875	...	152.134
30	40	10	No Calc	...	141.545
40	50	10	No Calc	...	141.545
50	60	10	No Calc	...	141.545
60	70	10	No Calc	...	717.594
70	80	10	No Calc	...	434.353
80	90	10	No Calc	...	2049.35
90	100	10	7	...	No Calc
100	110	10	7	...	No Calc
110	120	6	No Calc	...	882.795
Minimum					141.545

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm	Allowable Length Bet. Stiffeners mm	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	950	No Calc	No Calc	No Calc
20	30	No Calc	No Calc	No Calc	No Calc
30	40	4593.84	No Calc	No Calc	No Calc
40	50	4593.84	No Calc	No Calc	No Calc
50	60	4593.84	No Calc	No Calc	No Calc
60	70	737.907	737.907	No Calc	No Calc
70	80	4544	No Calc	No Calc	No Calc
80	90	315.734	315.734	No Calc	No Calc
90	100	No Calc	No Calc	No Calc	No Calc
100	110	No Calc	No Calc	No Calc	No Calc
110	120	4885.7	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

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Elliptical Head From 20 to 30 Ext. Chart: CS-2 at 80 °C

Elliptical bottom head

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
3.350	1066.80	318.45	0.0004361	43.60

EMAP = B/(K0*D/t) = 43.6/(0.9 *318.4) = 152.1 kPa

*Check the requirements of UG-33(a)(1) using P = 1.67 * External Design pressure for this head.*

Material UNS Number: K02100

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
  = ((2*S*E*t)/(K*D+0.2*t))/1.67 per Appendix 1-4 (c)
  = ((2*117.9*1*3.35)/(1*1060+0.2*3.35))/1.67
  = 445.888 kPa
```

Maximum Allowable External Pressure [MAEP]:
```
  = min( MAEP, MAWP )
  = min( 152.1, 445.9 )
  = 152.134 kPa
```

Cylindrical Shell From 30 to 40 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 1/2

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cylindrical Shell From 40 to 50 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 2/2

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cylindrical Shell From 50 to 60 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 3/3

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

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Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cone From 60 to 70 Ext. Chart: CS-2 at 80 °C

CONE WS TO RISER

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.742	1066.80	737.91	158.24	0.6917	0.0009957	85.17

EMAP = (4*B)/(3*(D/t)) = (4*85.17)/(3*158.2) = 717.6 kPa

Note: The cone thickness used in the calculation has been modified per UG-33(f), te = t * cos(alpha).

Cylindrical Shell From 70 to 80 Ext. Chart: CS-2 at 80 °C

Riser

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	508.00	4544.00	72.57	8.9449	0.0002365	23.64

EMAP = (4*B)/(3*(D/t)) = (4*23.64)/(3*72.57) = 434.4 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	508.00	4544.00	72.57	8.9449	0.0002365	23.64

EMAP = (4*B)/(3*(D/t)) = (4*23.64)/(3*72.57) = 434.4 kPa

Cone **From 80 to 90 Ext. Chart: CS-2 at 80 °C**

CONE

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.809	508.00	315.73	74.61	0.6215	0.0035425	114.68

EMAP = (4*B)/(3*(D/t)) = (4*114.7)/(3*74.61) = 2049 kPa

Note: The cone thickness used in the calculation has been modified per UG-33(f), te = t * cos(alpha).

Cylindrical Shell From 110 to 120 Ext. Chart: HA-2 at 80 °C

TIP

Elastic Modulus from Chart: HA-2 at 80 °C : 0.189E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.000	323.90	4885.70	53.98	15.0840	0.0003775	35.74

EMAP = (4*B)/(3*(D/t)) = (4*35.74)/(3*53.98) = 882.8 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.000	323.90	4885.70	53.98	15.0840	0.0003775	35.74

EMAP = (4*B)/(3*(D/t)) = (4*35.74)/(3*53.98) = 882.8 kPa

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Element and Detail Weights:

From	To	Element Metal Wgt. kgm	Element ID Volume cm3	Corroded Metal Wgt. kgm	Corroded ID Volume cm3	Extra due Misc % kgm
10	20	244.454	...	208.063	...	...
20	30	74.4388	196948	39.2708	200079	...
30	40	643.301	2151570	451.589	2176305	...
40	50	420.976	1407987	295.519	1424174	...
50	60	82.3426	275401	57.8033	278567	...
60	70	196.441	482036	138.06	489568	...
70	80	550.994	849897	388.019	870924	...
80	90	39.1679	48212.7	27.626	49701.9	...
90	100	...	9417.95	...	9770.1	...
100	110	...	9417.95	...	9770.1	...
110	120	235.011	373289	235.011	373289	...
Total		2487	5823012.50	1840	5901690.50	0

Weight of Details:

From	Type	Weight of Detail kgm	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Description
10	Insl	16.8396	...	650	Insulation ext
20	Liqd	196.864	...	-131.762	WS LIQUID 1/2
20	Insl	12.742	...	-108.35	Insulation ext
20	Nozl	5.38381	...	-388.531	N2
30	Liqd	731.221	...	425	WS Liquid 2/2
30	Insl	61.7452	...	1100	Insulation ext
30	Nozl	2.15915	535.554	700	N3
30	Nozl	2.15915	535.554	2200	N4
30	Nozl	2.15915	535.554	950	K1A
30	Nozl	2.15915	535.554	1950	K1B
30	Nozl	49.0437	624.759	...	HW
30	Wght	87.2711	...	850	WGHT:[1 OF 1]
40	Nozl	71.383	659.925	1500	N1
40	Wght	103.456	...	...	N1-INNER1OF2
40	Forc	...	...	1500	N10 Nozle Laod

```
   70|Plat|      181.4 |0.14523E-04 |      4044 |   PLT 1
 -------------------------------------------------
```

Total Weight of Each Detail Type:

```
 Platforms                          181.4
 Liquid                             928.1
 Insulation                          91.3
 Nozzles                            134.4
 Weights                            190.7
 ----------------------------------------
 Sum of the Detail Weights       1526.0 kgm
```

Weight Summation Results: (kgm)

```
               | Fabricated |  Shop Test |   Shipping |    Erected |      Empty |
Operating |
 ------------------------------------------------------------------------------------------
-----
 Main Elements |     2487.1 |     2487.1 |     2487.1 |     2487.1 |     2487.1 |
2487.1 |
       Nozzles |      134.4 |      134.4 |      134.4 |      134.4 |      134.4 |
134.4 |
   Wld Weights |      190.7 |      190.7 |      190.7 |      190.7 |      190.7 |
190.7 |
     Platforms |        ... |        ... |      181.4 |      181.4 |      181.4 |
181.4 |
    Insulation |        ... |        ... |       91.3 |       91.3 |       91.3 |
91.3 |
   Ope. Liquid |        ... |        ... |        ... |        ... |        ... |
928.1 |
   Test Liquid |        ... |     5820.5 |        ... |        ... |        ... |
... |
 ------------------------------------------------------------------------------------------
-----
        Totals |     2812.3 |     8632.8 |     3085.0 |     3085.0 |     3085.0 |
4013.1 |
```

Field Installation Options:

Weight Summary:

```
 Fabricated Wt.  - Bare Weight without Removable Internals          2812.3 kgm
 Shop Test Wt.   - Fabricated Weight + Water ( Full )               8632.8 kgm
 Shipping Wt.    - Fab. Weight + removable Intls.+ Shipping App.    3085.0 kgm
 Erected  Wt.    - Fab. Wt + or - loose items (trays,platforms etc.) 3085.0 kgm
 Ope. Wt. no Liq - Fab. Weight + Internals. + Details + Weights     3085.0 kgm
 Operating Wt.   - Empty Weight + Operating Liq. Uncorroded         4013.1 kgm
 Field Test Wt.  - Empty Weight + Water (Full)                      8905.6 kgm
 Mass of the Upper 1/3 of the Vertical Vessel                        262.2 kgm
```

Outside Surface Areas of Elements:

```
     |    |        Surface |
 From| To |           Area |
     |    |           cm^2 |
 ---------------------------
```

```
   10|  20|        31838.8 |
   20|  30|        14012.2 |
   30|  40|        83786.3 |
   40|  50|        54829.7 |
   50|  60|        10724.6 |
   60|  70|        25684.3 |
   70|  80|          72519 |
   80|  90|        5181.67 |
   90| 100|        823.971 |
  100| 110|        823.971 |
  110| 120|          49715 |
-----------------------------
  Total        349939.500 cm^2
```

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kgm	Total. Ele. Oper. Wgt. kgm	Total. Ele. Hydro. Wgt. kgm	Total Dtl. Offset Mom. kgf-m	Oper. Wgt. No Liquid kgm
10	20	261.293	261.293	261.293	...	261.293
20	30	92.5645	289.428	289.428	...	92.5645
30	40	849.998	1581.22	3000.65	35.2665	849.998
40	50	595.815	595.815	2003.2	47.1083	595.815
50	60	82.3426	82.3426	357.626	...	82.3426
60	70	196.441	196.441	678.271	...	196.441
70	80	732.394	732.394	1581.93	0.26346E-05	732.394
80	90	39.1679	39.1679	87.36	...	39.1679
90	100	...	...	9.41392	...	...
100	110	...	...	9.41392	...	...
110	120	235.011	235.011	608.141	...	235.011

```
Empty Support Force + the Sum of the Y forces          1640.03  kgf
Operating Support Force + the Sum of the Y forces      2568.11  kgf
Hydro Support Force + the Sum of the Y forces          7441.72  kgf
```

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kgm	Cumulative Oper. Wgt. kgm	Cumulative Hydro. Wgt. kgm
10	20	3085.03	4013.11	8886.72
20	30	2823.73	3751.82	8625.43
30	40	2731.17	3462.39	8336
40	50	1881.17	1881.17	5335.35
50	60	1285.36	1285.36	3332.15
60	70	1203.01	1203.01	2974.53
70	80	1006.57	1006.57	2296.26
80	90	274.179	274.179	714.329
90	100	235.011	235.011	626.969
100	110	235.011	235.011	617.555
110	120	235.011	235.011	608.141

Note: The cumulative operating weights no liquid in the column above

are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. kgf-m	Cumulative Oper. Mom. kgf-m	Cumulative Hydro. Mom. kgf-m
10	20	82.3749	82.3749	82.3749
20	30	82.3749	82.3749	82.3749
30	40	82.3749	82.3749	82.3749
40	50	47.1084	47.1084	47.1084
50	60	0.26346E-05	0.26346E-05	0.26346E-05
60	70	0.26346E-05	0.26346E-05	0.26346E-05
70	80	0.26346E-05	0.26346E-05	0.26346E-05
80	90	...	...	...
90	100	...	...	...
100	110	...	...	...
110	120	...	...	...

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Nozzle Flange MAWP Results:

Nozzle Description	Flange Rating Ope. kPa	Ambient kPa	Design Temp °C	Class	Grade/ Group	Equiv. Press	- - - - - - Max Pressure PVP	50% DNV kPa
N2	1834.0	1965.0	80	150	GR 1.1	...	...	...
N3	1834.0	1965.0	80	150	GR 1.1	...	...	...
N4	1834.0	1965.0	80	150	GR 1.1	...	...	...
K1A	1834.0	1965.0	80	150	GR 1.1	...	...	...
K1B	1834.0	1965.0	80	150	GR 1.1	...	...	...
HW	1834.0	1965.0	80	150	GR 1.1	...	...	...
N1	1834.0	1965.0	80	150	GR 1.1	...	...	...
Min Rating	833.988	1964.961 kPa [for Core Elements]				0.000	0.000	0.000

Selected Method for Derating ANSI B16.5 Flange MAWP: None Selected

ANSI Ratings are per ANSI/ASME B16.5 2013 Edition

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Natural Frequency for the Operating Case (No Liquid), Freese Method

Natural Frequency Calculation:

From	To	Element Total Wgt. kgm	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation	Element Empty Wgt. kgm
10	20	261.293	0.022501	0.08735	0.00017837	261.293
20	30	92.5645	0.091942	0.096799	0.00019959	92.5645
30	40	849.998	0.49252	1.13349	0.00059364	849.998
40	50	595.815	1.6555	2.24123	0.00074995	595.815
50	60	82.3426	2.3622	2.48507	0.00077371	82.3426
60	70	196.441	2.89338	3.34107	0.00093134	196.441
70	80	732.394	6.53869	11.0859	0.0021636	732.394
80	90	39.1679	11.5066	11.934	0.0022323	39.1679
90	100	...	12.062	12.191	0.0022652	...
100	110	...	12.3209	12.4518	0.002298	...
110	120	235.011	18.8898	26.0078	0.0029332	235.011

The Natural Frequency for the Vessel (Empty.) is 4.86808 Hz.

Natural Frequency for the Operating Case, Freese Method

Natural Frequency Calculation:

From	To	Element Total Wgt. kgm	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation	Element Empty Wgt. kgm
10	20	261.293	0.024872	0.096009	0.00019486	261.293
20	30	289.428	0.10102	0.10632	0.00021753	92.5645
30	40	1581.22	0.53207	1.20936	0.00062304	849.998
40	50	595.815	1.75541	2.36519	0.00077934	595.815
50	60	82.3426	2.49086	2.61843	0.00080311	82.3426
60	70	196.441	3.04145	3.50383	0.00096074	196.441
70	80	732.394	6.76824	11.3822	0.002193	732.394
80	90	39.1679	11.8086	12.2416	0.0022617	39.1679
90	100	...	12.3714	12.502	0.0022945	...
100	110	...	12.6337	12.7662	0.0023274	...
110	120	235.011	19.276	26.4658	0.0029626	235.011

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Natural Frequency for the Filled Case, Freese Method

The Natural Frequency for the Vessel (Filled) is 3.64821 Hz.

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Forces/Moments Applied to Vessel (Combined w/Wind Loads)

From	To	X and Z Dir Force Res. kgf	X,Z Moment and For Res kgf-m
10	20	...	...
20	30	...	...
30	40	...	...
40	50	1641.13	3250.94
50	60	...	...
60	70	...	...
70	80	...	...
80	90	...	...
90	100	...	...
100	110	...	...
110	120	...	...

Forces/Moments Applied to Vessel (Combined w/Seismic Loads)

From	To	X and Z Dir Force Res. kgf	X,Z Moment and For Res kgf-m
10	20	...	...
20	30	...	...
30	40	...	...
40	50	1641.13	3250.94
50	60	...	...
60	70	...	...
70	80	...	...
80	90	...	...
90	100	...	...
100	110	...	...
110	120	...	...

User Input Forces and Moments:

From Node	Distance From	Forces Fx	Fy	Fz	Moments Mx	My	Mz
40	1500.00	1445.	1445.	-778.	474.		631.

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Wind Load results per EN 1991-1-4:2005+A1:2010

Input Data:

Fundamental Wind Velocity	Vb	100.800 Km/hr
Air Density per Section 4.5	Rho	1.250 kg/m³
Wind Direction Factor	Cdir	1.000
Season Factor	CSeason	1.000
Structural Factor	CsCd	1.000
Wind Force Coefficient	Cf	0.700
Vessel Base Height (site)	Hb	31310.000 mm
Terrain Category		0

Note: The Wind Load Results below are in Metric Units.

Category 2 Basic Wind Velocity [Vb]:
= Cdir * CSeason * Vb,0
= 1 * 1 * 28
= 28.001 m/s

Terrain Factor dependant on Roughness Length [kr]:
= 0.19 * (Zo / Z0,ii) ^ 0.07
= 0.19 * (0.003/0.05)$^{0.07}$
= 0.156

Sample Calculation for the first Element:

Determine the Roughness factor as a function of Elevation [Cr(z)]:
= kr * ln(z / zo)
= 0.156 * ln(31.78/0.003)
= 1.446

Mean Velocity at Height z [Vm(z)]:
= cr(z) * 1.0 * Vb
= 1.446 * 1.0 * 28
= 40.493 m/s

Turbulence Intensity at Height z [Vm(z)]:
= 1.0 / (1.0 * ln(z / zo))
= 1.0/(1.0 * ln(31.78/0.003))
= 0.108

Peak Velocity Pressure at Height z [qp(z)]:
= [1.0 + 7.0 * Iv(z)] * 1/2 * 1.25 * Vm(z)^2
= [1.0 + 7.0 * 0.108] * 1/2 * 1.25 * 40.49^2
= 1798.849 N/m^2

Force on the First Element at Height z [Fw(z)]:
= qp(z) * CsCd * Aref * Cf
= 1799 * 1 * 1.288 * 0.7
= 1622.039 Newtons

Note: The orography factor co(z) and the turbulence factor ki(z) are taken to be 1.0.

Wind Vibration Calculations

This evaluation is based on work by Kanti Mahajan and Ed Zorilla

Nomenclature

Cf - Correction factor for natural frequency
D - Average internal diameter of vessel mm
Df - Damping Factor < 0.75 Unstable, > 0.95 Stable
Dr - Average internal diameter of top half of vessel mm
f - Natural frequency of vibration (Hertz)
f1 - Natural frequency of bare vessel based on a unit value of $(D/L^2)(10^4)$
L - Total height of structure mm
Lc - Total length of conical section(s) of vessel mm

```
tb  - Uncorroded plate thickness at bottom of vessel mm
V30 - Design Wind Speed provided by user Km/hr
Vc  - Critical wind velocity Km/hr
Vw  - Maximum wind speed at top of structure Km/hr
W   - Total corroded weight of structure kgf
Ws  - Cor. vessel weight excl. weight of parts which do not effect stiff. kgf
 Z  - Maximum amplitude of vibration at top of vessel mm
Dl  - Logarithmic decrement ( taken as 0.03 for Welded Structures )
Vp  - Vib. Chance, <= 0.32037E-06 (High); 0.32037E-06 < 0.40047E-06 (Probable)
P30 - wind pressure 30 feet above the base
```

Check other Conditions and Basic Assumptions:

```
#1 - Total Cone Length / Total Length < 0.5
     1386/16510 = 0.0839

#2 - ( D / L² ) * 10⁴ < 8.0 (English Units)
   - ( 2.189/54.17² ) * 10⁴ = 7.462
```

Compute the vibration possibility. If Vp > 0.40047E-06 no chance. [Vp]:

```
  = W / ( L * Dr²)
  = 3367/( 16510 * 377.2² )
  = 0.14333E-05
```

Since Vp is > 0.40047E-06 no further vibration analysis is required !

Platform Load Calculations

ID	Wind Area cm^2	Elevation mm	Pressure kg/m^2	Force kgf	Cf
PLT 1	14080.00	41810.00	192.03	270.38	1.60

Wind Loads on Masses/Equipment/Piping

ID	Wind Area cm^2	Elevation mm	Pressure kg/m^2	Force kgf
WGHT:[1 OF 1]	3153.73	33985.00	185.51	58.51
N1-INNER1OF2	3738.60	35628.00	187.00	69.91

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Wind Load Calculation:

From	To	Wind Height mm	Wind Diameter mm	Wind Area cm^2	Wind Pressure kg/m^2	Element Wind Load kgf
10	20	31785	1355.95	12881.5	183.435	165.4
20	30	32285	1400.16	700.08	183.921	9.01285
30	40	33560	1385.76	34644	185.127	508.18
40	50	35628	1280.16	20943.4	186.997	344.047
50	60	36606	1280.16	4096.51	187.847	53.8645
60	70	37205.3	943.961	9439.61	188.357	124.457
70	80	40038	609.6	27700.2	190.672	652.054

80	90	42487.9	498.466	1922.58	192.554	25.9133
90	100	42752.8	388.68	444.261	192.752	5.99407
100	110	42876.7	388.68	444.261	192.844	5.99693
110	120	45376.7	388.68	18989.7	194.65	258.736

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Input Values for G Loading:

Horizontal Acceleration factor	(GX)	0.700
Horizontal Acceleration factor	(GZ)	0.700
Vertical Acceleration factor	(GY)	0.700

Computed Results:

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height mm	Earthquake Weight kgf	Element Ope Load kgf	Element Emp Load kgf
10	20	475	261.293	258.667	258.667
20	30	975	289.428	286.519	91.6342
30	40	2250	1581.22	1565.33	841.455
40	50	4318	595.815	589.827	589.827
50	60	5296	82.3426	81.515	81.515
60	70	5956	196.441	194.467	194.467
70	80	8728	732.394	725.033	725.033
80	90	11192.8	39.1679	38.7742	38.7742
90	100	11442.8	...	...	...
100	110	11566.7	...	...	...
110	120	14066.7	235.011	232.649	232.649

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Bending Moments due to user defined forces and moments.

User Force/Moment Shear and Bending

From	To	Distance to Support mm	Cumulative Shr Wind Cas kgf	Cumulative Shr Eqk Cas kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	1641.13	1641.13	8986.89	8986.89
20	30	975	1641.13	1641.13	7427.95	7427.95
30	40	2250	1641.13	1641.13	7345.9	7345.9
40	50	4318	1641.13	1641.13	3244.19	3244.19
50	60	5296	...	...	...	...
60	70	5956	...	...	...	...
70	80	8728	...	...	...	...
80	90	11192.8	...	...	...	...
90	100	11442.8	...	...	...	...
100	110	11566.7	...	...	...	...

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110	120	14066.7	...	...	...	...

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 1.000.

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The following table is for the Operating Case.

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	2153.66	3972.78	13501.8	18096.1
20	30	975	1988.26	3714.11	11534.4	14444.7
30	40	2250	1979.24	3427.59	11435.2	14266.2
40	50	4318	1471.06	1862.26	7122.23	7653.73
50	60	5296	1127.02	1272.44	4996.96	5089.49
60	70	5956	1073.15	1190.92	4644.93	4695.34
70	80	8728	948.694	996.456	3633.98	3601.63
80	90	11192.8	296.641	271.423	804.526	720.951
90	100	11442.8	270.727	232.649	695.107	623.739
100	110	11566.7	264.733	232.649	661.983	594.93
110	120	14066.7	258.736	232.649	632.066	568.338

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 1.000.

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Wind Deflection Calculations:

The following table is for the Applied Forces Case.

Wind Deflection:

From	To	Cumulative Wind Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	1641.13	0.012094	0.046937	0.95783E-04
20	30	1641.13	0.049403	0.052011	0.00010713
30	40	1641.13	0.26325	0.59739	0.00030378
40	50	1641.13	0.85061	1.10773	0.00031466
50	60	...	1.15807	1.20842	0.00031466
60	70	...	1.36575	1.52308	0.00031466

70	80	...	2.23798	2.95288	0.00031466
80	90	...	3.01356	3.07424	0.00031466
90	100	...	3.09222	3.1102	0.00031466
100	110	...	3.12819	3.14617	0.00031466
110	120	...	3.91483	4.68349	0.00031466

Allowable deflection at the Tower Top (For)(6.000"/100ft. Criteria)
Allowable deflection : 82.548 Actual deflection : 4.683 mm

The following table is for the Operating Case.

Wind Deflection:

From	To	Cumulative Wind Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	2153.66	0.018465	0.072	0.00014771
20	30	1988.26	0.075805	0.079833	0.00016556
30	40	1979.24	0.41172	0.95847	0.00051032
40	50	1471.06	1.40978	1.92146	0.00065821
50	60	1127.02	2.02772	2.13584	0.0006814
60	70	1073.15	2.49763	2.89838	0.00083732
70	80	948.694	5.89415	10.2938	0.0021126
80	90	296.641	10.7051	11.1236	0.0021884
90	100	270.727	11.2492	11.3758	0.0022247
100	110	264.733	11.5035	11.6322	0.0022608
110	120	258.736	18.0626	25.2416	0.0029601

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	119.344	745.901
20	30	123.235	770.221
30	40	121.968	762.3
40	50	112.674	704.21
50	60	112.674	704.21
60	70	83.0829	519.268
70	80	53.6541	335.338
80	90	43.8726	274.204
90	100	34.2098	213.811
100	110	34.2098	213.811
110	120	34.2098	213.811

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
Allowable deflection : 82.548 Actual deflection : 25.242 mm

Total Deflection in the Operating Condition + Applied Forces :
Allowable deflection : 82.548 Actual deflection : 29.925 mm

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Longitudinal Stress Constants:

From	To	Metal Area New cm^2	Metal Area Corroded cm^2	Section Modulus New mm³	Section Modulus Corroded mm³
10	20	332.004	233.063	8690112	6134741
20	30	211.55	111.92	5575274	2966227
30	40	332.004	233.062	8690095	6134733
40	50	332.004	233.062	8690095	6134733
50	60	332.004	233.062	8690095	6134733
60	70	344.594	241.927	9013156	6364886
70	80	156.451	110.175	1910244	1361197
80	90	160.754	113.225	1960618	1397796
90	100	160.754	114.532	1960618	1413453
100	110	59.9227	30.2441	467580	240407
110	120	59.9227	59.9227	467580	467580

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Longitudinal Allowable Stresses:

From	To	Tensile N/mm^2	Hydrotest Tensile N/mm^2	Compressive N/mm^2	Hydrotest Compressive N/mm^2
10	20	137.19	178.296	-118.874	-128.609
20	30	120.258	156.366	-93.0141	-115.899
30	40	120.258	156.366	-118.874	-128.609
40	50	120.258	156.366	-118.874	-128.609
50	60	120.258	156.366	-118.874	-128.609
60	70	120.258	156.366	-119.985	-129.529
70	80	120.258	156.366	-137.086	-143.047
80	90	120.258	156.366	-137.614	-143.434
90	100	165.48	215.16	-137.833	-143.434
100	110	138.12	179.64	-84.5316	-103.301
110	120	148.56	215.16	-107.249	-110.081

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Longitudinal Stress Report

Note: Longitudinal Operating and Empty Stresses are computed in the corroded condition. Stresses due to loads in the hydrostatic test cases have been computed in the new and cold condition.

Longitudinal Pressure Stresses due to:

From	To	Longitudinal Stress Internal Pressure N/mm^2	Longitudinal Stress External Pressure N/mm^2	Longitudinal Stress Hydrotest Pressure N/mm^2
10	20	...	...	...

20	30	27.6208	...	20.6718
30	40	13.0908	...	12.9987
40	50	13.0908	...	12.9987
50	60	13.0908	...	12.9987
60	70	13.0814	...	12.9853
70	80	6.10535	...	6.00635
80	90	6.09847	...	5.99651
90	100	...	...	...
100	110	...	...	...
110	120	4.4788	...	6.40469

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty N/mm^2	Wght. Str. Operating N/mm^2	Wght. Str. Hydrotest N/mm^2	Wght. Str. Emp. Mom. N/mm^2	Wght. Str. Opr. Mom. N/mm^2
10	20	-1.29812	-1.68864	-2.62499	0.13168	0.13168
20	30	-2.47425	-2.47425	-1.309	0.27234	0.27234
30	40	-1.14923	-1.14923	-0.80674	0.13168	0.13168
40	50	-0.79156	-0.79156	-0.55567	0.075305	0.075305
50	60	-0.54086	-0.54086	-0.37967	0.42114E-08	0.42114E-08
60	70	-0.48766	-0.48766	-0.34237	0.40592E-08	0.40592E-08
70	80	-0.89596	-0.89596	-0.63095	0.18980E-07	0.18980E-07
80	90	-0.23748	-0.23748	-0.16726	...	...
90	100	-0.20123	-0.20123	-0.14337	...	...
100	110	-0.76204	-0.76204	-0.38461	...	...
110	120	-0.38461	-0.38461	-0.38461	...	...

Longitudinal Stresses due to Weight Loads and Bending for these Conditions:

From	To	Wght. Str. Hyd. Mom. N/mm^2	Bend. Str. Oper. Wind N/mm^2	Bend. Str. Oper. Equ. N/mm^2	Bend. Str. Hyd. Wind N/mm^2	Bend. Str. Hyd. Equ. N/mm^2
10	20	0.092959	21.5832	28.9273	5.02807	...
20	30	0.14489	38.1338	47.7557	6.69518	...
30	40	0.092959	18.2797	22.8051	4.25847	...
40	50	0.053161	11.3852	12.2348	2.65232	...
50	60	0.29731E-08	7.98786	8.13577	1.86087	...
60	70	0.28665E-08	7.15662	7.2343	1.66777	...
70	80	0.13525E-07	26.1807	25.9477	6.15642	...
80	90	...	5.64438	5.05803	1.32795	...
90	100	...	4.8227	4.32754	1.14734	...
100	110	...	27.0035	24.2683	4.58168	...
110	120	...	13.2564	11.9198	4.37462	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case N/mm^2	Vortex Shedding Empty Case N/mm^2	Vortex Shedding Test Case N/mm^2	Earthquake Empty Case N/mm^2
10	20	...	...	...	26.0199

20	30	...	...	...	44.6283
30	40	...	...	...	21.3586
40	50	...	...	...	12.2348
50	60	...	...	...	8.13577
60	70	...	...	...	7.2343
70	80	...	...	...	25.9477
80	90	...	...	...	5.05803
90	100	...	...	...	4.32754
100	110	...	...	...	24.2683
110	120	...	...	...	11.9198

Longitudinal Stresses due to Applied Axial Forces:

From	To	Longitudinal Stress Y Forces Wind N/mm^2	Longitudinal Stress Y Forces Seismic N/mm^2
10	20	0.60803	1.79008
20	30	1.26616	3.56738
30	40	0.60803	1.62787
40	50	0.60803	1.16212
50	60	...	0.3786
60	70	...	0.34136
70	80	...	0.62717
80	90	...	0.16623
90	100	...	0.14086
100	110	...	0.53343
110	120	...	0.26923

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded N/mm^2	Earthquake For/Mom Corroded N/mm^2	Wind For/Mom No Corrosion N/mm^2	Earthquake For/Mom No Corrosion N/mm^2
10	20	14.3659	14.3659	10.1415	10.1415
20	30	24.5575	24.5575	13.0654	13.0654
30	40	11.7427	11.7427	8.28973	8.28973
40	50	5.18599	5.18599	3.66102	3.66102
50	60	...	...	...	...
60	70	...	...	...	...
70	80	...	...	...	...
80	90	...	...	...	...
90	100	...	...	...	...
100	110	...	...	...	...
110	120	...	...	...	...

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Stress Combination Load Cases for Vertical Vessels:

Load Case Definition Key

IP = Longitudinal Stress due to Internal Pressure

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EP = Longitudinal Stress due to External  Pressure
HP = Longitudinal Stress due to Hydrotest Pressure
NP = No Pressure
EW = Longitudinal Stress due to Weight (No Liquid)
OW = Longitudinal Stress due to Weight (Operating)
HW = Longitudinal Stress due to Weight (Hydrotest)
WI = Bending Stress due to Wind Moment (Operating)
EQ = Bending Stress due to Earthquake Moment (Operating)
EE = Bending Stress due to Earthquake Moment (Empty)
HI = Bending Stress due to Wind Moment (Hydrotest)
HE = Bending Stress due to Earthquake Moment (Hydrotest)
WE = Bending Stress due to Wind Moment (Empty) (no CA)
WF = Bending Stress due to Wind Moment (Filled) (no CA)
CW = Longitudinal Stress due to Weight (Empty) (no CA)
VO = Bending Stress due to Vortex Shedding Loads ( Ope )
VE = Bending Stress due to Vortex Shedding Loads ( Emp )
VF = Bending Stress due to Vortex Shedding Loads ( Test No CA. )
FW = Axial Stress due to Vertical Forces for the Wind Case
FS = Axial Stress due to Vertical Forces for the Seismic Case
BW = Bending Stress due to Lat. Forces for the Wind Case, Corroded
BS = Bending Stress due to Lat. Forces for the Seismic Case, Corroded
BN = Bending Stress due to Lat. Forces for the Wind Case, UnCorroded
BU = Bending Stress due to Lat. Forces for the Seismic Case, UnCorroded
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General Notes:

Case types HI and HE are in the Un-Corroded condition.

Case types WE, WF, and CW are in the Un-Corroded condition.

A blank stress and stress ratio indicates that the corresponding stress comprising those components that did not contribute to that type of stress.

An asterisk (*) in the final column denotes overstress.

Analysis of Load Case 1 : NP+EW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.39	137.19	-36.77	118.87	0.2580	0.3093
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 2 : NP+EW+EE+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	41.01	137.19	-40.03	118.87	0.2989	0.3367
20	70.55	120.26	-68.37	93.01	0.5867	0.7350
30	33.71	120.26	-32.75	118.87	0.2803	0.2755
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698

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60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 3 : NP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 4 : NP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	73.68	120.26	-71.49	93.01	0.6127	0.7686
30	35.16	120.26	-34.20	118.87	0.2924	0.2877
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698
60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 5 : NP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.50	178.30	-7.75	128.61	0.0140	0.0602
20	5.53	156.37	-8.15	115.90	0.0354	0.0703
30	3.54	156.37	-5.16	128.61	0.0227	0.0401
40	2.15	156.37	-3.26	128.61	0.0137	0.0254
50	1.48	156.37	-2.24	128.61	0.0095	0.0174
60	1.33	156.37	-2.01	129.53	0.0085	0.0155
70	5.53	156.37	-6.79	143.05	0.0353	0.0474
80	1.16	156.37	-1.50	143.43	0.0074	0.0104
110	3.99	215.16	-4.76	110.08	0.0185	0.0432

Analysis of Load Case 6 : NP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		178.30	-2.72	128.61		0.0211
20		156.37	-1.45	115.90		0.0125
30		156.37	-0.90	128.61		0.0070
40		156.37	-0.61	128.61		0.0047
50		156.37	-0.38	128.61		0.0030
60		156.37	-0.34	129.53		0.0026
70		156.37	-0.63	143.05		0.0044
80		156.37	-0.17	143.43		0.0012
110		215.16	-0.38	110.08		0.0035

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Analysis of Load Case 7 : IP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	89.38	120.26	-36.55	93.01	0.7432	0.3930
30	42.70	120.26	-17.60	118.87	0.3551	0.1481
40	29.55	120.26	-3.74	118.87	0.2458	0.0315
50	20.54	120.26		118.87	0.1708	
60	19.75	120.26		119.99	0.1642	
70	31.39	120.26	-20.97	137.09	0.2610	0.1530
80	11.51	120.26		137.61	0.0957	
110	17.35	148.56	-9.16	107.25	0.1168	0.0854

Analysis of Load Case 8 : IP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	101.30	120.26	-43.87	93.01	0.8424	0.4717
30	48.25	120.26	-21.11	118.87	0.4012	0.1776
40	30.96	120.26	-4.03	118.87	0.2574	0.0339
50	21.06	120.26		118.87	0.1752	
60	20.17	120.26		119.99	0.1677	
70	31.78	120.26	-20.11	137.09	0.2643	0.1467
80	11.09	120.26		137.61	0.0922	
110	16.28	148.56	-7.56	107.25	0.1096	0.0705

Analysis of Load Case 9 : EP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 10 : EP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	73.68	120.26	-71.49	93.01	0.6127	0.7686
30	35.16	120.26	-34.20	118.87	0.2924	0.2877
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698
60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 11 : HP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.50	178.30	-7.75	128.61	0.0140	0.0602
20	26.20	156.37		115.90	0.1676	

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30	16.54	156.37		128.61	0.1058	
40	15.15	156.37		128.61	0.0969	
50	14.48	156.37		128.61	0.0926	
60	14.31	156.37		129.53	0.0915	
70	11.53	156.37	-0.78	143.05	0.0737	0.0055
80	7.16	156.37		143.43	0.0458	
110	10.39	215.16		110.08	0.0483	

Analysis of Load Case 12 : HP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		178.30	-2.72	128.61		0.0211
20	19.51	156.37		115.90	0.1248	
30	12.28	156.37		128.61	0.0786	
40	12.50	156.37		128.61	0.0799	
50	12.62	156.37		128.61	0.0807	
60	12.64	156.37		129.53	0.0809	
70	5.38	156.37		143.05	0.0344	
80	5.83	156.37		143.43	0.0373	
110	6.02	215.16		110.08	0.0280	

Analysis of Load Case 13 : IP+WE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.43	118.87		0.0120
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	
80	5.86	120.26		137.61	0.0487	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 14 : IP+WF+CW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.19	118.87		0.0100
20	26.31	120.26		93.01	0.2188	
30	12.28	120.26		118.87	0.1021	
40	12.54	120.26		118.87	0.1042	
50	12.71	120.26		118.87	0.1057	
60	12.74	120.26		119.99	0.1059	
70	5.47	120.26		137.09	0.0455	
80	5.93	120.26		137.61	0.0493	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 15 : IP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.82	118.87		0.0153
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	

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80	5.86	120.26		137.61	0.0487
110	4.09	148.56		107.25	0.0276

Analysis of Load Case 16 : IP+VE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.43	118.87		0.0120
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	
80	5.86	120.26		137.61	0.0487	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 17 : NP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.82	118.87		0.0153
20		120.26	-2.75	93.01		0.0295
30		120.26	-1.28	118.87		0.0108
40		120.26	-0.87	118.87		0.0073
50		120.26	-0.54	118.87		0.0045
60		120.26	-0.49	119.99		0.0041
70		120.26	-0.90	137.09		0.0065
80		120.26	-0.24	137.61		0.0017
110		148.56	-0.38	107.25		0.0036

Analysis of Load Case 18 : FS+BS+IP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	14.60	137.19	-14.40	118.87	0.1064	0.1211
20	53.54	120.26		93.01	0.4452	
30	25.44	120.26		118.87	0.2116	
40	18.72	120.26		118.87	0.1557	
50	12.93	120.26		118.87	0.1075	
60	12.94	120.26		119.99	0.1076	
70	5.84	120.26		137.09	0.0485	
80	6.03	120.26		137.61	0.0501	
110	4.36	148.56		107.25	0.0294	

Analysis of Load Case 19 : FS+BS+EP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	14.60	137.19	-14.40	118.87	0.1064	0.1211
20	25.92	120.26	-23.74	93.01	0.2156	0.2552
30	12.35	120.26	-11.40	118.87	0.1027	0.0959
40	5.63	120.26	-4.89	118.87	0.0468	0.0411
50		120.26	-0.16	118.87		0.0014
60		120.26	-0.15	119.99		0.0012
70		120.26	-0.27	137.09		0.0020
80		120.26	-0.07	137.61		0.0005
110		148.56	-0.12	107.25		0.0011

Absolute Maximum of the all of the Stress Ratio's 0.8424

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Governing Element: Elliptical bottom head
Governing Load Case 8 : IP+OW+EQ+FS+BS

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Shop/Field Installation Options :

Platform(s) installed in the Shop.
Insulation is installed in the Shop.

Note : The CG is computed from the first Element From Node

Center of Gravity of Platforms	10500.001 mm
Center of Gravity of Liquid	1296.295 mm
Center of Gravity of Insulation	1657.071 mm
Center of Gravity of Nozzles	3199.334 mm
Center of Gravity of Added Weights (Operating)	2745.008 mm
Center of Gravity of Added Weights (Empty)	2745.008 mm
Center of Gravity of Bare Shell New and Cold	5464.207 mm
Center of Gravity of Bare Shell Corroded	5727.950 mm
Vessel CG in the Operating Condition	4383.118 mm
Vessel CG in the Fabricated (Shop/Empty) Condition	5380.793 mm
Vessel CG in the Test Condition	5108.408 mm

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Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 60 To 70 SA-516 60

CONE WS TO RISER

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Axial Force on Small End of Cone	301.97	kgf
Axial Force on Large End of Cone	360.90	kgf
Moment on Small End of Cone	3633.98	kgf-m
Moment on Large End of Cone	4695.34	kgf-m

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	15.2762	mm

```
Maximum Centroid Reinforcement Distance Small End    10.5416  mm
```

Note: No ring was found close enough to the large end to be considered.

Note: No ring was found close enough to the small end to be considered.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

```
Large end ratio of pressure to allowable stress      0.00349
Large end max. half apex angle w/o reinforcement      19.478  degrees
Large end actual half apex angle                      15.610  degrees
```

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

```
Small end ratio of pressure to allowable stress      0.00349
Small end max. half apex angle w/o reinforcement      4.995  degrees
Small end actual half apex angle                     15.610  degrees
```

Intermediate Value [k]:

```
= max( Y / ( Sr * Ers ), 1 )
= max( 23.50E+09/( 117.9 * 199328640 ), 1 )
= 1.0000
```

where [Y] is:

```
= Small End All. Stress * Small End Elastic Modulus (Int. temp.)
= 117.9 * 199328640
= 23500847104.0 N/mm^2^2
```

Decay Length, Cone Small End:

```
= 1.4 * sqrt( Rs( ts - ca ) )
= 1.4 * sqrt( 247 ( 10 - 3 ) )
= 58.214 mm
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
= k*QS*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
= 1 * 22.43 * 247/( 117.9 * 0.85 ) *
  ( 1 - 4.995/15.61 )0.279
= 1.03 cm^2
```

Force per Length, Cone Small End [QS]:

```
= P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
= 350 ( 247/2 ) - 302/(pi(494 + 10 )) +
  3634/(pi(247 + 10/2)(247 + 10/2))
= 22.430 kgf/mm
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
= 0.78(Rs*Ts)½*((Ts-t)+(Tc-Tr)/cos(alpha) ))
= 0.78(247 *7 )½*(( 7 -0.865 )+( 7 -0.898 )/0.963 )
= 4.0450 cm^2
```

Summary of Reinforcement Area, Small End, Internal Pressure:

```
Area of reinforcement required per App. 1-5(3)       1.0300  cm^2
Area of reinforcement in shell per App. 1-5(4)       4.0450  cm^2
Area of reinforcement in stiffening ring             0.0000  cm^2
```

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Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	93.31	353.70	Small Cyl. Long.
Compres. Stress	-58.16	-353.70	Small Cyl. Long.
Membrane Stress	46.37	176.85	Small End Tang.
Tensile Stress	94.53	353.70	Cone Longitudinal
Compres. Stress	-58.92	-353.70	Cone Longitudinal
Tensile Stress	46.85	176.85	Cone Tangential
Tensile Stress	78.33	353.70	Large Cyl. Long.
Compres. Stress	-37.22	-353.70	Large Cyl. Long.
Membrane Stress	17.77	-176.85	Large End Tang.
Tensile Stress	79.11	353.70	Cone Longitudinal
Compres. Stress	-36.43	-353.70	Cone Longitudinal
Compres Stress	18.79	-176.85	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure kPa	Reason for Failure at this Pressure
MAWP	1274.481	Thickness due to internal pressure, Cone Large End
MAPnc	1825.126	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

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Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 80 To 90 SA-516 60

CONE

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C

```
Elastic Modulus of Small End Reinforcement       0.199E+09 kPa at 80 °C

Axial Force on Small End of Cone                      70.50  kgf
Axial Force on Large End of Cone                      82.25  kgf
Moment on Small End of Cone                            0.00  kgf-m
Moment on Large End of Cone                          804.53  kgf-m
```

Note: Both ends of the Cone are Lines of Support

```
Maximum Centroid Reinforcement Distance Large End    10.5416  mm
Maximum Centroid Reinforcement Distance Small End     8.4101  mm
```

Note: No ring was found close enough to the large end to be considered.

Note: No ring was found close enough to the small end to be considered.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

```
Large end ratio of pressure to allowable stress      0.00349
Large end max. half apex angle w/o reinforcement      19.478  degrees
Large end actual half apex angle                      13.423  degrees
```

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

```
Small end ratio of pressure to allowable stress      0.00349
Small end max. half apex angle w/o reinforcement      4.995  degrees
Small end actual half apex angle                     13.423  degrees
```

Intermediate Value [k]:

```
= max( Y / ( Sr * Ers ), 1 )
= max( 23.50E+09/( 117.9 * 199328640 ), 1 )
= 1.0000
```

where [Y] is:

```
= Small End All. Stress * Small End Elastic Modulus (Int. temp.)
= 117.9 * 199328640
= 23500847104.0 N/mm^2^2
```

Decay Length, Cone Small End:

```
= 1.4 * sqrt( Rs( ts - ca ) )
= 1.4 * sqrt( 154.7 ( 10 - 3 ) )
= 46.066 mm
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
= k*QS*Rs/(Sc*E2)*tan(alpha)
= 1 * 2.689 * 154.7/( 117.9 * 0.85 ) * 0.239
= 0.0971 cm^2
```

Force per Length, Cone Small End [QS]:

```
= P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
= 350 ( 154.7/2 ) - 70.5/(pi(309.3 + 10 )) +
  0/(pi(154.7 + 10/2)(154.7 + 10/2))
= 2.689 kgf/mm
```

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Area of Reinforcement Available in Small End Shell [Aes]:

```
  = ( tc - tr ) * sqrt( Rs*tc/cos(alpha) )
  = ( 7 - 0.557 ) * sqrt( 154.7 * 7/0.973 )
  = 2.1497 cm^2
```

Summary of Reinforcement Area, Small End, Internal Pressure:

Area of reinforcement required per App. 1-5(3)	0.0971	cm^2
Area of reinforcement in shell per App. 1-5(4)	2.1497	cm^2
Area of reinforcement in stiffening ring	0.0000	cm^2

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	8.92	353.70	Small Cyl. Long.
Compres. Stress	-1.21	-353.70	Small Cyl. Long.
Membrane Stress	10.70	-176.85	Small End Tang.
Tensile Stress	9.03	353.70	Cone Longitudinal
Compres. Stress	-1.11	-353.70	Cone Longitudinal
Compres Stress	10.92	-176.85	Cone Tangential
Tensile Stress	31.61	353.70	Large Cyl. Long.
Compres. Stress	-7.80	-353.70	Large Cyl. Long.
Membrane Stress	12.10	-176.85	Large End Tang.
Tensile Stress	31.95	353.70	Cone Longitudinal
Compres. Stress	-7.46	-353.70	Cone Longitudinal
Compres Stress	12.45	-176.85	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure kPa	Reason for Failure at this Pressure
MAWP	2720.389	Thickness due to internal pressure, Cone Large End
MAPnc	3905.757	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

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Nozzle Calculation Summary:

Description	MAWP kPa	Ext	MAPNC kPa	UG-45	[tr] mm	Weld Path	Areas or Stresses
N2	621.53	...	...	OK	4.42	OK	No Calc[*]

```
 N3                |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*]  |
 N4                |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*]  |
 K1A               |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*]  |
 K1B               |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*]  |
 HW                |           |    ...  |        ...  |   ...  |        |     OK   | No
Calc[*]  |
 N1                |           |    ...  |        ...  |    OK  |  4.59  |     OK   | No
Calc[*]  |
 ------------------------------------------------------------------------------------
------
```

MAWP Summary:

```
 Minimum MAWP Nozzles         :         621.533 Nozzle  : N2
 Minimum MAWP Shells/Flanges  :         621.533 Element : Elliptical bottom he
 Minimum MAPnc Shells/Flanges :        1205.880 Element : Elliptical bottom he
 ------------------------------------------------------------------------
 Computed Vessel M.A.W.P.     :         621.533 kPa
```

[*] - This was a small opening and the areas were not computed or
the MAWP of this connection could not be computed because
the longitudinal bending stress was greater than the hoop stress.

Note: MAWPs (Internal Case) shown above are at the High Point.

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	Y Coordinate mm	Layout Angle deg	Dia. Limit mm
20	N2	0.000	0.000	102.501
30	N3	750.000	135.000	52.616
30	N4	2250.000	135.000	52.616
30	K1A	1000.000	45.000	52.616
30	K1B	2000.000	45.000	52.616
30	HW	50.000	45.000	417.435
40	N1	4049.999	180.000	521.016

The nozzle spacing is computed by the following:
= Sqrt($ll^2 + lc^2$) where
ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.
No interference violations have been detected !

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Input, Nozzle Desc: N2 From: 20

```
 Pressure for Reinforcement Calculations        P     361.405  kPa
 Temperature for Internal Pressure           Temp          80  °C
```

Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Elliptical Head	D	1054.10	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	6.3500	mm
Head Internal Corrosion Allowance	c	3.0000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	0.0000	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

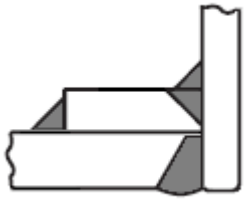
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-105	
Flange Type		None	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 60	
Pad Allowable Stress at Temperature	Sp	117.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	117.90	N/mm^2
Diameter of Pad along vessel surface	Dp	150.0000	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	6.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		44.8375	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

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Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: N2

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation            2.375  in.
Actual Thickness Used in Calculation                   0.218  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]
```
  = (P*K1*D))/(2*Sv*E-0.2*P) per UG-37(a)(3)
  = (361.4*0.9*1060)/(2 *117.9*1-0.2*361.4)
  = 1.4628 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (361.4*30.16)/(117.9*1+0.4*361.4)
  = 0.0923 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   102.5012  mm
Parallel to Vessel Wall, opening length              d    51.2506  mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp     8.3750  mm
```

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N2.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 1.0923 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.6254 mm
Wall Thickness                tb1 = max(trb1, tr16b) = 4.6254 mm
Wall Thickness                tb2 = max(trb2, tr16b) = 4.5875 mm
```

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```
Wall Thickness per table UG-45                    tb3 = 4.4200 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 4.42, max( 4.625, 4.588 ) ]
  = 4.4200 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.092, 4.42 )
  = 4.4200 mm
```

Available Nozzle Neck Thickness = 0.875 * 5.537 = 4.845 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: C

Govrn. thk, tg = 4.845, tr = 0.0923, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.024, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, Curve: C

Govrn. thk, tg = 6.35, tr = 1.463, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.437, Temp. Reduction = 42 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 4.845, tr = 0.0923, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.024, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :    -48 °C
Governing MDMT of all the sub-joints of this Junction :    -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -17 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
```

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Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 361.40/1964.96 = 0.184

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds	Tmin	4.5372	mm
Intermediate Calc. for pad/shell Welds	TminPad	3.3500	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.1760 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm
Pad Weld	1.6750 = 0.5*TminPad	4.2420 = 0.7 * Wp mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case		632.938	kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.4770 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 156.8270 mm

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Input, Nozzle Desc: N3 From: 30

Pressure for Reinforcement Calculations	P	351.470	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		750.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

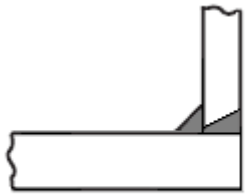
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		135.00	deg
Diameter		1.0000	in.

Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N3

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	0.957	in.
Actual Thickness Used in Calculation	0.179	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (351.5*526.4)/(117.9*1-0.6*351.5)
= 1.5721 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)

```
  = (351.5*13.15)/(117.9*1-0.6*351.5)
  = 0.0393 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
 Parallel to Vessel Wall (Diameter Limit)              Dl    52.6156  mm
 Parallel to Vessel Wall, opening length                d    26.3078  mm
 Normal to Vessel Wall (Thickness Limit), no pad     Tlnp     8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
 Wall Thickness for Internal/External pressures       ta = 1.0393 mm
 Wall Thickness per UG16(b),                       tr16b = 4.5875 mm
 Wall Thickness, shell/head, internal pressure      trb1 = 4.5721 mm
 Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5875 mm
 Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5875 mm
 Wall Thickness per table UG-45                     tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification        -46 °C

 Calculated Minimum Design Metal Temperature              -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0393, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0132, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Governing MDMT of all the sub-joints of this Junction : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ANSI B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3) -104 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 351.47/1964.96 = 0.179

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N3

Intermediate Calc. for nozzle/shell Welds Tmin 3.5466 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 1315.159 kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: N4 From: 30

Pressure for Reinforcement Calculations	P	350.000	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		2250.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

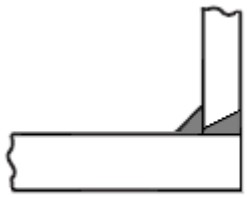
Type of Element Connected to the Shell : Nozzle

Material	[Impact Tested]	SA-333 6

Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		135.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N4

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	0.957	in.
Actual Thickness Used in Calculation	0.179	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

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The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	52.6156	mm
Parallel to Vessel Wall, opening length	d	26.3078	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	8.8665	mm

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N4.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta	= 1.0391 mm
Wall Thickness per UG16(b),	tr16b	= 4.5875 mm
Wall Thickness, shell/head, internal pressure	trb1	= 4.5656 mm
Wall Thickness	tb1 = max(trb1, tr16b)	= 4.5875 mm
Wall Thickness	tb2 = max(trb2, tr16b)	= 4.5875 mm
Wall Thickness per table UG-45	tb3	= 3.9464 mm

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification	-46 °C
Calculated Minimum Design Metal Temperature	-104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification      -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)         -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)         -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
`Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178`

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N4

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
`Converged Max. Allow. Pressure in Operating case     1313.689  kPa`

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: K1A **From: 30**

```
Pressure for Reinforcement Calculations        P     350.000  kPa
Temperature for Internal Pressure           Temp          80  °C

Shell Material                                      SA-516 60
Shell Allowable Stress at Temperature          Sv     117.90  N/mm^2
Shell Allowable Stress At Ambient             Sva     117.90  N/mm^2

Inside Diameter of Cylindrical Shell           D     1046.80  mm
Shell Finished (Minimum) Thickness             t     10.0000  mm
Shell Internal Corrosion Allowance             c      3.0000  mm
```

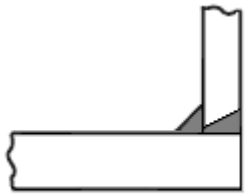
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1000.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: K1A

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

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```
Actual Inside Diameter Used in Calculation            0.957  in.
Actual Thickness Used in Calculation                  0.179  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
Parallel to Vessel Wall (Diameter Limit)            Dl    52.6156  mm
Parallel to Vessel Wall, opening length              d    26.3078  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: K1A.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
Wall Thickness for Internal/External pressures      ta = 1.0391 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                    tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: K1A

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     1313.689  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: K1B From: 30

```
Pressure for Reinforcement Calculations        P     350.000  kPa
```

Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		2000.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

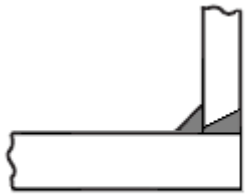
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

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Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: K1B

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation              0.957  in.
Actual Thickness Used in Calculation                    0.179  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
Parallel to Vessel Wall (Diameter Limit)            Dl    52.6156  mm
Parallel to Vessel Wall, opening length              d    26.3078  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: K1B.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
Wall Thickness for Internal/External pressures      ta = 1.0391 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
```

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```
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                  tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                  tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                   tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification        -46 °C

Calculated Minimum Design Metal Temperature              -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification      -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)         -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)         -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: K1B

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

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Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case		1313.689	kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: HW **From: 30**

Pressure for Reinforcement Calculations	P	358.332	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		50.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

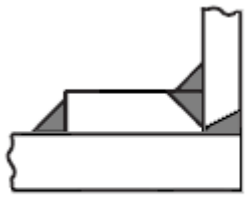
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		8.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	STD	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm

Groove weld depth between Nozzle and Vessel	Wgnv	8.1788	mm
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N/mm^2
Diameter of Pad along vessel surface	Dp	319.0750	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		50.0000	mm
This is a Manway or Access Opening.			
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle With Pad

Reinforcement CALCULATION, Description: HW

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	7.981	in.
Actual Thickness Used in Calculation	0.322	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (358.3*526.4)/(117.9*1-0.6*358.3)
= 1.6029 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
= (358.3*104.4)/(117.9*1-0.6*358.3)
= 0.3178 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

```
 Parallel to Vessel Wall (Diameter Limit)              Dl    417.4348  mm
 Parallel to Vessel Wall, opening length                d    208.7174  mm
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp     17.5000  mm
```

Weld Strength Reduction Factor [fr1]:

```
  = 1.000
```

Weld Strength Reduction Factor [fr2]:

```
  = min( 1, Sn/Sv )
  = min( 1, 117.9/117.9 )
  = 1.000
```

Weld Strength Reduction Factor [fr4]:

```
  = min( 1, Sp/Sv )
  = min( 1, 137.9/117.9 )
  = 1.000
```

Weld Strength Reduction Factor [fr3]:

```
  = min( fr2, fr4 )
  = min( 1, 1 )
  = 1.000
```

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	5.862	NA	NA
Area in Shell	A1	8.748	NA	NA
Area in Nozzle Wall	A2	1.701	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA
Area in Welds	A41+A42+A43	1.000	NA	NA
Area in Element	A5	8.000	NA	NA
TOTAL AREA AVAILABLE	Atot	19.450	NA	NA

The Internal Pressure Case Governs the Analysis.

```
 Nozzle Angle Used in Area Calculations                 90.00  Degs.
```

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

Area Required [A]:

```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (208.7*2.808*1+2*5.179*2.808*1*(1-1))
  = 5.862 cm^2
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 208.7 ( 1 * 7 - 1 * 2.808 ) - 2 * 5.179
    ( 1 * 7 - 1 * 2.808 ) * ( 1 - 1 )
  = 8.748 cm^2
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 17.5 ) * ( 5.179 - 0.318 ) * 1
  = 1.701 cm^2
```

Area Available in Welds [A41 + A42 + A43]:

```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 6² * 1 + (0 )² * 1 + 8² * 1
  = 1.000 cm^2
```

Area Available in Element [A5]:

```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 319.1 - 219.1 ) * 8 * 1
  = 8.000 cm^2
```

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification         -46 °C

 Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification         -46 °C

 Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B

Govrn. thk, tg = 7.156, tr = 0.318, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0765, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, min(Curve:B, Curve:C)

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.229, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 7.156, tr = 0.318, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0765, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
```

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```
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :   -104 °C
Governing MDMT of all the sub-joints of this Junction :   -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 358.33/1964.96 = 0.182
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: HW

```
Intermediate Calc. for nozzle/shell Welds   Tmin      5.1788  mm
Intermediate Calc. for pad/shell Welds    TminPad     7.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.6252 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

```
= ( Ar - A1 )* Sv
= ( 5.862 - 8.748 ) * 117.9
= 0.00 kgf
```

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 1.701 + 8 + 1 - 0 * 1 ) * 117.9
= 12865.43 kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 219.1 * 6 * 0.49 * 117.9
= 12164. kgf
```

Shear, Pad Element Weld [Spew]:

```
= (pi/2) * DP * WP * 0.49 * SEW
= ( 3.142/2.0 ) * 319.1 * 8 * 0.49 * 117.9
= 23620. kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
= ( pi/2) * Dlo * Wgpn * 0.74 * Seg
```

```
  =  (3.142/2 ) * 219.1 * 8 * 0.74 * 137.9
  = 28646. kgf
```

Shear, Nozzle Groove Weld [Sngw]:

```
  = (pi/2) * (Dlr+Wgnva) * (Wgnva-Can) * 0.60 * Sng
  = (3.142/2)*(208.7 +8.179 )*(8.179 -3 )*0.6*117.9
  = 12728. kgf
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNGW ) = ( 23620 + 12728 ) = 36348 kgf
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 36348 kgf, must exceed W = 0 kgf or W1 = 12865 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     1322.021  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 11.5904 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 238.1904 mm

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Input, Nozzle Desc: N1 From: 40

```
 Pressure for Reinforcement Calculations        P     350.000  kPa
 Temperature for Internal Pressure           Temp          80  °C

 Shell Material                                      SA-516 60
 Shell Allowable Stress at Temperature         Sv      117.90  N/mm^2
 Shell Allowable Stress At Ambient            Sva      117.90  N/mm^2

 Inside Diameter of Cylindrical Shell           D     1046.80  mm
 Shell Finished (Minimum) Thickness             t     10.0000  mm
 Shell Internal Corrosion Allowance             c      3.0000  mm
 Shell External Corrosion Allowance            co      0.0000  mm

 Distance from Bottom/Left Tangent                    4050.00  mm

 User Entered Minimum Design Metal Temperature         -10.00  °C
```

Type of Element Connected to the Shell : Nozzle

```
 Material        [Impact Tested]                     SA-333 6
 Material UNS Number                                  K03006
 Material Specification/Type               Smls. & wld. pipe
 Allowable Stress at Temperature              Sn      117.90  N/mm^2
 Allowable Stress At Ambient                 Sna      117.90  N/mm^2

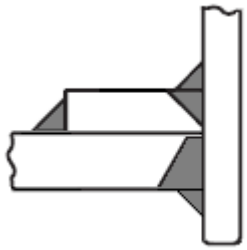
 Diameter Basis (for tr calc only)                        OD
 Layout Angle                                         180.00  deg
 Diameter                                            10.0000  in.

 Size and Thickness Basis                             Nominal
```

Nominal Thickness	tn	STD	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	533.4000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 60	
Pad Allowable Stress at Temperature	Sp	117.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	117.90	N/mm^2
Diameter of Pad along vessel surface	Dp	473.0500	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		100.0000	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, with Inside projection

Reinforcement CALCULATION, Description: N1

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	10.750	in.
Actual Thickness Used in Calculation	0.365	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (350*526.4)/(117.9*1-0.6*350)

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= 1.5656 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.2574 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*136.5)/(117.9*1+0.4*350)
= 0.4048 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	521.0160	mm
Parallel to Vessel Wall, opening length	d	260.5080	mm
Normal to Vessel Wall (Thickness Limit), pad side	Tlwp	17.5000	mm
Normal to Vessel Wall, Inward		8.1775	mm

Weld Strength Reduction Factor [fr1]:
= min(1, Sn/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr2]:
= min(1, Sn/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr4]:
= min(1, Sp/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr3]:
= min(fr2, fr4)
= min(1, 1)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	4.694	NA	NA
Area in Shell	A1	13.541	NA	NA
Area in Nozzle Wall	A2	2.053	NA	NA
Area in Inward Nozzle	A3	0.535	NA	NA
Area in Welds	A41+A42+A43	1.637	NA	NA
Area in Element	A5	16.000	NA	NA
TOTAL AREA AVAILABLE	Atot	33.767	NA	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

Area Required [A]:
```
= ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
= (260.5*1.802*1+2*6.271*1.802*1*(1-1))
= 4.694 cm^2
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
= d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
= 260.5 ( 1 * 7 - 1 * 1.802 ) - 2 * 6.271
  ( 1 * 7 - 1 * 1.802 ) * ( 1 - 1 )
= 13.541 cm^2
```

Area Available in Nozzle Wall Projecting Outward [A2]:
```
= ( 2 * Tlwp ) * ( tn - trn ) * fr2
= ( 2 * 17.5 ) * ( 6.271 - 0.405 ) * 1
= 2.053 cm^2
```

Area Available in Inward Nozzle [A3]:
```
= 2 * ti * min( h, Tl, 2.5 * ti) * fr2
= 2 * 3.271 * ( 8.177 ) * 1
= 0.535 cm^2
```

Area Available in Welds [A41 + A42 + A43]:
```
= (Wo² - Ar Lost)*Fr3+((Wi-can/0.707)² - Ar Lost)*fr2 + Wp²*fr4
= (0.997 ) * 1 + (0 ) * 1 + 203.2² * 1
= 1.637 cm^2
```

Area Available in Element [A5]:
```
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= ( 473 - 273 ) * 8 * 1
= 16.000 cm^2
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 3.4048 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                  tb3 = 11.1026 mm
```

Determine Nozzle Thickness candidate [tb]:
```
= min[ tb3, max( tb1,tb2) ]
= min[ 11.1, max( 4.588, 4.588 ) ]
= 4.5875 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
= max( ta, tb )
= max( 3.405, 4.588 )
= 4.5875 mm
```

Available Nozzle Neck Thickness = 0.875 * 9.271 = 8.112 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: C

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.224, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve C -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: C

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.224, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve C -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 8.112, tr = 0.405, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0792, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Governing MDMT of the Nozzle : -104 °C
Governing MDMT of the Reinforcement Pad : -104 °C
Governing MDMT of all the sub-joints of this Junction : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ANSI B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3) -104 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178

Note:

Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N1

```
Intermediate Calc. for nozzle/shell Welds   Tmin      6.2710  mm
Intermediate Calc. for pad/shell Welds    TminPad     7.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.3897 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

```
= max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
= max( 0, (4.694 - 13.54 + 2 * 6.271 * 1 *
  (1 * 7 - 1.802 ) )117.9 )
= max( 0, -9852.27) kgf
```

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 2.053 + 16 + 1.637 - 0 * 1 ) * 117.9
= 23672.58 kgf
```

Weld Load [W2]:

```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 2.053 + 0.535 + 1 + ( 0.878 ) ) * 117.9
= 5369.22 kgf
```

Weld Load [W3]:

```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 2.053 + 0.535 + 1.637 + 16 + ( 0.878 ) ) * 117.9
= 25371.21 kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 273 * 10 * 0.49 * 117.9
= 25267. kgf
```

Shear, Pad Element Weld [Spew]:

```
= (pi/2) * DP * WP * 0.49 * SEW
= ( 3.142/2.0 ) * 473 * 8 * 0.49 * 117.9
= 35019. kgf
```

Shear, Nozzle Wall [Snw]:

```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.142 * 133.4 ) * ( 9.271 - 3 ) * 0.7 * 117.9
= 22116. kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
= ( pi/2) * Dlo * Wgpn * 0.74 * Seg
=  (3.142/2 ) * 273 * 8 * 0.74 * 117.9
```

```
  = 30527. kgf
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 273 * ( 10 - 3 ) * 0.74 * 117.9
  = 26711. kgf
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 35019 + 22116 ) = 57135 kgf
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 25267 + 30527 + 26711 + 0 ) = 82506 kgf
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 35019 + 26711 + 0 ) = 61730 kgf
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 57134 kgf, must exceed W = 0 kgf or W1 = 23672 kgf
 Path 2-2 = 82505 kgf, must exceed W = 0 kgf or W2 = 5369 kgf
 Path 3-3 = 61729 kgf, must exceed W = 0 kgf or W3 = 25371 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     1136.355  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 18.1194 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 760.0001 mm

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Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm	Reinforcing Pad Diameter mm	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
HW	8.000 in	STD	WNF	8.625	8.179	319.08	8.00	238.19	150
K1A	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
K1B	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
N1	10.000 in	STD	WNF	10.750	9.271	473.05	8.00	760.00	150
N2	2.000 in	XS	None	2.375	5.537	150.00	8.00	156.83	150
N3	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
N4	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
HW	SA-333 6	8.179	6.000	8.000	8.000	...
K1A	SA-333 6	4.547	5.000	...	...	...
K1B	SA-333 6	4.547	5.000	...	...	...
N1	SA-333 6	10.000	10.000	8.000	8.000	...
N2	SA-333 6	6.350	10.000	6.000	8.000	...
N3	SA-333 6	4.547	5.000	...	...	...
N4	SA-333 6	4.547	5.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
HW	1000.000	45.0	216.60	0.00	WS CYLINDER 1/2
K1A	1950.000	45.0	216.60	0.00	WS CYLINDER 1/2
K1B	2950.000	45.0	216.60	0.00	WS CYLINDER 1/2
N1	4999.999	180.0	216.60	533.40	WS CYLINDER 2/2
N2	...	0.0	150.00	0.00	Elliptical botto

```
  N3              |        1700.000 |    135.0 |      216.60 |    0.00 |     WS CYLINDER
1/2 |
  N4              |        3200.000 |    135.0 |      216.60 |    0.00 |     WS CYLINDER
1/2 |
```

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Minimum Design Metal Temperature Results Summary :

Description	Notes	Curve	Basic MDMT °C	Reduced MDMT °C	UG-20(f) MDMT °C	Thickness ratio	Gov Thk mm	E*	PWHT reqd
Elliptical bo	[10]	C	-48	-48	-29	0.487	6.350	0.85	No
Elliptical bot	[7]	C	-48	-48	-29	0.487	6.350	0.85	No
WS CYLINDER 1	[20]	C	-44	-48	-29	0.487	10.000	0.85	No
WS CYLINDER 2	[20]	C	-44	-104	-29	0.313	10.000	0.85	No
WS CYLINDER 3/	[8]	C	-44	-104	-29	0.226	10.000	0.85	No
CONE WS TO RIS	[8]	C	-44	-104	-29	0.235	10.000	0.85	No
Riser	[20]	C	-44	-104	-29	0.321	10.000	0.85	No
CONE	[8]	C	-44	-104	-29	0.193	10.000	0.85	No
TIP	[16]		-196						
N2	[1]	C	-48	-48	-29	0.437	6.350	1.00	No
Nozzle Flg	[5]	!	-17	-104					
N3	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
N4	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
K1A	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
K1B	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
HW	[1]	B	-46	-104		0.076	7.156	1.00	No
Nozzle Flg	[4]	!	-46	-104					
N1	[1]	C	-46	-104		0.079	8.112	1.00	No
Nozzle Flg	[4]	!	-46	-104					
Warmest MDMT:			-17	-48					

Required Minimum Design Metal Temperature -10.0 °C
Warmest Computed Minimum Design Metal Temperature -48.0 °C

Notes:
[!] - This was an impact tested material.
[1] - Governing Nozzle Weld.
[4] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-c).
[5] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-b).
[6] - MDMT Calculations at the Shell/Head Joint.
[7] - MDMT Calculations for the Straight Flange.
[8] - Cylinder/Cone/Flange Junction MDMT.
[9] - Calculations in the Spherical Portion of the Head.
[10] - Calculations in the Knuckle Portion of the Head.
[11] - Calculated (Body Flange) Flange MDMT.
[12] - Calculated Flat Head MDMT per UCS-66.3
[13] - Tubesheet MDMT, shell side, if applicable
[14] - Tubesheet MDMT, tube side, if applicable
[15] - Nozzle Material

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[16] - Shell or Head Material
[17] - Impact Testing required
[18] - Impact Testing not required, see UCS-66(b)(3)
[20] - Cylinder/Cone Junction MDMT based on Longitudinal Stress considerations
[21] - Bolting Material

UG-84(b)(2) was not considered.
UCS-66(g) was not considered.
UCS-66(i) was not considered.

Notes:
Impact test temps were not entered in and not considered in the analysis.
UCS-66(i) applies to impact tested materials not by specification and
UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c).
The Basic MDMT includes the (30F) PWHT credit if applicable.

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ASME Code, Section VIII Division 1, 2023

```
Diameter Spec : 1066.800 x 508.000 x 323.900 mm OD
Vessel Design Length, Tangent to Tangent          15559.52  mm

Distance of Bottom Tangent above Grade            32260.00  mm
Distance of Base above Grade                      31310.00  mm
Specified Datum Line Distance                         0.00  mm

Internal Design Temperature                             80  °C
Internal Design Pressure                           350.000  kPa

External Design Temperature                             80  °C

Maximum Allowable Working Pressure                 621.533  kPa
Hydrostatic Test Pressure                          500.500  kPa

Required Minimum Design Metal Temperature            -10.0  °C
Warmest Computed Minimum Design Metal Temperature    -48.0  °C

Wind Design Code                                   EN-2010
Earthquake Design Code                            G-Loading
```

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-516 60	...	...	K02100	No	No
Shell	SA-213 TP316	...	...	S31600	No	No
Head	SA-516 60	...	...	K02100	No	No
Cone	SA-516 60	...	...	K02100	No	No

Flange	SA-350 LF2	1	...	K03011	No	Yes
Flange	SA-182 F316L	...	> 5	S31603	No	No
Skirt	SA/EN 10028-2	P355GH	6 < t <= 10		No	No
Nozzle	SA-333 6	...	...	K03006	No	Yes
Re-Pad	SA-516 60	...	...	K02100	No	No
Re-Pad	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-105	...	...	K03504	No	Yes
Nozzle Flg	SA-350 LF2	1	...	K03011	No	Yes

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (kPa & mm):

Element Description	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Elliptical bottom head	361.405	0.00	621.533	3.0000	No	No
WS CYLINDER 1/2	358.332	0.00	1313.689	3.0000	N/A	No
WS CYLINDER 2/2	350.000	0.00	1322.021	3.0000	N/A	No
WS CYLINDER 3/3	350.000	0.00	1322.021	3.0000	N/A	No
CONE WS TO RISER	350.000	0.00	1273.009	3.0000	N/A	No
Riser	350.000	0.00	2792.454	3.0000	N/A	No
CONE	350.000	0.00	2715.345	3.0000	N/A	No
FLANGE WN 12" 150# ASME	350.000	0.00	1833.988	3.0000	N/A	No
FLANGE WN 12" 150# ASME	350.000	0.00	1833.988	3.0000	N/A	?
TIP	350.000	0.00	4655.324	0.0000	N/A	No

Liquid Level: 1163.53 mm Dens.: 0.001 kg/cm^3 Sp. Gr.: 1.000

Element Types and Properties:

Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Skirt	950.0	950.0	...	10.0	...	...	0.85	0.85
Ellipse	1000.0	50.0	...	6.3	4.9	4.6	0.85	0.85
Cylinder	3500.0	2500.0	...	10.0	4.9	...	0.85	0.85
Cylinder	5136.0	1636.0	...	10.0	4.9	...	0.85	0.85
Cylinder	5456.0	320.0	...	10.0	4.9	...	0.85	0.85
Conical	6456.0	1000.0	...	10.0	4.9	...	0.85	0.85
Cylinder	11000.0	4544.0	...	10.0	4.6	...	0.85	0.85
Conical	11385.7	385.7	...	10.0	4.6	...	0.85	0.85
Body Flg	11500.0	114.3	...	10.0	...	7.0	1.00	1.00
Body Flg	11623.8	114.3	...	10.0	...	7.0	1.00	1.00
Cylinder	16509.5	4885.7	...	6.0	1.6	...	1.00	1.00

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	2153.66	3972.78	13501.8	18096.1
20	30	975	1988.26	3714.11	11534.4	14444.7
30	40	2250	1979.24	3427.59	11435.2	14266.2
40	50	4318	1471.06	1862.26	7122.23	7653.73
50	60	5296	1127.02	1272.44	4996.96	5089.49
60	70	5956	1073.15	1190.92	4644.93	4695.34
70	80	8728	948.694	996.456	3633.98	3601.63
80	90	11192.8	296.641	271.423	804.526	720.951
90	100	11442.8	270.727	232.649	695.107	623.739
100	110	11566.7	264.733	232.649	661.983	594.93
110	120	14066.7	258.736	232.649	632.066	568.338

Abs Max of the all of the Stress Ratio's : 0.8424

Total Wind Shear on Support 3795. kgf
Total Earthquake Shear on Support 5614. kgf

Note: The Wind and Seismic loads were not load factored in this analysis.

Note:
Wind and Earthquake moments include the effects of user defined forces and moments if any exist in the job and were specified to act (compute loads and stresses) during these cases. Also included are moment effects due to eccentric weights if any are present in the input.

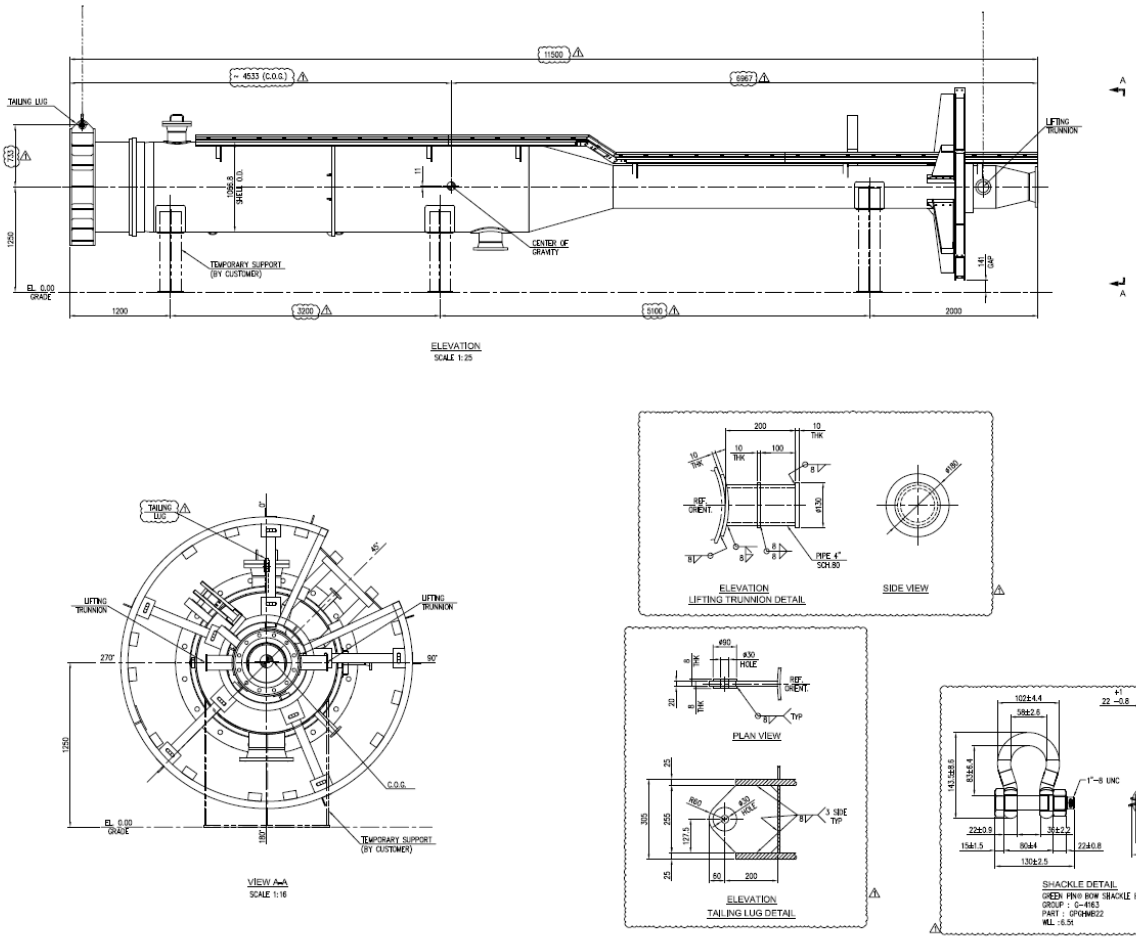
Weights:

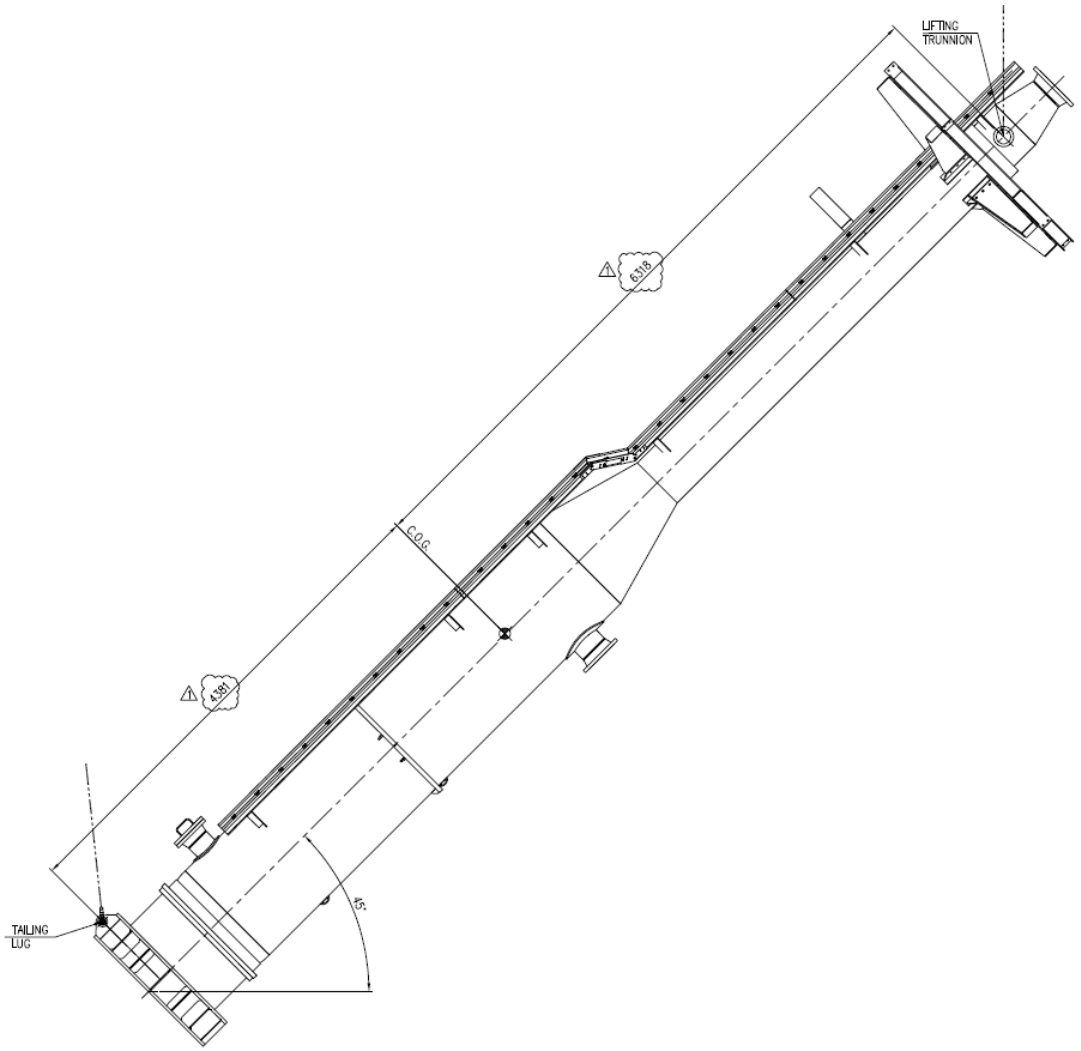
Fabricated	- Bare W/O Removable Internals	2812.3	kgm
Shop Test	- Fabricated + Water (Full)	8632.8	kgm
Shipping	- Fab. + Rem. Intls.+ Shipping App.	3085.0	kgm
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	3085.0	kgm
Empty	- Fab. + Intls. + Details + Wghts.	3085.0	kgm
Operating	- Empty + Operating Liquid (No CA)	4013.1	kgm
Field Test	- Empty Weight + Water (Full)	8905.6	kgm

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B - LIFTING ANALYSIS CONFIGURATION WITHOUT TIP INSTALLED

The configuration for the lifting is shown here after.

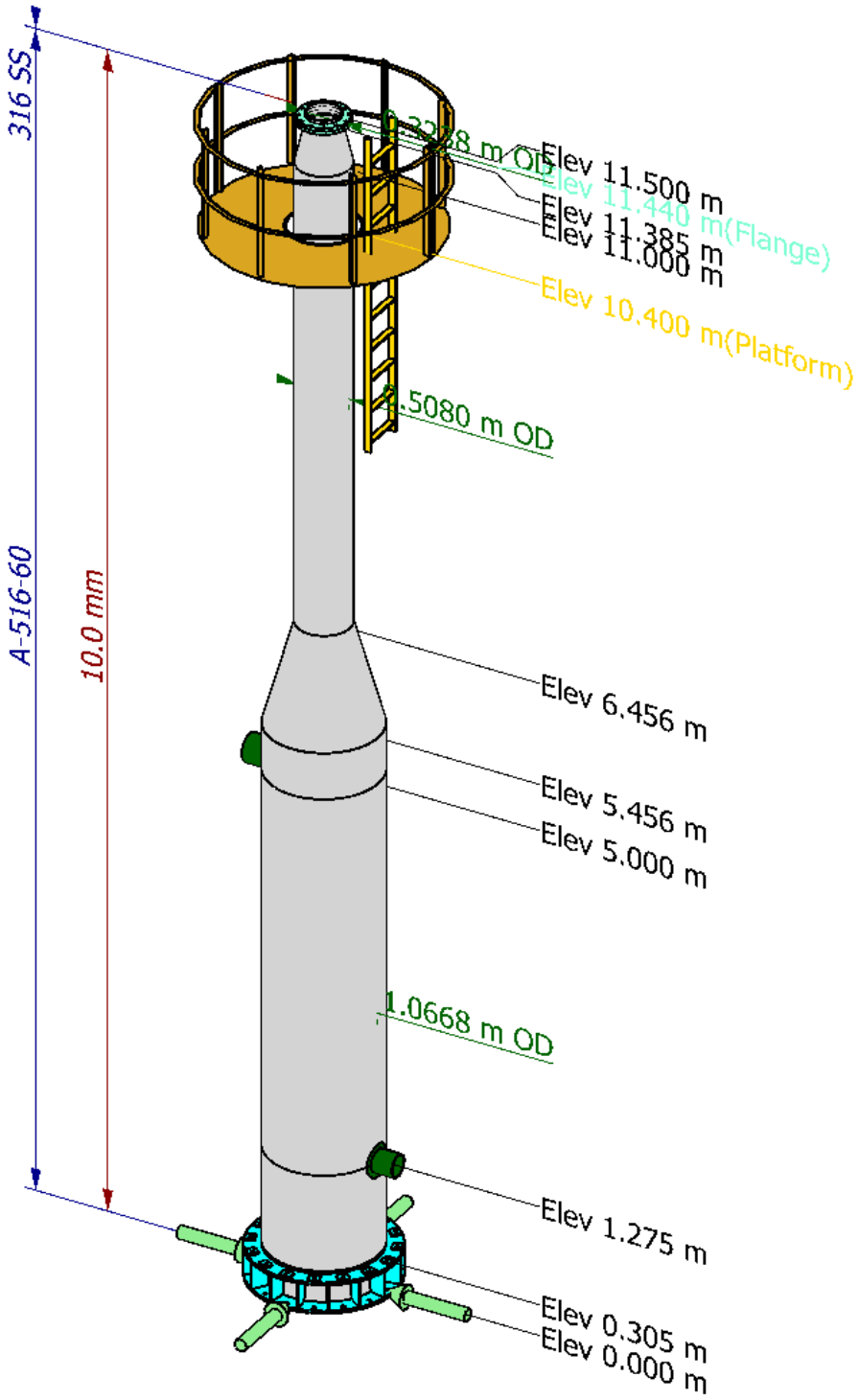


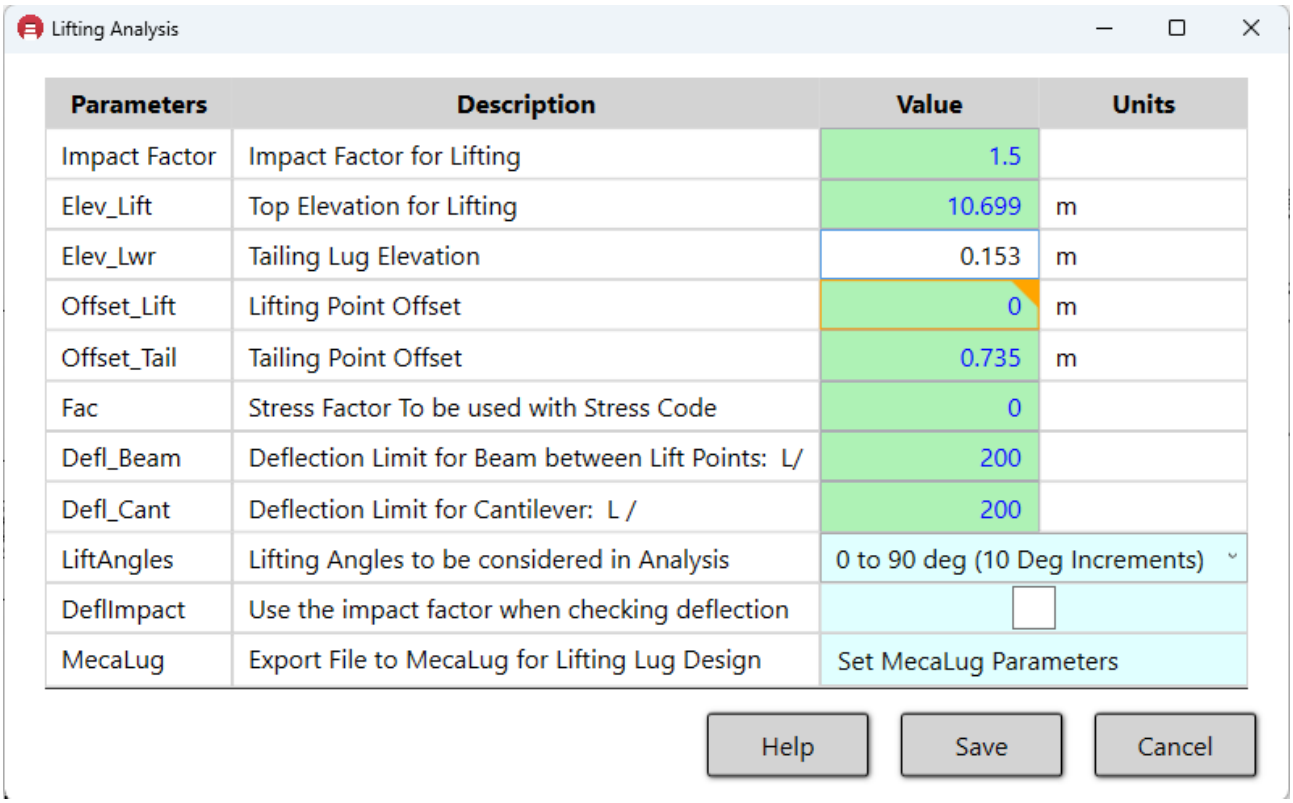


The tip will be installed after the precise vertical alignment of the bottom part.

A specialized model has been developed to analyze the lifting phases. For safety, the top platform is assumed to be fully assembled during the lift. In practice, some components will be added later to avoid potential conflicts with the lifting hardware.

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316 SS
A-516-60
10.0 mm
Elev 11.500 m
Elev 11.440 m(Flange)
Elev 11.385 m
Elev 11.000 m
Elev 10.400 m(Platform)
.5080 m OD
Elev 6.456 m
Elev 5.456 m
Elev 5.000 m
1.0668 m OD
Elev 1.275 m
Elev 0.305 m
Elev 0.000 m



MecaStack v5630

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Calculations Prepared by:
Date: Oct 17, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Lifting analysis-20240920-01.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height	= 11.50 m	Top of Stack Elevation	= 11.5 m
Grade Elevation	= 0.00 m	Bottom of Stack	= 0.0 m

All elevations are based upon the bottom of stack being at 0 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
11.5	0.3238	11.5	10.0	11.5	3.0
11.385	0.3238			0.305	0.0
11.0	0.5080				
6.456	0.5080				
5.456	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
11.5	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		21.11	206.84	195121	1.53E-05	137.89	8000	517.11
11.5	A-516-60	120.00	198.71	196914	1.22E-05	117.90	7849	413.68
		21.11	220.63	202705	1.15E-05	117.90	7849	413.68

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
11.500	8.400	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	2.450	0.950	0.0000	758.00	Oper
External insulation	3.100	0.350	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	0.305	0.000	200.0	Dead

Nozzles:

Num	Description	Elevation m	Nominal Diameter	Schedule	Outer Diameter mm	Thickness mm	Tilt Deg	Orien-tation Deg	Proj-ection mm

```
 1  1N              5.000 10 inch [254.0 mm]    Std       273.1        9.3  0.0  180.0
200.0
 2  HW              1.275  8 inch [203.2 mm]    Std       219.1        8.2  0.0    0.0
200.0
```

Num	Description	Repad Width mm	Repad Thickness mm	Flange Spec	Flange Radial Width mm	Flange Thickness mm	Nozzle Loads
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx KN	Fy KN	Fz KN	Mx KN-m	My KN-m	Mz KN-m	Local/ Global	Load Applied	Load Type	Check WRC 107
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC KN	FyC KN	FzC KN	MxC KN-m	MyC KN-m	MzC KN-m	Ver KN	Shear KN	Mom KN-m	Mbase KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	14.46	16.42	7.89	89.99

```
   Equivalent Nozzle Loads Applied on Stack:
   Ver   = Stack Vertical Load considered at Nozzle Elev: Fy
   Shear = Stack Shear Load considered at Nozzle Elev:  [Fx^2+Fz^2]^0.5
   Mom   = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
   Mbase = Est Mom at base if no Support:  Mom + Shear*Elev
           Provided only to evaluate the impact of the load on overall stack
```

```
Type      = Type of Baseplate                                          = Chair
                                                                         Continuous
Plate
SupType   = Type of Support                                            = Rigid Steel
Base
Friction  = Coefficient of Friction for Support                        = 0.300
BasisBolt = Basis for Bolt Design                                      = Brownell &
Young
Nbolt     = Number of Bolts                                            = 16
Dbolt     = Nominal Bolt Diameter                                      = 27.0 mm
Dbh       = Bolt Hole Diameter                                         = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                                = 3.0 mm
CAplt     = Corrosion Allowance on Plates                              = 0.0 mm
ID        = Inside Diameter of Baseplate                               = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                          = 1270.0 mm
OD        = Outer Diameter of Baseplate                                = 1385.0 mm
Tb        = Thickness of Bottom Plate                                  = 25.0 mm
Tt        = Thickness of Top Plate                                     = 25.0 mm
Fw        = Fillet Weld Size                                           = 5.0 mm
```

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```
Fwu       = Weld Ultimate Tensile Strength                          = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                              = 1
Hg        = Height of Anchor Chair                                  = 305.0 mm
Tg        = Thickness of Gusset                                     = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                  = S275J0
Dens      = Material Density                                        = 7849 Kg/m^3
Temp      = Design Temperature                                      = 21.11 Deg C
Fy        = Minimum Yield Stress                                    = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                 = 410030.5
KPa
Sa        = Allowable Tensile Stress                                = 117141.7
KPa
E         = Modulus of Elasticity                                   = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                        = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                               = False
Matl      = Bolt Material Specification                             = Gr. 8.8
Fu        = Ultimate Tensile Stress                                 = 800548.8
KPa
Fy        = Yield Stress                                            = 640440.4
KPa
Fproof    = Proof Stress                                            = 544374.4
KPa
Eb        = Modulus of Elasticity                                   = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile            = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                            = 800.55 MPa
PreStress = Pretension Stress on Bolt                               = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                = Rectangular
Pt        = Plate Washer Thickness                                  = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                  = 90.0 mm
Pl        = Length of Washer Parallel to Shell                      = 100.0 mm
Pdh       = Bolt Hole Diameter                                      = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 11.44 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                 = 323.8 mm
Do        = Outside Diameter of Flange                              = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange            = 25.4 mm
Dbc       = Bolt Circle Diameter                                    = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle             = 54.0 mm
Tf        = Thickness of Flange                                     = 31.8 mm
Tw        = Fillet Weld Size                                        = 6.0 mm
Gus       = Gussets                                                 = False
Db        = Nominal Bolt Diameter                                   = 22.2 mm
Nb        = Number of Bolts                                         = 12
BMatl     = Bolt Material                                           = Gr 8 (US)
```

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```
Fu        = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
FMatl     = Flange Material                                               = A-36
Fyf       = Yield Stress of Flange                                        = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                               = 193742.33
MPa
```

Design Codes

```
Stress Criteria:  Eurocde 3 - Design of Steel structures:  Part 3-2: Towers, masts and
chimneys
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)     = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters       = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset              = False

Lifting Criteria:

Impact    = Impact Factor                                                 = 1.50
Lift_El   = Elevation of Lifting Point                                    = 10.699 m
UprOff    = Longitudinal Offset for Lifting Lug point from Lift Elev to Lift Eye= 0.0000
m
Tail_El   = Elevation of Tailing Point                                    = 0.153 m
LwrOff    = Radial Offset for Tailing Lug point from Ctr Line to Tail Pt  = 0.7350 m
SF        = Stress Factor of Safety                                       = 0.000
Defl_Beam = Deflection Limit between Lifting Points:  L /                 = 200.0
Defl_Cant = Deflection Limit for Cantilevers:         L /                 = 200.0
Defl_Impact= Consider Impact loading for deflection check?                 = False
Check Stack for 0 to 90 Deg in 10 Deg increments
```

Damping Criteria:

```
Structural Damping Criteria:
     Criteria:      ASME STS-1-2021
     Stack Type:   UnLined
     Support:      ELASTIC
```

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

```
   Log Decrement Damping = 2 * PI * Bs


Aerodynamic Damping Criteria:
     (Only used in Along wind analysis, Not considered for vortex shedding)
```

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Criteria: EN 1994-1-4

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
11.500	11.467	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.467	11.385	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.385	11.257	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.257	11.128	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
11.128	11.000	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
11.000	10.699	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.699	10.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.400	8.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
8.400	7.667	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
7.667	6.456	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.456	6.123	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.123	5.789	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
5.789	5.456	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
5.456	5.137	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
5.137	5.000	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
5.000	4.863	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
4.863	3.100	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
3.100	2.450	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
2.450	1.385	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
1.385	1.275	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
1.275	1.165	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
1.165	0.950	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.950	0.350	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.350	0.305	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.305	0.153	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5
0.153	0.000	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	6

Section Props - If a number is shown, then the section contains something unusual
(Breach, nozzle, stiffeners, etc..) and so the properties were
calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0
6	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Weight Summary (Lifting)

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Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1583.0 kg)	4.698	2219.1	21762
Ladders	9.950	69.2	679
Platforms	10.400	319.3	3132
Baseplate	0.127	389.0	3815
Structural Flange(s)	11.440	58.0	569
Nozzle(s)	3.537	53.2	521
General Attachment Uniform)	1.725	82.5	809
General Attachment Concentrated	0.305	200.0	1961
Total	4.584	3390.3	33248

Cylindrical Shells Wt: (Wt = 2219.1 kg, El COG = 4.698 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
11.500	11.385	11.443	0.3238	10.0	8000	6.4	78.86	9.1
11.385	11.000	11.193	0.4159	10.0	7849	27.2	100.09	38.5
11.000	6.456	8.728	0.5080	10.0	7849	393.0	122.80	558.0
6.456	5.456	5.956	0.7874	10.0	7849	134.7	191.69	191.7
5.456	0.305	2.881	1.0668	10.0	7849	942.3	260.59	1342.3
0.305	0.000	0.153	1.0668	10.0	7849	79.5	260.59	79.5
Total		4.698				1583.0		2219.1

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 9.950 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	11.500	8.400	9.950	22.32	69.2
Total			9.950		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 10.400 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	10.400	319.3
Total					10.400	319.3

Baseplate Wt: (Wt = 389.0 kg, El COG = 0.127 m)

Description	Elevation COG m	Weight kg

Bottom Plate	0.013	192.0
Top Plate	0.293	120.2
Gussets	0.153	61.1
Washers	0.153	15.6
Total	0.127	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 11.440 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
11.440	482.6	31.8	0.0	0.0	0.0	25.1	7.9	11.440	2	58.0
Total					0.0	25.1	7.9	11.440		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 3.537 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	5.000	273.1	-3.99	12.06	7.36	16.85	0.00	5.000	32.27
2	1.275	219.1	-2.53	8.51	2.65	12.26	0.00	1.275	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	3.537	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 1.725 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	3.100	0.350	1.725	30.00	82.5
Total	0.000	0.000	1.725		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 0.305 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	0.305	0.000	200.0
Total	0.305		200.0

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Impact Load	I

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Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	I
3	Dead Weight		X	0.000	0	1.0	
4	Dead Weight + Impact	X		0.000	0	1.0	1.0

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
7	Upper Lift Point	10.6990	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Free	Free
28	Lower Lift Point	0.1530	0.7350	0.0000	Free	Fixed	Free	Free	Free	Free

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
11.500	11.467	4	Dead Weight + Impact	Buckling	0.000	PASS
11.467	11.385	4	Dead Weight + Impact	Buckling	0.000	PASS
11.385	11.257	4	Dead Weight + Impact	Buckling	0.001	PASS
11.257	11.128	4	Dead Weight + Impact	Buckling	0.001	PASS
11.128	11.000	4	Dead Weight + Impact	Buckling	0.002	PASS
11.000	10.699	4	Dead Weight + Impact	Buckling	0.002	PASS
10.699	10.400	4	Dead Weight + Impact	Buckling	0.023	PASS
10.400	8.400	4	Dead Weight + Impact	Buckling	0.018	PASS
8.400	7.667	4	Dead Weight + Impact	Buckling	0.096	PASS
7.667	6.456	4	Dead Weight + Impact	Buckling	0.118	PASS
6.456	6.123	4	Dead Weight + Impact	Buckling	0.147	PASS
6.123	5.789	4	Dead Weight + Impact	Buckling	0.081	PASS
5.789	5.456	4	Dead Weight + Impact	Buckling	0.051	PASS
5.456	5.137	4	Dead Weight + Impact	Buckling	0.036	PASS
5.137	5.000	4	Dead Weight + Impact	Buckling	0.036	PASS
5.000	4.863	4	Dead Weight + Impact	Buckling	0.039	PASS
4.863	3.100	4	Dead Weight + Impact	Buckling	0.036	PASS
3.100	2.450	4	Dead Weight + Impact	Buckling	0.032	PASS
2.450	1.385	4	Dead Weight + Impact	Buckling	0.028	PASS
1.385	1.275	4	Dead Weight + Impact	Buckling	0.020	PASS
1.275	1.165	4	Dead Weight + Impact	Buckling	0.020	PASS
1.165	0.950	4	Dead Weight + Impact	Buckling	0.018	PASS
0.950	0.350	4	Dead Weight + Impact	Buckling	0.016	PASS

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0.350	0.305	4	Dead Weight + Impact	Buckling	0.011 PASS
0.305	0.153	4	Dead Weight + Impact	Buckling	0.006 PASS
0.153	0.000	4	Dead Weight + Impact	Buckling	0.001 PASS
0.000	0.000	0			0.000 PASS

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	0.00	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	0.00	0.00	0.00	0.00	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.08	0.00	0.00	0.11	0.11	0.00	145.11	71.15	1.990	1.613	0.001	0.000	0.001
11.257	0.23	0.00	0.00	0.21	0.21	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.40	0.00	0.00	0.27	0.27	0.00	147.09	37.61	2.000	1.442	0.002	0.000	0.002
11.000	0.61	0.00	0.00	0.32	0.32	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.22	0.00	0.00	0.64	0.64	0.00	147.09	29.38	2.000	1.400	0.004	0.000	0.004
10.400	4.22	0.00	0.00	2.21	2.21	0.00	147.09	29.38	2.000	1.400	0.015	0.000	0.015
8.400	26.33	0.00	0.00	13.78	13.78	0.00	147.09	29.38	2.000	1.400	0.094	0.009	0.094
7.667	32.39	0.00	0.00	16.95	16.95	0.00	147.09	29.38	2.000	1.400	0.115	0.013	0.115
6.456	40.26	0.00	0.00	21.07	21.07	0.00	147.09	29.38	2.000	1.400	0.143	0.021	0.143
6.123	41.90	0.00	0.00	11.56	11.56	0.00	147.09	17.46	2.000	1.339	0.079	0.006	0.079
5.789	43.24	0.00	0.00	7.35	7.35	0.00	147.09	14.88	2.000	1.326	0.050	0.002	0.050
5.456	44.25	0.00	0.00	5.09	5.09	0.00	145.82	15.12	1.994	1.327	0.035	0.001	0.035
5.137	44.89	0.00	0.00	5.14	5.14	0.00	145.82	15.12	1.994	1.327	0.035	0.001	0.035
5.000	45.04	0.00	0.00	5.60	5.60	0.00	145.82	15.12	1.994	1.327	0.038	0.002	0.038
4.863	45.05	0.00	0.00	5.18	5.18	0.00	145.82	15.12	1.994	1.327	0.036	0.001	0.036
3.100	38.81	0.00	0.00	4.47	4.47	0.00	145.82	15.12	1.994	1.327	0.031	0.001	0.031
2.450	33.41	0.00	0.00	3.84	3.84	0.00	145.82	15.12	1.994	1.327	0.026	0.001	0.026
1.385	20.65	0.00	0.00	2.37	2.37	0.00	145.82	15.12	1.994	1.327	0.016	0.000	0.016
1.275	19.07	0.00	0.00	2.40	2.40	0.00	145.82	15.12	1.994	1.327	0.016	0.000	0.016
1.165	17.40	0.00	0.00	2.00	2.00	0.00	145.82	15.12	1.994	1.327	0.014	0.000	0.014
0.950	13.96	0.00	0.00	1.61	1.61	0.00	145.82	15.12	1.994	1.327	0.011	0.000	0.011
0.350	3.34	0.00	0.00	0.38	0.38	0.00	145.82	15.12	1.994	1.327	0.003	0.000	0.003
0.305	2.48	0.00	0.00	0.17	0.17	0.00	145.82	147.09	1.994	2.000	0.001	0.000	0.001
0.153	0.92	0.00	0.00	0.06	0.06	0.00	145.82	147.09	1.994	2.000	0.000	0.000	0.000

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 0 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 0.00 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN

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Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.00	3.0	0.466	220.63	0.300	1.080	0.200	1.000	5492.02	220.63	147.09
11.000	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
10.699	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
10.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
8.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3532.85	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.281	1.000	2785.52	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
3.100	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
2.450	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.385	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.275	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.165	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82

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 0.950  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.350  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
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```
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	0.00	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.17	-0.02	0.00	-0.02	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.08	-0.20	-0.02	0.10	0.08	0.00	145.11	71.15	1.990	1.613	0.001	0.000	0.001
11.257	0.22	-0.24	-0.02	0.21	0.19	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.40	-0.28	-0.02	0.27	0.25	0.00	147.09	37.61	2.000	1.442	0.002	0.000	0.002
11.000	0.60	-0.35	-0.02	0.31	0.29	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.20	3.22	0.21	0.63	0.84	0.00	147.09	29.38	2.000	1.400	0.006	0.000	0.006
10.400	4.26	1.98	0.13	2.23	2.36	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	26.73	1.49	0.10	13.99	14.09	0.00	147.09	29.38	2.000	1.400	0.096	0.009	0.096
7.667	32.94	1.19	0.08	17.25	17.32	0.00	147.09	29.38	2.000	1.400	0.118	0.014	0.118
6.456	41.12	0.92	0.06	21.52	21.58	0.00	147.09	29.38	2.000	1.400	0.147	0.022	0.147
6.123	42.85	0.76	0.04	11.82	11.86	0.00	147.09	17.46	2.000	1.339	0.081	0.006	0.081
5.789	44.28	0.59	0.02	7.52	7.55	0.00	147.09	14.88	2.000	1.326	0.051	0.003	0.051
5.456	45.40	0.40	0.01	5.22	5.24	0.00	145.77	15.12	1.993	1.327	0.036	0.001	0.036
5.137	46.13	0.25	0.01	5.28	5.29	0.00	145.79	15.12	1.993	1.327	0.036	0.001	0.036
5.000	46.33	0.08	0.00	5.76	5.76	0.00	145.81	15.12	1.993	1.327	0.039	0.002	0.039
4.863	46.39	-0.55	-0.02	5.34	5.32	0.00	145.88	15.12	1.994	1.327	0.036	0.001	0.036
3.100	40.86	-1.38	-0.04	4.70	4.66	0.00	146.00	15.12	1.994	1.327	0.032	0.001	0.032
2.450	35.76	-2.02	-0.06	4.12	4.05	0.00	146.13	15.12	1.995	1.327	0.028	0.001	0.028
1.385	23.57	-2.45	-0.07	2.71	2.64	0.00	146.38	15.12	1.996	1.327	0.018	0.000	0.018
1.275	22.04	-2.59	-0.08	2.77	2.69	0.00	146.45	15.12	1.997	1.327	0.018	0.000	0.018
1.165	20.44	-2.71	-0.08	2.35	2.27	0.00	146.57	15.12	1.997	1.327	0.015	0.000	0.015
0.950	17.13	-3.01	-0.09	1.97	1.88	0.00	146.83	15.12	1.999	1.327	0.013	0.000	0.013
0.350	6.88	-3.25	-0.10	0.79	0.69	0.00	147.09	15.12	2.000	1.327	0.005	0.000	0.005
0.305	6.05	-3.83	-0.06	0.40	0.34	0.00	147.09	147.09	2.000	2.000	0.002	0.000	0.002
0.153	0.91	1.04	0.02	0.06	0.08	0.00	143.16	147.09	1.980	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 10 Deg
Per EN 1993-3-2: Para 5.2.3

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Nb        = Design Value of Total Vertical Load at Base [5.5]              = 1.04 KN
Ncrit     = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio    = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.03	3.0	0.466	220.63	0.308	1.080	0.197	1.000	5670.24	220.63	147.09
11.000	111.7	5.6275	1.0	1.03	3.1	0.455	220.63	0.308	1.067	0.211	1.000	4978.62	220.63	147.09
10.699	111.7	5.6275	1.0	0.90	3.1	0.455	220.63	0.275	1.067	0.225	1.000	4352.26	220.63	147.09
10.400	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4724.50	220.63	147.09
8.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4815.12	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4819.74	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4822.97	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3528.66	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.282	1.000	2782.32	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.02	218.65	145.77
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.93	218.68	145.79
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2298.77	218.71	145.81
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2302.04	218.82	145.88
3.100	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2307.37	219.01	146.00
2.450	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2312.95	219.19	146.13
1.385	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2323.81	219.56	146.38

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 1.275  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.95 219.67
146.45
 1.165  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.996 2332.22 219.85
146.57
 0.950  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.54 220.24
146.83
 0.350  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.301 1.000 2428.99 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.318 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.279 0.979 0.310 0.973 2299.16 214.75
143.16

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

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```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.01	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.33	-0.03	0.00	-0.03	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.07	-0.39	-0.04	0.10	0.06	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.21	-0.47	-0.04	0.20	0.16	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.38	-0.55	-0.04	0.26	0.22	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.57	-0.70	-0.04	0.30	0.25	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.15	6.47	0.41	0.60	1.01	0.00	147.09	29.38	2.000	1.400	0.007	0.000	0.007
10.400	4.17	4.03	0.26	2.18	2.44	0.00	147.09	29.38	2.000	1.400	0.017	0.000	0.017
8.400	26.29	3.07	0.20	13.76	13.96	0.00	147.09	29.38	2.000	1.400	0.095	0.009	0.095
7.667	32.48	2.47	0.16	17.00	17.16	0.00	147.09	29.38	2.000	1.400	0.117	0.014	0.117
6.456	40.69	1.93	0.12	21.30	21.42	0.00	147.09	29.38	2.000	1.400	0.146	0.021	0.146
6.123	42.46	1.61	0.08	11.71	11.79	0.00	147.09	17.46	2.000	1.339	0.080	0.006	0.080
5.789	43.94	1.29	0.05	7.47	7.51	0.00	147.09	14.88	2.000	1.326	0.051	0.003	0.051
5.456	45.12	0.92	0.03	5.19	5.22	0.00	145.71	15.12	1.993	1.327	0.036	0.001	0.036
5.137	45.93	0.62	0.02	5.26	5.28	0.00	145.75	15.12	1.993	1.327	0.036	0.001	0.036
5.000	46.16	0.28	0.01	5.74	5.74	0.00	145.79	15.12	1.993	1.327	0.039	0.002	0.039
4.863	46.27	-0.96	-0.03	5.32	5.29	0.00	145.93	15.12	1.994	1.327	0.036	0.001	0.036
3.100	41.59	-2.60	-0.08	4.79	4.71	0.00	146.16	15.12	1.995	1.327	0.032	0.001	0.032
2.450	36.96	-3.85	-0.12	4.25	4.14	0.00	146.40	15.12	1.997	1.327	0.028	0.001	0.028
1.385	25.69	-4.71	-0.14	2.95	2.82	0.00	146.82	15.12	1.999	1.327	0.019	0.000	0.019
1.275	24.27	-4.97	-0.16	3.05	2.90	0.00	146.94	15.12	1.999	1.327	0.020	0.000	0.020
1.165	22.77	-5.21	-0.16	2.62	2.46	0.00	147.09	15.12	2.000	1.327	0.017	0.000	0.017
0.950	19.69	-5.81	-0.17	2.27	2.09	0.00	147.09	15.12	2.000	1.327	0.014	0.000	0.014
0.350	10.11	-6.28	-0.19	1.16	0.97	0.00	147.09	15.12	2.000	1.327	0.007	0.000	0.007
0.305	9.34	-7.41	-0.12	0.62	0.51	0.00	147.09	147.09	2.000	2.000	0.003	0.000	0.003
0.153	0.86	2.06	0.03	0.06	0.09	0.00	141.45	147.09	1.971	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

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Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 20 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 2.06 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.07	3.0	0.466	220.63	0.318	1.080	0.193	1.000	5894.65	220.63	147.09
11.000	111.7	5.6275	1.0	1.07	3.1	0.455	220.63	0.318	1.067	0.207	1.000	5166.73	220.63	147.09
10.699	111.7	5.6275	1.0	0.84	3.1	0.455	220.63	0.259	1.067	0.234	1.000	4040.81	220.63	147.09
10.400	111.7	5.6275	1.0	0.96	3.1	0.455	220.63	0.289	1.067	0.218	1.000	4624.50	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4801.08	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4810.46	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4817.08	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3523.86	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2778.52	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.991	2294.27	218.56	145.71
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.13	218.62	145.75
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.76	218.68	145.79
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2304.21	218.90	145.93
3.100	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.302	0.979	0.309	0.994	2314.43	219.25	146.16
2.450	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2324.94	219.60	146.40

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 1.385  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.45 220.24
146.82
 1.275  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.306 0.999 2348.77 220.42
146.94
 1.165  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2357.76 220.63
147.09
 0.950  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2376.12 220.63
147.09
 0.350  77.1 5.6275 1.0 1.08 4.6 0.383 220.63 0.319 0.979 0.298 1.000 2477.53 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.323 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.264 0.979 0.310 0.962 2299.16 212.17
141.45

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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```
 0.305 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09
 0.153 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.01	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.48	-0.05	0.00	-0.05	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.07	-0.57	-0.06	0.09	0.03	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.20	-0.69	-0.06	0.18	0.12	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.35	-0.80	-0.06	0.24	0.18	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.53	-1.02	-0.07	0.28	0.21	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	1.06	9.66	0.62	0.55	1.17	0.00	147.09	29.38	2.000	1.400	0.008	0.000	0.008
10.400	3.95	6.09	0.39	2.07	2.46	0.00	147.09	29.38	2.000	1.400	0.017	0.000	0.017
8.400	25.04	4.69	0.30	13.11	13.41	0.00	147.09	29.38	2.000	1.400	0.091	0.008	0.091
7.667	30.99	3.81	0.24	16.22	16.47	0.00	147.09	29.38	2.000	1.400	0.112	0.013	0.112
6.456	38.98	3.03	0.19	20.41	20.60	0.00	147.09	29.38	2.000	1.400	0.140	0.020	0.140
6.123	40.73	2.56	0.12	11.24	11.35	0.00	147.09	17.46	2.000	1.339	0.077	0.006	0.077
5.789	42.21	2.09	0.08	7.17	7.25	0.00	147.09	14.88	2.000	1.326	0.049	0.002	0.049
5.456	43.42	1.55	0.05	5.00	5.04	0.00	145.62	15.12	1.993	1.327	0.035	0.001	0.035
5.137	44.27	1.11	0.03	5.07	5.10	0.00	145.69	15.12	1.993	1.327	0.035	0.001	0.035
5.000	44.54	0.61	0.02	5.53	5.55	0.00	145.75	15.12	1.993	1.327	0.038	0.001	0.038
4.863	44.68	-1.21	-0.04	5.14	5.11	0.00	145.97	15.12	1.994	1.327	0.035	0.001	0.035
3.100	40.99	-3.59	-0.11	4.72	4.61	0.00	146.31	15.12	1.996	1.327	0.032	0.001	0.032
2.450	36.95	-5.43	-0.16	4.25	4.09	0.00	146.65	15.12	1.998	1.327	0.028	0.001	0.028
1.385	26.93	-6.68	-0.19	3.10	2.90	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.275	25.66	-7.07	-0.22	3.23	3.00	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	24.32	-7.42	-0.22	2.80	2.58	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
0.950	21.56	-8.29	-0.25	2.48	2.23	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015
0.350	12.94	-8.97	-0.27	1.49	1.22	0.00	147.09	15.12	2.000	1.327	0.008	0.000	0.008
0.305	12.24	-10.63	-0.17	0.81	0.65	0.00	147.09	147.09	2.000	2.000	0.004	0.000	0.004
0.153	0.80	3.01	0.05	0.05	0.10	0.00	140.18	147.09	1.965	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
```

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Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 30 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 3.01 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.13	3.0	0.466	220.63	0.333	1.080	0.189	1.000	6207.59	220.63	147.09
11.000	111.7	5.6275	1.0	1.12	3.1	0.455	220.63	0.331	1.067	0.202	1.000	5426.67	220.63	147.09
10.699	111.7	5.6275	1.0	0.79	3.1	0.455	220.63	0.247	1.067	0.241	1.000	3809.96	220.63	147.09
10.400	111.7	5.6275	1.0	0.94	3.1	0.455	220.63	0.284	1.067	0.221	1.000	4522.13	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4785.04	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4799.65	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4810.07	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3518.03	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2773.78	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2290.65	218.44	145.62
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.56	218.53	145.69
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.00	218.62	145.75
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2305.72	218.95	145.97

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 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.302 0.979 0.308 0.995 2320.76 219.46
146.31
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.997 2335.93 219.98
146.65
 1.385  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2360.14 220.63
147.09
 1.275  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000 2367.10 220.63
147.09
 1.165  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.309 0.979 0.305 1.000 2378.93 220.63
147.09
 0.950  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2402.08 220.63
147.09
 0.350  77.1 5.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2503.05 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.326 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.253 0.979 0.310 0.953 2299.16 210.27
140.18

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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 1.275 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 1.165 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 0.950 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 0.350 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 0.305 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09
 0.153 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.62	-0.06	0.00	-0.06	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.06	-0.73	-0.07	0.08	0.01	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.17	-0.88	-0.07	0.16	0.09	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.31	-1.03	-0.08	0.21	0.14	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.47	-1.31	-0.08	0.24	0.16	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	0.94	12.73	0.81	0.49	1.30	0.00	146.11	29.38	1.995	1.400	0.009	0.000	0.009
10.400	3.60	8.13	0.52	1.89	2.40	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	22.99	6.34	0.41	12.04	12.44	0.00	147.09	29.38	2.000	1.400	0.085	0.007	0.085
7.667	28.53	5.21	0.33	14.93	15.27	0.00	147.09	29.38	2.000	1.400	0.104	0.011	0.104
6.456	36.04	4.20	0.27	18.87	19.14	0.00	147.09	29.38	2.000	1.400	0.130	0.017	0.130
6.123	37.71	3.60	0.17	10.40	10.57	0.00	147.09	17.46	2.000	1.339	0.072	0.005	0.072
5.789	39.14	3.00	0.11	6.65	6.76	0.00	147.09	14.88	2.000	1.326	0.046	0.002	0.046
5.456	40.33	2.30	0.07	4.64	4.71	0.00	145.51	15.12	1.992	1.327	0.032	0.001	0.032
5.137	41.21	1.74	0.05	4.72	4.77	0.00	145.60	15.12	1.992	1.327	0.033	0.001	0.033
5.000	41.49	1.10	0.03	5.16	5.19	0.00	145.68	15.12	1.993	1.327	0.036	0.001	0.036
4.863	41.67	-1.24	-0.04	4.80	4.76	0.00	145.98	15.12	1.994	1.327	0.033	0.001	0.033
3.100	39.05	-4.31	-0.13	4.49	4.36	0.00	146.44	15.12	1.997	1.327	0.030	0.001	0.030
2.450	35.71	-6.67	-0.20	4.11	3.91	0.00	146.89	15.12	1.999	1.327	0.027	0.001	0.027
1.385	27.25	-8.28	-0.24	3.13	2.89	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.275	26.17	-8.78	-0.28	3.29	3.01	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	25.02	-9.23	-0.28	2.88	2.60	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
0.950	22.65	-10.35	-0.31	2.61	2.30	0.00	147.09	15.12	2.000	1.327	0.016	0.000	0.016
0.350	15.25	-11.23	-0.34	1.76	1.42	0.00	147.09	15.12	2.000	1.327	0.010	0.000	0.010
0.305	14.65	-13.36	-0.21	0.98	0.77	0.00	147.09	147.09	2.000	2.000	0.005	0.000	0.005
0.153	0.71	3.87	0.06	0.05	0.11	0.00	139.15	147.09	1.960	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
```

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s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 40 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 3.87 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.22	3.0	0.466	220.63	0.356	1.080	0.181	1.000	6712.18	220.63	147.09
11.000	111.7	5.6275	1.0	1.21	3.1	0.455	220.63	0.352	1.067	0.194	1.000	5840.15	220.63	147.09
10.699	111.7	5.6275	1.0	0.75	3.1	0.455	220.63	0.238	1.067	0.247	0.993	3622.67	219.16	146.11
10.400	111.7	5.6275	1.0	0.91	3.1	0.455	220.63	0.278	1.067	0.224	1.000	4410.67	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4765.34	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4786.11	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4801.11	220.63	147.09
6.123	95.5	5.6275	1.0	0.99	3.7	0.427	220.63	0.298	1.033	0.251	1.000	3510.47	220.63	147.09
5.789	84.8	5.6275	1.0	0.99	4.1	0.403	220.63	0.298	1.004	0.282	1.000	2767.47	220.63	147.09
5.456	77.1	5.6275	1.0	0.99	4.6	0.383	220.63	0.299	0.979	0.311	0.989	2285.64	218.27	145.51
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2289.79	218.41	145.60

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 5.000  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2293.11 218.52
145.68
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.301 0.979 0.309 0.992 2306.41 218.97
145.98
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.52 219.66
146.44
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.999 2346.40 220.34
146.89
 1.385  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2374.99 220.63
147.09
 1.275  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2383.26 220.63
147.09
 1.165  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2397.40 220.63
147.09
 0.950  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2424.03 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.324 0.979 0.296 1.000 2518.57 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.327 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.244 0.979 0.310 0.946 2299.16 208.72
139.15

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.74	-0.07	0.00	-0.07	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.05	-0.87	-0.09	0.07	-0.02	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.15	-1.05	-0.09	0.13	0.05	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.26	-1.23	-0.09	0.18	0.09	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.39	-1.56	-0.10	0.20	0.10	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	0.79	15.65	1.00	0.41	1.41	0.00	144.62	29.38	1.987	1.400	0.010	0.000	0.010
10.400	3.14	10.17	0.65	1.64	2.29	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	20.21	8.03	0.51	10.58	11.09	0.00	147.09	29.38	2.000	1.400	0.075	0.006	0.075
7.667	25.15	6.68	0.43	13.17	13.59	0.00	147.09	29.38	2.000	1.400	0.092	0.009	0.092
6.456	31.94	5.49	0.35	16.72	17.07	0.00	147.09	29.38	2.000	1.400	0.116	0.013	0.116
6.123	33.47	4.77	0.22	9.23	9.46	0.00	147.09	17.46	2.000	1.339	0.064	0.004	0.064
5.789	34.81	4.05	0.15	5.91	6.06	0.00	147.09	14.88	2.000	1.326	0.041	0.002	0.041
5.456	35.94	3.22	0.10	4.14	4.23	0.00	145.34	15.12	1.991	1.327	0.029	0.001	0.029
5.137	36.80	2.55	0.07	4.22	4.29	0.00	145.47	15.12	1.992	1.327	0.029	0.001	0.029
5.000	37.09	1.78	0.06	4.61	4.66	0.00	145.57	15.12	1.992	1.327	0.032	0.001	0.032
4.863	37.30	-1.01	-0.03	4.29	4.26	0.00	145.97	15.12	1.994	1.327	0.029	0.001	0.029
3.100	35.81	-4.66	-0.14	4.12	3.98	0.00	146.55	15.12	1.997	1.327	0.027	0.001	0.027
2.450	33.26	-7.47	-0.22	3.83	3.60	0.00	147.09	15.12	2.000	1.327	0.024	0.001	0.024
1.385	26.59	-9.39	-0.27	3.06	2.79	0.00	147.09	15.12	2.000	1.327	0.019	0.000	0.019
1.275	25.72	-9.99	-0.31	3.23	2.92	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	24.80	-10.52	-0.32	2.85	2.54	0.00	147.09	15.12	2.000	1.327	0.017	0.000	0.017
0.950	22.90	-11.85	-0.36	2.64	2.28	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015
0.350	16.93	-12.90	-0.39	1.95	1.56	0.00	147.09	15.12	2.000	1.327	0.011	0.000	0.011
0.305	16.45	-15.45	-0.24	1.09	0.85	0.00	147.09	147.09	2.000	2.000	0.006	0.000	0.006
0.153	0.59	4.61	0.07	0.04	0.11	0.00	138.24	147.09	1.955	2.000	0.001	0.000	0.001

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   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 50 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 4.61 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.41	3.0	0.466	220.63	0.403	1.080	0.169	1.000	7752.70	220.63	147.09
11.000	111.7	5.6275	1.0	1.38	3.1	0.455	220.63	0.395	1.067	0.182	1.000	6671.30	220.63	147.09
10.699	111.7	5.6275	1.0	0.72	3.1	0.455	220.63	0.229	1.067	0.253	0.983	3459.45	216.93	144.62
10.400	111.7	5.6275	1.0	0.89	3.1	0.455	220.63	0.272	1.067	0.227	1.000	4281.00	220.63	147.09
8.400	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4738.88	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4767.53	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4788.55	220.63	147.09
6.123	95.5	5.6275	1.0	0.99	3.7	0.427	220.63	0.298	1.033	0.251	1.000	3499.72	220.63	147.09
5.789	84.8	5.6275	1.0	0.99	4.1	0.403	220.63	0.298	1.004	0.283	1.000	2758.33	220.63	147.09

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 5.456  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2278.11 218.01
145.34
 5.137  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.989 2283.88 218.21
145.47
 5.000  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.311 0.990 2288.22 218.35
145.57
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.301 0.979 0.309 0.992 2305.71 218.95
145.97
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.996 2331.60 219.83
146.55
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2356.59 220.63
147.09
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.52 220.63
147.09
 1.275  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2397.91 220.63
147.09
 1.165  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.302 1.000 2413.99 220.63
147.09
 0.950  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.316 0.979 0.301 1.000 2443.28 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.325 0.979 0.295 1.000 2528.26 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.328 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.235 0.979 0.310 0.940 2299.16 207.37
138.24

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46

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5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.83	-0.08	0.00	-0.08	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.04	-0.99	-0.10	0.05	-0.05	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.11	-1.19	-0.10	0.10	0.00	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.20	-1.39	-0.10	0.14	0.04	0.00	147.09	37.61	2.000	1.442	0.000	0.000	0.000
11.000	0.30	-1.77	-0.11	0.16	0.05	0.00	147.09	29.38	2.000	1.400	0.000	0.000	0.000
10.699	0.61	18.47	1.18	0.32	1.50	0.00	143.23	29.38	1.980	1.400	0.010	0.000	0.010
10.400	2.58	12.28	0.78	1.35	2.13	0.00	147.09	29.38	2.000	1.400	0.015	0.000	0.015
8.400	16.75	9.85	0.63	8.77	9.40	0.00	147.09	29.38	2.000	1.400	0.064	0.004	0.064
7.667	20.93	8.33	0.53	10.95	11.49	0.00	147.09	29.38	2.000	1.400	0.078	0.006	0.078
6.456	26.75	6.98	0.45	14.00	14.45	0.00	147.09	29.38	2.000	1.400	0.098	0.010	0.098
6.123	28.10	6.17	0.29	7.75	8.04	0.00	147.09	17.46	2.000	1.339	0.055	0.003	0.055
5.789	29.28	5.35	0.20	4.98	5.17	0.00	147.09	14.88	2.000	1.326	0.035	0.001	0.035
5.456	30.31	4.41	0.13	3.49	3.62	0.00	145.05	15.12	1.990	1.327	0.025	0.001	0.025
5.137	31.13	3.66	0.10	3.57	3.67	0.00	145.24	15.12	1.991	1.327	0.025	0.001	0.025
5.000	31.41	2.79	0.09	3.90	3.99	0.00	145.36	15.12	1.991	1.327	0.027	0.001	0.027
4.863	31.63	-0.36	-0.01	3.64	3.63	0.00	145.88	15.12	1.994	1.327	0.025	0.001	0.025
3.100	31.27	-4.49	-0.14	3.60	3.46	0.00	146.63	15.12	1.998	1.327	0.024	0.001	0.024
2.450	29.58	-7.67	-0.23	3.40	3.17	0.00	147.09	15.12	2.000	1.327	0.022	0.000	0.022
1.385	24.87	-9.84	-0.28	2.86	2.58	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
1.275	24.25	-10.51	-0.33	3.05	2.72	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
1.165	23.58	-11.11	-0.33	2.71	2.38	0.00	147.09	15.12	2.000	1.327	0.016	0.000	0.016
0.950	22.20	-12.62	-0.38	2.55	2.17	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015

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 0.350  17.83 -13.81 -0.42  2.05  1.64  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.305  17.47 -16.68 -0.26  1.16  0.90  0.00 147.09 147.09 2.000 2.000 0.006 0.000 0.006
 0.153   0.46   5.21  0.08  0.03  0.11  0.00 137.40 147.09 1.951 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 60 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.21 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	2.12	3.0	0.466	220.63	0.580	1.080	0.138	1.000	11650.99	220.63	147.09
11.000	111.7	5.6275	1.0	1.98	3.1	0.455	220.63	0.544	1.067	0.152	1.000	9549.63	220.63	147.09
10.699	111.7	5.6275	1.0	0.69	3.1	0.455	220.63	0.221	1.067	0.258	0.974	3308.53	214.85	143.23
10.400	111.7	5.6275	1.0	0.85	3.1	0.455	220.63	0.263	1.067	0.231	1.000	4118.08	220.63	147.09
8.400	111.7	5.6275	1.0	0.97	3.1	0.455	220.63	0.293	1.067	0.217	1.000	4698.81	220.63	147.09
7.667	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4738.66	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4768.59	220.63	147.09

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```
 6.123  95.5 5.6275 1.0 0.99 3.7 0.427 220.63 0.296 1.033 0.252 1.000  3482.41 220.63
147.09
 5.789  84.8 5.6275 1.0 0.98 4.1 0.403 220.63 0.296 1.004 0.284 1.000  2743.35 220.63
147.09
 5.456  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.296 0.979 0.312 0.986  2265.39 217.58
145.05
 5.137  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.312 0.987  2273.52 217.85
145.24
 5.000  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988  2279.11 218.04
145.36
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992  2301.91 218.82
145.88
 3.100  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.997  2335.08 219.95
146.63
 2.450  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000  2366.07 220.63
147.09
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000  2400.42 220.63
147.09
 1.275  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000  2410.83 220.63
147.09
 1.165  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.301 1.000  2428.57 220.63
147.09
 0.950  77.1 5.6275 1.0 1.07 4.6 0.383 220.63 0.317 0.979 0.299 1.000  2459.98 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.325 0.979 0.295 1.000  2533.05 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.329 0.979 0.310 1.000  2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.227 0.979 0.310 0.934  2299.16 206.10
137.40

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38

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8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.91	-0.09	0.00	-0.09	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.03	-1.07	-0.11	0.04	-0.07	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.08	-1.29	-0.11	0.07	-0.04	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.14	-1.51	-0.11	0.09	-0.02	0.00	NaN	37.61	NaN	1.442	0.000	0.000	0.000
11.000	0.21	-1.92	-0.12	0.11	-0.01	0.00	NaN	29.38	NaN	1.400	0.000	0.000	0.000
10.699	0.42	21.48	1.37	0.22	1.59	0.00	141.87	29.38	1.973	1.400	0.011	0.000	0.011
10.400	1.92	14.77	0.94	1.01	1.95	0.00	147.09	29.38	2.000	1.400	0.013	0.000	0.013
8.400	12.67	12.14	0.78	6.63	7.41	0.00	147.09	29.38	2.000	1.400	0.050	0.003	0.050
7.667	15.91	10.49	0.67	8.33	9.00	0.00	147.09	29.38	2.000	1.400	0.061	0.004	0.061
6.456	20.53	9.02	0.58	10.75	11.32	0.00	147.09	29.38	2.000	1.400	0.077	0.006	0.077
6.123	21.62	8.13	0.38	5.96	6.34	0.00	147.09	17.46	2.000	1.339	0.043	0.002	0.043
5.789	22.61	7.25	0.27	3.84	4.11	0.00	147.09	14.88	2.000	1.326	0.028	0.001	0.028
5.456	23.49	6.23	0.19	2.70	2.89	0.00	144.46	15.12	1.987	1.327	0.020	0.000	0.020
5.137	24.21	5.41	0.15	2.77	2.92	0.00	144.74	15.12	1.988	1.327	0.020	0.000	0.020
5.000	24.48	4.47	0.14	3.04	3.18	0.00	144.90	15.12	1.989	1.327	0.022	0.001	0.022
4.863	24.71	1.05	0.03	2.84	2.87	0.00	145.59	15.12	1.992	1.327	0.020	0.000	0.020
3.100	25.38	-3.43	-0.10	2.92	2.82	0.00	146.58	15.12	1.997	1.327	0.019	0.000	0.019
2.450	24.57	-6.87	-0.21	2.83	2.62	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018

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 1.385  21.90  -9.23 -0.27  2.52  2.25  0.00 147.09  15.12 2.000 1.327 0.015 0.000 0.015
 1.275  21.54  -9.96 -0.31  2.71  2.40  0.00 147.09  15.12 2.000 1.327 0.016 0.000 0.016
 1.165  21.14 -10.62 -0.32  2.43  2.11  0.00 147.09  15.12 2.000 1.327 0.014 0.000 0.014
 0.950  20.31 -12.25 -0.37  2.34  1.97  0.00 147.09  15.12 2.000 1.327 0.013 0.000 0.013
 0.350  17.63 -13.54 -0.41  2.03  1.62  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.305  17.41 -16.66 -0.26  1.16  0.90  0.00 147.09 147.09 2.000 2.000 0.006 0.000 0.006
 0.153   0.31   5.65  0.09  0.02  0.11  0.00 136.56 147.09 1.946 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 70 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.65 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	-1.76	3.0	0.466	220.63	-0.391	1.080	NaN	NaN	-9686.24	NaN	NaN
11.000	111.7	5.6275	1.0	-2.58	3.1	0.455	220.63	-0.595	1.067	NaN	NaN	-12459.55	NaN	NaN
10.699	111.7	5.6275	1.0	0.65	3.1	0.455	220.63	0.214	1.067	0.264	0.965	3162.27	212.81	141.87
10.400	111.7	5.6275	1.0	0.81	3.1	0.455	220.63	0.252	1.067	0.238	1.000	3893.06	220.63	147.09
8.400	111.7	5.6275	1.0	0.96	3.1	0.455	220.63	0.290	1.067	0.218	1.000	4625.97	220.63	147.09

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```
 7.667 111.7 5.6275 1.0  0.97 3.1 0.455 220.63  0.293 1.067 0.217 1.000   4684.35 220.63
147.09
 6.456 111.7 5.6275 1.0  0.98 3.1 0.455 220.63  0.295 1.067 0.216 1.000   4729.91 220.63
147.09
 6.123  95.5 5.6275 1.0  0.98 3.7 0.427 220.63  0.294 1.033 0.253 1.000   3448.55 220.63
147.09
 5.789  84.8 5.6275 1.0  0.97 4.1 0.403 220.63  0.294 1.004 0.285 1.000   2713.59 220.63
147.09
 5.456  77.1 5.6275 1.0  0.97 4.6 0.383 220.63  0.294 0.979 0.314 0.982   2239.42 216.70
144.46
 5.137  77.1 5.6275 1.0  0.98 4.6 0.383 220.63  0.295 0.979 0.313 0.984   2251.58 217.11
144.74
 5.000  77.1 5.6275 1.0  0.98 4.6 0.383 220.63  0.296 0.979 0.313 0.985   2258.88 217.36
144.90
 4.863  77.1 5.6275 1.0  1.00 4.6 0.383 220.63  0.299 0.979 0.310 0.990   2289.01 218.38
145.59
 3.100  77.1 5.6275 1.0  1.01 4.6 0.383 220.63  0.304 0.979 0.308 0.997   2332.87 219.87
146.58
 2.450  77.1 5.6275 1.0  1.03 4.6 0.383 220.63  0.308 0.979 0.305 1.000   2371.83 220.63
147.09
 1.385  77.1 5.6275 1.0  1.05 4.6 0.383 220.63  0.312 0.979 0.303 1.000   2407.81 220.63
147.09
 1.275  77.1 5.6275 1.0  1.05 4.6 0.383 220.63  0.313 0.979 0.302 1.000   2419.28 220.63
147.09
 1.165  77.1 5.6275 1.0  1.06 4.6 0.383 220.63  0.315 0.979 0.301 1.000   2438.33 220.63
147.09
 0.950  77.1 5.6275 1.0  1.08 4.6 0.383 220.63  0.319 0.979 0.299 1.000   2471.65 220.63
147.09
 0.350  77.1 5.6275 1.0  1.10 4.6 0.383 220.63  0.325 0.979 0.295 1.000   2530.51 220.63
147.09
 0.305   2.1 0.1525 1.0  1.00 4.6 0.383 220.63  0.329 0.979 0.310 1.000   2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0  1.00 4.6 0.383 220.63  0.219 0.979 0.310 0.928   2299.16 204.84
136.56

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28

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11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.95	-0.10	0.00	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.01	-1.12	-0.11	0.02	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.04	-1.35	-0.11	0.04	-0.08	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.07	-1.58	-0.12	0.05	-0.07	0.00	126.03	37.61	1.893	1.442	0.000	0.000	0.000
11.000	0.11	-2.01	-0.13	0.06	-0.07	0.00	122.06	29.38	1.872	1.400	0.000	0.000	0.000
10.699	0.21	26.02	1.66	0.11	1.77	0.00	140.51	29.38	1.966	1.400	0.013	0.000	0.013
10.400	1.16	18.97	1.21	0.61	1.82	0.00	145.37	29.38	1.991	1.400	0.013	0.000	0.013
8.400	7.85	16.22	1.04	4.11	5.15	0.00	147.09	29.38	2.000	1.400	0.035	0.001	0.035
7.667	9.95	14.49	0.93	5.21	6.13	0.00	147.09	29.38	2.000	1.400	0.042	0.002	0.042
6.456	13.04	12.95	0.83	6.83	7.65	0.00	147.09	29.38	2.000	1.400	0.052	0.003	0.052
6.123	13.80	12.02	0.56	3.81	4.37	0.00	147.09	17.46	2.000	1.339	0.030	0.001	0.030
5.789	14.51	11.10	0.41	2.47	2.87	0.00	146.61	14.88	1.998	1.326	0.020	0.000	0.020
5.456	15.16	10.03	0.30	1.74	2.05	0.00	142.75	15.12	1.978	1.327	0.014	0.000	0.014
5.137	15.73	9.17	0.26	1.80	2.06	0.00	143.23	15.12	1.980	1.327	0.014	0.000	0.014

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 5.000  15.95   8.19  0.26  1.98  2.24  0.00 143.45  15.12 1.981 1.327 0.016 0.000 0.016
 4.863  16.14   4.60  0.14  1.86  2.00  0.00 144.37  15.12 1.986 1.327 0.014 0.000 0.014
 3.100  17.57  -0.09  0.00  2.02  2.02  0.00 145.85  15.12 1.994 1.327 0.014 0.000 0.014
 2.450  17.56  -3.70 -0.11  2.02  1.91  0.00 147.04  15.12 2.000 1.327 0.013 0.000 0.013
 1.385  16.87  -6.18 -0.18  1.94  1.76  0.00 147.09  15.12 2.000 1.327 0.012 0.000 0.012
 1.275  16.75  -6.94 -0.22  2.11  1.89  0.00 147.09  15.12 2.000 1.327 0.013 0.000 0.013
 1.165  16.61  -7.63 -0.23  1.91  1.68  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.950  16.32  -9.34 -0.28  1.88  1.60  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.350  15.34 -10.69 -0.32  1.76  1.44  0.00 147.09  15.12 2.000 1.327 0.010 0.000 0.010
 0.305  15.25 -13.96 -0.22  1.02  0.80  0.00 147.09 147.09 2.000 2.000 0.005 0.000 0.005
 0.153   0.16   5.92  0.09  0.01  0.10  0.00 135.66 147.09 1.942 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 80 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.92 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev     w      l     Cxb  Cx  Dwk   ax    Fyk   Lxo   Lpx    Lx    Xx  s_xRcr  s_xRk
s_xRd
   m             m             mm          MPa                            MPa     MPa
MPa
------ ----- ------ --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ----
--
11.500 139.9 5.6275 1.0 0.60 2.5 0.491 206.84 0.200 1.108 0.217 0.988 4374.86 204.46
136.31
11.467 139.9 5.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 139.9 5.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 128.2 5.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 119.1 5.6275 1.0 0.32 3.0 0.466 220.63 0.129 1.080 0.356 0.857 1741.04 189.05
126.03
11.000 111.7 5.6275 1.0 0.30 3.1 0.455 220.63 0.124 1.067 0.392 0.830 1438.01 183.09
122.06
10.699 111.7 5.6275 1.0 0.63 3.1 0.455 220.63 0.206 1.067 0.270 0.955 3017.84 210.77
140.51
```

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```
10.400 111.7 5.6275 1.0 0.73 3.1 0.455 220.63 0.233 1.067 0.250 0.988 3541.13 218.05
145.37
 8.400 111.7 5.6275 1.0 0.92 3.1 0.455 220.63 0.280 1.067 0.223 1.000 4439.19 220.63
147.09
 7.667 111.7 5.6275 1.0 0.94 3.1 0.455 220.63 0.285 1.067 0.221 1.000 4536.61 220.63
147.09
 6.456 111.7 5.6275 1.0 0.96 3.1 0.455 220.63 0.289 1.067 0.219 1.000 4619.38 220.63
147.09
 6.123  95.5 5.6275 1.0 0.95 3.7 0.427 220.63 0.287 1.033 0.257 1.000 3351.83 220.63
147.09
 5.789  84.8 5.6275 1.0 0.94 4.1 0.403 220.63 0.286 1.004 0.290 0.997 2628.03 219.92
146.61
 5.456  77.1 5.6275 1.0 0.94 4.6 0.383 220.63 0.285 0.979 0.319 0.970 2163.39 214.12
142.75
 5.137  77.1 5.6275 1.0 0.95 4.6 0.383 220.63 0.288 0.979 0.318 0.974 2184.56 214.84
143.23
 5.000  77.1 5.6275 1.0 0.95 4.6 0.383 220.63 0.289 0.979 0.317 0.975 2194.30 215.17
143.45
 4.863  77.1 5.6275 1.0 0.97 4.6 0.383 220.63 0.293 0.979 0.314 0.982 2235.30 216.56
144.37
 3.100  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2300.45 218.77
145.85
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2352.91 220.56
147.04
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2392.12 220.63
147.09
 1.275  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2405.34 220.63
147.09
 1.165  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2424.73 220.63
147.09
 0.950  77.1 5.6275 1.0 1.07 4.6 0.383 220.63 0.318 0.979 0.299 1.000 2461.19 220.63
147.09
 0.350  77.1 5.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2504.40 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.328 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.210 0.979 0.310 0.922 2299.16 203.49
135.66

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa

11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.96	-0.10	0.00	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.00	-1.14	-0.12	0.00	-0.12	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.00	-1.37	-0.12	0.00	-0.12	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.00	-1.60	-0.12	0.00	-0.12	0.00	141.19	37.61	1.970	1.442	0.000	0.000	0.000
11.000	0.00	-2.04	-0.13	0.00	-0.13	0.00	139.35	29.38	1.961	1.400	0.000	0.000	0.000
10.699	0.00	49.87	3.19	0.00	3.19	0.00	139.35	29.38	1.961	1.400	0.023	0.001	0.023
10.400	0.00	40.04	2.56	0.00	2.56	0.00	139.35	29.38	1.961	1.400	0.018	0.000	0.018
8.400	0.00	37.24	2.38	0.00	2.38	0.00	139.35	29.38	1.961	1.400	0.017	0.000	0.017
7.667	0.00	35.49	2.27	0.00	2.27	0.00	139.35	29.38	1.961	1.400	0.016	0.000	0.016
6.456	0.00	33.92	2.17	0.00	2.17	0.00	139.35	29.38	1.961	1.400	0.016	0.000	0.016

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 6.123   0.00 32.98  1.53  0.00  1.53  0.00 134.09  17.46 1.934 1.339 0.011 0.000 0.011
 5.789   0.00 32.04  1.17  0.00  1.17  0.00 129.16  14.88 1.909 1.326 0.009 0.000 0.009
 5.456   0.00 30.96  0.93  0.00  0.93  0.00 124.44  15.12 1.885 1.327 0.007 0.000 0.007
 5.137   0.00 30.09  0.84  0.00  0.84  0.00 124.44  15.12 1.885 1.327 0.007 0.000 0.007
 5.000   0.00 29.09  0.91  0.00  0.91  0.00 124.44  15.12 1.885 1.327 0.007 0.000 0.007
 4.863   0.00 25.45  0.77  0.00  0.77  0.00 124.44  15.12 1.885 1.327 0.006 0.000 0.006
 3.100   0.00 20.68  0.62  0.00  0.62  0.00 124.44  15.12 1.885 1.327 0.005 0.000 0.005
 2.450   0.00 17.01  0.51  0.00  0.51  0.00 124.44  15.12 1.885 1.327 0.004 0.000 0.004
 1.385   0.00 14.50  0.42  0.00  0.42  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 1.275   0.00 13.73  0.43  0.00  0.43  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 1.165   0.00 13.03  0.39  0.00  0.39  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 0.950   0.00 11.29  0.34  0.00  0.34  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 0.350   0.00  9.92  0.30  0.00  0.30  0.00 124.44  15.12 1.885 1.327 0.002 0.000 0.002
 0.305   0.00  6.60  0.10  0.00  0.10  0.00 134.65 147.09 1.937 2.000 0.001 0.000 0.001
 0.153   0.00  6.02  0.09  0.00  0.09  0.00 134.65 147.09 1.937 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 90 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 6.02 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev    w     l    Cxb  Cx  Dwk   ax    Fyk   Lxo   Lpx    Lx    Xx  s_xRcr  s_xRk
s_xRd
  m           m             mm          MPa                           MPa     MPa
MPa
------ ----- ------ --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ----
--
11.500 139.9 5.6275 1.0 0.60 2.5 0.491 206.84 0.200 1.108 0.217 0.988 4374.86 204.46
136.31
11.467 139.9 5.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 139.9 5.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 128.2 5.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 119.1 5.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
```

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```
11.000 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 7.667 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123  95.5 5.6275 1.0 0.60 3.7 0.427 220.63 0.200 1.033 0.323 0.912 2119.71 201.14
134.09
 5.789  84.8 5.6275 1.0 0.60 4.1 0.403 220.63 0.200 1.004 0.363 0.878 1671.31 193.74
129.16
 5.456  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.137  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.000  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 4.863  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 3.100  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 2.450  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.385  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.275  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.165  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.950  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.350  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.200 0.979 0.310 0.915 2299.16 201.98
134.65
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.200 0.979 0.310 0.915 2299.16 201.98
134.65

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

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Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Structural Flange Analysis, Angle = 0 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 0 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 0.8 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= 0 N
S	= Shear Load on Flange	= 25 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm

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```
Tw        = Fillet Weld Size                                          = 6.0 mm

Db        = Nominal Bolt Diameter                                     = 22.2 mm
Nb        = Number of Bolts                                           = 12
Fu        = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu              = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb        = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys       = Yield Stress of Shell                                     = 215.81 MPa
Fw        = Tensile Stress of Weld                                    = 413.68 MPa
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                = 194.22 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt            = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters          = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                           = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                      = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N   = 1 N
Ab        = Nominal Area of Bolt                                      = 3.879 sq cm
Km        = Stiffness of Material                                     = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                         = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)    = 0.173
Fby       = Bolt Yield Stress                                         = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                              = 761869.3
KPa
Aroot     = Bolt Root Area                                            = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}          = 123659 N
K         = Coefficient of Thread Friction                            = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                   = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                  = 1 N
Fact      = Actual force on bolt                                      = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi      = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                = 144440 N
Ratio     = Fb / Fbcomb                                               = 0.856

Sh        = Shear on Bolt                                             = 2 N
Sallow    = Allowable Shear on Bolt                                   = 92281 N
Ratio     = Sh / Sallow                                               = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                        = 11310.74
cm^4
```

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```
Jw        = Polar Moment of Inertia for Weld                          = 22621.48
cm^4
Aw        = Area of Weld                                              = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                        = 1.2 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw               = 124.11 MPa
Ratio     = Fba / Sw                                                  = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                              = 87.6 mm
Lg        = Gross Flange area for each bolt                           = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                 = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                          = 54.0 mm
A         = Distance from Bolt CL to Flange OD                        = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                = 42.9 mm
Rho       = Calculated Parameter                                      = 3.377
Beta      = Calulcated Parameter                                      = 70918.0591
Alpha'    = Alpha where treq'd is minimum                             = 1
Tc        = Required thickness to develop load w/no prying            = 0.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                          = 0
Q         = Prying Force per bolt                                     = 0 N
Treq'd    = Required Flange Thickness                                 = 0.1 mm
Ratio     = Treqd / Tf                                                = 0.002
```

Structural Flange Analysis, Angle = 10 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 10 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                          = 0.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -4 N
S         = Shear Load on Flange                                      = 24 N

Ds        = Outer Diameter of Shell                                   = 323.8 mm
Do        = Outside Diameter of Flange                                = 482.6 mm
Dbc       = Bolt Circle Diameter                                      = 431.8 mm
Tf        = Thickness of Flange                                       = 31.8 mm
Tw        = Fillet Weld Size                                          = 6.0 mm

Db        = Nominal Bolt Diameter                                     = 22.2 mm
Nb        = Number of Bolts                                           = 12
Fu        = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu              = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb        = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys       = Yield Stress of Shell                                     = 215.81 MPa
Fw        = Tensile Stress of Weld                                    = 413.68 MPa
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                = 194.22 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa
```

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```
Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                  = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters               = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                                = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                           = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N        = 0 N
Ab        = Nominal Area of Bolt                                           = 3.879 sq cm
Km        = Stiffness of Material                                          = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                              = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)         = 0.173
Fby       = Bolt Yield Stress                                              = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                   = 761869.3
KPa
Aroot     = Bolt Root Area                                                 = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}               = 123659 N
K         = Coefficient of Thread Friction                                 = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                        = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                       = 0 N
Fact      = Actual force on bolt                                           = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact     = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi           = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                     = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                     = 144440 N
Ratio     = Fb / Fbcomb                                                    = 0.856

Sh        = Shear on Bolt                                                  = 2 N
Sallow    = Allowable Shear on Bolt                                        = 92281 N
Ratio     = Sh / Sallow                                                    = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                             = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                               = 22621.48
cm^4
Aw        = Area of Weld                                                   = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                             = 1.7 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                    = 124.11 MPa
Ratio     = Fba / Sw                                                       = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                   = 87.6 mm
Lg        = Gross Flange area for each bolt                                = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                     = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                      = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                               = 54.0 mm
A         = Distance from Bolt CL to Flange OD                             = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                     = 42.9 mm
Rho       = Calculated Parameter                                           = 3.377
Beta      = Calulcated Parameter                                           = 169521.3588
```

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```
Alpha'    = Alpha where treq'd is minimum                          = 1
Tc        = Required thickness to develop load w/no prying         = 0.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 0.0 mm
Ratio     = Treqd / Tf                                             = 0.002
```

Structural Flange Analysis, Angle = 20 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 20 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 0.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -8 N
S         = Shear Load on Flange                                   = 23 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa

Fys       = Yield Stress of Shell                                  = 215.81 MPa
Fw        = Tensile Stress of Weld                                 = 413.68 MPa
Fyc       = Yield Stress of Flange                                 = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy             = 194.22 MPa
E         = Modulus of Elasticity of Flange                        = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt         = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters       = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                        = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                   = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                   = 3.879 sq cm
Km        = Stiffness of Material                                  = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                      = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)  = 0.173
Fby       = Bolt Yield Stress                                      = 896316.8
KPa
```

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```
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 0 N
Fact      = Actual force on bolt                                          = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144440 N
Ratio     = Fb / Fbcomb                                                   = 0.856

Sh        = Shear on Bolt                                                 = 2 N
Sallow    = Allowable Shear on Bolt                                       = 92281 N
Ratio     = Sh / Sallow                                                   = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw        = Area of Weld                                                  = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                            = 2.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                   = 124.11 MPa
Ratio     = Fba / Sw                                                      = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                  = 87.6 mm
Lg        = Gross Flange area for each bolt                               = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                    = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                     = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                              = 54.0 mm
A         = Distance from Bolt CL to Flange OD                            = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                    = 42.9 mm
Rho       = Calculated Parameter                                          = 3.377
Beta      = Calulcated Parameter                                          = 0
Alpha'    = Alpha where treq'd is minimum                                 = 0
Tc        = Required thickness to develop load w/no prying                = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                              = 0
Q         = Prying Force per bolt                                         = 0 N
Treq'd    = Required Flange Thickness                                     = 0.0 mm
Ratio     = Treqd / Tf                                                    = 0.000
```

Structural Flange Analysis, Angle = 30 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 30 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                              = 0.7 N-m
V         = Vertical Load on Flange (- is compression, + is tension)      = -12 N
S         = Shear Load on Flange                                          = 22 N
```

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```
Ds        = Outer Diameter of Shell                                  = 323.8 mm
Do        = Outside Diameter of Flange                               = 482.6 mm
Dbc       = Bolt Circle Diameter                                     = 431.8 mm
Tf        = Thickness of Flange                                      = 31.8 mm
Tw        = Fillet Weld Size                                         = 6.0 mm

Db        = Nominal Bolt Diameter                                    = 22.2 mm
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu             = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy               = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 0 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.856

Sh        = Shear on Bolt                                            = 2 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.000
```

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```
Check Welding
Iw        = Bending Moment of Inertia for Weld                          = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                            = 22621.48
cm^4
Aw        = Area of Weld                                                = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                          = 2.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                 = 124.11 MPa
Ratio     = Fba / Sw                                                    = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 40 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 40 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 0.6 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -16 N
S         = Shear Load on Flange                                        = 19 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
```

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```
Fyc       = Yield Stress of Flange                                  = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy              = 194.22 MPa
E         = Modulus of Elasticity of Flange                         = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt          = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters        = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                         = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                    = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N = 0 N
Ab        = Nominal Area of Bolt                                    = 3.879 sq cm
Km        = Stiffness of Material                                   = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                       = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)  = 0.173
Fby       = Bolt Yield Stress                                       = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                            = 761869.3
KPa
Aroot     = Bolt Root Area                                          = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}        = 123659 N
K         = Coefficient of Thread Friction                          = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                 = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                = 0 N
Fact      = Actual force on bolt                                    = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi    = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)              = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)              = 144440 N
Ratio     = Fb / Fbcomb                                             = 0.856

Sh        = Shear on Bolt                                           = 2 N
Sallow    = Allowable Shear on Bolt                                 = 92281 N
Ratio     = Sh / Sallow                                             = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                      = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                        = 22621.48
cm^4
Aw        = Area of Weld                                            = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                      = 2.7 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw             = 124.11 MPa
Ratio     = Fba / Sw                                                = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                            = 87.6 mm
Lg        = Gross Flange area for each bolt                         = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area              = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge               = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                        = 54.0 mm
```

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```
A          = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho        = Calculated Parameter                                        = 3.377
Beta       = Calulcated Parameter                                        = 0
Alpha'     = Alpha where treq'd is minimum                               = 0
Tc         = Required thickness to develop load w/no prying              = 0.0 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                            = 0
Q          = Prying Force per bolt                                       = 0 N
Treq'd     = Required Flange Thickness                                   = 0.0 mm
Ratio      = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 50 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 50 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M          = Moment on Flange                                            = 0.5 N-m
V          = Vertical Load on Flange (- is compression, + is tension)    = -19 N
S          = Shear Load on Flange                                        = 16 N

Ds         = Outer Diameter of Shell                                     = 323.8 mm
Do         = Outside Diameter of Flange                                  = 482.6 mm
Dbc        = Bolt Circle Diameter                                        = 431.8 mm
Tf         = Thickness of Flange                                         = 31.8 mm
Tw         = Fillet Weld Size                                            = 6.0 mm

Db         = Nominal Bolt Diameter                                       = 22.2 mm
Nb         = Number of Bolts                                             = 12
Fu         = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb         = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys        = Yield Stress of Shell                                       = 215.81 MPa
Fw         = Tensile Stress of Weld                                      = 413.68 MPa
Fyc        = Yield Stress of Flange                                      = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E          = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 0 N
Ab         = Nominal Area of Bolt                                        = 3.879 sq cm
Km         = Stiffness of Material                                       = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                           = 1238416.78
N/mm
```

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```
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)          = 0.173
Fby       = Bolt Yield Stress                                               = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                    = 761869.3
KPa
Aroot     = Bolt Root Area                                                  = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}                = 123659 N
K         = Coefficient of Thread Friction                                  = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                         = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                        = 0 N
Fact      = Actual force on bolt                                            = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact      = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi            = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                      = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                      = 144440 N
Ratio     = Fb / Fbcomb                                                     = 0.856

Sh        = Shear on Bolt                                                   = 1 N
Sallow    = Allowable Shear on Bolt                                         = 92281 N
Ratio     = Sh / Sallow                                                     = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                              = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                                = 22621.48
cm^4
Aw        = Area of Weld                                                    = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                              = 3.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                     = 124.11 MPa
Ratio     = Fba / Sw                                                        = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                    = 87.6 mm
Lg        = Gross Flange area for each bolt                                 = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                      = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                       = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                                = 54.0 mm
A         = Distance from Bolt CL to Flange OD                              = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                      = 42.9 mm
Rho       = Calculated Parameter                                            = 3.377
Beta      = Calulcated Parameter                                            = 0
Alpha'    = Alpha where treq'd is minimum                                   = 0
Tc        = Required thickness to develop load w/no prying                  = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                                = 0
Q         = Prying Force per bolt                                           = 0 N
Treq'd    = Required Flange Thickness                                       = 0.0 mm
Ratio     = Treqd / Tf                                                      = 0.000
```

Structural Flange Analysis, Angle = 60 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 60 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

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```
M          = Moment on Flange                                              = 0.4 N-m
V          = Vertical Load on Flange (- is compression, + is tension)      = -21 N
S          = Shear Load on Flange                                          = 12 N

Ds         = Outer Diameter of Shell                                       = 323.8 mm
Do         = Outside Diameter of Flange                                    = 482.6 mm
Dbc        = Bolt Circle Diameter                                          = 431.8 mm
Tf         = Thickness of Flange                                           = 31.8 mm
Tw         = Fillet Weld Size                                              = 6.0 mm

Db         = Nominal Bolt Diameter                                         = 22.2 mm
Nb         = Number of Bolts                                               = 12
Fu         = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                  = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb         = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys        = Yield Stress of Shell                                         = 215.81 MPa
Fw         = Tensile Stress of Weld                                        = 413.68 MPa
Fyc        = Yield Stress of Flange                                        = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E          = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 0 N
Ab         = Nominal Area of Bolt                                          = 3.879 sq cm
Km         = Stiffness of Material                                         = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                             = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby        = Bolt Yield Stress                                             = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 0 N
Fact       = Actual force on bolt                                          = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.000

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 123659 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144440 N
Ratio      = Fb / Fbcomb                                                   = 0.856
```

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```
Sh        = Shear on Bolt                                          = 1 N
Sallow    = Allowable Shear on Bolt                                = 92281 N
Ratio     = Sh / Sallow                                            = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                     = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                       = 22621.48
cm^4
Aw        = Area of Weld                                           = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                     = 3.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw            = 124.11 MPa
Ratio     = Fba / Sw                                               = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                           = 87.6 mm
Lg        = Gross Flange area for each bolt                        = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area             = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge              = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                       = 54.0 mm
A         = Distance from Bolt CL to Flange OD                     = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole             = 42.9 mm
Rho       = Calculated Parameter                                   = 3.377
Beta      = Calulcated Parameter                                   = 0
Alpha'    = Alpha where treq'd is minimum                          = 0
Tc        = Required thickness to develop load w/no prying         = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 0.0 mm
Ratio     = Treqd / Tf                                             = 0.000
```

Structural Flange Analysis, Angle = 70 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 70 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 0.3 N-m
V         = Vertical Load on Flange (- is compression, + is tension) = -23 N
S         = Shear Load on Flange                                   = 8 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa
```

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```
Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 0 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.856

Sh        = Shear on Bolt                                            = 1 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw        = Area of Weld                                             = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                       = 3.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw              = 124.11 MPa
Ratio     = Fba / Sw                                                 = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                             = 87.6 mm
Lg        = Gross Flange area for each bolt                          = 113.0 mm
```

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```
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 80 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 80 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 0.1 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -24 N
S         = Shear Load on Flange                                        = 4 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 0 N
Ab        = Nominal Area of Bolt                                        = 3.879 sq cm
```

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```
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 0 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.856

Sh        = Shear on Bolt                                            = 0 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw        = Area of Weld                                             = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                       = 3.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw              = 124.11 MPa
Ratio     = Fba / Sw                                                 = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                             = 87.6 mm
Lg        = Gross Flange area for each bolt                          = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area               = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                         = 54.0 mm
A         = Distance from Bolt CL to Flange OD                       = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole               = 42.9 mm
Rho       = Calculated Parameter                                     = 3.377
Beta      = Calulcated Parameter                                     = 0
Alpha'    = Alpha where treq'd is minimum                            = 0
Tc        = Required thickness to develop load w/no prying           = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                         = 0
Q         = Prying Force per bolt                                    = 0 N
Treq'd    = Required Flange Thickness                                = 0.0 mm
Ratio     = Treqd / Tf                                               = 0.000
```

Structural Flange Analysis, Angle = 90 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 90 Deg , Load # 4

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Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 0.0 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -25 N
S	= Shear Load on Flange	= 0 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 0 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 0 N
Fact	= Actual force on bolt	= 91479 N
Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.000
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 123659 N

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```
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                  = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                  = 144440 N
Ratio     = Fb / Fbcomb                                                 = 0.856

Sh        = Shear on Bolt                                               = 0 N
Sallow    = Allowable Shear on Bolt                                     = 92281 N
Ratio     = Sh / Sallow                                                 = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                          = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                            = 22621.48
cm^4
Aw        = Area of Weld                                                = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                          = 2.9 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                 = 124.11 MPa
Ratio     = Fba / Sw                                                    = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Conical Transition Analysis, Angle = 0 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65

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```
M:     Overturning Moment (KN-m)                          0.08        0.00
0.61
V:     Vertical Axial Loading (KN)                        0.00        0.00
0.00
Sx:    Section Modulus (cm^3)                            750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                      98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.00        0.00
0.00
fb:    Bending Strss - M/Sx (MPa)                         0.11        0.11
0.32
fb':   Localized Bending Stress (MPa)                     0.12        0.12
0.46
fh':   Hoop Stress (MPa)                                  0.07        0.00
0.24
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.11        0.11
0.32
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.23        0.23
0.78
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
```

```
OD:    Outer Diameter (mm)                              508.0         0.0
1066.8
T:     Thickness (mm)                                    10.0        10.0
10.0
Fys:   Yield Stress (MPa)                               220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                   202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                     117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                             412.65      412.65
412.65

M:     Overturning Moment (KN-m)                         40.26        0.00
44.25
V:     Vertical Axial Loading (KN)                        0.00        0.00
0.00
Sx:    Section Modulus (cm^3)                          1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                    156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.00        0.00
0.00
fb:    Bending Strss - M/Sx (MPa)                        21.07       21.88
5.09
fb':   Localized Bending Stress (MPa)                    35.61       35.61
12.47
fh':   Hoop Stress (MPa)                                 18.88        0.00
6.61
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              21.07       21.88
5.09
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        56.68       57.49
17.56
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.159	PASS	0.165	PASS	0.043	PASS
Check 2: Stot1 / Ft	0.137	PASS	0.139	PASS	0.043	PASS
Check 3: fh' < Fh	0.171	PASS	0.000	PASS	0.066	PASS

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Stiff Ring Req'd? 0.171 Not Req'd 0.165 Cone OK 0.066 Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 10 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.08	0.00	0.60
V:	Vertical Axial Loading (KN)	0.17	0.00	0.28
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.02	0.02	0.02
fb:	Bending Strss - M/Sx (MPa)	0.10	0.11	0.31
fb':	Localized Bending Stress (MPa)	0.14	0.14	0.48
fh':	Hoop Stress (MPa)	0.07	0.00	0.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.12	0.13	0.33

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```
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)              0.26        0.27
0.81
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                       132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                               110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       41.12        0.00
45.40
V:     Vertical Axial Loading (KN)                      1.19        0.00
0.59
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                  156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.08        0.08
0.02
fb:    Bending Strss - M/Sx (MPa)                      21.52       22.35
5.22
fb':   Localized Bending Stress (MPa)                  36.50       36.50
12.84
fh':   Hoop Stress (MPa)                               19.36        0.00
6.81
```

```
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               21.60       22.43
5.24
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         58.10       58.92
18.08
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.163	PASS	0.169	PASS	0.044	PASS
Check 2: Stot1 / Ft	0.141	PASS	0.143	PASS	0.044	PASS
Check 3: fh' < Fh	0.175	PASS	0.000	PASS	0.068	PASS
Stiff Ring Req'd?	0.175	Not Req'd	0.169	Cone OK	0.068	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 20 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.07        0.00
0.57
V:     Vertical Axial Loading (KN)                    0.33        0.00
0.55
```

```
Sx:    Section Modulus (cm^3)                          750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                    98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.03        0.03
0.04
fb:    Bending Strss - M/Sx (MPa)                        0.10        0.10
0.30
fb':   Localized Bending Stress (MPa)                    0.15        0.15
0.48
fh':   Hoop Stress (MPa)                                 0.08        0.00
0.26
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               0.13        0.14
0.33
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         0.29        0.29
0.82
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
```

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```
E:     Modulus of Elasticity (MPa)                    202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                      117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                              412.65      412.65
412.65

M:     Overturning Moment (KN-m)                          40.69        0.00
45.12
V:     Vertical Axial Loading (KN)                         2.47        0.00
1.29
Sx:    Section Modulus (cm^3)                           1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                      156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.16        0.16
0.04
fb:    Bending Strss - M/Sx (MPa)                         21.30       22.12
5.19
fb':   Localized Bending Stress (MPa)                     36.26       36.26
12.81
fh':   Hoop Stress (MPa)                                  19.23        0.00
6.79
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                     1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                     2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                21.46       22.28
5.23
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          57.72       58.54
18.04
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.162	PASS	0.168	PASS	0.044	PASS
Check 2: Stot1 / Ft	0.140	PASS	0.142	PASS	0.044	PASS
Check 3: fh' < Fh	0.174	PASS	0.000	PASS	0.068	PASS
Stiff Ring Req'd?	0.174	Not Req'd	0.168	Cone OK	0.068	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 30 Deg

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Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.07	0.00	0.53
V:	Vertical Axial Loading (KN)	0.48	0.00	0.80
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.05	0.05	0.05
fb:	Bending Strss - M/Sx (MPa)	0.09	0.09	0.28
fb':	Localized Bending Stress (MPa)	0.16	0.16	0.47
fh':	Hoop Stress (MPa)	0.09	0.00	0.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.14	0.14	0.33
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	0.30	0.31	0.80
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

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Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	38.98	0.00	43.42
V:	Vertical Axial Loading (KN)	3.81	0.00	2.09
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.24	0.25	0.06
fb:	Bending Strss - M/Sx (MPa)	20.41	21.19	5.00
fb':	Localized Bending Stress (MPa)	34.90	34.90	12.39
fh':	Hoop Stress (MPa)	18.51	0.00	6.57
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)             20.65       21.44
5.06
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       55.55       56.34
17.45
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.156	PASS	0.162	PASS	0.042	PASS
Check 2: Stot1 / Ft	0.135	PASS	0.137	PASS	0.042	PASS
Check 3: fh' < Fh	0.168	PASS	0.000	PASS	0.065	PASS
Stiff Ring Req'd?	0.168	Not Req'd	0.162	Cone OK	0.065	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 40 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.06        0.00
0.47
V:     Vertical Axial Loading (KN)                    0.62        0.00
1.03
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.06        0.06
0.07
```

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```
fb:    Bending Strss - M/Sx (MPa)                          0.08        0.08
0.24
fb':   Localized Bending Stress (MPa)                      0.17        0.17
0.45
fh':   Hoop Stress (MPa)                                   0.09        0.00
0.24
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                     2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                     3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                 0.14        0.15
0.31
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)           0.31        0.31
0.76
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65
```

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```
M:     Overturning Moment (KN-m)                          36.04        0.00
40.33
V:     Vertical Axial Loading (KN)                         5.21        0.00
3.00
Sx:    Section Modulus (cm^3)                           1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                     156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.33        0.35
0.09
fb:    Bending Strss - M/Sx (MPa)                         18.87       19.59
4.64
fb':   Localized Bending Stress (MPa)                     32.45       32.45
11.59
fh':   Hoop Stress (MPa)                                  17.21        0.00
6.14
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               19.20       19.94
4.73
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         51.65       52.38
16.32
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.145	PASS	0.151	PASS	0.040	PASS
Check 2: Stot1 / Ft	0.125	PASS	0.127	PASS	0.040	PASS
Check 3: fh' < Fh	0.156	PASS	0.000	PASS	0.061	PASS
Stiff Ring Req'd?	0.156	Not Req'd	0.151	Cone OK	0.061	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 50 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
```

```
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.05        0.00
0.39
V:     Vertical Axial Loading (KN)                    0.74        0.00
1.23
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.07        0.08
0.08
fb:    Bending Strss - M/Sx (MPa)                     0.07        0.07
0.20
fb':   Localized Bending Stress (MPa)                 0.17        0.17
0.41
fh':   Hoop Stress (MPa)                              0.09        0.00
0.22
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)               2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                        220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                 110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                        220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)            0.14        0.15
0.28
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)      0.31        0.31
0.69
Fb:    Allow Bend (ASD): .6*Fxc (MPa)               132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                       110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS

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Stiff Ring Req'd? 0.001 Not Req'd 0.001 Cone OK 0.002 Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	31.94	0.00	35.94
V:	Vertical Axial Loading (KN)	6.68	0.00	4.05
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.43	0.44	0.12
fb:	Bending Strss - M/Sx (MPa)	16.72	17.36	4.14
fb':	Localized Bending Stress (MPa)	28.97	28.97	10.42
fh':	Hoop Stress (MPa)	15.37	0.00	5.53
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	17.15	17.80	4.26
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	46.12	46.78	14.68

```
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.130	PASS	0.134	PASS	0.036	PASS
Check 2: Stot1 / Ft	0.112	PASS	0.113	PASS	0.036	PASS
Check 3: fh' < Fh	0.139	PASS	0.000	PASS	0.055	PASS
Stiff Ring Req'd?	0.139	Not Req'd	0.134	Cone OK	0.055	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 60 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                        0.04        0.00
0.30
V:     Vertical Axial Loading (KN)                      0.83        0.00
1.39
Sx:    Section Modulus (cm^3)                          750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                    98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.08        0.09
0.09
fb:    Bending Strss - M/Sx (MPa)                       0.05        0.05
0.16
fb':   Localized Bending Stress (MPa)                   0.16        0.16
0.36
fh':   Hoop Stress (MPa)                                0.08        0.00
0.19
```

```
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.14        0.14
0.25
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.30        0.30
0.61
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     26.75        0.00
30.31
V:     Vertical Axial Loading (KN)                    8.33        0.00
5.35
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
```

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```
Ax:    Cross Sectional Area (sq cm)                    156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.53        0.55
0.16
fb:    Bending Strss - M/Sx (MPa)                       14.00       14.54
3.49
fb':   Localized Bending Stress (MPa)                   24.56       24.56
8.94
fh':   Hoop Stress (MPa)                                13.03        0.00
4.74
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              14.54       15.09
3.65
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        39.10       39.66
12.59
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.110	PASS	0.114	PASS	0.031	PASS
Check 2: Stot1 / Ft	0.095	PASS	0.096	PASS	0.030	PASS
Check 3: fh' < Fh	0.118	PASS	0.000	PASS	0.047	PASS
Stiff Ring Req'd?	0.118	Not Req'd	0.114	Cone OK	0.047	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 70 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
```

```
E:     Modulus of Elasticity (MPa)                    202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                      117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                              412.65      412.65
412.65

M:     Overturning Moment (KN-m)                           0.03        0.00
0.21
V:     Vertical Axial Loading (KN)                         0.91        0.00
1.51
Sx:    Section Modulus (cm^3)                             750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                       98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.09        0.09
0.10
fb:    Bending Strss - M/Sx (MPa)                          0.04        0.04
0.11
fb':   Localized Bending Stress (MPa)                      0.15        0.15
0.30
fh':   Hoop Stress (MPa)                                   0.08        0.00
0.16
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                     2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                     3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                 0.13        0.13
0.21
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)           0.28        0.28
0.50
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 70 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	20.53	0.00	23.49
V:	Vertical Axial Loading (KN)	10.49	0.00	7.25
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.67	0.70	0.22
fb:	Bending Strss - M/Sx (MPa)	10.75	11.16	2.70
fb':	Localized Bending Stress (MPa)	19.29	19.29	7.15
fh':	Hoop Stress (MPa)	10.23	0.00	3.79
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	11.42	11.85	2.92
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	30.71	31.15	10.08
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.086	PASS	0.090	PASS	0.024	PASS
Check 2: Stot1 / Ft	0.074	PASS	0.075	PASS	0.024	PASS
Check 3: fh' < Fh	0.093	PASS	0.000	PASS	0.038	PASS
Stiff Ring Req'd?	0.093	Not Req'd	0.090	Cone OK	0.038	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 80 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.01	0.00	0.11
V:	Vertical Axial Loading (KN)	0.95	0.00	1.58
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.10	0.10	0.10
fb:	Bending Strss - M/Sx (MPa)	0.02	0.02	0.06
fb':	Localized Bending Stress (MPa)	0.13	0.13	0.23
fh':	Hoop Stress (MPa)	0.07	0.00	0.12
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)              0.11        0.12
0.16
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        0.25        0.25
0.38
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.001	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.001	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     13.04        0.00
15.16
V:     Vertical Axial Loading (KN)                   14.49        0.00
11.10
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                     0.93        0.96
0.33
fb:    Bending Strss - M/Sx (MPa)                    6.83        7.09
1.74
```

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```
fb':   Localized Bending Stress (MPa)                    13.10       13.10
5.09
fh':   Hoop Stress (MPa)                                  6.95        0.00
2.70
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                7.75        8.05
2.08
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          20.85       21.15
7.17
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.059	PASS	0.061	PASS	0.017	PASS
Check 2: Stot1 / Ft	0.051	PASS	0.051	PASS	0.017	PASS
Check 3: fh' < Fh	0.063	PASS	0.000	PASS	0.027	PASS
Stiff Ring Req'd?	0.063	Not Req'd	0.061	Cone OK	0.027	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 90 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65
```

```
M:     Overturning Moment (KN-m)                          0.00        0.00
0.00
V:     Vertical Axial Loading (KN)                        0.96        0.00
1.60
Sx:    Section Modulus (cm^3)                            750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                      98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.10        0.10
0.10
fb:    Bending Strss - M/Sx (MPa)                         0.00        0.00
0.00
fb':   Localized Bending Stress (MPa)                     0.11        0.11
0.15
fh':   Hoop Stress (MPa)                                  0.06        0.00
0.08
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.10        0.10
0.10
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.21        0.21
0.25
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.001	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.001	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
```

```
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.00        0.00
0.00
V:     Vertical Axial Loading (KN)                   35.49        0.00
32.04
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                 156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                     2.27        2.36
0.97
fb:    Bending Strss - M/Sx (MPa)                    0.00        0.00
0.00
fb':   Localized Bending Stress (MPa)                3.83        3.83
2.36
fh':   Hoop Stress (MPa)                             2.03        0.00
1.25
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)               1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                       220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)               2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                       220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)           2.27        2.36
0.97
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)     6.10        6.19
3.33
Fb:    Allow Bend (ASD): .6*Fxc (MPa)              132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                      110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.017	PASS	0.018	PASS	0.008	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.008	PASS
Check 3: fh' < Fh	0.018	PASS	0.000	PASS	0.012	PASS
Stiff Ring Req'd?	0.018	Not Req'd	0.018	Cone OK	0.012	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Stack Deflection Lift Angle = 0 Deg
Load Combination Dead Weight

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
11.500	0.0	0.5	0.0	0.5	4.0	0.120	Pass
11.467	0.0	0.5	0.0	0.5	3.8	0.120	Pass
11.385	0.0	0.4	0.0	0.4	3.4	0.120	Pass
11.257	0.0	0.3	0.0	0.3	2.8	0.120	Pass
11.128	0.0	0.3	0.0	0.3	2.1	0.121	Pass
11.000	0.0	0.2	0.0	0.2	1.5	0.121	Pass
10.699	0.0	0.0	0.0	0.0	52.7	0.000	Pass
10.400	0.0	-0.2	0.0	0.2	52.7	0.003	Pass
8.400	0.0	-1.2	0.0	1.2	52.7	0.023	Pass
7.667	0.0	-1.5	0.0	1.5	52.7	0.028	Pass
6.456	0.0	-1.6	0.0	1.6	52.7	0.030	Pass
6.123	0.0	-1.6	0.0	1.6	52.7	0.030	Pass
5.789	0.0	-1.5	0.0	1.5	52.7	0.028	Pass
5.456	0.0	-1.4	0.0	1.4	52.7	0.027	Pass
5.137	0.0	-1.4	0.0	1.4	52.7	0.026	Pass
5.000	0.0	-1.3	0.0	1.3	52.7	0.026	Pass
4.863	0.0	-1.3	0.0	1.3	52.7	0.025	Pass
3.100	0.0	-0.9	0.0	0.9	52.7	0.017	Pass
2.450	0.0	-0.7	0.0	0.7	52.7	0.013	Pass
1.385	0.0	-0.4	0.0	0.4	52.7	0.007	Pass
1.275	0.0	-0.4	0.0	0.4	52.7	0.007	Pass
1.165	0.0	-0.3	0.0	0.3	52.7	0.006	Pass
0.950	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
0.350	0.0	-0.1	0.0	0.1	52.7	0.001	Pass
0.305	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.153	0.0	0.0	0.0	0.0	52.7	0.000	Pass
0.000	0.0	0.0	0.0	0.0	0.8	0.063	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dy^2 + Dz^2)
Ratio = Dres / Limit

Lifting Reactions Summary - Dead Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	13924	19324
10.0	14158	19089
20.0	14402	18846
30.0	14671	18576
40.0	14991	18256
50.0	15406	17842
60.0	16005	17243
70.0	17029	16218
80.0	19398	13850
90.0	33248	0

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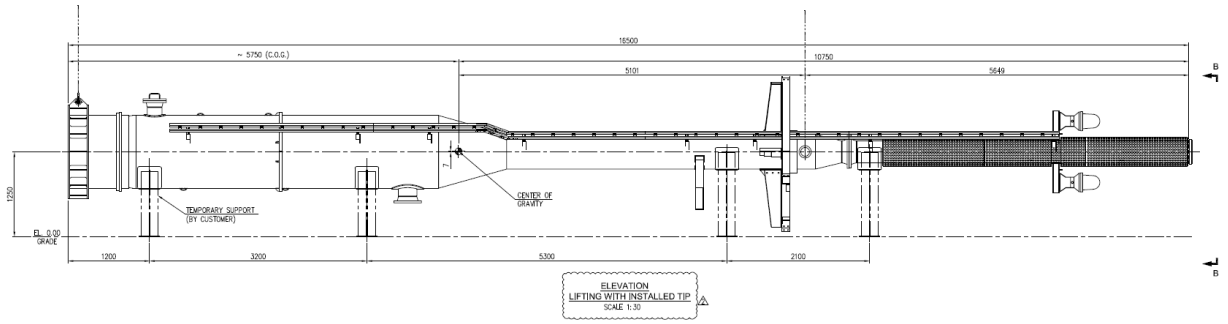
Lifting Reactions Summary - Dead + Impact Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

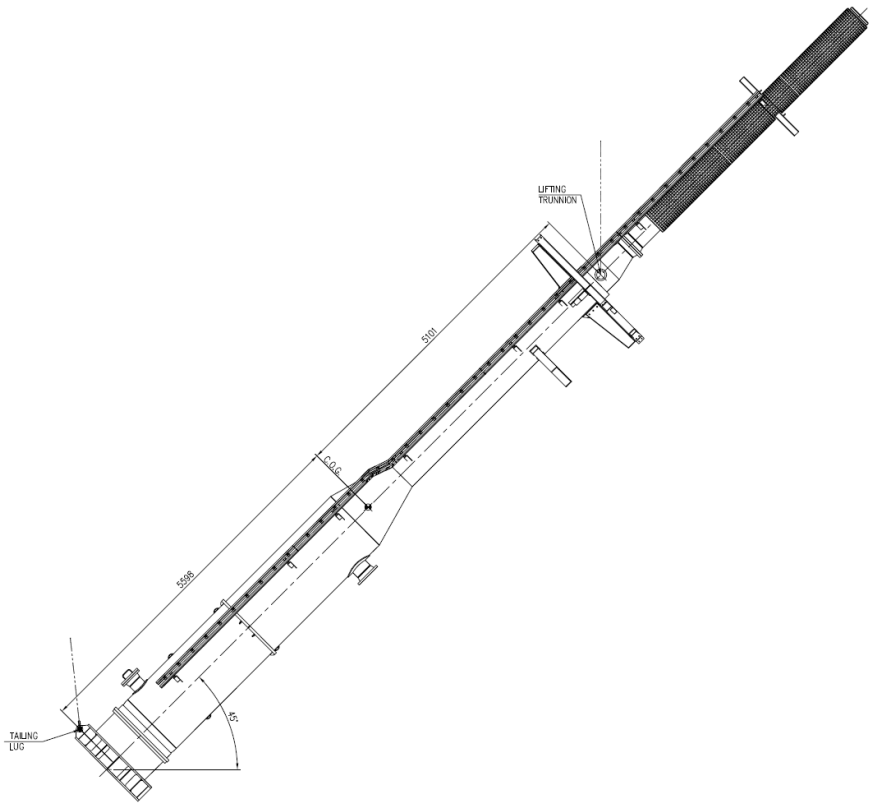
Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	20885	28986
10.0	21237	28634
20.0	21602	28269
30.0	22007	27865
40.0	22487	27384
50.0	23108	26763
60.0	24008	25864
70.0	25544	24328
80.0	29097	20775
90.0	49871	0

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C- LIFTING ANALYSIS CONFIGURATION WITH INSTALLED TIP

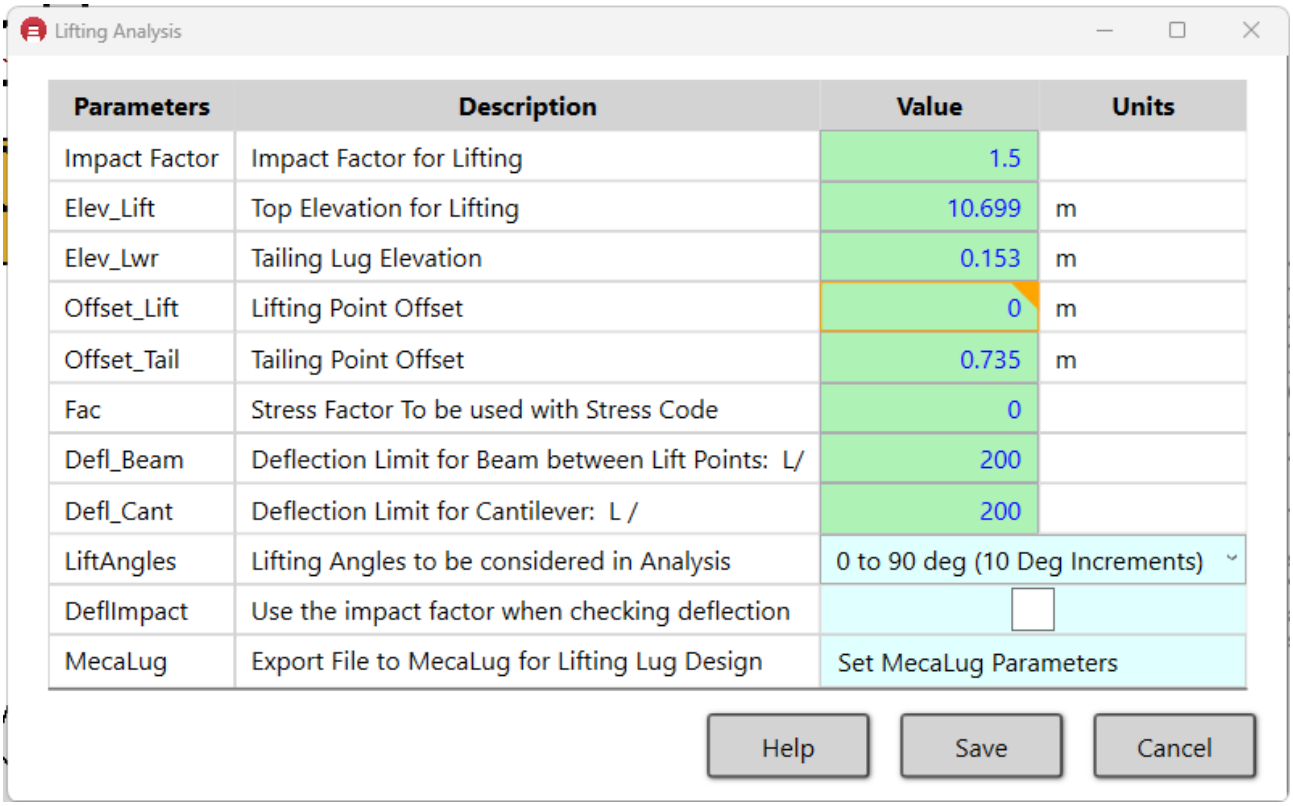
The configuration for the lifting is shown here after.





Differently than what analyzed in the annex D, here the tip will be installed before lifting.

A specialized model has been developed to analyze the lifting phases. For safety, the top platform is assumed to be fully assembled during the lift. In practice, some components will be added later to avoid potential conflicts with the lifting hardware.



Parameters	Description	Value	Units
Impact Factor	Impact Factor for Lifting	1.5	
Elev_Lift	Top Elevation for Lifting	10.699	m
Elev_Lwr	Tailing Lug Elevation	0.153	m
Offset_Lift	Lifting Point Offset	0	m
Offset_Tail	Tailing Point Offset	0.735	m
Fac	Stress Factor To be used with Stress Code	0	
Defl_Beam	Deflection Limit for Beam between Lift Points: L/	200	
Defl_Cant	Deflection Limit for Cantilever: L /	200	
LiftAngles	Lifting Angles to be considered in Analysis	0 to 90 deg (10 Deg Increments)	
DeflImpact	Use the impact factor when checking deflection	☐	
MecaLug	Export File to MecaLug for Lifting Lug Design	Set MecaLug Parameters	

MecaStack v5630

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Calculations Prepared by:
Date: Dec 04, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Vent Cross wind-20241204-00.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height = 16.50 m Top of Stack Elevation = 16.5 m

Grade Elevation = 0.00 m Bottom of Stack = 0.0 m

All elevations are based upon the bottom of stack being at 0 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
16.5	0.3238	16.5	6.0	16.5	0.0
11.385	0.3238	11.5	10.0	11.5	3.0
11.0	0.5080			0.305	0.0
6.456	0.5080				
5.456	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
16.5	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		-10.00	206.84	195121	1.53E-05	137.89	8000	517.11
11.5	A-516-60	80.00	204.66	199333	1.20E-05	117.90	7849	413.68
		-10.00	220.63	202705	1.15E-05	117.90	7849	413.68
0.446	S275J0	80.00	239.00	207692	1.20E-05	101.79	7849	356.33
		-10.00	275.00	210000	1.20E-05	117.14	7849	410.03

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
11.500	8.400	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	2.450	0.950	0.0000	758.00	Oper
External insulation	3.100	0.350	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	0.950	0.000	200.0	Dead

Nozzles:

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Num	Description	Elevation	Nominal Diameter	Schedule	Outer Diameter	Thickness	Tilt	Orien-tation	Proj-ection
		m			mm	mm	Deg	Deg	mm
1	1N	5.000	10 inch [254.0 mm]	Std	273.1	9.3	0.0	180.0	200.0
2	HW	1.275	8 inch [203.2 mm]	Std	219.1	8.2	0.0	0.0	200.0

Num	Description	Repad Width	Repad Thickness	Flange Spec	Flange Radial Width	Flange Thickness	Nozzle Loads
		mm	mm		mm	mm	
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx	Fy	Fz	Mx	My	Mz	Local/ Global	Load Applied	Load Type	Check WRC 107
		KN	KN	KN	KN-m	KN-m	KN-m				
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC	FyC	FzC	MxC	MyC	MzC	|	Ver	Shear	Mom	Mbase
			KN	KN	KN	KN-m	KN-m	KN-m	|	KN	KN	KN-m	KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	|	14.46	16.42	7.89	89.99

Equivalent Nozzle Loads Applied on Stack:
Ver = Stack Vertical Load considered at Nozzle Elev: Fy
Shear = Stack Shear Load considered at Nozzle Elev: [Fx^2+Fz^2]^0.5
Mom = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
Mbase = Est Mom at base if no Support: Mom + Shear*Elev
Provided only to evaluate the impact of the load on overall stack

Helical Strakes: (3 Vanes 120 deg apart assumed)

ElTop	= Top Strake Elevation	= 16.5 m
ElBot	= Bottom Strake Elevation	= 11.0 m
Pitch	= Strake Pitch (One complete wrap)	= 1.6190 m
Width	= Strake Width	= 32.4 mm
Thick	= Strake Thickness	= 3.2 mm
OD	= Outer Diameter of Stack and Insulation (If Applicable)	= 323.8 mm
ShapeFac	= Strake Shape Factor (Applied to bare stack shell)	= 1.40
SO	= Stand-off from OD of shell to strake	= 0.0 mm
Len	= Pitch Length: [(PI*(OD+2*SO+2*Width))^2+(Pitch^2)]^0.5	= 2.028 m

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Area      = Total Painted Area (3 vanes): (2*Width*Len*3*Wraps)            = 92.932 sq
cm
Wraps     = Total Number of Wraps (Top elev - Bot elev)/ Pitch             = 3.40
WtUni     = Estimated Linear Weight of Strakes and Clips: Wt/(ElTop-ElBot) = 4.54 kg/m
Wt        = Estimated total Wt of Strakes and Clips: 1.5*(Area/2)*Thick*Dens= 25.0 kg

Type      = Type of Baseplate                                              = Chair
                                                                             Continuous
Plate
SupType   = Type of Support                                                = Rigid Steel
Base
Friction  = Coefficient of Friction for Support                            = 0.300
BasisBolt = Basis for Bolt Design                                          = Brownell &
Young
Nbolt     = Number of Bolts                                                = 16
Dbolt     = Nominal Bolt Diameter                                          = 27.0 mm
Dbh       = Bolt Hole Diameter                                             = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                                    = 3.0 mm
CAplt     = Corrosion Allowance on Plates                                  = 0.0 mm
ID        = Inside Diameter of Baseplate                                   = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                              = 1270.0 mm
OD        = Outer Diameter of Baseplate                                    = 1385.0 mm
Tb        = Thickness of Bottom Plate                                      = 25.0 mm
Tt        = Thickness of Top Plate                                         = 25.0 mm
Fw        = Fillet Weld Size                                               = 5.0 mm
Fwu       = Weld Ultimate Tensile Strength                                 = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                                     = 1
Hg        = Height of Anchor Chair                                         = 305.0 mm
Tg        = Thickness of Gusset                                            = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                         = S275J0
Dens      = Material Density                                               = 7849 Kg/m^3
Temp      = Design Temperature                                             = 21.11 Deg C
Fy        = Minimum Yield Stress                                           = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                        = 410030.5
KPa
Sa        = Allowable Tensile Stress                                       = 117141.7
KPa
E         = Modulus of Elasticity                                          = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                               = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                                      = False
Matl      = Bolt Material Specification                                    = Gr. 8.8
Fu        = Ultimate Tensile Stress                                        = 800548.8
KPa
Fy        = Yield Stress                                                   = 640440.4
KPa
Fproof    = Proof Stress                                                   = 544374.4
KPa
Eb        = Modulus of Elasticity                                          = 202705497.9
KPa
```

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Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile                    = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                                    = 800.55 MPa
PreStress = Pretension Stress on Bolt                                       = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                        = Rectangular
Pt        = Plate Washer Thickness                                          = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                          = 90.0 mm
Pl        = Length of Washer Parallel to Shell                              = 100.0 mm
Pdh       = Bolt Hole Diameter                                              = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 11.44 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                         = 323.8 mm
Do        = Outside Diameter of Flange                                      = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange                    = 25.4 mm
Dbc       = Bolt Circle Diameter                                            = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle                     = 54.0 mm
Tf        = Thickness of Flange                                             = 31.8 mm
Tw        = Fillet Weld Size                                                = 6.0 mm
Gus       = Gussets                                                         = False
Db        = Nominal Bolt Diameter                                           = 22.2 mm
Nb        = Number of Bolts                                                 = 12
BMatl     = Bolt Material                                                   = Gr 8 (US)
Fu        = Ultimate Bolt Tensile Stress                                    = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                  = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                    = 60.00 %
Fw        = Tensile Stress of Weld                                          = 413.68 MPa
FMatl     = Flange Material                                                 = A-36
Fyf       = Yield Stress of Flange                                          = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                                 = 193742.33
MPa
```

Design Codes

```
Stress Criteria:  Eurocde 3 - Design of Steel structures:  Part 3-2: Towers, masts and
chimneys
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)       = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters         = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset                = False

Lifting Criteria:

Impact    = Impact Factor                                                   = 1.50
Lift_El   = Elevation of Lifting Point                                      = 10.699 m
UprOff    = Longitudinal Offset for Lifting Lug point from Lift Elev to Lift Eye= 0.0000
m
Tail_El   = Elevation of Tailing Point                                      = 0.153 m
LwrOff    = Radial Offset for Tailing Lug point from Ctr Line to Tail Pt    = 0.7350 m
SF        = Stress Factor of Safety                                         = 0.000
Defl_Beam = Deflection Limit between Lifting Points:  L /                   = 200.0
Defl_Cant = Deflection Limit for Cantilevers:         L /                   = 200.0
Defl_Impact= Consider Impact loading for deflection check?                   = False
```

Check Stack for 0 to 90 Deg in 10 Deg increments

Damping Criteria:

Structural Damping Criteria:
Criteria: ASME STS-1-2021
Stack Type: UnLined
Support: ELASTIC

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

Log Decrement Damping = 2 * PI * Bs

Aerodynamic Damping Criteria:
(Only used in Along wind analysis, Not considered for vortex shedding)

Criteria: EN 1994-1-4

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
16.500	13.452	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
13.452	11.500	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
11.500	11.467	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.467	11.385	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.385	11.257	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.257	11.128	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
11.128	11.000	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
11.000	10.699	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.699	10.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.400	8.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
8.400	6.456	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.456	6.123	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.123	5.789	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
5.789	5.456	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
5.456	5.137	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
5.137	5.000	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
5.000	4.863	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
4.863	3.100	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
3.100	2.450	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
2.450	1.385	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
1.385	1.275	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
1.275	1.165	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
1.165	0.950	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal

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0.950	0.446	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.446	0.350	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.350	0.305	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.305	0.153	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5
0.153	0.000	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	6

Section Props - If a number is shown, then the section contains something unusual (Breach, nozzle, stiffeners, etc..) and so the properties were calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0
6	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Weight Summary (Lifting)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	5.604	2458.5	24110
Ladders	9.950	69.2	679
Platforms	10.400	319.3	3132
Helical Strakes	13.750	25.0	245
Baseplate	0.127	389.0	3815
Structural Flange(s)	11.440	58.0	569
Nozzle(s)	3.537	53.2	521
General Attachment Uniform)	1.725	82.5	809
General Attachment Concentrated	0.950	200.0	1961
Total	5.299	3654.7	35841

Cylindrical Shells Wt: (Wt = 2458.5 kg, El COG = 5.604 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
16.500	11.500	14.000	0.3238	6.0	8000	239.6	47.92	239.6
11.500	11.385	11.443	0.3238	10.0	7849	6.3	77.38	8.9
11.385	11.000	11.193	0.4159	10.0	7849	27.2	100.09	38.5
11.000	6.456	8.728	0.5080	10.0	7849	393.0	122.80	558.0
6.456	5.456	5.956	0.7874	10.0	7849	134.7	191.69	191.7
5.456	0.446	2.951	1.0668	10.0	7849	916.5	260.59	1305.6
0.446	0.305	0.376	1.0668	10.0	7849	25.8	260.59	36.7
0.305	0.000	0.153	1.0668	10.0	7849	79.5	260.59	79.5

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Total	5.604					1822.5		2458.5

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 9.950 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	11.500	8.400	9.950	22.32	69.2
Total			9.950		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 10.400 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	10.400	319.3
Total					10.400	319.3

Helical Strakes Wt: (Wt = 25.0 kg, El COG = 13.750 m)

El Top m	El Bot m	El COG m	Lin Wt kg/m	TOt Wt kg
16.500	11.000	13.750	4.54	25.0
Total		13.750		25.0

Baseplate Wt: (Wt = 389.0 kg, El COG = 0.127 m)

Description	Elevation COG m	Weight kg
Bottom Plate	0.013	192.0
Top Plate	0.293	120.2
Gussets	0.153	61.1
Washers	0.153	15.6
Total	0.127	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 11.440 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
11.440	482.6	31.8	0.0	0.0	0.0	25.1	7.9	11.440	2	58.0
Total					0.0	25.1	7.9	11.440		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

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Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 3.537 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	5.000	273.1	-3.99	12.06	7.36	16.85	0.00	5.000	32.27
2	1.275	219.1	-2.53	8.51	2.65	12.26	0.00	1.275	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	3.537	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 1.725 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	3.100	0.350	1.725	30.00	82.5
Total	0.000	0.000	1.725		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 0.950 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	0.950	0.000	200.0
Total	0.950		200.0

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Impact Load	I

Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	I
3	Dead Weight		X	0.000	0	1.0	
4	Dead Weight + Impact	X		0.000	0	1.0	1.0

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
9	Upper Lift Point	10.6990	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Free	Free
30	Lower Lift Point	0.1530	0.7350	0.0000	Free	Fixed	Free	Free	Free	Free

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
16.500	13.452	4	Dead Weight + Impact	Buckling	0.000	PASS
13.452	11.500	4	Dead Weight + Impact	Buckling	0.059	PASS
11.500	11.467	4	Dead Weight + Impact	Buckling	0.089	PASS
11.467	11.385	4	Dead Weight + Impact	Buckling	0.090	PASS
11.385	11.257	4	Dead Weight + Impact	Buckling	0.093	PASS
11.257	11.128	4	Dead Weight + Impact	Buckling	0.070	PASS
11.128	11.000	4	Dead Weight + Impact	Buckling	0.056	PASS
11.000	10.699	4	Dead Weight + Impact	Buckling	0.046	PASS
10.699	10.400	4	Dead Weight + Impact	Buckling	0.053	PASS
10.400	8.400	4	Dead Weight + Impact	Buckling	0.031	PASS
8.400	6.456	4	Dead Weight + Impact	Buckling	0.066	PASS
6.456	6.123	4	Dead Weight + Impact	Buckling	0.129	PASS
6.123	5.789	4	Dead Weight + Impact	Buckling	0.069	PASS
5.789	5.456	4	Dead Weight + Impact	Buckling	0.045	PASS
5.456	5.137	4	Dead Weight + Impact	Buckling	0.032	PASS
5.137	5.000	4	Dead Weight + Impact	Buckling	0.032	PASS
5.000	4.863	4	Dead Weight + Impact	Buckling	0.035	PASS
4.863	3.100	4	Dead Weight + Impact	Buckling	0.033	PASS
3.100	2.450	4	Dead Weight + Impact	Buckling	0.030	PASS
2.450	1.385	4	Dead Weight + Impact	Buckling	0.027	PASS
1.385	1.275	4	Dead Weight + Impact	Buckling	0.020	PASS
1.275	1.165	4	Dead Weight + Impact	Buckling	0.020	PASS
1.165	0.950	4	Dead Weight + Impact	Buckling	0.018	PASS
0.950	0.446	4	Dead Weight + Impact	Buckling	0.015	PASS
0.446	0.350	4	Dead Weight + Impact	Buckling	0.009	PASS
0.350	0.305	4	Dead Weight + Impact	Buckling	0.008	PASS
0.305	0.153	4	Dead Weight + Impact	Buckling	0.005	PASS
0.153	0.000	4	Dead Weight + Impact	Buckling	0.001	PASS
0.000	0.000	0			0.000	PASS

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
16.500	0.00	0.00	0.00	0.00	0.00	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.58	0.00	0.00	7.67	7.67	0.00	130.14	24.57	1.958	1.384	0.059	0.004	0.059
11.500	9.65	0.00	0.00	12.86	12.86	0.00	145.11	71.07	1.990	1.612	0.089	0.008	0.089
11.467	9.78	0.00	0.00	13.03	13.03	0.00	145.11	71.07	1.990	1.612	0.090	0.008	0.090
11.385	10.17	0.00	0.00	13.56	13.56	0.00	145.11	71.07	1.990	1.612	0.093	0.009	0.093

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11.257  10.81 0.00  0.00 10.03 10.03  0.00 143.11  50.11 1.980 1.505 0.070 0.005  0.070
11.128  11.49 0.00  0.00  7.84  7.84  0.00 141.19  37.29 1.970 1.440 0.056 0.003  0.056
11.000  12.19 0.00  0.00  6.38  6.38  0.00 139.35  28.85 1.961 1.397 0.046 0.002  0.046
10.699  13.98 0.00  0.00  7.32  7.32  0.00 139.35  28.85 1.961 1.397 0.053 0.003  0.053
10.400   8.12 0.00  0.00  4.25  4.25  0.00 139.35  28.85 1.961 1.397 0.030 0.001  0.030
 8.400  16.77 0.00  0.00  8.78  8.78  0.00 139.35  28.85 1.961 1.397 0.063 0.004  0.063
 6.456  33.40 0.00  0.00 17.48 17.48  0.00 139.35  28.85 1.961 1.397 0.125 0.017  0.125
 6.123  35.51 0.00  0.00  9.79  9.79  0.00 147.09  15.58 2.000 1.329 0.067 0.004  0.067
 5.789  37.30 0.00  0.00  6.34  6.34  0.00 147.09  10.00 2.000 1.301 0.043 0.002  0.043
 5.456  38.78 0.00  0.00  4.46  4.46  0.00 145.82   7.41 1.994 1.288 0.031 0.001  0.031
 5.137  39.86 0.00  0.00  4.57  4.57  0.00 145.82   7.41 1.994 1.288 0.031 0.001  0.031
 5.000  40.20 0.00  0.00  5.00  5.00  0.00 145.82   7.41 1.994 1.288 0.034 0.001  0.034
 4.863  40.40 0.00  0.00  4.65  4.65  0.00 145.82   7.41 1.994 1.288 0.032 0.001  0.032
 3.100  36.61 0.00  0.00  4.21  4.21  0.00 145.82   7.41 1.994 1.288 0.029 0.001  0.029
 2.450  32.12 0.00  0.00  3.70  3.70  0.00 145.82   7.41 1.994 1.288 0.025 0.001  0.025
 1.385  20.84 0.00  0.00  2.40  2.40  0.00 145.82   7.41 1.994 1.288 0.016 0.000  0.016
 1.275  19.41 0.00  0.00  2.44  2.44  0.00 145.82   7.41 1.994 1.288 0.017 0.000  0.017
 1.165  17.89 0.00  0.00  2.06  2.06  0.00 145.82   7.41 1.994 1.288 0.014 0.000  0.014
 0.950  14.75 0.00  0.00  1.70  1.70  0.00 145.82   7.41 1.994 1.288 0.012 0.000  0.012
 0.446   5.15 0.00  0.00  0.59  0.59  0.00 176.89   7.68 1.974 1.281 0.003 0.000  0.003
 0.350   3.20 0.00  0.00  0.37  0.37  0.00 176.89   7.68 1.974 1.281 0.002 0.000  0.002
 0.305   2.27 0.00  0.00  0.15  0.15  0.00 176.89 183.33 1.974 2.000 0.001 0.000  0.001
 0.153   0.92 0.00  0.00  0.06  0.06  0.00 176.89 183.33 1.974 2.000 0.000 0.000  0.000

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 0 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 0.00 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000

           Since Nratio <= 0.1 then Secondary Moments need not be considered.
```

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev     w       l     Cxb  Cx  Dwk   ax    Fyk    Lxo    Lpx    Lx     Xx  s_xRcr  s_xRk
s_xRd
  m              m              mm          MPa                              MPa     MPa
MPa
------ ----- ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
```

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```
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 1.00 3.7 0.427 220.63 0.300 1.033 0.250 1.000 3532.85 220.63
147.09
 5.789 160.2 10.6275 1.0 1.00 4.1 0.403 220.63 0.300 1.004 0.281 1.000 2785.52 220.63
147.09
 5.456 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 5.137 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 5.000 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 3.100 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 2.450 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.385 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.275 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.165 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.950 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.446 145.5 10.6275 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.350 145.5 10.6275 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
```

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```
   w     = Length Param:  l/(r*t)^0.5  [D.1]     Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]       Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]              Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]     s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                      s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]        fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.20	-0.03	0.00	-0.03	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.53	-0.54	-0.09	7.56	7.47	0.00	130.14	24.57	1.958	1.384	0.057	0.004	0.057
11.500	9.50	-0.67	-0.07	12.66	12.59	0.00	145.11	71.07	1.990	1.612	0.087	0.008	0.087
11.467	9.63	-0.84	-0.09	12.83	12.75	0.00	145.11	71.07	1.990	1.612	0.088	0.008	0.088
11.385	10.02	-0.87	-0.09	13.35	13.26	0.00	145.11	71.07	1.990	1.612	0.091	0.009	0.091
11.257	10.65	-0.91	-0.08	9.88	9.80	0.00	143.11	50.11	1.980	1.505	0.069	0.005	0.069
11.128	11.31	-0.95	-0.07	7.73	7.66	0.00	141.19	37.29	1.970	1.440	0.054	0.003	0.054
11.000	12.01	-1.03	-0.07	6.29	6.22	0.00	139.35	28.85	1.961	1.397	0.045	0.002	0.045
10.699	13.76	3.46	0.22	7.21	7.43	0.00	139.35	28.85	1.961	1.397	0.053	0.003	0.053
10.400	7.90	2.22	0.14	4.13	4.27	0.00	139.35	28.85	1.961	1.397	0.031	0.001	0.031
8.400	17.27	1.54	0.10	9.04	9.14	0.00	139.35	28.85	1.961	1.397	0.066	0.005	0.066
6.456	34.29	1.16	0.07	17.95	18.02	0.00	139.35	28.85	1.961	1.397	0.129	0.018	0.129
6.123	36.48	0.99	0.05	10.06	10.11	0.00	147.09	15.58	2.000	1.329	0.069	0.005	0.069
5.789	38.36	0.83	0.03	6.52	6.55	0.00	147.09	10.00	2.000	1.301	0.045	0.002	0.045
5.456	39.93	0.64	0.02	4.59	4.61	0.00	145.73	7.41	1.993	1.288	0.032	0.001	0.032
5.137	41.09	0.49	0.01	4.71	4.72	0.00	145.76	7.41	1.993	1.288	0.032	0.001	0.032
5.000	41.47	0.32	0.01	5.15	5.16	0.00	145.78	7.41	1.993	1.288	0.035	0.001	0.035
4.863	41.72	-0.31	-0.01	4.80	4.79	0.00	145.86	7.41	1.994	1.288	0.033	0.001	0.033
3.100	38.57	-1.14	-0.03	4.44	4.40	0.00	145.98	7.41	1.994	1.288	0.030	0.001	0.030
2.450	34.35	-1.78	-0.05	3.95	3.90	0.00	146.10	7.41	1.995	1.288	0.027	0.001	0.027
1.385	23.60	-2.22	-0.06	2.71	2.65	0.00	146.32	7.41	1.996	1.288	0.018	0.000	0.018
1.275	22.22	-2.35	-0.07	2.79	2.72	0.00	146.38	7.41	1.996	1.288	0.019	0.000	0.019
1.165	20.76	-2.47	-0.07	2.39	2.31	0.00	146.49	7.41	1.997	1.288	0.016	0.000	0.016
0.950	17.74	-3.25	-0.10	2.04	1.94	0.00	146.87	7.41	1.999	1.288	0.013	0.000	0.013
0.446	8.45	-3.47	-0.10	0.97	0.87	0.00	180.06	7.68	1.987	1.281	0.005	0.000	0.005
0.350	6.56	-3.52	-0.11	0.76	0.65	0.00	181.20	7.68	1.991	1.281	0.004	0.000	0.004
0.305	5.67	-3.59	-0.06	0.38	0.32	0.00	179.63	183.33	1.985	2.000	0.002	0.000	0.002
0.153	0.91	1.04	0.02	0.06	0.08	0.00	173.73	183.33	1.961	2.000	0.000	0.000	0.000

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 10 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 1.04 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

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Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3526.39	220.63	147.09
5.789	160.2	10.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.282	1.000	2780.35	220.63	147.09
5.456	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2295.30	218.59	145.73
5.137	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.49	218.63	145.76
5.000	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.40	218.67	145.78
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2300.98	218.79	145.86
3.100	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2306.35	218.97	145.98
2.450	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2311.80	219.16	146.10
1.385	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.302	0.979	0.308	0.995	2321.33	219.48	146.32
1.275	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2324.11	219.58	146.38
1.165	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.996	2328.73	219.73	146.49
0.950	145.5	10.6275	1.0	1.02	4.6	0.383	220.63	0.305	0.979	0.307	0.999	2345.46	220.30	146.87

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 0.446 145.5 10.6275 1.0 1.05 4.6 0.383 275.00 0.312 0.979 0.332 0.982 2496.62 270.09
180.06
 0.350 145.5 10.6275 1.0 1.07 4.6 0.383 275.00 0.316 0.979 0.329 0.988 2537.56 271.79
181.20
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.318 0.979 0.340 0.980 2381.90 269.45
179.63
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.279 0.979 0.340 0.948 2381.90 260.59
173.73

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

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   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.40	-0.07	0.00	-0.07	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.37	-1.06	-0.18	7.21	7.03	0.00	130.14	24.57	1.958	1.384	0.054	0.003	0.054
11.500	9.07	-1.33	-0.13	12.08	11.95	0.00	145.11	71.07	1.990	1.612	0.082	0.007	0.082
11.467	9.19	-1.65	-0.17	12.24	12.08	0.00	145.11	71.07	1.990	1.612	0.083	0.007	0.083
11.385	9.56	-1.71	-0.17	12.74	12.56	0.00	145.11	71.07	1.990	1.612	0.087	0.008	0.087
11.257	10.16	-1.80	-0.15	9.43	9.28	0.00	143.11	50.11	1.980	1.505	0.065	0.004	0.065
11.128	10.79	-1.88	-0.14	7.37	7.23	0.00	141.19	37.29	1.970	1.440	0.051	0.003	0.051
11.000	11.46	-2.03	-0.13	6.00	5.87	0.00	139.35	28.85	1.961	1.397	0.042	0.002	0.042
10.699	13.13	6.94	0.44	6.88	7.32	0.00	139.35	28.85	1.961	1.397	0.053	0.003	0.053
10.400	7.44	4.49	0.29	3.89	4.18	0.00	139.35	28.85	1.961	1.397	0.030	0.001	0.030
8.400	17.23	3.16	0.20	9.02	9.22	0.00	139.35	28.85	1.961	1.397	0.066	0.005	0.066
6.456	34.11	2.40	0.15	17.85	18.01	0.00	139.35	28.85	1.961	1.397	0.129	0.018	0.129
6.123	36.30	2.08	0.10	10.01	10.11	0.00	147.09	15.58	2.000	1.329	0.069	0.005	0.069
5.789	38.20	1.75	0.06	6.49	6.56	0.00	147.09	10.00	2.000	1.301	0.045	0.002	0.045
5.456	39.81	1.38	0.04	4.58	4.62	0.00	145.63	7.41	1.993	1.288	0.032	0.001	0.032
5.137	41.02	1.09	0.03	4.70	4.73	0.00	145.68	7.41	1.993	1.288	0.032	0.001	0.032
5.000	41.43	0.74	0.02	5.15	5.17	0.00	145.72	7.41	1.993	1.288	0.035	0.001	0.035
4.863	41.71	-0.50	-0.02	4.80	4.78	0.00	145.88	7.41	1.994	1.288	0.033	0.001	0.033
3.100	39.28	-2.13	-0.06	4.52	4.46	0.00	146.12	7.41	1.995	1.288	0.030	0.001	0.030
2.450	35.47	-3.39	-0.10	4.08	3.98	0.00	146.35	7.41	1.996	1.288	0.027	0.001	0.027
1.385	25.56	-4.25	-0.12	2.94	2.82	0.00	146.72	7.41	1.998	1.288	0.019	0.000	0.019
1.275	24.28	-4.51	-0.14	3.05	2.91	0.00	146.83	7.41	1.999	1.288	0.020	0.000	0.020
1.165	22.92	-4.75	-0.14	2.64	2.50	0.00	147.02	7.41	2.000	1.288	0.017	0.000	0.017
0.950	20.11	-6.28	-0.19	2.31	2.13	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.446	11.42	-6.72	-0.20	1.31	1.11	0.00	181.69	7.68	1.993	1.281	0.006	0.000	0.006
0.350	9.65	-6.82	-0.21	1.11	0.90	0.00	182.89	7.68	1.998	1.281	0.005	0.000	0.005
0.305	8.80	-6.95	-0.11	0.59	0.48	0.00	180.49	183.33	1.988	2.000	0.003	0.000	0.003
0.153	0.86	2.06	0.03	0.06	0.09	0.00	171.68	183.33	1.952	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
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Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 20 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 2.06 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3519.35	220.63	147.09
5.789	160.2	10.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2774.62	220.63	147.09
5.456	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2290.86	218.44	145.63
5.137	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.26	218.52	145.68
5.000	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2295.04	218.59	145.72
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2302.06	218.82	145.88

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 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.301 0.979 0.309 0.993 2312.42 219.18
146.12
 2.450 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2322.73 219.53
146.35
 1.385 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.998 2339.11 220.09
146.72
 1.275 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.90 220.25
146.83
 1.165 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2351.88 220.52
147.02
 0.950 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2381.01 220.63
147.09
 0.446 145.5 10.6275 1.0 1.07 4.6 0.383 275.00 0.318 0.979 0.328 0.991 2555.37 272.54
181.69
 0.350 145.5 10.6275 1.0 1.09 4.6 0.383 275.00 0.323 0.979 0.325 0.998 2598.22 274.34
182.89
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.323 0.979 0.340 0.985 2381.90 270.74
180.49
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.264 0.979 0.340 0.936 2381.90 257.52
171.68

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41

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3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.59	-0.10	0.00	-0.10	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.10	-1.55	-0.26	6.64	6.38	0.00	130.14	24.57	1.958	1.384	0.049	0.003	0.049
11.500	8.35	-1.94	-0.20	11.14	10.94	0.00	145.11	71.07	1.990	1.612	0.075	0.006	0.075
11.467	8.47	-2.41	-0.24	11.28	11.04	0.00	145.11	71.07	1.990	1.612	0.076	0.006	0.076
11.385	8.81	-2.50	-0.25	11.74	11.49	0.00	145.11	71.07	1.990	1.612	0.079	0.006	0.079
11.257	9.36	-2.62	-0.22	8.69	8.47	0.00	143.11	50.11	1.980	1.505	0.059	0.004	0.059
11.128	9.95	-2.74	-0.20	6.79	6.59	0.00	141.19	37.29	1.970	1.440	0.047	0.002	0.047
11.000	10.56	-2.96	-0.19	5.53	5.34	0.00	139.35	28.85	1.961	1.397	0.038	0.002	0.038
10.699	12.10	10.33	0.66	6.34	7.00	0.00	139.35	28.85	1.961	1.397	0.050	0.003	0.050
10.400	6.75	6.76	0.43	3.54	3.97	0.00	139.35	28.85	1.961	1.397	0.028	0.001	0.028
8.400	16.65	4.81	0.31	8.72	9.02	0.00	139.35	28.85	1.961	1.397	0.065	0.005	0.065
6.456	32.85	3.70	0.24	17.19	17.43	0.00	139.35	28.85	1.961	1.397	0.125	0.017	0.125
6.123	34.98	3.23	0.15	9.65	9.80	0.00	147.09	15.58	2.000	1.329	0.067	0.004	0.067
5.789	36.84	2.76	0.10	6.26	6.36	0.00	147.09	10.00	2.000	1.301	0.043	0.002	0.043
5.456	38.44	2.22	0.07	4.42	4.49	0.00	145.51	7.41	1.992	1.288	0.031	0.001	0.031
5.137	39.66	1.78	0.05	4.54	4.59	0.00	145.59	7.41	1.992	1.288	0.032	0.001	0.032
5.000	40.08	1.28	0.04	4.98	5.02	0.00	145.65	7.41	1.993	1.288	0.034	0.001	0.034
4.863	40.39	-0.54	-0.02	4.65	4.63	0.00	145.89	7.41	1.994	1.288	0.032	0.001	0.032
3.100	38.73	-2.93	-0.09	4.46	4.37	0.00	146.24	7.41	1.996	1.288	0.030	0.001	0.030
2.450	35.44	-4.76	-0.14	4.08	3.94	0.00	146.58	7.41	1.997	1.288	0.027	0.001	0.027
1.385	26.66	-6.01	-0.17	3.07	2.89	0.00	147.07	7.41	2.000	1.288	0.020	0.000	0.020
1.275	25.52	-6.40	-0.20	3.21	3.01	0.00	147.09	7.41	2.000	1.288	0.020	0.000	0.020
1.165	24.30	-6.75	-0.20	2.80	2.59	0.00	147.09	7.41	2.000	1.288	0.018	0.000	0.018
0.950	21.79	-8.99	-0.27	2.51	2.24	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
0.446	13.94	-9.63	-0.29	1.60	1.31	0.00	182.72	7.68	1.998	1.281	0.007	0.000	0.007
0.350	12.34	-9.78	-0.29	1.42	1.13	0.00	183.33	7.68	2.000	1.281	0.006	0.000	0.006
0.305	11.58	-9.96	-0.16	0.77	0.61	0.00	180.92	183.33	1.990	2.000	0.003	0.000	0.003

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```
 0.153   0.80  3.01  0.05  0.05  0.10  0.00 170.17 183.33 1.946 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 30 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 3.01 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35

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 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.298 1.033 0.251 1.000 3511.20 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.298 1.004 0.282 1.000 2767.86 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.989 2285.49 218.26
145.51
 5.137 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2289.20 218.39
145.59
 5.000 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2291.86 218.48
145.65
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2302.39 218.84
145.89
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.302 0.979 0.309 0.994 2317.71 219.36
146.24
 2.450 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.997 2332.66 219.87
146.58
 1.385 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2354.28 220.60
147.07
 1.275 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2360.63 220.63
147.09
 1.165 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2371.24 220.63
147.09
 0.950 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2410.51 220.63
147.09
 0.446 145.5 10.6275 1.0 1.09 4.6 0.383 275.00 0.322 0.979 0.326 0.997 2592.22 274.08
182.72
 0.350 145.5 10.6275 1.0 1.10 4.6 0.383 275.00 0.326 0.979 0.323 1.000 2631.20 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.325 0.979 0.340 0.987 2381.90 271.38
180.92
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.253 0.979 0.340 0.928 2381.90 255.26
170.17

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11

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11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.76	-0.13	0.00	-0.13	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	2.75	-2.00	-0.33	5.88	5.54	0.00	130.14	24.57	1.958	1.384	0.043	0.002	0.043
11.500	7.39	-2.50	-0.25	9.85	9.60	0.00	145.11	71.07	1.990	1.612	0.066	0.004	0.066
11.467	7.49	-3.10	-0.31	9.98	9.67	0.00	145.11	71.07	1.990	1.612	0.067	0.005	0.067
11.385	7.79	-3.22	-0.33	10.38	10.06	0.00	145.11	71.07	1.990	1.612	0.069	0.005	0.069
11.257	8.28	-3.37	-0.29	7.69	7.40	0.00	143.11	50.11	1.980	1.505	0.052	0.003	0.052
11.128	8.80	-3.53	-0.26	6.01	5.75	0.00	141.19	37.29	1.970	1.440	0.041	0.002	0.041
11.000	9.34	-3.81	-0.24	4.89	4.65	0.00	139.35	28.85	1.961	1.397	0.033	0.001	0.033
10.699	10.71	13.58	0.87	5.60	6.47	0.00	139.35	28.85	1.961	1.397	0.046	0.002	0.046
10.400	5.87	8.98	0.57	3.07	3.65	0.00	139.35	28.85	1.961	1.397	0.026	0.001	0.026
8.400	15.53	6.48	0.41	8.13	8.54	0.00	139.35	28.85	1.961	1.397	0.061	0.004	0.061
6.456	30.54	5.05	0.32	15.99	16.31	0.00	139.35	28.85	1.961	1.397	0.117	0.015	0.117
6.123	32.54	4.44	0.21	8.98	9.18	0.00	147.09	15.58	2.000	1.329	0.062	0.004	0.062
5.789	34.31	3.84	0.14	5.83	5.97	0.00	147.09	10.00	2.000	1.301	0.041	0.002	0.041
5.456	35.83	3.14	0.09	4.12	4.22	0.00	145.35	7.41	1.991	1.288	0.029	0.001	0.029

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 5.137  37.03   2.58  0.07  4.24  4.31  0.00 145.47   7.41 1.992 1.288 0.030 0.001 0.030
 5.000  37.45   1.94  0.06  4.65  4.71  0.00 145.55   7.41 1.992 1.288 0.032 0.001 0.032
 4.863  37.77  -0.40 -0.01  4.35  4.33  0.00 145.88   7.41 1.994 1.288 0.030 0.001 0.030
 3.100  36.92  -3.47 -0.10  4.25  4.14  0.00 146.34   7.41 1.996 1.288 0.028 0.001 0.028
 2.450  34.24  -5.82 -0.18  3.94  3.76  0.00 146.79   7.41 1.998 1.288 0.026 0.001 0.026
 1.385  26.84  -7.44 -0.21  3.09  2.87  0.00 147.09   7.41 2.000 1.288 0.020 0.000 0.020
 1.275  25.87  -7.94 -0.25  3.25  3.00  0.00 147.09   7.41 2.000 1.288 0.020 0.000 0.020
 1.165  24.84  -8.38 -0.25  2.86  2.61  0.00 147.09   7.41 2.000 1.288 0.018 0.000 0.018
 0.950  22.69 -11.26 -0.34  2.61  2.27  0.00 147.09   7.41 2.000 1.288 0.015 0.000 0.015
 0.446  15.92 -12.09 -0.36  1.83  1.47  0.00 183.33   7.68 2.000 1.281 0.008 0.000 0.008
 0.350  14.54 -12.27 -0.37  1.67  1.30  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.305  13.88 -12.52 -0.20  0.92  0.73  0.00 181.17 183.33 1.991 2.000 0.004 0.000 0.004
 0.153   0.71   3.87  0.06  0.05  0.11  0.00 168.95 183.33 1.941 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 40 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 3.87 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev     w       l     Cxb  Cx  Dwk   ax    Fyk    Lxo    Lpx    Lx     Xx   s_xRcr  s_xRk
s_xRd
  m              m              mm          MPa                              MPa     MPa
MPa
------ ----- ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
```

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```
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.298 1.033 0.251 1.000 3501.05 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.298 1.004 0.283 1.000 2759.32 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2278.52 218.02
145.35
 5.137 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.989 2283.78 218.20
145.47
 5.000 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.990 2287.38 218.32
145.55
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2301.72 218.81
145.88
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2322.33 219.51
146.34
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2342.01 220.19
146.79
 1.385 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000 2367.79 220.63
147.09
 1.275 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2375.45 220.63
147.09
 1.165 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.27 220.63
147.09
 0.950 145.5 10.6275 1.0 1.06 4.6 0.383 220.63 0.315 0.979 0.301 1.000 2436.51 220.63
147.09
 0.446 145.5 10.6275 1.0 1.10 4.6 0.383 275.00 0.325 0.979 0.324 1.000 2618.16 275.00
183.33
 0.350 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2652.15 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.327 0.979 0.340 0.988 2381.90 271.76
181.17
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.244 0.979 0.340 0.922 2381.90 253.42
168.95

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
16.500	0.00	-0.90	-0.15	0.00	-0.15	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	2.30	-2.38	-0.40	4.93	4.53	0.00	130.14	24.57	1.958	1.384	0.035	0.001	0.035
11.500	6.20	-2.98	-0.30	8.26	7.96	0.00	145.11	71.07	1.990	1.612	0.055	0.003	0.055

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11.467	6.28	-3.70	-0.38	8.38	8.00	0.00	145.11	71.07	1.990	1.612	0.055	0.003	0.055
11.385	6.54	-3.84	-0.39	8.71	8.32	0.00	145.11	71.07	1.990	1.612	0.057	0.003	0.057
11.257	6.95	-4.02	-0.34	6.45	6.11	0.00	143.11	50.11	1.980	1.505	0.043	0.002	0.043
11.128	7.38	-4.20	-0.31	5.04	4.74	0.00	141.19	37.29	1.970	1.440	0.034	0.001	0.034
11.000	7.84	-4.54	-0.29	4.10	3.81	0.00	139.35	28.85	1.961	1.397	0.027	0.001	0.027
10.699	8.98	16.63	1.06	4.70	5.77	0.00	139.35	28.85	1.961	1.397	0.041	0.002	0.041
10.400	4.81	11.15	0.71	2.52	3.23	0.00	139.35	28.85	1.961	1.397	0.023	0.001	0.023
8.400	13.91	8.17	0.52	7.28	7.80	0.00	139.35	28.85	1.961	1.397	0.056	0.004	0.056
6.456	27.24	6.47	0.41	14.26	14.67	0.00	139.35	28.85	1.961	1.397	0.105	0.012	0.105
6.123	29.05	5.75	0.27	8.01	8.28	0.00	147.09	15.58	2.000	1.329	0.056	0.003	0.056
5.789	30.66	5.03	0.18	5.21	5.39	0.00	147.09	10.00	2.000	1.301	0.037	0.001	0.037
5.456	32.06	4.20	0.13	3.69	3.82	0.00	145.13	7.41	1.990	1.288	0.026	0.001	0.026
5.137	33.19	3.53	0.10	3.80	3.90	0.00	145.29	7.41	1.991	1.288	0.027	0.001	0.027
5.000	33.59	2.76	0.09	4.17	4.26	0.00	145.40	7.41	1.991	1.288	0.029	0.001	0.029
4.863	33.91	-0.02	0.00	3.90	3.90	0.00	145.82	7.41	1.994	1.288	0.027	0.001	0.027
3.100	33.87	-3.68	-0.11	3.90	3.79	0.00	146.43	7.41	1.997	1.288	0.026	0.001	0.026
2.450	31.87	-6.49	-0.20	3.67	3.47	0.00	146.99	7.41	2.000	1.288	0.024	0.001	0.024
1.385	26.07	-8.41	-0.24	3.00	2.75	0.00	147.09	7.41	2.000	1.288	0.019	0.000	0.019
1.275	25.29	-9.00	-0.28	3.18	2.90	0.00	147.09	7.41	2.000	1.288	0.020	0.000	0.020
1.165	24.47	-9.54	-0.29	2.82	2.53	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
0.950	22.74	-12.97	-0.39	2.62	2.23	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
0.446	17.26	-13.95	-0.42	1.99	1.57	0.00	183.33	7.68	2.000	1.281	0.009	0.000	0.009
0.350	16.13	-14.17	-0.43	1.86	1.43	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	15.60	-14.46	-0.23	1.04	0.81	0.00	181.33	183.33	1.992	2.000	0.004	0.000	0.004
0.153	0.59	4.61	0.07	0.04	0.11	0.00	167.87	183.33	1.937	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 50 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 4.61 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
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16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.297 1.033 0.252 1.000 3487.22 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.297 1.004 0.283 1.000 2747.53 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.312 0.987 2268.68 217.69
145.13
 5.137 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.311 0.988 2275.89 217.93
145.29
 5.000 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2280.57 218.09
145.40
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.34 218.73
145.82
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.06 219.64
146.43
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 0.999 2350.92 220.49
146.99
 1.385 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2380.08 220.63
147.09
 1.275 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.90 220.63
147.09
 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2403.65 220.63
147.09
 0.950 145.5 10.6275 1.0 1.07 4.6 0.383 220.63 0.318 0.979 0.299 1.000 2460.50 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.327 0.979 0.323 1.000 2637.58 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.330 0.979 0.321 1.000 2666.38 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.328 0.979 0.340 0.989 2381.90 272.00
181.33
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.235 0.979 0.340 0.916 2381.90 251.81
167.87
```

```
   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.02	-0.17	0.00	-0.17	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	1.79	-2.69	-0.45	3.84	3.39	0.00	130.14	24.57	1.958	1.384	0.026	0.001	0.026
11.500	4.82	-3.36	-0.34	6.43	6.09	0.00	145.11	71.07	1.990	1.612	0.042	0.002	0.042
11.467	4.89	-4.18	-0.42	6.51	6.09	0.00	145.11	71.07	1.990	1.612	0.042	0.002	0.042
11.385	5.09	-4.34	-0.44	6.78	6.34	0.00	145.11	71.07	1.990	1.612	0.044	0.002	0.044
11.257	5.41	-4.55	-0.39	5.02	4.63	0.00	143.11	50.11	1.980	1.505	0.032	0.001	0.032
11.128	5.74	-4.75	-0.35	3.92	3.58	0.00	141.19	37.29	1.970	1.440	0.025	0.001	0.025
11.000	6.10	-5.13	-0.33	3.19	2.86	0.00	139.35	28.85	1.961	1.397	0.021	0.000	0.021
10.699	6.99	19.54	1.25	3.66	4.91	0.00	139.35	28.85	1.961	1.397	0.035	0.001	0.035
10.400	3.61	13.35	0.85	1.89	2.75	0.00	139.35	28.85	1.961	1.397	0.020	0.000	0.020
8.400	11.80	9.98	0.64	6.18	6.82	0.00	139.35	28.85	1.961	1.397	0.049	0.003	0.049
6.456	23.00	8.05	0.51	12.04	12.56	0.00	139.35	28.85	1.961	1.397	0.090	0.009	0.090
6.123	24.55	7.24	0.34	6.77	7.11	0.00	147.09	15.58	2.000	1.329	0.048	0.002	0.048
5.789	25.95	6.43	0.23	4.41	4.64	0.00	147.09	10.00	2.000	1.301	0.032	0.001	0.032
5.456	27.18	5.49	0.17	3.13	3.29	0.00	144.77	7.41	1.988	1.288	0.023	0.001	0.023
5.137	28.20	4.73	0.13	3.23	3.36	0.00	145.00	7.41	1.989	1.288	0.023	0.001	0.023
5.000	28.57	3.87	0.12	3.55	3.67	0.00	145.13	7.41	1.990	1.288	0.025	0.001	0.025
4.863	28.87	0.71	0.02	3.32	3.34	0.00	145.68	7.41	1.993	1.288	0.023	0.001	0.023
3.100	29.60	-3.42	-0.10	3.41	3.30	0.00	146.47	7.41	1.997	1.288	0.023	0.001	0.023
2.450	28.32	-6.59	-0.20	3.26	3.06	0.00	147.09	7.41	2.000	1.288	0.021	0.000	0.021
1.385	24.26	-8.77	-0.25	2.79	2.54	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
1.275	23.71	-9.44	-0.30	2.98	2.68	0.00	147.09	7.41	2.000	1.288	0.018	0.000	0.018
1.165	23.11	-10.04	-0.30	2.66	2.36	0.00	147.09	7.41	2.000	1.288	0.016	0.000	0.016
0.950	21.86	-13.92	-0.42	2.52	2.10	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.446	17.81	-15.03	-0.45	2.05	1.60	0.00	183.33	7.68	2.000	1.281	0.009	0.000	0.009
0.350	16.98	-15.28	-0.46	1.95	1.49	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	16.58	-15.61	-0.24	1.10	0.86	0.00	181.43	183.33	1.992	2.000	0.005	0.000	0.005
0.153	0.46	5.21	0.08	0.03	0.11	0.00	166.86	183.33	1.933	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 60 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 5.21 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

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Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	0.98	3.7	0.427	220.63	0.295	1.033	0.252	1.000	3465.91	220.63	147.09
5.789	160.2	10.6275	1.0	0.98	4.1	0.403	220.63	0.295	1.004	0.284	1.000	2729.15	220.63	147.09
5.456	145.5	10.6275	1.0	0.98	4.6	0.383	220.63	0.295	0.979	0.313	0.984	2253.00	217.16	144.77
5.137	145.5	10.6275	1.0	0.98	4.6	0.383	220.63	0.296	0.979	0.312	0.986	2262.98	217.50	145.00
5.000	145.5	10.6275	1.0	0.99	4.6	0.383	220.63	0.297	0.979	0.312	0.987	2268.98	217.70	145.13
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.25	218.52	145.68
3.100	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.996	2327.81	219.70	146.47
2.450	145.5	10.6275	1.0	1.03	4.6	0.383	220.63	0.306	0.979	0.306	1.000	2358.83	220.63	147.09
1.385	145.5	10.6275	1.0	1.04	4.6	0.383	220.63	0.310	0.979	0.304	1.000	2390.74	220.63	147.09
1.275	145.5	10.6275	1.0	1.04	4.6	0.383	220.63	0.311	0.979	0.303	1.000	2400.68	220.63	147.09

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 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.313 0.979 0.302 1.000 2417.14 220.63
147.09
 0.950 145.5 10.6275 1.0 1.08 4.6 0.383 220.63 0.320 0.979 0.298 1.000 2483.05 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2651.95 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.331 0.979 0.321 1.000 2675.50 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.329 0.979 0.340 0.990 2381.90 272.14
181.43
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.227 0.979 0.340 0.910 2381.90 250.30
166.86

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68

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 0.305 1.00 2.11 0.500 0.274 1.118 0.818  0.000 0.000 1.0000  0.00 3660.74 275.00 183.33
 0.153 1.00 2.11 0.500 0.274 1.118 0.818  0.000 0.000 1.0000  0.00 3660.74 275.00 183.33

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.11	-0.18	0.00	-0.18	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	1.23	-2.92	-0.49	2.62	2.14	0.00	130.14	24.57	1.958	1.384	0.016	0.000	0.016
11.500	3.30	-3.65	-0.37	4.40	4.03	0.00	145.11	71.07	1.990	1.612	0.028	0.001	0.028
11.467	3.34	-4.54	-0.46	4.46	4.00	0.00	145.11	71.07	1.990	1.612	0.028	0.001	0.028
11.385	3.48	-4.71	-0.48	4.64	4.16	0.00	145.11	71.07	1.990	1.612	0.029	0.001	0.029
11.257	3.70	-4.93	-0.42	3.43	3.01	0.00	143.11	50.11	1.980	1.505	0.021	0.000	0.021
11.128	3.93	-5.16	-0.38	2.68	2.31	0.00	141.19	37.29	1.970	1.440	0.016	0.000	0.016
11.000	4.17	-5.57	-0.36	2.18	1.83	0.00	139.35	28.85	1.961	1.397	0.013	0.000	0.013
10.699	4.78	22.58	1.44	2.50	3.95	0.00	139.35	28.85	1.961	1.397	0.028	0.001	0.028
10.400	2.32	15.86	1.01	1.22	2.23	0.00	139.35	28.85	1.961	1.397	0.016	0.000	0.016
8.400	9.22	12.20	0.78	4.83	5.61	0.00	139.35	28.85	1.961	1.397	0.040	0.002	0.040
6.456	17.86	10.11	0.65	9.35	10.00	0.00	139.35	28.85	1.961	1.397	0.072	0.006	0.072
6.123	19.09	9.23	0.43	5.26	5.69	0.00	147.09	15.58	2.000	1.329	0.039	0.001	0.039
5.789	20.21	8.35	0.31	3.43	3.74	0.00	147.09	10.00	2.000	1.301	0.025	0.001	0.025
5.456	21.22	7.33	0.22	2.44	2.66	0.00	144.09	7.41	1.985	1.288	0.018	0.000	0.018
5.137	22.07	6.51	0.18	2.53	2.71	0.00	144.42	7.41	1.986	1.288	0.019	0.000	0.019
5.000	22.39	5.57	0.17	2.78	2.96	0.00	144.59	7.41	1.987	1.288	0.020	0.000	0.020
4.863	22.67	2.15	0.06	2.61	2.67	0.00	145.31	7.41	1.991	1.288	0.018	0.000	0.018
3.100	24.05	-2.33	-0.07	2.77	2.70	0.00	146.36	7.41	1.996	1.288	0.018	0.000	0.018
2.450	23.50	-5.78	-0.17	2.70	2.53	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
1.385	21.26	-8.14	-0.23	2.44	2.21	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
1.275	20.93	-8.87	-0.28	2.63	2.35	0.00	147.09	7.41	2.000	1.288	0.016	0.000	0.016
1.165	20.58	-9.52	-0.29	2.37	2.08	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.950	19.83	-13.73	-0.41	2.28	1.87	0.00	147.09	7.41	2.000	1.288	0.013	0.000	0.013
0.446	17.31	-14.93	-0.45	1.99	1.54	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.350	16.79	-15.21	-0.46	1.93	1.47	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	16.54	-15.56	-0.24	1.10	0.86	0.00	181.42	183.33	1.992	2.000	0.005	0.000	0.005
0.153	0.31	5.65	0.09	0.02	0.11	0.00	165.86	183.33	1.929	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
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   UR1    = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2    = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 70 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 5.65 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	0.97	3.7	0.427	220.63	0.292	1.033	0.254	1.000	3426.29	220.63	147.09
5.789	160.2	10.6275	1.0	0.97	4.1	0.403	220.63	0.292	1.004	0.286	1.000	2694.56	220.63	147.09
5.456	145.5	10.6275	1.0	0.97	4.6	0.383	220.63	0.292	0.979	0.315	0.980	2222.90	216.14	144.09
5.137	145.5	10.6275	1.0	0.97	4.6	0.383	220.63	0.293	0.979	0.314	0.982	2237.41	216.63	144.42

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 5.000 145.5 10.6275 1.0 0.98 4.6 0.383 220.63 0.294 0.979 0.313 0.983 2245.19 216.89
144.59
 4.863 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2276.90 217.97
145.31
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2323.12 219.54
146.36
 2.450 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2362.43 220.63
147.09
 1.385 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2396.78 220.63
147.09
 1.275 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2407.95 220.63
147.09
 1.165 145.5 10.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2425.85 220.63
147.09
 0.950 145.5 10.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2502.67 220.63
147.09
 0.446 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.329 0.979 0.322 1.000 2659.72 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.331 0.979 0.320 1.000 2677.92 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.328 0.979 0.340 0.990 2381.90 272.13
181.42
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.219 0.979 0.340 0.905 2381.90 248.79
165.86

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00

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5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.16	-0.19	0.00	-0.19	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	0.62	-3.06	-0.51	1.33	0.82	0.00	130.14	24.57	1.958	1.384	0.006	0.000	0.006
11.500	1.68	-3.83	-0.39	2.23	1.84	0.00	145.11	71.07	1.990	1.612	0.013	0.000	0.013
11.467	1.70	-4.75	-0.48	2.26	1.78	0.00	145.11	71.07	1.990	1.612	0.012	0.000	0.012
11.385	1.77	-4.93	-0.50	2.35	1.85	0.00	145.11	71.07	1.990	1.612	0.013	0.000	0.013
11.257	1.88	-5.17	-0.44	1.74	1.30	0.00	143.11	50.11	1.980	1.505	0.009	0.000	0.009
11.128	1.99	-5.40	-0.39	1.36	0.97	0.00	141.19	37.29	1.970	1.440	0.007	0.000	0.007
11.000	2.12	-5.84	-0.37	1.11	0.74	0.00	139.35	28.85	1.961	1.397	0.005	0.000	0.005
10.699	2.43	27.00	1.73	1.27	3.00	0.00	139.35	28.85	1.961	1.397	0.021	0.001	0.021
10.400	1.00	19.95	1.28	0.53	1.80	0.00	139.35	28.85	1.961	1.397	0.013	0.000	0.013
8.400	6.03	16.12	1.03	3.16	4.19	0.00	139.35	28.85	1.961	1.397	0.030	0.001	0.030
6.456	11.56	13.93	0.89	6.05	6.94	0.00	139.35	28.85	1.961	1.397	0.050	0.003	0.050
6.123	12.38	13.00	0.60	3.41	4.02	0.00	147.09	15.58	2.000	1.329	0.027	0.001	0.027
5.789	13.14	12.08	0.44	2.23	2.67	0.00	146.14	10.00	1.995	1.301	0.018	0.000	0.018
5.456	13.85	11.01	0.33	1.59	1.93	0.00	142.24	7.41	1.975	1.288	0.014	0.000	0.014
5.137	14.47	10.15	0.28	1.66	1.94	0.00	142.78	7.41	1.978	1.288	0.014	0.000	0.014
5.000	14.72	9.17	0.29	1.83	2.11	0.00	143.01	7.41	1.979	1.288	0.015	0.000	0.015
4.863	14.94	5.58	0.17	1.72	1.89	0.00	143.96	7.41	1.984	1.288	0.013	0.000	0.013
3.100	16.67	0.89	0.03	1.92	1.95	0.00	145.53	7.41	1.992	1.288	0.013	0.000	0.013
2.450	16.78	-2.72	-0.08	1.93	1.85	0.00	146.74	7.41	1.998	1.288	0.013	0.000	0.013
1.385	16.26	-5.20	-0.15	1.87	1.72	0.00	147.09	7.41	2.000	1.288	0.012	0.000	0.012
1.275	16.16	-5.96	-0.19	2.03	1.85	0.00	147.09	7.41	2.000	1.288	0.013	0.000	0.013
1.165	16.05	-6.65	-0.20	1.85	1.65	0.00	147.09	7.41	2.000	1.288	0.011	0.000	0.011

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 0.950  15.80 -11.06 -0.33  1.82  1.48  0.00 147.09   7.41 2.000 1.288 0.010 0.000 0.010
 0.446  14.81 -12.32 -0.37  1.70  1.33  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.350  14.60 -12.61 -0.38  1.68  1.30  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.305  14.50 -12.98 -0.20  0.97  0.76  0.00 181.13 183.33 1.991 2.000 0.004 0.000 0.004
 0.153   0.16   5.92  0.09  0.01  0.10  0.00 164.80 183.33 1.924 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 80 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.92 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000

          Since Nratio <= 0.1 then Secondary Moments need not be considered.
```

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35

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 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.94 3.7 0.427 220.63 0.285 1.033 0.258 1.000 3320.16 220.63
147.09
 5.789 160.2 10.6275 1.0 0.93 4.1 0.403 220.63 0.283 1.004 0.291 0.994 2601.54 219.21
146.14
 5.456 145.5 10.6275 1.0 0.93 4.6 0.383 220.63 0.283 0.979 0.321 0.967 2140.75 213.36
142.24
 5.137 145.5 10.6275 1.0 0.94 4.6 0.383 220.63 0.285 0.979 0.319 0.971 2164.72 214.17
142.78
 5.000 145.5 10.6275 1.0 0.95 4.6 0.383 220.63 0.286 0.979 0.318 0.972 2174.95 214.51
143.01
 4.863 145.5 10.6275 1.0 0.96 4.6 0.383 220.63 0.291 0.979 0.315 0.979 2217.21 215.94
143.96
 3.100 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.989 2286.54 218.30
145.53
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.998 2339.99 220.12
146.74
 1.385 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.309 0.979 0.305 1.000 2379.24 220.63
147.09
 1.275 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2392.46 220.63
147.09
 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2410.95 220.63
147.09
 0.950 145.5 10.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2505.46 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2647.01 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.329 0.979 0.322 1.000 2660.00 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.327 0.979 0.340 0.988 2381.90 271.69
181.13
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.210 0.979 0.340 0.899 2381.90 247.20
164.80

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57

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11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.18	-0.20	0.00	-0.20	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	0.00	-3.11	-0.52	0.00	-0.52	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
11.500	0.00	-3.88	-0.39	0.00	-0.39	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.467	0.00	-4.83	-0.49	0.00	-0.49	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.385	0.00	-5.01	-0.51	0.00	-0.51	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.257	0.00	-5.25	-0.45	0.00	-0.45	0.00	143.11	50.11	1.980	1.505	0.000	0.000	0.000
11.128	0.00	-5.49	-0.40	0.00	-0.40	0.00	141.19	37.29	1.970	1.440	0.000	0.000	0.000
11.000	0.00	-5.93	-0.38	0.00	-0.38	0.00	139.35	28.85	1.961	1.397	0.000	0.000	0.000
10.699	0.00	53.76	3.44	0.00	3.44	0.00	139.35	28.85	1.961	1.397	0.025	0.001	0.025
10.400	0.00	40.04	2.56	0.00	2.56	0.00	139.35	28.85	1.961	1.397	0.018	0.000	0.018
8.400	0.00	36.15	2.31	0.00	2.31	0.00	139.35	28.85	1.961	1.397	0.017	0.000	0.017

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```
 6.456   0.00 33.92  2.17  0.00  2.17  0.00 139.35  28.85 1.961 1.397 0.016 0.000 0.016
 6.123   0.00 32.98  1.53  0.00  1.53  0.00 134.09  15.58 1.934 1.329 0.011 0.000 0.011
 5.789   0.00 32.04  1.17  0.00  1.17  0.00 129.16  10.00 1.909 1.301 0.009 0.000 0.009
 5.456   0.00 30.96  0.93  0.00  0.93  0.00 124.44   7.41 1.885 1.288 0.007 0.000 0.007
 5.137   0.00 30.09  0.84  0.00  0.84  0.00 124.44   7.41 1.885 1.288 0.007 0.000 0.007
 5.000   0.00 29.09  0.91  0.00  0.91  0.00 124.44   7.41 1.885 1.288 0.007 0.000 0.007
 4.863   0.00 25.45  0.77  0.00  0.77  0.00 124.44   7.41 1.885 1.288 0.006 0.000 0.006
 3.100   0.00 20.68  0.62  0.00  0.62  0.00 124.44   7.41 1.885 1.288 0.005 0.000 0.005
 2.450   0.00 17.01  0.51  0.00  0.51  0.00 124.44   7.41 1.885 1.288 0.004 0.000 0.004
 1.385   0.00 14.50  0.42  0.00  0.42  0.00 124.44   7.41 1.885 1.288 0.003 0.000 0.003
 1.275   0.00 13.73  0.43  0.00  0.43  0.00 124.44   7.41 1.885 1.288 0.003 0.000 0.003
 1.165   0.00 13.03  0.39  0.00  0.39  0.00 124.44   7.41 1.885 1.288 0.003 0.000 0.003
 0.950   0.00  8.55  0.26  0.00  0.26  0.00 124.44   7.41 1.885 1.288 0.002 0.000 0.002
 0.446   0.00  7.27  0.22  0.00  0.22  0.00 149.63   7.68 1.862 1.281 0.001 0.000 0.001
 0.350   0.00  6.98  0.21  0.00  0.21  0.00 149.63   7.68 1.862 1.281 0.001 0.000 0.001
 0.305   0.00  6.60  0.10  0.00  0.10  0.00 163.59 183.33 1.919 2.000 0.001 0.000 0.001
 0.153   0.00  6.02  0.09  0.00  0.09  0.00 163.59 183.33 1.919 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 90 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 6.02 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev    w      l     Cxb  Cx  Dwk   ax    Fyk   Lxo   Lpx    Lx    Xx  s_xRcr  s_xRk
s_xRd
  m             m             mm          MPa                              MPa     MPa
MPa
------ ----- ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
```

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```
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.60 3.7 0.427 220.63 0.200 1.033 0.323 0.912 2119.71 201.14
134.09
 5.789 160.2 10.6275 1.0 0.60 4.1 0.403 220.63 0.200 1.004 0.363 0.878 1671.31 193.74
129.16
 5.456 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.137 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.000 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 4.863 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 3.100 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 2.450 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.385 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.275 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.165 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.950 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.446 145.5 10.6275 1.0 0.60 4.6 0.383 275.00 0.200 0.979 0.439 0.816 1429.14 224.44
149.63
 0.350 145.5 10.6275 1.0 0.60 4.6 0.383 275.00 0.200 0.979 0.439 0.816 1429.14 224.44
149.63
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.200 0.979 0.340 0.892 2381.90 245.39
163.59
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.200 0.979 0.340 0.892 2381.90 245.39
163.59

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
```

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l = Distance between stiffeners

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Structural Flange Analysis, Angle = 0 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 0 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M          = Moment on Flange                                              = 9775.9 N-m
V          = Vertical Load on Flange (- is compression, + is tension)      = 0 N
S          = Shear Load on Flange                                          = 3887 N

Ds         = Outer Diameter of Shell                                       = 323.8 mm
Do         = Outside Diameter of Flange                                    = 482.6 mm
Dbc        = Bolt Circle Diameter                                          = 431.8 mm
Tf         = Thickness of Flange                                           = 31.8 mm
Tw         = Fillet Weld Size                                              = 6.0 mm

Db         = Nominal Bolt Diameter                                         = 22.2 mm
Nb         = Number of Bolts                                               = 12
Fu         = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                  = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb         = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys        = Yield Stress of Shell                                         = 215.81 MPa
Fw         = Tensile Stress of Weld                                        = 413.68 MPa
Fyc        = Yield Stress of Flange                                        = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E          = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 7547 N
Ab         = Nominal Area of Bolt                                          = 3.879 sq cm
Km         = Stiffness of Material                                         = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                             = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby        = Bolt Yield Stress                                             = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 6866 N
Fact       = Actual force on bolt                                          = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.075

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 124964 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144438 N
Ratio      = Fb / Fbcomb                                                   = 0.865
```

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```
Sh        = Shear on Bolt                                          = 324 N
Sallow    = Allowable Shear on Bolt                                = 92281 N
Ratio     = Sh / Sallow                                            = 0.004

Check Welding
Iw        = Bending Moment of Inertia for Weld                     = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                       = 22621.48
cm^4
Aw        = Area of Weld                                           = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                     = 13993.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw            = 124.11 MPa
Ratio     = Fba / Sw                                               = 0.113

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                           = 87.6 mm
Lg        = Gross Flange area for each bolt                        = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area             = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge              = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                       = 54.0 mm
A         = Distance from Bolt CL to Flange OD                     = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole             = 42.9 mm
Rho       = Calculated Parameter                                   = 3.377
Beta      = Calulcated Parameter                                   = 5.6865
Alpha'    = Alpha where treq'd is minimum                          = 1
Tc        = Required thickness to develop load w/no prying         = 10.3 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 8.2 mm
Ratio     = Treqd / Tf                                             = 0.257
```

Structural Flange Analysis, Angle = 10 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 10 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 9627.4 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -674 N
S         = Shear Load on Flange                                   = 3826 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa
```

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```
Fys       = Yield Stress of Shell                                        = 215.81 MPa
Fw        = Tensile Stress of Weld                                       = 413.68 MPa
Fyc       = Yield Stress of Flange                                       = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                   = 194.22 MPa
E         = Modulus of Elasticity of Flange                              = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt               = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters             = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                              = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                         = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N      = 7376 N
Ab        = Nominal Area of Bolt                                         = 3.879 sq cm
Km        = Stiffness of Material                                        = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                            = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)       = 0.173
Fby       = Bolt Yield Stress                                            = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                 = 761869.3
KPa
Aroot     = Bolt Root Area                                               = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}             = 123659 N
K         = Coefficient of Thread Friction                               = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                      = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                     = 6710 N
Fact      = Actual force on bolt                                         = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact   = 0.073

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi         = 124934 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                   = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                   = 144439 N
Ratio     = Fb / Fbcomb                                                  = 0.865

Sh        = Shear on Bolt                                                = 319 N
Sallow    = Allowable Shear on Bolt                                      = 92281 N
Ratio     = Sh / Sallow                                                  = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                           = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                             = 22621.48
cm^4
Aw        = Area of Weld                                                 = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                           = 13858.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                  = 124.11 MPa
Ratio     = Fba / Sw                                                     = 0.112

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                 = 87.6 mm
Lg        = Gross Flange area for each bolt                              = 113.0 mm
```

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```
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 5.8251
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 10.2 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 8.1 mm
Ratio     = Treqd / Tf                                                  = 0.254
```

Structural Flange Analysis, Angle = 20 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 20 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 9186.3 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -1328 N
S         = Shear Load on Flange                                        = 3651 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 6981 N
Ab        = Nominal Area of Bolt                                        = 3.879 sq cm
```

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```
Km          = Stiffness of Material                                    = 5922221.21
N/mm
Kb          = Stiffness of Bolt                                        = 1238416.78
N/mm
CC          = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby         = Bolt Yield Stress                                        = 896316.8
KPa
Fproof      = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot       = Bolt Root Area                                           = 2.705 sq cm
Fi          = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K           = Coefficient of Thread Friction                           = 0.000
Tb          = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin        = Min. Force to keep Flange in Compression                 = 6351 N
Fact        = Actual force on bolt                                     = 91479 N
Ratio       = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.069

Fb          = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 124866 N
Fballow     = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb      = Allowable Bolt Tensile Load (Tens & Shear)               = 144439 N
Ratio       = Fb / Fbcomb                                              = 0.864

Sh          = Shear on Bolt                                            = 304 N
Sallow      = Allowable Shear on Bolt                                  = 92281 N
Ratio       = Sh / Sallow                                              = 0.003

Check Welding
Iw          = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw          = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw          = Area of Weld                                             = 86.303 sq
cm
Fba         = Weld Stress due to Axial & Bending                       = 13303.0 KPa
Sw          = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw              = 124.11 MPa
Ratio       = Fba / Sw                                                 = 0.107

Design Flange: NO GUSSETS
Ln          = Net Flange area at each bolt                             = 87.6 mm
Lg          = Gross Flange area for each bolt                          = 113.0 mm
Delta       = Ratio of net area(@bolt line) & gross area               = 0.7753
A'          = Distance from Flange OD to Bolt Hole Edge                = 12.7 mm
B           = Distance from Bolt CL to Pipe OD                         = 54.0 mm
A           = Distance from Bolt CL to Flange OD                       = 25.4 mm
B'          = Distance from Pipe OD to edge of Bolt Hole               = 42.9 mm
Rho         = Calculated Parameter                                     = 3.377
Beta        = Calulcated Parameter                                     = 6.1714
Alpha'      = Alpha where treq'd is minimum                            = 1
Tc          = Required thickness to develop load w/no prying           = 9.9 mm
Alpha       = Ratio mom@ BL to Mom @ stem line                         = 0
Q           = Prying Force per bolt                                    = 0 N
Treq'd      = Required Flange Thickness                                = 7.8 mm
Ratio       = Treqd / Tf                                               = 0.247
```

Structural Flange Analysis, Angle = 30 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 30 Deg , Load # 4

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Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 8466.2 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -1942 N
S	= Shear Load on Flange	= 3364 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 6374 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 5799 N
Fact	= Actual force on bolt	= 91479 N
Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.063
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 124761 N

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```
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                  = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                  = 144439 N
Ratio     = Fb / Fbcomb                                                 = 0.864

Sh        = Shear on Bolt                                               = 280 N
Sallow    = Allowable Shear on Bolt                                     = 92281 N
Ratio     = Sh / Sallow                                                 = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                          = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                            = 22621.48
cm^4
Aw        = Area of Weld                                                = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                          = 12343.3 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                 = 124.11 MPa
Ratio     = Fba / Sw                                                    = 0.099

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 6.7874
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 9.5 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 7.5 mm
Ratio     = Treqd / Tf                                                  = 0.236
```

Structural Flange Analysis, Angle = 40 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 40 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 7488.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -2497 N
S         = Shear Load on Flange                                        = 2977 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
```

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```
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys       = Yield Stress of Shell                                         = 215.81 MPa
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
Fyc       = Yield Stress of Flange                                        = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E         = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 5573 N
Ab        = Nominal Area of Bolt                                          = 3.879 sq cm
Km        = Stiffness of Material                                         = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                             = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby       = Bolt Yield Stress                                             = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 5070 N
Fact      = Actual force on bolt                                          = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.055

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 124622 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144439 N
Ratio     = Fb / Fbcomb                                                   = 0.863

Sh        = Shear on Bolt                                                 = 248 N
Sallow    = Allowable Shear on Bolt                                       = 92281 N
Ratio     = Sh / Sallow                                                   = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw        = Area of Weld                                                  = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                            = 11008.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                   = 124.11 MPa
Ratio     = Fba / Sw                                                      = 0.089
```

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```
Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 7.8052
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 8.9 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 7.0 mm
Ratio     = Treqd / Tf                                                  = 0.221
```

Structural Flange Analysis, Angle = 50 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 50 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 6283.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -2975 N
S         = Shear Load on Flange                                        = 2497 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509
```

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```
BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N          = 4603 N
Ab         = Nominal Area of Bolt                                             = 3.879 sq cm
Km         = Stiffness of Material                                            = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                                = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)           = 0.173
Fby        = Bolt Yield Stress                                                = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                     = 761869.3
KPa
Aroot      = Bolt Root Area                                                   = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}                 = 123659 N
K          = Coefficient of Thread Friction                                   = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                          = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                         = 4188 N
Fact       = Actual force on bolt                                             = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact       = 0.046

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi             = 124455 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                       = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                       = 144439 N
Ratio      = Fb / Fbcomb                                                      = 0.862

Sh         = Shear on Bolt                                                    = 208 N
Sallow     = Allowable Shear on Bolt                                          = 92281 N
Ratio      = Sh / Sallow                                                      = 0.002

Check Welding
Iw         = Bending Moment of Inertia for Weld                               = 11310.74
cm^4
Jw         = Polar Moment of Inertia for Weld                                 = 22621.48
cm^4
Aw         = Area of Weld                                                     = 86.303 sq
cm
Fba        = Weld Stress due to Axial & Bending                               = 9339.3 KPa
Sw         = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                      = 124.11 MPa
Ratio      = Fba / Sw                                                         = 0.075

Design Flange: NO GUSSETS
Ln         = Net Flange area at each bolt                                     = 87.6 mm
Lg         = Gross Flange area for each bolt                                  = 113.0 mm
Delta      = Ratio of net area(@bolt line) & gross area                       = 0.7753
A'         = Distance from Flange OD to Bolt Hole Edge                        = 12.7 mm
B          = Distance from Bolt CL to Pipe OD                                 = 54.0 mm
A          = Distance from Bolt CL to Flange OD                               = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                       = 42.9 mm
Rho        = Calculated Parameter                                             = 3.377
Beta       = Calulcated Parameter                                             = 9.5125
Alpha'     = Alpha where treq'd is minimum                                    = 1
Tc         = Required thickness to develop load w/no prying                   = 8.0 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                                 = 0
Q          = Prying Force per bolt                                            = 0 N
Treq'd     = Required Flange Thickness                                        = 6.4 mm
Ratio      = Treqd / Tf                                                       = 0.200
```

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Structural Flange Analysis, Angle = 60 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 60 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 4887.9 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -3364 N
S	= Shear Load on Flange	= 1942 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 3493 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 3178 N
Fact	= Actual force on bolt	= 91479 N

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Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.035
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 124263 N
Fballow	= Allowable Bolt Tensile Load (Pure Tension)	= 152464 N
Fbcomb	= Allowable Bolt Tensile Load (Tens & Shear)	= 144439 N
Ratio	= Fb / Fbcomb	= 0.860
Sh	= Shear on Bolt	= 162 N
Sallow	= Allowable Shear on Bolt	= 92281 N
Ratio	= Sh / Sallow	= 0.002

Check Welding

Iw	= Bending Moment of Inertia for Weld	= 11310.74 cm^4
Jw	= Polar Moment of Inertia for Weld	= 22621.48 cm^4
Aw	= Area of Weld	= 86.303 sq cm
Fba	= Weld Stress due to Axial & Bending	= 7386.2 KPa
Sw	= Allowable Fillet Weld Stress: (ASD) 0.3*Fuw	= 124.11 MPa
Ratio	= Fba / Sw	= 0.060

Design Flange: NO GUSSETS

Ln	= Net Flange area at each bolt	= 87.6 mm
Lg	= Gross Flange area for each bolt	= 113.0 mm
Delta	= Ratio of net area(@bolt line) & gross area	= 0.7753
A'	= Distance from Flange OD to Bolt Hole Edge	= 12.7 mm
B	= Distance from Bolt CL to Pipe OD	= 54.0 mm
A	= Distance from Bolt CL to Flange OD	= 25.4 mm
B'	= Distance from Pipe OD to edge of Bolt Hole	= 42.9 mm
Rho	= Calculated Parameter	= 3.377
Beta	= Calulcated Parameter	= 12.6293
Alpha'	= Alpha where treq'd is minimum	= 1
Tc	= Required thickness to develop load w/no prying	= 7.0 mm
Alpha	= Ratio mom@ BL to Mom @ stem line	= 0
Q	= Prying Force per bolt	= 0 N
Treq'd	= Required Flange Thickness	= 5.5 mm
Ratio	= Treqd / Tf	= 0.175

Structural Flange Analysis, Angle = 70 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 70 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 3343.5 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -3650 N
S	= Shear Load on Flange	= 1328 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm

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```
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu             = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy               = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 2277 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 2071 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.023

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 124052 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.859

Sh        = Shear on Bolt                                            = 111 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.001

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw        = Area of Weld                                             = 86.303 sq
cm
```

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```
Fba       = Weld Stress due to Axial & Bending                    = 5208.8 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw           = 124.11 MPa
Ratio     = Fba / Sw                                              = 0.042

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                          = 87.6 mm
Lg        = Gross Flange area for each bolt                       = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area            = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge             = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                      = 54.0 mm
A         = Distance from Bolt CL to Flange OD                    = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole            = 42.9 mm
Rho       = Calculated Parameter                                  = 3.377
Beta      = Calulcated Parameter                                  = 19.5326
Alpha'    = Alpha where treq'd is minimum                         = 1
Tc        = Required thickness to develop load w/no prying        = 5.7 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                      = 0
Q         = Prying Force per bolt                                 = 0 N
Treq'd    = Required Flange Thickness                             = 4.5 mm
Ratio     = Treqd / Tf                                            = 0.141
```

Structural Flange Analysis, Angle = 80 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 80 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                      = 1697.6 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -3825 N
S         = Shear Load on Flange                                  = 674 N

Ds        = Outer Diameter of Shell                               = 323.8 mm
Do        = Outside Diameter of Flange                            = 482.6 mm
Dbc       = Bolt Circle Diameter                                  = 431.8 mm
Tf        = Thickness of Flange                                   = 31.8 mm
Tw        = Fillet Weld Size                                      = 6.0 mm

Db        = Nominal Bolt Diameter                                 = 22.2 mm
Nb        = Number of Bolts                                       = 12
Fu        = Ultimate Bolt Tensile Stress                          = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu          = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy            = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                          = 60.00 %
Eb        = Modulus of Elasticity for Bolt                        = 202705.50
MPa

Fys       = Yield Stress of Shell                                 = 215.81 MPa
Fw        = Tensile Stress of Weld                                = 413.68 MPa
Fyc       = Yield Stress of Flange                                = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy            = 194.22 MPa
E         = Modulus of Elasticity of Flange                       = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt        = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters      = 10.00
```

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```
Spmax     = Maximum bolt spacing: Bspace*Db                              = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                         = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N      = 992 N
Ab        = Nominal Area of Bolt                                         = 3.879 sq cm
Km        = Stiffness of Material                                        = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                            = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)       = 0.173
Fby       = Bolt Yield Stress                                            = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                 = 761869.3
KPa
Aroot     = Bolt Root Area                                               = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}             = 123659 N
K         = Coefficient of Thread Friction                               = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                      = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                     = 902 N
Fact      = Actual force on bolt                                         = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact   = 0.010

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi         = 123830 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                   = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                   = 144440 N
Ratio     = Fb / Fbcomb                                                  = 0.857

Sh        = Shear on Bolt                                                = 56 N
Sallow    = Allowable Shear on Bolt                                      = 92281 N
Ratio     = Sh / Sallow                                                  = 0.001

Check Welding
Iw        = Bending Moment of Inertia for Weld                           = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                             = 22621.48
cm^4
Aw        = Area of Weld                                                 = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                           = 2873.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                  = 124.11 MPa
Ratio     = Fba / Sw                                                     = 0.023

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                 = 87.6 mm
Lg        = Gross Flange area for each bolt                              = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                   = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                    = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                             = 54.0 mm
A         = Distance from Bolt CL to Flange OD                           = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                   = 42.9 mm
Rho       = Calculated Parameter                                         = 3.377
Beta      = Calulcated Parameter                                         = 45.2309
Alpha'    = Alpha where treq'd is minimum                                = 1
Tc        = Required thickness to develop load w/no prying               = 3.7 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                             = 0
Q         = Prying Force per bolt                                        = 0 N
```

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```
Treq'd    = Required Flange Thickness                                  = 3.0 mm
Ratio     = Treqd / Tf                                                 = 0.093
```

Structural Flange Analysis, Angle = 90 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 90 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                           = 0.0 N-m
V         = Vertical Load on Flange (- is compression, + is tension)   = -3884 N
S         = Shear Load on Flange                                       = 0 N

Ds        = Outer Diameter of Shell                                    = 323.8 mm
Do        = Outside Diameter of Flange                                 = 482.6 mm
Dbc       = Bolt Circle Diameter                                       = 431.8 mm
Tf        = Thickness of Flange                                        = 31.8 mm
Tw        = Fillet Weld Size                                           = 6.0 mm

Db        = Nominal Bolt Diameter                                      = 22.2 mm
Nb        = Number of Bolts                                            = 12
Fu        = Ultimate Bolt Tensile Stress                               = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu               = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                 = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                               = 60.00 %
Eb        = Modulus of Elasticity for Bolt                             = 202705.50
MPa

Fys       = Yield Stress of Shell                                      = 215.81 MPa
Fw        = Tensile Stress of Weld                                     = 413.68 MPa
Fyc       = Yield Stress of Flange                                     = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                 = 194.22 MPa
E         = Modulus of Elasticity of Flange                            = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt             = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters           = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                            = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                       = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N    = 0 N
Ab        = Nominal Area of Bolt                                       = 3.879 sq cm
Km        = Stiffness of Material                                      = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                          = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)     = 0.173
Fby       = Bolt Yield Stress                                          = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                               = 761869.3
KPa
Aroot     = Bolt Root Area                                             = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}           = 123659 N
K         = Coefficient of Thread Friction                             = 0.000
```

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```
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                    = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                   = 0 N
Fact      = Actual force on bolt                                       = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi       = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                 = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                 = 144440 N
Ratio     = Fb / Fbcomb                                                = 0.856

Sh        = Shear on Bolt                                              = 0 N
Sallow    = Allowable Shear on Bolt                                    = 92281 N
Ratio     = Sh / Sallow                                                = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                         = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                           = 22621.48
cm^4
Aw        = Area of Weld                                               = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                         = 450.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                = 124.11 MPa
Ratio     = Fba / Sw                                                   = 0.004

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                               = 87.6 mm
Lg        = Gross Flange area for each bolt                            = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                 = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                  = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                           = 54.0 mm
A         = Distance from Bolt CL to Flange OD                         = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                 = 42.9 mm
Rho       = Calculated Parameter                                       = 3.377
Beta      = Calulcated Parameter                                       = 0
Alpha'    = Alpha where treq'd is minimum                              = 0
Tc        = Required thickness to develop load w/no prying             = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                           = 0
Q         = Prying Force per bolt                                      = 0 N
Treq'd    = Required Flange Thickness                                  = 0.0 mm
Ratio     = Treqd / Tf                                                 = 0.000
```

Conical Transition Analysis, Angle = 0 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63

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```
E:     Modulus of Elasticity (MPa)                    202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                      117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                              412.65      412.65
412.65

M:     Overturning Moment (KN-m)                          10.17        0.00
12.19
V:     Vertical Axial Loading (KN)                         0.00        0.00
0.00
Sx:    Section Modulus (cm^3)                            750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                       98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.00        0.00
0.00
fb:    Bending Strss - M/Sx (MPa)                         13.56       13.94
6.38
fb':   Localized Bending Stress (MPa)                     15.66       15.66
9.23
fh':   Hoop Stress (MPa)                                   8.30        0.00
4.90
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                     2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                     3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                13.56       13.94
6.38
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          29.21       29.60
15.62
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.102	PASS	0.105	PASS	0.048	PASS
Check 2: Stot1 / Ft	0.071	PASS	0.072	PASS	0.038	PASS
Check 3: fh' < Fh	0.075	PASS	0.000	PASS	0.044	PASS
Stiff Ring Req'd?	0.102	Not Req'd	0.105	Cone OK	0.048	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 0 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	33.40	0.00	38.78
V:	Vertical Axial Loading (KN)	0.00	0.00	0.00
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.00	0.00	0.00
fb:	Bending Strss - M/Sx (MPa)	17.48	18.15	4.46
fb':	Localized Bending Stress (MPa)	29.54	29.54	10.93
fh':	Hoop Stress (MPa)	15.67	0.00	5.80
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	17.48	18.15	4.46
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	47.03	47.69	15.39
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.132	PASS	0.137	PASS	0.037	PASS
Check 2: Stot1 / Ft	0.114	PASS	0.116	PASS	0.037	PASS
Check 3: fh' < Fh	0.142	PASS	0.000	PASS	0.058	PASS
Stiff Ring Req'd?	0.142	Not Req'd	0.137	Cone OK	0.058	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 10 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	10.02	0.00	12.01
V:	Vertical Axial Loading (KN)	0.84	0.00	0.95
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.09	0.09	0.06
fb:	Bending Strss - M/Sx (MPa)	13.35	13.73	6.29
fb':	Localized Bending Stress (MPa)	15.52	15.52	9.18
fh':	Hoop Stress (MPa)	8.23	0.00	4.87
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)             13.44       13.81
6.35
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       28.95       29.33
15.53
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.101	PASS	0.104	PASS	0.048	PASS
Check 2: Stot1 / Ft	0.070	PASS	0.071	PASS	0.038	PASS
Check 3: fh' < Fh	0.075	PASS	0.000	PASS	0.044	PASS
Stiff Ring Req'd?	0.101	Not Req'd	0.104	Cone OK	0.048	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     34.29        0.00
39.93
V:     Vertical Axial Loading (KN)                    1.54        0.00
0.83
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.10        0.10
0.03
fb:    Bending Strss - M/Sx (MPa)                    17.95       18.64
4.59
```

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```
fb':   Localized Bending Stress (MPa)                    30.50       30.50
11.31
fh':   Hoop Stress (MPa)                                 16.17        0.00
6.00
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               18.05       18.74
4.62
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         48.55       49.24
15.93
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.136	PASS	0.142	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.119	PASS	0.039	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.060	PASS
Stiff Ring Req'd?	0.147	Not Req'd	0.142	Cone OK	0.060	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 20 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65
```

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M:	Overturning Moment (KN-m)	9.56	0.00
11.46			
V:	Vertical Axial Loading (KN)	1.65	0.00
1.88			
Sx:	Section Modulus (cm^3)	750.3	750.3
1910.2			
Ax:	Cross Sectional Area (sq cm)	98.583	98.583
156.451			

CALCULATE STRESSES:

fa:	Axial Stress - V/Ax (MPa)	0.17	0.17
0.12			
fb:	Bending Strss - M/Sx (MPa)	12.74	13.10
6.00			
fb':	Localized Bending Stress (MPa)	14.91	14.91
8.85			
fh':	Hoop Stress (MPa)	7.91	0.00
4.69			
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08
1596.11			
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63
220.63			
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32
110.32			
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12
2394.16			
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63
220.63			
Stot:	Total Stress Check 1: fa + fb (MPa)	12.91	13.27
6.12			
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	27.81	28.18
14.97			
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38
132.38			
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32
110.32			

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.097	PASS	0.100	PASS	0.046	PASS
Check 2: Stot1 / Ft	0.067	PASS	0.068	PASS	0.036	PASS
Check 3: fh' < Fh	0.072	PASS	0.000	PASS	0.043	PASS
Stiff Ring Req'd?	0.097	Not Req'd	0.100	Cone OK	0.046	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	
0.0				
OD:	Outer Diameter (mm)	508.0	0.0	
1066.8				

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```
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     34.11        0.00
39.81
V:     Vertical Axial Loading (KN)                    3.16        0.00
1.75
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                 156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.20        0.21
0.05
fb:    Bending Strss - M/Sx (MPa)                    17.85       18.54
4.58
fb':   Localized Bending Stress (MPa)                30.51       30.51
11.35
fh':   Hoop Stress (MPa)                             16.18        0.00
6.02
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                         220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                  110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                         220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)            18.06       18.75
4.63
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)      48.57       49.26
15.98
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                        110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.136	PASS	0.142	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.119	PASS	0.039	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.060	PASS
Stiff Ring Req'd?	0.147	Not Req'd	0.142	Cone OK	0.060	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 30 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	8.81	0.00	10.56
V:	Vertical Axial Loading (KN)	2.41	0.00	2.74
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.24	0.25	0.18
fb:	Bending Strss - M/Sx (MPa)	11.74	12.07	5.53
fb':	Localized Bending Stress (MPa)	13.84	13.84	8.25
fh':	Hoop Stress (MPa)	7.34	0.00	4.38
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	11.98	12.32	5.70
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	25.83	26.17	13.95

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```
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.091	PASS	0.093	PASS	0.043	PASS
Check 2: Stot1 / Ft	0.063	PASS	0.063	PASS	0.034	PASS
Check 3: fh' < Fh	0.067	PASS	0.000	PASS	0.040	PASS
Stiff Ring Req'd?	0.091	Not Req'd	0.093	Cone OK	0.043	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       32.85        0.00
38.44
V:     Vertical Axial Loading (KN)                      4.81        0.00
2.76
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                 156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.31        0.32
0.08
fb:    Bending Strss - M/Sx (MPa)                      17.19       17.85
4.42
fb':   Localized Bending Stress (MPa)                  29.57       29.57
11.03
fh':   Hoop Stress (MPa)                               15.68        0.00
5.85
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                  1596.11     1596.11
760.05
```

```
Fhc:   Hoop Comp - Fys (MPa)                          220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                   110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                  2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)             17.50       18.17
4.51
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       47.08       47.75
15.54
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.132	PASS	0.137	PASS	0.038	PASS
Check 2: Stot1 / Ft	0.114	PASS	0.116	PASS	0.038	PASS
Check 3: fh' < Fh	0.142	PASS	0.000	PASS	0.058	PASS
Stiff Ring Req'd?	0.142	Not Req'd	0.137	Cone OK	0.058	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 40 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      7.79        0.00
9.34
V:     Vertical Axial Loading (KN)                    3.10        0.00
3.53
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
```

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```
Ax:    Cross Sectional Area (sq cm)                      98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.31        0.32
0.23
fb:    Bending Strss - M/Sx (MPa)                        10.38       10.68
4.89
fb':   Localized Bending Stress (MPa)                    12.36       12.36
7.40
fh':   Hoop Stress (MPa)                                  6.55        0.00
3.92
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               10.70       11.00
5.11
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         23.06       23.36
12.51
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.081	PASS	0.083	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.056	PASS	0.057	PASS	0.030	PASS
Check 3: fh' < Fh	0.059	PASS	0.000	PASS	0.036	PASS
Stiff Ring Req'd?	0.081	Not Req'd	0.083	Cone OK	0.039	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small        Cone       Large
Ht:    Height of Cone (mm)                                0.0      1000.0
0.0
OD:    Outer Diameter (mm)                              508.0         0.0
1066.8
T:     Thickness (mm)                                    10.0        10.0
10.0
Fys:   Yield Stress (MPa)                               220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                   202705.50   202705.50
202705.50
```

```
Sa:    Allowable Axial Stress (MPa)                    117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                            412.65      412.65
412.65

M:     Overturning Moment (KN-m)                        30.54        0.00
35.83
V:     Vertical Axial Loading (KN)                       6.48        0.00
3.84
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                    156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.41        0.43
0.12
fb:    Bending Strss - M/Sx (MPa)                       15.99       16.60
4.12
fb':   Localized Bending Stress (MPa)                   27.71       27.71
10.38
fh':   Hoop Stress (MPa)                                14.70        0.00
5.51
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              16.40       17.03
4.24
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        44.12       44.74
14.62
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.124	PASS	0.129	PASS	0.036	PASS
Check 2: Stot1 / Ft	0.107	PASS	0.108	PASS	0.035	PASS
Check 3: fh' < Fh	0.133	PASS	0.000	PASS	0.055	PASS
Stiff Ring Req'd?	0.133	Not Req'd	0.129	Cone OK	0.055	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 50 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 50 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	6.54	0.00	7.84
V:	Vertical Axial Loading (KN)	3.70	0.00	4.20
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.38	0.39	0.27
fb:	Bending Strss - M/Sx (MPa)	8.71	8.96	4.10
fb':	Localized Bending Stress (MPa)	10.50	10.50	6.32
fh':	Hoop Stress (MPa)	5.57	0.00	3.35
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	9.09	9.35	4.37
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	19.59	19.84	10.69
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.069	PASS	0.071	PASS	0.033	PASS
Check 2: Stot1 / Ft	0.047	PASS	0.048	PASS	0.026	PASS
Check 3: fh' < Fh	0.050	PASS	0.000	PASS	0.030	PASS
Stiff Ring Req'd?	0.069	Not Req'd	0.071	Cone OK	0.033	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	27.24	0.00	32.06
V:	Vertical Axial Loading (KN)	8.17	0.00	5.03
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.52	0.54	0.15
fb:	Bending Strss - M/Sx (MPa)	14.26	14.81	3.69
fb':	Localized Bending Stress (MPa)	24.98	24.98	9.41
fh':	Hoop Stress (MPa)	13.25	0.00	4.99
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75

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```
Stot:  Total Stress Check 1: fa + fb (MPa)                  14.78       15.35
3.84
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)            39.76       40.33
13.25
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                      132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                              110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.112	PASS	0.116	PASS	0.032	PASS
Check 2: Stot1 / Ft	0.096	PASS	0.098	PASS	0.032	PASS
Check 3: fh' < Fh	0.120	PASS	0.000	PASS	0.050	PASS
Stiff Ring Req'd?	0.120	Not Req'd	0.116	Cone OK	0.050	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 60 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      5.09        0.00
6.10
V:     Vertical Axial Loading (KN)                    4.18        0.00
4.75
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.42        0.44
0.30
fb:    Bending Strss - M/Sx (MPa)                     6.78        6.97
3.19
```

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```
fb':   Localized Bending Stress (MPa)                    8.32        8.32
5.06
fh':   Hoop Stress (MPa)                                 4.41        0.00
2.68
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               7.20        7.41
3.49
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        15.52       15.72
8.55
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.054	PASS	0.056	PASS	0.026	PASS
Check 2: Stot1 / Ft	0.038	PASS	0.038	PASS	0.021	PASS
Check 3: fh' < Fh	0.040	PASS	0.000	PASS	0.024	PASS
Stiff Ring Req'd?	0.054	Not Req'd	0.056	Cone OK	0.026	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       23.00        0.00
27.18
```

```
V:     Vertical Axial Loading (KN)                          9.98        0.00
6.43
Sx:    Section Modulus (cm^3)                             1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                       156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                            0.64        0.66
0.19
fb:    Bending Strss - M/Sx (MPa)                          12.04       12.50
3.13
fb':   Localized Bending Stress (MPa)                      21.43       21.43
8.13
fh':   Hoop Stress (MPa)                                   11.36        0.00
4.31
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                      1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                               220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                        110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                      2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                               220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                 12.68       13.17
3.32
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)           34.11       34.59
11.46
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                      132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                              110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.096	PASS	0.099	PASS	0.028	PASS
Check 2: Stot1 / Ft	0.083	PASS	0.084	PASS	0.028	PASS
Check 3: fh' < Fh	0.103	PASS	0.000	PASS	0.043	PASS
Stiff Ring Req'd?	0.103	Not Req'd	0.099	Cone OK	0.043	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 70 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small        Cone       Large
Ht:    Height of Cone (mm)                                0.0       385.0
0.0
OD:    Outer Diameter (mm)                              323.8         0.0
508.0
```

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```
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      3.48        0.00
4.17
V:     Vertical Axial Loading (KN)                    4.54        0.00
5.16
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.46        0.47
0.33
fb:    Bending Strss - M/Sx (MPa)                     4.64        4.77
2.18
fb':   Localized Bending Stress (MPa)                 5.89        5.89
3.63
fh':   Hoop Stress (MPa)                              3.12        0.00
1.93
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                        220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                 110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                        220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)            5.10        5.24
2.51
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)     10.98       11.13
6.15
Fb:    Allow Bend (ASD): .6*Fxc (MPa)               132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                       110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.038	PASS	0.040	PASS	0.019	PASS
Check 2: Stot1 / Ft	0.027	PASS	0.027	PASS	0.015	PASS
Check 3: fh' < Fh	0.028	PASS	0.000	PASS	0.017	PASS
Stiff Ring Req'd?	0.038	Not Req'd	0.040	Cone OK	0.019	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	17.86	0.00	21.22
V:	Vertical Axial Loading (KN)	12.20	0.00	8.35
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.78	0.81	0.25
fb:	Bending Strss - M/Sx (MPa)	9.35	9.71	2.44
fb':	Localized Bending Stress (MPa)	17.12	17.12	6.59
fh':	Hoop Stress (MPa)	9.08	0.00	3.50
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	10.13	10.52	2.69
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	27.24	27.63	9.29
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25

```
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.077	PASS	0.079	PASS	0.023	PASS
Check 2: Stot1 / Ft	0.066	PASS	0.067	PASS	0.023	PASS
Check 3: fh' < Fh	0.082	PASS	0.000	PASS	0.035	PASS
Stiff Ring Req'd?	0.082	Not Req'd	0.079	Cone OK	0.035	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 80 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      1.77        0.00
2.12
V:     Vertical Axial Loading (KN)                    4.75        0.00
5.40
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.48        0.50
0.35
fb:    Bending Strss - M/Sx (MPa)                     2.35        2.42
1.11
fb':   Localized Bending Stress (MPa)                 3.28        3.28
2.10
fh':   Hoop Stress (MPa)                              1.74        0.00
1.12
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                2504.08     2504.08
1596.11
```

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Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	2.84	2.92	1.45
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	6.11	6.19	3.56
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.021	PASS	0.022	PASS	0.011	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.009	PASS
Check 3: fh' < Fh	0.016	PASS	0.000	PASS	0.010	PASS
Stiff Ring Req'd?	0.021	Not Req'd	0.022	Cone OK	0.011	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	11.56	0.00	13.85
V:	Vertical Axial Loading (KN)	16.12	0.00	12.08
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002

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```
CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          1.03        1.07
0.36
fb:    Bending Strss - M/Sx (MPa)                         6.05        6.28
1.59
fb':   Localized Bending Stress (MPa)                    11.97       11.97
4.79
fh':   Hoop Stress (MPa)                                  6.35        0.00
2.54
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                7.08        7.35
1.96
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         19.05       19.32
6.75
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.053	PASS	0.056	PASS	0.016	PASS
Check 2: Stot1 / Ft	0.046	PASS	0.047	PASS	0.016	PASS
Check 3: fh' < Fh	0.058	PASS	0.000	PASS	0.025	PASS
Stiff Ring Req'd?	0.058	Not Req'd	0.056	Cone OK	0.025	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 90 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
```

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```
Sa:    Allowable Axial Stress (MPa)                    117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                            412.65      412.65
412.65

M:     Overturning Moment (KN-m)                         0.00        0.00
0.00
V:     Vertical Axial Loading (KN)                       4.83        0.00
5.49
Sx:    Section Modulus (cm^3)                           750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                     98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.49        0.50
0.35
fb:    Bending Strss - M/Sx (MPa)                        0.00        0.00
0.00
fb':   Localized Bending Stress (MPa)                    0.57        0.57
0.51
fh':   Hoop Stress (MPa)                                 0.30        0.00
0.27
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               0.49        0.50
0.35
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         1.06        1.07
0.86
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.004	PASS	0.004	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.003	PASS	0.003	PASS	0.002	PASS
Check 3: fh' < Fh	0.003	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.004	Not Req'd	0.004	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

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		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.00	0.00	0.00
V:	Vertical Axial Loading (KN)	36.15	0.00	32.04
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	2.31	2.40	0.97
fb:	Bending Strss - M/Sx (MPa)	0.00	0.00	0.00
fb':	Localized Bending Stress (MPa)	3.90	3.90	2.36
fh':	Hoop Stress (MPa)	2.07	0.00	1.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	2.31	2.40	0.97
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	6.21	6.30	3.33
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result

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Check 1: Stot / Fb	0.017	PASS	0.018	PASS	0.008	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.008	PASS
Check 3: fh' < Fh	0.019	PASS	0.000	PASS	0.012	PASS
Stiff Ring Req'd?	0.019	Not Req'd	0.018	Cone OK	0.012	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Stack Deflection Lift Angle = 0 Deg
Load Combination Dead Weight

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
16.500	0.0	-1.6	0.0	1.6	29.0	0.055	Pass
13.452	0.0	0.0	0.0	0.0	13.8	0.001	Pass
11.500	0.0	0.2	0.0	0.2	4.0	0.061	Pass
11.467	0.0	0.2	0.0	0.2	3.8	0.062	Pass
11.385	0.0	0.2	0.0	0.2	3.4	0.063	Pass
11.257	0.0	0.2	0.0	0.2	2.8	0.065	Pass
11.128	0.0	0.1	0.0	0.1	2.1	0.067	Pass
11.000	0.0	0.1	0.0	0.1	1.5	0.068	Pass
10.699	0.0	0.0	0.0	0.0	52.7	0.000	Pass
10.400	0.0	-0.1	0.0	0.1	52.7	0.002	Pass
8.400	0.0	-0.9	0.0	0.9	52.7	0.016	Pass
6.456	0.0	-1.2	0.0	1.2	52.7	0.023	Pass
6.123	0.0	-1.2	0.0	1.2	52.7	0.022	Pass
5.789	0.0	-1.1	0.0	1.1	52.7	0.022	Pass
5.456	0.0	-1.1	0.0	1.1	52.7	0.021	Pass
5.137	0.0	-1.0	0.0	1.0	52.7	0.020	Pass
5.000	0.0	-1.0	0.0	1.0	52.7	0.019	Pass
4.863	0.0	-1.0	0.0	1.0	52.7	0.019	Pass
3.100	0.0	-0.7	0.0	0.7	52.7	0.013	Pass
2.450	0.0	-0.5	0.0	0.5	52.7	0.010	Pass
1.385	0.0	-0.3	0.0	0.3	52.7	0.006	Pass
1.275	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
1.165	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
0.950	0.0	-0.2	0.0	0.2	52.7	0.004	Pass
0.446	0.0	-0.1	0.0	0.1	52.7	0.001	Pass
0.350	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.305	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.153	0.0	0.0	0.0	0.0	52.7	0.000	Pass
0.000	0.0	0.0	0.0	0.0	0.8	0.050	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dy^2 + Dz^2)
Ratio = Dres / Limit

Lifting Reactions Summary - Dead Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	17443	18398
10.0	17666	18174
20.0	17898	17943

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30.0	18155	17686
40.0	18459	17381
50.0	18854	16987
60.0	19425	16416
70.0	20400	15441
80.0	22655	13186
90.0	35841	0

Lifting Reactions Summary - Dead + Impact Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	26164	27597
10.0	26499	27262
20.0	26847	26914
30.0	27232	26529
40.0	27689	26072
50.0	28281	25480
60.0	29137	24624
70.0	30599	23162
80.0	33982	19779
90.0	53761	0

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D – LIFTING LUGS ANALYSIS

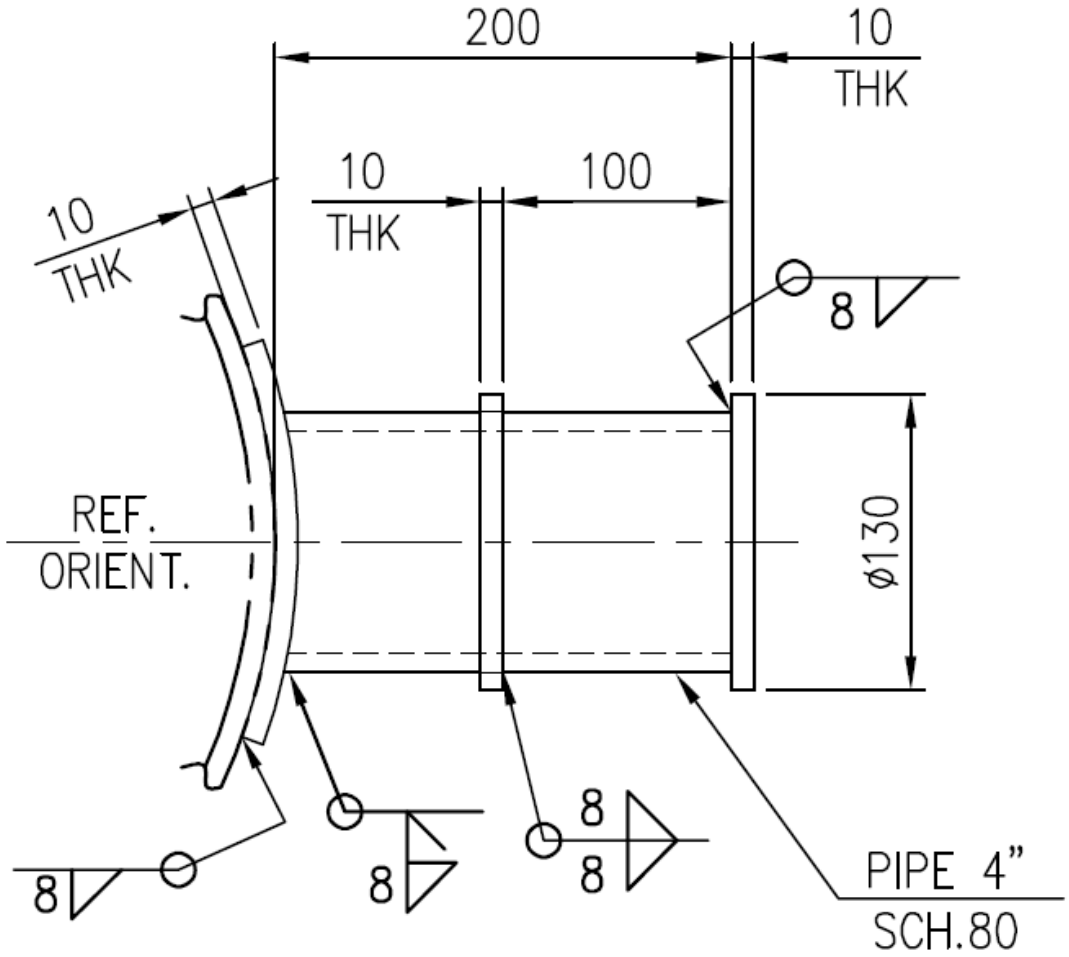
The desing of the liftign lugs is performed using the loads amplified by a contingency factor that safely envelope the results of both configuration of lifting. The loads are included in the drawing 1724000887-MAC-DD-00019_01 (23-0193-0530A_01) and they are reported hereafter.

LIFT ANGLE Deg.	LIFTING LOAD kN	TAILING LOAD kN
0	24.95	34.62
10	25.37	34.20
20	25.80	33.77
30	26.29	33.29
40	26.86	32.71
50	27.60	31.97
60	28.68	30.89
70	30.51	29.06
80	34.76	24.82
90	59.57	0.00

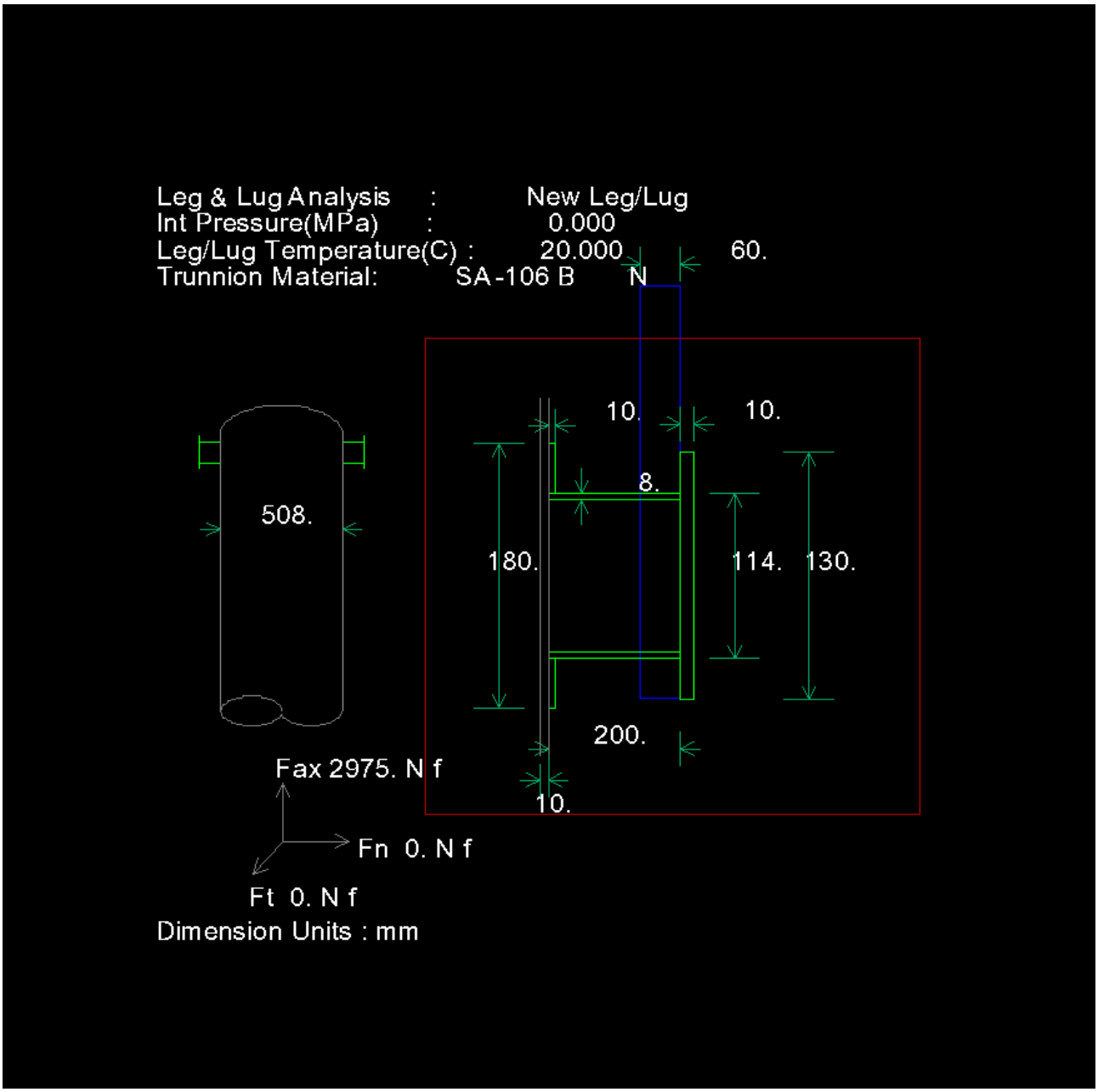
D.1 LIFTING TRUNNIONS

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The trunnion geoemtry is reported here after.



D.1.1 90° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                                0.00  MPa
Design Temperature for Attachment            TEMP      20.00  C
Vessel Outside Diameter                        OD     508.000  mm.
Vessel Wall Thickness                          Ts     10.0000  mm.
Vessel Corrosion Allowance                    Cas      0.0000  mm.
Vessel Material                                     SA-516 70
Vessel Material UNS Number                             K02700
Vessel Allowable Stress at Design               S     137.90  MPa
```

```
Analysis Type:                                        Trunnion

Empty Weight of Vessel                        Wemp       0.00  N f
Operating Weight of Vessel (vertical load )     W       0.00  N f

Trunnion Material                                    SA-106 B
Trunnion Material UNS Number                           K03006
Trunnion Yield Stress                           SY     241.32  MPa
Trunnion Outside Diameter                      TOD    114.300  mm.
Trunnion Thickness                            TTHK     8.0000  mm.
Trunnion Length                                 TL   200.0000  mm.
Bail/Sling Width                                TT    60.0000  mm.
Pad Outside Diameter                           POD    180.000  mm.
Pad Thickness                                 PTHK    10.0000  mm.
Ring Outside Diameter                          Rod     130.00  mm.
Ring Thickness                                Rthk      10.00  mm.
Trunnion Type                                        Hollow
Lift Orientation                                     Horizontal
Impact Factor                              Impfac       1.00

Force Along Vessel Axis                         Fax    2975.00  N f
Force Normal to Vessel                           Fn       0.00  N f
Force Tangential to Vessel                       Ft       0.00  N f
Perform WRC-107 Analysis on the Trunnion                 Yes

Occasional Load Factor (AISC A5.2)         Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((2975.00^2 + 0.00^2)^1/2) * 1.00
 = 2975.00 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 2975.00
 = 505955.12 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 505955 *1.000/ 66402.77
 = 7.62 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 2975.00 / 2671.61
 = 1.11 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
 = SBC / SBA + SSC / SSA
 = 7.62 / 159.27 + 1.11 / 96.53
 = 0.06 [Passed] UCHK, Must be less than 1.
```

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Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 2975.00 / 6858.00
 = 0.43 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                     VC          0.0  N f
Longitudinal Shear                        VL      -2975.0  N f
Circumferential Moment                    MC          0.0  N-mm 0.
Longitudinal Moment                       ML    -505955.1  N-mm 0.
Torsional Moment                          MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)

              |                   Stress Intensity Values at                                |
Type of       |                                                                             |
Stress   Load |       Au        Al        Bu        Bl        Cu        Cl        Du        Dl|
```

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Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	2.8	2.8	-2.8	-2.8	0.0	0.0	0.0	0.0
Circ. Bend. ML	6.7	-6.7	-6.7	6.7	0.0	0.0	0.0	0.0
Tot. Circ. Str.	9.4	-3.9	-9.4	3.9	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.8	0.8	-0.8	-0.8	0.0	0.0	0.0	0.0
Long. Bend. ML	10.5	-10.5	-10.5	10.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	11.3	-9.7	-11.3	9.7	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	0.8	0.8	-0.8	-0.8
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	0.8	0.8	-0.8	-0.8
Str. Int.	11.3	9.7	11.3	9.7	1.7	1.7	1.7	1.7

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	5.6	5.6	-5.6	-5.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	7.1	-7.1	-7.1	7.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	12.6	-1.5	-12.6	1.5	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	2.6	2.6	-2.6	-2.6	0.0	0.0	0.0	0.0
Long. Bend. ML	11.7	-11.7	-11.7	11.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	14.2	-9.1	-14.2	9.1	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	1.1	1.1	-1.1	-1.1
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	1.1	1.1	-1.1	-1.1
Str. Int.	14.2	9.1	14.2	9.1	2.1	2.1	2.1	2.1

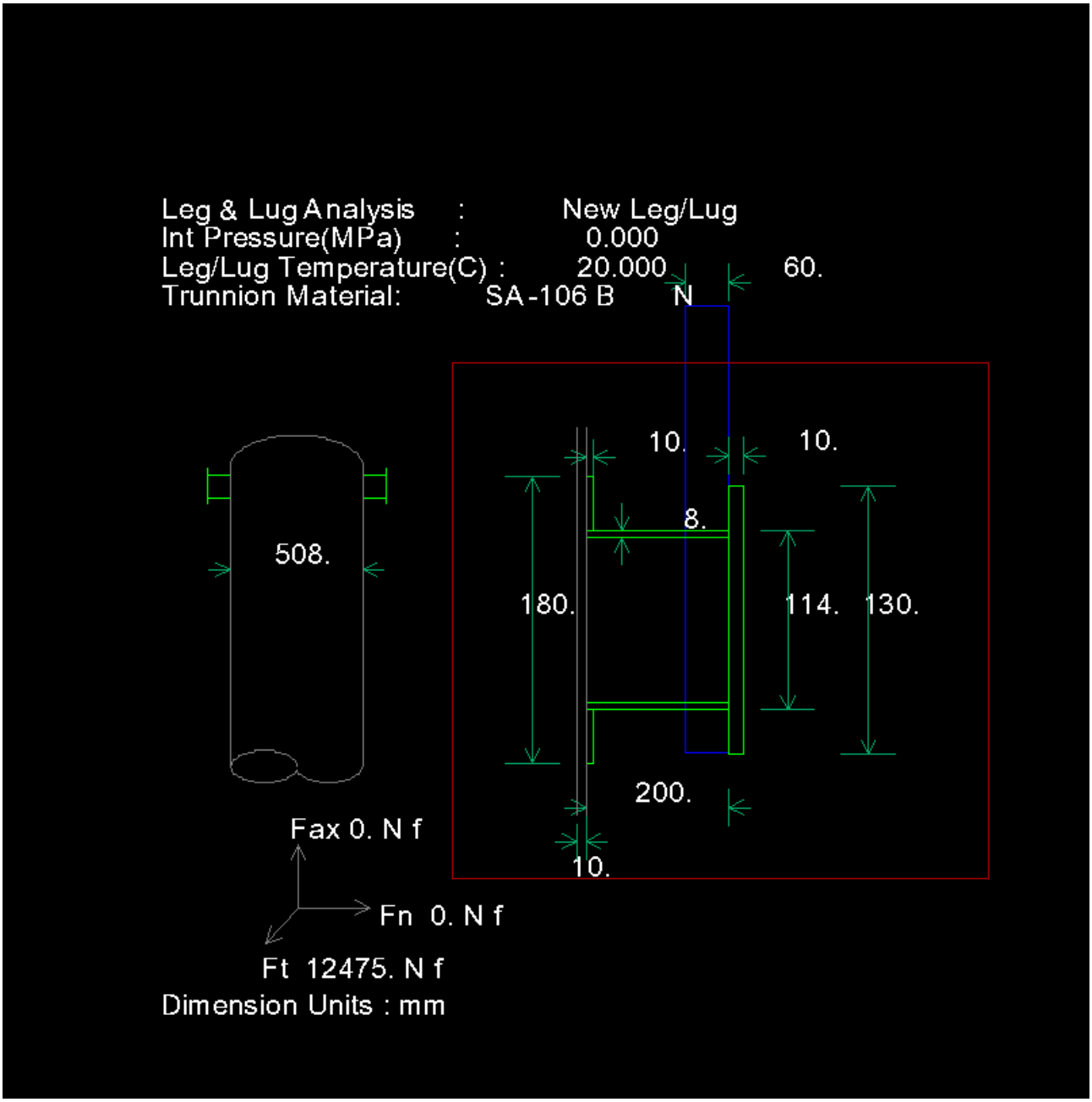
SUMMARY OF RESULTS:

Trunnion unity check value: 0.0594

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	7.62	159.27	Pass
Shear Stress (MPa)	1.11	96.53	Pass
Bearing Stress (MPa)	0.43	180.99	Pass

Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 11.32 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 14.24 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.1.2 0° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                                0.00  MPa
Design Temperature for Attachment           TEMP       20.00  C
Vessel Outside Diameter                       OD     508.000  mm.
Vessel Wall Thickness                         Ts     10.0000  mm.
Vessel Corrosion Allowance                   Cas      0.0000  mm.
```

```
Vessel Material                                    SA-516 70
Vessel Material UNS Number                           K02700
Vessel Allowable Stress at Design              S     137.90  MPa
Analysis Type:                                    Trunnion

Empty Weight of Vessel                      Wemp       0.00  N f
Operating Weight of Vessel (vertical load )    W       0.00  N f

Trunnion Material                                  SA-106 B
Trunnion Material UNS Number                         K03006
Trunnion Yield Stress                         SY     241.32  MPa
Trunnion Outside Diameter                    TOD    114.300  mm.
Trunnion Thickness                          TTHK     8.0000  mm.
Trunnion Length                               TL   200.0000  mm.
Bail/Sling Width                              TT    60.0000  mm.
Pad Outside Diameter                         POD    180.000  mm.
Pad Thickness                               PTHK    10.0000  mm.
Ring Outside Diameter                        Rod     130.00  mm.
Ring Thickness                              Rthk      10.00  mm.
Trunnion Type                                     Hollow
Lift Orientation                                  Horizontal
Impact Factor                            Impfac       1.00

Force Along Vessel Axis                       Fax       0.00  N f
Force Normal to Vessel                         Fn       0.00  N f
Force Tangential to Vessel                     Ft   12475.00  N f
Perform WRC-107 Analysis on the Trunnion             Yes

Occasional Load Factor (AISC A5.2)       Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((.00^2 + 12475.00^2)^1/2) * 1.00
 = 12475.00 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 12475.00
 = 2121610.00 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 2121610 *1.000/ 66402.77
 = 31.94 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 12475.00 / 2671.61
 = 4.67 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
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```
 = SBC / SBA + SSC / SSA
 = 31.94 / 159.27 + 4.67 / 96.53
 = 0.25 [Passed] UCHK, Must be less than 1.

Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 12475.00 / 6858.00
 = 1.82 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                      VC     -12475.0  N f
Longitudinal Shear                         VL          0.0  N f
Circumferential Moment                     MC    2121610.0  N-mm 0.
Longitudinal Moment                        ML          0.0  N-mm 0.
Torsional Moment                           MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)
```

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Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	-3.5	-3.5	3.5	3.5
Circ. Memb.	MC	0.0	0.0	0.0	0.0	-60.1	60.1	60.1	-60.1
Circ. Memb.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.		0.0	0.0	0.0	0.0	-63.6	56.5	63.6	-56.5
Long. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb.	MC	0.0	0.0	0.0	0.0	-5.5	-5.5	5.5	5.5
Long. Bend.	MC	0.0	0.0	0.0	0.0	-33.7	33.7	33.7	-33.7
Long. Memb.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.		0.0	0.0	0.0	0.0	-39.2	28.1	39.2	-28.1
Shear	VC	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Shear	VL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear		-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Str. Int.		6.9	6.9	6.9	6.9	63.6	56.5	63.6	56.5

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.316	4C		3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C		1.702	(C,D)
M(PHI) / (P)	0.316	2C1		0.022	(A,B)
M(PHI) / (P)	0.316	1C	!	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A		1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A		0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B		2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B		0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C		1.702	(A,B)
N(x) / (P/Rm)	0.316	4C		3.031	(C,D)
M(x) / (P)	0.316	1C1		0.046	(A,B)
M(x) / (P)	0.316	2C	!	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A		2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A		0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B		1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B		0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of	Stress Intensity Values at

Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-11.5	-11.5	11.5	11.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-121.2	121.2	121.2	-121.2
Circ. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.0	0.0	0.0	0.0	-132.7	109.7	132.7	-109.7
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-23.4	-23.4	23.4	23.4
Long. Bend. MC	0.0	0.0	0.0	0.0	-51.5	51.5	51.5	-51.5
Long. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.0	0.0	0.0	0.0	-74.9	28.1	74.9	-28.1
Shear VC	-4.4	-4.4	4.4	4.4	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-4.4	-4.4	4.4	4.4	0.0	0.0	0.0	0.0
Str. Int.	8.8	8.8	8.8	8.8	132.7	109.7	132.7	109.7

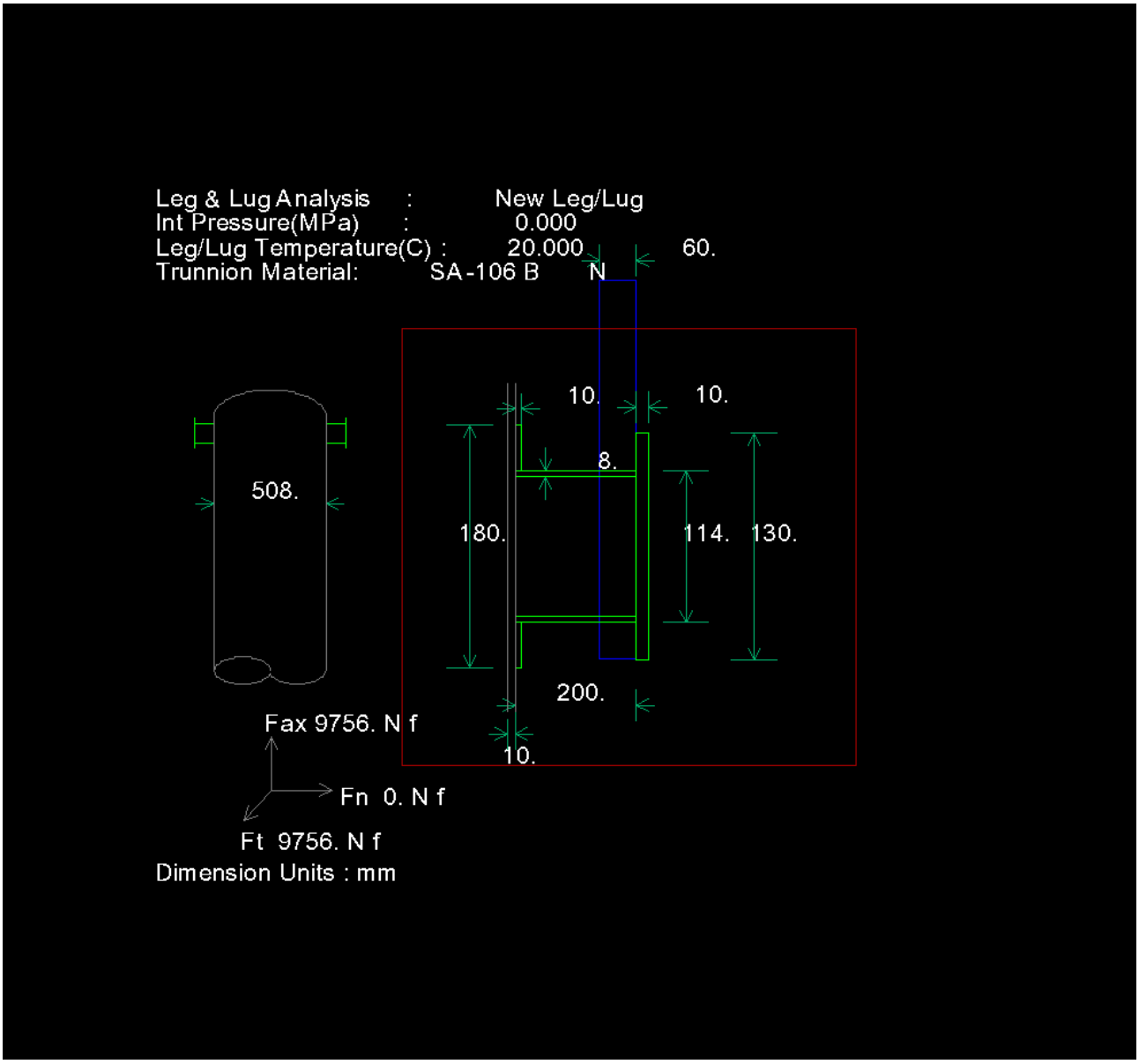
SUMMARY OF RESULTS:

Trunnion unity check value: 0.2489

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	31.94	159.27	Pass
Shear Stress (MPa)	4.67	96.53	Pass
Bearing Stress (MPa)	1.82	180.99	Pass

Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 63.60 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 132.71 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.1.3 45° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                                0.00  MPa
Design Temperature for Attachment            TEMP      20.00  C
Vessel Outside Diameter                        OD     508.000  mm.
Vessel Wall Thickness                          Ts     10.0000  mm.
Vessel Corrosion Allowance                    Cas      0.0000  mm.
Vessel Material                                     SA-516 70
Vessel Material UNS Number                             K02700
Vessel Allowable Stress at Design                S     137.90  MPa
```

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Analysis Type:                                        Trunnion

Empty Weight of Vessel                        Wemp       0.00  N f
Operating Weight of Vessel (vertical load )     W       0.00  N f

Trunnion Material                                    SA-106 B
Trunnion Material UNS Number                           K03006
Trunnion Yield Stress                           SY     241.32  MPa
Trunnion Outside Diameter                      TOD    114.300  mm.
Trunnion Thickness                            TTHK     8.0000  mm.
Trunnion Length                                 TL   200.0000  mm.
Bail/Sling Width                                TT    60.0000  mm.
Pad Outside Diameter                           POD    180.000  mm.
Pad Thickness                                 PTHK    10.0000  mm.
Ring Outside Diameter                          Rod     130.00  mm.
Ring Thickness                                Rthk      10.00  mm.
Trunnion Type                                        Hollow
Lift Orientation                                     Horizontal
Impact Factor                                Impfac       1.00

Force Along Vessel Axis                         Fax    9756.00  N f
Force Normal to Vessel                           Fn       0.00  N f
Force Tangential to Vessel                       Ft    9756.00  N f
Perform WRC-107 Analysis on the Trunnion             Yes

Occasional Load Factor (AISC A5.2)           Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((9756.00^2 + 9756.00^2)^1/2) * 1.00
 = 13797.07 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 13797.07
 = 2346452.50 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 2346452 *1.000/ 66402.77
 = 35.33 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 13797.07 / 2671.61
 = 5.16 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
 = SBC / SBA + SSC / SSA
 = 35.33 / 159.27 + 5.16 / 96.53
 = 0.28 [Passed] UCHK, Must be less than 1.
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Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 13797.07 / 6858.00
 = 2.01 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                     VC      -9756.0  N f
Longitudinal Shear                        VL      -9756.0  N f
Circumferential Moment                    MC    1659192.5  N-mm 0.
Longitudinal Moment                       ML   -1659192.5  N-mm 0.
Torsional Moment                          MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)

              |                   Stress Intensity Values at                                |
Type of       |                                                                             |
Stress   Load |       Au        Al        Bu        Bl        Cu        Cl        Du        Dl|
```

Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	-47.0	47.0	47.0	-47.0
Circ. Memb. ML	9.1	9.1	-9.1	-9.1	0.0	0.0	0.0	0.0
Circ. Bend. ML	21.8	-21.8	-21.8	21.8	0.0	0.0	0.0	0.0
Tot. Circ. Str.	30.9	-12.7	-30.9	12.7	-49.7	44.2	49.7	-44.2
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-4.3	-4.3	4.3	4.3
Long. Bend. MC	0.0	0.0	0.0	0.0	-26.3	26.3	26.3	-26.3
Long. Memb. ML	2.7	2.7	-2.7	-2.7	0.0	0.0	0.0	0.0
Long. Bend. ML	34.4	-34.4	-34.4	34.4	0.0	0.0	0.0	0.0
Tot. Long. Str.	37.1	-31.7	-37.1	31.7	-30.7	22.0	30.7	-22.0
Shear VC	-2.7	-2.7	2.7	2.7	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	2.7	2.7	-2.7	-2.7
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-2.7	-2.7	2.7	2.7	2.7	2.7	-2.7	-2.7
Str. Int.	38.1	32.1	38.1	32.1	50.1	44.5	50.1	44.5

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-9.0	-9.0	9.0	9.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-94.8	94.8	94.8	-94.8
Circ. Memb. ML	18.3	18.3	-18.3	-18.3	0.0	0.0	0.0	0.0
Circ. Bend. ML	23.2	-23.2	-23.2	23.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	41.5	-4.9	-41.5	4.9	-103.8	85.8	103.8	-85.8
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-18.3	-18.3	18.3	18.3
Long. Bend. MC	0.0	0.0	0.0	0.0	-40.3	40.3	40.3	-40.3
Long. Memb. ML	8.5	8.5	-8.5	-8.5	0.0	0.0	0.0	0.0
Long. Bend. ML	38.2	-38.2	-38.2	38.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	46.7	-29.8	-46.7	29.8	-58.6	22.0	58.6	-22.0
Shear VC	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	3.5	3.5	-3.5	-3.5
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-3.5	-3.5	3.5	3.5	3.5	3.5	-3.5	-3.5
Str. Int.	48.4	30.2	48.4	30.2	104.0	85.9	104.0	85.9

SUMMARY OF RESULTS:

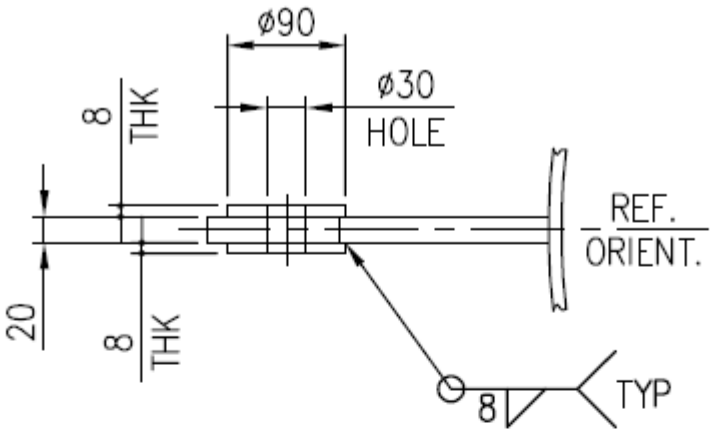
Trunnion unity check value: 0.2753

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	35.33	159.27	Pass
Shear Stress (MPa)	5.16	96.53	Pass
Bearing Stress (MPa)	2.01	180.99	Pass

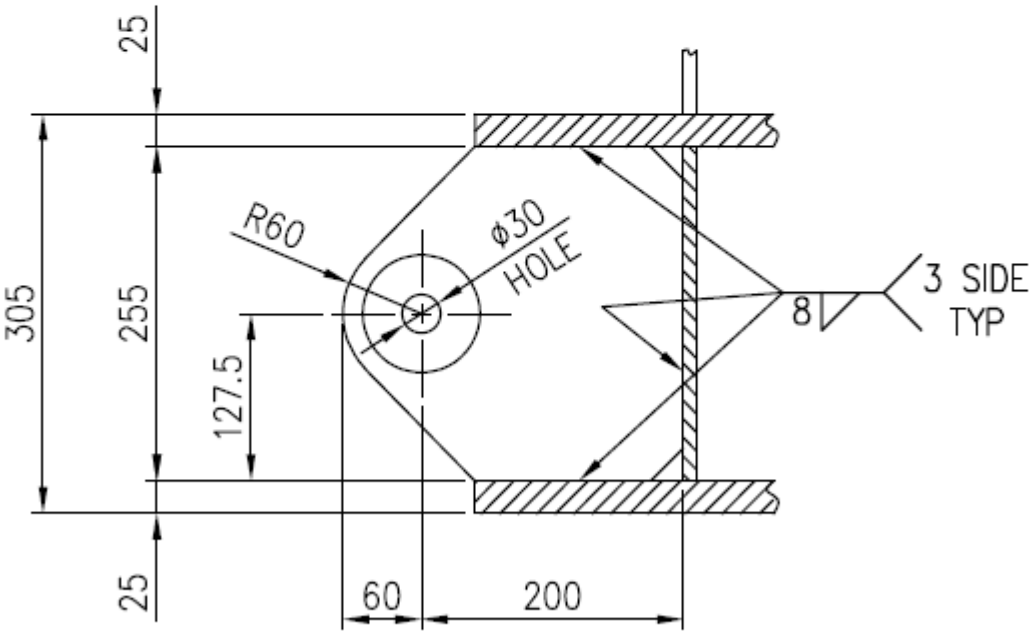
Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 50.12 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 104.04 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.2 TAILING LUG

The tailng lug is obtained by one hole on one of the gusset of the base plate as shown below.



PLAN VIEW



ELEVATION

TAILING LUG DETAIL

The maximum load from the analysis is at 0° and it is 34.62 kN. Considering the stiffnes of the basbearing e ring the only relevant check is related to the bearing strenght of the bolt. Copnsidering EN 1993-3 for the verification the following is the formula for the strenght.

Bearing strength of bolts

The bearing resistance of the bolt $F_{b,Rd}$ should be verified against the applied shear load $F_{v,Ed}$ in accordance with *EN1993-1-8 Table 3.4*:

$F_{b,Rd} = k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t / \gamma_{M2}$

where:

- f_u is the ultimate tensile strength of the connected plate
- d is the nominal diameter of the bolt.
- t is the thickness of the connected plate.
- γ_{M2} is the partial safety factor for the resistance of bolts in accordance with *EN1993-1-8 §2.2(2) Table 2.1* and the National Annex. The recommended value in EN1993-1-8 is $\gamma_{M2} = 1.25$.

The coefficient k_1 is:

for edge bolts: $k_1 = \min(2.8 \cdot e_2/d_0 - 1.7, 1.4 \cdot p_2/d_0 - 1.7, 2.5)$
for inner bolts: $k_1 = \min(1.4 \cdot p_2/d_0 - 1.7, 2.5)$

where e_2 is the distance between the center of the edge bolt and the end of the plate measured perpendicular to the load transfer direction, p_2 is the distance between the centers of neighboring bolts measured perpendicular to the load transfer direction, and d_0 is the diameter of the bolt hole.

The coefficient α_b is:

$\alpha_b = \min(\alpha_d, f_{ub}/f_u, 1.0)$

for end bolts: $\alpha_d = e_1/(3 \cdot d_0)$
for inner bolts: $\alpha_d = p_1/(3 \cdot d_0) - 1/4$

where e_1 is the distance between the center of the end bolt and the end of the plate measured parallel to the load direction, p_1 is the distance between the centers of neighboring bolts measured parallel to the load direction, and d_0 is the diameter of the bolt hole.

Therefore, based on the equations above, the bearing resistance of the bolt $F_{b,Rd}$ is not affected by the distances e_1, p_1, e_2, p_2 when the following conditions are satisfied:

for edge bolts: $e_1 \geq 3.0 \cdot d_0$ and $e_2 \geq 1.5 \cdot d_0$
for inner bolts: $p_1 \geq 3.75 \cdot d_0$ and $p_2 \geq 3.0 \cdot d_0$

Being:

α_b=1

K1=2.5

FU=430 FOR s275 jr

D= 27 MM

T= 20 MM

Hence the resistance is :

$$F_b = 1 \cdot 2.5 \cdot 430\ MPa \cdot 27\ mm \cdot 20\ mm \frac{1}{1.25} = 464\ kN$$

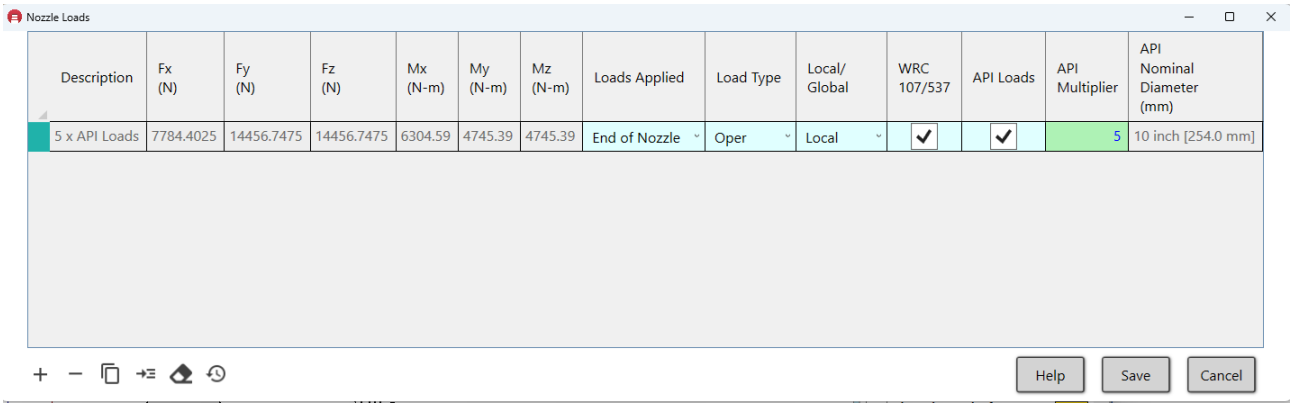
Considering a factoe LRFD action of $35\ kN \cdot 1.5 = 52.5\ kN$

The verification is passed.

E – MISCELLANEUS CALC – DERATING CALCULATION OF THE INLET FLANGE N1 AS PER UG 44(B)

The flange is loaded by the followings external loads:

Nozzle 1N's loads have been calculated with a factor of 5 times the value from API 537.



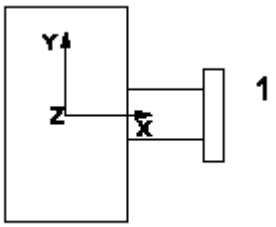


Figure 9 Nozzle 1N loads

As per Ug-44(b) due to the external loads the flange shall be derated to P_D as follow:

$$P_D = \min\left(P_R;\ F_M P_R + P_R - \frac{(16\ M_E + 4\ F_E G)}{\pi\ G^3} \right)$$

To respect the equation:

$$16\ M_E + 4\ F_E\ G\ \leq\ \pi\ G^3\ [\ (P_R - P_D) + (F_M\ P_R)]$$

Being

P_R flange pressure rating at 80°C for flange group 1 (material SA-350 LF2) is 18.42 bar

F_M as per taable UG-44-1 equal to 1.2 for ASME B16.5 Flange #150 less than NPS 12

M_E External moment resultant equal to:

$$M_E = \sqrt{M_Y^2 + M_Z^2} = 4.75\ kNm\ \cdot \sqrt{2} = 6.72\ kNm$$

F_E External tensile axiale force equal to $F_X = 7.78\ kN$

G is the mean gasket diameter (gasket reaction) equal to $G = (D_i + D_o)\frac{1}{2} = (273.05 + 339.73)mm\frac{1}{2} = 306.39\ mm$

Accordingly, the derated pressure of the flange is :

$$P_D = \min\left(18.42\ barg;\ \ 1.2\ \cdot 18.42\ barg + \ \ 18.42\ barg - \frac{16\ \cdot 6.72\ kNm + 4\ \cdot 7.78\ kN\ \cdot 0.306\ m}{\pi\ 0.306^3\ m^3}\ \frac{1}{100}\frac{barg}{kPa}\right)$$
$$= \min(\ 18.42\ barg\ ; 27.52\ barg) = 18.42\ barg$$

There is no change in the pressure-temperature rating of the flange due to the external loads hence the flange doesn't have to be derated.

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1.6 DATASHEETS

1.6.1 Equipment Datasheet

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

EQUIPMENT DATA SHEETS - HYDROGEN VENT (Q-43004)

Document Number 1724000887-MAC-DS-00006

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	12/12/24

Document Class: 2

Rev.	Date	Description	Prepared	Reviewed	Approved
04	06/12/2024	Accepted for Construction (AFC)	SB	RV	ADL
03	20/10/2024	Accepted for Construction (AFC)	SB	RV	UL
02	04/09/2024	Issue for Review (IFR)	SB	RV	UL
01	25/07/2024	Issue for Review (IFR)	SB	RV	UL
00	07/06/2024	Issue for Review (IFR)	ADL	GP	UL

THERMO ENGINEERING
AN ENCORE COMBUSTION COMPANY

Revision / Change Log

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Rev.	Description
00	Issue for Review (IFR)
01	Issue for Review (IFR)
02	Issue for Review (IFR)
03	Acceptance for Constrcution (AFC)
04	Accepted for Construction (AFC)

HOLDS LIST

No.	Description
1	
2	
3	
4	

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TECHNICAL SPECIFICATION FOR

12 " – SVT - STANDARD VENT TIP

ITEM : Q-43004

Equipment description

The Vent tip type SVT (Standard Vent Tip) is a tip capable to vent into atmosphere the specified gas flow.

The tip will be supplied complete with the following items:

- Vent shell realised from stainless steel plate.
- Protection windshield realised from stainless steel perforated plate to avoid the flame came down (in case of combustion), for wind effect, on the external part of the tip shell down wind direction.

This undesirable effect is the responsible of short tip life of tips located in exposed wind sites.

- 150# W.N.R.F. flange for riser connection.
- Set of stainless-steel supports for the windshield.
- Lifting hooks for tip assembling realised in stainless steel material.
- 2 nos. MIOL-C (red steady burning) will be installed at approx. 1.5 meter from the top of the vent.
- Electrical ladder type cable tray (100 mm width) with supports will be provided for AWL.
- Bird screen will be provided in top of vent tip.

The tip will be delivered completely assembled with all components and ready to be installed.

The tip will be provided with a bird screen at the top.

Please see attached table (Attachment 1_Maintenance) and please refers to Operation Maintenance Manual Doc. No.: 1724000887-MAC-MAN-00017_01

DESIGN DATA				
- Release case		CASE HOT BLOWDOWN		
- Max. gas flow	(kg/h)	13485		
- Gas temperature	(°C)	120		
- Average gas molecular weight	(kg/kmol)	2		
- Cp/Cv ratio		1.4		
FLARE PHYSICAL DATA				
- Exit gas velocity at max. flow	(m/s)	678.47		
- Mach number		.44		
- Flare tip pres.drop at max.flow	(mmH2O)	1704.8		
CONSTRUCTION DATA				

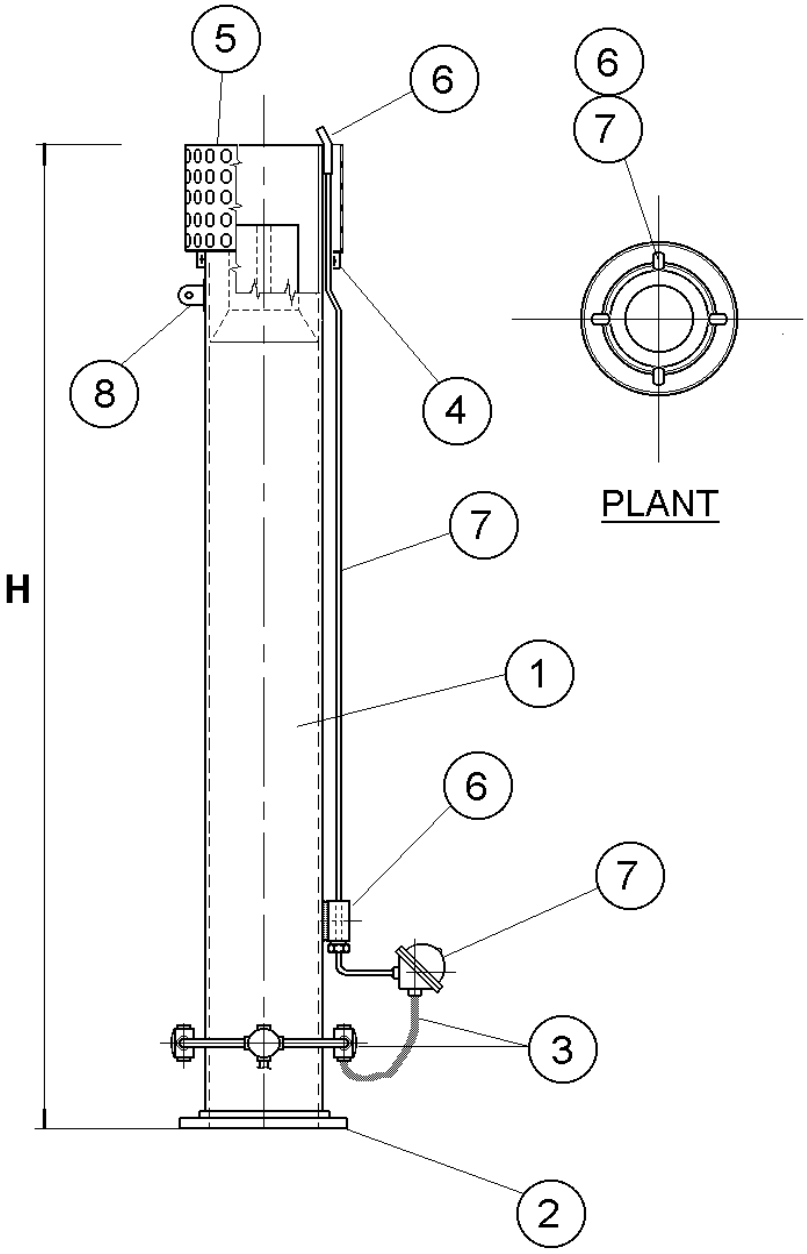
Pos.	Description	No.	Diameter "	Conn. rating	Material	Notes
1	Vent shell	1	12	-	AISI - 316	
2	Connection flange	1	12	150# WNRF	AISI – 316L	
3	Conduit for thermocoup.	0	-	-	-	
4	Windshield support/s	3	-	-	AISI-316	
5	Windshield	1	-	-	AISI-316	
6	Thermocouples guide	0	-	-	-	
7	Thermocouples	0	-	-	-	-
8	Lifting hooks	2	-	-	AISI-316	-
9						
10						
11						
12						
13						
14						

REQUIRED UTILITIES		
- Purge gas or min. gas flow	(Nm^3/h)	3.41

DIMENSIONS AND WEIGHTS		
- Tip net weight	(kg)	450
- Dimension for transport	(cm)	505 H X 120 L X 60 W
- Gross weight for transport	(kg)	500
- Flare tip height	(m)	H = 5

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VENT TIP GENERAL SCHEME



TECHNICAL SPECIFICATION FOR
12 " – SVS - SPIRAL VENTURI SEAL
ITEM : Q-43004

Equipment description

The Seal type SVS (Spiral Venturi Seal) is a system capable to avoid the air inlet into the flare riser using the minimum possible purge gas quantity as indicated on this specification.

The indicated flow is the minimum quantity necessary to maintain the oxygen concentration below the seal **less than 6%.** Into the seal are located strategically four sagomated plates that produce a vorticosity at the exit gas.

The vorticosity flow produce an excellent air/gas mixture immediately at the top of the tip. It is intuitive that the phenomena increases with the increasing of the exit gas velocity and consequently the combustion efficiency does not change at any flow.

The main components are:

- Internal reduction cone. The size reduction is calculated in function of the available gas pressure.
- Internal shell to keep the required restriction and to obtain the venturi effect.
- Shaped plates to produce the necessary vorticosity to exit gas. It is important note that the above plates do not create any size restriction.

The specified quantity does not consider the purge gas volume change due to ambient temperature variations.

The seal is self-draining type, and no external drain line is required. Normally the seal is directly installed into the flare tip. No internal seal parts are in movement and no block is possible.

No maintenance is required during the normal operations.

Please see attached table (Attachment 1_Maintenance) and please refers to Operation Maintenance Manual Doc. No.: 1724000887-MAC-MAN-00017_01

DESIGN DATA				
Release case		CASE HOT BLOWDOWN		
Max. gas flow	(kg/h)	13485		
Gas temperature	(°C)	120		

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Average gas molecular weight (kg/kmol)		2		
Cp/Cv ratio		1.4		

FLARE PHYSICAL DATA				
Seal pressure drop at max. flow (mmH2O)		271.94		

CONSTRUCTION DATA

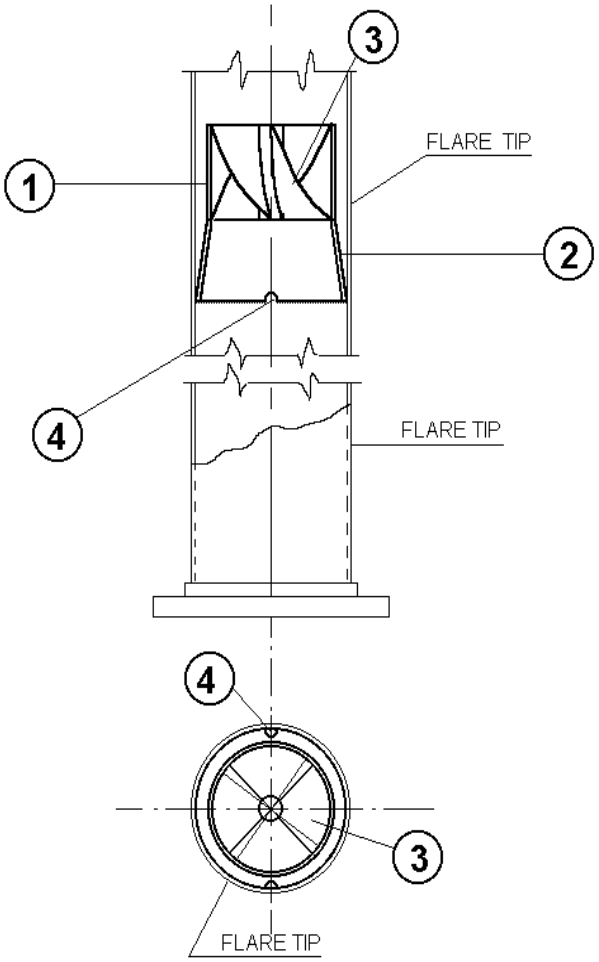
Pos	Description	No.	Diameter "	Conn. rating	Material	Notes
1	Seal diameter	1	12	-	AISI-316	
2	Reduction cone	1	-	-	AISI-316	
3	Internal sectors	4	-	-	AISI-316	
4	Drain	2	-	-		Internal
5						
6						
7						
8						

REQUIRED UTILITIES				
- Purge gas or min. gas flow (Nm^3/h)		3.41(2)		

DIMENSIONS AND WEIGHTS				
- Seal net weight (kg)		40		

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EQUIPMENT SCHEME



GENERAL NOTES	
1	The seal is assembled into the flare tip.
2	The indicated purge quantity is of inert or combustible gas in order of preference.
3	
4	
5	
6	

TECHNICAL SPECIFICATION FOR
16.5 m SELF-SUPPORTING TYPE ELEVATED VENT
ITEM: Q-43004

DESIGN DATA				
Release case		CASE HOT BLOWDOWN		
Max. gas flow	(kg/h)	13485		
Gas temperature	(°C)	120		
Average gas molecular weight	(kg/kmol)	2		
Cp/Cv ratio		1.4		
VENT PHYSICAL DATA				
Vent total pres. drop at max. flow	(mmH2O)	3000	TO BE ADDED TO DELTA P OF WS	

CONSTRUCTION DATA

Description	No.	Diameter "	Conn. rating	Material	Notes
Vent riser	1	12	150# WN. RF.	SA350 GR. LF2	For flanged connections
- upper stack	1	20	-	SA516 GR.60 or equiv.	
- bottom stack (WATER SEAL)	1	42		SA516 GR.60 or equiv.	-
Gas inlet connection	1				See attached Nozzle List table on sheet 13 of 14
Nozzle for instrument					See attached Nozzle List table on sheet 13 of 14

REQUIRED UTILITIES				
- Purge gas or min. gas flow	(Nm^3/h)	3.41		

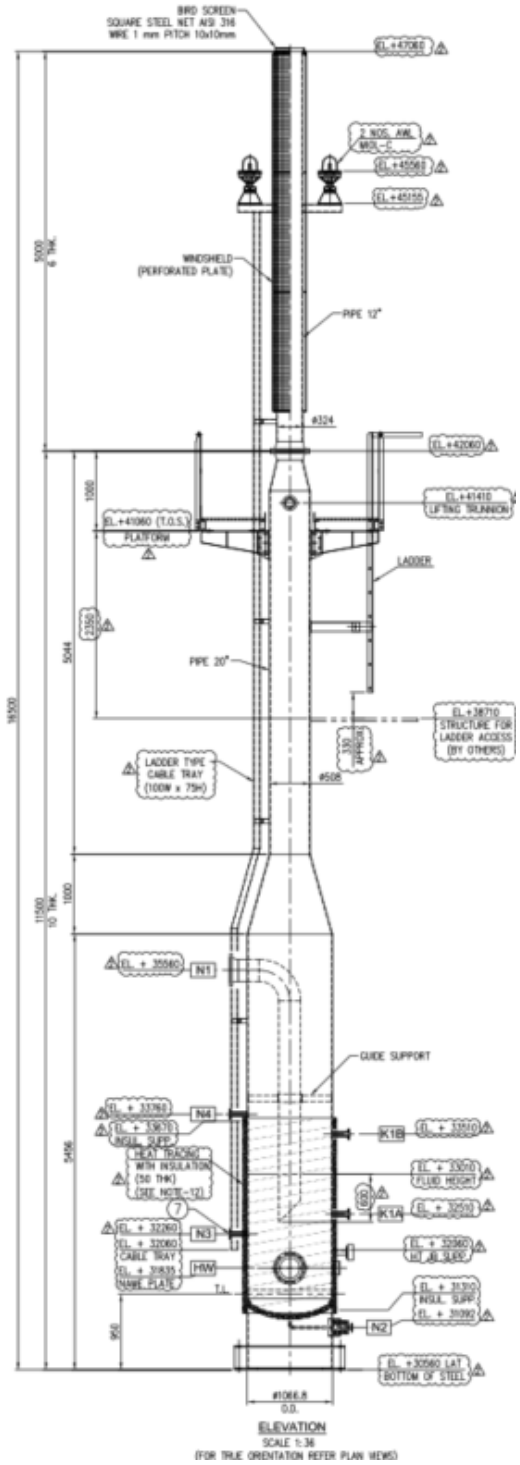
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DIMENSIONS AND WEIGHTS				
- Total vent height (including 5m tip)	(m)	16.5		
- Vent total weight	(kg)	4500		
- Delivered number of trunks (excluding tip)		1		
- Trunks max. length	(m)	11.5		

Please see attached table (Attachment 1_Maintenance) and please refers to Operation Maintenance Manual Doc. No.: 1724000887-MAC-MAN-00017_01

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VENT RISER GENERAL ARRANGEMENT



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TECHNICAL SPECIFICATION
FOR
VERTICAL LIQUID SEAL

Equipment description

The Vertical Liquid Seal (V-WS) is an equipment capable to avoid the flame return into the gas header in case of no purge gas presence in the flare system.

- The seal will be located directly under the flare stack and will be itself part of the riser. The vessel will be calculated for the design internal pressure and temperature and verified as part of riser at the mechanical stability.
- The seal base will be complete with baseplate and anchor boxes for connection with foundation by means of foundation bolts (foundation and foundation anchor bolts are not in our scope of supply).
- The top of the seal (gas exit connection) will be constituted of a reduction cone to connect to the stack.
- The seal will be delivered completely assembled and ready for field installation.
- the liquid consumption is based on the assumption of the refilling of water and glycol every 6 months.
-The liquid seal drum, instrument connection, drain line to be electrically traced for avoiding ice formation (set temp.+5°C).
- ETE shall supply loose Thermostat to be installed by customer.
- ETE shall provide and installed self-regulating heating cable. (for details - see attached datasheet)
- All supports (clips) for 50 THK insulation are provided and installed by ETE.

Please see attached table (Attachment 1_Maintenance) and please refers to Operation Maintenance Manual Doc. No.: 1724000887-MAC-MAN-00017_01

DESIGN DATA		
- Max. gas flow	(kg/h)	13485
- Operating temperature	(°C)	120
- Design temperature	(°C)	80
- Operating pressure	(mmH2O)	ATM
- Design pressure	(barg)	3.5
- Average gas molecular weight	(kg/kmol)	2
- Water seal pressure drop at max. flow	(mmH2O)	1109.352
- Shell corrosion allowance	(mm)	3
- Head and cone corrosion allowance	(mm)	3
- Liquid type for seal	(vol/vol)	Water/Glycol (50%)
- Liquid consumption	(l/h)	0.12 l/h

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- External insulation		Yes
- Design code		ASME VIII Div 1 and 2014/68/EU (PED CE)
- Test by		ETE (Per Code)
-Hydrotest pressure	(barg)	5.5
- MDMT	(°C)	-29
-Fluid Group		1
-Volume	Liter	4700
-Filling liquid Volume	Liter	1700
-Category		IV
-Module		G
- Noise Requirements		<85 dBA @1mt distance
- Painting Project Spec.		123A90-DDL-MAT-SP-60006
- ATEX Area		ATEX (2014/34/EU)
-Area Classification		ZONE 2 IIC T1

CONSTRUCTION DATA (See scheme at next page)

Description	No.	Material	Notes
Seal shell	1	A-516 Gr.60 or equiv.	
Upper reduction cone	1	A-516 Gr.60 or equiv.	
2 : 1 elliptical head	1	A-516 Gr.60 or equiv.	
Seal skirt	1	S275 J0 or equiv.	
Internal gas header	1	A-333 Gr.6 or equiv.	

DIMENSIONS AND WEIGHTS

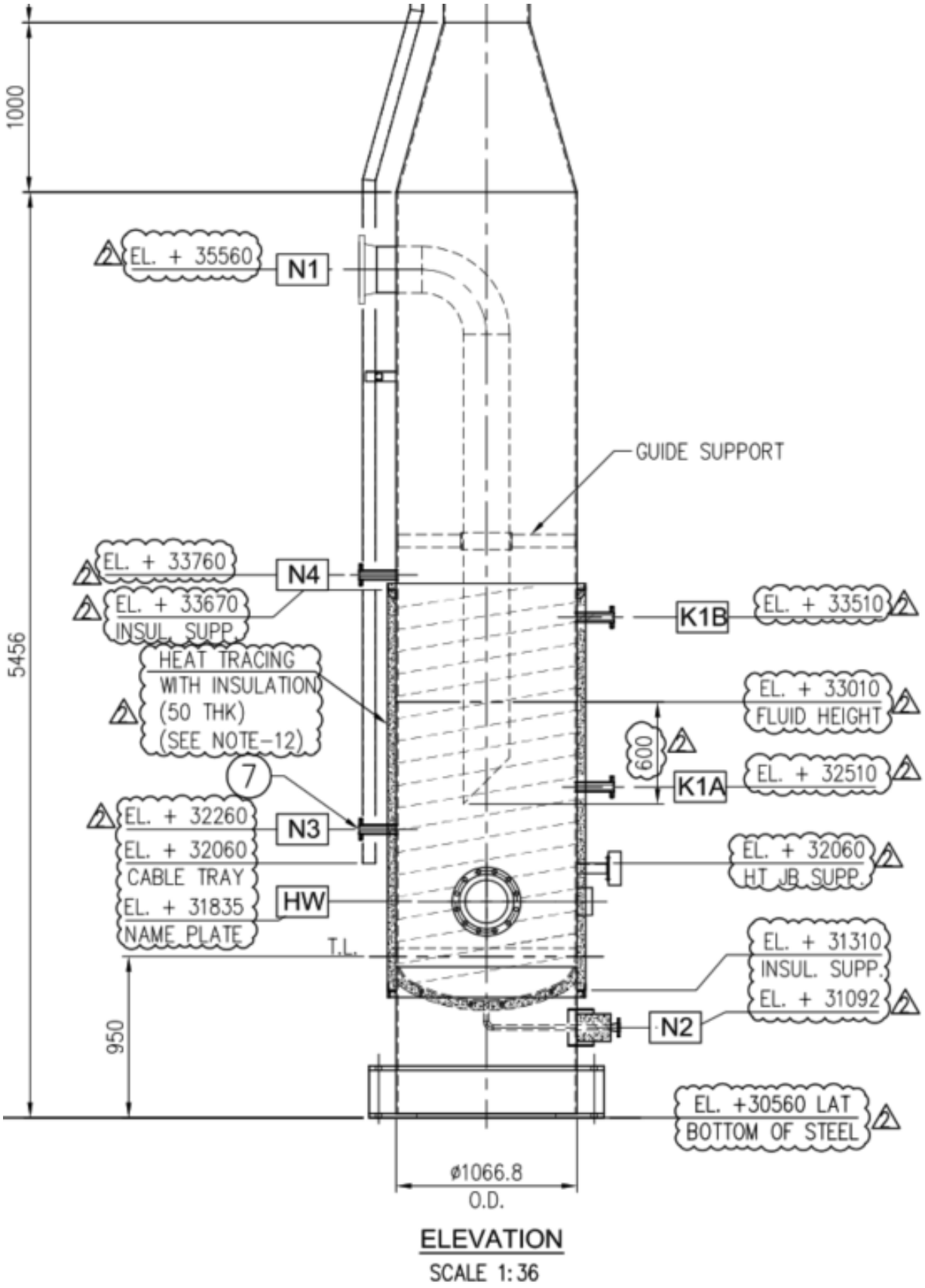
D = shell diameter	(mm)	1066.8
H = seal height	(mm)	4506
H1 = cone height	(mm)	1000
H2 = skirt height	(mm)	950
H4 = total seal height	(mm)	6456
T = shell Thickness	(mm)	10

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Total seal weight	(kg)	2400

ITEM	DIAM. (inch)	TYPE	CLASS	FACING 2)	THICKNESS (sch/mm)	ELEVAT. 5)	DISTANCES from C.L.	DIA.REINF.	THK. REINF.	SERVICE
N1	**10"**	**WN**	**150**	**RF**	SCH.40	EL.+35560	750 mm	Dia.473	8 THK	**Vent Inlet from V-43001 (with dip pipe)**
N2	**1"**	WN	**150**	**RF**	SCH.XS	EL.+31092	800 mm	-	-	**Drain**
N3	**1"**	**LWN**	**150**	**RF**	12.7 mm	EL.+32260	750 mm	-	-	**Swan Neck Connection**
N4	**1"**	**LWN**	**150**	**RF**	12.7 mm	EL.+33760	750 mm	-	-	**Filling Line**
K1A	**1"**	**LWN**	150	**RF**	12.7 mm	EL.+32510	750 mm	-	-	**Level Transm.**
HW	8"	WN	150	RF	SCH.40	EL.+31835	750 mm	Dia.320	8 THK	**HAND HOLE**
K1B	1"	LWN	150	RF	12.7 mm	EL.+33510	750 mm			Level Transm.

- All flanges shall be ASME B16.5



ELEVATION
SCALE 1:36

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2 CERTIFICATION DOSSIER

2.1 ACCEPTANCE

2.1.1 Declaration of Conformity

SEE ATTACHED NEXT PAGE

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CE

EU DECLARATION OF CONFORMITY

This Declaration of Conformity is issued under the sole responsibility of the maker.

OBJECT OF THE DECLARATION	
Denomination	Hydrogen Vent
Model / type	23-0193 / SVT-SSVR
Function	Gas venting to atmoshere
FLUID GROUP - PED category/module	1 - IV/G
For ATEX area	Zone 2, IIC T1
Year of construction	2024

The assembly consists of:

ITEM	**HYDROGEN VENT**
MAKER	ENCORE THERMOENGINEERING
CODE	23-0193 / SVT-SSVR
PED MARKING	FLUID 1 CATEGORY IV MODULE G No.Bo. CODE 0496
CERTIFICATES / DECLARATIONS	C713698- EU Certificate of Conformity Mod. G - Rev. 00-20250127-20250127
ATEX MARKING	ZONE 2 IIC T1
CERTIFICATES / DECLARATIONS	ATEX REGISTER1724000887-QC-LIS-00012; ATEX CERTIFICATION 1724000887-MAC-LIS-00013

The Maker ENCORE THERMOENGINEERING S.r.l DECLARES

that the object of the declaration described above is in conformity with the Union harmonization legislation:

- DIRECTIVE 2014/68/EU ON PRESSURE EQUIPMENT
- DIRECTIVE 2014/34/EU ON EQUIPMENT INTENDED FOR USE IN POTENTIALLY HAZARDOUS AREAS

Milano, 31/01/2025

ENCORE THERMOENGINEERING S.r.l.
Ugo LEVI
Managing Director

2.1.2 Inspection Certificates

SEE ATTACHED NEXT PAGE

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Release Note	☐ FOR PAYMENT	☒ FOR SHIPMENT

RELEASE NOTE FOR PAYMENT

PO Art.	
Letter	

RELEASE NOTE FOR SHIPMENT

POS. Item	Q.TA' Quantity	DESCRIZIONE Description	Nr. TAG TAG No.	TIPO DI ISPEZIONE / Kind of Inspection	ESITO / Result
10	1	**HYDROGEN VENT** ACCORDING TO FOLLOWING CONFIGURATION: VENT TIP 12", LENGHT 5M RISER 20" WATER SEAL INCLUDED CABLE TRAY HDG INCLUDED complete with all components and ancillaries requested in the Material Requisition n°123A90-DDL-MAC-MR-50042 and amendments defined in Exhibit A.1	Q-43004	FINAL	SATISFACTORY
20	1	**SPARE PARTS** SET OF GASKETS 100% SET OF BOLTS AND NUTS 10% WITH A MINIMUM OF 1 PIECE PER TYPE	n/a	FINAL	SATISFACTORY
30	1	**SPARE PARTS** SET OF GASKETS 100% SET OF BOLTS AND NUTS 10% WITH A MINIMUM OF 1 PIECE PER TYPE	n/a	FINAL	SATISFACTORY

DOCUMENTI APPLICABILI / *APPLICABLE DOCUMENTS*

POSIZIONE *Items*	TIPO DI DOCUMENTO *Type of Document*	NUMERO DI DOCUMENTO *Document Number*	Rev.	COD. DI APPROV. *Approv. Code*
All	Purchase order	1724000887	2	n/a

PUNCH LIST: ☐ SI / *YES* VEDI PUNCH LIST ALLEGATA N° / *REFER TO ATTACHED PUNCH LIST N°*
☒ NO/ *NO*

CONTROLLO VALIDITA' FIDEJUSSIONE / *PERFORMANCE or WARRANTY BOND expiration date check*
Estensione Fidejussione Richiesta *(Performance or Warranty Bond Extension of Validity required)*
☐ SI / *YES* ☒ NO/ *NO*
Acceptance Method: *Performance or Warranty Bond valid if actually delivery date it's not greater than two weeks from contractual delivery date.*

RELEASE NOTE			
RISULTATO / *RESULT*	**FORNITURA /** *SUPPLY*	**DISTRIBUZIONE A: /** *DISTRIBUTION TO:*	
☒POSITIVO / *POSITIVE* ☐ NEGATIVO / *NEGATIVE* ☐PUNTI PENDENTI / *PUNCH-LIST*	☒COMPLETA / *COMPLETE* ☐ PARZIALE / *PARTIAL* ☐ ULTIMA / *FINAL*	☒Project Manager ☒ Project Quality Manager ☒ Warehouse	☒Administration ☒ Project Eng-/Procurement Coord ☒ Supplier
NOTE / *NOTES*			
Note: None			

2.2 MANFACTURING AND TESTING RECORDS

2.2.1 Notified Body acceptance certificate

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EU CERTIFICATE OF CONFORMITY

Certificate No.:
C713698

Initial date:
24 January, 2025

This certificate consists of 3 pages

This is to certify that the products manufactured by:

T.I.C.I. S.r.l.
Via dell'Artigianato, 6 - 26010 Montodine (CR) - Italy

have been assessed with respect to the conformity assessment procedure described in:

ANNEX III MODULE G OF DIRECTIVE 2014/68/EU ON PRESSURE EQUIPMENT

and found to comply with the requirements in Annex I – Essential Safety Requirements of the Directive.

The certificate is valid for the following products:

Type of Pressure Equipment	**Pressure vessel**
Product Name	**Hydrogen vent**
Product Identification	**Q-43004**

Place and date:
Vimercate, 24 January, 2025

Check Validity

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

N° 0003 PRD

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC

Signatory of EA, IAF and ILAC Mutual Recognition Agreements

For the issuing office:
Notified Body 0496, Italy
DNV Business Assurance Italy S.r.l.

Maurizio Bellina
Management Representative

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.

DMSP-5-PA-PED-05-A13 rev.1

Certificate No.: C713698
Place and date: Vimercate 24 January, 2025
Revision No.: 00

Jurisdiction

Application of Directive 2014/68/EU and Decreto Legislativo n. 26 of 15 February 2016.

Certificate history:

Revision	Description	Issue Date
00	Original certificate	24 January, 2025

Design review reference

Documents id	Issued
PRJN804006-20241007–DER-MAULOM-03	24 December, 2024

Products covered by this Certificate:

Product Name	Product Description	PED Category	Product standard
Hydrogen vent	Hydrogen vent Q-43004	IV	ASME VIII Div.1

Design data:

Product Name	Maximum allowable pressure (PS)	Minimum allowable temperature (TS)	Maximum allowable temperature (TS)	Test pressure (PT)
Hydrogen vent	3,5 barg	-10°C	80°C	5,5 barg

Design data:

Product Name	Volume	DN	Fluid	Fluid group
Hydrogen Vent	6000 L	42”/20”/12”	Hydrogen Gas	1

Sites covered by this certificate:

Site Name	Site Address	Inspected by	Date	Report ref
T.I.C.I. S.r.l.	Via dell’Artigianato, 6 - 26010 Montodine (CR) - Italy	DNV Business Assurance Italy S.r.l.	25.10.2024	PRJN-804006 _ RPINS_2024-10-25 _0

Certificate No.: C713698
Place and date: Vimercate 24 January, 2025
Revision No.: 00

Documents reviewed:

Document No	Rev	Date	Title	Status *)
1724000887-MAC-DA-00003	3	10.10.2024	Hydrogen Vent General Arrangements	A
1724000887-MAC-CA-00004	4	29.11.2024	Mechanical Calculation Hydrogen Vent	A
Analysis of RES_23-0193-0101	-	11.09.2024	Satisfaction to RES	FI
Risk Analysis _ 1724000887	2	10.09.2024	Analysis of PED risks in accordance with Annex I point 1.2	FI
1724000887-MAC-MAN-00017	1	24.10.2024	Installation operating and maintenance Manual (IOM)	FI
1724000887-MAC-DD-00019 01	1	20.09.2024	Hydrogen Vent Lifting Drawing	A
1724000887-MAC-DD-00005	2	08.10.2024	Hydrogen Vent detailed Drawing with part list	A

*) A=Approved, FI=For information

Terms and conditions

Valid terms and conditions are found in the DNV´s PED Certification Requirements

End of Certificate

2.2.2 PED Documentation

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Base Load Power Hub (BLPH)

MECHANICAL CALCULATION
HYDROGEN VENT

Document Number: 1724000887-MAC-CA-00004

Document Class: 2

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	16/01/25

Rev.	Date	Description	Prepared	Reviewed	Approved
05	10/12/2024	Accepted for Construction (AFC)			
04	04/12/2024	Accepted for Construction (AFC)	DB	RV	AL
03	14/10/2024	Accepted for Construction (AFC)	DB	RV	AL
02	03/09/2024	Accepted for Construction (AFC)	DB	RV	AL
01	26/07/2024	Issue for Review (IFR)	DB	RV	AL
00	12/06/2024	Issue for Review (IFR)	DB	GP	AL

THERMO ENGINEERING
AN ENCORE COMBUSTION COMPANY

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Issue for Review (IFR)
02	Accepted for Costruction AFC)
03	Accepted for Costruction AFC)
04	Accepted for Construction (AFC)
05	Accepted for Construction (AFC)

HOLDS LIST

No.	Description
1	
2	
3	
4	

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REVISED TEXT AND PART IN BLU COLOR

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.

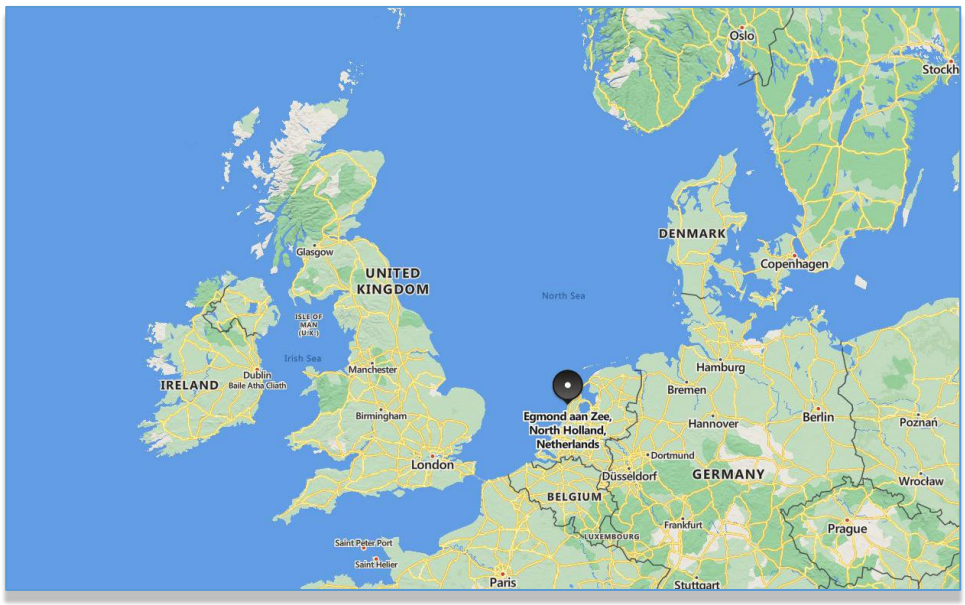


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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 located on coordinates E 590719.1, N 5841602.3 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.

1.1.2Project 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.

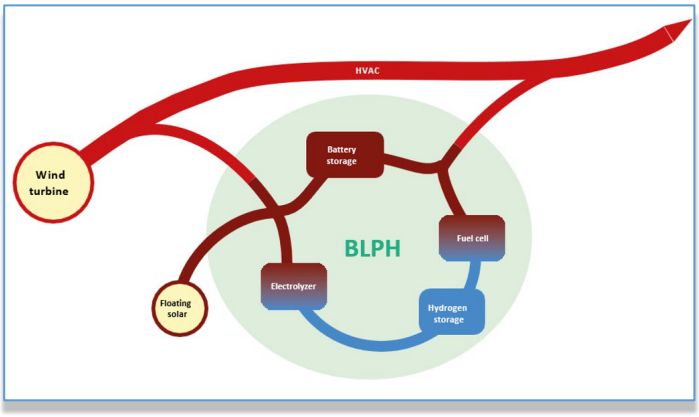


Figure 3 – BLPH Concept

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 s 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 aim of this document is to show the mechanical calculation for the hydrogen vent stack

2.1 References

Doc. No.	Description
1724000887-MAC-DA-00003	GENERAL ARRANGEMENT DRAWINGS, INCLUDING FOUNDATION LOADS-HYDROGEN VENT

Table 1 - Reference Documents

2.2 Definitions and Abbreviations

COMPANY - CPY	CrossWind
CONTRACTOR - CTR	ROSETTI MARINO S.p.A. -
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
ETE	Encore Thermoengineering srl
ASME	American Society of Mechanical Engineers
HKN	Hollandse Kust Noord
BLPH	Base Load Power Hub
B.O.P.	Bottom of Baseplate
BESS	Battery Energy Storage System
COG	Center of Gravity
DNV	Det Norske Veritas (notified body)
EDMS	Electronic Document Management System
HW	Hydrotest
ID	Inside Diameter
PV	Pressure Vessel
LRFD	Load and Resistance Factor Design

MAWP	Maximum allowable working Pressure
MDMT	Minimum Design Metal Temperature
MSL	Mean Sea Level
NP	No Pressure
OD	Outside Diameter
PP	Plot Plans
PVP	Pressure Vessel and Piping
SP	Specification
ST	Structural
THK	Thickness
TP	Transport Protocol
VooW	Van Oord Offshore Wind
W	Wind
Wt	Weight

Table 2 - Definitions and Abbreviations

2.3 Code and Rules

Doc. No.	Description
/1/ BS EN ISO 19900	General requirements for offshore structures - 2019
/2/ BS EN ISO 19901-1	Specific requirements for offshore structures - Part 1: Metocean design and operating considerations - 2015
/3/ BS EN ISO 19901-2	Seismic design procedures and criteria
/4/ BS EN ISO 19901-3	Specific requirements for offshore structures – Part 3: Topsides structure - 2014
/5/ BS EN ISO 19901-5	Specific requirements for offshore structures – Part 5: Weight Management - 2021
/6/ BS EN ISO 19901-6	Specific requirements for offshore structures – Part 6: Marine Operations – 2009

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/7/ BS EN ISO 19902	Petroleum and natural gas industries - Fixed steel offshore structures – 2020
/8/ ISO 19906:2019	Petroleum and natural gas industries – Arctic offshore structures
/9/ ANSI / AISC 360-16	Specification for Structural Steel Buildings - July 2016
/10/ API RP 2A-WSD	Recommended practice for planning, designing and constructing fixed offshore platforms – Working stress design – 22nd edition – 2014
/11/ DNVGL-ST-N001	DNV GL - Marine operation and marine warranty - 2021
/12/ EN 1991-1-3:2003 & A1:2015	EN, Eurocode 1 – Actions on Structures – Part 1-3: General actions – Snow loads - Incorporating corrigenda December 2004 and March 2009, December 2015.
/13/ DNV-ST-0145	DNV, Offshore substations
/14/ DNV-RP-C201	DNV, Buckling Strength of Plated Structures, October 2010.
/15/ DNVGL-RP-C203	DNV GL, Fatigue design of offshore steel structures, September 2019 and Amendment January 2020
/16/ DNVGL-RP-C204	DNVGL-RP-C204 Design against accidental loads – 2019
/17/ DNVGL-RP-C205	DNV GL - Environmental conditions and environmental loads - September 2019, amended September 2021.
/18/ DNV-OS-C101	Design of offshore steel structures, general- LRFD method, 2021
/19/ DNV-OS-B101	Metallic materials, 2021
/20/ DNVGL-ST-0126	Support structures for wind turbine, 2018

2.4 Company Specifications

Doc. No.	Description
/21/ DEP 37.19.00.12	Gen - Offshore Topsides Structures
/22/ DEP 37.19.00.30	Gen - Fixed Steel Offshore Structures (Adoption of IOGP S-631-11, Amendments / Supplements to ISO 19902:2020).

/23/ DEP 37.81.10.19	Gen - Marine Operations Requirements – Loadout, Transportation and Installation of Offshore Structures (Amendments / Supplements to ISO 19901-6)
/24/ DEP 37.91.10.11	Mobile Mooring Systems (Amendments / Supplements to API RP 2SK, API RP 2SM AND API RP 2I)

2.5 Project Documents

Doc. No.	Description
/25/ 123A90-DDL-MD-RE-01006	Weight Control Report
/26/ 123A90-PML-MD-PRO-01002	Weight Control Procedure
/27/ 123A90-DDL-PP-DS-70070	Plot Plans
/28/ Pending	Handling Philosophy Report
/29/ 123A90-DDL-ST-SP-90018	Structural Material Specification for Topside
/30/ Pending	Structural Material Specification for Transition Piece
/31/ 123A90-DDL-ST-SP-90019	Structural Fabrication Specification
/32/ 123A90-DDL-TI-SP-99014	Specification for TP, Topside and Caissons Transportation and Installation

2.6 Other Documents

Doc. No.	Description
/33/ K559–2254-ST-PHI-001	BLPH Structural Topsides Design & Installation Philosophy, Rev.1, 09 December 2022
/34/ K559–2254-ST-REP-001	BLPH Structural Topsides and Transition Piece Design and Analysis Report, Rev.0, 27 February 2023
/35/ 144671-VOOW-TF-ENG-REP-1011	Design Basis Part C, Re.4, 05-07-2021

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/36/ SR.20.01165 (not received)	Meteocean criteria for Hollandse Kust Noord Wind Farm zone (shell), Rev A03, 05-02-2021
/37/ K559–2254-WC-REP-001	BLPH Weight Control Report, Rev.2, 17 March 2023
/38/ 144671-VOOW-TF-ENG-REP-1051	Design Basis Part C for BLPH, Rev. 3, 28 June 2022
/39/ 144671-VOOW-TF-ENG-REP-1052	Wave Loads and Effects for BLPH, Rev. 0, 16 December 2021
/40/ 144671-VOOW-TF-ENG-REP-1016	Wave Run-up Study, Rev.2, 29 November 2021
/41/ 144671-VOOW-TF-ENG-REP-1103	Wave Impact Analysis, Rev.1, 7 May 2021
/42/ 144671-VOOW-TF-ENG-REP-1053	Axial Pile Capacity Assessment for BLPH, Rev.3, 07 July 2022
/43/ 144671-VOOW-TF-ENG-REP-1054	Foundation Load Document for BLPH, Rev.1, 07 April 2022
/44/ 144671-VOOW-TF-ENG-REP-1055	Design Verification Primary Steel for BLPH, Rev.1, 13 April 2022
/45/ 144671-VOOW-TF-ENG-REP-1056	Ship Impact for BLPH, Rev.0, 07 March 2022
/46/ 144671-VOOW-TF-ENG-REP-1502	Main Access Platform – Wave Run-up Braces
/47/ 144671-VOOW-GEN-SUR-REP-0074	Foundation As-built Survey CW70 HNA6
/48/ K559-2254-PM-PLN-003	Basic Design Engineering Package, Rev2, 06 July 2023

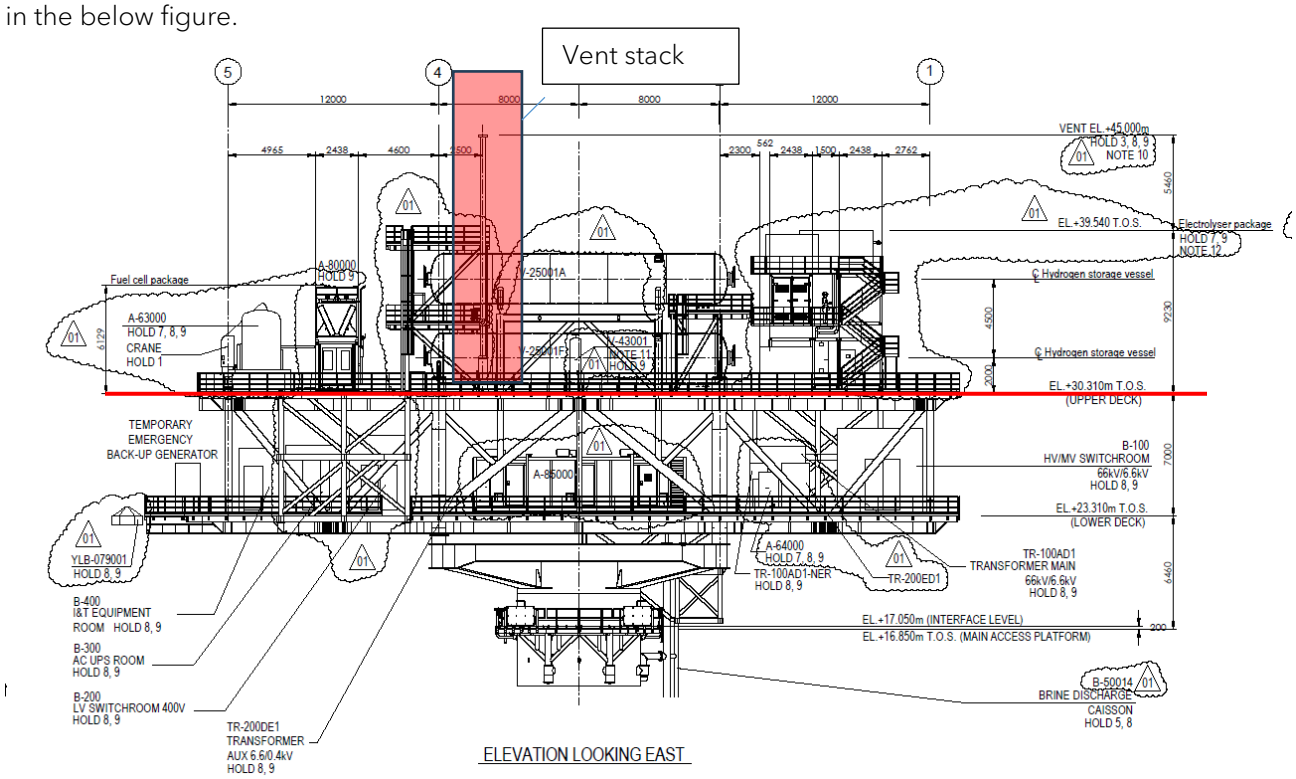
2.7 Code for Calculation of Equipment Under Pressure

This design of the bottom adheres to the guidelines and standards set forth by ASME Section VIII, Division 1, which governs the construction of pressure vessels. ASME (American Society of Mechanical Engineers) Section VIII, Division 1, is an internationally recognized code that provides detailed criteria for the design, fabrication, inspection, and testing of pressure vessels, thereby ensuring the safety, reliability, and efficiency of the equipment under pressure.

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3. SYSTEM DESCRIPTION

The bottom of the vent stack is located on the topside at el. 30.310 m B.O.P. (Bottom of baseplate) as shown in the below figure.



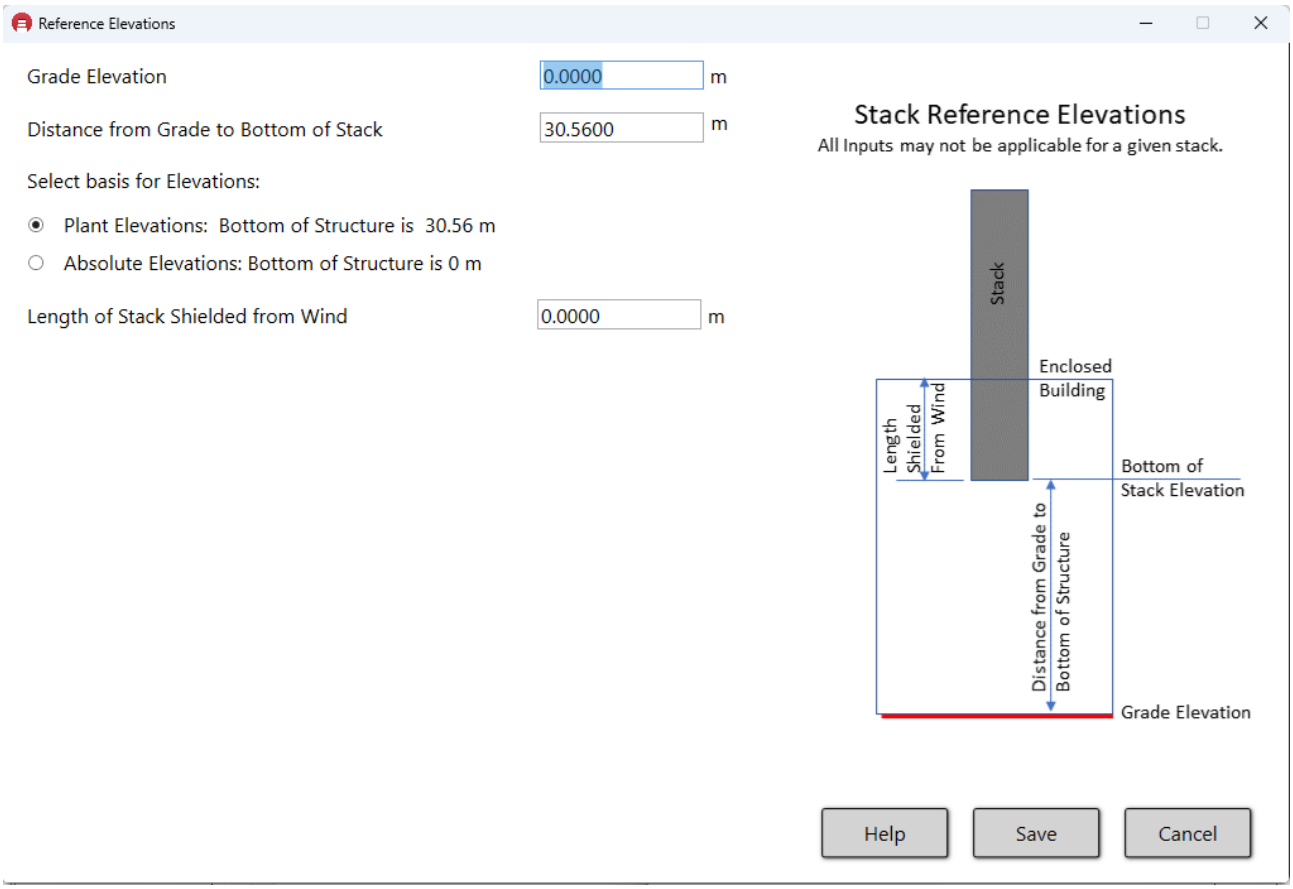
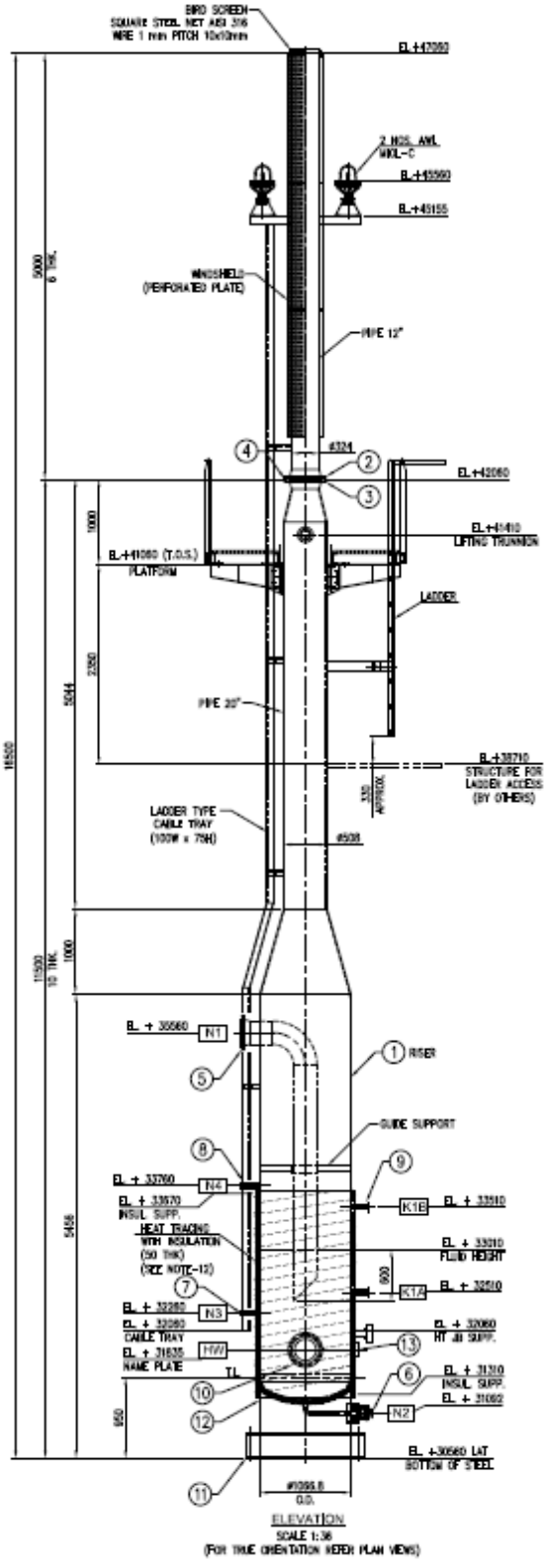
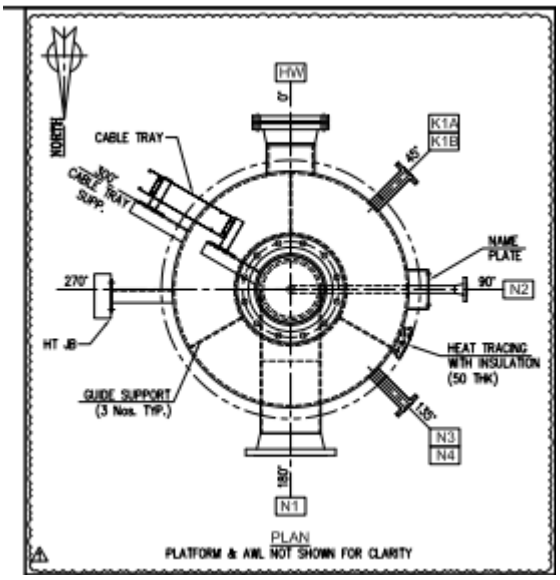


Figure 4 Elevation of the vent stack

The geometry of the vent stack is depicted in the document 1724000887-MAC-DA-00003 and shown hereafter for a quick reference.





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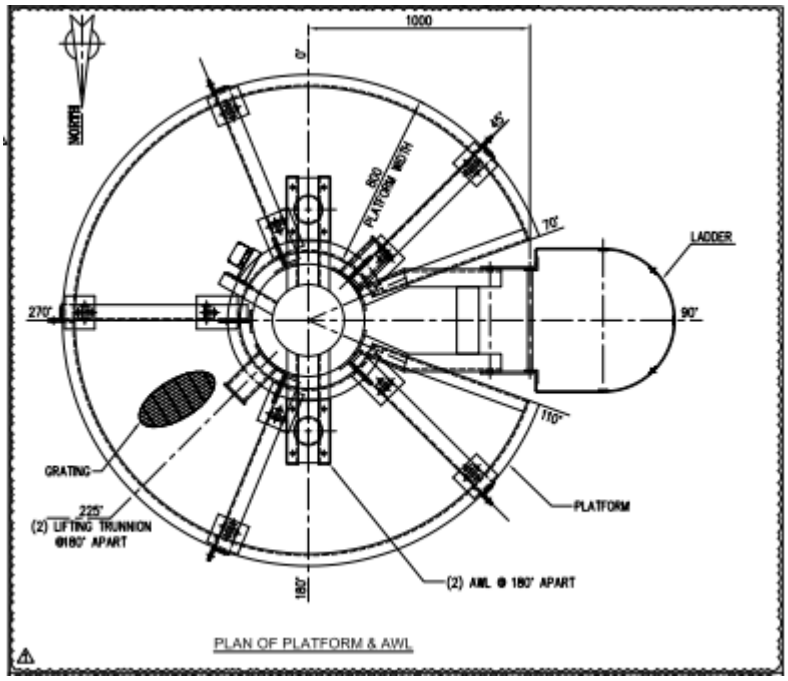


Figure 5 General Arrangment

The structure has a vortex disrupter device at the top, which is covered by a perforated shield to prevent the occurrence of vibrations caused by vortices.

4. LOADS

4.1 DEAD LOADS

The dead loads of the structural element are calculated according to the specific weight of the materials and the involved volumes.

The dead loads which is not parts of the resisting system has been inputted manually in the calculation.

4.2 DEAD LOAD OF EQUIPMENT CONTENT WEIGHT

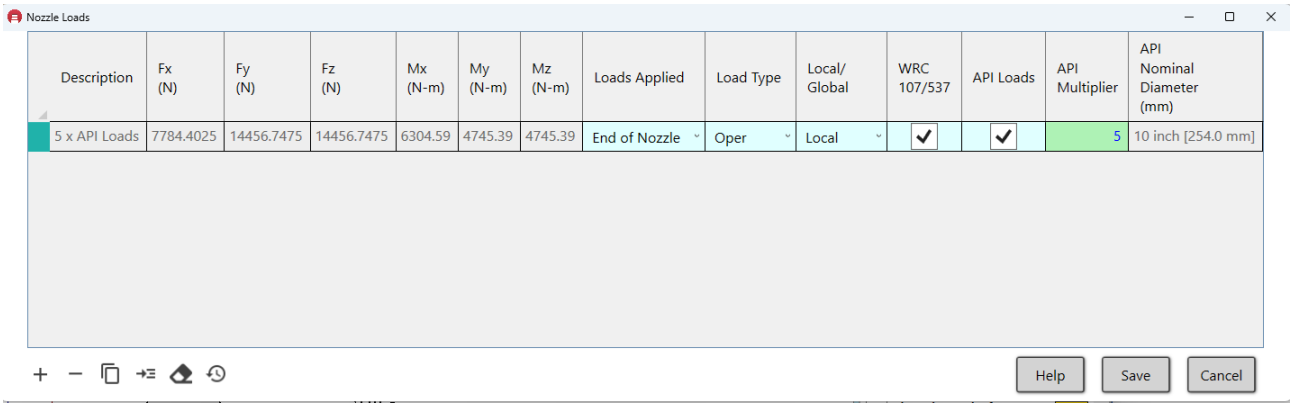
The dead load of the equipment content weight is coming from a water level up to 2.45 m inside of the stack from the elliptical bottom head.

4.3 LOADS ON PLATFORM

Not applicable

4.4 NOZZLE LOADS

Nozzle 1N's loads have been calculated with a factor of 5 times the value from API 537.



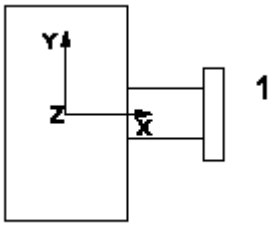


Figure 6 Nozzle 1N loads

4.5 WIND LOADS

For the pourpose of the calculation the desing wind load is considered according to 100 -years period of return (extreme environmental condition) according to the data K559-2254-PM-PLN-003 - Basic Design Engineering Package_rev2 §6.1.3.

6.1.3 Wind Speed Data

Omni-Directional wind data is to be used as shown in Table 6.6

Table 6.6 - Omni-Directional Extreme Values at 125 m MSL

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

Figure 6.6 Omni direction Extreme value of wind loads at 125 MSL

As the calculation is performed using the Eurocode the input shall be the design wind loads at 10 m and 10 min average. At the same time the structural verification following Eurocode procedure are performed consider 3s gust in conformity with the requirement of ISO 19901-3 (2014) .

A 10 min average wind speed of 42.9 m/s at 125 msl for a category II terrain is derived from a basic wind speed of 28 m/s. The latter is used for the calculations.

The following image is showing the detail of the porous shroud.

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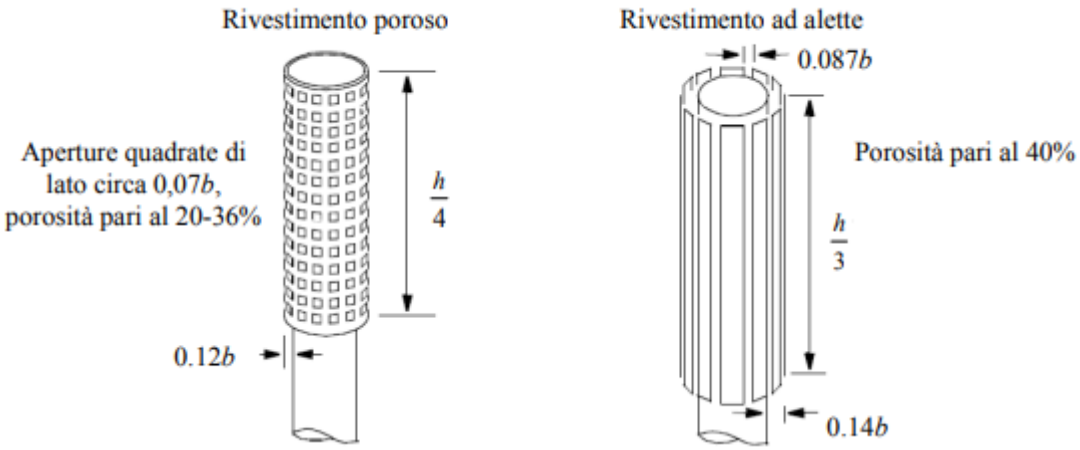


Figure 7 Porous shroud information

4.6 WAVE AND CURRENT LOADS

According to the structural design basis the table below reported applied to the case to evaluate the inertia forces.

Case	Location	Elevation (LAT) [m]	Sea State	Max acceleration [m/s2]
Operational	Topsides CoG	28	Normal	0.67
Extreme	Topsides CoG	28	Extreme	1.61

Figure 8 Topsides acceleration to evaluate inertia forces

According to the table an horizontal and vertical acceleration of $\frac{1.61}{9.806}g = 0.164$ is applied on the structure.

4.7 SEISMIC LOADS

Not applied

Transportation Loads

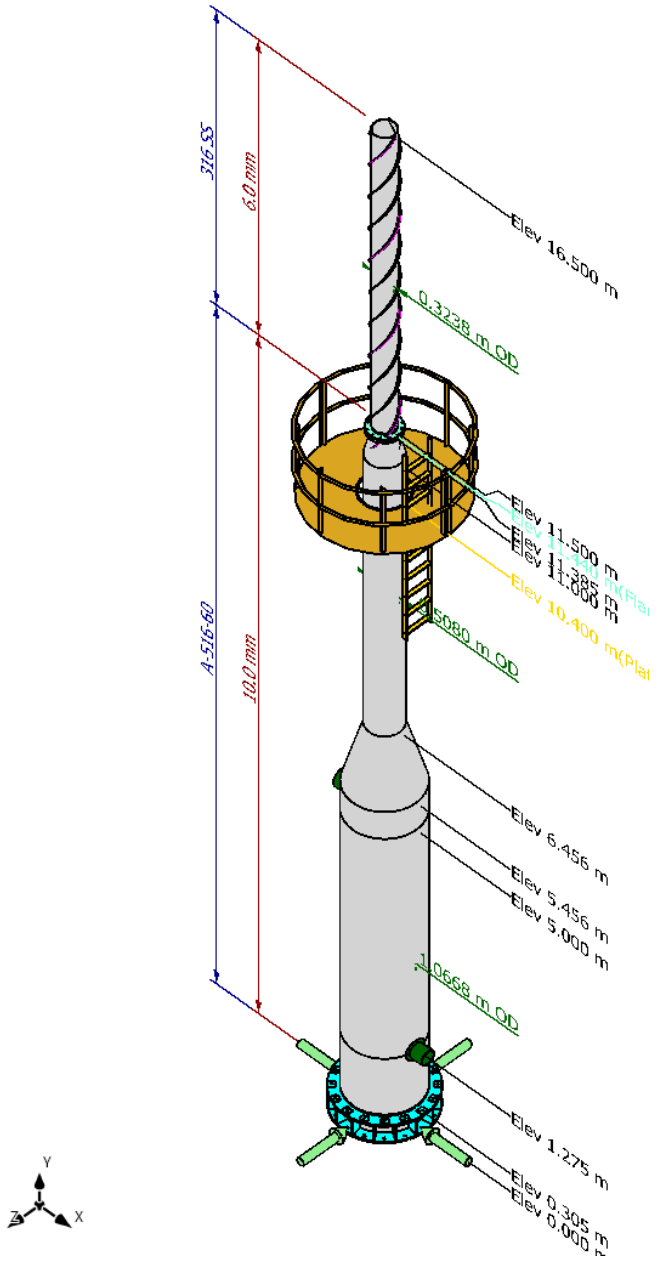
An horizontal load of 0.7 g us applied at the vent center of gravity to cater for the acceleration during the transportation

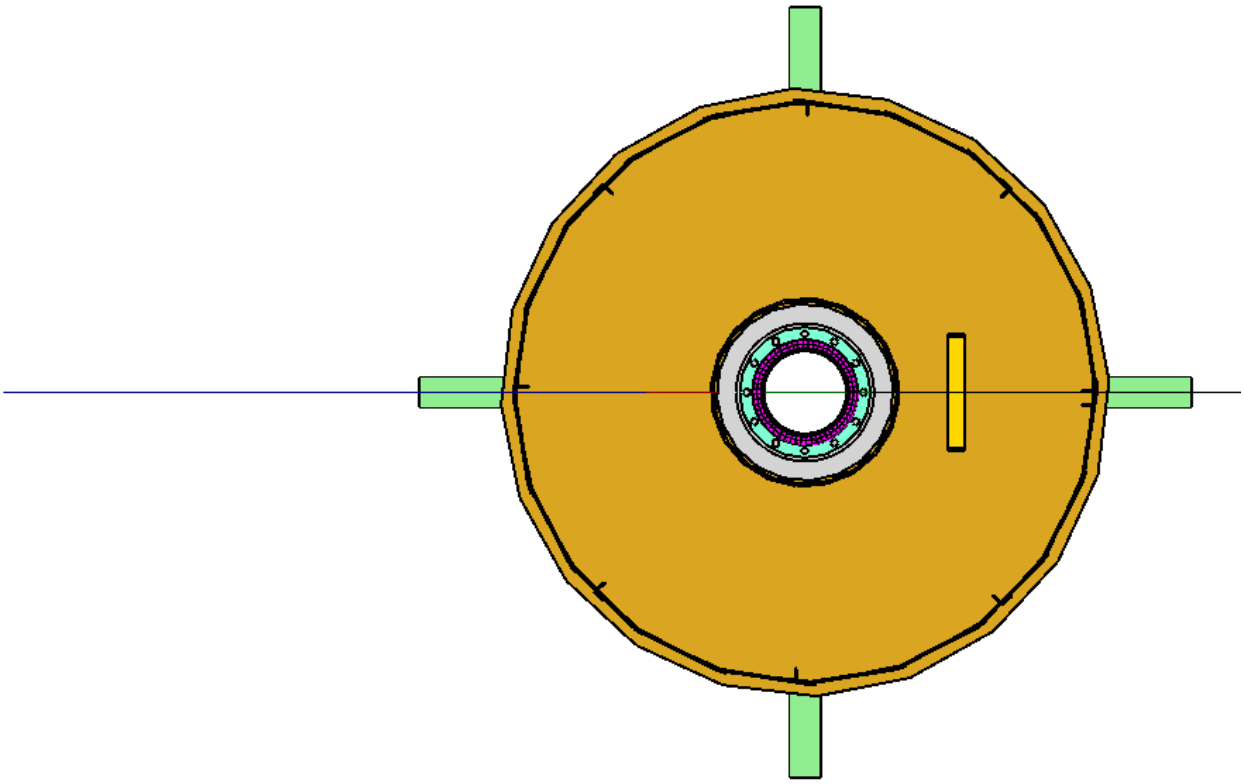
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5 STRUCTURAL CALCULATIONS

The calculation is performed using Mecastack one of the most reliable software in this field.

The Mecastack software is a specialized tool for the design and analysis of steel piles subjected to axial, transverse and moment loads. The software allows to check the strength, stability and deformability of the stacks according to international standards. In particular the calculation has been performed according to Eurocode standards.







Note:

1- We use helical strakes in the calculation instead of the porous shroud. The results are not affected because we only need to consider a large wind area. We size the porous shroud based on reliable literature and previous experience.

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2- A dummy high damping ratio of 10% has been added to the calculation to make the software ignore the vortex shedding (which is not important because of the shroud).

3- The loads case named "seismic" are referring to the maximum between transportation loads and case "wave and current loads" as shown above in this document. This is required because the software can handle only one seismic loads during the analysis.

MecaStack v5630

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Calculations Prepared by:
Date: Dec 04, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Vent Cross wind-20241204-00.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height = 16.50 m Top of Stack Elevation = 47.06 m
Grade Elevation = 0.00 m Bottom of Stack = 30.56 m

All elevations are entered based upon the bottom of the structure being at Elevation 30.56 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
47.06	0.3238	47.06	6.0	47.06	0.0
41.945	0.3238	42.06	10.0	42.06	3.0
41.56	0.5080			30.865	0.0
37.016	0.5080				
36.016	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
47.06	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		-10.00	206.84	195121	1.53E-05	137.89	8000	517.11
42.06	A-516-60	80.00	204.66	199333	1.20E-05	117.90	7849	413.68
		-10.00	220.63	202705	1.15E-05	117.90	7849	413.68
31.006	S275J0	80.00	239.00	207692	1.20E-05	101.79	7849	356.33

```
                -10.00 275.00   210000 1.20E-05     117.14    7849  410.03
```

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
40.960	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
42.060	38.960	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	33.010	31.510	0.0000	758.00	Oper
External insulation	33.660	30.910	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	31.510	0.000	200.0	Dead

Nozzles:

Num	Description	Elevation m	Nominal Diameter	Schedule	Outer Diameter mm	Thickness mm	Tilt Deg	Orien-tation Deg	Proj-ection mm
1	1N	35.560	10 inch [254.0 mm]	Std	273.1	9.3	0.0	180.0	200.0
2	HW	31.835	8 inch [203.2 mm]	Std	219.1	8.2	0.0	0.0	200.0

Num	Description	Repad Width mm	Repad Thickness mm	Flange Spec	Flange Radial Width mm	Flange Thickness mm	Nozzle Loads
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx	Fy	Fz	Mx	My	Mz	Local/ Global	Load Applied	Load Type	Check WRC 107

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			KN	KN	KN	KN-m	KN-m	KN-m				
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper		Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC KN	FyC KN	FzC KN	MxC KN-m	MyC KN-m	MzC KN-m		Ver KN	Shear KN	Mom KN-m	Mbase KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	|	14.46	16.42	7.89	89.99

Equivalent Nozzle Loads Applied on Stack:
Ver = Stack Vertical Load considered at Nozzle Elev: Fy
Shear = Stack Shear Load considered at Nozzle Elev: [Fx^2+Fz^2]^0.5
Mom = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
Mbase = Est Mom at base if no Support: Mom + Shear*Elev
Provided only to evaluate the impact of the load on overall stack

Helical Strakes: (3 Vanes 120 deg apart assumed)

ElTop	= Top Strake Elevation	= 47.06 m
ElBot	= Bottom Strake Elevation	= 41.56 m
Pitch	= Strake Pitch (One complete wrap)	= 1.6190 m
Width	= Strake Width	= 32.4 mm
Thick	= Strake Thickness	= 3.2 mm
OD	= Outer Diameter of Stack and Insulation (If Applicable)	= 323.8 mm
ShapeFac	= Strake Shape Factor (Applied to bare stack shell)	= 1.40
SO	= Stand-off from OD of shell to strake	= 0.0 mm
Len	= Pitch Length: [(PI*(OD+2*SO+2*Width))^2+(Pitch^2)]^0.5	= 32.588 m
Area	= Total Painted Area (3 vanes): (2*Width*Len*3*Wraps)	= 92.932 sq cm
Wraps	= Total Number of Wraps (Top elev - Bot elev)/ Pitch	= 3.40
WtUni	= Estimated Linear Weight of Strakes and Clips: Wt/(ElTop-ElBot)	= 4.54 kg/m
Wt	= Estimated total Wt of Strakes and Clips: 1.5*(Area/2)*Thick*Dens	= 25.0 kg

Type	= Type of Baseplate	= Chair Continuous Plate
SupType	= Type of Support	= Rigid Steel Base
Friction	= Coefficient of Friction for Support	= 0.300
BasisBolt	= Basis for Bolt Design	= Brownell & Young
Nbolt	= Number of Bolts	= 16
Dbolt	= Nominal Bolt Diameter	= 27.0 mm
Dbh	= Bolt Hole Diameter	= 36.0 mm
CAbolt	= Corrosion Allowance on Bolt	= 3.0 mm
CAplt	= Corrosion Allowance on Plates	= 0.0 mm
ID	= Inside Diameter of Baseplate	= 820.0 mm
BCD	= Bolt Circle Diameter of Baseplate	= 1270.0 mm
OD	= Outer Diameter of Baseplate	= 1385.0 mm
Tb	= Thickness of Bottom Plate	= 25.0 mm
Tt	= Thickness of Top Plate	= 25.0 mm
Fw	= Fillet Weld Size	= 5.0 mm

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```
Fwu       = Weld Ultimate Tensile Strength                          = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                              = 1
Hg        = Height of Anchor Chair                                  = 305.0 mm
Tg        = Thickness of Gusset                                     = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                  = S275J0
Dens      = Material Density                                        = 7849 Kg/m^3
Temp      = Design Temperature                                      = 21.11 Deg C
Fy        = Minimum Yield Stress                                    = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                 = 410030.5
KPa
Sa        = Allowable Tensile Stress                                = 117141.7
KPa
E         = Modulus of Elasticity                                   = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                        = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                               = False
Matl      = Bolt Material Specification                             = Gr. 8.8
Fu        = Ultimate Tensile Stress                                 = 800548.8
KPa
Fy        = Yield Stress                                            = 640440.4
KPa
Fproof    = Proof Stress                                            = 544374.4
KPa
Eb        = Modulus of Elasticity                                   = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile            = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                            = 800.55 MPa
PreStress = Pretension Stress on Bolt                               = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                = Rectangular
Pt        = Plate Washer Thickness                                  = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                  = 90.0 mm
Pl        = Length of Washer Parallel to Shell                      = 100.0 mm
Pdh       = Bolt Hole Diameter                                      = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 42.0 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                 = 323.8 mm
Do        = Outside Diameter of Flange                              = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange            = 25.4 mm
Dbc       = Bolt Circle Diameter                                    = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle             = 54.0 mm
Tf        = Thickness of Flange                                     = 31.8 mm
Tw        = Fillet Weld Size                                        = 6.0 mm
Gus       = Gussets                                                 = False
Db        = Nominal Bolt Diameter                                   = 22.2 mm
Nb        = Number of Bolts                                         = 12
BMatl     = Bolt Material                                           = Gr 8 (US)
```

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```
Fu        = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
FMatl     = Flange Material                                               = A-36
Fyf       = Yield Stress of Flange                                        = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                               = 193742.33
MPa
```

Design Codes

Comprehensive Design Standard:

Stress Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

```
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)     = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters       = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset              = False
```

Wind Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'

```
Vbo       = Basic Wind Velocity (10 minute mean)                          = 28.00 m/s
Cdir      = Directional Factor per Para 4.2                               = 1.000
Cseason   = Season factor per Para 4.2                                    = 1.000
Ki        = Turbulence Factor per Para 4.3.2                              = 1.000
K         = Equivalent Surface Roughness per Table 7.13                   = 0.0200 mm
Terrain   = Terrain Category Per Table 4.1                                = 0
Alt       = Altitude of the site above sea level                          = 0.0000 m
```

Vortex Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'

```
Arrange   = Stack Arrangement                                             = Single
Simplified= Use the simplified method found in Para E.1.5.3 'Approach 2'  = False
Modes     = Number of Modes to consider in Vortex Shedding Analysis       = 1
```

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

```
Life      = Fatigue Life Of Stack In Years                                = 50.0 Years
GMf       = Partial Safety Factor for Fatigue Strength                    = 1.35
GFf       = Partial Safety Factor for Equiv Const Amplitude Stress Range  = 1.00
```

Fatigue Categories: Euro

Elev m	Cat
47.060	69

Seismic Criteria: Manually Specify Seismic Loading

```
Spec      = What is the basis for the loads being entered                 =
Ft        = Load applied at the top of the stack (0 if none)              = 0 N
RatioShear= Ratio of Base Shear to Dead Weight (g-force)                  = 0.700
RatioVer  = Ratio of Base Vertical Load to Dead Weight (g-force)          = 0.700
Method    = Method used to apply the loads to the structure               = ASCE 7-10
Fac_Live  = Factor to apply to Live loads to be treated as Mass           = 0.000
```

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```
Fac_Oper  = Factor to apply to operating loads to be treated as Masses      = 1.000
```

Deflection Criteria:

```
Deflection Criteria for Static Loading:
MaxDefl   = Limitation based upon Stack Ht: Stack_Ht / 133                  = 124.1 mm

Deflection Criteria for Vortex Loading:
DeflLimit = Limitation based upon a % of Top OD: Stack_Top_OD x 0.05        = 16.2 mm
```

Damping Criteria:

```
Structural Damping Criteria:
     Criteria:      ASME STS-1-2021
     Stack Type:   UnLined
     Support:      ELASTIC
```

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

```
   Log Decrement Damping = 2 * PI * Bs

Aerodynamic Damping Criteria:
     (Only used in Along wind analysis, Not considered for vortex shedding)

     Criteria:   EN 1994-1-4
```

Weight Summary (Live)

Component	Elev COG m	Weight kg	Weight N
Platforms (Live, Fac = 1)	40.960	1360.1	13338
Total	40.960	1360.1	13338

Platforms (Live Load)

Platform Elevation m	Platform Total Angle Deg	Platform Width m	Platform Area sq m	Live Load Pressure kPa	Live Load Force kg
40.960	360.0	0.7500	2.964	4.500	1360.1
Total	0.0	0.0000	0.000	0.000	1360.1

Weight Summary (Oper)

Component	Elev COG	Weight	Weight

	m	kg	N
General Attachment Uniform (Oper, Fac = 1)	32.260	1137.0	11150
Nozzle(s)	35.560	-1474.2	-14457
Total	46.688	-337.2	-3307

General Attach Uniform Wt (Oper, Factor = 1): (Wt = 1137.0 kg, El COG = 32.260 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
Water	33.010	31.510	32.260	758.00	1137.0
Total	30.560	30.560	32.260		1137.0

Nozzle Wt (Oper): (Wt = -1474.2 kg, El COG = 35.560 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	35.560	273.1	0.00	0.00	0.00	0.00	-1474.18	35.560	-1474.18
Total		0.0	0.00	0.00	0.00	0.00	-1474.18	35.560	-1474.18

Weight Summary (Dead)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	36.164	2458.5	24110
Ladders	40.510	69.2	679
Platforms	40.960	319.3	3132
Helical Strakes	44.310	25.0	245
Baseplate	30.687	389.0	3815
Structural Flange(s)	42.000	58.0	569
Nozzle(s)	34.097	53.2	521
General Attachment Uniform)	32.285	82.5	809
General Attachment Concentrated	31.510	200.0	1961
Total	35.859	3654.7	35841

Cylindrical Shells Wt: (Wt = 2458.5 kg, El COG = 36.164 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
47.060	42.060	44.560	0.3238	6.0	8000	239.6	47.92	239.6
42.060	41.945	42.003	0.3238	10.0	7849	6.3	77.38	8.9
41.945	41.560	41.753	0.4159	10.0	7849	27.2	100.09	38.5
41.560	37.016	39.288	0.5080	10.0	7849	393.0	122.80	558.0
37.016	36.016	36.516	0.7874	10.0	7849	134.7	191.69	191.7
36.016	31.006	33.511	1.0668	10.0	7849	916.5	260.59	1305.6
31.006	30.865	30.936	1.0668	10.0	7849	25.8	260.59	36.7
30.865	30.560	30.713	1.0668	10.0	7849	79.5	260.59	79.5

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Total	36.164					1822.5		2458.5

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 40.510 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	42.060	38.960	40.510	22.32	69.2
Total			40.510		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 40.960 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
40.960	0.0	360.0	0.7500	0.5080	40.960	319.3
Total					40.960	319.3

Helical Strakes Wt: (Wt = 25.0 kg, El COG = 44.310 m)

El Top m	El Bot m	El COG m	Lin Wt kg/m	TOt Wt kg
47.060	41.560	44.310	4.54	25.0
Total		44.310		25.0

Baseplate Wt: (Wt = 389.0 kg, El COG = 30.687 m)

Description	Elevation COG m	Weight kg
Bottom Plate	30.573	192.0
Top Plate	30.853	120.2
Gussets	30.713	61.1
Washers	30.713	15.6
Total	30.687	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 42.000 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
42.000	482.6	31.8	0.0	0.0	0.0	25.1	7.9	42.000	2	58.0
Total					0.0	25.1	7.9	42.000		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

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Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 34.097 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	35.560	273.1	-3.99	12.06	7.36	16.85	0.00	35.560	32.27
2	31.835	219.1	-2.53	8.51	2.65	12.26	0.00	31.835	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	34.097	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 32.285 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	33.660	30.910	32.285	30.00	82.5
Total	30.560	30.560	32.285		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 31.510 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	31.510	0.000	200.0
Total	31.510		200.0

Weights of Each Lifting Section
Assumes each section with a flange or field weld is a lifting section

Lift Section Number	Elev Bottom m	Elev Top m	Section Length m	Elev Center of Gravity m	Weight kg
1	30.560	42.000	11.4400	35.099	3357.1
2	42.000	47.060	5.0600	44.257	297.6
Total	30.560	47.060	16.5000	35.845	3654.7

Lifting Weight Detailed Breakdown

Component	Lift # 1 kg	Lift # 2 kg	Total kg
Stack	2214.3	244.2	2458.5
Ladder(s)	67.9	1.3	69.2
Platform(s)	319.3	0.0	319.3
Helical Strakes	2.0	23.0	25.0
Baseplate	389.0	0.0	389.0
Structural Flange(s)	29.0	29.0	58.0
Nozzle(s)	53.2	0.0	53.2
Gen Attach Uniform	82.5	0.0	82.5
Gen Attach Concentrated	200.0	0.0	200.0
Total	3357.1	297.6	3654.7

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Wind Area Summary

Elev m	Shape Fac Riser	Riser Area m^2/m	Ladder Area m^2/m	Platform Area m^2/m	Piping Area m^2/m	Attach Area m^2/m	Tot Uni Area m^2/m	Total Area sq m
47.060	1.400	0.453	0.000	0.000	0.000	0.000	0.453	1.360
44.060	1.400	0.453	0.000	0.000	0.000	0.000	0.453	0.907
42.060	1.400	0.453	0.305	0.000	0.000	0.000	0.758	0.025
42.027	1.400	0.453	0.305	1.824	0.000	0.000	2.582	0.211
41.945	1.400	0.453	0.305	1.824	0.000	0.000	2.582	0.331
41.817	1.400	0.539	0.305	1.885	0.000	0.000	2.729	0.350
41.688	1.400	0.625	0.305	1.947	0.000	0.000	2.877	0.369
41.560	0.512	0.260	0.305	2.008	0.000	0.000	2.573	1.544
40.960	0.511	0.260	0.305	0.000	0.000	0.000	0.565	1.129
38.960	0.510	0.259	0.000	0.000	0.000	0.000	0.259	0.504
37.016	0.508	0.258	0.000	0.000	0.000	0.000	0.258	0.086
36.683	0.509	0.353	0.000	0.000	0.000	0.000	0.353	0.118
36.349	0.507	0.446	0.000	0.000	0.000	0.000	0.446	0.149
36.016	0.504	0.538	0.000	0.000	0.000	0.000	0.538	0.172
35.697	0.504	0.537	0.000	0.000	0.000	0.000	0.537	0.073
35.560	0.504	0.537	0.000	0.000	0.000	0.000	0.537	0.073
35.423	0.503	0.537	0.000	0.000	0.000	0.000	0.537	0.947
33.660	0.501	0.534	0.000	0.000	0.000	0.000	0.534	0.347
33.010	0.499	0.533	0.000	0.000	0.000	0.000	0.533	0.567
31.945	0.495	0.528	0.000	0.000	0.000	0.000	0.528	0.058
31.835	0.495	0.528	0.000	0.000	0.000	0.000	0.528	0.058
31.725	0.494	0.527	0.000	0.000	0.000	0.000	0.527	0.114
31.510	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.265
31.006	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.050
30.910	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.024
30.865	0.493	0.526	0.000	0.000	0.000	2.244	2.770	0.845
Total (m^2/m)								10.676

1. Total Riser Wind Area = 6.967 sq m (65.26 % of Total Area)
2. Total Ladder Wind Area = 0.945 sq m (8.85 % of Total Area)
3. Total Platform Wind Area = 2.080 sq m (19.48 % of Total Area)
4. Total Piping Wind Area = 0.000 sq m (0.00 % of Total Area)
5. Total Attachment Wind Area = 0.684 sq m (6.41 % of Total Area)

Wind Area: Ladders

Elev Bot m	Elev Top m	Shape Factor	Overlap	Wind Area m^2/m
42.027	42.060	2.000	No	0.305
41.945	42.027	2.000	No	0.305
41.817	41.945	2.000	No	0.305
41.688	41.817	2.000	No	0.305
41.560	41.688	2.000	No	0.305
40.960	41.560	2.000	No	0.305
38.960	40.960	2.000	No	0.305

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Overlap : When 2 ladders overlap only 25% of one ladder is considered due to shielding.

Wind Area: Platforms

Elev Top m	Elev Bot m	Shape Factor	Wind Area m^2/m	Tot Wind Area sq m
42.027	40.960	2.000	2.008	2.142

Wind Area: General Attachment (Uniform)

Elev Top m	Elev Bot m	Wind Area m^2/m
33.010	31.510	0.000
33.660	30.910	0.000

Wind Area: General Attachment (Concentrated)
Shape factor is accounted for manually by the user in the wind areas entered

Wind Area: General Attachment (Concentrated)

Elev Top m	Elev Bot m	Wind Area m^2/m
31.725	31.510	0.000

Wind Area: Baseplate

OD = Outer diameter of baseplate = 1.3850 m
StackOD = Outer Diameter of Stack = 1.0668 m
Cf_Riser = Wind Shape Factor for Riser = 0.493
Cf_LandP = Wind Shape Factor for Ladders & Platforms = 2.000
Wind Area = OD * Cf_LandP - StackOD * Cf_Riser = 2.244 m^2/m
The Baseplate wind area is included in the 'Attachment' category.

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
47.060	44.060	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
44.060	42.060	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
42.060	42.027	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
42.027	41.945	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
41.945	41.817	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
41.817	41.688	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
41.688	41.560	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
41.560	40.960	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
40.960	38.960	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal

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38.960	37.016	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
37.016	36.683	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
36.683	36.349	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
36.349	36.016	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
36.016	35.697	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
35.697	35.560	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
35.560	35.423	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
35.423	33.660	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
33.660	33.010	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
33.010	31.945	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.945	31.835	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
31.835	31.725	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
31.725	31.510	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.510	31.006	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.006	30.910	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
30.910	30.865	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
30.865	30.560	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5

Section Props - If a number is shown, then the section contains something unusual (Breach, nozzle, stiffeners, etc..) and so the properties were calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Thermal Expansion of Stack
+ values are in the +Y (up) direction and - values are in the -Y (Down)

Elev m	Installation Temperature Deg C	Hot Temperature Deg C	Hot Expansion mm	Cold Temperature Deg C	Cold Expansion mm
47.060	21.11	200.00	23.4	-10.00	-6.5
44.060	21.11	200.00	14.2	-10.00	-5.1
42.060	21.11	80.00	8.1	-10.00	-4.1
42.027	21.11	80.00	8.1	-10.00	-4.1
41.945	21.11	80.00	8.0	-10.00	-4.1
41.817	21.11	80.00	7.9	-10.00	-4.0
41.688	21.11	80.00	7.8	-10.00	-4.0
41.560	21.11	80.00	7.8	-10.00	-3.9
40.960	21.11	80.00	7.3	-10.00	-3.7
38.960	21.11	80.00	5.9	-10.00	-3.0
37.016	21.11	80.00	4.6	-10.00	-2.3
36.683	21.11	80.00	4.3	-10.00	-2.2
36.349	21.11	80.00	4.1	-10.00	-2.1

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36.016	21.11	80.00	3.8	-10.00	-2.0
35.697	21.11	80.00	3.6	-10.00	-1.8
35.560	21.11	80.00	3.5	-10.00	-1.8
35.423	21.11	80.00	3.4	-10.00	-1.7
33.660	21.11	80.00	2.2	-10.00	-1.1
33.010	21.11	80.00	1.7	-10.00	-0.9
31.945	21.11	80.00	1.0	-10.00	-0.5
31.835	21.11	80.00	0.9	-10.00	-0.5
31.725	21.11	80.00	0.8	-10.00	-0.4
31.510	21.11	80.00	0.7	-10.00	-0.3
31.006	21.11	80.00	0.3	-10.00	-0.2
30.910	21.11	80.00	0.2	-10.00	-0.1
30.865	21.11	80.00	0.2	-10.00	-0.1
30.560	21.11	80.00	0.0	-10.00	0.0

1. Elevation for Y restraint = 30.56 m

Frequency Summary

Description	Direction Deg	Mode # 1 Hz	Mode # 2 Hz	Mode # 3 Hz
Hot & Corroded	0.0	3.822	11.290	26.499
Hot & UnCorroded	0.0	4.472	12.368	29.949
Cold & Corroded	0.0	3.860	11.502	26.899
Cold & Uncorroded	0.0	4.518	12.625	30.382

Mode Shape (Hot & Corroded)

Elevation m	Mode # 1 (3.822 Hz) Normalized	Mode # 2 (11.290 Hz) Normalized	Mode # 3 (26.499 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.620	0.111	-0.430
42.060	0.404	-0.224	-0.487
42.027	0.401	-0.226	-0.479
41.945	0.394	-0.231	-0.460
41.817	0.383	-0.237	-0.426
41.688	0.372	-0.242	-0.391
41.560	0.361	-0.247	-0.354
40.960	0.312	-0.260	-0.175
38.960	0.168	-0.240	0.370
37.016	0.077	-0.161	0.535
36.683	0.068	-0.147	0.514
36.349	0.061	-0.134	0.483
36.016	0.054	-0.121	0.448
35.697	0.049	-0.109	0.414
35.560	0.046	-0.105	0.399
35.423	0.044	-0.100	0.384
33.660	0.018	-0.044	0.186
33.010	0.011	-0.027	0.121
31.945	0.003	-0.008	0.037

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31.835	0.003	-0.007	0.031
31.725	0.002	-0.005	0.025
31.510	0.001	-0.003	0.016
31.006	0.000	0.000	0.002
30.910	0.000	0.000	0.001
30.865	0.000	0.000	0.001

Mode Shape (Hot & UnCorroded)

Elevation m	Mode # 1 (4.472 Hz) Normalized	Mode # 2 (12.368 Hz) Normalized	Mode # 3 (29.949 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.597	0.073	-0.510
42.060	0.380	-0.245	-0.485
42.027	0.377	-0.246	-0.476
41.945	0.370	-0.249	-0.452
41.817	0.360	-0.252	-0.414
41.688	0.350	-0.255	-0.375
41.560	0.339	-0.257	-0.334
40.960	0.293	-0.260	-0.143
38.960	0.158	-0.221	0.403
37.016	0.072	-0.143	0.547
36.683	0.064	-0.130	0.524
36.349	0.057	-0.118	0.492
36.016	0.051	-0.107	0.456
35.697	0.046	-0.097	0.421
35.560	0.044	-0.092	0.405
35.423	0.041	-0.088	0.390
33.660	0.017	-0.039	0.189
33.010	0.011	-0.024	0.124
31.945	0.003	-0.007	0.039
31.835	0.003	-0.006	0.033
31.725	0.002	-0.005	0.027
31.510	0.001	-0.003	0.017
31.006	0.000	-0.001	0.003
30.910	0.000	0.000	0.002
30.865	0.000	0.000	0.001

Mode Shape (Cold & Corroded)

Elevation m	Mode # 1 (3.860 Hz) Normalized	Mode # 2 (11.502 Hz) Normalized	Mode # 3 (26.899 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.623	0.117	-0.418
42.060	0.408	-0.221	-0.487
42.027	0.405	-0.223	-0.480
41.945	0.397	-0.228	-0.461
41.817	0.386	-0.235	-0.428
41.688	0.375	-0.240	-0.393
41.560	0.364	-0.245	-0.357
40.960	0.314	-0.260	-0.180

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38.960	0.169	-0.243	0.364
37.016	0.078	-0.164	0.533
36.683	0.069	-0.150	0.512
36.349	0.061	-0.137	0.482
36.016	0.055	-0.124	0.447
35.697	0.049	-0.112	0.413
35.560	0.047	-0.107	0.398
35.423	0.044	-0.102	0.383
33.660	0.018	-0.044	0.186
33.010	0.011	-0.028	0.121
31.945	0.003	-0.008	0.038
31.835	0.003	-0.007	0.031
31.725	0.002	-0.006	0.026
31.510	0.001	-0.003	0.016
31.006	0.000	0.000	0.002
30.910	0.000	0.000	0.001
30.865	0.000	0.000	0.001

Mode Shape (Cold & Uncorroded)

Elevation m	Mode # 1 (4.518 Hz) Normalized	Mode # 2 (12.625 Hz) Normalized	Mode # 3 (30.382 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.601	0.078	-0.497
42.060	0.384	-0.241	-0.486
42.027	0.381	-0.243	-0.477
41.945	0.374	-0.246	-0.454
41.817	0.364	-0.250	-0.416
41.688	0.353	-0.253	-0.377
41.560	0.343	-0.255	-0.338
40.960	0.296	-0.260	-0.148
38.960	0.160	-0.224	0.397
37.016	0.073	-0.145	0.545
36.683	0.065	-0.132	0.522
36.349	0.058	-0.121	0.490
36.016	0.052	-0.109	0.455
35.697	0.046	-0.099	0.420
35.560	0.044	-0.094	0.404
35.423	0.042	-0.090	0.389
33.660	0.017	-0.039	0.189
33.010	0.011	-0.025	0.124
31.945	0.003	-0.008	0.039
31.835	0.003	-0.006	0.033
31.725	0.002	-0.005	0.027
31.510	0.001	-0.003	0.017
31.006	0.000	-0.001	0.003
30.910	0.000	0.000	0.002
30.865	0.000	0.000	0.001

Wind Loads per Eurocode - EN 1991-1-4:2005(E)

Wind Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'
Vbo = Basic Wind Velocity (10 minute mean) = 28.00 m/s
Cdir = Directional Factor per Para 4.2 = 1.000

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Cseason   = Season factor per Para 4.2                                  = 1.000
Ki        = Turbulence Factor per Para 4.3.2                           = 1.000
K         = Equivalent Surface Roughness per Table 7.13                = 0.0200 mm
Terrain   = Terrain Category Per Table 4.1                             = 0
Alt       = Altitude of the site above sea level                       = 0.0000 m
```

Orography Factors {Ref Para 4.3.1}

Elev m	Co
47.060	1.000

```
H         = Distance from Bottom of Stack to Top of Stack              = 16.5000 m
zbase     = Distance from Grade to Bottom of Stack                     = 30.5600 m
b         = Average Wind OD for entire Stack                           = 0.6441 m
Zs        = 0.6*H + zbase  {Fig 6.1}                                   = 40.4600 m
Calt      = 1 + 0.001 * Alt * (10/Zs)^0.2   {Since z > 10 m NA.2b}     = 1.000
Vb        = Basic Wind Velocity: Vbo * Cdir * Calt * Cseason {Eqn 4.1} = 28.00 m/s
Zo        = Terrain Categories and parameters (Table 4.1)              = 0.0030 m
Zmin      = Terrain Categories and parameters (Table 4.1)              = 1.0000 m
Kr        = 0.19 * (Zo / 0.05)^0.07   {Eqn 4.5}                        = 0.156
Sy        = Wind Turbulence: Kr * Vb * Ki {Eqn 4.6}                    = 4.37

Zs        = 0.6*H + zbase  {Fig 6.1}                                   = 40.4600 m
Zt        = Reference height provided in Annex B.1                     = 200.00
Lt        = Reference length scale provided in Annex B.1               = 300.00
Alpha     = 0.67 + 0.05 * Ln(Zo)  {Eqn B.1}                            = 0.380
Lzs       = Lt * (Zs / Zt)^Alpha   {Eqn B.1}                           = 163.575
Cr(Zs)    = Roughness Factor: Kr * ln(Zs/Zo)   {Eqn 4.4}               = 1.484
Co        = Orography factor based upon user entered data @ Elev = 71.020 m = 1.00
Vm(Zs)    = Cr(Zs) * Co(Zs) * Vb  {Eqn 4.3}                            = 41.55 m/s
n         = Natural Frequency                                          = 3.822 Hz
Fl(Zs)    = n * L(Zs) / Vm(Zs)  {Eqn B.2}                              = 15.049
Sl(Zs)    = Spectral - 6.8*Fl(Zs) / (1+10.2*fl(Zs))^(5/3)  {Eqn B.2}   = 0.023

d         = Diameter used for Reynolds Number Calculation              = 0.6441 m
V         = V used for Reynolds Number Calculation                     = 54.74 m/s
Re        = Reynolds Number: d * V / 0.000015  {Eqn 7.15}               = 2.35E+06
Cfo       = Force Coeff for Cylinder without Free End flow per Fig 7.28 = 0.650
Lambda    = Effective Slenderness Ratio per Table 7.16                 = 25.288
Pl        = Lookup value based upon Lambda from Fig 7.16               = 0.801
me        = Equivalent mass per unit length   {F.14}                   = 74.71 kg/m
Ba        = Aero Log Decrement Damping:  Cf*Rho*b*Vm(Zs)/(2*n*me)  [F.18] = 0.0299
Bs        = Structural Log Damping                                     = 0.6283
Bt        = Total Logarithmic Damping: (Bs+Ba)*2*PI  {Eqn B.6}         = 0.658
B2        = Background: 1/(1+0.9*((b+h)/L(Zs))^0.63)  {Eqn B.3}        = 0.821
Nh        = 4.6 * h * fl(Zs) / L(Zs)  {Eqn B.8}                        = 6.983
Nh        = 4.6 * b * fl(Zs) / L(Zs)  {Eqn B.8}                        = 0.273
Rh        = 1/Nh - (1-e^(-2*Nh))/(2*Nh^2)  {Eqn B.7}                   = 0.133
Rb        = 1/Nb - (1-e^(-2*Nb))/(2*Nb^2)  {Eqn B.8}                   = 0.841
Rt        = ((PI^2) / (2*Del)) * Sl * Rh * Rb   {Eqn B.6}              = 0.019
v         = n * (R2 / (B2 + R2))^0.5   {Eqn B.5}                       = 0.579
kp        = (2 * ln(v * 600))^0.5 + 0.6 / (2 * ln(v*600))^0.5  {Eqn B4} = 3.596
Iv(Zs)    = Sv / Vm(Zs)    {Eqn B.7}                                   = 0.105
CsCd      = (1 + 2*kp*Iv(Zs) * (B2+R2)^0.5) / (1 + 7*Iv(Zs))  {Eqn 6.1} = 0.975
Cs        = (1 + 7 * Iv(Zs) * B2^0.5) / (1 + 7 * Iv(Zs))  {Eqn 6.2}    = 0.960
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Cd        = (1 + 2*kp*Iv(Zs)*((B2+R2)^0.5))/(1+7*Iv(Zs)*B2^0.5)   {Eqn 6.3} = 1.016
Rho       = Air Density                                                      = 1.225
Kg/m^3
qb        = 0.5 * Rho * Vb^2  {Eqn 4.10}                                     = 480.357 kPa
```

Calculate Riser Shape Factors

Z m	D m	V m/s	Re	Lambda	Pl	Cfo	Cf
47.060	0.32	56.06	1.21E+06	50.302	0.88	0.589	0.515
44.060	0.32	55.15	1.19E+06	50.302	0.88	0.587	0.514
42.060	0.32	54.43	1.17E+06	50.302	0.88	0.586	0.513
42.027	0.32	54.41	1.17E+06	50.302	0.88	0.586	0.513
41.945	0.32	54.38	1.17E+06	50.302	0.88	0.586	0.513
41.817	0.39	54.33	1.40E+06	42.284	0.86	0.603	0.517
41.688	0.45	54.28	1.62E+06	36.471	0.84	0.617	0.519
41.560	0.51	54.22	1.84E+06	32.063	0.83	0.629	0.520
40.960	0.51	53.97	1.83E+06	32.063	0.83	0.628	0.519
38.960	0.51	53.00	1.79E+06	32.063	0.83	0.627	0.518
37.016	0.51	51.80	1.75E+06	32.063	0.83	0.625	0.516
36.683	0.69	51.56	2.39E+06	23.460	0.79	0.651	0.516
36.349	0.88	51.30	3.01E+06	18.498	0.77	0.670	0.514
36.016	1.07	51.03	3.63E+06	15.268	0.75	0.684	0.510
35.697	1.07	50.76	3.61E+06	15.268	0.75	0.684	0.510
35.560	1.07	50.64	3.60E+06	15.268	0.75	0.684	0.510
35.423	1.07	50.51	3.59E+06	15.268	0.75	0.683	0.510
33.660	1.07	48.45	3.45E+06	15.268	0.75	0.680	0.507
33.010	1.07	47.37	3.37E+06	15.268	0.75	0.679	0.506
31.945	1.07	44.74	3.18E+06	15.268	0.75	0.674	0.503
31.835	1.07	44.36	3.16E+06	15.268	0.75	0.674	0.502
31.725	1.07	43.95	3.13E+06	15.268	0.75	0.673	0.502
31.510	1.07	43.00	3.06E+06	15.268	0.75	0.671	0.501
31.006	1.07	39.48	2.81E+06	15.268	0.75	0.665	0.496
30.910	1.07	38.34	2.73E+06	15.268	0.75	0.662	0.494
30.865	1.07	37.69	2.68E+06	15.268	0.75	0.661	0.493

```
   Re     = Reynolds Num: D*V / v {Eqn 7.15}          | v  = Air Viscosity: 15*10^-6 m^2/s
   Lambda = Eff Slenderness Ratio {Table 7.16}        | Pl = End Effect Factor {Fig 7.36}
   Cfo    = Force coeff w/o Free-end Flow {Fig 7.28} | Cf = Force coefficient {Eqn 7.19}
```

Wind Pressures and Forces

Z m	Z ft	Cr	Co	Vm m/s	Iv	Ce	Linear Area m^2/m	Total Area sq m	qp kPa	Fw lb	Fw N
47.060	154.396	1.507	1.000	42.21	0.104	3.919	0.453	1.360	1.882	561	2497
44.060	144.553	1.497	1.000	41.92	0.104	3.877	0.453	0.907	1.862	370	1647
42.060	137.992	1.490	1.000	41.72	0.105	3.847	0.758	0.025	1.848	10	45
42.027	137.883	1.490	1.000	41.71	0.105	3.847	2.582	0.211	1.848	86	381
41.945	137.614	1.489	1.000	41.70	0.105	3.845	2.582	0.331	1.847	134	597
41.817	137.193	1.489	1.000	41.69	0.105	3.843	2.729	0.350	1.846	142	631
41.688	136.772	1.488	1.000	41.68	0.105	3.841	2.877	0.369	1.845	149	664
41.560	136.351	1.488	1.000	41.66	0.105	3.839	2.573	1.544	1.844	624	2777
40.960	134.383	1.486	1.000	41.60	0.105	3.830	0.565	1.129	1.840	456	2027

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38.960	127.821	1.478	1.000	41.38	0.106	3.799	0.259	0.504	1.825	201	896
37.016	121.443	1.470	1.000	41.16	0.106	3.766	0.258	0.086	1.809	34	152
36.683	120.350	1.469	1.000	41.12	0.106	3.761	0.353	0.118	1.806	47	208
36.349	119.256	1.467	1.000	41.08	0.106	3.755	0.446	0.149	1.804	59	262
36.016	118.162	1.466	1.000	41.04	0.106	3.749	0.538	0.172	1.801	68	302
35.697	117.114	1.464	1.000	41.00	0.107	3.743	0.537	0.073	1.798	29	129
35.560	116.666	1.464	1.000	40.98	0.107	3.741	0.537	0.073	1.797	29	129
35.423	116.218	1.463	1.000	40.97	0.107	3.739	0.537	0.947	1.796	373	1659
33.660	110.433	1.455	1.000	40.74	0.107	3.707	0.534	0.347	1.781	136	603
33.010	108.300	1.452	1.000	40.66	0.107	3.694	0.533	0.567	1.775	221	982
31.945	104.805	1.447	1.000	40.51	0.108	3.674	0.528	0.058	1.765	22	100
31.835	104.445	1.446	1.000	40.50	0.108	3.672	0.528	0.058	1.764	22	99
31.725	104.086	1.446	1.000	40.48	0.108	3.670	0.527	0.114	1.763	44	195
31.510	103.379	1.445	1.000	40.45	0.108	3.666	0.526	0.265	1.761	102	455
31.006	101.725	1.442	1.000	40.38	0.108	3.656	0.526	0.050	1.756	19	86
30.910	101.410	1.442	1.000	40.37	0.108	3.654	0.526	0.024	1.755	9	41
30.865	101.263	1.442	1.000	40.36	0.108	3.653	2.770	0.845	1.755	325	1446
Total								10.676		4273	19009

Cr = Roughness: kr * ln(z/zo) {Eqn 4.4} | Co = Orography factor {Sec 4.3.1}
Vm = Mean Velocity: Cr(z)*Co(z)*Vb {Eqn 4.3} | Iv = Turbulence: Sv/Vm(z) {Eqn 4.7}
Ce = Exposure: qp(z) / qb {Eqn 4.9} | qp = Peak Vel Press: Ce(z)*qb {Eqn 4.8}
Fw = Force: qp*CsCd*(Total Area) {Eqn 5.3}

Wind Loads Applied to the Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	832.4	2497
44.060	42.060	823.4	1647
42.060	42.027	1366.5	45
42.027	41.945	4653.4	381
41.945	41.817	4651.9	597
41.817	41.688	4914.9	631
41.688	41.560	5177.7	664
41.560	40.960	4628.5	2777
40.960	38.960	1013.3	2027
38.960	37.016	461.0	896
37.016	36.683	455.3	152
36.683	36.349	622.5	208
36.349	36.016	785.5	262
36.016	35.697	944.6	302
35.697	35.560	942.5	129
35.560	35.423	941.6	129
35.423	33.660	940.7	1659
33.660	33.010	927.7	603
33.010	31.945	921.9	982
31.945	31.835	909.7	100
31.835	31.725	908.1	99
31.725	31.510	906.4	195
31.510	31.006	903.3	455

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31.006	30.910	900.8	86
30.910	30.865	900.4	41
30.865	30.560	4740.9	1446
Total			19009

Weight Summary (Seismic)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	36.164	2458.5	24110
Ladders	40.510	69.2	679
Platforms	40.960	319.3	3132
Helical Strakes	44.310	25.0	245
Baseplate	30.687	389.0	3815
Structural Flange(s)	42.000	58.0	569
Nozzle(s)	34.097	53.2	521
General Attachment Uniform)	32.285	82.5	809
General Attachment Uniform (Oper, Fac = 1)	32.260	1137.0	11150
General Attachment Concentrated	31.510	200.0	1961
Nozzle(s)	35.560	-1474.2	-14457
Platforms (Live, Fac = 0)	30.560	0.0	0
Total	34.758	3317.6	32534

Seismic Loads Entered by User are Based upon

Seismic Criteria: Manually Specify Seismic Loading

Spec	= What is the basis for the loads being entered	=
Ft	= Load applied at the top of the stack (0 if none)	= 0 N
RatioShear	= Ratio of Base Shear to Dead Weight (g-force)	= 0.700
RatioVer	= Ratio of Base Vertical Load to Dead Weight (g-force)	= 0.700
Method	= Method used to apply the loads to the structure	= ASCE 7-10
Fac_Live	= Factor to apply to Live loads to be treated as Mass	= 0.000
Fac_Oper	= Factor to apply to operating loads to be treated as Masses	= 1.000
T	= Period of Structure	= 0.221 s
Wt	= Weight of stack	= 3317.6 kg
Wt	= Weight of stack	= 32534 N
Base_Shear	= Seismic Base Shear (RatioShear * Wt)	= 22774 N
Base_Ver	= Seismic Base Vertical Load (RatioVer * Wt)	= 22774 N
Kfac	= Exponent based upon Period per ASCE 7-10 Eqn 12.8-12	= 1.000

Elev m	hx m	wx N	wx*hx^k	Cvx	Shear N	Ver N
45.560	15.0000	1544	23161.8	0.171	3893	1080
43.060	12.5000	1029	12867.7	0.095	2163	720
42.043	11.4834	319	3659.2	0.027	615	223
41.986	11.4259	368	4208.9	0.031	707	258
41.881	11.3208	160	1809.5	0.013	304	112
41.753	11.1925	160	1789.0	0.013	301	112
41.624	11.0642	160	1768.5	0.013	297	112
41.260	10.7000	2420	25900.7	0.191	4353	1694

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39.960	9.4000	4412	41490.0	0.306	6973	3088
37.988	7.4280	2341	17396.3	0.128	2924	1639
36.849	6.2893	627	3942.6	0.029	663	439
36.516	5.9560	627	3733.7	0.028	628	439
36.183	5.6227	627	3524.7	0.026	592	439
35.856	5.2963	816	4325.7	0.032	727	571
35.628	5.0683	-6721	-34078.4	-0.252	-5728	-4705
35.492	4.9317	-6721	-33160.4	-0.245	-5573	-4705
34.542	3.9817	4507	17951.1	0.132	3017	3155
33.335	2.7750	1852	5142.2	0.038	864	1297
32.477	1.9173	10956	21014.5	0.155	3532	7669
31.890	1.3298	1229	1634.7	0.012	275	860
31.780	1.2202	1229	1500.0	0.011	252	860
31.618	1.0577	3196	3382.2	0.025	568	2237
31.258	0.6980	2417	1687.7	0.012	284	1692
30.958	0.3980	274	108.9	0.001	18	192
30.888	0.3275	115	37.7	0.000	6	80
30.713	0.1525	4594	700.9	0.005	118	3216
Total	0.0000	32534	135499.2	1.000	22774	22774

hx = Distance from Bottom of Stack
Elev = Elevation above grade
Denom = Summation(wx*hx^k) = 135499
Cvx = % of Total Base Shear: wx*hx^k / Denom
Ver = RatioVer * wx

Seismic Loads Applied to Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	1297.6	3893
44.060	42.060	1081.4	2163
42.060	42.027	18526.7	615
42.027	41.945	8647.6	707
41.945	41.817	2369.8	304
41.817	41.688	2343.0	301
41.688	41.560	2316.1	297
41.560	40.960	7255.4	4353
40.960	38.960	3486.7	6973
38.960	37.016	1504.0	2924
37.016	36.683	1988.0	663
36.683	36.349	1882.6	628
36.349	36.016	1777.2	592
36.016	35.697	2275.7	727
35.697	35.560	-41953.3	-5728
35.560	35.423	-40823.2	-5573
35.423	33.660	1710.9	3017
33.660	33.010	1329.6	864
33.010	31.945	3315.0	3532
31.945	31.835	2508.2	275
31.835	31.725	2301.6	252
31.725	31.510	2638.3	568
31.510	31.006	562.8	284

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31.006	30.910	190.7	18
30.910	30.865	140.7	6
30.865	30.560	386.2	118
------	------	--------	-----
Total			22774

Vortex Shedding Summary

Mode Num	Configuration	Frequency Hz	Crit Wind Speed m/s	Reduced Mass kg	Defl Max m	Defl Limit m	Defl Ratio	Comment
1	Hot & Corroded	3.822	6.88	208	0.0007	0.0162	0.041	PASS
1	Hot & UnCorroded	4.472	8.05	194	0.0007	0.0162	0.043	PASS
1	Cold & Corroded	3.860	6.95	210	0.0007	0.0162	0.041	PASS
1	Cold & Uncorroded	4.518	8.13	196	0.0007	0.0162	0.043	PASS

1. Defl Ratio = Defl Max / Defl Limit

Vortex Shedding Analysis per Eurocode: EN 1991-1-4:2005+A1:2010
Ref Para E.1.5.2 Approach 1 for calculation of cross wind amplitudes

```
Zcr       = (5/6) * Stack Ht + Dist from Grade To Base Of Stack            = 74.870 m
Co        = Orography factor based upon user entered data @ Elev = 74.870 m = 1.00
Vm        = Mean Wind Velocity: Cr * Co * Vb {Eqn 4.3}                     = 41.94 m/s
Bs        = Structural Log Decrement Damping                               = 0.6283
St        = Strouhal number for a single stack                             = 0.180
Vc        = Critical Wind Speed:  b * n / S                                = 8.13 m/s
b         = Diameter at Turbulence Zone (Mode # 1)                         = 0.3238 m
n         = Natural Frequency of Mode # 1                                  = 4.518 Hz
me        = Equivalent mass per unit length                                = 73.40 kg/m
Nodes     = Number of Nodes                                                = 1
AntiNodes = Number of AntiNodes                                            = 1
```

Summary of Nodes and Antinodes

Num	Node Elevation m	Anti-Node Elevation m
1	30.560	47.060

Nodes are where the lateral deflection is zero
Anti-Nodes are the points between nodes where the deflection is maximum

```
Correlation Length #  1:
b1        = Average Diameter for Correction Length # 1                     = 0.3238 m
yf/b1     = Ratio of yf / b1                                               = 0.00
L1        = Since Yf/b < 0.1: 6 * b                                        = 1.9428 m
L1_Top    = Top Elevation for Correlation Length # 1                       = 47.060 m
L1_Bot    = Bot Elevation for Correlation Length # 1                       = 45.117 m

Clat Calculation for Correlation Length #  1:
b1        = Average diameter for correlation length # 1                    = 0.3238 m
```

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```
Vm1       = Mean wind speed for Correlation Length # 1 {Eqn 4.3}            = 37.63 m/s
Vcrit1    = Critical Wind Speed:  b1 * n / St  {Eqn E.2}                    = 8.13 m/s
Re1       = Reynolds Number:  b1 * Vcrit1 / (15*10^-6 m^2/2)   {Eqn E.5}    = 1.75E+05
Ratio1    = Ratio:  Vcrit1 / Vm1  {Ref Table E.3}                           = 0.216
Clat01    = Basic lateral force coeffic for circular cylinders {Fig E.2}    = 0.700
Clat1     = Since Ratio <= 0.83: Clat0 {Table E.3}                          = 0.700

Clat      = Maximum value of Clat from all considered correlation lengths   = 0.700

Check to Determine if Strakes Adequate to Meet EN 1993-3-2:2006 Sec B.2(3):
b         = Average Wind OD in Strake Region                                = 0.3281 m
h         = Stack Height                                                    = 16.5000 m
P         = Strake Pitch                                                    = 1.6190 m
Pmin      = Minimum Acceptable Pitch: 4.5*b                                 = 1.4764 m
Pmax      = Maximum Acceptable Pitch: 5*b                                   = 1.6405 m
Chk1      = Pitch in Acceptable Range:  Pmin <= P <= Pmax                   = True

T         = Strake Depth                                                    = 32.4 mm
Tmin      = Minimum Acceptable Strake Depth: 0.1*b                          = 32.8 mm
Tmax      = Maximum Acceptable Strake Depth: 0.12*b                         = 39.4 mm
Chk2      = Depth in Acceptable Range:  Tmin <= T <= Tmax                   = False

Ls        = Length of Straked Region                                        = 5.5000 m
Lmin      = Minimum Req'd Strake Length: 0.3*h                              = 4.9500 m
Lmax      = Maximum Req'd Strake Length: 0.5*h                              = 8.2500 m
Chk3      = Length in Acceptable Range:  Lmin <= L <= Lmax                  = True

Lu        = Length of Unstraked Portion at top of Stack                     = 0.0000 m
Lu_Max    = Max Allowed Unstraked Length: b                                 = 0.3281 m
Chk4      = Unstraked Length @ Top Acceptable: Lu <= Lu_max                 = True

Sc        = Scruton Number: 2 * me * Bs / (Rho * D1^2)                      = 699.25
Chk5      = Scruton Number is Larger than 8                                 = True

Straked?  = Are all strake criteria from EN 1993-3-2 Section B.2(3) Met?    = False

Kw        = Effective Correlation length Factor Kw {Eqn E.8}                = 0.522
K         = Mode shape factor K                                             = 0.137

Calculate yf for Correlation Length # 1:
b1        = Average Outer Diameter at correlation length # 1                = 0.3238 m
St        = Strouhal number for a single stack                              = 0.180
Sc        = Scruton Number: 2 * me * Bs / (Rho * D1^2)                      = 717.94
yf1       = (1/St^2) * (1/Sc) * K * Kw * clat * b     {Eqn E.7}             = 0.0007 m

yf        = Maximum yf from all correlation lengths considered  {Eqn E.7}   = 0.0007 m

Eo        = Bandwidth factor:  0.3    {Eqn E.10}                            = 0.300
Number of cycles calculations based upon EN 1991-1-4 Section E.1.5.2.6:
Vcrit     = Critical Wind Speed corresponding to Clat calculation           = 8.13 m/s
Vm        = Mean Wind Speed corresponding to Clat calculation               = 41.94 m/s
Vo        = Weibull probability distribution * (2)^0.5: 0.2*Vm  {Eqn E.10}  = 8.39 m/s
Tyrs      = Life of Structure in Years                                      = 50.0 Years
T         = Life of Structure in Seconds: 3.2*10^7 * T                      = 1.60E+09
N         = Num Cycles: 2*T*n*Eo*(Vcrit/Vo)^2*Exp(-(Vcrit/Vo)^2) {Eqn E.10} = 1.593E+09

 Elev      Elev     mtot         m        Phi       Ht        Fw         Fw       Fw
```

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m	ft	kg	kg/m		m	Uniform N/m	Total lb	Total N
77.620	254.658	157.4	52.46	1.000	3.0000	29.5	20	88
74.620	244.815	104.9	52.46	0.601	2.0000	17.7	8	35
72.620	238.254	3.5	104.24	0.384	0.0332	22.5	0	1
72.587	238.145	37.5	459.00	0.381	0.0818	98.3	2	8
72.505	237.877	16.3	126.96	0.374	0.1283	26.7	1	3
72.377	237.455	16.3	126.96	0.364	0.1283	25.9	1	3
72.248	237.034	16.3	126.96	0.353	0.1283	25.2	1	3
72.120	236.613	246.7	411.23	0.343	0.6000	79.2	11	48
71.520	234.645	449.9	224.95	0.296	2.0000	37.4	17	75
69.520	228.083	238.7	122.80	0.160	1.9440	11.0	5	21
67.576	221.705	63.9	191.69	0.073	0.3333	7.9	1	3
67.243	220.612	63.9	191.69	0.065	0.3333	7.0	1	2
66.909	219.518	63.9	191.69	0.058	0.3333	6.3	0	2
66.576	218.424	83.3	260.59	0.052	0.3195	7.6	1	2
66.257	217.376	-685.4	-5020.12	0.046	0.1365	-130.8	-4	-18
66.120	216.928	-685.4	-5020.12	0.044	0.1365	-124.3	-4	-17
65.983	216.481	459.5	260.59	0.042	1.7635	6.1	2	11
64.220	210.695	188.9	290.59	0.017	0.6500	2.8	0	2
63.570	208.562	1117.2	1048.59	0.011	1.0655	6.3	2	7
62.505	205.067	125.3	1143.92	0.003	0.1095	2.0	0	0
62.395	204.707	125.3	1143.92	0.003	0.1095	1.7	0	0
62.285	204.348	325.9	1512.71	0.002	0.2155	1.8	0	0
62.070	203.641	246.5	489.00	0.001	0.5040	0.4	0	0
61.566	201.988	27.9	290.59	0.000	0.0960	0.0	0	0
61.470	201.673	11.7	260.59	0.000	0.0450	0.0	0	0
61.425	201.525	468.5	1536.00	0.000	0.3050	0.1	0	0
Total		3288.5					63	281

Fw = m * (2*PI*n)^2 * Phi * yf {Eqn E.6} m = Uniform mass

Vortex Shedding Loads Applied to Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	29.5	88
44.060	42.060	17.7	35
42.060	42.027	22.5	1
42.027	41.945	98.3	8
41.945	41.817	26.7	3
41.817	41.688	25.9	3
41.688	41.560	25.2	3
41.560	40.960	79.2	48
40.960	38.960	37.4	75
38.960	37.016	11.0	21
37.016	36.683	7.9	3
36.683	36.349	7.0	2
36.349	36.016	6.3	2
36.016	35.697	7.6	2
35.697	35.560	-130.8	-18
35.560	35.423	-124.3	-17

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35.423	33.660	6.1	11
33.660	33.010	2.8	2
33.010	31.945	6.3	7
31.945	31.835	2.0	0
31.835	31.725	1.7	0
31.725	31.510	1.8	0
31.510	31.006	0.4	0
31.006	30.910	0.0	0
30.910	30.865	0.0	0
30.865	30.560	0.1	0
------	------	-------	-----
Total			281

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Live	L
3	Operating	O
4	Thermal Hot	TH
5	Wind	W
6	Seismic Hor	Eh
7	Seismic Ver	Ev
8	Vortex Across	V

Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	L	O	TH	W	Eh	Ev	V
9	A: 0.9*D 0 Deg	X		1.100	0	0.9							
10	A: 1.1*D+1.5*W+0.9*L+0.9*O 0 D	X		1.100	0	1.1	0.9	0.9		1.5			
11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0	X		1.100	0	1.35	0.9	0.9		1.5			
12	B: 1.0*D 0 Deg	X		1.100	0	1.0							
13	C: 1.0*D+1.3*W+0.78*L+0.78*O 0	X		1.100	0	1.0	0.78	0.78		1.3			
14	Serviceability: 1.0*D+1.0*W 0		X	1.100	0	1.0				1.0			
15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	X		1.100	0	1.0	1.0	1.0			1.0		
16	1.0*D+1.0*S 0 Deg	X		1.100	0	1.0					1.0		
17	Serviceability: 1.0*D+1.0*S 0		X	1.100	0	1.0					1.0		
18	D+O+P 0 Deg	X		1.000	0	1.0		1.0					

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated
Stress Criteria: EN 1993-3-2 (Limit States)
Wind Criteria: EN 1991-1-4 (Ultimate)
Seismic Criteria: MANUAL (N/A)
Wind Combinations:
Service wind loads specified, use combos per EN 1990 Appendix A

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Seismic Combinations:
Seismic code is based upon ultimate loads, and so are the EN 1990 Table A1.3 combinations,
so we use the factors from that table

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
27	Fixed	0.0000	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed

Riser Stiffening Ring Property Summary
All stiffening rings as well as other components that behave as stiffening rings

ID	Country	Shape	Size	Config	Material	Inside Stack?

The material properties for the shell/ring section are based upon the shell.
Software does not evaluate any problems that could arise if the riser is a different material than the stiffening rings.

Ring Num	Elev m	Stiff Ring	Eff Shell Width mm	Shell Thickness mm	Ls m	Area sq cm	Mom of Inertia cm^4	Section Modulus cm^3	Xc mm
1	42.000	Flange	65.6	7.0	10.6275	55.014	343.67	79.4	36.1
2	30.865	Baseplate Top	493.3	10.0	5.7200	89.110	2417.41	191.3	32.7
3	30.560	Baseplate Bot	493.3	10.0	0.1525	119.960	10913.54	541.9	81.1

Properties are for the combined stiffener and effective shell (Corroded)
Ls = Ring spacing, 1/2 of shell on each side of ring.
Xc = Centroid of combined section from OD of stack shell
Effective Shell Width Each Side of Stiff = 0.975*(0.5*D*Shell_Thk)^0.4 [EN 1993-1-6 Sec B3.1]

Stiffening Ring: [1] Flange
El 42.0 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	79.4	63.5	39.7	0.0	50.419	264.88	271.45
Shell Above	7.0	32.8	-3.5	16.4	2.298	0.09	36.11
Shell Below	7.0	32.8	-3.5	-16.4	2.298	0.09	36.11
Total			36.1	0.0	55.014		343.67

X & Y axis are local used for this calculation & may not correspond to global X & Y.

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Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 79.4 cm^3

Stiffening Ring: [2] Baseplate Top
El 30.865 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	159.1	25.0	79.6	0.0	39.775	839.04	1710.61
Shell Above	10.0	246.7	-5.0	123.3	24.667	2.06	353.40
Shell Below	10.0	246.7	-5.0	-123.3	24.667	2.06	353.40
Total			32.7	0.0	89.110		2417.41

X & Y axis are local used for this calculation & may not correspond to global X & Y.
Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 191.3 cm^3

Stiffening Ring: [3] Baseplate Bot
El 30.56 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	282.5	25.0	141.3	0.0	70.625	4696.93	7251.88
Shell Above	10.0	246.7	-5.0	123.3	24.667	2.06	1830.83
Shell Below	10.0	246.7	-5.0	-123.3	24.667	2.06	1830.83
Total			81.1	0.0	119.960		10913.54

X & Y axis are local used for this calculation & may not correspond to global X & Y.
Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 541.9 cm^3

Summary of Stiffening Ring Check for Static Ovalling
Are Stiff Rings are Adequate to consider riser 'Stiffened'

Ring Num	Elev m	d m	t mm	rm m	we kPa	Ls m	My N-m	Sact cm^3	Sreqd cm^3	Unity Sreqd/Sact
1	72.560	0.3238	7.0	0.1584	1.848	10.6275	246.3	79.4	1.3	0.017
2	61.425	1.0668	10.0	0.5284	1.755	5.7200	1401.1	191.3	6.4	0.034
3	61.120	1.0668	10.0	0.5284	1.755	0.1525	37.4	541.9	0.2	0.000

d = Outer Diameter of Stack
Ls = 1/2 of dist each side of stiff
My = Moment: 0.5*rm^2*we*Ls
t = Corroded Thickness of shell
Sact = Act Sec Modulus of Ring+Shell
we = Wind Press at Elevation

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Sreqd = My / (Fy / 1.1)

Verify that Beam Theory can be Used per EN 1993-3-2 [5.1]

Since the Chimney is considered to be Stiffend then Beam Theory can be used.

Fatigue Analysis Vortex Shedding per Eurocode
Ref EN 1993-2 Sect 9.2 and EN 1993-1-9

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

Life = Fatigue Life Of Stack In Years = 50.0 Years
GMf = Partial Safety Factor for Fatigue Strength = 1.35
GFf = Partial Safety Factor for Equiv Const Amplitude Stress Range = 1.00

Fatigue Categories: Euro

Elev m	Cat
47.060	69

Number of cycles calculations based upon EN 1991-1-4 Section E.1.5.2.6:
Vcrit = Critical Wind Speed corresponding to Clat calculation = 8.13 m/s
Vm = Mean Wind Speed corresponding to Clat calculation = 41.94 m/s
Vo = Weibull probability distribution * (2)^0.5: 0.2*Vm {Eqn E.10} = 8.39 m/s
Tyrs = Life of Structure in Years = 50.0 Years
T = Life of Structure in Seconds: 3.2*10^7 * T = 1.60E+09
N = Num Cycles: 2*T*n*Eo*(Vcrit/Vo)^2*Exp(-(Vcrit/Vo)^2) {Eqn E.10} = 1.593E+09
m = Slope of S-N curve per EN 1993-1-9 Figure 7.1 = 0.000
Since N > 1E08 then the S-N curve Is flat And m = 0

Lambda = Equivalence Factor (N / 2E6)^(1/m) [EN 1993-3-2 9.2] = 2.187
Since N > 1E8 then use N = 1e8 And m = 5 for Lamda calculation

Fatigue Analysis Vortex Shedding for Load # 8 - Vortex Across
Fatigue Analysis per Eurocode EN 1993-1-9

Top El m	Bot El m	Moment KN-m	DSE MPa	DSE2 MPa	DSc MPa	Ratio
47.060	44.060	0.13	0.57	1.24	69.00	0.024
44.060	42.060	0.34	1.48	3.23	69.00	0.063
42.060	42.027	0.35	1.29	2.83	69.00	0.055
42.027	41.945	0.36	1.33	2.91	69.00	0.057
41.945	41.817	0.38	1.39	3.05	69.00	0.060
41.817	41.688	0.39	1.02	2.23	69.00	0.044
41.688	41.560	0.41	0.79	1.72	69.00	0.034
41.560	40.960	0.51	0.75	1.65	69.00	0.032
40.960	38.960	0.97	1.42	3.11	69.00	0.061
38.960	37.016	1.50	2.21	4.83	69.00	0.094
37.016	36.683	1.60	2.35	5.14	69.00	0.101
36.683	36.349	1.70	1.32	2.88	69.00	0.056
36.349	36.016	1.79	0.86	1.88	69.00	0.037
36.016	35.697	1.89	0.62	1.35	69.00	0.026

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35.697	35.560	1.93	0.62	1.36	69.00	0.027
35.560	35.423	1.96	0.66	1.45	69.00	0.028
35.423	33.660	2.43	0.79	1.73	69.00	0.034
33.660	33.010	2.61	0.85	1.86	69.00	0.036
33.010	31.945	2.91	0.95	2.07	69.00	0.041
31.945	31.835	2.94	0.96	2.09	69.00	0.041
31.835	31.725	2.97	1.03	2.26	69.00	0.044
31.725	31.510	3.03	0.99	2.16	69.00	0.042
31.510	31.006	3.17	1.03	2.26	69.00	0.044
31.006	30.910	3.20	1.04	2.28	69.00	0.045
30.910	30.865	3.21	1.05	2.29	69.00	0.045
30.865	30.560	3.29	0.44	0.96	69.00	0.019

DSE = 2 x Bending Stress DSE2 = DSE * Lambda [EN 1993-3-2 9.1]
DSc = Fatigue Strength Category Ratio: GFf*DSE2 / (DSc / GMf) [EN 1993-1-9 8.2]

Fatigue Analysis Along Wind per Eurocode
Ref EN 1993-2 Sect 9.2.1, EN 1993-3-1 9.2.1 and EN 1993-1-9

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

Life = Fatigue Life Of Stack In Years = 50.0 Years
GMf = Partial Safety Factor for Fatigue Strength = 1.35
GFf = Partial Safety Factor for Equiv Const Amplitude Stress Range = 1.00

Fatigue Categories: Euro

Elev m	Cat
47.060	69

N = Number of cycles: EN 1993-3-1 Eqn 9.1: 10^5*Tyrs/50 = 1.000E+05
m = Slope of S-N curve per EN 1993-1-9 Figure 7.1 = 3.000
Lambda = Equivalence Factor [EN 1993-3-2 9.2] = 0.368
qp = (1 + 7 * Iv(Z) * 0.5 * Rho * Vm(Z) {Eqn 4.10} = 1572.585 kPa
Rho = Air Density = 1.225 Kg/m^3
qb = 0.5 * Rho * Vb^2 {Eqn 4.10} = 480.357 kPa
Ce = qp(Z) / qb {Eqn 4.9} = 3.274
G = Gust Response Factor: ce*cs*cd-1 {EN 1993-3-1 Eqn 9.1} = 2.193

Fatigue Analysis Along Wind for Load # 5 - Wind
Fatigue Analysis per Eurocode EN 1993-1-9

Top El m	Bot El m	Moment KN-m	SR MPa	DSE MPa	DSE2 MPa	DSc MPa	Ratio
47.060	44.060	3.75	16.03	7.96	2.93	69.00	0.057
44.060	42.060	10.39	44.45	22.09	8.14	69.00	0.159
42.060	42.027	10.52	38.97	19.36	7.13	69.00	0.140
42.027	41.945	10.88	40.30	20.02	7.38	69.00	0.144
41.945	41.817	11.51	42.61	21.17	7.80	69.00	0.153
41.817	41.688	12.21	31.62	15.71	5.79	69.00	0.113

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41.688	41.560	13.00	24.85	12.35	4.55	69.00	0.089
41.560	40.960	17.71	26.02	12.93	4.76	69.00	0.093
40.960	38.960	38.21	56.15	27.89	10.28	69.00	0.201
38.960	37.016	60.99	89.60	44.52	16.40	69.00	0.321
37.016	36.683	65.06	95.60	47.50	17.50	69.00	0.342
36.683	36.349	69.20	53.84	26.75	9.85	69.00	0.193
36.349	36.016	73.42	35.28	17.53	6.46	69.00	0.126
36.016	35.697	77.55	25.28	12.56	4.63	69.00	0.091
35.697	35.560	79.35	25.70	12.77	4.70	69.00	0.092
35.560	35.423	81.16	27.39	13.61	5.01	69.00	0.098
35.423	33.660	106.15	34.61	17.19	6.33	69.00	0.124
33.660	33.010	116.10	37.85	18.80	6.93	69.00	0.136
33.010	31.945	133.25	43.44	21.58	7.95	69.00	0.156
31.945	31.835	135.07	43.98	21.85	8.05	69.00	0.157
31.835	31.725	136.90	47.60	23.65	8.71	69.00	0.170
31.725	31.510	140.54	45.82	22.76	8.39	69.00	0.164
31.510	31.006	149.21	48.65	24.17	8.90	69.00	0.174
31.006	30.910	150.89	49.19	24.44	9.00	69.00	0.176
30.910	30.865	151.68	49.45	24.57	9.05	69.00	0.177
30.865	30.560	157.26	20.93	10.40	3.83	69.00	0.075

Moment = Moment due to 1.0 x Wind Loads (10 minute mean wind speed)
SR = Full Stress Range due to 10 minute Mean wind speed: Moment / Sec Mod
DSE = 1.1*(SR-(G/r)*SR) [EN 1993-3-1 9.1] DSE2 = DSE * Lambda [EN 1993-3-2 9.1]
DSc = Fatigue Strength Category Ratio: GFf*DSE2 / (DSc / GMf) [EN 1993-1-9 8.2]

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
47.060	44.060	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.097	PASS
44.060	42.060	16	1.0*D+1.0*S 0 Deg	Buckling	0.261	PASS
42.060	42.027	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.168	PASS
42.027	41.945	16	1.0*D+1.0*S 0 Deg	Buckling	0.174	PASS
41.945	41.817	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.184	PASS
41.817	41.688	16	1.0*D+1.0*S 0 Deg	Buckling	0.139	PASS
41.688	41.560	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.111	PASS
41.560	40.960	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.118	PASS
40.960	38.960	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.263	PASS
38.960	37.016	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.442	PASS
37.016	36.683	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.476	PASS
36.683	36.349	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.249	PASS
36.349	36.016	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.171	PASS
36.016	35.697	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.129	PASS
35.697	35.560	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.131	PASS
35.560	35.423	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.145	PASS
35.423	33.660	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.193	PASS
33.660	33.010	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.214	PASS
33.010	31.945	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.252	PASS
31.945	31.835	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.257	PASS
31.835	31.725	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.279	PASS
31.725	31.510	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.271	PASS

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31.510	31.006	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.291	PASS
31.006	30.910	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.258	PASS
30.910	30.865	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.260	PASS
30.865	30.560	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.103	PASS

STACK COMPRESSIVE STRESSES PER EN 1991-1-6, Worst Case
Highest Unity ratios for each member and the load case that produces it.

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio	Load Case
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097	15
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261	16
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168	15
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174	16
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184	15
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139	16
41.560	19.50	4.94	0.51	18.64	19.15	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111	11
40.960	26.56	5.62	0.51	19.51	20.02	0.04	169.82	18.98	1.935	1.327	0.118	0.016	0.118	11
38.960	58.10	22.49	2.04	42.68	44.73	0.04	169.82	18.98	1.935	1.327	0.263	0.076	0.263	15
37.016	99.06	25.08	2.28	72.77	75.05	0.04	169.82	18.98	1.935	1.327	0.442	0.206	0.442	15
36.683	106.68	26.56	2.41	78.37	80.78	0.04	169.82	18.98	1.935	1.327	0.476	0.238	0.476	15
36.349	114.52	27.19	1.80	44.54	46.34	0.06	186.06	10.34	2.000	1.292	0.249	0.063	0.249	15
36.016	122.56	27.82	1.45	29.45	30.89	0.07	180.23	6.85	1.977	1.278	0.171	0.034	0.171	15
35.697	130.47	28.54	1.22	21.27	22.49	0.09	173.90	5.47	1.951	1.272	0.129	0.024	0.129	15
35.560	133.51	29.12	1.13	21.62	22.75	0.09	174.04	5.47	1.952	1.272	0.131	0.024	0.131	15
35.423	145.91	15.33	0.67	24.62	25.28	0.09	174.71	5.47	1.954	1.272	0.145	0.028	0.145	15
33.660	201.93	17.76	0.76	32.92	33.68	0.09	174.82	5.47	1.955	1.272	0.193	0.045	0.193	15
33.010	223.84	20.94	0.90	36.49	37.39	0.09	174.78	5.47	1.955	1.272	0.214	0.054	0.214	15
31.945	260.40	35.63	1.53	42.45	43.98	0.09	174.47	5.47	1.953	1.272	0.252	0.073	0.252	11
31.835	264.75	41.82	1.69	43.10	44.79	0.09	174.38	5.47	1.953	1.272	0.257	0.075	0.257	11

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```
31.725 269.12 43.25  1.91 46.78 48.69  0.09 174.34   5.47 1.953 1.272 0.279 0.088 0.279
11
31.510 277.76 44.96  1.93 45.28 47.21  0.09 174.29   5.47 1.953 1.272 0.271 0.083 0.271
11
31.006 298.22 49.72  2.13 48.61 50.74  0.09 174.26   5.47 1.952 1.272 0.291 0.095 0.291
11
30.910 302.15 50.87  2.18 49.25 51.44  0.09 199.09   5.70 1.937 1.270 0.258 0.078 0.258
11
30.865 304.00 51.13  2.19 49.55 51.75  0.09 199.09   5.70 1.937 1.270 0.260 0.078 0.260
11
30.560 316.88 57.41  0.90 21.09 21.99  0.08 212.95 217.27 1.985 2.000 0.103 0.011 0.103
11

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Buckling Summary Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.69	0.12	0.00	0.12	0.03	130.79	31.32	1.976	1.424	0.001	0.000	0.001
42.060	0.00	1.85	0.31	0.00	0.31	0.03	130.79	31.32	1.976	1.424	0.002	0.000	0.002
42.027	0.00	2.33	0.33	0.00	0.33	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.945	0.00	2.90	0.42	0.00	0.42	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.817	0.00	3.01	0.43	0.00	0.43	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.688	0.00	3.15	0.38	0.00	0.38	0.03	175.79	32.93	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.29	0.34	0.00	0.34	0.04	172.76	24.52	1.946	1.349	0.002	0.000	0.002
40.960	0.00	3.75	0.34	0.00	0.34	0.04	169.82	18.98	1.935	1.327	0.002	0.000	0.002
38.960	0.00	8.23	0.75	0.00	0.75	0.04	169.82	18.98	1.935	1.327	0.004	0.000	0.004
37.016	0.00	10.57	0.96	0.00	0.96	0.04	169.82	18.98	1.935	1.327	0.006	0.000	0.006
36.683	0.00	11.90	1.08	0.00	1.08	0.04	169.82	18.98	1.935	1.327	0.006	0.000	0.006
36.349	0.00	12.47	0.82	0.00	0.82	0.06	161.35	10.34	1.900	1.292	0.006	0.001	0.006
36.016	0.00	13.03	0.68	0.00	0.68	0.07	153.32	6.85	1.868	1.278	0.011	0.003	0.011
35.697	0.00	13.68	0.59	0.00	0.59	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
35.560	0.00	14.20	0.55	0.00	0.55	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
35.423	0.00	14.80	0.64	0.00	0.64	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
33.660	0.00	16.99	0.73	0.00	0.73	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
33.010	0.00	19.85	0.85	0.00	0.85	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.945	0.00	22.05	0.95	0.00	0.95	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.835	0.00	23.56	0.95	0.00	0.95	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.725	0.00	24.02	1.06	0.00	1.06	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.510	0.00	24.44	1.05	0.00	1.05	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.006	0.00	27.13	1.16	0.00	1.16	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
30.910	0.00	27.90	1.20	0.00	1.20	0.09	165.11	5.70	1.820	1.270	0.015	0.005	0.015
30.865	0.00	28.07	1.20	0.00	1.20	0.09	165.11	5.70	1.820	1.270	0.015	0.005	0.015

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30.560 0.00 32.26 0.51 0.00 0.51 0.08 197.44 217.27 1.932 2.000 0.003 0.000 0.003

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 9
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 32.26 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	w m	l m	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.60	3.1	0.391	204.66	0.200	0.989	0.375	0.867	1459.11	177.49	161.35

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36.016 191.4 10.6275 1.0 0.60 3.5 0.366 204.66 0.200 0.956 0.422 0.824 1150.45 168.65
153.32
35.697 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.560 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.423 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.660 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.010 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.945 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.835 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.725 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.510 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.006 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
30.910 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.865 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.200 0.979 0.319 0.909 2355.72 217.18
197.44

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98

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37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.62	0.85	0.14	12.02	12.17	0.03	130.79	31.32	1.976	1.424	0.093	0.009	0.093
42.060	15.58	2.26	0.38	33.34	33.72	0.03	130.79	31.32	1.976	1.424	0.258	0.069	0.258
42.027	15.79	2.85	0.41	29.23	29.64	0.03	178.95	46.59	1.971	1.438	0.166	0.029	0.166
41.945	16.32	3.54	0.51	30.22	30.73	0.03	178.95	46.59	1.971	1.438	0.172	0.031	0.172
41.817	17.26	3.67	0.53	31.96	32.49	0.03	178.95	46.59	1.971	1.438	0.182	0.035	0.182
41.688	18.32	3.85	0.46	23.72	24.18	0.03	175.79	32.93	1.959	1.383	0.138	0.021	0.138
41.560	19.50	4.02	0.42	18.64	19.06	0.04	172.76	24.52	1.946	1.349	0.110	0.014	0.110
40.960	26.56	4.58	0.42	19.51	19.93	0.04	169.82	18.98	1.935	1.327	0.117	0.016	0.117
38.960	57.32	22.07	2.00	42.11	44.11	0.04	169.82	18.98	1.935	1.327	0.260	0.074	0.260
37.016	91.48	24.92	2.26	67.20	69.46	0.04	169.82	18.98	1.935	1.327	0.409	0.178	0.409
36.683	97.60	26.55	2.41	71.70	74.11	0.04	169.82	18.98	1.935	1.327	0.436	0.201	0.436
36.349	103.81	27.24	1.80	40.38	42.18	0.06	186.06	10.34	2.000	1.292	0.227	0.053	0.227
36.016	110.13	27.93	1.45	26.46	27.91	0.07	180.09	6.85	1.976	1.278	0.155	0.028	0.155
35.697	116.33	28.72	1.23	18.96	20.19	0.09	173.71	5.47	1.950	1.272	0.116	0.020	0.116
35.560	119.02	29.36	1.13	19.27	20.41	0.09	173.87	5.47	1.951	1.272	0.117	0.021	0.117
35.423	130.86	17.09	0.74	22.08	22.82	0.09	174.53	5.47	1.954	1.272	0.131	0.024	0.131
33.660	194.41	19.76	0.85	31.69	32.54	0.09	174.72	5.47	1.954	1.272	0.186	0.043	0.186
33.010	218.93	23.25	1.00	35.69	36.68	0.09	174.68	5.47	1.954	1.272	0.210	0.053	0.210
31.945	260.40	29.51	1.27	42.45	43.71	0.09	174.63	5.47	1.954	1.272	0.250	0.072	0.250
31.835	264.75	35.28	1.42	43.10	44.52	0.09	174.55	5.47	1.954	1.272	0.255	0.075	0.255

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31.725 269.12 36.58  1.62 46.78 48.40  0.09 174.51   5.47 1.953 1.272 0.277 0.087 0.277
31.510 277.76 38.18  1.64 45.28 46.91  0.09 174.46   5.47 1.953 1.272 0.269 0.082 0.269
31.006 298.22 42.18  1.81 48.61 50.42  0.09 174.43   5.47 1.953 1.272 0.289 0.094 0.289
30.910 302.15 43.12  1.85 49.25 51.10  0.09 199.30   5.70 1.938 1.270 0.256 0.076 0.256
30.865 304.00 43.34  1.86 49.55 51.41  0.09 199.31   5.70 1.938 1.270 0.258 0.077 0.258
30.560 316.88 48.45  0.76 21.09 21.85  0.08 213.07 217.27 1.985 2.000 0.103 0.011 0.103

   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 10
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 48.45 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82

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```
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.296 0.989 0.293 1.000 2390.29 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.295 0.956 0.330 0.968 1877.48 198.10
180.09
35.697 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1544.00 191.08
173.71
35.560 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1547.44 191.25
173.87
35.423 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.06 191.99
174.53
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.361 0.939 1566.14 192.19
174.72
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1565.42 192.15
174.68
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1564.30 192.10
174.63
31.835 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.42 192.00
174.55
31.725 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.48 191.96
174.51
31.510 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.53 191.91
174.46
31.006 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.938 1559.91 191.88
174.43
30.910 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.12 219.23
199.30
30.865 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.15 219.24
199.31
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.297 0.979 0.319 0.981 2355.72 234.38
213.07

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59

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41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.62	1.04	0.17	12.02	12.20	0.03	130.79	31.32	1.976	1.424	0.093	0.009	0.093
42.060	15.58	2.78	0.46	33.34	33.80	0.03	130.79	31.32	1.976	1.424	0.258	0.069	0.258
42.027	15.79	3.50	0.50	29.23	29.73	0.03	178.95	46.59	1.971	1.438	0.166	0.029	0.166
41.945	16.32	4.34	0.62	30.22	30.85	0.03	178.95	46.59	1.971	1.438	0.172	0.031	0.172
41.817	17.26	4.51	0.65	31.96	32.61	0.03	178.95	46.59	1.971	1.438	0.182	0.035	0.182
41.688	18.32	4.72	0.57	23.72	24.28	0.03	175.79	32.93	1.959	1.383	0.138	0.021	0.138
41.560	19.50	4.94	0.51	18.64	19.15	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	26.56	5.62	0.51	19.51	20.02	0.04	169.82	18.98	1.935	1.327	0.118	0.016	0.118
38.960	57.32	24.35	2.21	42.11	44.32	0.04	169.82	18.98	1.935	1.327	0.261	0.075	0.261
37.016	91.48	27.85	2.53	67.20	69.73	0.04	169.82	18.98	1.935	1.327	0.411	0.179	0.411
36.683	97.60	29.86	2.71	71.70	74.41	0.04	169.82	18.98	1.935	1.327	0.438	0.203	0.438
36.349	103.81	30.70	2.03	40.38	42.41	0.06	186.06	10.34	2.000	1.292	0.228	0.053	0.228
36.016	110.13	31.55	1.64	26.46	28.10	0.07	179.91	6.85	1.975	1.278	0.156	0.029	0.156
35.697	116.33	32.52	1.40	18.96	20.36	0.09	173.49	5.47	1.949	1.272	0.117	0.021	0.117

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```
35.560 119.02 33.31  1.29 19.27 20.56  0.09 173.66   5.47 1.950 1.272 0.118 0.021 0.118
35.423 130.86 21.20  0.92 22.08 23.00  0.09 174.32   5.47 1.953 1.272 0.132 0.024 0.132
33.660 194.41 24.48  1.05 31.69 32.74  0.09 174.54   5.47 1.954 1.272 0.188 0.043 0.188
33.010 218.93 28.77  1.23 35.69 36.92  0.09 174.51   5.47 1.953 1.272 0.212 0.053 0.212
31.945 260.40 35.63  1.53 42.45 43.98  0.09 174.47   5.47 1.953 1.272 0.252 0.073 0.252
31.835 264.75 41.82  1.69 43.10 44.79  0.09 174.38   5.47 1.953 1.272 0.257 0.075 0.257
31.725 269.12 43.25  1.91 46.78 48.69  0.09 174.34   5.47 1.953 1.272 0.279 0.088 0.279
31.510 277.76 44.96  1.93 45.28 47.21  0.09 174.29   5.47 1.953 1.272 0.271 0.083 0.271
31.006 298.22 49.72  2.13 48.61 50.74  0.09 174.26   5.47 1.952 1.272 0.291 0.095 0.291
30.910 302.15 50.87  2.18 49.25 51.44  0.09 199.09   5.70 1.937 1.270 0.258 0.078 0.258
30.865 304.00 51.13  2.19 49.55 51.75  0.09 199.09   5.70 1.937 1.270 0.260 0.078 0.260
30.560 316.88 57.41  0.90 21.09 21.99  0.08 212.95 217.27 1.985 2.000 0.103 0.011 0.103

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 11
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 57.41 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                                 MPa     MPa
MPa
------ ------ ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
```

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41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.295 0.989 0.293 1.000 2385.26 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.294 0.956 0.331 0.967 1872.60 197.90
179.91
35.697 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.293 0.928 0.365 0.932 1539.24 190.84
173.49
35.560 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.294 0.928 0.364 0.933 1543.00 191.03
173.66
35.423 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1557.31 191.75
174.32
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.33 192.00
174.54
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.47 191.96
174.51
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.63 191.91
174.47
31.835 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1558.81 191.82
174.38
31.725 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1557.77 191.77
174.34
31.510 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1556.76 191.72
174.29
31.006 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1556.02 191.68
174.26
30.910 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.916 1621.01 219.00
199.09
30.865 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.916 1621.04 219.00
199.09
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.980 2355.72 234.25
212.95

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

```
  Bot   Cq  Cqs    aq    Lq   Lpq    Kw  qw_max  qeq    Xq   f_qEd s_qRcr  s_qRk  s_qRd
```

Elev m							kPa	kPa		MPa	MPa	MPa	MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.77	0.13	0.00	0.13	0.03	130.79	31.32	1.976	1.424	0.001	0.000	0.001
42.060	0.00	2.06	0.34	0.00	0.34	0.03	130.79	31.32	1.976	1.424	0.003	0.000	0.003
42.027	0.00	2.59	0.37	0.00	0.37	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.945	0.00	3.22	0.46	0.00	0.46	0.03	178.95	46.59	1.971	1.438	0.003	0.000	0.003
41.817	0.00	3.34	0.48	0.00	0.48	0.03	178.95	46.59	1.971	1.438	0.003	0.000	0.003
41.688	0.00	3.50	0.42	0.00	0.42	0.03	175.79	32.93	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.66	0.38	0.00	0.38	0.04	172.76	24.52	1.946	1.349	0.002	0.000	0.002
40.960	0.00	4.17	0.38	0.00	0.38	0.04	169.82	18.98	1.935	1.327	0.002	0.000	0.002

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38.960   0.00  9.15  0.83  0.00  0.83  0.04 169.82  18.98 1.935 1.327 0.005 0.000 0.005
37.016   0.00 11.74  1.07  0.00  1.07  0.04 169.82  18.98 1.935 1.327 0.006 0.000 0.006
36.683   0.00 13.22  1.20  0.00  1.20  0.04 169.82  18.98 1.935 1.327 0.007 0.000 0.007
36.349   0.00 13.85  0.92  0.00  0.92  0.06 161.35  10.34 1.900 1.292 0.006 0.001 0.006
36.016   0.00 14.48  0.75  0.00  0.75  0.07 153.32   6.85 1.868 1.278 0.011 0.003 0.011
35.697   0.00 15.20  0.65  0.00  0.65  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
35.560   0.00 15.78  0.61  0.00  0.61  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
35.423   0.00 16.45  0.71  0.00  0.71  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
33.660   0.00 18.88  0.81  0.00  0.81  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
33.010   0.00 22.05  0.95  0.00  0.95  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.945   0.00 24.50  1.05  0.00  1.05  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.835   0.00 26.17  1.06  0.00  1.06  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.725   0.00 26.69  1.18  0.00  1.18  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.510   0.00 27.15  1.17  0.00  1.17  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.006   0.00 30.14  1.29  0.00  1.29  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
30.910   0.00 30.99  1.33  0.00  1.33  0.09 165.11   5.70 1.820 1.270 0.015 0.005 0.015
30.865   0.00 31.19  1.34  0.00  1.34  0.09 165.11   5.70 1.820 1.270 0.015 0.005 0.015
30.560   0.00 35.84  0.56  0.00  0.56  0.08 197.44 217.27 1.932 2.000 0.003 0.000 0.003

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 12
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 35.84 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                              MPa     MPa
MPa
------ ------ -------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
```

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41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.60 3.1 0.391 204.66 0.200 0.989 0.375 0.867 1459.11 177.49
161.35
36.016 191.4 10.6275 1.0 0.60 3.5 0.366 204.66 0.200 0.956 0.422 0.824 1150.45 168.65
153.32
35.697 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.560 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.423 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.660 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.010 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.945 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.835 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.725 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.510 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.006 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
30.910 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.865 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.200 0.979 0.319 0.909 2355.72 217.18
197.44

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

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Circumferential Buckling Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	4.87	0.77	0.13	10.42	10.55	0.03	130.79	31.32	1.976	1.424	0.081	0.007	0.081

```
42.060  13.50  2.06  0.34 28.90 29.24  0.03 130.79  31.32 1.976 1.424 0.224 0.052 0.224
42.027  13.68  2.59  0.37 25.33 25.70  0.03 178.95  46.59 1.971 1.438 0.144 0.022 0.144
41.945  14.15  3.22  0.46 26.19 26.66  0.03 178.95  46.59 1.971 1.438 0.149 0.023 0.149
41.817  14.96  3.34  0.48 27.70 28.18  0.03 178.95  46.59 1.971 1.438 0.157 0.026 0.157
41.688  15.87  3.50  0.42 20.55 20.97  0.03 175.79  32.93 1.959 1.383 0.119 0.016 0.119
41.560  16.90  3.66  0.38 16.15 16.53  0.04 172.76  24.52 1.946 1.349 0.096 0.011 0.096
40.960  23.02  4.17  0.38 16.91 17.29  0.04 169.82  18.98 1.935 1.327 0.102 0.012 0.102
38.960  49.68 19.55  1.77 36.50 38.27  0.04 169.82  18.98 1.935 1.327 0.225 0.056 0.225
37.016  79.28 22.14  2.01 58.24 60.25  0.04 169.82  18.98 1.935 1.327 0.355 0.135 0.355
36.683  84.58 23.63  2.14 62.14 64.28  0.04 169.82  18.98 1.935 1.327 0.379 0.153 0.379
36.349  89.96 24.26  1.60 34.99 36.60  0.06 186.06  10.34 2.000 1.292 0.197 0.040 0.197
36.016  95.45 24.88  1.30 22.93 24.23  0.07 180.05   6.85 1.976 1.278 0.135 0.022 0.135
35.697 100.82 25.60  1.10 16.43 17.53  0.09 173.66   5.47 1.950 1.272 0.101 0.017 0.101
35.560 103.15 26.19  1.01 16.70 17.72  0.09 173.82   5.47 1.951 1.272 0.102 0.017 0.102
35.423 113.41 15.58  0.68 19.13 19.81  0.09 174.49   5.47 1.953 1.272 0.114 0.020 0.114
33.660 168.49 18.00  0.77 27.46 28.24  0.09 174.68   5.47 1.954 1.272 0.162 0.034 0.162
33.010 189.74 21.18  0.91 30.93 31.84  0.09 174.65   5.47 1.954 1.272 0.182 0.041 0.182
31.945 225.68 26.72  1.15 36.79 37.93  0.09 174.60   5.47 1.954 1.272 0.217 0.056 0.217
31.835 229.45 31.80  1.28 37.35 38.64  0.09 174.51   5.47 1.953 1.272 0.221 0.058 0.221
31.725 233.24 32.95  1.46 40.54 42.00  0.09 174.47   5.47 1.953 1.272 0.241 0.067 0.241
31.510 240.73 34.35  1.47 39.24 40.71  0.09 174.43   5.47 1.953 1.272 0.233 0.064 0.233
31.006 258.46 37.96  1.63 42.13 43.76  0.09 174.40   5.47 1.953 1.272 0.251 0.072 0.251
30.910 261.87 38.82  1.67 42.69 44.35  0.09 199.26   5.70 1.938 1.270 0.223 0.059 0.223
30.865 263.47 39.01  1.67 42.95 44.62  0.09 199.26   5.70 1.938 1.270 0.224 0.060 0.224
30.560 274.63 43.67  0.68 18.28 18.96  0.08 213.04 217.27 1.985 2.000 0.089 0.008 0.089

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 13
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 43.67 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000

           Since Nratio <= 0.1 then Secondary Moments need not be considered.
```

Meridional Buckling Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx    Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                            MPa     MPa
MPa
------ ------ -------- --- ---- --- ------ ------ ------ ------ ------ ------ ------- ------ ---
---
```

```
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.296 0.989 0.293 1.000 2389.20 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.295 0.956 0.330 0.968 1876.42 198.05
180.05
35.697 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.294 0.928 0.364 0.933 1542.97 191.03
173.66
35.560 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1546.47 191.21
173.82
35.423 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.03 191.93
174.49
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1565.32 192.15
174.68
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1564.57 192.11
174.65
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1563.51 192.06
174.60
31.835 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.63 191.96
174.51
31.725 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.68 191.92
174.47
31.510 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1559.72 191.87
174.43
31.006 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1559.07 191.84
174.40
30.910 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.917 1624.23 219.18
199.26
30.865 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.917 1624.26 219.19
199.26
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.981 2355.72 234.35
213.04

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
```

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```
   Lpx   = (ax / (1-B))^0.5  [8.16]          Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17] s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                  s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]    fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

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Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139
41.560	19.59	3.66	0.38	18.73	19.10	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	25.86	4.17	0.38	19.00	19.38	0.04	169.82	18.98	1.935	1.327	0.114	0.015	0.114
38.960	58.10	22.49	2.04	42.68	44.73	0.04	169.82	18.98	1.935	1.327	0.263	0.076	0.263
37.016	99.06	25.08	2.28	72.77	75.05	0.04	169.82	18.98	1.935	1.327	0.442	0.206	0.442
36.683	106.68	26.56	2.41	78.37	80.78	0.04	169.82	18.98	1.935	1.327	0.476	0.238	0.476
36.349	114.52	27.19	1.80	44.54	46.34	0.06	186.06	10.34	2.000	1.292	0.249	0.063	0.249
36.016	122.56	27.82	1.45	29.45	30.89	0.07	180.23	6.85	1.977	1.278	0.171	0.034	0.171
35.697	130.47	28.54	1.22	21.27	22.49	0.09	173.90	5.47	1.951	1.272	0.129	0.024	0.129
35.560	133.51	29.12	1.13	21.62	22.75	0.09	174.04	5.47	1.952	1.272	0.131	0.024	0.131
35.423	145.91	15.33	0.67	24.62	25.28	0.09	174.71	5.47	1.954	1.272	0.145	0.028	0.145
33.660	201.93	17.76	0.76	32.92	33.68	0.09	174.82	5.47	1.955	1.272	0.193	0.045	0.193
33.010	223.84	20.94	0.90	36.49	37.39	0.09	174.78	5.47	1.955	1.272	0.214	0.054	0.214
31.945	262.10	27.34	1.17	42.72	43.90	0.09	174.70	5.47	1.954	1.272	0.251	0.072	0.251
31.835	266.24	33.38	1.35	43.34	44.69	0.09	174.60	5.47	1.954	1.272	0.256	0.075	0.256
31.725	270.41	34.71	1.54	47.01	48.54	0.09	174.56	5.47	1.954	1.272	0.278	0.087	0.278
31.510	278.70	36.38	1.56	45.43	46.99	0.09	174.51	5.47	1.953	1.272	0.269	0.082	0.269
31.006	298.31	40.17	1.72	48.63	50.35	0.09	174.48	5.47	1.953	1.272	0.289	0.093	0.289
30.910	302.06	41.03	1.76	49.24	51.00	0.09	199.36	5.70	1.938	1.270	0.256	0.076	0.256
30.865	303.82	41.22	1.77	49.52	51.29	0.09	199.36	5.70	1.938	1.270	0.257	0.077	0.257
30.560	315.76	45.87	0.72	21.01	21.73	0.08	213.10	217.27	1.986	2.000	0.102	0.011	0.102

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 15
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 45.87 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

Bot	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd

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Elev m	m		mm			MPa						MPa	MPa	MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.98	3.1	0.391	204.66	0.296	0.989	0.292	1.000	2394.09	204.66	186.06
36.016	191.4	10.6275	1.0	0.98	3.5	0.366	204.66	0.295	0.956	0.330	0.969	1881.48	198.25	180.23
35.697	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.364	0.935	1548.17	191.29	173.90
35.560	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.935	1551.31	191.45	174.04
35.423	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.98	192.18	174.71
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.298	0.928	0.361	0.940	1568.32	192.30	174.82
33.010	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.298	0.928	0.361	0.939	1567.43	192.25	174.78
31.945	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.72	192.17	174.70
31.835	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.57	192.06	174.60
31.725	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.62	192.01	174.56
31.510	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.61	191.96	174.51
31.006	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1560.97	191.93	174.48
30.910	173.9	10.6275	1.0	0.99	3.8	0.345	239.00	0.297	0.928	0.383	0.918	1626.24	219.30	199.36
30.865	173.9	10.6275	1.0	0.99	3.8	0.345	239.00	0.297	0.928	0.383	0.918	1626.26	219.30	199.36
30.560	2.1	0.1525	1.0	1.00	4.6	0.383	239.00	0.297	0.979	0.319	0.981	2355.72	234.41	213.10

```
   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
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Buckling Summary Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139
41.560	19.59	3.66	0.38	18.73	19.10	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	25.86	4.17	0.38	19.00	19.38	0.04	169.82	18.98	1.935	1.327	0.114	0.015	0.114
38.960	58.10	9.15	0.83	42.68	43.51	0.04	169.82	18.98	1.935	1.327	0.256	0.072	0.256
37.016	99.06	11.74	1.07	72.77	73.84	0.04	169.82	18.98	1.935	1.327	0.435	0.200	0.435
36.683	106.68	13.22	1.20	78.37	79.57	0.04	169.82	18.98	1.935	1.327	0.469	0.231	0.469
36.349	114.52	13.85	0.92	44.54	45.46	0.06	186.06	10.34	2.000	1.292	0.244	0.061	0.244
36.016	122.56	14.48	0.75	29.45	30.20	0.07	180.83	6.85	1.979	1.278	0.167	0.032	0.167
35.697	130.47	15.20	0.65	21.27	21.92	0.09	174.61	5.47	1.954	1.272	0.126	0.023	0.126
35.560	133.51	15.78	0.61	21.62	22.23	0.09	174.68	5.47	1.954	1.272	0.127	0.023	0.127
35.423	135.78	16.45	0.71	22.91	23.62	0.09	174.60	5.47	1.954	1.272	0.135	0.025	0.135
33.660	162.85	18.88	0.81	26.55	27.35	0.09	174.62	5.47	1.954	1.272	0.157	0.032	0.157
33.010	174.08	22.05	0.95	28.38	29.32	0.09	174.54	5.47	1.954	1.272	0.168	0.036	0.168
31.945	194.85	24.50	1.05	31.76	32.81	0.09	174.55	5.47	1.954	1.272	0.188	0.043	0.188
31.835	197.19	26.17	1.06	32.10	33.16	0.09	174.55	5.47	1.954	1.272	0.190	0.044	0.190
31.725	199.56	26.69	1.18	34.69	35.87	0.09	174.52	5.47	1.953	1.272	0.206	0.051	0.206
31.510	204.32	27.15	1.17	33.30	34.47	0.09	174.49	5.47	1.953	1.272	0.198	0.047	0.198
31.006	215.65	30.14	1.29	35.15	36.45	0.09	174.45	5.47	1.953	1.272	0.209	0.052	0.209
30.910	217.82	30.99	1.33	35.51	36.84	0.09	199.31	5.70	1.938	1.270	0.185	0.043	0.185
30.865	218.84	31.19	1.34	35.67	37.01	0.09	199.31	5.70	1.938	1.270	0.186	0.043	0.186
30.560	225.77	35.84	0.56	15.03	15.59	0.08	213.05	217.27	1.985	2.000	0.073	0.006	0.073

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 16
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 35.84 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

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Meridional Buckling Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.99	3.1	0.391	204.66	0.298	0.989	0.291	1.000	2412.24	204.66	186.06
36.016	191.4	10.6275	1.0	0.99	3.5	0.366	204.66	0.298	0.956	0.328	0.972	1898.28	198.91	180.83
35.697	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.80	192.07	174.61
35.560	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.27	192.15	174.68
35.423	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.51	192.06	174.60
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.89	192.08	174.62
33.010	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.21	191.99	174.54
31.945	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.36	192.00	174.55
31.835	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.49	192.01	174.55
31.725	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.81	191.97	174.52
31.510	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.24	191.94	174.49
31.006	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.296	0.928	0.362	0.938	1560.17	191.89	174.45

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30.910 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.19 219.24
199.31
30.865 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.15 219.24
199.31
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.981 2355.72 234.35
213.05

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
```

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s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.77	0.13	0.00	0.13	0.03	143.87	34.45	1.976	1.424	0.001	0.000	0.001
42.060	0.00	2.06	0.34	0.00	0.34	0.03	143.87	34.45	1.976	1.424	0.002	0.000	0.002
42.027	0.00	2.59	0.37	0.00	0.37	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.945	0.00	3.22	0.46	0.00	0.46	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.817	0.00	3.34	0.48	0.00	0.48	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.688	0.00	3.50	0.42	0.00	0.42	0.03	193.37	36.23	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.66	0.38	0.00	0.38	0.04	190.03	26.97	1.946	1.349	0.002	0.000	0.002
40.960	0.00	4.17	0.38	0.00	0.38	0.04	186.80	20.88	1.935	1.327	0.002	0.000	0.002
38.960	0.00	9.15	0.83	0.00	0.83	0.04	186.80	20.88	1.935	1.327	0.004	0.000	0.004
37.016	0.00	11.74	1.07	0.00	1.07	0.04	186.80	20.88	1.935	1.327	0.006	0.000	0.006
36.683	0.00	13.22	1.20	0.00	1.20	0.04	186.80	20.88	1.935	1.327	0.006	0.000	0.006
36.349	0.00	13.85	0.92	0.00	0.92	0.06	177.49	11.38	1.900	1.292	0.005	0.001	0.005
36.016	0.00	14.48	0.75	0.00	0.75	0.07	168.65	7.53	1.868	1.278	0.010	0.003	0.010
35.697	0.00	15.20	0.65	0.00	0.65	0.09	160.12	6.02	1.837	1.272	0.015	0.005	0.015
35.560	0.00	15.78	0.61	0.00	0.61	0.09	160.12	6.02	1.837	1.272	0.015	0.005	0.015
35.423	10.13	1.99	0.09	1.71	1.80	0.09	191.49	6.02	1.952	1.272	0.015	0.005	0.015
33.660	39.09	4.42	0.19	6.37	6.56	0.09	192.10	6.02	1.954	1.272	0.034	0.006	0.034
33.010	49.76	7.60	0.33	8.11	8.44	0.09	191.79	6.02	1.953	1.272	0.044	0.007	0.044
31.945	67.25	14.00	0.60	10.96	11.56	0.09	191.37	6.02	1.951	1.272	0.060	0.009	0.060
31.835	69.05	20.04	0.81	11.24	12.05	0.09	190.89	6.02	1.950	1.272	0.063	0.009	0.063
31.725	70.85	21.37	0.95	12.32	13.26	0.09	190.76	6.02	1.949	1.272	0.070	0.010	0.070
31.510	74.39	23.05	0.99	12.13	13.11	0.09	190.63	6.02	1.949	1.272	0.069	0.010	0.069
31.006	82.66	26.83	1.15	13.47	14.63	0.09	190.52	6.02	1.948	1.272	0.077	0.011	0.077
30.910	84.24	27.69	1.19	13.73	14.92	0.09	217.62	6.27	1.933	1.270	0.069	0.010	0.069
30.865	84.98	27.88	1.20	13.85	15.05	0.09	217.62	6.27	1.933	1.270	0.069	0.010	0.069
30.560	89.99	32.53	0.51	5.99	6.50	0.08	233.49	239.00	1.983	2.000	0.028	0.001	0.028

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 18
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 32.53 KN

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Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	143.87
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	143.87
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	193.37
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	190.03
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
36.349	215.6	10.6275	1.0	0.60	3.1	0.391	204.66	0.200	0.989	0.375	0.867	1459.11	177.49	177.49
36.016	191.4	10.6275	1.0	0.60	3.5	0.366	204.66	0.200	0.956	0.422	0.824	1150.45	168.65	168.65
35.697	173.9	10.6275	1.0	0.60	3.8	0.345	204.66	0.200	0.928	0.464	0.782	949.58	160.12	160.12
35.560	173.9	10.6275	1.0	0.60	3.8	0.345	204.66	0.200	0.928	0.464	0.782	949.58	160.12	160.12
35.423	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.936	1552.18	191.49	191.49
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1564.34	192.10	192.10
33.010	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.296	0.928	0.362	0.937	1558.18	191.79	191.79
31.945	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.935	1549.75	191.37	191.37
31.835	173.9	10.6275	1.0	0.97	3.8	0.345	204.66	0.293	0.928	0.365	0.933	1540.19	190.89	190.89

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31.725 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.293 0.928 0.365 0.932 1537.51 190.76
190.76
31.510 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.292 0.928 0.365 0.931 1534.91 190.63
190.63
31.006 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.292 0.928 0.365 0.931 1532.80 190.52
190.52
30.910 173.9 10.6275 1.0 0.97 3.8 0.345 239.00 0.292 0.928 0.387 0.911 1596.48 217.62
217.62
30.865 173.9 10.6275 1.0 0.97 3.8 0.345 239.00 0.292 0.928 0.387 0.911 1596.57 217.62
217.62
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.292 0.979 0.319 0.977 2355.72 233.49
233.49

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	34.45
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	34.45
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	51.25
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	51.25
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	51.25
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	36.23
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	26.97
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	20.88
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	20.88
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	20.88
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	20.88
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	11.38
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	7.53
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	6.02
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	6.02
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	6.02
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	6.02
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	6.02
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	6.02
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	6.02
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	6.02
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	6.02
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	6.02
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	6.27
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	6.27

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30.560 1.00 2.11 0.500 0.257 1.118 0.818  1.755 1.435 1.0000  0.08 3620.51 239.00 239.00

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Summary of Maximum Stack Deflection

A summary of the worst lateral deflections for the stack and the load case the produced them.

Elev m	Load #	Load Case	Defl Max mm	Defl Limit mm	Unity	Result
47.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	67.4	124.1	0.543	Pass
44.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	42.9	101.5	0.422	Pass
42.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.7	86.5	0.332	Pass
42.027	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.5	86.2	0.331	Pass
41.945	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.0	85.6	0.327	Pass
41.817	17	Serviceability: 1.0*D+1.0*S 0 Deg	27.2	84.6	0.322	Pass
41.688	17	Serviceability: 1.0*D+1.0*S 0 Deg	26.5	83.7	0.316	Pass
41.560	17	Serviceability: 1.0*D+1.0*S 0 Deg	25.7	82.7	0.311	Pass
40.960	17	Serviceability: 1.0*D+1.0*S 0 Deg	22.3	78.2	0.285	Pass
38.960	17	Serviceability: 1.0*D+1.0*S 0 Deg	12.1	63.2	0.192	Pass
37.016	17	Serviceability: 1.0*D+1.0*S 0 Deg	5.6	48.5	0.114	Pass
36.683	17	Serviceability: 1.0*D+1.0*S 0 Deg	4.9	46.0	0.107	Pass
36.349	17	Serviceability: 1.0*D+1.0*S 0 Deg	4.4	43.5	0.101	Pass
36.016	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.9	41.0	0.095	Pass
35.697	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.5	38.6	0.090	Pass
35.560	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.3	37.6	0.088	Pass
35.423	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.1	36.6	0.086	Pass
33.660	17	Serviceability: 1.0*D+1.0*S 0 Deg	1.3	23.3	0.055	Pass
33.010	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.8	18.4	0.043	Pass
31.945	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	10.4	0.022	Pass
31.835	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	9.6	0.019	Pass
31.725	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	8.8	0.017	Pass
31.510	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.1	7.1	0.013	Pass
31.006	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	3.4	0.004	Pass
30.910	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	2.6	0.002	Pass
30.865	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	2.3	0.002	Pass
30.865	14	Serviceability: 1.0*D+1.0*W 0 Deg	0.0	NaN	0.000	Pass

```
   Ratio = Defl Max / Defl Limit
```

Stack Deflection Load # 14

Load Combination Serviceability: 1.0*D+1.0*W 0 Deg

Elev	Dx	Dy	Dz	Dres	Limit	Ratio	Rresult

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m	mm	mm	mm	mm	mm		
47.060	43.4	-0.1	0.0	43.4	124.1	0.350	Pass
44.060	27.6	-0.1	0.0	27.6	101.5	0.272	Pass
42.060	18.5	-0.1	0.0	18.5	86.5	0.214	Pass
42.027	18.3	-0.1	0.0	18.3	86.2	0.213	Pass
41.945	18.0	-0.1	0.0	18.0	85.6	0.211	Pass
41.817	17.5	-0.1	0.0	17.5	84.6	0.207	Pass
41.688	17.0	-0.1	0.0	17.0	83.7	0.204	Pass
41.560	16.6	0.0	0.0	16.6	82.7	0.200	Pass
40.960	14.4	0.0	0.0	14.4	78.2	0.184	Pass
38.960	7.9	0.0	0.0	7.9	63.2	0.125	Pass
37.016	3.7	0.0	0.0	3.7	48.5	0.076	Pass
36.683	3.3	0.0	0.0	3.3	46.0	0.071	Pass
36.349	2.9	0.0	0.0	2.9	43.5	0.068	Pass
36.016	2.6	0.0	0.0	2.6	41.0	0.064	Pass
35.697	2.3	0.0	0.0	2.3	38.6	0.061	Pass
35.560	2.2	0.0	0.0	2.2	37.6	0.059	Pass
35.423	2.1	0.0	0.0	2.1	36.6	0.058	Pass
33.660	0.9	0.0	0.0	0.9	23.3	0.038	Pass
33.010	0.5	0.0	0.0	0.5	18.4	0.029	Pass
31.945	0.2	0.0	0.0	0.2	10.4	0.015	Pass
31.835	0.1	0.0	0.0	0.1	9.6	0.013	Pass
31.725	0.1	0.0	0.0	0.1	8.8	0.012	Pass
31.510	0.1	0.0	0.0	0.1	7.1	0.009	Pass
31.006	0.0	0.0	0.0	0.0	3.4	0.003	Pass
30.910	0.0	0.0	0.0	0.0	2.6	0.002	Pass
30.865	0.0	0.0	0.0	0.0	2.3	0.001	Pass
30.560	0.0	0.0	0.0	0.0	NaN	0.000	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dz^2)
Ratio = Dres / Limit

Stack Deflection Load # 17
Load Combination Serviceability: 1.0*D+1.0*S 0 Deg

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
47.060	67.4	-0.1	0.0	67.4	124.1	0.543	Pass
44.060	42.9	-0.1	0.0	42.9	101.5	0.422	Pass
42.060	28.7	-0.1	0.0	28.7	86.5	0.332	Pass
42.027	28.5	-0.1	0.0	28.5	86.2	0.331	Pass
41.945	28.0	-0.1	0.0	28.0	85.6	0.327	Pass
41.817	27.2	-0.1	0.0	27.2	84.6	0.322	Pass
41.688	26.5	-0.1	0.0	26.5	83.7	0.316	Pass
41.560	25.7	0.0	0.0	25.7	82.7	0.311	Pass
40.960	22.3	0.0	0.0	22.3	78.2	0.285	Pass
38.960	12.1	0.0	0.0	12.1	63.2	0.192	Pass
37.016	5.6	0.0	0.0	5.6	48.5	0.114	Pass
36.683	4.9	0.0	0.0	4.9	46.0	0.107	Pass
36.349	4.4	0.0	0.0	4.4	43.5	0.101	Pass
36.016	3.9	0.0	0.0	3.9	41.0	0.095	Pass
35.697	3.5	0.0	0.0	3.5	38.6	0.090	Pass
35.560	3.3	0.0	0.0	3.3	37.6	0.088	Pass

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35.423	3.1	0.0	0.0	3.1	36.6	0.086	Pass
33.660	1.3	0.0	0.0	1.3	23.3	0.055	Pass
33.010	0.8	0.0	0.0	0.8	18.4	0.043	Pass
31.945	0.2	0.0	0.0	0.2	10.4	0.022	Pass
31.835	0.2	0.0	0.0	0.2	9.6	0.019	Pass
31.725	0.2	0.0	0.0	0.2	8.8	0.017	Pass
31.510	0.1	0.0	0.0	0.1	7.1	0.013	Pass
31.006	0.0	0.0	0.0	0.0	3.4	0.004	Pass
30.910	0.0	0.0	0.0	0.0	2.6	0.002	Pass
30.865	0.0	0.0	0.0	0.0	2.3	0.002	Pass
30.560	0.0	0.0	0.0	0.0	NaN	0.000	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dz^2)
Ratio = Dres / Limit

Conical Transition Analysis

Cone Analysis per API RP 2A-WSD: Elev 41.945 m to 41.560 m
Load Combination # 10, A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	7.0	7.0	7.0
Fys:	Yield Stress (MPa)	204.66	204.66	204.66
E:	Modulus of Elasticity (MPa)	199333.14	199333.14	199333.14
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	618.98	618.98	618.98
M:	Overturning Moment (KN-m)	16.32	0.00	19.50
V:	Vertical Axial Loading (KN)	3.54	0.00	4.02
Sx:	Section Modulus (cm^3)	540.1	540.1	1361.2
Ax:	Cross Sectional Area (sq cm)	69.668	69.668	110.176
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.51	0.52	0.37
fb:	Bending Strss - M/Sx (MPa)	30.22	31.08	14.32
fb':	Localized Bending Stress (MPa)	42.43	42.43	25.40
fh':	Hoop Stress (MPa)	22.50	0.00	13.47

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Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1723.70	1723.70
1098.69			
Fhc:	Hoop Comp - Fys (MPa)	307.00	307.00
300.96			
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	153.50	153.50
150.48			
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2585.54	2585.54
1648.03			
Fxc:	Crit Lcl Bklng (MPa)	204.66	204.66
198.26			
Stot:	Total Stress Check 1: fa + fb (MPa)	30.73	31.60
14.69			
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	73.16	74.03
40.09			
Fb:	Allow Bend (LRFD): .9*Fxc (MPa)	184.20	184.20
178.43			
Fh:	Min(Fb, 0.5*Fhc) (MPa)	153.50	153.50
150.48			

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.167	PASS	0.172	PASS	0.082	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.120	PASS	0.065	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.090	PASS
Stiff Ring Req'd?	0.167	Not Req'd	0.172	Cone OK	0.090	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 37.016 m to 36.016 m
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	
0.0				
OD:	Outer Diameter (mm)	508.0	0.0	
1066.8				
T:	Thickness (mm)	7.0	7.0	
7.0				
Fys:	Yield Stress (MPa)	204.66	204.66	
204.66				
E:	Modulus of Elasticity (MPa)	199333.14	199333.14	
199333.14				
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	
117.90				
Ft:	Tensile Stress (MPa)	618.98	618.98	
618.98				
M:	Overturning Moment (KN-m)	99.06	0.00	
122.56				
V:	Vertical Axial Loading (KN)	25.08	0.00	
27.82				
Sx:	Section Modulus (cm^3)	1361.2	1361.2	
6134.7				

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Ax:	Cross Sectional Area (sq cm)	110.176	110.176	233.061
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	2.28	2.36	1.19
fb:	Bending Strss - M/Sx (MPa)	72.77	75.56	19.98
fb':	Localized Bending Stress (MPa)	151.57	151.57	61.96
fh':	Hoop Stress (MPa)	80.38	0.00	32.86
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1098.69	1098.69	523.19
Fhc:	Hoop Comp - Fys (MPa)	300.96	300.96	260.94
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	150.48	150.48	130.47
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	1648.03	1648.03	784.78
Fxc:	Crit Lcl Bklng (MPa)	198.26	199.54	170.26
Stot:	Total Stress Check 1: fa + fb (MPa)	75.05	77.92	21.17
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	226.62	229.50	83.13
Fb:	Allow Bend (LRFD): .9*Fxc (MPa)	178.43	179.59	153.23
Fh:	Min(Fb, 0.5*Fhc) (MPa)	150.48	150.48	130.47

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.421	PASS	0.434	PASS	0.138	PASS
Check 2: Stot1 / Ft	0.366	PASS	0.371	PASS	0.134	PASS
Check 3: fh' < Fh	0.534	PASS	0.000	PASS	0.252	PASS
Stiff Ring Req'd?	0.534	Not Req'd	0.434	Cone OK	0.252	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Structural Flange Analysis

Structural Flange # 1: Elev 42.000 m, Load # 9
Load Combination # 9, A: 0.9*D 0 Deg
Controlling: Max Bolt Spacing

M	= Moment on Flange	= 0.0 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -2331 N
S	= Shear Load on Flange	= 0 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm

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```
Db        = Nominal Bolt Diameter                                    = 22.2 mm
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (LRFD) 0.56*Fu            = 579.16 MPa
Fv        = Allowable Bolt Tensile Stress: (LRFD) 0.34*Fy            = 351.63 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (LRFD) 1.35*Fy             = 291.34 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 0 N
Fact      = Actual force on bolt                                     = 134811 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 224684 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.856

Sh        = Shear on Bolt                                            = 0 N
Sallow    = Allowable Shear on Bolt                                  = 136415 N
Ratio     = Sh / Sallow                                              = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
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```
Aw        = Area of Weld                                              = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                        = 270.0 KPa
Sw        = Allowable Fillet Weld Stress: (LRFD) 0.45*Fuw             = 186.16 MPa
Ratio     = Fba / Sw                                                  = 0.001

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                              = 87.6 mm
Lg        = Gross Flange area for each bolt                           = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                 = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                          = 54.0 mm
A         = Distance from Bolt CL to Flange OD                        = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                = 42.9 mm
Rho       = Calculated Parameter                                      = 3.377
Beta      = Calulcated Parameter                                      = 0
Alpha'    = Alpha where treq'd is minimum                             = 0
Tc        = Required thickness to develop load w/no prying            = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                          = 0
Q         = Prying Force per bolt                                     = 0 N
Treq'd    = Required Flange Thickness                                 = 0.0 mm
Ratio     = Treqd / Tf                                                = 0.000
```

Structural Flange # 1: Elev 42.000 m, Load # 15
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg

Controlling: Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                          = 15999.1 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -2589 N
S         = Shear Load on Flange                                      = 6363 N

Ds        = Outer Diameter of Shell                                   = 323.8 mm
Do        = Outside Diameter of Flange                                = 482.6 mm
Dbc       = Bolt Circle Diameter                                      = 431.8 mm
Tf        = Thickness of Flange                                       = 31.8 mm
Tw        = Fillet Weld Size                                          = 6.0 mm

Db        = Nominal Bolt Diameter                                     = 22.2 mm
Nb        = Number of Bolts                                           = 12
Fu        = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (LRFD) 0.56*Fu             = 579.16 MPa
Fv        = Allowable Bolt Tensile Stress: (LRFD) 0.34*Fy             = 351.63 MPa
Fp        = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb        = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys       = Yield Stress of Shell                                     = 215.81 MPa
Fw        = Tensile Stress of Weld                                    = 413.68 MPa
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (LRFD) 1.35*Fy              = 291.34 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt            = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters          = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                           = 222.3 mm
```

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```
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 12135 N
Ab        = Nominal Area of Bolt                                          = 3.879 sq cm
Km        = Stiffness of Material                                         = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                             = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby       = Bolt Yield Stress                                             = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 11040 N
Fact      = Actual force on bolt                                          = 134811 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.082

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 125757 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 224684 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144436 N
Ratio     = Fb / Fbcomb                                                   = 0.871

Sh        = Shear on Bolt                                                 = 530 N
Sallow    = Allowable Shear on Bolt                                       = 136415 N
Ratio     = Sh / Sallow                                                   = 0.004

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw        = Area of Weld                                                  = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                            = 23200.7 KPa
Sw        = Allowable Fillet Weld Stress: (LRFD) 0.45*Fuw                 = 186.16 MPa
Ratio     = Fba / Sw                                                      = 0.125

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                  = 87.6 mm
Lg        = Gross Flange area for each bolt                               = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                    = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                     = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                              = 54.0 mm
A         = Distance from Bolt CL to Flange OD                            = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                    = 42.9 mm
Rho       = Calculated Parameter                                          = 3.377
Beta      = Calulcated Parameter                                          = 5.1868
Alpha'    = Alpha where treq'd is minimum                                 = 1
Tc        = Required thickness to develop load w/no prying                = 13.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                              = 0
Q         = Prying Force per bolt                                         = 0 N
Treq'd    = Required Flange Thickness                                     = 8.4 mm
```

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Ratio = Treqd / Tf = 0.266

Breach # 1: Elev 35.560 m, Load # 15
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg
Controlling: Shell Buckling Capacity w/ Breach

Breach Analysis based upon 'Tubular Steel Structures' by M.S. Troitsky
Analysis assumes that this is the only breach and doesn't consider interaction with other openings.

This breach opening is due to a nozzle and was automatically generated by the MecaStack.

Elev = Elevation Where Breach Ctr Line Intersects Stack Ctr Line = 35.56 m

ElTop = Elevation at Top of Breach = 35.697 m
ElBot = Elevation at Bottom of Breach = 35.423 m
Wid = Width of Ducting = 273.1 mm
Ht = Height of Ducting = 273.1 mm
Ht1 = Vertical Height of Breach Opening at Shell = 273.1 mm
Tilt = Tilt of Duct relative to grade (0 is Horizontal) = 0.0 Deg
OD = Outer Diameter at Elevation = 1066.8 mm
ThkUnc = Uncorroded Thickness of Stack = 10.0 mm
ThkCor = Corroded Thickness of Stack = 7.0 mm

Loads Acting @ Breach (Take worst of loads at Top, Mid and Bot of Breach):
Moment is for a perfect cylinder and won't match stress summary if eccentric moments are included.
V = Vertical Load = 15.33 KN
M = Moment due to Lateral Loads = 145.91 KN-m

Yc = Distance from Centerline to Elastic Neutral Axis = 60.2 mm
r = Radius to Outside of Stack = 533.4 mm
r1 = Radius to Inside of Stack = 20.7 mm
Dm = Mean Diameter: 2*(r+r1)/2 = 41.7 mm
Alpha = Half Angle of Opening: ArcSin(Wid/OD) = 0.2588 rads
Beta = Angle to Neutral Axis: ArcSin(Yc/r) = 0.1132 rads
Gamma1 = (PI/2 - Alpha + Beta)/2 = 0.7126 rads
Gamma2 = (PI/2 - Alpha - Beta)/2 = 0.5994 rads
Sc = Statical Moment Under Compression = 3536.6 cm^3
St = Statical Moment Under Tension = 198.6 cm^3
Ic = Moment of Inertia of Wall Under Compression = 3597.78 cm^4
It = Moment of Inertia of Wall Under Tension = 2892.11 cm^4
Phi = (Mom + Ver*Yc) / (Ic + It) = 200.2527
N = Phi * (Sc-St) = 3.45 KN

Breach # 1 Ld 15 Cylinder Buckling Capacity:
This checks the reduced buckling capacity for the cylinder considering that it is weakened by the breach cutout. Reduction is based upon Troitsky Fig 5-24 for Effect of Rect Cutout on Cylindrical Buckling Capacity.

fclassic = Classic Buckling Stress for Cylinder: 0.6*E*ThkCor/r = 1569.56 MPa
FS = Factor of Safety for Compression = 0.900
rbar = Non-dimensional parameter: (Wid+Ht) / (4*((OD/2)*ThkCor)^0.5) = 2.234
P/Pcl = Actual / Classical Buckling Capacity {Fig 5-23}; Max=0.2 = 0.200

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```
fmax      = Max Comp Stress: (Phi/2)*(2*Yc+(r+r1)*COS(Alpha))              = 4.51 MPa
fallow    = Allowable Reduced Buckling Stress: (P/Pcl)*fclassic*FS          = 282.52 MPa
UR_sb     = Shell Buckling Unity Ratio: fmax/fallow                         = 0.110
```

Breach # 2: Elev 31.835 m, Load # 11
Load Combination # 11, B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg
Controlling: Shell Buckling Capacity w/ Breach

Breach Analysis based upon 'Tubular Steel Structures' by M.S. Troitsky
Analysis assumes that this is the only breach and doesn't consider interaction with other openings.

This breach opening is due to a nozzle and was automatically generated by the MecaStack.

```
Elev      = Elevation Where Breach Ctr Line Intersects Stack Ctr Line       = 31.835 m

ElTop     = Elevation at Top of Breach                                      = 31.945 m
ElBot     = Elevation at Bottom of Breach                                   = 31.725 m
Wid       = Width of Ducting                                                = 219.1 mm
Ht        = Height of Ducting                                               = 219.1 mm
Ht1       = Vertical Height of Breach Opening at Shell                      = 219.1 mm
Tilt      = Tilt of Duct relative to grade (0 is Horizontal)                = 0.0 Deg
OD        = Outer Diameter at Elevation                                     = 1066.8 mm
ThkUnc    = Uncorroded Thickness of Stack                                   = 10.0 mm
ThkCor    = Corroded Thickness of Stack                                     = 7.0 mm

Loads Acting @ Breach (Take worst of loads at Top, Mid and Bot of Breach):
Moment is for a perfect cylinder and won't match stress summary if eccentric moments are
included.
V         = Vertical Load                                                   = 43.25 KN
M         = Moment due to Lateral Loads                                     = 269.12 KN-m

Yc        = Distance from Centerline to Elastic Neutral Axis                = 57.8 mm
r         = Radius to Outside of Stack                                      = 533.4 mm
r1        = Radius to Inside of Stack                                       = 20.7 mm
Dm        = Mean Diameter: 2*(r+r1)/2                                       = 41.7 mm
Alpha     = Half Angle of Opening:  ArcSin(Wid/OD)                          = 0.2068 rads
Beta      = Angle to Neutral Axis:  ArcSin(Yc/r)                            = 0.1085 rads
Gamma1    = (PI/2 - Alpha + Beta)/2                                         = 0.7362 rads
Gamma2    = (PI/2 - Alpha - Beta)/2                                         = 0.6277 rads
Sc        = Statical Moment Under Compression                               = 3731.6 cm^3
St        = Statical Moment Under Tension                                   = 200.2 cm^3
Ic        = Moment of Inertia of Wall Under Compression                     = 3860.45
cm^4
It        = Moment of Inertia of Wall Under Tension                         = 2931.06
cm^4
Phi       = (Mom + Ver*Yc) / (Ic + It)                                      = 353.9735
N         = Phi * (Sc-St)                                                   = 9.72 KN
```

Breach # 2 Ld 11 Cylinder Buckling Capacity:
*This checks the reduced buckling capacity for the cylinder considering that it is weakened by
the breach cutout. Reduction is based upon Troitsky Fig 5-24 for Effect of Rect Cutout on Cylindrical Buckling Capacity.*

```
fclassic  = Classic Buckling Stress for Cylinder: 0.6*E*ThkCor/r            = 1569.56 MPa
FS        = Factor of Safety for Compression                                = 0.900
```

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```
rbar      = Non-dimensional parameter: (Wid+Ht) / (4*((OD/2)*ThkCor)^0.5)    = 1.793
P/Pcl     = Actual / Classical Buckling Capacity {Fig 5-23}; Max=0.2         = 0.200
fmax      = Max Comp Stress: (Phi/2)*(2*Yc+(r+r1)*COS(Alpha))                = 8.03 MPa
fallow    = Allowable Reduced Buckling Stress: (P/Pcl)*fclassic*FS           = 282.52 MPa
UR_sb     = Shell Buckling Unity Ratio: fmax/fallow                          = 0.196
```

Nozle # 1: Check Nozzle Loads Per WRC 107/537
Description: 1N

```
Elev      = Elev of Ctr of Nozzle to Ctr of Stack Intersection               = 35.56 m
OD        = Outer Diameter of Nozzle                                         = 273.1 mm
Thk       = Thickness of Nozzle                                              = 9.3 mm
Proj      = Radial Projection from OD of Stack to end of Nozzle/Flange       = 200.0 mm
RW        = Radial Width of Repad from OD of Nozzle ot OD of Repad           = 100.0 mm
RT        = Repad Thickness                                                  = 8.0 mm
Tilt      = Tilt Relative to Horizonal (0 is Horizzontal, + is down)         = 0.0 Deg
Orien     = Orientation of Nozzle in the Plan View                           = 180.0 Deg
FW        = Flange Width                                                     = 66.7 mm
FT        = Flange Thickness                                                 = 30.2 mm
```

Nozzle # 1 Nozzle WRC Load Summary

Load Num	Description	Fx KN	Fy KN	Fz KN	Mx KN-m	My KN-m	Mz KN-m	Local/ Global	Load Applied	Load Type	Max Ratio	Worst Case
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	0.475	*

* is the worst case loading

Nozzle # 1 WRC Load Summary of Transformed Loads
Transformation of Loads to Global Coordinates and at Nozzle to Shell Intersection

Load Num	Description	Fxt [P] KN	Fyt [Vl] KN	Fzt [Vc] KN	Mxt [Mt] KN-m	Myt [Mc] KN-m	Mzt [Ml] KN-m	Load Type	Max Ratio	Worst Case
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Oper	0.475	*

* WRC 107 Analysis is based upon loads being at the Nozzle to Shell Interface
* Values in [] represent those values that are used in WRC 537 stress analysis

Nozzle # 1 Nozzle Load Detailed Calculations for Load Producing Highest Stress Ratio:
Load #'s Refer to the Load # for the Nozzle Loads Only

```
Ds        = Outer Diameter of Stack @ Nozzle                                 = 1066.8 mm
Ts        = Corroded thickness of Stack @ Nozzle                             = 7.0 mm
Rw        = Repad Width                                                      = 3.9 mm
Rt        = Repad Thickness                                                  = 0.3 mm
Teff      = Effective Thickness: (Ts^2+Rt^2)^0.5                             = 0.4 mm
Rcyl      = Mean Cylinder Radius: [(Ds+2*Rt) + (Ds-2*Ts)]/4                  = 21.0 mm
Sallow    = Allowable Local Stress: 2 * Fy                                   = 409.33 MPa
```

Nozzle # 1 Local Stress per WRC 537: Cylinder to Repad

```
P         = Radial Force                                                     = 7.78 KN
```

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```
Mc        = Circumferential Moment                                    = 474.54 KN-
cm
Ml        = Longitudinal Moment                                       = 474.54 KN-
cm
Mt        = Torsional Moment                                          = 630.46 KN-
cm
Vc        = Shear in Circumferential Direction                        = 14.46 KN
Vl        = Shear in Longitudinal Direction                           = 14.46 KN
```

Parameter	Cylinder	Cylinder	Round Attachment	Round Attachment
		mm		mm
Outer Diameter	Do	1082.8	do	273.1
Mean Diameter	Dm	1067.8	dm	263.8
Inside Diameter	Di	1052.8	di	254.5
Mean Radius	Rm	533.9	rm	131.9
Thickness	T	15.0	t	9.3

Parameter	Expected Range	Actual Value	Status
Gamma = Rm/T	5 <= Gamma <= 300	35.593	OK
Beta = 0.875*ro/Rm	Beta <= 0.5	0.224	OK
di/Di	di/Di <= 0.6	0.242	OK
t/T	t/T >= 1	0.618	Warning
Lambda = (dm/Dm)*(Dm/T)^0.5	Lambda <= 2.8	2.084	OK

One ore more criteria was not met so please use the results with caution.
It is recommended to verify the local stress using Finite Element Analysis
When checking FEA it is recommended to use the Loads x Nd to apply the appropriate safety factor

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Circumferential Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.224	-4.77	-4.77	-4.77	-4.77	-2.91	-2.91	-2.91	-2.91
P	Bending	0.224	-6.43	6.43	-6.43	6.43	-12.52	12.52	-12.52	12.52
Mc	Membrane	0.224	0.00	0.00	0.00	0.00	-7.55	-7.55	7.55	7.55
Mc	Bending	0.224	0.00	0.00	0.00	0.00	-81.97	81.97	81.97	-81.97
Ml	Membrane	0.224	-17.88	-17.88	17.88	17.88	0.00	0.00	0.00	0.00

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Ml	Bending	0.224	-25.19	25.19	25.19	-25.19	0.00	0.00	0.00	0.00
TOTAL	Circumferential		-54.27	8.96	31.87	-5.65	-104.96	84.03	74.09	-64.81

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Longitudinal Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.224	-2.91	-2.91	-2.91	-2.91	-4.77	-4.77	-4.77	-4.77
P	Bending	0.224	-12.75	12.75	-12.75	12.75	-6.40	6.40	-6.40	6.40
Mc	Membrane	0.224	0.00	0.00	0.00	0.00	-14.64	-14.64	14.64	14.64
Mc	Bending	0.224	0.00	0.00	0.00	0.00	-38.06	38.06	38.06	-38.06
Ml	Membrane	0.224	-7.50	-7.50	7.50	7.50	0.00	0.00	0.00	0.00
Ml	Bending	0.224	-42.63	42.63	42.63	-42.63	0.00	0.00	0.00	0.00
TOTAL	Longitudinal		-65.79	44.96	34.48	-25.30	-63.87	25.05	41.53	-21.80

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Shear Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Vc	Shear	0.000	2.25	2.25	-2.25	-2.25	0.00	0.00	0.00	0.00
Vl	Shear	0.000	0.00	0.00	0.00	0.00	-2.25	-2.25	2.25	2.25
Mt	Shear	0.000	3.59	3.59	3.59	3.59	3.59	3.59	3.59	3.59
TOTAL	Shear		5.84	5.84	1.34	1.34	1.34	1.34	5.84	5.84

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Combined Stress Intensity

Description	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Total Circumferential (Sc)	-54.27	8.96	31.87	-5.65	-104.96	84.03	74.09	-64.81
Total Longitudinal (Sl)	-65.79	44.96	34.48	-25.30	-63.87	25.05	41.53	-21.80

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```
Total Shear (Ss)              5.84   5.84   1.34    1.34     1.34    1.34    5.84
5.84
-------------------------  ------  -----  -----  ------  -------  -----  -----  -----
-
Combined Intensity           16.40  45.88  35.04   19.83    41.18   84.06  75.11
44.57

   When Sc & Sl have like signs:   S = 0.5*(Sc+Sl +/- [(Sc-Sl)^2 + 4*Ss^2]^0.5
                                or S = [(Sc-Sl)^2+4*Ss^2]^0.5
   When Ss=0:                      S = Max of [Abs(Sc), Abs(Sl) or Abs(Sc-Sl)]
   When Sc & Sl have unlike Signs: S = [(Sc-Sl)^2+4*Ss^2]^0.5


SI_Max    = Maximum Combined Stress Intensity                          = 84.06 MPa
Sallow    = Allowable Local Stress: 2 * Fy                             = 409.33 MPa
UR        = Unity Stress Ratio:  SI_Max / Allow                        = 0.205

Nozzle # 1 Local Stress per WRC 537: Repad to Shell
P         = Radial Force                                               = 7.78 KN
Mc        = Circumferential Moment                                     = 474.54 KN-
cm
Ml        = Longitudinal Moment                                        = 474.54 KN-
cm
Mt        = Torsional Moment                                           = 630.46 KN-
cm
Vc        = Shear in Circumferential Direction                         = 14.46 KN
Vl        = Shear in Longitudinal Direction                            = 14.46 KN

   Parameter          Cylinder       Cylinder       Round Attachment       Round
Attachment
                                        mm                                    mm
---------------       --------       --------       ----------------       ----------
-
Outer Diameter           Do             1066.8              do
487.1
Mean Diameter            Dm             1059.8              dm
480.1
Inside Diameter          Di             1052.8              di
473.1
Mean Radius              Rm              529.9              rm
240.0
Thickness                 T                7.0               t
7.0

          Parameter                  Expected Range          Actual Value          Status
---------------------------        -----------------        ------------          ------
-
Gamma = Rm/T                       5 <= Gamma <= 300            75.700               OK
Beta = 0.875*ro/Rm                 Beta <= 0.5                   0.402               OK
di/Di                              di/Di <= 0.6                  0.449               OK
t/T                                t/T >= 1                      1.000               OK
Lambda = (dm/Dm)*(Dm/T)^0.5        Lambda <= 2.8                 5.573
Warning

One ore more criteria was not met so please use the results with caution.
It is recommended to verify the local stress using Finite Element Analysis
```

When checking FEA it is recommended to use the Loads x Nd to apply the appropriate safety factor

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Circumferential Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.391	-10.78	-10.78	-10.78	-10.78	-3.51	-3.51	-3.51	-3.51
P	Bending	0.391	-4.73	4.73	-4.73	4.73	-47.66	47.66	-47.66	47.66
Mc	Membrane	0.391	0.00	0.00	0.00	0.00	-9.40	-9.40	9.40	9.40
Mc	Bending	0.391	0.00	0.00	0.00	0.00	-159.53	159.53	159.53	-159.53
Ml	Membrane	0.391	-17.68	-17.68	17.68	17.68	0.00	0.00	0.00	0.00
Ml	Bending	0.391	-19.14	19.14	19.14	-19.14	0.00	0.00	0.00	0.00
TOTAL	Circumferential		-52.34	-4.59	21.31	-7.51	-220.09	194.28	117.76	-105.98

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Longitudinal Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.391	-3.51	-3.51	-3.51	-3.51	-10.78	-10.78	-10.78	-10.78
P	Bending	0.391	-13.32	13.32	-13.32	13.32	-19.06	19.06	-19.06	19.06
Mc	Membrane	0.391	0.00	0.00	0.00	0.00	-40.97	-40.97	40.97	40.97
Mc	Bending	0.391	0.00	0.00	0.00	0.00	-60.13	60.13	60.13	-60.13
Ml	Membrane	0.391	-9.74	-9.74	9.74	9.74	0.00	0.00	0.00	0.00
Ml	Bending	0.391	-40.79	40.79	40.79	-40.79	0.00	0.00	0.00	0.00
TOTAL	Longitudinal		-67.36	40.86	33.71	-21.24	-130.96	27.44	71.26	-10.88

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Shear Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa

Vc	Shear	0.000	2.78	2.78	-2.78	-2.78	0.00	0.00	0.00	0.00
Vl	Shear	0.000	0.00	0.00	0.00	0.00	-2.78	-2.78	2.78	2.78
Mt	Shear	0.000	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56
TOTAL	Shear		5.34	5.34	-0.22	-0.22	-0.22	-0.22	5.34	5.34

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Combined Stress Intensity

Description	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Total Circumferential (Sc)	-52.34	-4.59	21.31	-7.51	-220.09	194.28	117.76	-105.98
Total Longitudinal (Sl)	-67.36	40.86	33.71	-21.24	-130.96	27.44	71.26	-10.88
Total Shear (Ss)	5.34	5.34	-0.22	-0.22	-0.22	-0.22	5.34	5.34
Combined Intensity	18.43	46.69	33.72	13.73	89.14	194.28	118.36	95.70

When Sc & Sl have like signs: S = 0.5*(Sc+Sl +/- [(Sc-Sl)^2 + 4*Ss^2]^0.5
or S = [(Sc-Sl)^2+4*Ss^2]^0.5
When Ss=0: S = Max of [Abs(Sc), Abs(Sl) or Abs(Sc-Sl)]
When Sc & Sl have unlike Signs: S = [(Sc-Sl)^2+4*Ss^2]^0.5

SI_Max = Maximum Combined Stress Intensity = 194.28 MPa
Sallow = Allowable Local Stress: 2 * Fy = 409.33 MPa
UR = Unity Stress Ratio: SI_Max / Allow = 0.475

Baseplate Analysis, Worst Case Load # 10 - A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg
Based Upon 'Process Equipment Design' by Brownell & Young

The following components are Controlled by this Load Case:
Bolt Tension, Top Plate, Gussets, Local, Weld

M = Moment on Baseplate = 316.88 KN-m
V = Vertical Load on Baseplate (+ is compression / - is tension) = 48.45 KN
S = Shear Load on Baseplate = 43.29 KN
Ds = Outer Diameter of Stack at Base = 1066.8 mm
Type = Type of Baseplate = Chair Continuous Plate
SupType = Type of Support = Rigid Steel Base
Friction = Coefficient of Friction for Support = 0.300
BasisBolt = Basis for Bolt Design = Brownell & Young

```
Nbolt     = Number of Bolts                                          = 16
Dbolt     = Nominal Bolt Diameter                                    = 27.0 mm
Dbh       = Bolt Hole Diameter                                       = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                              = 3.0 mm
CAplt     = Corrosion Allowance on Plates                            = 0.0 mm
ID        = Inside Diameter of Baseplate                             = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                        = 1270.0 mm
OD        = Outer Diameter of Baseplate                              = 1385.0 mm
Tb        = Thickness of Bottom Plate                                = 25.0 mm
Tt        = Thickness of Top Plate                                   = 25.0 mm
Fw        = Fillet Weld Size                                         = 5.0 mm
Fwu       = Weld Ultimate Tensile Strength                           = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                               = 1
Hg        = Height of Anchor Chair                                   = 305.0 mm
Tg        = Thickness of Gusset                                      = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                   = S275J0
Dens      = Material Density                                         = 7849 Kg/m^3
Temp      = Design Temperature                                       = 21.11 Deg C
Fy        = Minimum Yield Stress                                     = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                  = 410030.5
KPa
Sa        = Allowable Tensile Stress                                 = 117141.7
KPa
E         = Modulus of Elasticity                                    = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                         = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                                = False
Matl      = Bolt Material Specification                              = Gr. 8.8
Fu        = Ultimate Tensile Stress                                  = 800548.8
KPa
Fy        = Yield Stress                                             = 640440.4
KPa
Fproof    = Proof Stress                                             = 544374.4
KPa
Eb        = Modulus of Elasticity                                    = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile             = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                             = 800.55 MPa
PreStress = Pretension Stress on Bolt                                = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                 = Rectangular
Pt        = Plate Washer Thickness                                   = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                   = 90.0 mm
Pl        = Length of Washer Parallel to Shell                       = 100.0 mm
Pdh       = Bolt Hole Diameter                                       = 30.0 mm
Bolt Properties:
P         = Thread Pitch                                             = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                     = 19.3 mm
```

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```
Aroot     = Bolt Minor Area:  (PI/4)*Dminor^2                                  = 2.921 sq cm

Bolt Tensile Strength per 'Process Equipment Design' by Brownell and Young:
Fu        = Bolt Ultimate Tensile Stress                                       = 800.55 MPa
Dbolt     = Diameter of Bolt                                                   = 27.0 mm
Cor Allow = Bolt Corrosion Allowance                                           = 3.0 mm
Dboltc    = Bolt Diameter Corroded:  Dbolt - Cor Allow                         = 24.0 mm
P         = Thread Pitch                                                       = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                               = 19.3 mm
Abolt     = Bolt Minor Area:  (PI/4)*Dminor^2                                  = 2.921 sq cm
Phi       = Factor for LRFD:   0.33*1.5                                        = 0.50
Pallow    = Bolt Tensile Strength: Phi*Fu*Abolt                                = 116.94 KN

Stack Shell Properties: (Uses Stack Hot Properties at the Baseplate Location)
Fys       = Yield Stress of Shell Material                                     = 239.00 MPa
Fb_shell  = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                       = 322.65 MPa

Baseplate Stress Limits: (Uses Baseplate Material Properties)
Fb        = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                       = 371.25 MPa
Fbs       = Allowable Plate Strong Bending: (LRFD) 0.9*Fy                      = 247.50 MPa

BASEPLATE COMPRESSIVE STRESS:
fcmax     = [4*M/(PI*Ds^2) + V/(PI*Ds)] / [(OD-ID)*0.5]                        = 1306.1 KPa

BOLT LOADING:
Pbolt     = Max Bolt Load: 4*M/(N*Dbc) - V / N                                 = 59349 N
Pallow    = Allowable Bolt Tensile Load                                        = 116936 N
Ratio     = Unity Ratio: Pbolt / Pallow                                        = 0.508


Bottom (Bearing) Plate: ('Pressure Vessel Design Manual' 3rd Edition by Dennis Moss)
Tension Case Between Gussets where gussets attempt to Lift up Bottom Plate
b         = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg           = 237.4 mm
bs        = Gusset Inside Spacing Outside Gussets: b                           = 237.4 mm
Mo        = Moment due to Tension: Pbolt*b/8                                   = 107456.3
KPa
w         = Radial Width of Bottom Plate: 0.5*(OD-ID)                          = 282.5 mm
tbt       = Thickness Req'd for Tension: (6*Mo/((w-Dbh)*Fb)^0.5+CAplt          = 10.7 mm
Compression Case where concrete bearing is applied to Bottom Plate
bmax      = Controlling Inside Gusset Spacing: Max(b, bs)                      = 237.4 mm
l         = Radial bending width of baseplate: 0.5*(OD-Ds)                     = 159.1 mm
l/bmax    = Ratio used for Moment Calculation: l/b                             = 0.670
cc1       = Moment coefficient taken from Table 3-36 using l/b                 = 0.0563
cc2       = Moment coefficient taken from Table 3-36 using l/b                 = 0.2256
Mx        = Moment in x dir: cc1 * fcmax * b^2 {Units Force*Length/Length}     = 4.15 KN
My        = Moment in y dir: cc2 * fcmax * L^2 {Units Force*Length/Length}     = 7.46 KN
Mmax      = Maximum Moment: Max(Mx, My) {Units Force*Length/Length}            = 7.46 KN
tbc       = Thickness req'd for Compression: (6*Mmax/Fb)^.5+CAplt              = 11.0 mm
tb_reqd   = Thickness req'd for Bottom Plate: Max(tbc, tbt)                    = 11.0 mm
Ratio     = Unity Ratio: tb_reqd / Tb                                          = 0.439

TOP PLATE: ('Process Equipment Design' by Brownell & Young)
bt        = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg           = 237.4 mm
Lt        = Radial distance:  (Do-Dbc)/2                                       = 159.1 mm
bl        = bt / Lt                                                            = 1.492
ly        = Distance in x direction: lt                                        = 159.1 mm
at        = (Dbc - Ds) / 2                                                     = 101.6 mm
```

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```
G1        = Gamma1 Value from Table 10.6                                    = 0.171
G2        = Gamma 1 Value from Table 10.6                                   = 0.072
e         = 1/2 Distance across flats of Bolting Nut                        = 21.8 mm
Term1     = Pbolt / (4*PI)                                                  = 1061.7268
Term2     = [2*ly*Sin(PI*at1/ly)]/(PI*e)                                    = 4.2055
Mx        = Term1 * ((1 + U) * Log(Term2) + 1) - (1 - U - G2t) [Eqn 10.39]  = 0.27 KN-m
My        = Term1 * ((1 + U) * Log(Term2) + 1) - (G1t * Term1) [Eqn 10.38]  = 0.32 KN-m
tt_reqd   = Req'd Thickness: (6*Mmax / Fb)^0.5 + CAplt                      = 14.3 mm
Ratio     = Unity Ratio tt_reqd / Tt                                        = 0.574


GUSSET: (AISC 15th Edition for Column Buckling)
Gusset: Nominal Compressive Strength per AISC 360-16 Sec E3:
Lc        = Effective Length of Member                                      = 255.0 mm
r         = Minimum of Radius of gyration:  Min(rx, ry)                     = 3.5 mm
Lc/r      = Slenderness Ratio                                               = 73.612
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                           = 130.143
Fe        = Elastic Buckling Stress:  PI^2*E / (Lc/r)^2   {E3-4}            = 382.41 MPa
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                           = 130.143
Fcr       = Critical Stress: [0.658^(Fy/Fe)]*Fy   {E3-2}                    = 203.52 MPa
Ag        = Gross Cross Sectional Area of Member                            = 19.092 sq
cm
Pn        = Flexural Buckling Strength:  Fcr*Ag {E3-1}                      = 388.57 KN
Pc        = Design Compressive Strength: Pn*0.9 (LRFD)                      = 349.71 KN
Pg        = Bolt load per gusset:  Pbolt / Ngus                             = 59.35 KN
Ratio     = Unity Ratio: Pg / Pc                                            = 0.170

SHELL LOCAL STRESS: ('Process Equipment Design' by Brownell & Young)
a         = Radial Dist to Bolts:  (BCD-Ds)/2                               = 101.6 mm
m         = PI * BCD / Nbolt                                                = 249.4 mm
Fb_shell  = Allowable bending stress of shell                               = 322.65 MPa
ts        = 1.76*(Pbolt*a/(m*hg*Fb_shell))^0.6667 * [Ds/2]^0.333 [Eqn 10.59]= 5.6 mm
Ratio     = Unity Ratio ts / Ts                                             = 0.560

WELD STRESS: (Per AISC 15th ed)
m         = PI * Ds / Nbolt                                                 = 209.5 mm
Aw        = Weld Area per Bolt: Lw*Fw/1.414                                 = 14.814 sq
cm
Lw        = Weld Length per Bolt: 2*m                                       = 418.9 mm
Abm       = Area of Base Metal (Assumes Ts is thinnest): Ts*Lw              = 41.893 sq
cm
Fnw       = Nominal Stress of Weld Material:  0.6*Fwu {Table J2.5}          = 289579.3
KPa
Rnw       = Design Weld Strength (LRFD): Fnw*Aw*0.75 {Eqn J2-2}             = 321731 N
Rnpy      = Design Base Metal Strength (LRFD): 0.6*Fy*Abm {Eqn J4-3}        = 600743 N
Rnpr      = Allowable Base Rupture (ASD):  0.6*Fu*Abm*0.75 {Eqn J4-5}       = 671758 N
Pnw       = Minimum of Rnw, Rnpy, and Rnpr                                  = 321731 N
Ratio     = Unity Ratio:  Pbolt / Pnw                                       = 0.184
```

Baseplate Analysis, Worst Case Load # 11 - B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg
Based Upon 'Process Equipment Design' by Brownell & Young

```
The following components are Controlled by this Load Case:
Bottom Plate

M         = Moment on Baseplate                                             = 316.88 KN-m
V         = Vertical Load on Baseplate (+ is compression / - is tension)    = 57.41 KN
```

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```
S          = Shear Load on Baseplate                                    = 43.29 KN
Ds         = Outer Diameter of Stack at Base                            = 1066.8 mm
Type       = Type of Baseplate                                          = Chair
                                                                          Continuous

Plate
SupType    = Type of Support                                            = Rigid Steel
Base
Friction   = Coefficient of Friction for Support                        = 0.300
BasisBolt  = Basis for Bolt Design                                      = Brownell &
Young
Nbolt      = Number of Bolts                                            = 16
Dbolt      = Nominal Bolt Diameter                                      = 27.0 mm
Dbh        = Bolt Hole Diameter                                         = 36.0 mm
CAbolt     = Corrosion Allowance on Bolt                                = 3.0 mm
CAplt      = Corrosion Allowance on Plates                              = 0.0 mm
ID         = Inside Diameter of Baseplate                               = 820.0 mm
BCD        = Bolt Circle Diameter of Baseplate                          = 1270.0 mm
OD         = Outer Diameter of Baseplate                                = 1385.0 mm
Tb         = Thickness of Bottom Plate                                  = 25.0 mm
Tt         = Thickness of Top Plate                                     = 25.0 mm
Fw         = Fillet Weld Size                                           = 5.0 mm
Fwu        = Weld Ultimate Tensile Strength                             = 482632.1
KPa
Ngus       = Number of Gussets per Bolt                                 = 1
Hg         = Height of Anchor Chair                                     = 305.0 mm
Tg         = Thickness of Gusset                                        = 12.0 mm
Material: (Properties looked up from database)
Spec       = Material Specification                                     = S275J0
Dens       = Material Density                                           = 7849 Kg/m^3
Temp       = Design Temperature                                         = 21.11 Deg C
Fy         = Minimum Yield Stress                                       = 274996.9
KPa
Fu         = Ultimate Tensile Stress                                    = 410030.5
KPa
Sa         = Allowable Tensile Stress                                   = 117141.7
KPa
E          = Modulus of Elasticity                                      = 209957162.5
KPa
A          = Coefficient of Thermal Expansion                           = 1.20E-05
mm/mm/C


Bolt Material:
Override   = Manually Specify Material                                  = False
Matl       = Bolt Material Specification                                = Gr. 8.8
Fu         = Ultimate Tensile Stress                                    = 800548.8
KPa
Fy         = Yield Stress                                               = 640440.4
KPa
Fproof     = Proof Stress                                               = 544374.4
KPa
Eb         = Modulus of Elasticity                                      = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile                = 60.00 %
Fult       = Bolt Ultimate Tensile Stress                               = 800.55 MPa
PreStress  = Pretension Stress on Bolt                                  = 480.33 MPa
```

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```
Plate Washer:
Ptype     = The Type of Plate Washer                                    = Rectangular
Pt        = Plate Washer Thickness                                      = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                      = 90.0 mm
Pl        = Length of Washer Parallel to Shell                          = 100.0 mm
Pdh       = Bolt Hole Diameter                                          = 30.0 mm
Bolt Properties:
P         = Thread Pitch                                                = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                        = 19.3 mm
Aroot     = Bolt Minor Area:  (PI/4)*Dminor^2                           = 2.921 sq cm

Bolt Tensile Strength per 'Process Equipment Design' by Brownell and Young:
Fu        = Bolt Ultimate Tensile Stress                                = 800.55 MPa
Dbolt     = Diameter of Bolt                                            = 27.0 mm
Cor Allow = Bolt Corrosion Allowance                                    = 3.0 mm
Dboltc    = Bolt Diameter Corroded:  Dbolt - Cor Allow                  = 24.0 mm
P         = Thread Pitch                                                = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                        = 19.3 mm
Abolt     = Bolt Minor Area:  (PI/4)*Dminor^2                           = 2.921 sq cm
Phi       = Factor for LRFD:   0.33*1.5                                 = 0.50
Pallow    = Bolt Tensile Strength: Phi*Fu*Abolt                         = 116.94 KN

Stack Shell Properties: (Uses Stack Hot Properties at the Baseplate Location)
Fys       = Yield Stress of Shell Material                              = 239.00 MPa
Fb_shell  = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                = 322.65 MPa

Baseplate Stress Limits: (Uses Baseplate Material Properties)
Fb        = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                = 371.25 MPa
Fbs       = Allowable Plate Strong Bending: (LRFD) 0.9*Fy               = 247.50 MPa

BASEPLATE COMPRESSIVE STRESS:
fcmax     = [4*M/(PI*Ds^2) + V/(PI*Ds)] / [(OD-ID)*0.5]                 = 1315.6 KPa

BOLT LOADING:
Pbolt     = Max Bolt Load: 4*M/(N*Dbc) - V / N                          = 58789 N
Pallow    = Allowable Bolt Tensile Load                                 = 116936 N
Ratio     = Unity Ratio: Pbolt / Pallow                                 = 0.503


Bottom (Bearing) Plate: ('Pressure Vessel Design Manual' 3rd Edition by Dennis Moss)
Tension Case Between Gussets where gussets attempt to Lift up Bottom Plate
b         = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg     = 237.4 mm
bs        = Gusset Inside Spacing Outside Gussets: b                    = 237.4 mm
Mo        = Moment due to Tension: Pbolt*b/8                            = 106442.3
KPa
w         = Radial Width of Bottom Plate: 0.5*(OD-ID)                   = 282.5 mm
tbt       = Thickness Req'd for Tension: (6*Mo/((w-Dbh)*Fb)^0.5+CAplt   = 10.7 mm
Compression Case where concrete bearing is applied to Bottom Plate
bmax      = Controlling Inside Gusset Spacing: Max(b, bs)               = 237.4 mm
l         = Radial bending width of baseplate: 0.5*(OD-Ds)              = 159.1 mm
l/bmax    = Ratio used for Moment Calculation: l/b                      = 0.670
cc1       = Moment coefficient taken from Table 3-36 using l/b          = 0.0563
cc2       = Moment coefficient taken from Table 3-36 using l/b          = 0.2256
Mx        = Moment in x dir: cc1 * fcmax * b^2 {Units Force*Length/Length}  = 4.18 KN
My        = Moment in y dir: cc2 * fcmax * L^2 {Units Force*Length/Length}  = 7.51 KN
Mmax      = Maximum Moment: Max(Mx, My) {Units Force*Length/Length}     = 7.51 KN
```

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```
tbc       = Thickness req'd for Compression: (6*Mmax/Fb)^.5+CAplt          = 11.0 mm
tb_reqd   = Thickness req'd for Bottom Plate: Max(tbc, tbt)                = 11.0 mm
Ratio     = Unity Ratio: tb_reqd / Tb                                      = 0.441

TOP PLATE: ('Process Equipment Design' by Brownell & Young)
bt        = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg       = 237.4 mm
Lt        = Radial distance:  (Do-Dbc)/2                                   = 159.1 mm
bl        = bt / Lt                                                        = 1.492
ly        = Distance in x direction: lt                                    = 159.1 mm
at        = (Dbc - Ds) / 2                                                 = 101.6 mm
G1        = Gamma1 Value from Table 10.6                                   = 0.171
G2        = Gamma 1 Value from Table 10.6                                  = 0.072
e         = 1/2 Distance across flats of Bolting Nut                       = 21.8 mm
Term1     = Pbolt / (4*PI)                                                 = 1051.7084
Term2     = [2*ly*Sin(PI*at1/ly)]/(PI*e)                                   = 4.2055
Mx        = Term1 * ((1 + U) * Log(Term2) + 1) - (1 - U - G2t) [Eqn 10.39] = 0.27 KN-m
My        = Term1 * ((1 + U) * Log(Term2) + 1) - (G1t * Term1) [Eqn 10.38] = 0.32 KN-m
tt_reqd   = Req'd Thickness: (6*Mmax / Fb)^0.5 + CAplt                     = 14.3 mm
Ratio     = Unity Ratio tt_reqd / Tt                                       = 0.571


GUSSET: (AISC 15th Edition for Column Buckling)
Gusset: Nominal Compressive Strength per AISC 360-16 Sec E3:
Lc        = Effective Length of Member                                     = 255.0 mm
r         = Minimum of Radius of gyration:  Min(rx, ry)                    = 3.5 mm
Lc/r      = Slenderness Ratio                                              = 73.612
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                          = 130.143
Fe        = Elastic Buckling Stress:  PI^2*E / (Lc/r)^2   {E3-4}           = 382.41 MPa
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                          = 130.143
Fcr       = Critical Stress: [0.658^(Fy/Fe)]*Fy   {E3-2}                   = 203.52 MPa
Ag        = Gross Cross Sectional Area of Member                           = 19.092 sq
cm
Pn        = Flexural Buckling Strength:  Fcr*Ag {E3-1}                     = 388.57 KN
Pc        = Design Compressive Strength: Pn*0.9 (LRFD)                     = 349.71 KN
Pg        = Bolt load per gusset:  Pbolt / Ngus                            = 58.79 KN
Ratio     = Unity Ratio: Pg / Pc                                           = 0.168

SHELL LOCAL STRESS: ('Process Equipment Design' by Brownell & Young)
a         = Radial Dist to Bolts:  (BCD-Ds)/2                              = 101.6 mm
m         = PI * BCD / Nbolt                                               = 249.4 mm
Fb_shell  = Allowable bending stress of shell                              = 322.65 MPa
ts        = 1.76*(Pbolt*a/(m*hg*Fb_shell))^0.6667 * [Ds/2]^0.333 [Eqn 10.59]= 5.6 mm
Ratio     = Unity Ratio ts / Ts                                            = 0.556

WELD STRESS: (Per AISC 15th ed)
m         = PI * Ds / Nbolt                                                = 209.5 mm
Aw        = Weld Area per Bolt: Lw*Fw/1.414                                = 14.814 sq
cm
Lw        = Weld Length per Bolt: 2*m                                      = 418.9 mm
Abm       = Area of Base Metal (Assumes Ts is thinnest): Ts*Lw             = 41.893 sq
cm
Fnw       = Nominal Stress of Weld Material:  0.6*Fwu {Table J2.5}         = 289579.3
KPa
Rnw       = Design Weld Strength (LRFD): Fnw*Aw*0.75 {Eqn J2-2}            = 321731 N
Rnpy      = Design Base Metal Strength (LRFD): 0.6*Fy*Abm {Eqn J4-3}       = 600743 N
Rnpr      = Allowable Base Rupture (ASD):  0.6*Fu*Abm*0.75 {Eqn J4-5}      = 671758 N
Pnw       = Minimum of Rnw, Rnpy, and Rnpr                                 = 321731 N
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Ratio = Unity Ratio: Pbolt / Pnw = 0.183

Static Summation of Forces
Total sum of all loads acting on system, Shear = (Fx^2+Fz^2)^0.5

Ld	Load Case (P)=Primary, (C)=Combination	Dir	Fx	Fy	Fz	Shear
		Deg	KN	KN	KN	KN
1	(P)Dead	0	0.00	-35.84	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	16.42
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00
5	(P)Wind	0	19.01	0.00	0.00	19.01
6	(P)Seismic Hor	0	22.77	0.00	0.00	22.77
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	0.28
9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O	0	43.29	-48.45	0.00	43.29
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O	0	43.29	-57.41	0.00	43.29
12	(C)B: 1.0*D 0 Deg	0	0.00	-35.84	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*	0	37.52	-43.67	0.00	37.52
14	(C)Serviceability: 1.0*D+1.0*W	0	19.01	-35.84	0.00	19.01
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 D	0	39.19	-45.87	0.00	39.19
16	(C)1.0*D+1.0*S 0 Deg	0	22.77	-35.84	0.00	22.77
17	(C)Serviceability: 1.0*D+1.0*S	0	22.77	-35.84	0.00	22.77
18	(C)D+O+P 0 Deg	0	16.42	-32.53	0.00	16.42

Support Loading Notes
These notes apply to the support loading data which follows

1) Joint = Joint Number, Load = Load Number, Type = P(Primary) Or C(Combination)
2) Dir= Direction Of Lateral Loads (Wind/Seismic/Vortex), 0 Deg=+X axis, 90 Deg=+Z Axis
3) Fx/Fy/Fz = Forces In X/Y/Z directions, Mx/My/Mz = Moments about X/Y/Z Axis
4) Y Is the vertical direction, And + loads are acting up, And - Is acting down.

Detailed Support Loads: Fixed @ El 30.56 m
Loads acting on the support points (+Y is Vertical and Upward)

Load	Load Case (P)=Primary,(C)=Combo	Dir	Fx	Fy	Fz	Mx	My	Mz
		Deg	KN	KN	KN	KN-m	KN-m	KN-m
1	(P)Dead	0	0.00	-35.84	0.00	0.00	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	0.00	0.00	-89.99
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00	0.00	0.00
5	(P)Wind	0	19.01	0.00	0.00	0.00	0.00	-157.26
6	(P)Seismic Hor	0	22.77	0.00	0.00	0.00	0.00	-225.77
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	3.29	0.00	0.00
9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg	0	43.29	-48.45	0.00	0.00	0.00	-316.88
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O 0 De	0	43.29	-57.41	0.00	0.00	0.00	-316.88

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12	(C)B: 1.0*D 0 Deg	0	0.00	-35.84	0.00	0.00	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*O 0 D	0	37.52	-43.67	0.00	0.00	0.00	-274.63
14	(C)Serviceability: 1.0*D+1.0*W 0 De	0	19.01	-35.84	0.00	0.00	0.00	-157.26
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	0	39.19	-45.87	0.00	0.00	0.00	-315.76
16	(C)1.0*D+1.0*S 0 Deg	0	22.77	-35.84	0.00	0.00	0.00	-225.77
17	(C)Serviceability: 1.0*D+1.0*S 0 De	0	22.77	-35.84	0.00	0.00	0.00	-225.77
18	(C)D+O+P 0 Deg	0	16.42	-32.53	0.00	0.00	0.00	-89.99

Load	Load Case (P)=Primary,(C)=Combo	Vertical KN	Shear KN	Moment KN-m
1	(P)Dead	-35.84	0.00	0.00
2	(P)Live	-13.34	0.00	0.00
3	(P)Operating	3.31	16.42	89.99
4	(P)Thermal Hot	0.00	0.00	0.00
5	(P)Wind	0.00	19.01	157.26
6	(P)Seismic Hor	0.00	22.77	225.77
7	(P)Seismic Ver	-22.77	0.00	0.00
8	(P)Vortex Across	0.00	0.28	3.29
9	(C)A: 0.9*D 0 Deg	-32.26	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg	-48.45	43.29	316.88
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O 0 De	-57.41	43.29	316.88
12	(C)B: 1.0*D 0 Deg	-35.84	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*O 0 D	-43.67	37.52	274.63
14	(C)Serviceability: 1.0*D+1.0*W 0 De	-35.84	19.01	157.26
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	-45.87	39.19	315.76
16	(C)1.0*D+1.0*S 0 Deg	-35.84	22.77	225.77
17	(C)Serviceability: 1.0*D+1.0*S 0 De	-35.84	22.77	225.77
18	(C)D+O+P 0 Deg	-32.53	16.42	89.99

These are the resultant forces and the shear and moment can occur in any direction
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Mom: (Mx^2 + Mz^2)^0.5
Vertical load is the Fy force.

Maximum Support Loads for All Load Combinations
Maximum loading for each restraint, but loads may not necessarily occur at the same time

Restraint Description	Vertical KN	Uplift KN	Shear KN	Moment KN-m	Torsion KN-m
Fixed	-57.41	0.00	43.29	316.88	0.00

Vertical = Max downward acting Fy (Largest negative Fy value)
Uplift = Max upward acting Fy (Largest postive Fy value)
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Overturning Moment: (Mx^2 + Mz^2)^0.5
Torsion = Maximum magnitude of My

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6. MAIN RESULTS

Stack Stress Worst Case Summary

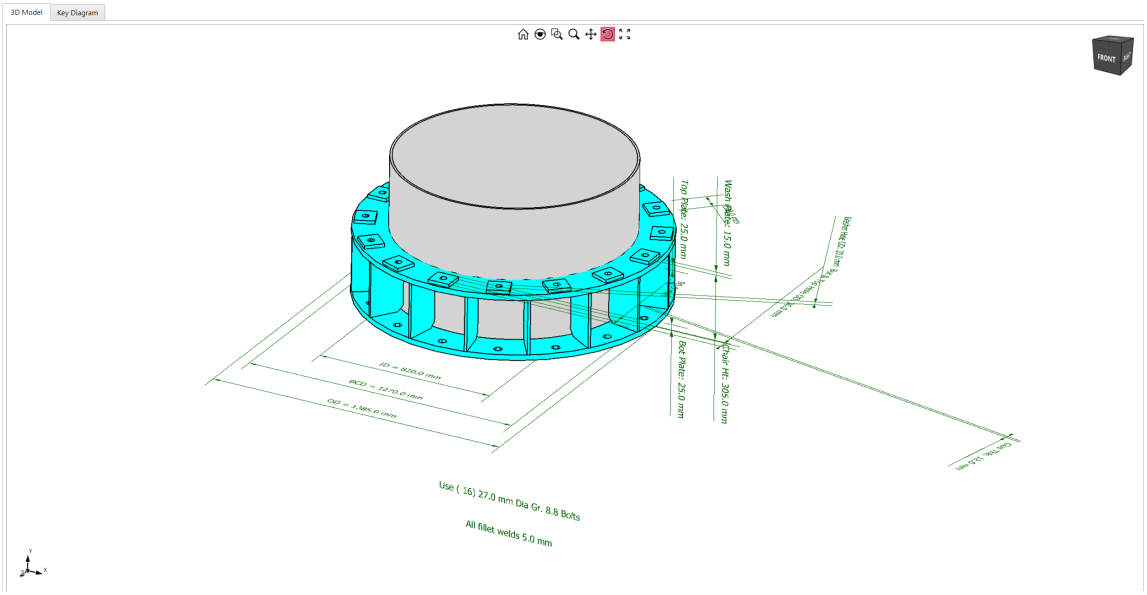
Summary of the load and highest stress ratios for each stack element

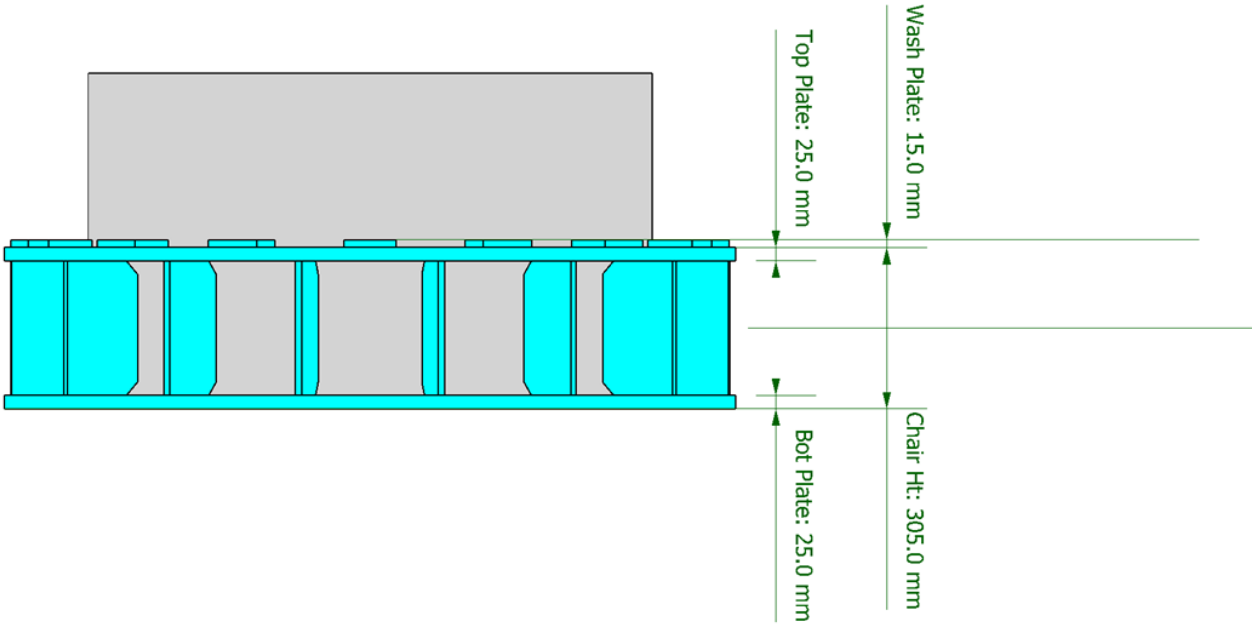
Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
16.500	13.500	16	1.0*D+1.0*S 0 Deg	Buckling	0.097	PASS
13.500	11.500	16	1.0*D+1.0*S 0 Deg	Buckling	0.263	PASS
11.500	11.467	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.174	PASS
11.467	11.385	16	1.0*D+1.0*S 0 Deg	Buckling	0.181	PASS
11.385	11.257	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.191	PASS
11.257	11.128	16	1.0*D+1.0*S 0 Deg	Buckling	0.144	PASS
11.128	11.000	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.115	PASS
11.000	10.400	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.121	PASS
10.400	8.400	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.273	PASS
8.400	6.456	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.458	PASS
6.456	6.123	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.493	PASS
6.123	5.789	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.259	PASS
5.789	5.456	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.178	PASS
5.456	5.137	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.134	PASS
5.137	5.000	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.135	PASS
5.000	4.863	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.150	PASS
4.863	3.100	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.199	PASS
3.100	2.450	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.221	PASS
2.450	1.385	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.260	PASS
1.385	1.275	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.265	PASS
1.275	1.165	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.287	PASS
1.165	0.950	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.278	PASS
0.950	0.350	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.302	PASS
0.350	0.305	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.304	PASS
0.305	0.000	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.122	PASS

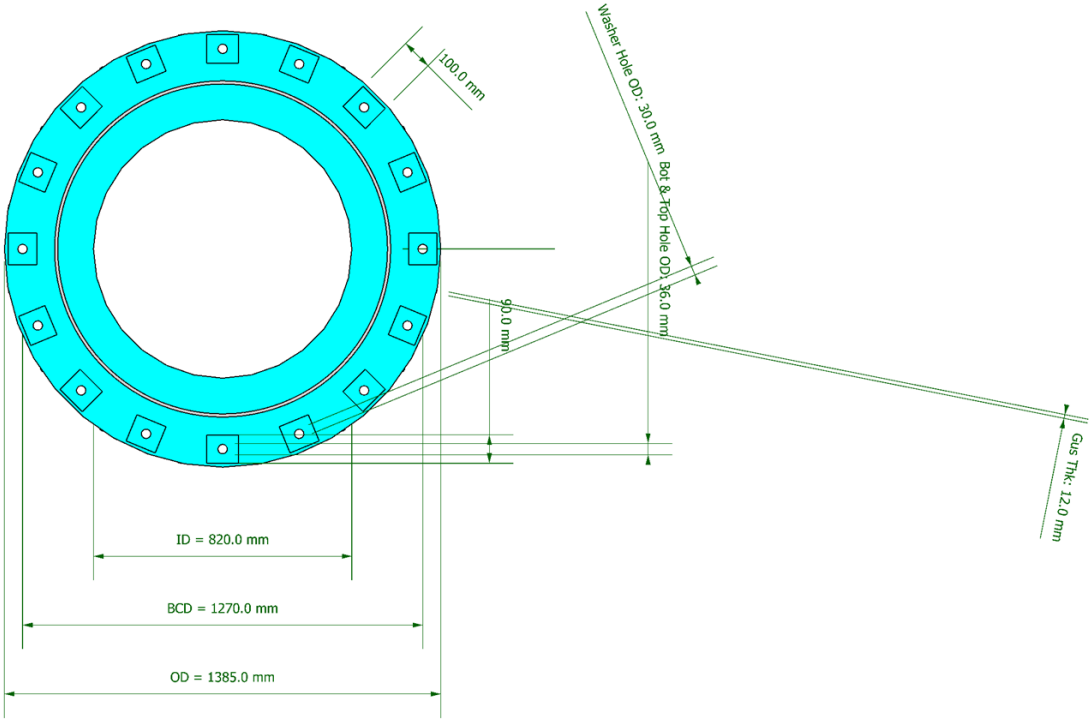
The maximum ratio of demand/capacity for the shell is lower than 1 showing a good structural behavior of the structure which has enough safety margin. All the verification are passed.

7. LOADS AT THE BASE

7.2 BASE PLATE

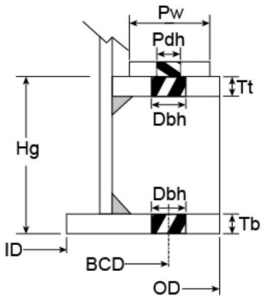


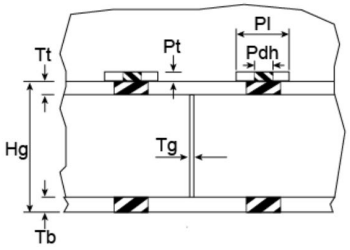




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Parameters	Description	Value	Units
Type	Type of Baseplate	Chair Continuous Plate	
Standard	Populate with Standard Dimensions	Get Standard Dimensions	
SupType	Type of Support	Rigid Steel Base	
Friction	Coefficient of Friction for Support	0.3	
Bolt	Bolt Material	Gr. 8.8	
BasisBolt	Basis for Bolt Design	Brownell & Young	
Pretension	Anchor Bolt Pretension	60.00 % of Ult / 480.33 MPa	
Nbolt	Number of Bolts	16	
Dbolt	Nominal Bolt Diameter	27	mm
Dbh	Bolt Hole Diameter	36	mm
CAbolt	Corrosion Allowance on Bolt	3	mm
Matl	Baseplate Material	S275J0	
CAplt	Corrosion Allowance on Plates	0	mm
ID	Inside Diameter of Baseplate	820	mm
BCD	Bolt Circle Diameter of Baseplate	1270	mm
OD	Outer Diameter of Baseplate	1385	mm
Tb	Thickness of Bottom Plate	25	mm
Tt	Thickness of Top Plate	25	mm
Fw	Fillet Weld Size	5	mm
Fwu	Weld Ultimate Tensile Strength	482632.1	KPa
Ngus	Number of Gussets per Bolt	1	
Hg	Height of Anchor Chair	305	mm
Tg	Thickness of Gusset	12	mm
Washer	Plate Washer	100.0 x 90.0 x 15.0 mm	





7.3Resultant Actions

The Case 6 below is representing the Transportation loads which provides the highest reactions effect among the horizontal acceleration applied with the load cases "transportation Loads" and " Wave and current Loads"

Detailed Support Loads: Fixed @ El 0.0 m

Loads acting on the support points (+Y is Vertical and Upward)

Load	Load Case (P)=Primary, (C)=Combo	Dir	Fx	Fy	Fz	Mx	My	Mz
		Deg	KN	KN	KN	KN-m	KN-m	KN-m
1	(P)Dead	0	0.00	-35.84	0.00	0.00	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	0.00	0.00	-89.99
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00	0.00	0.00
5	(P)Wind	0	18.99	0.00	0.00	0.00	0.00	-157.10
6	(P)Seismic Hor	0	22.77	0.00	0.00	0.00	0.00	-227.63
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	3.29	0.00	0.00

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9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00	0.00

Load	Load Case (P)=Primary,(C)=Combo	Vertical KN	Shear KN	Moment KN-m
1	(P)Dead	-35.84	0.00	0.00
2	(P)Live	-13.34	0.00	0.00
3	(P)Operating	3.31	16.42	89.99
4	(P)Thermal Hot	0.00	0.00	0.00
5	(P)Wind	0.00	18.99	157.10
6	(P)Seismic Hor	0.00	22.77	227.63
7	(P)Seismic Ver	-22.77	0.00	0.00
8	(P)Vortex Across	0.00	0.28	3.29

These are the resultant forces and the shear and moment can occur in any direction
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Mom: (Mx^2 + Mz^2)^0.5
Vertical load is the Fy force.

Maximum Support Loads for All Load Combinations

Maximum loading for each restraint, but loads may not necessarily occur at the same time

Restraint Description	Vertical KN	Uplift KN	Shear KN	Moment KN-m	Torsion KN-m
Fixed	-57.41	0.00	43.26	317.61	0.00

Vertical = Max downward acting Fy (Largest negative Fy value)
Uplift = Max upward acting Fy (Largest postive Fy value)
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Overturning Moment: (Mx^2 + Mz^2)^0.5
Torsion = Maximum magnitude of My

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8. LIST OF ATTACHMENT

A- ASME VIII PRESSURE CALCULATION OF BOTTOM KOD

B- LIFTING ANALYSIS CONFIGURATION WITHOUT TIP

C- LIFTING ANALYSIS CONFIGURATION WITH TIP

D- LIFTING LUG CALCULATION

E- MISCELLANUES CALCULATION

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9. CONCLUSIONS

Based on the results of the analysis, the following conclusions can be drawn:

- All the load cases have been considered and checked for the stability of the structure.
- The resultant stresses are within the allowable limits for all the load cases.
- The structure is stable and safe under the applied loads.

A – PRESSURE CALCULATION ACCORDING TO ASME VIII div.1

The calculation is performed using PV ELITE one of the most reliable software in this field.

PV Elite is a comprehensive software tool used for the design and analysis of pressure vessels and heat exchangers. It offers capabilities such as finite element analysis, wind and seismic analysis, and the ability to model various types of vessel components.

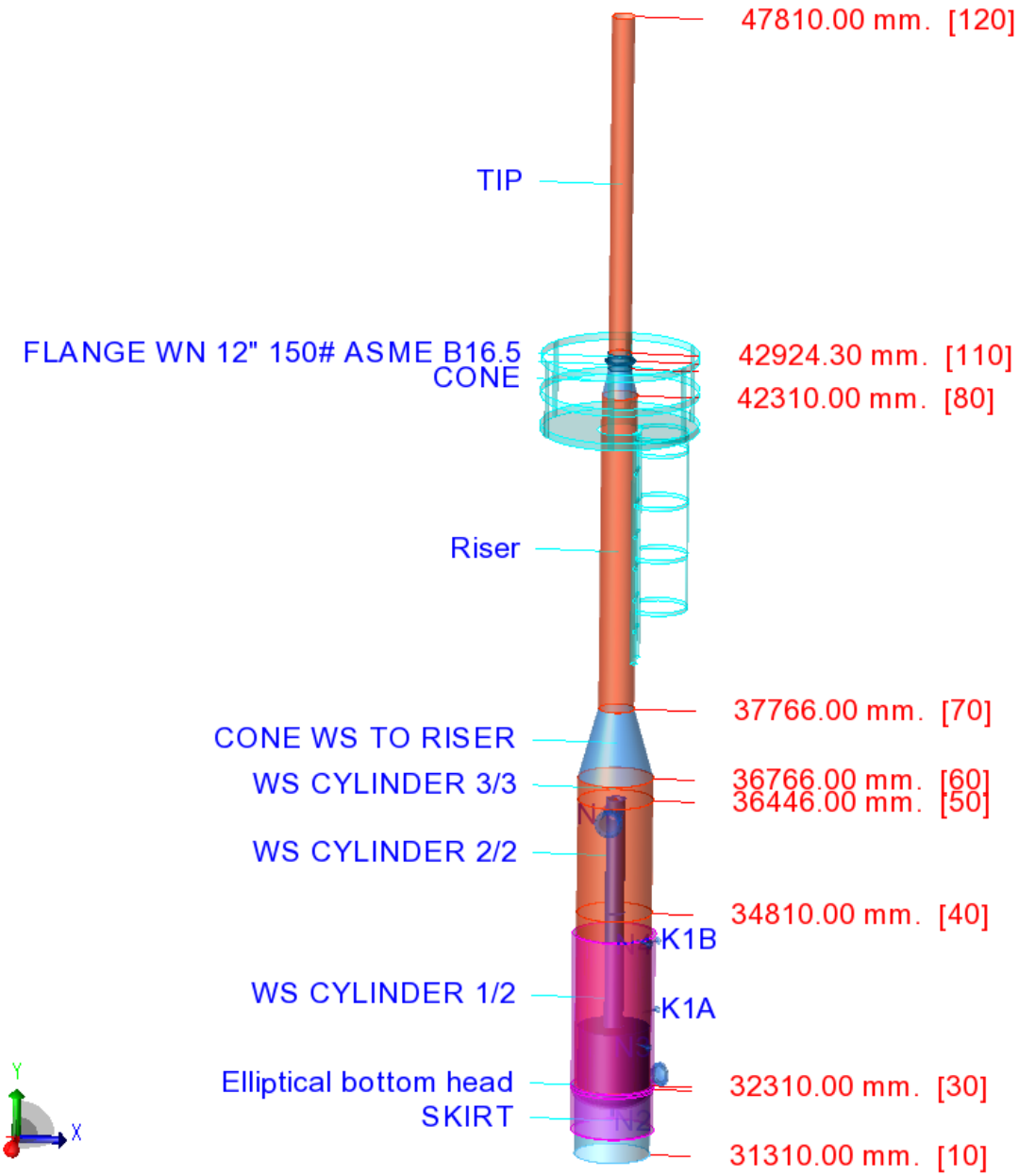
Note:

1- Base Plate analysis is not included. For details refers to the structural calculation in this document.

2- The loads case named "seismic" are referring to the maximum between transportation loads and case "wave and current loads" as shown above in this document. This is required because the software can handle only one seismic loads during the analysis.

3- The skirt is modeled with a dummy material of SA516-60 but for its verification , as it is not an element under pressure, please refer to the structural analysis where S75J0 has been used.

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47810.00 mm. [120]
TIP
FLANGE WN 12" 150# ASME B16.5
CONE
42924.30 mm. [110]
42310.00 mm. [80]
Riser
37766.00 mm. [70]
CONE WS TO RISER
WS CYLINDER 3/3
36766.00 mm. [60]
36446.00 mm. [50]
WS CYLINDER 2/2
34810.00 mm. [40]
K1B
WS CYLINDER 1/2
K1A
Elliptical bottom head
SKIRT
32310.00 mm. [30]
31310.00 mm. [10]
Y
X

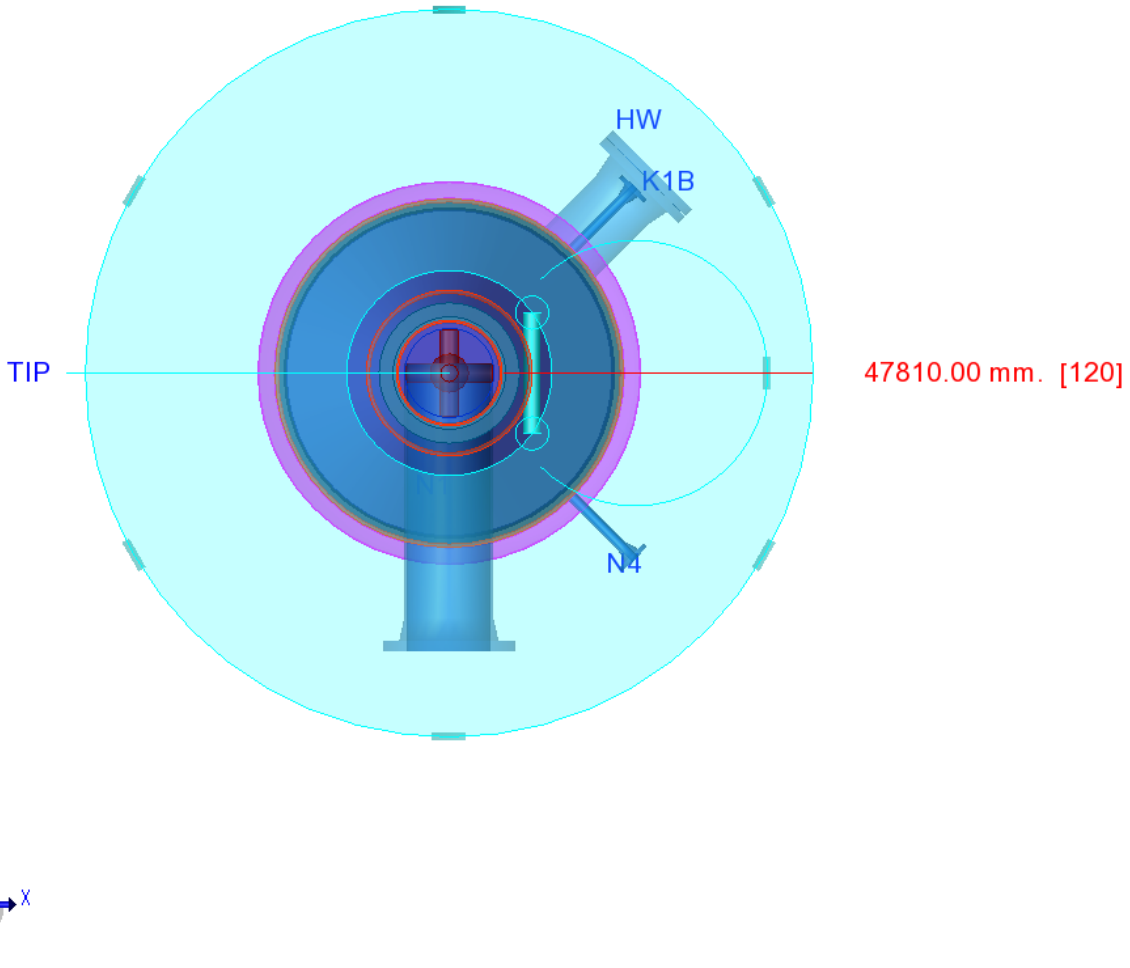

HW
K1B
TIP
47810.00 mm. [120]
N4
Y
X
Z

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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

```
ASME Code Version      : 2023

Analysis Performed by : Ing.Diego Bruciafreddo

Job File              : W:\1.COMMESSE\DB-ENCORE-C16-23-0193-ROSETTI MARI

Date of Analysis      : Dec 4,2024    9:40pm
```

Note:
PV Elite performs all calculations internally in Imperial Units
to remain compliant with the ASME Code and any built in assumptions
in the ASME Code formulas. The finalized results are reflected to show
the user's set of selected units.

PV Elite is a trademark of Hexagon AB, 2024, All rights reserved.

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	350	kPa
Design Internal Temperature	80.0	°C
Type of Hydrotest	1.43 * MAWP (PED)	
Hydrotest Position	Vertical	
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-10.0	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-2	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	N	

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS

Load Case 9	EP+OW+WI+FW+BW	
Load Case 10	EP+OW+EQ+FS+BS	
Load Case 11	HP+HW+HI	
Load Case 12	HP+HW+HE	
Load Case 13	IP+WE+EW	
Load Case 14	IP+WF+CW	
Load Case 15	IP+VO+OW	
Load Case 16	IP+VE+EW	
Load Case 17	NP+VO+OW	
Load Case 18	FS+BS+IP+OW	
Load Case 19	FS+BS+EP+OW	
Wind Design Code	EN 1991-1-4:2005+A1:2010	
Fundamental Wind Velocity [Vb,0]	100.8	Km/hr
Direction Factor [Cdir]	1.0	
Seasonal Factor [CSeason]	1.0	
Force Coefficient [Cf]	0.69999999	
Structural Factor [CsCd]	1.0	
Terrain Category	0 - Sea or Costal Area	
Seismic Design Code	G Loading	
Seismic Importance Factor	1.000	
G Loading Coefficient Gx	0.700	
G Loading Coefficient Gz	0.700	
G Loading Coefficient Gy	0.700	
Percent Seismic for Hydrotest	0.000	
Design Pressure + Static Head	Y	
Consider MAP New and Cold in Noz. Design	N	
Consider External Loads for Nozzle Des.	Y	
Use ASME VIII-1 Appendix 1-9	N	
Material Database Year	1997	

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	No
Shell Head Joints are Tapered	No
Compute "K" in corroded condition	No
Use Code Case 2286	No
Use the MAWP to compute the MDMT	No
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes
Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT calcs. (Div. 1)	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Skirt Sup.	
Description	SKIRT	
Distance "FROM" to "TO"	950	mm

Skirt Outside Diameter	1066.8	mm
Diameter of Skirt at Base	1066.8	mm
Skirt Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Temperature Internal Pressure	80	°C
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA/EN 10028-2	
Allowable Stress, Ambient	134.5	N/mm^2
Allowable Stress, Operating	134.5	N/mm^2
Allowable Stress, Hydrotest	174.8	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	266.6	N/mm^2
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number		
Class / Thickness / Grade P355GH:: 6	< t <= 10	
Product Form	Plate	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Head-to-Skirt or Circ. Seam	0.85	
Weld is pre-Heated	No	
Element From Node	10	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	350	mm
Height/Length of Insulation	600	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3

Element From Node	20	
Element To Node	30	
Element Type	Elliptical	
Description	Elliptical bottom head	
Distance "FROM" to "TO"	50	mm
Element Outside Diameter	1066.8	mm
Element Thickness	6.35	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Allowable Stress, Ambient	117.9	N/mm^2
Allowable Stress, Operating	117.9	N/mm^2
Allowable Stress, Hydrotest	153.3	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	204.7	N/mm^2

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UCS-66 Chart Curve Designation	C	
External Pressure Chart Name	CS-2	
UNS Number	K02100	
Product Form	Plate	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Liquid	
Detail ID	WS LIQUID 1/2	
Dist. from "FROM" Node / Offset dist	-263.52	mm
Height/Length of Liquid	313.52	mm
Liquid Density	0.0009996	kg/cm^3
Element From Node	20	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	-266.7	mm
Height/Length of Insulation	316.7	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	2	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	5.3838	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Element To Node	40	
Element Type	Cylinder	
Description	WS CYLINDER 1/2	
Distance "FROM" to "TO"	2500	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	

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Weld is pre-Heated	No	
Element From Node	30	
Detail Type	Liquid	
Detail ID	WS Liquid 2/2	
Dist. from "FROM" Node / Offset dist	0	mm
Height/Length of Liquid	850	mm
Liquid Density	0.0009996	kg/cm^3
Element From Node	30	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	0	mm
Height/Length of Insulation	2200	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3
Element From Node	30	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	700	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	135.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	
Detail Type	Nozzle	
Detail ID	N4	
Dist. from "FROM" Node / Offset dist	2200	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	135.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	
Detail Type	Nozzle	
Detail ID	K1A	
Dist. from "FROM" Node / Offset dist	950	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	

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Detail Type	Nozzle	
Detail ID	K1B	
Dist. from "FROM" Node / Offset dist	1950	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Detail Type	Nozzle	
Detail ID	HW	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	8	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	49.044	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Detail Type	Weight	
Detail ID	WGHT:[1 OF 1]	
Dist. from "FROM" Node / Offset dist	850	mm
Miscellaneous Weight	87.271	kgf
Offset from Element Centerline	0	mm

Element From Node	40	
Element To Node	50	
Element Type	Cylinder	
Description	WS CYLINDER 2/2	
Distance "FROM" to "TO"	1636	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Nozzle	
Detail ID	N1	

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Dist. from "FROM" Node / Offset dist	1500	mm
Nozzle Diameter	10	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	71.383	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	40	
Detail Type	Weight	
Detail ID	N1-INNER1OF2	
Dist. from "FROM" Node / Offset dist	0	mm
Miscellaneous Weight	103.46	kgf
Offset from Element Centerline	0	mm

Element From Node	40	
Detail Type	For./Mom.	
Detail ID	N10 Nozle Laod	
Dist. from "FROM" Node / Offset dist	1500	mm
Force in X Direction	1445	kgf
Force in Y Direction	1445	kgf
Force in Z Direction	-778	kgf
Moment about X Axis	474	kgf-m
Moment about Y Axis	0	kgf-m
Moment about Z Axis	631	kgf-m
Force/Moment Combination Method	SRSS	

Element From Node	50	
Element To Node	60	
Element Type	Cylinder	
Description	WS CYLINDER 3/3	
Distance "FROM" to "TO"	320	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	60	
Element To Node	70	
Element Type	Conical	
Description	CONE WS TO RISER	

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Distance "FROM" to "TO"	1000	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Cone Diameter at "To" End	508	mm
Design Length of Cone	1000	mm
Half Apex Angle of Cone	15.61036	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	70	
Element To Node	80	
Element Type	Cylinder	
Description	Riser	
Distance "FROM" to "TO"	4544	mm
Element Outside Diameter	508	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	70	
Detail Type	Platform	
Detail ID	PLT 1	
Dist. from "FROM" Node / Offset dist	4044	mm
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	360.0	
Platform Wind Area	14080	cm^2
Platform Weight	181.4	kgf
Platform Railing Weight	0.03	kgf/mm
Platform Grating Weight	0.003026	kg/cm^2
Platform Width	800	mm
Platform Height	1100	mm
Platform Clearance or End Offset	60	mm
Platform Force Coefficient	1.6	
Ladder Layout Angle	90.0	

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Ladder Start Elevation	39865	mm
Ladder End Elevation	43200	mm
Unit Weight of Ladder	0.04	kgf/mm
Platform Length (top head platform)	0	mm

Element From Node	80	
Element To Node	90	
Element Type	Conical	
Description	CONE	
Distance "FROM" to "TO"	385.7	mm
Element Outside Diameter	508	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Cone Diameter at "To" End	323.9	mm
Design Length of Cone	385.7	mm
Half Apex Angle of Cone	13.422951	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	90	
Element To Node	100	
Element Type	Flange	
Description	FLANGE WN 12" 150# ASME B16.5	
Distance "FROM" to "TO"	114.3	mm
Flange Inside Diameter	323.9	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-350 LF2 [Impact Tested]	
Allowable Stress, Ambient	137.9	N/mm^2
Allowable Stress, Operating	137.9	N/mm^2
Allowable Stress, Hydrotest	179.3	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	230.2	N/mm^2
UCS-66 Chart Curve Designation	Impact Tested	
External Pressure Chart Name	CS-2	

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UNS Number	K03011	
Class / Thickness / Grade 1::		
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0	kgf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Weld is pre-Heated	No	

Element From Node	100	
Element To Node	110	
Element Type	Flange	
Description	FLANGE WN 12" 150# ASME B16.5	
Distance "FROM" to "TO"	114.3	mm
Flange Inside Diameter	323.9	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-182 F316L	
Allowable Stress, Ambient	115.1	N/mm^2
Allowable Stress, Operating	115.1	N/mm^2
Allowable Stress, Hydrotest	149.7	N/mm^2
Material Density	0.008027	kg/cm^3
P Number Thickness	0	mm
Yield Stress, Operating	151.5	N/mm^2
External Pressure Chart Name	HA-4	
UNS Number	S31603	
Class / Thickness / Grade :: > 5		
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0	kgf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Weld is pre-Heated	No	

Element From Node	110	
Element To Node	120	
Element Type	Cylinder	
Description	TIP	
Distance "FROM" to "TO"	4885.7	mm
Element Outside Diameter	323.9	mm
Element Thickness	6	mm
Internal Corrosion Allowance	0	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C

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Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-213 TP316	
Allowable Stress, Ambient	137.9	N/mm^2
Allowable Stress, Operating	123.8	N/mm^2
Allowable Stress, Hydrotest	179.3	N/mm^2
Material Density	0.008027	kg/cm^3
P Number Thickness	0	mm
Yield Stress, Operating	183.5	N/mm^2
External Pressure Chart Name	HA-2	
UNS Number	S31600	
Product Form	Smls. tube	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

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XY Coordinate Calculations:

From	To	X (Horiz.) mm	Y (Vert.) mm	DX (Horiz.) mm	DY (Vert.) mm
SKIRT		...	950	...	950
Elliptical bott		...	1000	...	50
WS CYLINDER 1/2		...	3500	...	2500
WS CYLINDER 2/2		...	5136	...	1636
WS CYLINDER 3/3		...	5456	...	320
CONE WS TO RISE		...	6456	...	1000
Riser		...	11000	...	4544
CONE		...	11385.7	...	385.7
FLANGE WN 12" 1		...	11500	...	114.3
FLANGE WN 12" 1		...	11623.8	...	114.3
TIP		...	16509.5	...	4885.7

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Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd kPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) N/mm^2
SKIRT		...	...	3	1066.8	...
Elliptical botto		361.4	...	3	1066.8	100.22
WS CYLINDER 1/2		358.33	...	3	1066.8	100.22
WS CYLINDER 2/2		350	...	3	1066.8	100.22
WS CYLINDER 3/3		350	...	3	1066.8	100.22
CONE WS TO RISER		350	...	3	1066.8	100.22
Riser		350	...	3	508	100.22
CONE		350	...	3	508	100.22
FLANGE WN 12" 15		350	...	3	323.9	137.9
FLANGE WN 12" 15		350	...	3	323.9	115.1
TIP		350	...	...	323.9	123.8

Element Required Thickness and MAWP :

From	To	Design Pressure kPa	M.A.W.P. Corroded kPa	M.A.P. New & Cold kPa	Minimum Thickness mm	Required Thickness mm
	SKIRT	...	No Calc	No Calc	10	No Calc
Elliptical botto		350	621.533	1205.89	6.35	4.91749
WS CYLINDER 1/2		350	1313.69	1892.88	10	4.90463
WS CYLINDER 2/2		350	1322.02	1892.88	10	4.8604
WS CYLINDER 3/3		350	1322.02	1892.88	10	4.8604
CONE WS TO RISER		350	1273.01	1822.55	10	4.93166
	Riser	350	2792.45	4008.37	10	4.5875
	CONE	350	2715.34	3897.17	10	4.5875
FLANGE WN 12" 15		350	1833.99	1964.96	10	No Calc
FLANGE WN 12" 15		350	1833.99	1964.96	10	No Calc
	TIP	350	4655.32	5185.53	6	1.5875
Minimum			621.533	1205.880		

MAWP: 621.533 kPa, limited by: Elliptical bottom head.

Internal Pressure Calculation Results :

ASME Code, Section VIII Division 1, 2023

Elliptical Head From 20 To 30 SA-516 60 , UCS-66 Crv. C at 80 °C

Elliptical bottom head

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
= (P*Do*K)/(2*S*E+2*P*(K-0.1)) per Appendix 1-4 (c)
= (361.4*1067*1)/(2*117.9*0.85+2*361.4*(1-0.1))
= 1.9175 + 3.0000 = 4.9175 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 11.405 kPa
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*3.35)/(1*1067-2*3.35*(1-0.1))
= 632.938 - 11.405 = 621.533 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.35)/(1*1067-2*6.35*(1-0.1))
= 1205.887 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(K*Do-2*t*(K-0.1)))/(2*E*t)
= (361.4*(1*1067-2*3.35*(1-0.1)))/(2*0.85*3.35)
= 67.320 N/mm^2

Straight Flange Required Thickness:

```
= (P*Ro)/(S*E+0.4*P) + ca   per Appendix 1-1 (a)(1)
= (361.4*533.4)/(117.9*0.85+0.4*361.4)+3
= 4.921 mm
```

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 8.822 kPa

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 3.35 )/(533.4 - 0.4 * 3.35 )
= 630.945 - 8.822 = 622.123  kPa
```

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 2.611 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 6.35, tr = 1.917, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
```

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 6.35, tr = 1.921, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
```

Cylindrical Shell From 30 To 40 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 1/2

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:

```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (358.3*533.4)/(117.9*0.85+0.4*358.3)
= 1.9046 + 3.0000 = 4.9046 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 8.332 kPa

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 - 8.332 = 1313.689  kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(Ro-0.4*t))/(E*t)
= (358.3*((533.4-0.4*7))/(0.85*7)
= 31.957 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

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Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 4.012, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -48 °C
```

Cylindrical Shell From 40 To 50 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 2/2

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*533.4)/(117.9*0.85+0.4*350)
= 1.8604 + 3.0000 = 4.8604 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
= (P*(Ro-0.4*t))/(E*t)
= (350*((533.4-0.4*7))/(0.85*7)
= 31.214 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 2.574, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.313, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Cylindrical Shell From 50 To 60 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 3/3

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*533.4)/(117.9*0.85+0.4*350)
= 1.8604 + 3.0000 = 4.8604 mm
```

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Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (350*((533.4-0.4*7))/(0.85*7)
= 31.214 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 1.86, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.226, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C	-44 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Conical Section From 60 To 70 SA-516 60 , UCS-66 Crv. C at 80 °C

CONE WS TO RISER

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
= (P*Do)/(2*cos(a)*(S*E+0.4*P)) per Appendix 1-4 (e)
= (350*1067)/(2*0.963*(117.9*0.85+0.4*350))
= 1.9317 + 3.0000 = 4.9317 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4 (e)(5)
= (2*117.9*0.85*(7)*0.963)/(1067-0.8*(7)*0.963)
= 1273.009 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4(e)
= (2*117.9*0.85*10*0.963)/(1067-0.8*10*0.963)
= 1822.553 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(D-0.8*t*cos(a)))/(2*E*t*cos(a))
= (350*(1067-0.8*(7)*0.963))/(2*0.85*(7)*0.963)
= 32.415 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.010 %

Minimum Design Metal Temperature Results:

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Govrn. thk, tg = 10, tr = 1.932, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.235, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Cylindrical Shell From 70 To 80 SA-516 60 , UCS-66 Crv. C at 80 °C

Riser

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*254)/(117.9*0.85+0.4*350)
= 0.8859 + 3.0000 = 3.8859 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(254-0.4*7)
= 2792.454 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(254-0.4*10)
= 4008.367 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
= (P*(Ro-0.4*t))/(E*t)
= (350*((254-0.4*7))/(0.85*7)
= 14.777 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.008 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 2.643, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.321, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Conical Section From 80 To 90 SA-516 60 , UCS-66 Crv. C at 80 °C

CONE

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Do)/(2*cos(a)*(S*E+0.4*P)) per Appendix 1-4 (e)
```

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```
= (350*508)/(2*0.973*(117.9*0.85+0.4*350))
= 0.9108 + 3.0000 = 3.9108 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4 (e)(5)
= (2*117.9*0.85*(7)*0.973)/(508-0.8*(7)*0.973)
= 2715.345 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4(e)
= (2*117.9*0.85*10*0.973)/(508-0.8*10*0.973)
= 3897.167 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(D-0.8*t*cos(a)))/(2*E*t*cos(a))
= (350*(508-0.8*(7)*0.973))/(2*0.85*(7)*0.973)
= 15.197 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 3.189 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 1.587, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.193, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C          -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C
```

Cylindrical Shell From 110 To 120 SA-213 TP316 at 80 °C

TIP

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:

```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*161.9)/(123.8*1+0.4*350)
= 0.4574 + 0.0000 = 0.4574 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (123.8*1*6)/(161.9-0.4*6)
= 4655.324 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*1*6)/(161.9-0.4*6)
= 5185.534 kPa
```

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Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(Ro-0.4*t))/(E*t)
= (350*((161.9-0.4*6))/(1*6)
= 9.308 N/mm^2
```

SA-213 TP316, Min Metal Temp without impact per UHA-51: -196 °C

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

```
Pressure per UG99b     = 1.30 * M.A.W.P. * Sa/S        807.993  kPa
Pressure per UG99b[36] = 1.30 * Design Pres * Sa/S      455.000  kPa
Pressure per UG99c     = 1.30 * M.A.P. - Head(Hyd)    1412.639  kPa
Pressure per UG100     = 1.10 * M.A.W.P. * Sa/S        683.686  kPa
Pressure per PED       = max(1.43*DP, 1.25*DP*ratio)   500.500  kPa
Pressure per App 27-4  = M.A.W.P.                      621.533  kPa
```

Pressure per the PED:
= max(1.43 * Design Pressure, 1.25 * Design Pressure * Stress ratio)
= max(1.43 * 350, 1.25 * 350 * 1)
= max(500.5, 437.5)
= 500.500 kPa

Vertical Test performed per: PED

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (N/mm^2 & kPa):

From To	Stress	Allowable	Ratio	Pressure
Elliptical bottom he	64.1	153.3	0.418	655.50
WS CYLINDER 1/2	40.6	153.3	0.265	652.43
WS CYLINDER 2/2	39.1	153.3	0.255	627.93
WS CYLINDER 3/3	38.1	153.3	0.249	611.89
CONE WS TO RISER	39.4	153.3	0.257	608.75
Riser	17.6	153.3	0.115	598.95
CONE	16.8	153.3	0.109	554.41
TIP	14.6	179.3	0.081	548.39

Stress ratios for Nozzle and Pad Materials (N/mm^2):

Description	Pad/Nozzle	Ambient	Operating	Ratio
N2	Nozzle	117.90	117.90	1.000
N2	Pad	117.90	117.90	1.000
N3	Nozzle	117.90	117.90	1.000
N4	Nozzle	117.90	117.90	1.000
K1A	Nozzle	117.90	117.90	1.000
K1B	Nozzle	117.90	117.90	1.000
HW	Nozzle	117.90	117.90	1.000
HW	Pad	137.90	137.90	1.000

N1	Nozzle	117.90	117.90	1.000
N1	Pad	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (N/mm^2):

Description	Ambient	Operating	Ratio
Elliptical bottom he	117.90	117.90	1.000
WS CYLINDER 1/2	117.90	117.90	1.000
WS CYLINDER 2/2	117.90	117.90	1.000
WS CYLINDER 3/3	117.90	117.90	1.000
CONE WS TO RISER	117.90	117.90	1.000
Riser	117.90	117.90	1.000
CONE	117.90	117.90	1.000
FLANGE WN 12" 150# A	137.90	137.90	1.000
FLANGE WN 12" 150# A	115.10	115.10	1.000
TIP	137.90	123.80	1.114
Minimum			1.000

Hoop Stress in Nozzle Wall during Pressure Test (N/mm^2):

Description	Ambient	Operating	Ratio
N2	3.31	153.28	0.022
N3	2.11	153.28	0.014
N4	2.07	153.28	0.013
K1A	2.11	153.28	0.014
K1B	2.07	153.28	0.014
HW	8.48	153.28	0.055
N1	8.79	153.28	0.057

Elements Suitable for Internal Pressure.

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External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm	Outside Diameter mm	Corroded Thickness mm	Factor A	Factor B N/mm^2
10	20	950	...	...	No Calc	No Calc
20	30	No Calc	1066.8	3.35	0.00043614	43.6045
30	40	4593.84	1066.8	7	0.00016183	16.1796
40	50	4593.84	1066.8	7	0.00016183	16.1796
50	60	4593.84	1066.8	7	0.00016183	16.1796
60	70	737.907	1066.8	7	0.00099569	85.1672
70	80	4544	508	7	0.00023648	23.6426
80	90	315.734	508	7	0.0035425	114.682
90	100	No Calc	...	7	No Calc	No Calc
100	110	No Calc	...	7	No Calc	No Calc

110	120	4885.7	323.9	6	0.00037746	35.7443

External Pressure Calculations:

From	To	External Actual T. mm	External Required T. mm	External Design Pressure kPa	External M.A.W.P. kPa
10	20	...	No Calc	...	No Calc
20	30	6.35	4.5875	...	152.134
30	40	10	No Calc	...	141.545
40	50	10	No Calc	...	141.545
50	60	10	No Calc	...	141.545
60	70	10	No Calc	...	717.594
70	80	10	No Calc	...	434.353
80	90	10	No Calc	...	2049.35
90	100	10	7	...	No Calc
100	110	10	7	...	No Calc
110	120	6	No Calc	...	882.795
Minimum					141.545

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm	Allowable Length Bet. Stiffeners mm	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	950	No Calc	No Calc	No Calc
20	30	No Calc	No Calc	No Calc	No Calc
30	40	4593.84	No Calc	No Calc	No Calc
40	50	4593.84	No Calc	No Calc	No Calc
50	60	4593.84	No Calc	No Calc	No Calc
60	70	737.907	737.907	No Calc	No Calc
70	80	4544	No Calc	No Calc	No Calc
80	90	315.734	315.734	No Calc	No Calc
90	100	No Calc	No Calc	No Calc	No Calc
100	110	No Calc	No Calc	No Calc	No Calc
110	120	4885.7	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

ASME Code, Section VIII Division 1, 2023

Elliptical Head From 20 to 30 Ext. Chart: CS-2 at 80 °C

Elliptical bottom head

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
3.350	1066.80	318.45	0.0004361	43.60

EMAP = B/(K0*D/t) = 43.6/(0.9 *318.4) = 152.1 kPa

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*Check the requirements of UG-33(a)(1) using P = 1.67 * External Design pressure for this head.*

Material UNS Number: K02100

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
  = ((2*S*E*t)/(K*D+0.2*t))/1.67 per Appendix 1-4 (c)
  = ((2*117.9*1*3.35)/(1*1060+0.2*3.35))/1.67
  = 445.888 kPa
```

Maximum Allowable External Pressure [MAEP]:
```
  = min( MAEP, MAWP )
  = min( 152.1, 445.9 )
  = 152.134 kPa
```

Cylindrical Shell From 30 to 40 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 1/2

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cylindrical Shell From 40 to 50 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 2/2

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cylindrical Shell From 50 to 60 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 3/3

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

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Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cone From 60 to 70 Ext. Chart: CS-2 at 80 °C

CONE WS TO RISER

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.742	1066.80	737.91	158.24	0.6917	0.0009957	85.17

EMAP = (4*B)/(3*(D/t)) = (4*85.17)/(3*158.2) = 717.6 kPa

Note: The cone thickness used in the calculation has been modified per UG-33(f), te = t * cos(alpha).

Cylindrical Shell From 70 to 80 Ext. Chart: CS-2 at 80 °C

Riser

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	508.00	4544.00	72.57	8.9449	0.0002365	23.64

EMAP = (4*B)/(3*(D/t)) = (4*23.64)/(3*72.57) = 434.4 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	508.00	4544.00	72.57	8.9449	0.0002365	23.64

EMAP = (4*B)/(3*(D/t)) = (4*23.64)/(3*72.57) = 434.4 kPa

Cone **From 80 to 90 Ext. Chart: CS-2 at 80 °C**

CONE

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.809	508.00	315.73	74.61	0.6215	0.0035425	114.68

EMAP = (4*B)/(3*(D/t)) = (4*114.7)/(3*74.61) = 2049 kPa

Note: The cone thickness used in the calculation has been modified per UG-33(f), te = t * cos(alpha).

Cylindrical Shell From 110 to 120 Ext. Chart: HA-2 at 80 °C

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TIP

Elastic Modulus from Chart: HA-2 at 80 °C : 0.189E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.000	323.90	4885.70	53.98	15.0840	0.0003775	35.74

EMAP = (4*B)/(3*(D/t)) = (4*35.74)/(3*53.98) = 882.8 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.000	323.90	4885.70	53.98	15.0840	0.0003775	35.74

EMAP = (4*B)/(3*(D/t)) = (4*35.74)/(3*53.98) = 882.8 kPa

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Element and Detail Weights:

From	To	Element Metal Wgt. kgm	Element ID Volume cm3	Corroded Metal Wgt. kgm	Corroded ID Volume cm3	Extra due Misc % kgm
10	20	244.454	...	208.063	...	...
20	30	74.4388	196948	39.2708	200079	...
30	40	643.301	2151570	451.589	2176305	...
40	50	420.976	1407987	295.519	1424174	...
50	60	82.3426	275401	57.8033	278567	...
60	70	196.441	482036	138.06	489568	...
70	80	550.994	849897	388.019	870924	...
80	90	39.1679	48212.7	27.626	49701.9	...
90	100	...	9417.95	...	9770.1	...
100	110	...	9417.95	...	9770.1	...
110	120	235.011	373289	235.011	373289	...
Total		2487	5823012.50	1840	5901690.50	0

Weight of Details:

From	Type	Weight of Detail kgm	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Description
10	Insl	16.8396	...	650	Insulation ext
20	Liqd	196.864	...	-131.762	WS LIQUID 1/2
20	Insl	12.742	...	-108.35	Insulation ext
20	Nozl	5.38381	...	-388.531	N2
30	Liqd	731.221	...	425	WS Liquid 2/2
30	Insl	61.7452	...	1100	Insulation ext
30	Nozl	2.15915	535.554	700	N3
30	Nozl	2.15915	535.554	2200	N4
30	Nozl	2.15915	535.554	950	K1A
30	Nozl	2.15915	535.554	1950	K1B
30	Nozl	49.0437	624.759	...	HW
30	Wght	87.2711	...	850	WGHT:[1 OF 1]
40	Nozl	71.383	659.925	1500	N1
40	Wght	103.456	...	...	N1-INNER1OF2
40	Forc	...	...	1500	N10 Nozle Laod

```
   70|Plat|      181.4 |0.14523E-04 |      4044 |   PLT 1
 ------------------------------------------------
```

Total Weight of Each Detail Type:

```
 Platforms                          181.4
 Liquid                             928.1
 Insulation                          91.3
 Nozzles                            134.4
 Weights                            190.7
 ----------------------------------------
 Sum of the Detail Weights       1526.0 kgm
```

Weight Summation Results: (kgm)

```
               | Fabricated |  Shop Test |   Shipping |    Erected |      Empty |
Operating |
 ------------------------------------------------------------------------------------------
-----
 Main Elements |     2487.1 |     2487.1 |     2487.1 |     2487.1 |     2487.1 |
2487.1 |
       Nozzles |      134.4 |      134.4 |      134.4 |      134.4 |      134.4 |
134.4 |
   Wld Weights |      190.7 |      190.7 |      190.7 |      190.7 |      190.7 |
190.7 |
     Platforms |        ... |        ... |      181.4 |      181.4 |      181.4 |
181.4 |
    Insulation |        ... |        ... |       91.3 |       91.3 |       91.3 |
91.3 |
   Ope. Liquid |        ... |        ... |        ... |        ... |        ... |
928.1 |
   Test Liquid |        ... |     5820.5 |        ... |        ... |        ... |
... |
 ------------------------------------------------------------------------------------------
-----
        Totals |     2812.3 |     8632.8 |     3085.0 |     3085.0 |     3085.0 |
4013.1 |
```

Field Installation Options:

Weight Summary:

```
 Fabricated Wt.  - Bare Weight without Removable Internals              2812.3 kgm
 Shop Test Wt.   - Fabricated Weight + Water ( Full )                   8632.8 kgm
 Shipping Wt.    - Fab. Weight + removable Intls.+ Shipping App.        3085.0 kgm
 Erected  Wt.    - Fab. Wt + or - loose items (trays,platforms etc.)    3085.0 kgm
 Ope. Wt. no Liq - Fab. Weight + Internals. + Details + Weights         3085.0 kgm
 Operating Wt.   - Empty Weight + Operating Liq. Uncorroded             4013.1 kgm
 Field Test Wt.  - Empty Weight + Water (Full)                          8905.6 kgm
 Mass of the Upper 1/3 of the Vertical Vessel                            262.2 kgm
```

Outside Surface Areas of Elements:

```
     |    |        Surface |
 From| To |           Area |
     |    |           cm^2 |
 ---------------------------
```

```
   10|  20|        31838.8 |
   20|  30|        14012.2 |
   30|  40|        83786.3 |
   40|  50|        54829.7 |
   50|  60|        10724.6 |
   60|  70|        25684.3 |
   70|  80|          72519 |
   80|  90|        5181.67 |
   90| 100|        823.971 |
  100| 110|        823.971 |
  110| 120|          49715 |
-----------------------------
  Total        349939.500 cm^2
```

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kgm	Total. Ele. Oper. Wgt. kgm	Total. Ele. Hydro. Wgt. kgm	Total Dtl. Offset Mom. kgf-m	Oper. Wgt. No Liquid kgm
10	20	261.293	261.293	261.293	...	261.293
20	30	92.5645	289.428	289.428	...	92.5645
30	40	849.998	1581.22	3000.65	35.2665	849.998
40	50	595.815	595.815	2003.2	47.1083	595.815
50	60	82.3426	82.3426	357.626	...	82.3426
60	70	196.441	196.441	678.271	...	196.441
70	80	732.394	732.394	1581.93	0.26346E-05	732.394
80	90	39.1679	39.1679	87.36	...	39.1679
90	100	...	...	9.41392	...	...
100	110	...	...	9.41392	...	...
110	120	235.011	235.011	608.141	...	235.011

```
Empty Support Force + the Sum of the Y forces          1640.03  kgf
Operating Support Force + the Sum of the Y forces      2568.11  kgf
Hydro Support Force + the Sum of the Y forces          7441.72  kgf
```

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kgm	Cumulative Oper. Wgt. kgm	Cumulative Hydro. Wgt. kgm
10	20	3085.03	4013.11	8886.72
20	30	2823.73	3751.82	8625.43
30	40	2731.17	3462.39	8336
40	50	1881.17	1881.17	5335.35
50	60	1285.36	1285.36	3332.15
60	70	1203.01	1203.01	2974.53
70	80	1006.57	1006.57	2296.26
80	90	274.179	274.179	714.329
90	100	235.011	235.011	626.969
100	110	235.011	235.011	617.555
110	120	235.011	235.011	608.141

Note: The cumulative operating weights no liquid in the column above

are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. kgf-m	Cumulative Oper. Mom. kgf-m	Cumulative Hydro. Mom. kgf-m
10	20	82.3749	82.3749	82.3749
20	30	82.3749	82.3749	82.3749
30	40	82.3749	82.3749	82.3749
40	50	47.1084	47.1084	47.1084
50	60	0.26346E-05	0.26346E-05	0.26346E-05
60	70	0.26346E-05	0.26346E-05	0.26346E-05
70	80	0.26346E-05	0.26346E-05	0.26346E-05
80	90	...	...	...
90	100	...	...	...
100	110	...	...	...
110	120	...	...	...

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Nozzle Flange MAWP Results:

Nozzle Description	Flange Rating Ope. kPa	Ambient kPa	Design Temp °C	Class	Grade/ Group	Equiv. Press	- - - - - - Max Pressure PVP	50% DNV kPa
N2	1834.0	1965.0	80	150	GR 1.1	...	...	...
N3	1834.0	1965.0	80	150	GR 1.1	...	...	...
N4	1834.0	1965.0	80	150	GR 1.1	...	...	...
K1A	1834.0	1965.0	80	150	GR 1.1	...	...	...
K1B	1834.0	1965.0	80	150	GR 1.1	...	...	...
HW	1834.0	1965.0	80	150	GR 1.1	...	...	...
N1	1834.0	1965.0	80	150	GR 1.1	...	...	...
Min Rating	833.988	1964.961 kPa [for Core Elements]				0.000	0.000	0.000

Selected Method for Derating ANSI B16.5 Flange MAWP: None Selected

ANSI Ratings are per ANSI/ASME B16.5 2013 Edition

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Natural Frequency for the Operating Case (No Liquid), Freese Method

Natural Frequency Calculation:

From	To	Element Total Wgt. kgm	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation	Element Empty Wgt. kgm
10	20	261.293	0.022501	0.08735	0.00017837	261.293
20	30	92.5645	0.091942	0.096799	0.00019959	92.5645
30	40	849.998	0.49252	1.13349	0.00059364	849.998
40	50	595.815	1.6555	2.24123	0.00074995	595.815
50	60	82.3426	2.3622	2.48507	0.00077371	82.3426
60	70	196.441	2.89338	3.34107	0.00093134	196.441
70	80	732.394	6.53869	11.0859	0.0021636	732.394
80	90	39.1679	11.5066	11.934	0.0022323	39.1679
90	100	...	12.062	12.191	0.0022652	...
100	110	...	12.3209	12.4518	0.002298	...
110	120	235.011	18.8898	26.0078	0.0029332	235.011

The Natural Frequency for the Vessel (Empty.) is 4.86808 Hz.

Natural Frequency for the Operating Case, Freese Method

Natural Frequency Calculation:

From	To	Element Total Wgt. kgm	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation	Element Empty Wgt. kgm
10	20	261.293	0.024872	0.096009	0.00019486	261.293
20	30	289.428	0.10102	0.10632	0.00021753	92.5645
30	40	1581.22	0.53207	1.20936	0.00062304	849.998
40	50	595.815	1.75541	2.36519	0.00077934	595.815
50	60	82.3426	2.49086	2.61843	0.00080311	82.3426
60	70	196.441	3.04145	3.50383	0.00096074	196.441
70	80	732.394	6.76824	11.3822	0.002193	732.394
80	90	39.1679	11.8086	12.2416	0.0022617	39.1679
90	100	...	12.3714	12.502	0.0022945	...
100	110	...	12.6337	12.7662	0.0023274	...
110	120	235.011	19.276	26.4658	0.0029626	235.011

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Natural Frequency for the Filled Case, Freese Method

The Natural Frequency for the Vessel (Filled) is 3.64821 Hz.

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Forces/Moments Applied to Vessel (Combined w/Wind Loads)

From	To	X and Z Dir Force Res. kgf	X,Z Moment and For Res kgf-m
10	20	...	...
20	30	...	...
30	40	...	...
40	50	1641.13	3250.94
50	60	...	...
60	70	...	...
70	80	...	...
80	90	...	...
90	100	...	...
100	110	...	...
110	120	...	...

Forces/Moments Applied to Vessel (Combined w/Seismic Loads)

From	To	X and Z Dir Force Res. kgf	X,Z Moment and For Res kgf-m
10	20	...	...
20	30	...	...
30	40	...	...
40	50	1641.13	3250.94
50	60	...	...
60	70	...	...
70	80	...	...
80	90	...	...
90	100	...	...
100	110	...	...
110	120	...	...

User Input Forces and Moments:

From Node	Distance From	Forces Fx	Fy	Fz	Moments Mx	My	Mz
40	1500.00	1445.	1445.	-778.	474.		631.

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Wind Load results per EN 1991-1-4:2005+A1:2010

Input Data:

Fundamental Wind Velocity	Vb	100.800 Km/hr
Air Density per Section 4.5	Rho	1.250 kg/m³
Wind Direction Factor	Cdir	1.000
Season Factor	CSeason	1.000
Structural Factor	CsCd	1.000
Wind Force Coefficient	Cf	0.700
Vessel Base Height (site)	Hb	31310.000 mm
Terrain Category		0

Note: The Wind Load Results below are in Metric Units.

Category 2 Basic Wind Velocity [Vb]:
= Cdir * CSeason * Vb,0
= 1 * 1 * 28
= 28.001 m/s

Terrain Factor dependant on Roughness Length [kr]:
= 0.19 * (Zo / Z0,ii) ^ 0.07
= 0.19 * (0.003/0.05)$^{0.07}$
= 0.156

Sample Calculation for the first Element:

Determine the Roughness factor as a function of Elevation [Cr(z)]:
= kr * ln(z / zo)
= 0.156 * ln(31.78/0.003)
= 1.446

Mean Velocity at Height z [Vm(z)]:
= cr(z) * 1.0 * Vb
= 1.446 * 1.0 * 28
= 40.493 m/s

Turbulence Intensity at Height z [Vm(z)]:
= 1.0 / (1.0 * ln(z / zo))
= 1.0/(1.0 * ln(31.78/0.003))
= 0.108

Peak Velocity Pressure at Height z [qp(z)]:
= [1.0 + 7.0 * Iv(z)] * 1/2 * 1.25 * Vm(z)^2
= [1.0 + 7.0 * 0.108] * 1/2 * 1.25 * 40.49^2
= 1798.849 N/m^2

Force on the First Element at Height z [Fw(z)]:
= qp(z) * CsCd * Aref * Cf
= 1799 * 1 * 1.288 * 0.7
= 1622.039 Newtons

Note: The orography factor co(z) and the turbulence factor ki(z) are taken to be 1.0.

Wind Vibration Calculations

This evaluation is based on work by Kanti Mahajan and Ed Zorilla

Nomenclature

Cf - Correction factor for natural frequency
D - Average internal diameter of vessel mm
Df - Damping Factor < 0.75 Unstable, > 0.95 Stable
Dr - Average internal diameter of top half of vessel mm
f - Natural frequency of vibration (Hertz)
f1 - Natural frequency of bare vessel based on a unit value of $(D/L^2)(10^4)$
L - Total height of structure mm
Lc - Total length of conical section(s) of vessel mm

```
tb  - Uncorroded plate thickness at bottom of vessel mm
V30 - Design Wind Speed provided by user Km/hr
Vc  - Critical wind velocity Km/hr
Vw  - Maximum wind speed at top of structure Km/hr
W   - Total corroded weight of structure kgf
Ws  - Cor. vessel weight excl. weight of parts which do not effect stiff. kgf
 Z  - Maximum amplitude of vibration at top of vessel mm
Dl  - Logarithmic decrement ( taken as 0.03 for Welded Structures )
Vp  - Vib. Chance, <= 0.32037E-06 (High); 0.32037E-06 < 0.40047E-06 (Probable)
P30 - wind pressure 30 feet above the base
```

Check other Conditions and Basic Assumptions:

```
#1 - Total Cone Length / Total Length < 0.5
     1386/16510 = 0.0839

#2 - ( D / L² ) * 10⁴ < 8.0 (English Units)
   - ( 2.189/54.17² ) * 10⁴ = 7.462
```

Compute the vibration possibility. If Vp > 0.40047E-06 no chance. [Vp]:

```
  = W / ( L * Dr²)
  = 3367/( 16510 * 377.2² )
  = 0.14333E-05
```

Since Vp is > 0.40047E-06 no further vibration analysis is required !

Platform Load Calculations

ID	Wind Area cm^2	Elevation mm	Pressure kg/m^2	Force kgf	Cf
PLT 1	14080.00	41810.00	192.03	270.38	1.60

Wind Loads on Masses/Equipment/Piping

ID	Wind Area cm^2	Elevation mm	Pressure kg/m^2	Force kgf
WGHT:[1 OF 1]	3153.73	33985.00	185.51	58.51
N1-INNER1OF2	3738.60	35628.00	187.00	69.91

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Wind Load Calculation:

From	To	Wind Height mm	Wind Diameter mm	Wind Area cm^2	Wind Pressure kg/m^2	Element Wind Load kgf
10	20	31785	1355.95	12881.5	183.435	165.4
20	30	32285	1400.16	700.08	183.921	9.01285
30	40	33560	1385.76	34644	185.127	508.18
40	50	35628	1280.16	20943.4	186.997	344.047
50	60	36606	1280.16	4096.51	187.847	53.8645
60	70	37205.3	943.961	9439.61	188.357	124.457
70	80	40038	609.6	27700.2	190.672	652.054

80	90	42487.9	498.466	1922.58	192.554	25.9133
90	100	42752.8	388.68	444.261	192.752	5.99407
100	110	42876.7	388.68	444.261	192.844	5.99693
110	120	45376.7	388.68	18989.7	194.65	258.736

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Input Values for G Loading:

Horizontal Acceleration factor	(GX)	0.700
Horizontal Acceleration factor	(GZ)	0.700
Vertical Acceleration factor	(GY)	0.700

Computed Results:

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height mm	Earthquake Weight kgf	Element Ope Load kgf	Element Emp Load kgf
10	20	475	261.293	258.667	258.667
20	30	975	289.428	286.519	91.6342
30	40	2250	1581.22	1565.33	841.455
40	50	4318	595.815	589.827	589.827
50	60	5296	82.3426	81.515	81.515
60	70	5956	196.441	194.467	194.467
70	80	8728	732.394	725.033	725.033
80	90	11192.8	39.1679	38.7742	38.7742
90	100	11442.8	...	...	...
100	110	11566.7	...	...	...
110	120	14066.7	235.011	232.649	232.649

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Bending Moments due to user defined forces and moments.

User Force/Moment Shear and Bending

From	To	Distance to Support mm	Cumulative Shr Wind Cas kgf	Cumulative Shr Eqk Cas kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	1641.13	1641.13	8986.89	8986.89
20	30	975	1641.13	1641.13	7427.95	7427.95
30	40	2250	1641.13	1641.13	7345.9	7345.9
40	50	4318	1641.13	1641.13	3244.19	3244.19
50	60	5296	...	...	...	...
60	70	5956	...	...	...	...
70	80	8728	...	...	...	...
80	90	11192.8	...	...	...	...
90	100	11442.8	...	...	...	...
100	110	11566.7	...	...	...	...

110	120	14066.7	...	...	...	...

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 1.000.

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The following table is for the Operating Case.

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	2153.66	3972.78	13501.8	18096.1
20	30	975	1988.26	3714.11	11534.4	14444.7
30	40	2250	1979.24	3427.59	11435.2	14266.2
40	50	4318	1471.06	1862.26	7122.23	7653.73
50	60	5296	1127.02	1272.44	4996.96	5089.49
60	70	5956	1073.15	1190.92	4644.93	4695.34
70	80	8728	948.694	996.456	3633.98	3601.63
80	90	11192.8	296.641	271.423	804.526	720.951
90	100	11442.8	270.727	232.649	695.107	623.739
100	110	11566.7	264.733	232.649	661.983	594.93
110	120	14066.7	258.736	232.649	632.066	568.338

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 1.000.

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Wind Deflection Calculations:

The following table is for the Applied Forces Case.

Wind Deflection:

From	To	Cumulative Wind Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	1641.13	0.012094	0.046937	0.95783E-04
20	30	1641.13	0.049403	0.052011	0.00010713
30	40	1641.13	0.26325	0.59739	0.00030378
40	50	1641.13	0.85061	1.10773	0.00031466
50	60	...	1.15807	1.20842	0.00031466
60	70	...	1.36575	1.52308	0.00031466

70	80	...	2.23798	2.95288	0.00031466
80	90	...	3.01356	3.07424	0.00031466
90	100	...	3.09222	3.1102	0.00031466
100	110	...	3.12819	3.14617	0.00031466
110	120	...	3.91483	4.68349	0.00031466

Allowable deflection at the Tower Top (For)(6.000"/100ft. Criteria)
Allowable deflection : 82.548 Actual deflection : 4.683 mm

The following table is for the Operating Case.

Wind Deflection:

From	To	Cumulative Wind Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	2153.66	0.018465	0.072	0.00014771
20	30	1988.26	0.075805	0.079833	0.00016556
30	40	1979.24	0.41172	0.95847	0.00051032
40	50	1471.06	1.40978	1.92146	0.00065821
50	60	1127.02	2.02772	2.13584	0.0006814
60	70	1073.15	2.49763	2.89838	0.00083732
70	80	948.694	5.89415	10.2938	0.0021126
80	90	296.641	10.7051	11.1236	0.0021884
90	100	270.727	11.2492	11.3758	0.0022247
100	110	264.733	11.5035	11.6322	0.0022608
110	120	258.736	18.0626	25.2416	0.0029601

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	119.344	745.901
20	30	123.235	770.221
30	40	121.968	762.3
40	50	112.674	704.21
50	60	112.674	704.21
60	70	83.0829	519.268
70	80	53.6541	335.338
80	90	43.8726	274.204
90	100	34.2098	213.811
100	110	34.2098	213.811
110	120	34.2098	213.811

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
Allowable deflection : 82.548 Actual deflection : 25.242 mm

Total Deflection in the Operating Condition + Applied Forces :
Allowable deflection : 82.548 Actual deflection : 29.925 mm

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Longitudinal Stress Constants:

From	To	Metal Area New cm^2	Metal Area Corroded cm^2	Section Modulus New mm³	Section Modulus Corroded mm³
10	20	332.004	233.063	8690112	6134741
20	30	211.55	111.92	5575274	2966227
30	40	332.004	233.062	8690095	6134733
40	50	332.004	233.062	8690095	6134733
50	60	332.004	233.062	8690095	6134733
60	70	344.594	241.927	9013156	6364886
70	80	156.451	110.175	1910244	1361197
80	90	160.754	113.225	1960618	1397796
90	100	160.754	114.532	1960618	1413453
100	110	59.9227	30.2441	467580	240407
110	120	59.9227	59.9227	467580	467580

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Longitudinal Allowable Stresses:

From	To	Tensile N/mm^2	Hydrotest Tensile N/mm^2	Compressive N/mm^2	Hydrotest Compressive N/mm^2
10	20	137.19	178.296	-118.874	-128.609
20	30	120.258	156.366	-93.0141	-115.899
30	40	120.258	156.366	-118.874	-128.609
40	50	120.258	156.366	-118.874	-128.609
50	60	120.258	156.366	-118.874	-128.609
60	70	120.258	156.366	-119.985	-129.529
70	80	120.258	156.366	-137.086	-143.047
80	90	120.258	156.366	-137.614	-143.434
90	100	165.48	215.16	-137.833	-143.434
100	110	138.12	179.64	-84.5316	-103.301
110	120	148.56	215.16	-107.249	-110.081

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Longitudinal Stress Report

Note: Longitudinal Operating and Empty Stresses are computed in the corroded condition. Stresses due to loads in the hydrostatic test cases have been computed in the new and cold condition.

Longitudinal Pressure Stresses due to:

From	To	Longitudinal Stress Internal Pressure N/mm^2	Longitudinal Stress External Pressure N/mm^2	Longitudinal Stress Hydrotest Pressure N/mm^2
10	20	...	...	...

20	30	27.6208	...	20.6718
30	40	13.0908	...	12.9987
40	50	13.0908	...	12.9987
50	60	13.0908	...	12.9987
60	70	13.0814	...	12.9853
70	80	6.10535	...	6.00635
80	90	6.09847	...	5.99651
90	100	...	...	...
100	110	...	...	...
110	120	4.4788	...	6.40469

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty N/mm^2	Wght. Str. Operating N/mm^2	Wght. Str. Hydrotest N/mm^2	Wght. Str. Emp. Mom. N/mm^2	Wght. Str. Opr. Mom. N/mm^2
10	20	-1.29812	-1.68864	-2.62499	0.13168	0.13168
20	30	-2.47425	-2.47425	-1.309	0.27234	0.27234
30	40	-1.14923	-1.14923	-0.80674	0.13168	0.13168
40	50	-0.79156	-0.79156	-0.55567	0.075305	0.075305
50	60	-0.54086	-0.54086	-0.37967	0.42114E-08	0.42114E-08
60	70	-0.48766	-0.48766	-0.34237	0.40592E-08	0.40592E-08
70	80	-0.89596	-0.89596	-0.63095	0.18980E-07	0.18980E-07
80	90	-0.23748	-0.23748	-0.16726	...	...
90	100	-0.20123	-0.20123	-0.14337	...	...
100	110	-0.76204	-0.76204	-0.38461	...	...
110	120	-0.38461	-0.38461	-0.38461	...	...

Longitudinal Stresses due to Weight Loads and Bending for these Conditions:

From	To	Wght. Str. Hyd. Mom. N/mm^2	Bend. Str. Oper. Wind N/mm^2	Bend. Str. Oper. Equ. N/mm^2	Bend. Str. Hyd. Wind N/mm^2	Bend. Str. Hyd. Equ. N/mm^2
10	20	0.092959	21.5832	28.9273	5.02807	...
20	30	0.14489	38.1338	47.7557	6.69518	...
30	40	0.092959	18.2797	22.8051	4.25847	...
40	50	0.053161	11.3852	12.2348	2.65232	...
50	60	0.29731E-08	7.98786	8.13577	1.86087	...
60	70	0.28665E-08	7.15662	7.2343	1.66777	...
70	80	0.13525E-07	26.1807	25.9477	6.15642	...
80	90	...	5.64438	5.05803	1.32795	...
90	100	...	4.8227	4.32754	1.14734	...
100	110	...	27.0035	24.2683	4.58168	...
110	120	...	13.2564	11.9198	4.37462	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case N/mm^2	Vortex Shedding Empty Case N/mm^2	Vortex Shedding Test Case N/mm^2	Earthquake Empty Case N/mm^2
10	20	...	...	...	26.0199

20	30	...	...	...	44.6283
30	40	...	...	...	21.3586
40	50	...	...	...	12.2348
50	60	...	...	...	8.13577
60	70	...	...	...	7.2343
70	80	...	...	...	25.9477
80	90	...	...	...	5.05803
90	100	...	...	...	4.32754
100	110	...	...	...	24.2683
110	120	...	...	...	11.9198

Longitudinal Stresses due to Applied Axial Forces:

From	To	Longitudinal Stress Y Forces Wind N/mm^2	Longitudinal Stress Y Forces Seismic N/mm^2
10	20	0.60803	1.79008
20	30	1.26616	3.56738
30	40	0.60803	1.62787
40	50	0.60803	1.16212
50	60	...	0.3786
60	70	...	0.34136
70	80	...	0.62717
80	90	...	0.16623
90	100	...	0.14086
100	110	...	0.53343
110	120	...	0.26923

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded N/mm^2	Earthquake For/Mom Corroded N/mm^2	Wind For/Mom No Corrosion N/mm^2	Earthquake For/Mom No Corrosion N/mm^2
10	20	14.3659	14.3659	10.1415	10.1415
20	30	24.5575	24.5575	13.0654	13.0654
30	40	11.7427	11.7427	8.28973	8.28973
40	50	5.18599	5.18599	3.66102	3.66102
50	60	...	...	...	...
60	70	...	...	...	...
70	80	...	...	...	...
80	90	...	...	...	...
90	100	...	...	...	...
100	110	...	...	...	...
110	120	...	...	...	...

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Stress Combination Load Cases for Vertical Vessels:

Load Case Definition Key

IP = Longitudinal Stress due to Internal Pressure

```
EP = Longitudinal Stress due to External  Pressure
HP = Longitudinal Stress due to Hydrotest Pressure
NP = No Pressure
EW = Longitudinal Stress due to Weight (No Liquid)
OW = Longitudinal Stress due to Weight (Operating)
HW = Longitudinal Stress due to Weight (Hydrotest)
WI = Bending Stress due to Wind Moment (Operating)
EQ = Bending Stress due to Earthquake Moment (Operating)
EE = Bending Stress due to Earthquake Moment (Empty)
HI = Bending Stress due to Wind Moment (Hydrotest)
HE = Bending Stress due to Earthquake Moment (Hydrotest)
WE = Bending Stress due to Wind Moment (Empty) (no CA)
WF = Bending Stress due to Wind Moment (Filled) (no CA)
CW = Longitudinal Stress due to Weight (Empty) (no CA)
VO = Bending Stress due to Vortex Shedding Loads ( Ope )
VE = Bending Stress due to Vortex Shedding Loads ( Emp )
VF = Bending Stress due to Vortex Shedding Loads ( Test No CA. )
FW = Axial Stress due to Vertical Forces for the Wind Case
FS = Axial Stress due to Vertical Forces for the Seismic Case
BW = Bending Stress due to Lat. Forces for the Wind Case, Corroded
BS = Bending Stress due to Lat. Forces for the Seismic Case, Corroded
BN = Bending Stress due to Lat. Forces for the Wind Case, UnCorroded
BU = Bending Stress due to Lat. Forces for the Seismic Case, UnCorroded
```

General Notes:

Case types HI and HE are in the Un-Corroded condition.

Case types WE, WF, and CW are in the Un-Corroded condition.

A blank stress and stress ratio indicates that the corresponding stress comprising those components that did not contribute to that type of stress.

An asterisk (*) in the final column denotes overstress.

Analysis of Load Case 1 : NP+EW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.39	137.19	-36.77	118.87	0.2580	0.3093
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 2 : NP+EW+EE+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	41.01	137.19	-40.03	118.87	0.2989	0.3367
20	70.55	120.26	-68.37	93.01	0.5867	0.7350
30	33.71	120.26	-32.75	118.87	0.2803	0.2755
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698

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60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 3 : NP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 4 : NP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	73.68	120.26	-71.49	93.01	0.6127	0.7686
30	35.16	120.26	-34.20	118.87	0.2924	0.2877
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698
60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 5 : NP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.50	178.30	-7.75	128.61	0.0140	0.0602
20	5.53	156.37	-8.15	115.90	0.0354	0.0703
30	3.54	156.37	-5.16	128.61	0.0227	0.0401
40	2.15	156.37	-3.26	128.61	0.0137	0.0254
50	1.48	156.37	-2.24	128.61	0.0095	0.0174
60	1.33	156.37	-2.01	129.53	0.0085	0.0155
70	5.53	156.37	-6.79	143.05	0.0353	0.0474
80	1.16	156.37	-1.50	143.43	0.0074	0.0104
110	3.99	215.16	-4.76	110.08	0.0185	0.0432

Analysis of Load Case 6 : NP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		178.30	-2.72	128.61		0.0211
20		156.37	-1.45	115.90		0.0125
30		156.37	-0.90	128.61		0.0070
40		156.37	-0.61	128.61		0.0047
50		156.37	-0.38	128.61		0.0030
60		156.37	-0.34	129.53		0.0026
70		156.37	-0.63	143.05		0.0044
80		156.37	-0.17	143.43		0.0012
110		215.16	-0.38	110.08		0.0035

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Analysis of Load Case 7 : IP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	89.38	120.26	-36.55	93.01	0.7432	0.3930
30	42.70	120.26	-17.60	118.87	0.3551	0.1481
40	29.55	120.26	-3.74	118.87	0.2458	0.0315
50	20.54	120.26		118.87	0.1708	
60	19.75	120.26		119.99	0.1642	
70	31.39	120.26	-20.97	137.09	0.2610	0.1530
80	11.51	120.26		137.61	0.0957	
110	17.35	148.56	-9.16	107.25	0.1168	0.0854

Analysis of Load Case 8 : IP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	101.30	120.26	-43.87	93.01	0.8424	0.4717
30	48.25	120.26	-21.11	118.87	0.4012	0.1776
40	30.96	120.26	-4.03	118.87	0.2574	0.0339
50	21.06	120.26		118.87	0.1752	
60	20.17	120.26		119.99	0.1677	
70	31.78	120.26	-20.11	137.09	0.2643	0.1467
80	11.09	120.26		137.61	0.0922	
110	16.28	148.56	-7.56	107.25	0.1096	0.0705

Analysis of Load Case 9 : EP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 10 : EP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	73.68	120.26	-71.49	93.01	0.6127	0.7686
30	35.16	120.26	-34.20	118.87	0.2924	0.2877
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698
60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 11 : HP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.50	178.30	-7.75	128.61	0.0140	0.0602
20	26.20	156.37		115.90	0.1676	

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30	16.54	156.37		128.61	0.1058	
40	15.15	156.37		128.61	0.0969	
50	14.48	156.37		128.61	0.0926	
60	14.31	156.37		129.53	0.0915	
70	11.53	156.37	-0.78	143.05	0.0737	0.0055
80	7.16	156.37		143.43	0.0458	
110	10.39	215.16		110.08	0.0483	

Analysis of Load Case 12 : HP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		178.30	-2.72	128.61		0.0211
20	19.51	156.37		115.90	0.1248	
30	12.28	156.37		128.61	0.0786	
40	12.50	156.37		128.61	0.0799	
50	12.62	156.37		128.61	0.0807	
60	12.64	156.37		129.53	0.0809	
70	5.38	156.37		143.05	0.0344	
80	5.83	156.37		143.43	0.0373	
110	6.02	215.16		110.08	0.0280	

Analysis of Load Case 13 : IP+WE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.43	118.87		0.0120
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	
80	5.86	120.26		137.61	0.0487	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 14 : IP+WF+CW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.19	118.87		0.0100
20	26.31	120.26		93.01	0.2188	
30	12.28	120.26		118.87	0.1021	
40	12.54	120.26		118.87	0.1042	
50	12.71	120.26		118.87	0.1057	
60	12.74	120.26		119.99	0.1059	
70	5.47	120.26		137.09	0.0455	
80	5.93	120.26		137.61	0.0493	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 15 : IP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.82	118.87		0.0153
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	

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80	5.86	120.26		137.61	0.0487
110	4.09	148.56		107.25	0.0276

Analysis of Load Case 16 : IP+VE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.43	118.87		0.0120
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	
80	5.86	120.26		137.61	0.0487	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 17 : NP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.82	118.87		0.0153
20		120.26	-2.75	93.01		0.0295
30		120.26	-1.28	118.87		0.0108
40		120.26	-0.87	118.87		0.0073
50		120.26	-0.54	118.87		0.0045
60		120.26	-0.49	119.99		0.0041
70		120.26	-0.90	137.09		0.0065
80		120.26	-0.24	137.61		0.0017
110		148.56	-0.38	107.25		0.0036

Analysis of Load Case 18 : FS+BS+IP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	14.60	137.19	-14.40	118.87	0.1064	0.1211
20	53.54	120.26		93.01	0.4452	
30	25.44	120.26		118.87	0.2116	
40	18.72	120.26		118.87	0.1557	
50	12.93	120.26		118.87	0.1075	
60	12.94	120.26		119.99	0.1076	
70	5.84	120.26		137.09	0.0485	
80	6.03	120.26		137.61	0.0501	
110	4.36	148.56		107.25	0.0294	

Analysis of Load Case 19 : FS+BS+EP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	14.60	137.19	-14.40	118.87	0.1064	0.1211
20	25.92	120.26	-23.74	93.01	0.2156	0.2552
30	12.35	120.26	-11.40	118.87	0.1027	0.0959
40	5.63	120.26	-4.89	118.87	0.0468	0.0411
50		120.26	-0.16	118.87		0.0014
60		120.26	-0.15	119.99		0.0012
70		120.26	-0.27	137.09		0.0020
80		120.26	-0.07	137.61		0.0005
110		148.56	-0.12	107.25		0.0011

Absolute Maximum of the all of the Stress Ratio's 0.8424

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Governing Element: Elliptical bottom head
Governing Load Case 8 : IP+OW+EQ+FS+BS

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Shop/Field Installation Options :

Platform(s) installed in the Shop.
Insulation is installed in the Shop.

Note : The CG is computed from the first Element From Node

Center of Gravity of Platforms	10500.001 mm
Center of Gravity of Liquid	1296.295 mm
Center of Gravity of Insulation	1657.071 mm
Center of Gravity of Nozzles	3199.334 mm
Center of Gravity of Added Weights (Operating)	2745.008 mm
Center of Gravity of Added Weights (Empty)	2745.008 mm
Center of Gravity of Bare Shell New and Cold	5464.207 mm
Center of Gravity of Bare Shell Corroded	5727.950 mm
Vessel CG in the Operating Condition	4383.118 mm
Vessel CG in the Fabricated (Shop/Empty) Condition	5380.793 mm
Vessel CG in the Test Condition	5108.408 mm

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Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 60 To 70 SA-516 60

CONE WS TO RISER

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Axial Force on Small End of Cone	301.97	kgf
Axial Force on Large End of Cone	360.90	kgf
Moment on Small End of Cone	3633.98	kgf-m
Moment on Large End of Cone	4695.34	kgf-m

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	15.2762	mm

Maximum Centroid Reinforcement Distance Small End 10.5416 mm

Note: No ring was found close enough to the large end to be considered.

Note: No ring was found close enough to the small end to be considered.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

Large end ratio of pressure to allowable stress	0.00349	
Large end max. half apex angle w/o reinforcement	19.478	degrees
Large end actual half apex angle	15.610	degrees

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

Small end ratio of pressure to allowable stress	0.00349	
Small end max. half apex angle w/o reinforcement	4.995	degrees
Small end actual half apex angle	15.610	degrees

Intermediate Value [k]:

= max(Y / (Sr * Ers), 1)
= max(23.50E+09/(117.9 * 199328640), 1)
= 1.0000

where [Y] is:

= Small End All. Stress * Small End Elastic Modulus (Int. temp.)
= 117.9 * 199328640
= 23500847104.0 N/mm^2^2

Decay Length, Cone Small End:

= 1.4 * sqrt(Rs(ts - ca))
= 1.4 * sqrt(247 (10 - 3))
= 58.214 mm

Required Area of Reinforcement, Small End, Internal [Ars]:

= k*QS*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
= 1 * 22.43 * 247/(117.9 * 0.85) *
(1 - 4.995/15.61)0.279
= 1.03 cm^2

Force per Length, Cone Small End [QS]:

= P(Rs/2) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
= 350 (247/2) - 302/(pi(494 + 10)) +
3634/(pi(247 + 10/2)(247 + 10/2))
= 22.430 kgf/mm

Area of Reinforcement Available in Small End Shell [Aes]:

= 0.78(Rs*Ts)½*((Ts-t)+(Tc-Tr)/cos(alpha)))
= 0.78(247 *7)½*((7 -0.865)+(7 -0.898)/0.963)
= 4.0450 cm^2

Summary of Reinforcement Area, Small End, Internal Pressure:

Area of reinforcement required per App. 1-5(3)	1.0300	cm^2
Area of reinforcement in shell per App. 1-5(4)	4.0450	cm^2
Area of reinforcement in stiffening ring	0.0000	cm^2

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	93.31	353.70	Small Cyl. Long.
Compres. Stress	-58.16	-353.70	Small Cyl. Long.
Membrane Stress	46.37	176.85	Small End Tang.
Tensile Stress	94.53	353.70	Cone Longitudinal
Compres. Stress	-58.92	-353.70	Cone Longitudinal
Tensile Stress	46.85	176.85	Cone Tangential
Tensile Stress	78.33	353.70	Large Cyl. Long.
Compres. Stress	-37.22	-353.70	Large Cyl. Long.
Membrane Stress	17.77	-176.85	Large End Tang.
Tensile Stress	79.11	353.70	Cone Longitudinal
Compres. Stress	-36.43	-353.70	Cone Longitudinal
Compres Stress	18.79	-176.85	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure kPa	Reason for Failure at this Pressure
MAWP	1274.481	Thickness due to internal pressure, Cone Large End
MAPnc	1825.126	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

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Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 80 To 90 SA-516 60

CONE

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C

```
Elastic Modulus of Small End Reinforcement       0.199E+09 kPa at 80 °C

Axial Force on Small End of Cone                      70.50  kgf
Axial Force on Large End of Cone                      82.25  kgf
Moment on Small End of Cone                            0.00  kgf-m
Moment on Large End of Cone                          804.53  kgf-m
```

Note: Both ends of the Cone are Lines of Support

```
Maximum Centroid Reinforcement Distance Large End    10.5416  mm
Maximum Centroid Reinforcement Distance Small End     8.4101  mm
```

Note: No ring was found close enough to the large end to be considered.

Note: No ring was found close enough to the small end to be considered.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

```
Large end ratio of pressure to allowable stress      0.00349
Large end max. half apex angle w/o reinforcement      19.478  degrees
Large end actual half apex angle                      13.423  degrees
```

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

```
Small end ratio of pressure to allowable stress      0.00349
Small end max. half apex angle w/o reinforcement       4.995  degrees
Small end actual half apex angle                      13.423  degrees
```

Intermediate Value [k]:

```
= max( Y / ( Sr * Ers ), 1 )
= max( 23.50E+09/( 117.9 * 199328640 ), 1 )
= 1.0000
```

where [Y] is:

```
= Small End All. Stress * Small End Elastic Modulus (Int. temp.)
= 117.9 * 199328640
= 23500847104.0 N/mm^2^2
```

Decay Length, Cone Small End:

```
= 1.4 * sqrt( Rs( ts - ca ) )
= 1.4 * sqrt( 154.7 ( 10 - 3 ) )
= 46.066 mm
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
= k*QS*Rs/(Sc*E2)*tan(alpha)
= 1 * 2.689 * 154.7/( 117.9 * 0.85 ) * 0.239
= 0.0971 cm^2
```

Force per Length, Cone Small End [QS]:

```
= P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
= 350 ( 154.7/2 ) - 70.5/(pi(309.3 + 10 )) +
  0/(pi(154.7 + 10/2)(154.7 + 10/2))
= 2.689 kgf/mm
```

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Area of Reinforcement Available in Small End Shell [Aes]:

```
  = ( tc - tr ) * sqrt( Rs*tc/cos(alpha) )
  = ( 7 - 0.557 ) * sqrt( 154.7 * 7/0.973 )
  = 2.1497 cm^2
```

Summary of Reinforcement Area, Small End, Internal Pressure:

Area of reinforcement required per App. 1-5(3)	0.0971	cm^2
Area of reinforcement in shell per App. 1-5(4)	2.1497	cm^2
Area of reinforcement in stiffening ring	0.0000	cm^2

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	8.92	353.70	Small Cyl. Long.
Compres. Stress	-1.21	-353.70	Small Cyl. Long.
Membrane Stress	10.70	-176.85	Small End Tang.
Tensile Stress	9.03	353.70	Cone Longitudinal
Compres. Stress	-1.11	-353.70	Cone Longitudinal
Compres Stress	10.92	-176.85	Cone Tangential
Tensile Stress	31.61	353.70	Large Cyl. Long.
Compres. Stress	-7.80	-353.70	Large Cyl. Long.
Membrane Stress	12.10	-176.85	Large End Tang.
Tensile Stress	31.95	353.70	Cone Longitudinal
Compres. Stress	-7.46	-353.70	Cone Longitudinal
Compres Stress	12.45	-176.85	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure kPa	Reason for Failure at this Pressure
MAWP	2720.389	Thickness due to internal pressure, Cone Large End
MAPnc	3905.757	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

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Nozzle Calculation Summary:

Description	MAWP kPa	Ext	MAPNC kPa	UG-45	[tr] mm	Weld Path	Areas or Stresses
N2	621.53	...	...	OK	4.42	OK	No Calc[*]

```
 N3                |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 N4                |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 K1A               |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 K1B               |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 HW                |           |    ...  |        ...  |   ...  |        |     OK   | No
Calc[*] |
 N1                |           |    ...  |        ...  |    OK  |  4.59  |     OK   | No
Calc[*] |
 ------------------------------------------------------------------------------------
------
```

MAWP Summary:

```
 Minimum MAWP Nozzles         :         621.533 Nozzle  : N2
 Minimum MAWP Shells/Flanges  :         621.533 Element : Elliptical bottom he
 Minimum MAPnc Shells/Flanges :        1205.880 Element : Elliptical bottom he
 ------------------------------------------------------------------------
 Computed Vessel M.A.W.P.     :         621.533 kPa
```

[*] - This was a small opening and the areas were not computed or the MAWP of this connection could not be computed because the longitudinal bending stress was greater than the hoop stress.

Note: MAWPs (Internal Case) shown above are at the High Point.

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	Y Coordinate mm	Layout Angle deg	Dia. Limit mm
20	N2	0.000	0.000	102.501
30	N3	750.000	135.000	52.616
30	N4	2250.000	135.000	52.616
30	K1A	1000.000	45.000	52.616
30	K1B	2000.000	45.000	52.616
30	HW	50.000	45.000	417.435
40	N1	4049.999	180.000	521.016

The nozzle spacing is computed by the following:
= Sqrt($ll^2 + lc^2$) where
ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.
No interference violations have been detected !

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Input, Nozzle Desc: N2 From: 20

```
 Pressure for Reinforcement Calculations        P     361.405  kPa
 Temperature for Internal Pressure           Temp          80  °C
```

Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Elliptical Head	D	1054.10	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	6.3500	mm
Head Internal Corrosion Allowance	c	3.0000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	0.0000	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

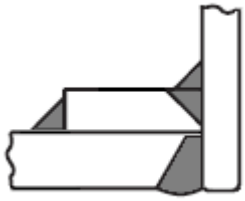
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-105	
Flange Type		None	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 60	
Pad Allowable Stress at Temperature	Sp	117.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	117.90	N/mm^2
Diameter of Pad along vessel surface	Dp	150.0000	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	6.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		44.8375	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

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Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: N2

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation            2.375  in.
Actual Thickness Used in Calculation                   0.218  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]
```
  = (P*K1*D))/(2*Sv*E-0.2*P) per UG-37(a)(3)
  = (361.4*0.9*1060)/(2 *117.9*1-0.2*361.4)
  = 1.4628 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (361.4*30.16)/(117.9*1+0.4*361.4)
  = 0.0923 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   102.5012  mm
Parallel to Vessel Wall, opening length              d    51.2506  mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp     8.3750  mm
```

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N2.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 1.0923 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.6254 mm
Wall Thickness                tb1 = max(trb1, tr16b) = 4.6254 mm
Wall Thickness                tb2 = max(trb2, tr16b) = 4.5875 mm
```

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```
Wall Thickness per table UG-45                    tb3 = 4.4200 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 4.42, max( 4.625, 4.588 ) ]
  = 4.4200 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.092, 4.42 )
  = 4.4200 mm
```

Available Nozzle Neck Thickness = 0.875 * 5.537 = 4.845 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: C

Govrn. thk, tg = 4.845, tr = 0.0923, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.024, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, Curve: C

Govrn. thk, tg = 6.35, tr = 1.463, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.437, Temp. Reduction = 42 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 4.845, tr = 0.0923, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.024, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :    -48 °C
Governing MDMT of all the sub-joints of this Junction :    -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -17 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
```

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Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 361.40/1964.96 = 0.184

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds	Tmin	4.5372	mm
Intermediate Calc. for pad/shell Welds	TminPad	3.3500	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.1760 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm
Pad Weld	1.6750 = 0.5*TminPad	4.2420 = 0.7 * Wp mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 632.938 kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.4770 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 156.8270 mm

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Input, Nozzle Desc: N3 From: 30

Pressure for Reinforcement Calculations	P	351.470	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		750.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

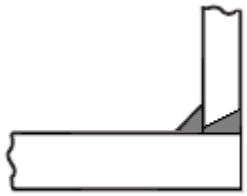
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		135.00	deg
Diameter		1.0000	in.

Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N3

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	0.957	in.
Actual Thickness Used in Calculation	0.179	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (351.5*526.4)/(117.9*1-0.6*351.5)
= 1.5721 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)

```
  = (351.5*13.15)/(117.9*1-0.6*351.5)
  = 0.0393 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
 Parallel to Vessel Wall (Diameter Limit)              Dl    52.6156  mm
 Parallel to Vessel Wall, opening length                d    26.3078  mm
 Normal to Vessel Wall (Thickness Limit), no pad     Tlnp     8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
 Wall Thickness for Internal/External pressures       ta = 1.0393 mm
 Wall Thickness per UG16(b),                       tr16b = 4.5875 mm
 Wall Thickness, shell/head, internal pressure      trb1 = 4.5721 mm
 Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5875 mm
 Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5875 mm
 Wall Thickness per table UG-45                     tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification        -46 °C

 Calculated Minimum Design Metal Temperature              -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0393, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0132, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Governing MDMT of all the sub-joints of this Junction : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ANSI B16.5/47 flange per Matl. Specification	-46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)	-104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)	-104 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 351.47/1964.96 = 0.179

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N3

Intermediate Calc. for nozzle/shell Welds Tmin 3.5466 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 1315.159 kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: N4 From: 30

Pressure for Reinforcement Calculations	P	350.000	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		2250.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

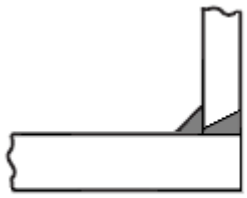
Type of Element Connected to the Shell : Nozzle

Material	[Impact Tested]	SA-333 6

Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		135.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N4

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	0.957	in.
Actual Thickness Used in Calculation	0.179	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

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The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	52.6156	mm
Parallel to Vessel Wall, opening length	d	26.3078	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	8.8665	mm

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N4.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta	= 1.0391 mm
Wall Thickness per UG16(b),	tr16b	= 4.5875 mm
Wall Thickness, shell/head, internal pressure	trb1	= 4.5656 mm
Wall Thickness	tb1 = max(trb1, tr16b)	= 4.5875 mm
Wall Thickness	tb2 = max(trb2, tr16b)	= 4.5875 mm
Wall Thickness per table UG-45	tb3	= 3.9464 mm

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification	-46 °C
Calculated Minimum Design Metal Temperature	-104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification      -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)         -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)         -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
`Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178`

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N4

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
`Converged Max. Allow. Pressure in Operating case     1313.689  kPa`

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: K1A **From: 30**

```
Pressure for Reinforcement Calculations        P     350.000  kPa
Temperature for Internal Pressure           Temp          80  °C

Shell Material                                      SA-516 60
Shell Allowable Stress at Temperature          Sv     117.90  N/mm^2
Shell Allowable Stress At Ambient             Sva     117.90  N/mm^2

Inside Diameter of Cylindrical Shell           D     1046.80  mm
Shell Finished (Minimum) Thickness             t     10.0000  mm
Shell Internal Corrosion Allowance             c      3.0000  mm
```

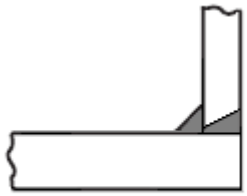
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1000.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: K1A

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

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```
Actual Inside Diameter Used in Calculation            0.957  in.
Actual Thickness Used in Calculation                  0.179  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
Parallel to Vessel Wall (Diameter Limit)            Dl    52.6156  mm
Parallel to Vessel Wall, opening length              d    26.3078  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: K1A.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
Wall Thickness for Internal/External pressures      ta = 1.0391 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                   tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: K1A

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     1313.689  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: K1B From: 30

```
Pressure for Reinforcement Calculations        P     350.000  kPa
```

Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		2000.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

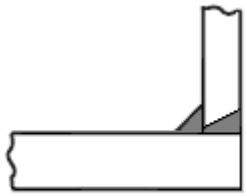
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

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Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: K1B

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation              0.957  in.
Actual Thickness Used in Calculation                    0.179  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl    52.6156  mm
Parallel to Vessel Wall, opening length              d    26.3078  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: K1B.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 1.0391 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
```

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```
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                  tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                  tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                   tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification        -46 °C

Calculated Minimum Design Metal Temperature              -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification      -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)         -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)         -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: K1B

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case		1313.689	kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: HW **From: 30**

Pressure for Reinforcement Calculations	P	358.332	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		50.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

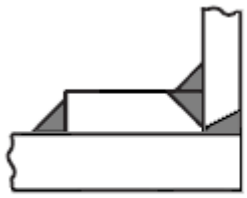
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		8.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	STD	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm

Groove weld depth between Nozzle and Vessel	Wgnv	8.1788	mm
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N/mm^2
Diameter of Pad along vessel surface	Dp	319.0750	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		50.0000	mm
This is a Manway or Access Opening.			
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle With Pad

Reinforcement CALCULATION, Description: HW

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	7.981	in.
Actual Thickness Used in Calculation	0.322	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (358.3*526.4)/(117.9*1-0.6*358.3)
= 1.6029 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
= (358.3*104.4)/(117.9*1-0.6*358.3)
= 0.3178 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

```
 Parallel to Vessel Wall (Diameter Limit)              Dl    417.4348  mm
 Parallel to Vessel Wall, opening length                d    208.7174  mm
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp     17.5000  mm
```

Weld Strength Reduction Factor [fr1]:

```
  = 1.000
```

Weld Strength Reduction Factor [fr2]:

```
  = min( 1, Sn/Sv )
  = min( 1, 117.9/117.9 )
  = 1.000
```

Weld Strength Reduction Factor [fr4]:

```
  = min( 1, Sp/Sv )
  = min( 1, 137.9/117.9 )
  = 1.000
```

Weld Strength Reduction Factor [fr3]:

```
  = min( fr2, fr4 )
  = min( 1, 1 )
  = 1.000
```

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	5.862	NA	NA
Area in Shell	A1	8.748	NA	NA
Area in Nozzle Wall	A2	1.701	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA
Area in Welds	A41+A42+A43	1.000	NA	NA
Area in Element	A5	8.000	NA	NA
TOTAL AREA AVAILABLE	Atot	19.450	NA	NA

The Internal Pressure Case Governs the Analysis.

```
 Nozzle Angle Used in Area Calculations                 90.00  Degs.
```

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

Area Required [A]:

```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (208.7*2.808*1+2*5.179*2.808*1*(1-1))
  = 5.862 cm^2
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 208.7 ( 1 * 7 - 1 * 2.808 ) - 2 * 5.179
    ( 1 * 7 - 1 * 2.808 ) * ( 1 - 1 )
  = 8.748 cm^2
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 17.5 ) * ( 5.179 - 0.318 ) * 1
  = 1.701 cm^2
```

Area Available in Welds [A41 + A42 + A43]:

```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 6² * 1 + (0 )² * 1 + 8² * 1
  = 1.000 cm^2
```

Area Available in Element [A5]:

```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 319.1 - 219.1 ) * 8 * 1
  = 8.000 cm^2
```

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification         -46 °C

 Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification         -46 °C

 Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B

Govrn. thk, tg = 7.156, tr = 0.318, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0765, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, min(Curve:B, Curve:C)

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.229, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 7.156, tr = 0.318, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0765, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
```

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```
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :   -104 °C
Governing MDMT of all the sub-joints of this Junction :   -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 358.33/1964.96 = 0.182
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: HW

```
Intermediate Calc. for nozzle/shell Welds   Tmin      5.1788  mm
Intermediate Calc. for pad/shell Welds    TminPad     7.0000  mm
```

Results Per UW-16.1:

```
                      Required Thickness     Actual Thickness
Nozzle Weld          3.6252 = 0.7 * tmin.   4.2420 = 0.7 * Wo mm
Pad Weld             3.5000 = 0.5*TminPad   5.6560 = 0.7 * Wp mm
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

```
= ( Ar - A1 )* Sv
= ( 5.862 - 8.748 ) * 117.9
= 0.00 kgf
```

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 1.701 + 8 + 1 - 0 * 1 ) * 117.9
= 12865.43 kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 219.1 * 6 * 0.49 * 117.9
= 12164. kgf
```

Shear, Pad Element Weld [Spew]:

```
= (pi/2) * DP * WP * 0.49 * SEW
= ( 3.142/2.0 ) * 319.1 * 8 * 0.49 * 117.9
= 23620. kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
= ( pi/2) * Dlo * Wgpn * 0.74 * Seg
```

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```
  =  (3.142/2 ) * 219.1 * 8 * 0.74 * 137.9
  = 28646. kgf
```

Shear, Nozzle Groove Weld [Sngw]:

```
  = (pi/2) * (Dlr+Wgnva) * (Wgnva-Can) * 0.60 * Sng
  = (3.142/2)*(208.7 +8.179 )*(8.179 -3 )*0.6*117.9
  = 12728. kgf
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNGW ) = ( 23620 + 12728 ) = 36348 kgf
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 36348 kgf, must exceed W = 0 kgf or W1 = 12865 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     1322.021  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 11.5904 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 238.1904 mm

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Input, Nozzle Desc: N1 From: 40

```
 Pressure for Reinforcement Calculations        P     350.000  kPa
 Temperature for Internal Pressure           Temp          80  °C

 Shell Material                                      SA-516 60
 Shell Allowable Stress at Temperature         Sv      117.90  N/mm^2
 Shell Allowable Stress At Ambient            Sva      117.90  N/mm^2

 Inside Diameter of Cylindrical Shell           D     1046.80  mm
 Shell Finished (Minimum) Thickness             t     10.0000  mm
 Shell Internal Corrosion Allowance             c      3.0000  mm
 Shell External Corrosion Allowance            co      0.0000  mm

 Distance from Bottom/Left Tangent                    4050.00  mm

 User Entered Minimum Design Metal Temperature         -10.00  °C
```

Type of Element Connected to the Shell : Nozzle

```
 Material        [Impact Tested]                     SA-333 6
 Material UNS Number                                  K03006
 Material Specification/Type               Smls. & wld. pipe
 Allowable Stress at Temperature              Sn      117.90  N/mm^2
 Allowable Stress At Ambient                 Sna      117.90  N/mm^2

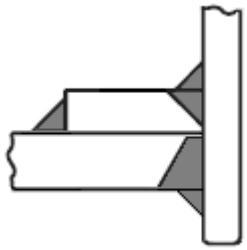
 Diameter Basis (for tr calc only)                        OD
 Layout Angle                                         180.00  deg
 Diameter                                            10.0000  in.

 Size and Thickness Basis                             Nominal
```

Nominal Thickness	tn	STD	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	533.4000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 60	
Pad Allowable Stress at Temperature	Sp	117.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	117.90	N/mm^2
Diameter of Pad along vessel surface	Dp	473.0500	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		100.0000	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, with Inside projection

Reinforcement CALCULATION, Description: N1

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	10.750	in.
Actual Thickness Used in Calculation	0.365	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (350*526.4)/(117.9*1-0.6*350)

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= 1.5656 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.2574 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*136.5)/(117.9*1+0.4*350)
= 0.4048 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	521.0160	mm
Parallel to Vessel Wall, opening length	d	260.5080	mm
Normal to Vessel Wall (Thickness Limit), pad side	Tlwp	17.5000	mm
Normal to Vessel Wall, Inward		8.1775	mm

Weld Strength Reduction Factor [fr1]:
= min(1, Sn/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr2]:
= min(1, Sn/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr4]:
= min(1, Sp/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr3]:
= min(fr2, fr4)
= min(1, 1)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	4.694	NA	NA
Area in Shell	A1	13.541	NA	NA
Area in Nozzle Wall	A2	2.053	NA	NA
Area in Inward Nozzle	A3	0.535	NA	NA
Area in Welds	A41+A42+A43	1.637	NA	NA
Area in Element	A5	16.000	NA	NA
TOTAL AREA AVAILABLE	Atot	33.767	NA	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

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Area Required [A]:
```
= ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
= (260.5*1.802*1+2*6.271*1.802*1*(1-1))
= 4.694 cm^2
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
= d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
= 260.5 ( 1 * 7 - 1 * 1.802 ) - 2 * 6.271
  ( 1 * 7 - 1 * 1.802 ) * ( 1 - 1 )
= 13.541 cm^2
```

Area Available in Nozzle Wall Projecting Outward [A2]:
```
= ( 2 * Tlwp ) * ( tn - trn ) * fr2
= ( 2 * 17.5 ) * ( 6.271 - 0.405 ) * 1
= 2.053 cm^2
```

Area Available in Inward Nozzle [A3]:
```
= 2 * ti * min( h, Tl, 2.5 * ti) * fr2
= 2 * 3.271 * ( 8.177 ) * 1
= 0.535 cm^2
```

Area Available in Welds [A41 + A42 + A43]:
```
= (Wo² - Ar Lost)*Fr3+((Wi-can/0.707)² - Ar Lost)*fr2 + Wp²*fr4
= (0.997 ) * 1 + (0 ) * 1 + 203.2² * 1
= 1.637 cm^2
```

Area Available in Element [A5]:
```
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= ( 473 - 273 ) * 8 * 1
= 16.000 cm^2
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 3.4048 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                   tb3 = 11.1026 mm
```

Determine Nozzle Thickness candidate [tb]:
```
= min[ tb3, max( tb1,tb2) ]
= min[ 11.1, max( 4.588, 4.588 ) ]
= 4.5875 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
= max( ta, tb )
= max( 3.405, 4.588 )
= 4.5875 mm
```

Available Nozzle Neck Thickness = 0.875 * 9.271 = 8.112 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: C

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.224, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, Curve: C

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.224, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 8.112, tr = 0.405, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0792, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :   -104 °C
Governing MDMT of all the sub-joints of this Junction :   -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:

Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N1

```
Intermediate Calc. for nozzle/shell Welds   Tmin      6.2710  mm
Intermediate Calc. for pad/shell Welds    TminPad     7.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.3897 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:
```
= max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
= max( 0, (4.694 - 13.54 + 2 * 6.271 * 1 *
  (1 * 7 - 1.802 ) )117.9 )
= max( 0, -9852.27) kgf
```

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:
```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 2.053 + 16 + 1.637 - 0 * 1 ) * 117.9
= 23672.58 kgf
```

Weld Load [W2]:
```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 2.053 + 0.535 + 1 + ( 0.878 ) ) * 117.9
= 5369.22 kgf
```

Weld Load [W3]:
```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 2.053 + 0.535 + 1.637 + 16 + ( 0.878 ) ) * 117.9
= 25371.21 kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 273 * 10 * 0.49 * 117.9
= 25267. kgf
```

Shear, Pad Element Weld [Spew]:
```
= (pi/2) * DP * WP * 0.49 * SEW
= ( 3.142/2.0 ) * 473 * 8 * 0.49 * 117.9
= 35019. kgf
```

Shear, Nozzle Wall [Snw]:
```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.142 * 133.4 ) * ( 9.271 - 3 ) * 0.7 * 117.9
= 22116. kgf
```

Tension, Pad Groove Weld [Tpgw]:
```
= ( pi/2) * Dlo * Wgpn * 0.74 * Seg
=  (3.142/2 ) * 273 * 8 * 0.74 * 117.9
```

```
  = 30527. kgf
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 273 * ( 10 - 3 ) * 0.74 * 117.9
  = 26711. kgf
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 35019 + 22116 ) = 57135 kgf
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 25267 + 30527 + 26711 + 0 ) = 82506 kgf
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 35019 + 26711 + 0 ) = 61730 kgf
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 57134 kgf, must exceed W = 0 kgf or W1 = 23672 kgf
 Path 2-2 = 82505 kgf, must exceed W = 0 kgf or W2 = 5369 kgf
 Path 3-3 = 61729 kgf, must exceed W = 0 kgf or W3 = 25371 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     1136.355  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 18.1194 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 760.0001 mm

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Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm	Reinforcing Pad Diameter mm	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
HW	8.000 in	STD	WNF	8.625	8.179	319.08	8.00	238.19	150
K1A	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
K1B	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
N1	10.000 in	STD	WNF	10.750	9.271	473.05	8.00	760.00	150
N2	2.000 in	XS	None	2.375	5.537	150.00	8.00	156.83	150
N3	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
N4	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
HW	SA-333 6	8.179	6.000	8.000	8.000	...
K1A	SA-333 6	4.547	5.000	...	...	...
K1B	SA-333 6	4.547	5.000	...	...	...
N1	SA-333 6	10.000	10.000	8.000	8.000	...
N2	SA-333 6	6.350	10.000	6.000	8.000	...
N3	SA-333 6	4.547	5.000	...	...	...
N4	SA-333 6	4.547	5.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
HW	1000.000	45.0	216.60	0.00	WS CYLINDER 1/2
K1A	1950.000	45.0	216.60	0.00	WS CYLINDER 1/2
K1B	2950.000	45.0	216.60	0.00	WS CYLINDER 1/2
N1	4999.999	180.0	216.60	533.40	WS CYLINDER 2/2
N2	...	0.0	150.00	0.00	Elliptical botto

```
  N3              |       1700.000 |    135.0 |      216.60 |    0.00 |     WS CYLINDER
1/2 |
  N4              |       3200.000 |    135.0 |      216.60 |    0.00 |     WS CYLINDER
1/2 |
```

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Minimum Design Metal Temperature Results Summary :

Description	Notes	Curve	Basic MDMT °C	Reduced MDMT °C	UG-20(f) MDMT °C	Thickness ratio	Gov Thk mm	E*	PWHT reqd
Elliptical bo	[10]	C	-48	-48	-29	0.487	6.350	0.85	No
Elliptical bot	[7]	C	-48	-48	-29	0.487	6.350	0.85	No
WS CYLINDER 1	[20]	C	-44	-48	-29	0.487	10.000	0.85	No
WS CYLINDER 2	[20]	C	-44	-104	-29	0.313	10.000	0.85	No
WS CYLINDER 3/	[8]	C	-44	-104	-29	0.226	10.000	0.85	No
CONE WS TO RIS	[8]	C	-44	-104	-29	0.235	10.000	0.85	No
Riser	[20]	C	-44	-104	-29	0.321	10.000	0.85	No
CONE	[8]	C	-44	-104	-29	0.193	10.000	0.85	No
TIP	[16]		-196						
N2	[1]	C	-48	-48	-29	0.437	6.350	1.00	No
Nozzle Flg	[5]	!	-17	-104					
N3	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
N4	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
K1A	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
K1B	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
HW	[1]	B	-46	-104		0.076	7.156	1.00	No
Nozzle Flg	[4]	!	-46	-104					
N1	[1]	C	-46	-104		0.079	8.112	1.00	No
Nozzle Flg	[4]	!	-46	-104					
Warmest MDMT:			-17	-48					

Required Minimum Design Metal Temperature -10.0 °C
Warmest Computed Minimum Design Metal Temperature -48.0 °C

Notes:
[!] - This was an impact tested material.
[1] - Governing Nozzle Weld.
[4] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-c).
[5] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-b).
[6] - MDMT Calculations at the Shell/Head Joint.
[7] - MDMT Calculations for the Straight Flange.
[8] - Cylinder/Cone/Flange Junction MDMT.
[9] - Calculations in the Spherical Portion of the Head.
[10] - Calculations in the Knuckle Portion of the Head.
[11] - Calculated (Body Flange) Flange MDMT.
[12] - Calculated Flat Head MDMT per UCS-66.3
[13] - Tubesheet MDMT, shell side, if applicable
[14] - Tubesheet MDMT, tube side, if applicable
[15] - Nozzle Material

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[16] - Shell or Head Material
[17] - Impact Testing required
[18] - Impact Testing not required, see UCS-66(b)(3)
[20] - Cylinder/Cone Junction MDMT based on Longitudinal Stress considerations
[21] - Bolting Material

UG-84(b)(2) was not considered.
UCS-66(g) was not considered.
UCS-66(i) was not considered.

Notes:
Impact test temps were not entered in and not considered in the analysis.
UCS-66(i) applies to impact tested materials not by specification and
UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c).
The Basic MDMT includes the (30F) PWHT credit if applicable.

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ASME Code, Section VIII Division 1, 2023

Diameter Spec : 1066.800 x 508.000 x 323.900 mm OD		
Vessel Design Length, Tangent to Tangent	15559.52	mm
Distance of Bottom Tangent above Grade	32260.00	mm
Distance of Base above Grade	31310.00	mm
Specified Datum Line Distance	0.00	mm
Internal Design Temperature	80	°C
Internal Design Pressure	350.000	kPa
External Design Temperature	80	°C
Maximum Allowable Working Pressure	621.533	kPa
Hydrostatic Test Pressure	500.500	kPa
Required Minimum Design Metal Temperature	-10.0	°C
Warmest Computed Minimum Design Metal Temperature	-48.0	°C
Wind Design Code	EN-2010	
Earthquake Design Code	G-Loading	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-516 60	...	...	K02100	No	No
Shell	SA-213 TP316	...	...	S31600	No	No
Head	SA-516 60	...	...	K02100	No	No
Cone	SA-516 60	...	...	K02100	No	No

```
        Flange |      SA-350 LF2 |     1 |                    ... |  K03011 |    No |
Yes |
        Flange |    SA-182 F316L |   ... |                  > 5 |  S31603 |    No |
No |
         Skirt |   SA/EN 10028-2 |P355GH |           6 < t <= 10 |         |    No |
No |
        Nozzle |        SA-333 6 |   ... |                    ... |  K03006 |    No |
Yes |
        Re-Pad |       SA-516 60 |   ... |                    ... |  K02100 |    No |
No |
        Re-Pad |       SA-516 70 |   ... |                    ... |  K02700 |    No |
No |
    Nozzle Flg |          SA-105 |   ... |                    ... |  K03504 |    No |
Yes |
    Nozzle Flg |      SA-350 LF2 |     1 |                    ... |  K03011 |    No |
Yes |
```

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (kPa & mm):

```
                          |        Design |          |           |             | Str. |
In |
     Element Description |      Pressure |    Ext.  |   Element |  Corrosion  | Flg. |
Creep |
                or Type |  + Stat. head |  Press.  |   M.A.W.P |  Allowance  | Gov. |
Range |
 ------------------------------------------------------------------------------------
----
  Elliptical bottom head |       361.405 |    0.00  |   621.533 |      3.0000 |   No |
No |
         WS CYLINDER 1/2 |       358.332 |    0.00  |  1313.689 |      3.0000 |  N/A |
No |
         WS CYLINDER 2/2 |       350.000 |    0.00  |  1322.021 |      3.0000 |  N/A |
No |
         WS CYLINDER 3/3 |       350.000 |    0.00  |  1322.021 |      3.0000 |  N/A |
No |
        CONE WS TO RISER |       350.000 |    0.00  |  1273.009 |      3.0000 |  N/A |
No |
                  Riser |       350.000 |    0.00  |  2792.454 |      3.0000 |  N/A |
No |
                   CONE |       350.000 |    0.00  |  2715.345 |      3.0000 |  N/A |
No |
 FLANGE WN 12" 150# ASME |       350.000 |    0.00  |  1833.988 |      3.0000 |  N/A |
No |
 FLANGE WN 12" 150# ASME |       350.000 |    0.00  |  1833.988 |      3.0000 |  N/A |
? |
                     TIP |       350.000 |    0.00  |  4655.324 |      0.0000 |  N/A |
No |

 Liquid Level: 1163.53 mm   Dens.: 0.001 kg/cm^3     Sp. Gr.: 1.000
```

Element Types and Properties:

Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Skirt	950.0	950.0	...	10.0	...	...	0.85	0.85
Ellipse	1000.0	50.0	...	6.3	4.9	4.6	0.85	0.85
Cylinder	3500.0	2500.0	...	10.0	4.9	...	0.85	0.85
Cylinder	5136.0	1636.0	...	10.0	4.9	...	0.85	0.85
Cylinder	5456.0	320.0	...	10.0	4.9	...	0.85	0.85
Conical	6456.0	1000.0	...	10.0	4.9	...	0.85	0.85
Cylinder	11000.0	4544.0	...	10.0	4.6	...	0.85	0.85
Conical	11385.7	385.7	...	10.0	4.6	...	0.85	0.85
Body Flg	11500.0	114.3	...	10.0	...	7.0	1.00	1.00
Body Flg	11623.8	114.3	...	10.0	...	7.0	1.00	1.00
Cylinder	16509.5	4885.7	...	6.0	1.6	...	1.00	1.00

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	2153.66	3972.78	13501.8	18096.1
20	30	975	1988.26	3714.11	11534.4	14444.7
30	40	2250	1979.24	3427.59	11435.2	14266.2
40	50	4318	1471.06	1862.26	7122.23	7653.73
50	60	5296	1127.02	1272.44	4996.96	5089.49
60	70	5956	1073.15	1190.92	4644.93	4695.34
70	80	8728	948.694	996.456	3633.98	3601.63
80	90	11192.8	296.641	271.423	804.526	720.951
90	100	11442.8	270.727	232.649	695.107	623.739
100	110	11566.7	264.733	232.649	661.983	594.93
110	120	14066.7	258.736	232.649	632.066	568.338

Abs Max of the all of the Stress Ratio's : 0.8424

Total Wind Shear on Support 3795. kgf
Total Earthquake Shear on Support 5614. kgf

Note: The Wind and Seismic loads were not load factored in this analysis.

Note:
Wind and Earthquake moments include the effects of user defined forces and moments if any exist in the job and were specified to act (compute loads and stresses) during these cases. Also included are moment effects due to eccentric weights if any are present in the input.

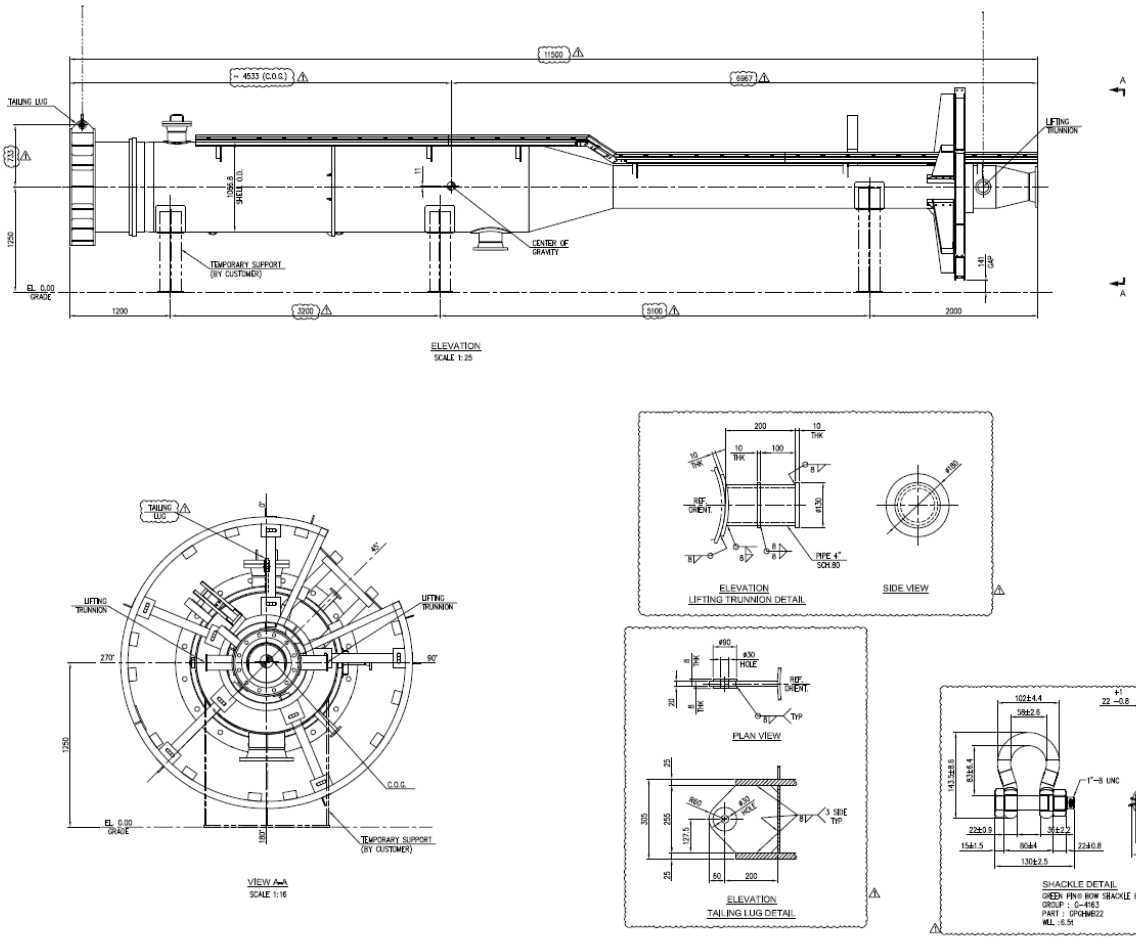
Weights:

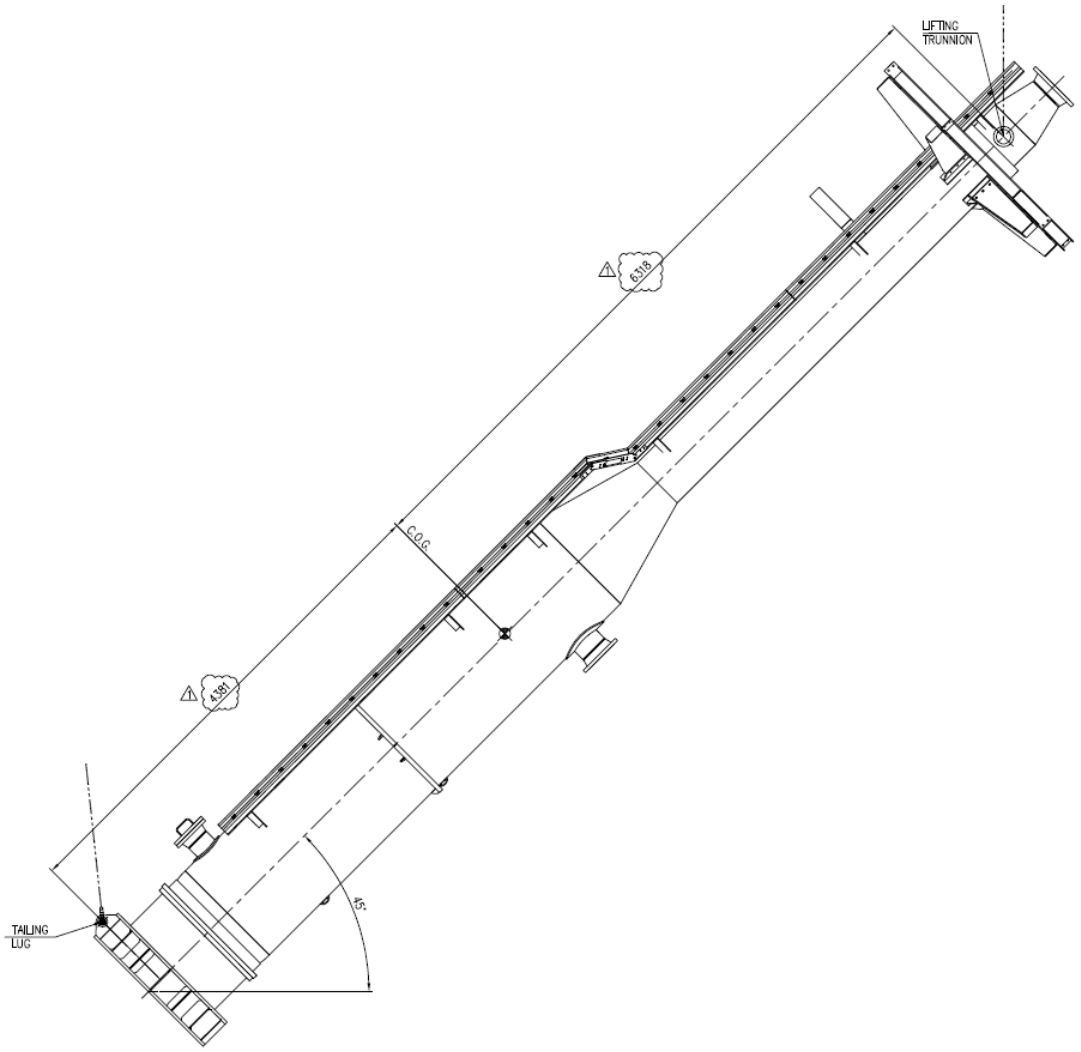
Fabricated	- Bare W/O Removable Internals	2812.3	kgm
Shop Test	- Fabricated + Water (Full)	8632.8	kgm
Shipping	- Fab. + Rem. Intls.+ Shipping App.	3085.0	kgm
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	3085.0	kgm
Empty	- Fab. + Intls. + Details + Wghts.	3085.0	kgm
Operating	- Empty + Operating Liquid (No CA)	4013.1	kgm
Field Test	- Empty Weight + Water (Full)	8905.6	kgm

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B - LIFTING ANALYSIS CONFIGURATION WITHOUT TIP INSTALLED

The configuration for the lifting is shown here after.

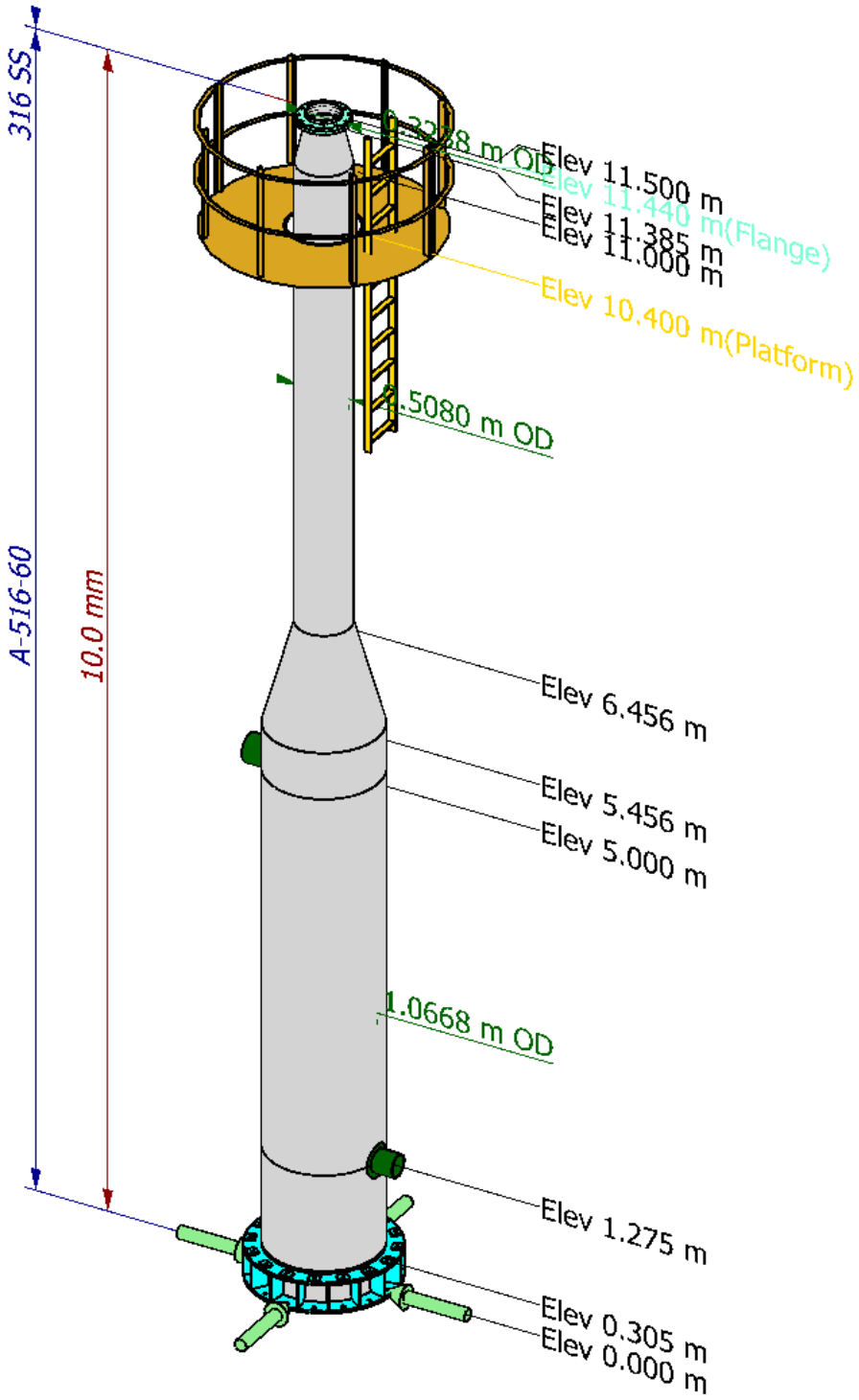


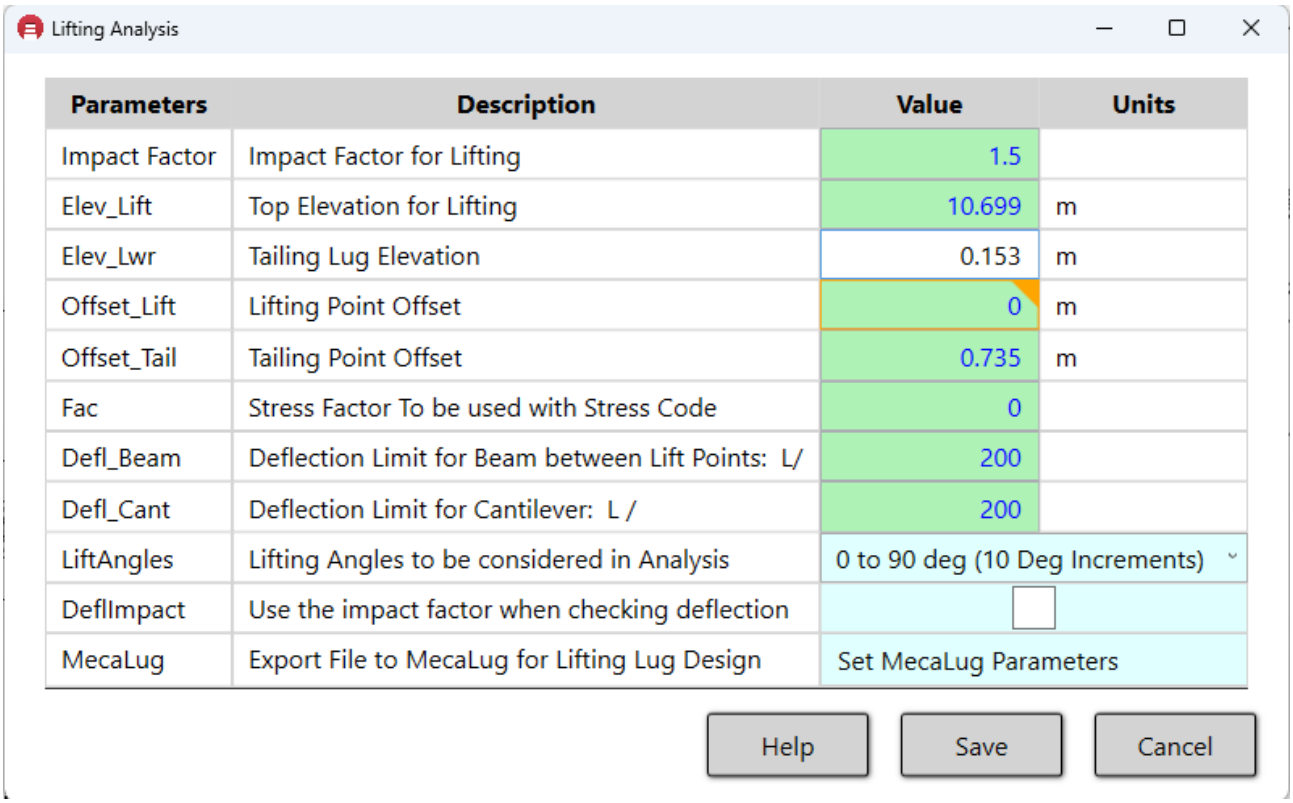


The tip will be installed after the precise vertical alignment of the bottom part.

A specialized model has been developed to analyze the lifting phases. For safety, the top platform is assumed to be fully assembled during the lift. In practice, some components will be added later to avoid potential conflicts with the lifting hardware.

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316 SS
A-516-60
10.0 mm
Elev 11.500 m
Elev 11.440 m(Flange)
Elev 11.385 m
Elev 11.000 m
Elev 10.400 m(Platform)
.5080 m OD
Elev 6.456 m
Elev 5.456 m
Elev 5.000 m
1.0668 m OD
Elev 1.275 m
Elev 0.305 m
Elev 0.000 m



MecaStack v5630

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Calculations Prepared by:
Date: Oct 17, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Lifting analysis-20240920-01.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height	= 11.50 m	Top of Stack Elevation	= 11.5 m
Grade Elevation	= 0.00 m	Bottom of Stack	= 0.0 m

All elevations are based upon the bottom of stack being at 0 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
11.5	0.3238	11.5	10.0	11.5	3.0
11.385	0.3238			0.305	0.0
11.0	0.5080				
6.456	0.5080				
5.456	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
11.5	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		21.11	206.84	195121	1.53E-05	137.89	8000	517.11
11.5	A-516-60	120.00	198.71	196914	1.22E-05	117.90	7849	413.68
		21.11	220.63	202705	1.15E-05	117.90	7849	413.68

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
11.500	8.400	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	2.450	0.950	0.0000	758.00	Oper
External insulation	3.100	0.350	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	0.305	0.000	200.0	Dead

Nozzles:

Num	Description	Elevation m	Nominal Diameter	Schedule	Outer Diameter mm	Thickness mm	Tilt Deg	Orien-tation Deg	Proj-ection mm

```
 1  1N              5.000 10 inch [254.0 mm]    Std       273.1        9.3  0.0  180.0
200.0
 2  HW              1.275  8 inch [203.2 mm]    Std       219.1        8.2  0.0    0.0
200.0
```

Num	Description	Repad Width mm	Repad Thickness mm	Flange Spec	Flange Radial Width mm	Flange Thickness mm	Nozzle Loads
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx KN	Fy KN	Fz KN	Mx KN-m	My KN-m	Mz KN-m	Local/ Global	Load Applied	Load Type	Check WRC 107
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC KN	FyC KN	FzC KN	MxC KN-m	MyC KN-m	MzC KN-m	|	Ver KN	Shear KN	Mom KN-m	Mbase KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	|	14.46	16.42	7.89	89.99

```
   Equivalent Nozzle Loads Applied on Stack:
   Ver   = Stack Vertical Load considered at Nozzle Elev: Fy
   Shear = Stack Shear Load considered at Nozzle Elev:  [Fx^2+Fz^2]^0.5
   Mom   = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
   Mbase = Est Mom at base if no Support:  Mom + Shear*Elev
           Provided only to evaluate the impact of the load on overall stack
```

```
Type      = Type of Baseplate                                          = Chair
                                                                         Continuous
Plate
SupType   = Type of Support                                            = Rigid Steel
Base
Friction  = Coefficient of Friction for Support                        = 0.300
BasisBolt = Basis for Bolt Design                                      = Brownell &
Young
Nbolt     = Number of Bolts                                            = 16
Dbolt     = Nominal Bolt Diameter                                      = 27.0 mm
Dbh       = Bolt Hole Diameter                                         = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                                = 3.0 mm
CAplt     = Corrosion Allowance on Plates                              = 0.0 mm
ID        = Inside Diameter of Baseplate                               = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                          = 1270.0 mm
OD        = Outer Diameter of Baseplate                                = 1385.0 mm
Tb        = Thickness of Bottom Plate                                  = 25.0 mm
Tt        = Thickness of Top Plate                                     = 25.0 mm
Fw        = Fillet Weld Size                                           = 5.0 mm
```

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```
Fwu       = Weld Ultimate Tensile Strength                          = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                              = 1
Hg        = Height of Anchor Chair                                  = 305.0 mm
Tg        = Thickness of Gusset                                     = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                  = S275J0
Dens      = Material Density                                        = 7849 Kg/m^3
Temp      = Design Temperature                                      = 21.11 Deg C
Fy        = Minimum Yield Stress                                    = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                 = 410030.5
KPa
Sa        = Allowable Tensile Stress                                = 117141.7
KPa
E         = Modulus of Elasticity                                   = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                        = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                               = False
Matl      = Bolt Material Specification                             = Gr. 8.8
Fu        = Ultimate Tensile Stress                                 = 800548.8
KPa
Fy        = Yield Stress                                            = 640440.4
KPa
Fproof    = Proof Stress                                            = 544374.4
KPa
Eb        = Modulus of Elasticity                                   = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile            = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                            = 800.55 MPa
PreStress = Pretension Stress on Bolt                               = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                = Rectangular
Pt        = Plate Washer Thickness                                  = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                  = 90.0 mm
Pl        = Length of Washer Parallel to Shell                      = 100.0 mm
Pdh       = Bolt Hole Diameter                                      = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 11.44 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                 = 323.8 mm
Do        = Outside Diameter of Flange                              = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange            = 25.4 mm
Dbc       = Bolt Circle Diameter                                    = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle             = 54.0 mm
Tf        = Thickness of Flange                                     = 31.8 mm
Tw        = Fillet Weld Size                                        = 6.0 mm
Gus       = Gussets                                                 = False
Db        = Nominal Bolt Diameter                                   = 22.2 mm
Nb        = Number of Bolts                                         = 12
BMatl     = Bolt Material                                           = Gr 8 (US)
```

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```
Fu        = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
FMatl     = Flange Material                                               = A-36
Fyf       = Yield Stress of Flange                                        = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                               = 193742.33
MPa
```

Design Codes

```
Stress Criteria:  Eurocde 3 - Design of Steel structures:  Part 3-2: Towers, masts and
chimneys
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)     = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters       = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset              = False

Lifting Criteria:

Impact    = Impact Factor                                                 = 1.50
Lift_El   = Elevation of Lifting Point                                    = 10.699 m
UprOff    = Longitudinal Offset for Lifting Lug point from Lift Elev to Lift Eye= 0.0000
m
Tail_El   = Elevation of Tailing Point                                    = 0.153 m
LwrOff    = Radial Offset for Tailing Lug point from Ctr Line to Tail Pt  = 0.7350 m
SF        = Stress Factor of Safety                                       = 0.000
Defl_Beam = Deflection Limit between Lifting Points:  L /                 = 200.0
Defl_Cant = Deflection Limit for Cantilevers:         L /                 = 200.0
Defl_Impact= Consider Impact loading for deflection check?                 = False
Check Stack for 0 to 90 Deg in 10 Deg increments
```

Damping Criteria:

```
Structural Damping Criteria:
     Criteria:      ASME STS-1-2021
     Stack Type:   UnLined
     Support:      ELASTIC
```

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

```
   Log Decrement Damping = 2 * PI * Bs


Aerodynamic Damping Criteria:
     (Only used in Along wind analysis, Not considered for vortex shedding)
```

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Criteria: EN 1994-1-4

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
11.500	11.467	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.467	11.385	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.385	11.257	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.257	11.128	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
11.128	11.000	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
11.000	10.699	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.699	10.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.400	8.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
8.400	7.667	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
7.667	6.456	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.456	6.123	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.123	5.789	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
5.789	5.456	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
5.456	5.137	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
5.137	5.000	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
5.000	4.863	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
4.863	3.100	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
3.100	2.450	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
2.450	1.385	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
1.385	1.275	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
1.275	1.165	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
1.165	0.950	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.950	0.350	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.350	0.305	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.305	0.153	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5
0.153	0.000	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	6

Section Props - If a number is shown, then the section contains something unusual
(Breach, nozzle, stiffeners, etc..) and so the properties were
calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0
6	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Weight Summary (Lifting)

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Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1583.0 kg)	4.698	2219.1	21762
Ladders	9.950	69.2	679
Platforms	10.400	319.3	3132
Baseplate	0.127	389.0	3815
Structural Flange(s)	11.440	58.0	569
Nozzle(s)	3.537	53.2	521
General Attachment Uniform)	1.725	82.5	809
General Attachment Concentrated	0.305	200.0	1961
Total	4.584	3390.3	33248

Cylindrical Shells Wt: (Wt = 2219.1 kg, El COG = 4.698 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
11.500	11.385	11.443	0.3238	10.0	8000	6.4	78.86	9.1
11.385	11.000	11.193	0.4159	10.0	7849	27.2	100.09	38.5
11.000	6.456	8.728	0.5080	10.0	7849	393.0	122.80	558.0
6.456	5.456	5.956	0.7874	10.0	7849	134.7	191.69	191.7
5.456	0.305	2.881	1.0668	10.0	7849	942.3	260.59	1342.3
0.305	0.000	0.153	1.0668	10.0	7849	79.5	260.59	79.5
Total		4.698				1583.0		2219.1

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 9.950 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	11.500	8.400	9.950	22.32	69.2
Total			9.950		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 10.400 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	10.400	319.3
Total					10.400	319.3

Baseplate Wt: (Wt = 389.0 kg, El COG = 0.127 m)

Description	Elevation COG m	Weight kg

Bottom Plate	0.013	192.0
Top Plate	0.293	120.2
Gussets	0.153	61.1
Washers	0.153	15.6
Total	0.127	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 11.440 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
11.440	482.6	31.8	0.0	0.0	0.0	25.1	7.9	11.440	2	58.0
Total					0.0	25.1	7.9	11.440		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 3.537 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	5.000	273.1	-3.99	12.06	7.36	16.85	0.00	5.000	32.27
2	1.275	219.1	-2.53	8.51	2.65	12.26	0.00	1.275	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	3.537	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 1.725 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	3.100	0.350	1.725	30.00	82.5
Total	0.000	0.000	1.725		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 0.305 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	0.305	0.000	200.0
Total	0.305		200.0

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Impact Load	I

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Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	I
3	Dead Weight		X	0.000	0	1.0	
4	Dead Weight + Impact	X		0.000	0	1.0	1.0

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
7	Upper Lift Point	10.6990	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Free	Free
28	Lower Lift Point	0.1530	0.7350	0.0000	Free	Fixed	Free	Free	Free	Free

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
11.500	11.467	4	Dead Weight + Impact	Buckling	0.000	PASS
11.467	11.385	4	Dead Weight + Impact	Buckling	0.000	PASS
11.385	11.257	4	Dead Weight + Impact	Buckling	0.001	PASS
11.257	11.128	4	Dead Weight + Impact	Buckling	0.001	PASS
11.128	11.000	4	Dead Weight + Impact	Buckling	0.002	PASS
11.000	10.699	4	Dead Weight + Impact	Buckling	0.002	PASS
10.699	10.400	4	Dead Weight + Impact	Buckling	0.023	PASS
10.400	8.400	4	Dead Weight + Impact	Buckling	0.018	PASS
8.400	7.667	4	Dead Weight + Impact	Buckling	0.096	PASS
7.667	6.456	4	Dead Weight + Impact	Buckling	0.118	PASS
6.456	6.123	4	Dead Weight + Impact	Buckling	0.147	PASS
6.123	5.789	4	Dead Weight + Impact	Buckling	0.081	PASS
5.789	5.456	4	Dead Weight + Impact	Buckling	0.051	PASS
5.456	5.137	4	Dead Weight + Impact	Buckling	0.036	PASS
5.137	5.000	4	Dead Weight + Impact	Buckling	0.036	PASS
5.000	4.863	4	Dead Weight + Impact	Buckling	0.039	PASS
4.863	3.100	4	Dead Weight + Impact	Buckling	0.036	PASS
3.100	2.450	4	Dead Weight + Impact	Buckling	0.032	PASS
2.450	1.385	4	Dead Weight + Impact	Buckling	0.028	PASS
1.385	1.275	4	Dead Weight + Impact	Buckling	0.020	PASS
1.275	1.165	4	Dead Weight + Impact	Buckling	0.020	PASS
1.165	0.950	4	Dead Weight + Impact	Buckling	0.018	PASS
0.950	0.350	4	Dead Weight + Impact	Buckling	0.016	PASS

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0.350	0.305	4	Dead Weight + Impact	Buckling	0.011 PASS
0.305	0.153	4	Dead Weight + Impact	Buckling	0.006 PASS
0.153	0.000	4	Dead Weight + Impact	Buckling	0.001 PASS
0.000	0.000	0			0.000 PASS

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	0.00	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	0.00	0.00	0.00	0.00	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.08	0.00	0.00	0.11	0.11	0.00	145.11	71.15	1.990	1.613	0.001	0.000	0.001
11.257	0.23	0.00	0.00	0.21	0.21	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.40	0.00	0.00	0.27	0.27	0.00	147.09	37.61	2.000	1.442	0.002	0.000	0.002
11.000	0.61	0.00	0.00	0.32	0.32	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.22	0.00	0.00	0.64	0.64	0.00	147.09	29.38	2.000	1.400	0.004	0.000	0.004
10.400	4.22	0.00	0.00	2.21	2.21	0.00	147.09	29.38	2.000	1.400	0.015	0.000	0.015
8.400	26.33	0.00	0.00	13.78	13.78	0.00	147.09	29.38	2.000	1.400	0.094	0.009	0.094
7.667	32.39	0.00	0.00	16.95	16.95	0.00	147.09	29.38	2.000	1.400	0.115	0.013	0.115
6.456	40.26	0.00	0.00	21.07	21.07	0.00	147.09	29.38	2.000	1.400	0.143	0.021	0.143
6.123	41.90	0.00	0.00	11.56	11.56	0.00	147.09	17.46	2.000	1.339	0.079	0.006	0.079
5.789	43.24	0.00	0.00	7.35	7.35	0.00	147.09	14.88	2.000	1.326	0.050	0.002	0.050
5.456	44.25	0.00	0.00	5.09	5.09	0.00	145.82	15.12	1.994	1.327	0.035	0.001	0.035
5.137	44.89	0.00	0.00	5.14	5.14	0.00	145.82	15.12	1.994	1.327	0.035	0.001	0.035
5.000	45.04	0.00	0.00	5.60	5.60	0.00	145.82	15.12	1.994	1.327	0.038	0.002	0.038
4.863	45.05	0.00	0.00	5.18	5.18	0.00	145.82	15.12	1.994	1.327	0.036	0.001	0.036
3.100	38.81	0.00	0.00	4.47	4.47	0.00	145.82	15.12	1.994	1.327	0.031	0.001	0.031
2.450	33.41	0.00	0.00	3.84	3.84	0.00	145.82	15.12	1.994	1.327	0.026	0.001	0.026
1.385	20.65	0.00	0.00	2.37	2.37	0.00	145.82	15.12	1.994	1.327	0.016	0.000	0.016
1.275	19.07	0.00	0.00	2.40	2.40	0.00	145.82	15.12	1.994	1.327	0.016	0.000	0.016
1.165	17.40	0.00	0.00	2.00	2.00	0.00	145.82	15.12	1.994	1.327	0.014	0.000	0.014
0.950	13.96	0.00	0.00	1.61	1.61	0.00	145.82	15.12	1.994	1.327	0.011	0.000	0.011
0.350	3.34	0.00	0.00	0.38	0.38	0.00	145.82	15.12	1.994	1.327	0.003	0.000	0.003
0.305	2.48	0.00	0.00	0.17	0.17	0.00	145.82	147.09	1.994	2.000	0.001	0.000	0.001
0.153	0.92	0.00	0.00	0.06	0.06	0.00	145.82	147.09	1.994	2.000	0.000	0.000	0.000

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 0 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 0.00 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN

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Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.00	3.0	0.466	220.63	0.300	1.080	0.200	1.000	5492.02	220.63	147.09
11.000	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
10.699	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
10.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
8.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3532.85	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.281	1.000	2785.52	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
3.100	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
2.450	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.385	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.275	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.165	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82

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 0.950  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.350  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
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Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
```

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```
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	0.00	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.17	-0.02	0.00	-0.02	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.08	-0.20	-0.02	0.10	0.08	0.00	145.11	71.15	1.990	1.613	0.001	0.000	0.001
11.257	0.22	-0.24	-0.02	0.21	0.19	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.40	-0.28	-0.02	0.27	0.25	0.00	147.09	37.61	2.000	1.442	0.002	0.000	0.002
11.000	0.60	-0.35	-0.02	0.31	0.29	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.20	3.22	0.21	0.63	0.84	0.00	147.09	29.38	2.000	1.400	0.006	0.000	0.006
10.400	4.26	1.98	0.13	2.23	2.36	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	26.73	1.49	0.10	13.99	14.09	0.00	147.09	29.38	2.000	1.400	0.096	0.009	0.096
7.667	32.94	1.19	0.08	17.25	17.32	0.00	147.09	29.38	2.000	1.400	0.118	0.014	0.118
6.456	41.12	0.92	0.06	21.52	21.58	0.00	147.09	29.38	2.000	1.400	0.147	0.022	0.147
6.123	42.85	0.76	0.04	11.82	11.86	0.00	147.09	17.46	2.000	1.339	0.081	0.006	0.081
5.789	44.28	0.59	0.02	7.52	7.55	0.00	147.09	14.88	2.000	1.326	0.051	0.003	0.051
5.456	45.40	0.40	0.01	5.22	5.24	0.00	145.77	15.12	1.993	1.327	0.036	0.001	0.036
5.137	46.13	0.25	0.01	5.28	5.29	0.00	145.79	15.12	1.993	1.327	0.036	0.001	0.036
5.000	46.33	0.08	0.00	5.76	5.76	0.00	145.81	15.12	1.993	1.327	0.039	0.002	0.039
4.863	46.39	-0.55	-0.02	5.34	5.32	0.00	145.88	15.12	1.994	1.327	0.036	0.001	0.036
3.100	40.86	-1.38	-0.04	4.70	4.66	0.00	146.00	15.12	1.994	1.327	0.032	0.001	0.032
2.450	35.76	-2.02	-0.06	4.12	4.05	0.00	146.13	15.12	1.995	1.327	0.028	0.001	0.028
1.385	23.57	-2.45	-0.07	2.71	2.64	0.00	146.38	15.12	1.996	1.327	0.018	0.000	0.018
1.275	22.04	-2.59	-0.08	2.77	2.69	0.00	146.45	15.12	1.997	1.327	0.018	0.000	0.018
1.165	20.44	-2.71	-0.08	2.35	2.27	0.00	146.57	15.12	1.997	1.327	0.015	0.000	0.015
0.950	17.13	-3.01	-0.09	1.97	1.88	0.00	146.83	15.12	1.999	1.327	0.013	0.000	0.013
0.350	6.88	-3.25	-0.10	0.79	0.69	0.00	147.09	15.12	2.000	1.327	0.005	0.000	0.005
0.305	6.05	-3.83	-0.06	0.40	0.34	0.00	147.09	147.09	2.000	2.000	0.002	0.000	0.002
0.153	0.91	1.04	0.02	0.06	0.08	0.00	143.16	147.09	1.980	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 10 Deg
Per EN 1993-3-2: Para 5.2.3

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Nb        = Design Value of Total Vertical Load at Base [5.5]              = 1.04 KN
Ncrit     = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio    = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.03	3.0	0.466	220.63	0.308	1.080	0.197	1.000	5670.24	220.63	147.09
11.000	111.7	5.6275	1.0	1.03	3.1	0.455	220.63	0.308	1.067	0.211	1.000	4978.62	220.63	147.09
10.699	111.7	5.6275	1.0	0.90	3.1	0.455	220.63	0.275	1.067	0.225	1.000	4352.26	220.63	147.09
10.400	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4724.50	220.63	147.09
8.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4815.12	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4819.74	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4822.97	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3528.66	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.282	1.000	2782.32	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.02	218.65	145.77
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.93	218.68	145.79
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2298.77	218.71	145.81
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2302.04	218.82	145.88
3.100	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2307.37	219.01	146.00
2.450	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2312.95	219.19	146.13
1.385	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2323.81	219.56	146.38

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 1.275  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.95 219.67
146.45
 1.165  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.996 2332.22 219.85
146.57
 0.950  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.54 220.24
146.83
 0.350  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.301 1.000 2428.99 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.318 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.279 0.979 0.310 0.973 2299.16 214.75
143.16

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

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```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.01	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.33	-0.03	0.00	-0.03	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.07	-0.39	-0.04	0.10	0.06	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.21	-0.47	-0.04	0.20	0.16	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.38	-0.55	-0.04	0.26	0.22	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.57	-0.70	-0.04	0.30	0.25	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.15	6.47	0.41	0.60	1.01	0.00	147.09	29.38	2.000	1.400	0.007	0.000	0.007
10.400	4.17	4.03	0.26	2.18	2.44	0.00	147.09	29.38	2.000	1.400	0.017	0.000	0.017
8.400	26.29	3.07	0.20	13.76	13.96	0.00	147.09	29.38	2.000	1.400	0.095	0.009	0.095
7.667	32.48	2.47	0.16	17.00	17.16	0.00	147.09	29.38	2.000	1.400	0.117	0.014	0.117
6.456	40.69	1.93	0.12	21.30	21.42	0.00	147.09	29.38	2.000	1.400	0.146	0.021	0.146
6.123	42.46	1.61	0.08	11.71	11.79	0.00	147.09	17.46	2.000	1.339	0.080	0.006	0.080
5.789	43.94	1.29	0.05	7.47	7.51	0.00	147.09	14.88	2.000	1.326	0.051	0.003	0.051
5.456	45.12	0.92	0.03	5.19	5.22	0.00	145.71	15.12	1.993	1.327	0.036	0.001	0.036
5.137	45.93	0.62	0.02	5.26	5.28	0.00	145.75	15.12	1.993	1.327	0.036	0.001	0.036
5.000	46.16	0.28	0.01	5.74	5.74	0.00	145.79	15.12	1.993	1.327	0.039	0.002	0.039
4.863	46.27	-0.96	-0.03	5.32	5.29	0.00	145.93	15.12	1.994	1.327	0.036	0.001	0.036
3.100	41.59	-2.60	-0.08	4.79	4.71	0.00	146.16	15.12	1.995	1.327	0.032	0.001	0.032
2.450	36.96	-3.85	-0.12	4.25	4.14	0.00	146.40	15.12	1.997	1.327	0.028	0.001	0.028
1.385	25.69	-4.71	-0.14	2.95	2.82	0.00	146.82	15.12	1.999	1.327	0.019	0.000	0.019
1.275	24.27	-4.97	-0.16	3.05	2.90	0.00	146.94	15.12	1.999	1.327	0.020	0.000	0.020
1.165	22.77	-5.21	-0.16	2.62	2.46	0.00	147.09	15.12	2.000	1.327	0.017	0.000	0.017
0.950	19.69	-5.81	-0.17	2.27	2.09	0.00	147.09	15.12	2.000	1.327	0.014	0.000	0.014
0.350	10.11	-6.28	-0.19	1.16	0.97	0.00	147.09	15.12	2.000	1.327	0.007	0.000	0.007
0.305	9.34	-7.41	-0.12	0.62	0.51	0.00	147.09	147.09	2.000	2.000	0.003	0.000	0.003
0.153	0.86	2.06	0.03	0.06	0.09	0.00	141.45	147.09	1.971	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

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Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 20 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 2.06 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.07	3.0	0.466	220.63	0.318	1.080	0.193	1.000	5894.65	220.63	147.09
11.000	111.7	5.6275	1.0	1.07	3.1	0.455	220.63	0.318	1.067	0.207	1.000	5166.73	220.63	147.09
10.699	111.7	5.6275	1.0	0.84	3.1	0.455	220.63	0.259	1.067	0.234	1.000	4040.81	220.63	147.09
10.400	111.7	5.6275	1.0	0.96	3.1	0.455	220.63	0.289	1.067	0.218	1.000	4624.50	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4801.08	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4810.46	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4817.08	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3523.86	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2778.52	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.991	2294.27	218.56	145.71
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.13	218.62	145.75
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.76	218.68	145.79
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2304.21	218.90	145.93
3.100	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.302	0.979	0.309	0.994	2314.43	219.25	146.16
2.450	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2324.94	219.60	146.40

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```
 1.385  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.45 220.24
146.82
 1.275  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.306 0.999 2348.77 220.42
146.94
 1.165  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2357.76 220.63
147.09
 0.950  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2376.12 220.63
147.09
 0.350  77.1 5.6275 1.0 1.08 4.6 0.383 220.63 0.319 0.979 0.298 1.000 2477.53 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.323 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.264 0.979 0.310 0.962 2299.16 212.17
141.45

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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 0.305 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09
 0.153 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.01	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.48	-0.05	0.00	-0.05	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.07	-0.57	-0.06	0.09	0.03	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.20	-0.69	-0.06	0.18	0.12	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.35	-0.80	-0.06	0.24	0.18	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.53	-1.02	-0.07	0.28	0.21	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	1.06	9.66	0.62	0.55	1.17	0.00	147.09	29.38	2.000	1.400	0.008	0.000	0.008
10.400	3.95	6.09	0.39	2.07	2.46	0.00	147.09	29.38	2.000	1.400	0.017	0.000	0.017
8.400	25.04	4.69	0.30	13.11	13.41	0.00	147.09	29.38	2.000	1.400	0.091	0.008	0.091
7.667	30.99	3.81	0.24	16.22	16.47	0.00	147.09	29.38	2.000	1.400	0.112	0.013	0.112
6.456	38.98	3.03	0.19	20.41	20.60	0.00	147.09	29.38	2.000	1.400	0.140	0.020	0.140
6.123	40.73	2.56	0.12	11.24	11.35	0.00	147.09	17.46	2.000	1.339	0.077	0.006	0.077
5.789	42.21	2.09	0.08	7.17	7.25	0.00	147.09	14.88	2.000	1.326	0.049	0.002	0.049
5.456	43.42	1.55	0.05	5.00	5.04	0.00	145.62	15.12	1.993	1.327	0.035	0.001	0.035
5.137	44.27	1.11	0.03	5.07	5.10	0.00	145.69	15.12	1.993	1.327	0.035	0.001	0.035
5.000	44.54	0.61	0.02	5.53	5.55	0.00	145.75	15.12	1.993	1.327	0.038	0.001	0.038
4.863	44.68	-1.21	-0.04	5.14	5.11	0.00	145.97	15.12	1.994	1.327	0.035	0.001	0.035
3.100	40.99	-3.59	-0.11	4.72	4.61	0.00	146.31	15.12	1.996	1.327	0.032	0.001	0.032
2.450	36.95	-5.43	-0.16	4.25	4.09	0.00	146.65	15.12	1.998	1.327	0.028	0.001	0.028
1.385	26.93	-6.68	-0.19	3.10	2.90	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.275	25.66	-7.07	-0.22	3.23	3.00	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	24.32	-7.42	-0.22	2.80	2.58	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
0.950	21.56	-8.29	-0.25	2.48	2.23	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015
0.350	12.94	-8.97	-0.27	1.49	1.22	0.00	147.09	15.12	2.000	1.327	0.008	0.000	0.008
0.305	12.24	-10.63	-0.17	0.81	0.65	0.00	147.09	147.09	2.000	2.000	0.004	0.000	0.004
0.153	0.80	3.01	0.05	0.05	0.10	0.00	140.18	147.09	1.965	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
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```
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 30 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 3.01 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.13	3.0	0.466	220.63	0.333	1.080	0.189	1.000	6207.59	220.63	147.09
11.000	111.7	5.6275	1.0	1.12	3.1	0.455	220.63	0.331	1.067	0.202	1.000	5426.67	220.63	147.09
10.699	111.7	5.6275	1.0	0.79	3.1	0.455	220.63	0.247	1.067	0.241	1.000	3809.96	220.63	147.09
10.400	111.7	5.6275	1.0	0.94	3.1	0.455	220.63	0.284	1.067	0.221	1.000	4522.13	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4785.04	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4799.65	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4810.07	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3518.03	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2773.78	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2290.65	218.44	145.62
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.56	218.53	145.69
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.00	218.62	145.75
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2305.72	218.95	145.97

```
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.302 0.979 0.308 0.995 2320.76 219.46
146.31
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.997 2335.93 219.98
146.65
 1.385  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2360.14 220.63
147.09
 1.275  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000 2367.10 220.63
147.09
 1.165  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.309 0.979 0.305 1.000 2378.93 220.63
147.09
 0.950  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2402.08 220.63
147.09
 0.350  77.1 5.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2503.05 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.326 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.253 0.979 0.310 0.953 2299.16 210.27
140.18

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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 1.275 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 1.165 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 0.950 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 0.350 1.00 1.01 0.500 2.205 1.118 0.650  0.000 0.000 0.1028  0.00   45.37  22.69  15.12
 0.305 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09
 0.153 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.62	-0.06	0.00	-0.06	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.06	-0.73	-0.07	0.08	0.01	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.17	-0.88	-0.07	0.16	0.09	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.31	-1.03	-0.08	0.21	0.14	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.47	-1.31	-0.08	0.24	0.16	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	0.94	12.73	0.81	0.49	1.30	0.00	146.11	29.38	1.995	1.400	0.009	0.000	0.009
10.400	3.60	8.13	0.52	1.89	2.40	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	22.99	6.34	0.41	12.04	12.44	0.00	147.09	29.38	2.000	1.400	0.085	0.007	0.085
7.667	28.53	5.21	0.33	14.93	15.27	0.00	147.09	29.38	2.000	1.400	0.104	0.011	0.104
6.456	36.04	4.20	0.27	18.87	19.14	0.00	147.09	29.38	2.000	1.400	0.130	0.017	0.130
6.123	37.71	3.60	0.17	10.40	10.57	0.00	147.09	17.46	2.000	1.339	0.072	0.005	0.072
5.789	39.14	3.00	0.11	6.65	6.76	0.00	147.09	14.88	2.000	1.326	0.046	0.002	0.046
5.456	40.33	2.30	0.07	4.64	4.71	0.00	145.51	15.12	1.992	1.327	0.032	0.001	0.032
5.137	41.21	1.74	0.05	4.72	4.77	0.00	145.60	15.12	1.992	1.327	0.033	0.001	0.033
5.000	41.49	1.10	0.03	5.16	5.19	0.00	145.68	15.12	1.993	1.327	0.036	0.001	0.036
4.863	41.67	-1.24	-0.04	4.80	4.76	0.00	145.98	15.12	1.994	1.327	0.033	0.001	0.033
3.100	39.05	-4.31	-0.13	4.49	4.36	0.00	146.44	15.12	1.997	1.327	0.030	0.001	0.030
2.450	35.71	-6.67	-0.20	4.11	3.91	0.00	146.89	15.12	1.999	1.327	0.027	0.001	0.027
1.385	27.25	-8.28	-0.24	3.13	2.89	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.275	26.17	-8.78	-0.28	3.29	3.01	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	25.02	-9.23	-0.28	2.88	2.60	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
0.950	22.65	-10.35	-0.31	2.61	2.30	0.00	147.09	15.12	2.000	1.327	0.016	0.000	0.016
0.350	15.25	-11.23	-0.34	1.76	1.42	0.00	147.09	15.12	2.000	1.327	0.010	0.000	0.010
0.305	14.65	-13.36	-0.21	0.98	0.77	0.00	147.09	147.09	2.000	2.000	0.005	0.000	0.005
0.153	0.71	3.87	0.06	0.05	0.11	0.00	139.15	147.09	1.960	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
```

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s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 40 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 3.87 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.22	3.0	0.466	220.63	0.356	1.080	0.181	1.000	6712.18	220.63	147.09
11.000	111.7	5.6275	1.0	1.21	3.1	0.455	220.63	0.352	1.067	0.194	1.000	5840.15	220.63	147.09
10.699	111.7	5.6275	1.0	0.75	3.1	0.455	220.63	0.238	1.067	0.247	0.993	3622.67	219.16	146.11
10.400	111.7	5.6275	1.0	0.91	3.1	0.455	220.63	0.278	1.067	0.224	1.000	4410.67	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4765.34	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4786.11	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4801.11	220.63	147.09
6.123	95.5	5.6275	1.0	0.99	3.7	0.427	220.63	0.298	1.033	0.251	1.000	3510.47	220.63	147.09
5.789	84.8	5.6275	1.0	0.99	4.1	0.403	220.63	0.298	1.004	0.282	1.000	2767.47	220.63	147.09
5.456	77.1	5.6275	1.0	0.99	4.6	0.383	220.63	0.299	0.979	0.311	0.989	2285.64	218.27	145.51
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2289.79	218.41	145.60

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 5.000  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2293.11 218.52
145.68
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.301 0.979 0.309 0.992 2306.41 218.97
145.98
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.52 219.66
146.44
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.999 2346.40 220.34
146.89
 1.385  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2374.99 220.63
147.09
 1.275  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2383.26 220.63
147.09
 1.165  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2397.40 220.63
147.09
 0.950  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2424.03 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.324 0.979 0.296 1.000 2518.57 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.327 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.244 0.979 0.310 0.946 2299.16 208.72
139.15

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.74	-0.07	0.00	-0.07	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.05	-0.87	-0.09	0.07	-0.02	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.15	-1.05	-0.09	0.13	0.05	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.26	-1.23	-0.09	0.18	0.09	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.39	-1.56	-0.10	0.20	0.10	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	0.79	15.65	1.00	0.41	1.41	0.00	144.62	29.38	1.987	1.400	0.010	0.000	0.010
10.400	3.14	10.17	0.65	1.64	2.29	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	20.21	8.03	0.51	10.58	11.09	0.00	147.09	29.38	2.000	1.400	0.075	0.006	0.075
7.667	25.15	6.68	0.43	13.17	13.59	0.00	147.09	29.38	2.000	1.400	0.092	0.009	0.092
6.456	31.94	5.49	0.35	16.72	17.07	0.00	147.09	29.38	2.000	1.400	0.116	0.013	0.116
6.123	33.47	4.77	0.22	9.23	9.46	0.00	147.09	17.46	2.000	1.339	0.064	0.004	0.064
5.789	34.81	4.05	0.15	5.91	6.06	0.00	147.09	14.88	2.000	1.326	0.041	0.002	0.041
5.456	35.94	3.22	0.10	4.14	4.23	0.00	145.34	15.12	1.991	1.327	0.029	0.001	0.029
5.137	36.80	2.55	0.07	4.22	4.29	0.00	145.47	15.12	1.992	1.327	0.029	0.001	0.029
5.000	37.09	1.78	0.06	4.61	4.66	0.00	145.57	15.12	1.992	1.327	0.032	0.001	0.032
4.863	37.30	-1.01	-0.03	4.29	4.26	0.00	145.97	15.12	1.994	1.327	0.029	0.001	0.029
3.100	35.81	-4.66	-0.14	4.12	3.98	0.00	146.55	15.12	1.997	1.327	0.027	0.001	0.027
2.450	33.26	-7.47	-0.22	3.83	3.60	0.00	147.09	15.12	2.000	1.327	0.024	0.001	0.024
1.385	26.59	-9.39	-0.27	3.06	2.79	0.00	147.09	15.12	2.000	1.327	0.019	0.000	0.019
1.275	25.72	-9.99	-0.31	3.23	2.92	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	24.80	-10.52	-0.32	2.85	2.54	0.00	147.09	15.12	2.000	1.327	0.017	0.000	0.017
0.950	22.90	-11.85	-0.36	2.64	2.28	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015
0.350	16.93	-12.90	-0.39	1.95	1.56	0.00	147.09	15.12	2.000	1.327	0.011	0.000	0.011
0.305	16.45	-15.45	-0.24	1.09	0.85	0.00	147.09	147.09	2.000	2.000	0.006	0.000	0.006
0.153	0.59	4.61	0.07	0.04	0.11	0.00	138.24	147.09	1.955	2.000	0.001	0.000	0.001

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   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 50 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 4.61 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.41	3.0	0.466	220.63	0.403	1.080	0.169	1.000	7752.70	220.63	147.09
11.000	111.7	5.6275	1.0	1.38	3.1	0.455	220.63	0.395	1.067	0.182	1.000	6671.30	220.63	147.09
10.699	111.7	5.6275	1.0	0.72	3.1	0.455	220.63	0.229	1.067	0.253	0.983	3459.45	216.93	144.62
10.400	111.7	5.6275	1.0	0.89	3.1	0.455	220.63	0.272	1.067	0.227	1.000	4281.00	220.63	147.09
8.400	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4738.88	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4767.53	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4788.55	220.63	147.09
6.123	95.5	5.6275	1.0	0.99	3.7	0.427	220.63	0.298	1.033	0.251	1.000	3499.72	220.63	147.09
5.789	84.8	5.6275	1.0	0.99	4.1	0.403	220.63	0.298	1.004	0.283	1.000	2758.33	220.63	147.09

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 5.456  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2278.11 218.01
145.34
 5.137  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.989 2283.88 218.21
145.47
 5.000  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.311 0.990 2288.22 218.35
145.57
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.301 0.979 0.309 0.992 2305.71 218.95
145.97
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.996 2331.60 219.83
146.55
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2356.59 220.63
147.09
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.52 220.63
147.09
 1.275  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2397.91 220.63
147.09
 1.165  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.302 1.000 2413.99 220.63
147.09
 0.950  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.316 0.979 0.301 1.000 2443.28 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.325 0.979 0.295 1.000 2528.26 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.328 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.235 0.979 0.310 0.940 2299.16 207.37
138.24

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46

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5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.83	-0.08	0.00	-0.08	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.04	-0.99	-0.10	0.05	-0.05	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.11	-1.19	-0.10	0.10	0.00	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.20	-1.39	-0.10	0.14	0.04	0.00	147.09	37.61	2.000	1.442	0.000	0.000	0.000
11.000	0.30	-1.77	-0.11	0.16	0.05	0.00	147.09	29.38	2.000	1.400	0.000	0.000	0.000
10.699	0.61	18.47	1.18	0.32	1.50	0.00	143.23	29.38	1.980	1.400	0.010	0.000	0.010
10.400	2.58	12.28	0.78	1.35	2.13	0.00	147.09	29.38	2.000	1.400	0.015	0.000	0.015
8.400	16.75	9.85	0.63	8.77	9.40	0.00	147.09	29.38	2.000	1.400	0.064	0.004	0.064
7.667	20.93	8.33	0.53	10.95	11.49	0.00	147.09	29.38	2.000	1.400	0.078	0.006	0.078
6.456	26.75	6.98	0.45	14.00	14.45	0.00	147.09	29.38	2.000	1.400	0.098	0.010	0.098
6.123	28.10	6.17	0.29	7.75	8.04	0.00	147.09	17.46	2.000	1.339	0.055	0.003	0.055
5.789	29.28	5.35	0.20	4.98	5.17	0.00	147.09	14.88	2.000	1.326	0.035	0.001	0.035
5.456	30.31	4.41	0.13	3.49	3.62	0.00	145.05	15.12	1.990	1.327	0.025	0.001	0.025
5.137	31.13	3.66	0.10	3.57	3.67	0.00	145.24	15.12	1.991	1.327	0.025	0.001	0.025
5.000	31.41	2.79	0.09	3.90	3.99	0.00	145.36	15.12	1.991	1.327	0.027	0.001	0.027
4.863	31.63	-0.36	-0.01	3.64	3.63	0.00	145.88	15.12	1.994	1.327	0.025	0.001	0.025
3.100	31.27	-4.49	-0.14	3.60	3.46	0.00	146.63	15.12	1.998	1.327	0.024	0.001	0.024
2.450	29.58	-7.67	-0.23	3.40	3.17	0.00	147.09	15.12	2.000	1.327	0.022	0.000	0.022
1.385	24.87	-9.84	-0.28	2.86	2.58	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
1.275	24.25	-10.51	-0.33	3.05	2.72	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
1.165	23.58	-11.11	-0.33	2.71	2.38	0.00	147.09	15.12	2.000	1.327	0.016	0.000	0.016
0.950	22.20	-12.62	-0.38	2.55	2.17	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015

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 0.350  17.83 -13.81 -0.42  2.05  1.64  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.305  17.47 -16.68 -0.26  1.16  0.90  0.00 147.09 147.09 2.000 2.000 0.006 0.000 0.006
 0.153   0.46   5.21  0.08  0.03  0.11  0.00 137.40 147.09 1.951 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 60 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.21 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	2.12	3.0	0.466	220.63	0.580	1.080	0.138	1.000	11650.99	220.63	147.09
11.000	111.7	5.6275	1.0	1.98	3.1	0.455	220.63	0.544	1.067	0.152	1.000	9549.63	220.63	147.09
10.699	111.7	5.6275	1.0	0.69	3.1	0.455	220.63	0.221	1.067	0.258	0.974	3308.53	214.85	143.23
10.400	111.7	5.6275	1.0	0.85	3.1	0.455	220.63	0.263	1.067	0.231	1.000	4118.08	220.63	147.09
8.400	111.7	5.6275	1.0	0.97	3.1	0.455	220.63	0.293	1.067	0.217	1.000	4698.81	220.63	147.09
7.667	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4738.66	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4768.59	220.63	147.09

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```
 6.123  95.5 5.6275 1.0 0.99 3.7 0.427 220.63 0.296 1.033 0.252 1.000  3482.41 220.63
147.09
 5.789  84.8 5.6275 1.0 0.98 4.1 0.403 220.63 0.296 1.004 0.284 1.000  2743.35 220.63
147.09
 5.456  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.296 0.979 0.312 0.986  2265.39 217.58
145.05
 5.137  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.312 0.987  2273.52 217.85
145.24
 5.000  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988  2279.11 218.04
145.36
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992  2301.91 218.82
145.88
 3.100  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.997  2335.08 219.95
146.63
 2.450  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000  2366.07 220.63
147.09
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000  2400.42 220.63
147.09
 1.275  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000  2410.83 220.63
147.09
 1.165  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.301 1.000  2428.57 220.63
147.09
 0.950  77.1 5.6275 1.0 1.07 4.6 0.383 220.63 0.317 0.979 0.299 1.000  2459.98 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.325 0.979 0.295 1.000  2533.05 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.329 0.979 0.310 1.000  2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.227 0.979 0.310 0.934  2299.16 206.10
137.40

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38

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8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.91	-0.09	0.00	-0.09	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.03	-1.07	-0.11	0.04	-0.07	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.08	-1.29	-0.11	0.07	-0.04	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.14	-1.51	-0.11	0.09	-0.02	0.00	NaN	37.61	NaN	1.442	0.000	0.000	0.000
11.000	0.21	-1.92	-0.12	0.11	-0.01	0.00	NaN	29.38	NaN	1.400	0.000	0.000	0.000
10.699	0.42	21.48	1.37	0.22	1.59	0.00	141.87	29.38	1.973	1.400	0.011	0.000	0.011
10.400	1.92	14.77	0.94	1.01	1.95	0.00	147.09	29.38	2.000	1.400	0.013	0.000	0.013
8.400	12.67	12.14	0.78	6.63	7.41	0.00	147.09	29.38	2.000	1.400	0.050	0.003	0.050
7.667	15.91	10.49	0.67	8.33	9.00	0.00	147.09	29.38	2.000	1.400	0.061	0.004	0.061
6.456	20.53	9.02	0.58	10.75	11.32	0.00	147.09	29.38	2.000	1.400	0.077	0.006	0.077
6.123	21.62	8.13	0.38	5.96	6.34	0.00	147.09	17.46	2.000	1.339	0.043	0.002	0.043
5.789	22.61	7.25	0.27	3.84	4.11	0.00	147.09	14.88	2.000	1.326	0.028	0.001	0.028
5.456	23.49	6.23	0.19	2.70	2.89	0.00	144.46	15.12	1.987	1.327	0.020	0.000	0.020
5.137	24.21	5.41	0.15	2.77	2.92	0.00	144.74	15.12	1.988	1.327	0.020	0.000	0.020
5.000	24.48	4.47	0.14	3.04	3.18	0.00	144.90	15.12	1.989	1.327	0.022	0.001	0.022
4.863	24.71	1.05	0.03	2.84	2.87	0.00	145.59	15.12	1.992	1.327	0.020	0.000	0.020
3.100	25.38	-3.43	-0.10	2.92	2.82	0.00	146.58	15.12	1.997	1.327	0.019	0.000	0.019
2.450	24.57	-6.87	-0.21	2.83	2.62	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018

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```
 1.385  21.90  -9.23 -0.27  2.52  2.25  0.00 147.09  15.12 2.000 1.327 0.015 0.000 0.015
 1.275  21.54  -9.96 -0.31  2.71  2.40  0.00 147.09  15.12 2.000 1.327 0.016 0.000 0.016
 1.165  21.14 -10.62 -0.32  2.43  2.11  0.00 147.09  15.12 2.000 1.327 0.014 0.000 0.014
 0.950  20.31 -12.25 -0.37  2.34  1.97  0.00 147.09  15.12 2.000 1.327 0.013 0.000 0.013
 0.350  17.63 -13.54 -0.41  2.03  1.62  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.305  17.41 -16.66 -0.26  1.16  0.90  0.00 147.09 147.09 2.000 2.000 0.006 0.000 0.006
 0.153   0.31   5.65  0.09  0.02  0.11  0.00 136.56 147.09 1.946 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 70 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.65 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	-1.76	3.0	0.466	220.63	-0.391	1.080	NaN	NaN	-9686.24	NaN	NaN
11.000	111.7	5.6275	1.0	-2.58	3.1	0.455	220.63	-0.595	1.067	NaN	NaN	-12459.55	NaN	NaN
10.699	111.7	5.6275	1.0	0.65	3.1	0.455	220.63	0.214	1.067	0.264	0.965	3162.27	212.81	141.87
10.400	111.7	5.6275	1.0	0.81	3.1	0.455	220.63	0.252	1.067	0.238	1.000	3893.06	220.63	147.09
8.400	111.7	5.6275	1.0	0.96	3.1	0.455	220.63	0.290	1.067	0.218	1.000	4625.97	220.63	147.09

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 7.667 111.7 5.6275 1.0  0.97 3.1 0.455 220.63  0.293 1.067 0.217 1.000   4684.35 220.63
147.09
 6.456 111.7 5.6275 1.0  0.98 3.1 0.455 220.63  0.295 1.067 0.216 1.000   4729.91 220.63
147.09
 6.123  95.5 5.6275 1.0  0.98 3.7 0.427 220.63  0.294 1.033 0.253 1.000   3448.55 220.63
147.09
 5.789  84.8 5.6275 1.0  0.97 4.1 0.403 220.63  0.294 1.004 0.285 1.000   2713.59 220.63
147.09
 5.456  77.1 5.6275 1.0  0.97 4.6 0.383 220.63  0.294 0.979 0.314 0.982   2239.42 216.70
144.46
 5.137  77.1 5.6275 1.0  0.98 4.6 0.383 220.63  0.295 0.979 0.313 0.984   2251.58 217.11
144.74
 5.000  77.1 5.6275 1.0  0.98 4.6 0.383 220.63  0.296 0.979 0.313 0.985   2258.88 217.36
144.90
 4.863  77.1 5.6275 1.0  1.00 4.6 0.383 220.63  0.299 0.979 0.310 0.990   2289.01 218.38
145.59
 3.100  77.1 5.6275 1.0  1.01 4.6 0.383 220.63  0.304 0.979 0.308 0.997   2332.87 219.87
146.58
 2.450  77.1 5.6275 1.0  1.03 4.6 0.383 220.63  0.308 0.979 0.305 1.000   2371.83 220.63
147.09
 1.385  77.1 5.6275 1.0  1.05 4.6 0.383 220.63  0.312 0.979 0.303 1.000   2407.81 220.63
147.09
 1.275  77.1 5.6275 1.0  1.05 4.6 0.383 220.63  0.313 0.979 0.302 1.000   2419.28 220.63
147.09
 1.165  77.1 5.6275 1.0  1.06 4.6 0.383 220.63  0.315 0.979 0.301 1.000   2438.33 220.63
147.09
 0.950  77.1 5.6275 1.0  1.08 4.6 0.383 220.63  0.319 0.979 0.299 1.000   2471.65 220.63
147.09
 0.350  77.1 5.6275 1.0  1.10 4.6 0.383 220.63  0.325 0.979 0.295 1.000   2530.51 220.63
147.09
 0.305   2.1 0.1525 1.0  1.00 4.6 0.383 220.63  0.329 0.979 0.310 1.000   2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0  1.00 4.6 0.383 220.63  0.219 0.979 0.310 0.928   2299.16 204.84
136.56

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28

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11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.95	-0.10	0.00	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.01	-1.12	-0.11	0.02	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.04	-1.35	-0.11	0.04	-0.08	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.07	-1.58	-0.12	0.05	-0.07	0.00	126.03	37.61	1.893	1.442	0.000	0.000	0.000
11.000	0.11	-2.01	-0.13	0.06	-0.07	0.00	122.06	29.38	1.872	1.400	0.000	0.000	0.000
10.699	0.21	26.02	1.66	0.11	1.77	0.00	140.51	29.38	1.966	1.400	0.013	0.000	0.013
10.400	1.16	18.97	1.21	0.61	1.82	0.00	145.37	29.38	1.991	1.400	0.013	0.000	0.013
8.400	7.85	16.22	1.04	4.11	5.15	0.00	147.09	29.38	2.000	1.400	0.035	0.001	0.035
7.667	9.95	14.49	0.93	5.21	6.13	0.00	147.09	29.38	2.000	1.400	0.042	0.002	0.042
6.456	13.04	12.95	0.83	6.83	7.65	0.00	147.09	29.38	2.000	1.400	0.052	0.003	0.052
6.123	13.80	12.02	0.56	3.81	4.37	0.00	147.09	17.46	2.000	1.339	0.030	0.001	0.030
5.789	14.51	11.10	0.41	2.47	2.87	0.00	146.61	14.88	1.998	1.326	0.020	0.000	0.020
5.456	15.16	10.03	0.30	1.74	2.05	0.00	142.75	15.12	1.978	1.327	0.014	0.000	0.014
5.137	15.73	9.17	0.26	1.80	2.06	0.00	143.23	15.12	1.980	1.327	0.014	0.000	0.014

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 5.000  15.95   8.19  0.26  1.98  2.24  0.00 143.45  15.12 1.981 1.327 0.016 0.000 0.016
 4.863  16.14   4.60  0.14  1.86  2.00  0.00 144.37  15.12 1.986 1.327 0.014 0.000 0.014
 3.100  17.57  -0.09  0.00  2.02  2.02  0.00 145.85  15.12 1.994 1.327 0.014 0.000 0.014
 2.450  17.56  -3.70 -0.11  2.02  1.91  0.00 147.04  15.12 2.000 1.327 0.013 0.000 0.013
 1.385  16.87  -6.18 -0.18  1.94  1.76  0.00 147.09  15.12 2.000 1.327 0.012 0.000 0.012
 1.275  16.75  -6.94 -0.22  2.11  1.89  0.00 147.09  15.12 2.000 1.327 0.013 0.000 0.013
 1.165  16.61  -7.63 -0.23  1.91  1.68  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.950  16.32  -9.34 -0.28  1.88  1.60  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.350  15.34 -10.69 -0.32  1.76  1.44  0.00 147.09  15.12 2.000 1.327 0.010 0.000 0.010
 0.305  15.25 -13.96 -0.22  1.02  0.80  0.00 147.09 147.09 2.000 2.000 0.005 0.000 0.005
 0.153   0.16   5.92  0.09  0.01  0.10  0.00 135.66 147.09 1.942 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 80 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.92 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	0.32	3.0	0.466	220.63	0.129	1.080	0.356	0.857	1741.04	189.05	126.03
11.000	111.7	5.6275	1.0	0.30	3.1	0.455	220.63	0.124	1.067	0.392	0.830	1438.01	183.09	122.06
10.699	111.7	5.6275	1.0	0.63	3.1	0.455	220.63	0.206	1.067	0.270	0.955	3017.84	210.77	140.51

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10.400 111.7 5.6275 1.0 0.73 3.1 0.455 220.63 0.233 1.067 0.250 0.988 3541.13 218.05
145.37
 8.400 111.7 5.6275 1.0 0.92 3.1 0.455 220.63 0.280 1.067 0.223 1.000 4439.19 220.63
147.09
 7.667 111.7 5.6275 1.0 0.94 3.1 0.455 220.63 0.285 1.067 0.221 1.000 4536.61 220.63
147.09
 6.456 111.7 5.6275 1.0 0.96 3.1 0.455 220.63 0.289 1.067 0.219 1.000 4619.38 220.63
147.09
 6.123  95.5 5.6275 1.0 0.95 3.7 0.427 220.63 0.287 1.033 0.257 1.000 3351.83 220.63
147.09
 5.789  84.8 5.6275 1.0 0.94 4.1 0.403 220.63 0.286 1.004 0.290 0.997 2628.03 219.92
146.61
 5.456  77.1 5.6275 1.0 0.94 4.6 0.383 220.63 0.285 0.979 0.319 0.970 2163.39 214.12
142.75
 5.137  77.1 5.6275 1.0 0.95 4.6 0.383 220.63 0.288 0.979 0.318 0.974 2184.56 214.84
143.23
 5.000  77.1 5.6275 1.0 0.95 4.6 0.383 220.63 0.289 0.979 0.317 0.975 2194.30 215.17
143.45
 4.863  77.1 5.6275 1.0 0.97 4.6 0.383 220.63 0.293 0.979 0.314 0.982 2235.30 216.56
144.37
 3.100  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2300.45 218.77
145.85
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2352.91 220.56
147.04
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2392.12 220.63
147.09
 1.275  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2405.34 220.63
147.09
 1.165  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2424.73 220.63
147.09
 0.950  77.1 5.6275 1.0 1.07 4.6 0.383 220.63 0.318 0.979 0.299 1.000 2461.19 220.63
147.09
 0.350  77.1 5.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2504.40 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.328 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.210 0.979 0.310 0.922 2299.16 203.49
135.66

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa

11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.96	-0.10	0.00	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.00	-1.14	-0.12	0.00	-0.12	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.00	-1.37	-0.12	0.00	-0.12	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.00	-1.60	-0.12	0.00	-0.12	0.00	141.19	37.61	1.970	1.442	0.000	0.000	0.000
11.000	0.00	-2.04	-0.13	0.00	-0.13	0.00	139.35	29.38	1.961	1.400	0.000	0.000	0.000
10.699	0.00	49.87	3.19	0.00	3.19	0.00	139.35	29.38	1.961	1.400	0.023	0.001	0.023
10.400	0.00	40.04	2.56	0.00	2.56	0.00	139.35	29.38	1.961	1.400	0.018	0.000	0.018
8.400	0.00	37.24	2.38	0.00	2.38	0.00	139.35	29.38	1.961	1.400	0.017	0.000	0.017
7.667	0.00	35.49	2.27	0.00	2.27	0.00	139.35	29.38	1.961	1.400	0.016	0.000	0.016
6.456	0.00	33.92	2.17	0.00	2.17	0.00	139.35	29.38	1.961	1.400	0.016	0.000	0.016

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```
 6.123   0.00 32.98  1.53  0.00  1.53  0.00 134.09  17.46 1.934 1.339 0.011 0.000 0.011
 5.789   0.00 32.04  1.17  0.00  1.17  0.00 129.16  14.88 1.909 1.326 0.009 0.000 0.009
 5.456   0.00 30.96  0.93  0.00  0.93  0.00 124.44  15.12 1.885 1.327 0.007 0.000 0.007
 5.137   0.00 30.09  0.84  0.00  0.84  0.00 124.44  15.12 1.885 1.327 0.007 0.000 0.007
 5.000   0.00 29.09  0.91  0.00  0.91  0.00 124.44  15.12 1.885 1.327 0.007 0.000 0.007
 4.863   0.00 25.45  0.77  0.00  0.77  0.00 124.44  15.12 1.885 1.327 0.006 0.000 0.006
 3.100   0.00 20.68  0.62  0.00  0.62  0.00 124.44  15.12 1.885 1.327 0.005 0.000 0.005
 2.450   0.00 17.01  0.51  0.00  0.51  0.00 124.44  15.12 1.885 1.327 0.004 0.000 0.004
 1.385   0.00 14.50  0.42  0.00  0.42  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 1.275   0.00 13.73  0.43  0.00  0.43  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 1.165   0.00 13.03  0.39  0.00  0.39  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 0.950   0.00 11.29  0.34  0.00  0.34  0.00 124.44  15.12 1.885 1.327 0.003 0.000 0.003
 0.350   0.00  9.92  0.30  0.00  0.30  0.00 124.44  15.12 1.885 1.327 0.002 0.000 0.002
 0.305   0.00  6.60  0.10  0.00  0.10  0.00 134.65 147.09 1.937 2.000 0.001 0.000 0.001
 0.153   0.00  6.02  0.09  0.00  0.09  0.00 134.65 147.09 1.937 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 90 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 6.02 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev    w     l    Cxb  Cx  Dwk   ax    Fyk   Lxo   Lpx    Lx    Xx  s_xRcr  s_xRk
s_xRd
  m           m             mm          MPa                           MPa     MPa
MPa
------ ----- ------ --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ----
--
11.500 139.9 5.6275 1.0 0.60 2.5 0.491 206.84 0.200 1.108 0.217 0.988 4374.86 204.46
136.31
11.467 139.9 5.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 139.9 5.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 128.2 5.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 119.1 5.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
```

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```
11.000 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 7.667 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123  95.5 5.6275 1.0 0.60 3.7 0.427 220.63 0.200 1.033 0.323 0.912 2119.71 201.14
134.09
 5.789  84.8 5.6275 1.0 0.60 4.1 0.403 220.63 0.200 1.004 0.363 0.878 1671.31 193.74
129.16
 5.456  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.137  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.000  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 4.863  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 3.100  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 2.450  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.385  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.275  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.165  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.950  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.350  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.200 0.979 0.310 0.915 2299.16 201.98
134.65
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.200 0.979 0.310 0.915 2299.16 201.98
134.65

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

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Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Structural Flange Analysis, Angle = 0 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 0 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 0.8 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= 0 N
S	= Shear Load on Flange	= 25 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm

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```
Tw        = Fillet Weld Size                                          = 6.0 mm

Db        = Nominal Bolt Diameter                                     = 22.2 mm
Nb        = Number of Bolts                                           = 12
Fu        = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu              = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb        = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys       = Yield Stress of Shell                                     = 215.81 MPa
Fw        = Tensile Stress of Weld                                    = 413.68 MPa
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                = 194.22 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt            = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters          = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                           = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                      = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N   = 1 N
Ab        = Nominal Area of Bolt                                      = 3.879 sq cm
Km        = Stiffness of Material                                     = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                         = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)    = 0.173
Fby       = Bolt Yield Stress                                         = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                              = 761869.3
KPa
Aroot     = Bolt Root Area                                            = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}          = 123659 N
K         = Coefficient of Thread Friction                            = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                   = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                  = 1 N
Fact      = Actual force on bolt                                      = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi      = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                = 144440 N
Ratio     = Fb / Fbcomb                                               = 0.856

Sh        = Shear on Bolt                                             = 2 N
Sallow    = Allowable Shear on Bolt                                   = 92281 N
Ratio     = Sh / Sallow                                               = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                        = 11310.74
cm^4
```

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```
Jw        = Polar Moment of Inertia for Weld                          = 22621.48
cm^4
Aw        = Area of Weld                                              = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                        = 1.2 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw               = 124.11 MPa
Ratio     = Fba / Sw                                                  = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                              = 87.6 mm
Lg        = Gross Flange area for each bolt                           = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                 = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                          = 54.0 mm
A         = Distance from Bolt CL to Flange OD                        = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                = 42.9 mm
Rho       = Calculated Parameter                                      = 3.377
Beta      = Calulcated Parameter                                      = 70918.0591
Alpha'    = Alpha where treq'd is minimum                             = 1
Tc        = Required thickness to develop load w/no prying            = 0.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                          = 0
Q         = Prying Force per bolt                                     = 0 N
Treq'd    = Required Flange Thickness                                 = 0.1 mm
Ratio     = Treqd / Tf                                                = 0.002
```

Structural Flange Analysis, Angle = 10 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 10 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                          = 0.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -4 N
S         = Shear Load on Flange                                      = 24 N

Ds        = Outer Diameter of Shell                                   = 323.8 mm
Do        = Outside Diameter of Flange                                = 482.6 mm
Dbc       = Bolt Circle Diameter                                      = 431.8 mm
Tf        = Thickness of Flange                                       = 31.8 mm
Tw        = Fillet Weld Size                                          = 6.0 mm

Db        = Nominal Bolt Diameter                                     = 22.2 mm
Nb        = Number of Bolts                                           = 12
Fu        = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu              = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb        = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys       = Yield Stress of Shell                                     = 215.81 MPa
Fw        = Tensile Stress of Weld                                    = 413.68 MPa
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                = 194.22 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa
```

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```
Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                  = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters               = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                                = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                           = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N        = 0 N
Ab        = Nominal Area of Bolt                                           = 3.879 sq cm
Km        = Stiffness of Material                                          = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                              = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)         = 0.173
Fby       = Bolt Yield Stress                                              = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                   = 761869.3
KPa
Aroot     = Bolt Root Area                                                 = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}               = 123659 N
K         = Coefficient of Thread Friction                                 = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                        = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                       = 0 N
Fact      = Actual force on bolt                                           = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact     = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi           = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                     = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                     = 144440 N
Ratio     = Fb / Fbcomb                                                    = 0.856

Sh        = Shear on Bolt                                                  = 2 N
Sallow    = Allowable Shear on Bolt                                        = 92281 N
Ratio     = Sh / Sallow                                                    = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                             = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                               = 22621.48
cm^4
Aw        = Area of Weld                                                   = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                             = 1.7 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                    = 124.11 MPa
Ratio     = Fba / Sw                                                       = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                   = 87.6 mm
Lg        = Gross Flange area for each bolt                                = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                     = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                      = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                               = 54.0 mm
A         = Distance from Bolt CL to Flange OD                             = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                     = 42.9 mm
Rho       = Calculated Parameter                                           = 3.377
Beta      = Calulcated Parameter                                           = 169521.3588
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```
Alpha'    = Alpha where treq'd is minimum                          = 1
Tc        = Required thickness to develop load w/no prying         = 0.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 0.0 mm
Ratio     = Treqd / Tf                                             = 0.002
```

Structural Flange Analysis, Angle = 20 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 20 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 0.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -8 N
S         = Shear Load on Flange                                   = 23 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa

Fys       = Yield Stress of Shell                                  = 215.81 MPa
Fw        = Tensile Stress of Weld                                 = 413.68 MPa
Fyc       = Yield Stress of Flange                                 = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy             = 194.22 MPa
E         = Modulus of Elasticity of Flange                        = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt         = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters       = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                        = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                   = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                   = 3.879 sq cm
Km        = Stiffness of Material                                  = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                      = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)  = 0.173
Fby       = Bolt Yield Stress                                      = 896316.8
KPa
```

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```
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 0 N
Fact      = Actual force on bolt                                          = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144440 N
Ratio     = Fb / Fbcomb                                                   = 0.856

Sh        = Shear on Bolt                                                 = 2 N
Sallow    = Allowable Shear on Bolt                                       = 92281 N
Ratio     = Sh / Sallow                                                   = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw        = Area of Weld                                                  = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                            = 2.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                   = 124.11 MPa
Ratio     = Fba / Sw                                                      = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                  = 87.6 mm
Lg        = Gross Flange area for each bolt                               = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                    = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                     = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                              = 54.0 mm
A         = Distance from Bolt CL to Flange OD                            = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                    = 42.9 mm
Rho       = Calculated Parameter                                          = 3.377
Beta      = Calulcated Parameter                                          = 0
Alpha'    = Alpha where treq'd is minimum                                 = 0
Tc        = Required thickness to develop load w/no prying                = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                              = 0
Q         = Prying Force per bolt                                         = 0 N
Treq'd    = Required Flange Thickness                                     = 0.0 mm
Ratio     = Treqd / Tf                                                    = 0.000
```

Structural Flange Analysis, Angle = 30 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 30 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                              = 0.7 N-m
V         = Vertical Load on Flange (- is compression, + is tension)      = -12 N
S         = Shear Load on Flange                                          = 22 N
```

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```
Ds        = Outer Diameter of Shell                                  = 323.8 mm
Do        = Outside Diameter of Flange                               = 482.6 mm
Dbc       = Bolt Circle Diameter                                     = 431.8 mm
Tf        = Thickness of Flange                                      = 31.8 mm
Tw        = Fillet Weld Size                                         = 6.0 mm

Db        = Nominal Bolt Diameter                                    = 22.2 mm
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu             = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy               = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 0 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.856

Sh        = Shear on Bolt                                            = 2 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.000
```

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```
Check Welding
Iw        = Bending Moment of Inertia for Weld                          = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                            = 22621.48
cm^4
Aw        = Area of Weld                                                = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                          = 2.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                 = 124.11 MPa
Ratio     = Fba / Sw                                                    = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 40 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 40 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 0.6 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -16 N
S         = Shear Load on Flange                                        = 19 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
```

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```
Fyc       = Yield Stress of Flange                                  = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy              = 194.22 MPa
E         = Modulus of Elasticity of Flange                         = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt          = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters        = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                         = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                    = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N = 0 N
Ab        = Nominal Area of Bolt                                    = 3.879 sq cm
Km        = Stiffness of Material                                   = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                       = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)  = 0.173
Fby       = Bolt Yield Stress                                       = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                            = 761869.3
KPa
Aroot     = Bolt Root Area                                          = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}        = 123659 N
K         = Coefficient of Thread Friction                          = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                 = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                = 0 N
Fact      = Actual force on bolt                                    = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi    = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)              = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)              = 144440 N
Ratio     = Fb / Fbcomb                                             = 0.856

Sh        = Shear on Bolt                                           = 2 N
Sallow    = Allowable Shear on Bolt                                 = 92281 N
Ratio     = Sh / Sallow                                             = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                      = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                        = 22621.48
cm^4
Aw        = Area of Weld                                            = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                      = 2.7 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw             = 124.11 MPa
Ratio     = Fba / Sw                                                = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                            = 87.6 mm
Lg        = Gross Flange area for each bolt                         = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area              = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge               = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                        = 54.0 mm
```

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```
A          = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho        = Calculated Parameter                                        = 3.377
Beta       = Calulcated Parameter                                        = 0
Alpha'     = Alpha where treq'd is minimum                               = 0
Tc         = Required thickness to develop load w/no prying              = 0.0 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                            = 0
Q          = Prying Force per bolt                                       = 0 N
Treq'd     = Required Flange Thickness                                   = 0.0 mm
Ratio      = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 50 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 50 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M          = Moment on Flange                                            = 0.5 N-m
V          = Vertical Load on Flange (- is compression, + is tension)    = -19 N
S          = Shear Load on Flange                                        = 16 N

Ds         = Outer Diameter of Shell                                     = 323.8 mm
Do         = Outside Diameter of Flange                                  = 482.6 mm
Dbc        = Bolt Circle Diameter                                        = 431.8 mm
Tf         = Thickness of Flange                                         = 31.8 mm
Tw         = Fillet Weld Size                                            = 6.0 mm

Db         = Nominal Bolt Diameter                                       = 22.2 mm
Nb         = Number of Bolts                                             = 12
Fu         = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb         = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys        = Yield Stress of Shell                                       = 215.81 MPa
Fw         = Tensile Stress of Weld                                      = 413.68 MPa
Fyc        = Yield Stress of Flange                                      = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E          = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 0 N
Ab         = Nominal Area of Bolt                                        = 3.879 sq cm
Km         = Stiffness of Material                                       = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                           = 1238416.78
N/mm
```

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```
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)          = 0.173
Fby       = Bolt Yield Stress                                               = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                    = 761869.3
KPa
Aroot     = Bolt Root Area                                                  = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}                = 123659 N
K         = Coefficient of Thread Friction                                  = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                         = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                        = 0 N
Fact      = Actual force on bolt                                            = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact      = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi            = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                      = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                      = 144440 N
Ratio     = Fb / Fbcomb                                                     = 0.856

Sh        = Shear on Bolt                                                   = 1 N
Sallow    = Allowable Shear on Bolt                                         = 92281 N
Ratio     = Sh / Sallow                                                     = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                              = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                                = 22621.48
cm^4
Aw        = Area of Weld                                                    = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                              = 3.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                     = 124.11 MPa
Ratio     = Fba / Sw                                                        = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                    = 87.6 mm
Lg        = Gross Flange area for each bolt                                 = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                      = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                       = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                                = 54.0 mm
A         = Distance from Bolt CL to Flange OD                              = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                      = 42.9 mm
Rho       = Calculated Parameter                                            = 3.377
Beta      = Calulcated Parameter                                            = 0
Alpha'    = Alpha where treq'd is minimum                                   = 0
Tc        = Required thickness to develop load w/no prying                  = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                                = 0
Q         = Prying Force per bolt                                           = 0 N
Treq'd    = Required Flange Thickness                                       = 0.0 mm
Ratio     = Treqd / Tf                                                      = 0.000
```

Structural Flange Analysis, Angle = 60 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 60 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

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```
M          = Moment on Flange                                              = 0.4 N-m
V          = Vertical Load on Flange (- is compression, + is tension)      = -21 N
S          = Shear Load on Flange                                          = 12 N

Ds         = Outer Diameter of Shell                                       = 323.8 mm
Do         = Outside Diameter of Flange                                    = 482.6 mm
Dbc        = Bolt Circle Diameter                                          = 431.8 mm
Tf         = Thickness of Flange                                           = 31.8 mm
Tw         = Fillet Weld Size                                              = 6.0 mm

Db         = Nominal Bolt Diameter                                         = 22.2 mm
Nb         = Number of Bolts                                               = 12
Fu         = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                  = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb         = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys        = Yield Stress of Shell                                         = 215.81 MPa
Fw         = Tensile Stress of Weld                                        = 413.68 MPa
Fyc        = Yield Stress of Flange                                        = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E          = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 0 N
Ab         = Nominal Area of Bolt                                          = 3.879 sq cm
Km         = Stiffness of Material                                         = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                             = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby        = Bolt Yield Stress                                             = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 0 N
Fact       = Actual force on bolt                                          = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.000

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 123659 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144440 N
Ratio      = Fb / Fbcomb                                                   = 0.856
```

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```
Sh        = Shear on Bolt                                          = 1 N
Sallow    = Allowable Shear on Bolt                                = 92281 N
Ratio     = Sh / Sallow                                            = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                     = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                       = 22621.48
cm^4
Aw        = Area of Weld                                           = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                     = 3.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw            = 124.11 MPa
Ratio     = Fba / Sw                                               = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                           = 87.6 mm
Lg        = Gross Flange area for each bolt                        = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area             = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge              = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                       = 54.0 mm
A         = Distance from Bolt CL to Flange OD                     = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole             = 42.9 mm
Rho       = Calculated Parameter                                   = 3.377
Beta      = Calulcated Parameter                                   = 0
Alpha'    = Alpha where treq'd is minimum                          = 0
Tc        = Required thickness to develop load w/no prying         = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 0.0 mm
Ratio     = Treqd / Tf                                             = 0.000
```

Structural Flange Analysis, Angle = 70 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 70 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 0.3 N-m
V         = Vertical Load on Flange (- is compression, + is tension) = -23 N
S         = Shear Load on Flange                                   = 8 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa
```

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```
Fys       = Yield Stress of Shell                                        = 215.81 MPa
Fw        = Tensile Stress of Weld                                       = 413.68 MPa
Fyc       = Yield Stress of Flange                                       = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                   = 194.22 MPa
E         = Modulus of Elasticity of Flange                              = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt               = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters             = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                              = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                         = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N      = 0 N
Ab        = Nominal Area of Bolt                                         = 3.879 sq cm
Km        = Stiffness of Material                                        = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                            = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)       = 0.173
Fby       = Bolt Yield Stress                                            = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                 = 761869.3
KPa
Aroot     = Bolt Root Area                                               = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}             = 123659 N
K         = Coefficient of Thread Friction                               = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                      = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                     = 0 N
Fact      = Actual force on bolt                                         = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact   = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi         = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                   = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                   = 144440 N
Ratio     = Fb / Fbcomb                                                  = 0.856

Sh        = Shear on Bolt                                                = 1 N
Sallow    = Allowable Shear on Bolt                                      = 92281 N
Ratio     = Sh / Sallow                                                  = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                           = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                             = 22621.48
cm^4
Aw        = Area of Weld                                                 = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                           = 3.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                  = 124.11 MPa
Ratio     = Fba / Sw                                                     = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                 = 87.6 mm
Lg        = Gross Flange area for each bolt                              = 113.0 mm
```

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```
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 80 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 80 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 0.1 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -24 N
S         = Shear Load on Flange                                        = 4 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 0 N
Ab        = Nominal Area of Bolt                                        = 3.879 sq cm
```

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```
Km          = Stiffness of Material                                    = 5922221.21
N/mm
Kb          = Stiffness of Bolt                                        = 1238416.78
N/mm
CC          = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby         = Bolt Yield Stress                                        = 896316.8
KPa
Fproof      = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot       = Bolt Root Area                                           = 2.705 sq cm
Fi          = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K           = Coefficient of Thread Friction                           = 0.000
Tb          = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin        = Min. Force to keep Flange in Compression                 = 0 N
Fact        = Actual force on bolt                                     = 91479 N
Ratio       = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb          = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow     = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb      = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio       = Fb / Fbcomb                                              = 0.856

Sh          = Shear on Bolt                                            = 0 N
Sallow      = Allowable Shear on Bolt                                  = 92281 N
Ratio       = Sh / Sallow                                              = 0.000

Check Welding
Iw          = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw          = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw          = Area of Weld                                             = 86.303 sq
cm
Fba         = Weld Stress due to Axial & Bending                       = 3.0 KPa
Sw          = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw              = 124.11 MPa
Ratio       = Fba / Sw                                                 = 0.000

Design Flange: NO GUSSETS
Ln          = Net Flange area at each bolt                             = 87.6 mm
Lg          = Gross Flange area for each bolt                          = 113.0 mm
Delta       = Ratio of net area(@bolt line) & gross area               = 0.7753
A'          = Distance from Flange OD to Bolt Hole Edge                = 12.7 mm
B           = Distance from Bolt CL to Pipe OD                         = 54.0 mm
A           = Distance from Bolt CL to Flange OD                       = 25.4 mm
B'          = Distance from Pipe OD to edge of Bolt Hole               = 42.9 mm
Rho         = Calculated Parameter                                     = 3.377
Beta        = Calulcated Parameter                                     = 0
Alpha'      = Alpha where treq'd is minimum                            = 0
Tc          = Required thickness to develop load w/no prying           = 0.0 mm
Alpha       = Ratio mom@ BL to Mom @ stem line                         = 0
Q           = Prying Force per bolt                                    = 0 N
Treq'd      = Required Flange Thickness                                = 0.0 mm
Ratio       = Treqd / Tf                                               = 0.000
```

Structural Flange Analysis, Angle = 90 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 90 Deg , Load # 4

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Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 0.0 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -25 N
S	= Shear Load on Flange	= 0 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 0 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 0 N
Fact	= Actual force on bolt	= 91479 N
Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.000
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 123659 N

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```
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                  = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                  = 144440 N
Ratio     = Fb / Fbcomb                                                 = 0.856

Sh        = Shear on Bolt                                               = 0 N
Sallow    = Allowable Shear on Bolt                                     = 92281 N
Ratio     = Sh / Sallow                                                 = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                          = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                            = 22621.48
cm^4
Aw        = Area of Weld                                                = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                          = 2.9 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                 = 124.11 MPa
Ratio     = Fba / Sw                                                    = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Conical Transition Analysis, Angle = 0 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65

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```
M:     Overturning Moment (KN-m)                          0.08        0.00
0.61
V:     Vertical Axial Loading (KN)                        0.00        0.00
0.00
Sx:    Section Modulus (cm^3)                            750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                      98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.00        0.00
0.00
fb:    Bending Strss - M/Sx (MPa)                         0.11        0.11
0.32
fb':   Localized Bending Stress (MPa)                     0.12        0.12
0.46
fh':   Hoop Stress (MPa)                                  0.07        0.00
0.24
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.11        0.11
0.32
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.23        0.23
0.78
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
```

```
OD:    Outer Diameter (mm)                              508.0         0.0
1066.8
T:     Thickness (mm)                                    10.0        10.0
10.0
Fys:   Yield Stress (MPa)                               220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                   202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                     117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                             412.65      412.65
412.65

M:     Overturning Moment (KN-m)                         40.26        0.00
44.25
V:     Vertical Axial Loading (KN)                        0.00        0.00
0.00
Sx:    Section Modulus (cm^3)                          1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                    156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.00        0.00
0.00
fb:    Bending Strss - M/Sx (MPa)                        21.07       21.88
5.09
fb':   Localized Bending Stress (MPa)                    35.61       35.61
12.47
fh':   Hoop Stress (MPa)                                 18.88        0.00
6.61
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              21.07       21.88
5.09
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        56.68       57.49
17.56
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.159	PASS	0.165	PASS	0.043	PASS
Check 2: Stot1 / Ft	0.137	PASS	0.139	PASS	0.043	PASS
Check 3: fh' < Fh	0.171	PASS	0.000	PASS	0.066	PASS

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Stiff Ring Req'd? 0.171 Not Req'd 0.165 Cone OK 0.066 Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 10 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.08	0.00	0.60
V:	Vertical Axial Loading (KN)	0.17	0.00	0.28
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.02	0.02	0.02
fb:	Bending Strss - M/Sx (MPa)	0.10	0.11	0.31
fb':	Localized Bending Stress (MPa)	0.14	0.14	0.48
fh':	Hoop Stress (MPa)	0.07	0.00	0.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.12	0.13	0.33

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```
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)              0.26        0.27
0.81
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                       132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                               110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       41.12        0.00
45.40
V:     Vertical Axial Loading (KN)                      1.19        0.00
0.59
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                  156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.08        0.08
0.02
fb:    Bending Strss - M/Sx (MPa)                      21.52       22.35
5.22
fb':   Localized Bending Stress (MPa)                  36.50       36.50
12.84
fh':   Hoop Stress (MPa)                               19.36        0.00
6.81
```

```
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               21.60       22.43
5.24
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         58.10       58.92
18.08
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.163	PASS	0.169	PASS	0.044	PASS
Check 2: Stot1 / Ft	0.141	PASS	0.143	PASS	0.044	PASS
Check 3: fh' < Fh	0.175	PASS	0.000	PASS	0.068	PASS
Stiff Ring Req'd?	0.175	Not Req'd	0.169	Cone OK	0.068	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 20 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.07        0.00
0.57
V:     Vertical Axial Loading (KN)                    0.33        0.00
0.55
```

```
Sx:    Section Modulus (cm^3)                          750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                    98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.03        0.03
0.04
fb:    Bending Strss - M/Sx (MPa)                        0.10        0.10
0.30
fb':   Localized Bending Stress (MPa)                    0.15        0.15
0.48
fh':   Hoop Stress (MPa)                                 0.08        0.00
0.26
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               0.13        0.14
0.33
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         0.29        0.29
0.82
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
```

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```
E:     Modulus of Elasticity (MPa)                    202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                      117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                              412.65      412.65
412.65

M:     Overturning Moment (KN-m)                          40.69        0.00
45.12
V:     Vertical Axial Loading (KN)                         2.47        0.00
1.29
Sx:    Section Modulus (cm^3)                           1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                      156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.16        0.16
0.04
fb:    Bending Strss - M/Sx (MPa)                         21.30       22.12
5.19
fb':   Localized Bending Stress (MPa)                     36.26       36.26
12.81
fh':   Hoop Stress (MPa)                                  19.23        0.00
6.79
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                     1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                     2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                21.46       22.28
5.23
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          57.72       58.54
18.04
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.162	PASS	0.168	PASS	0.044	PASS
Check 2: Stot1 / Ft	0.140	PASS	0.142	PASS	0.044	PASS
Check 3: fh' < Fh	0.174	PASS	0.000	PASS	0.068	PASS
Stiff Ring Req'd?	0.174	Not Req'd	0.168	Cone OK	0.068	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 30 Deg

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Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.07	0.00	0.53
V:	Vertical Axial Loading (KN)	0.48	0.00	0.80
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.05	0.05	0.05
fb:	Bending Strss - M/Sx (MPa)	0.09	0.09	0.28
fb':	Localized Bending Stress (MPa)	0.16	0.16	0.47
fh':	Hoop Stress (MPa)	0.09	0.00	0.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.14	0.14	0.33
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	0.30	0.31	0.80
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

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Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	38.98	0.00	43.42
V:	Vertical Axial Loading (KN)	3.81	0.00	2.09
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.24	0.25	0.06
fb:	Bending Strss - M/Sx (MPa)	20.41	21.19	5.00
fb':	Localized Bending Stress (MPa)	34.90	34.90	12.39
fh':	Hoop Stress (MPa)	18.51	0.00	6.57
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)             20.65       21.44
5.06
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       55.55       56.34
17.45
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.156	PASS	0.162	PASS	0.042	PASS
Check 2: Stot1 / Ft	0.135	PASS	0.137	PASS	0.042	PASS
Check 3: fh' < Fh	0.168	PASS	0.000	PASS	0.065	PASS
Stiff Ring Req'd?	0.168	Not Req'd	0.162	Cone OK	0.065	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 40 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.06        0.00
0.47
V:     Vertical Axial Loading (KN)                    0.62        0.00
1.03
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.06        0.06
0.07
```

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fb:	Bending Strss - M/Sx (MPa)	0.08	0.08
0.24			
fb':	Localized Bending Stress (MPa)	0.17	0.17
0.45			
fh':	Hoop Stress (MPa)	0.09	0.00
0.24			
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08
1596.11			
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63
220.63			
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32
110.32			
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12
2394.16			
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63
220.63			
Stot:	Total Stress Check 1: fa + fb (MPa)	0.14	0.15
0.31			
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	0.31	0.31
0.76			
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38
132.38			
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32
110.32			

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	
0.0				
OD:	Outer Diameter (mm)	508.0	0.0	
1066.8				
T:	Thickness (mm)	10.0	10.0	
10.0				
Fys:	Yield Stress (MPa)	220.63	220.63	
220.63				
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	
202705.50				
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	
117.90				
Ft:	Tensile Stress (MPa)	412.65	412.65	
412.65				

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```
M:     Overturning Moment (KN-m)                          36.04        0.00
40.33
V:     Vertical Axial Loading (KN)                         5.21        0.00
3.00
Sx:    Section Modulus (cm^3)                           1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                     156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.33        0.35
0.09
fb:    Bending Strss - M/Sx (MPa)                         18.87       19.59
4.64
fb':   Localized Bending Stress (MPa)                     32.45       32.45
11.59
fh':   Hoop Stress (MPa)                                  17.21        0.00
6.14
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               19.20       19.94
4.73
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         51.65       52.38
16.32
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.145	PASS	0.151	PASS	0.040	PASS
Check 2: Stot1 / Ft	0.125	PASS	0.127	PASS	0.040	PASS
Check 3: fh' < Fh	0.156	PASS	0.000	PASS	0.061	PASS
Stiff Ring Req'd?	0.156	Not Req'd	0.151	Cone OK	0.061	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 50 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
```

```
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.05        0.00
0.39
V:     Vertical Axial Loading (KN)                    0.74        0.00
1.23
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.07        0.08
0.08
fb:    Bending Strss - M/Sx (MPa)                     0.07        0.07
0.20
fb':   Localized Bending Stress (MPa)                 0.17        0.17
0.41
fh':   Hoop Stress (MPa)                              0.09        0.00
0.22
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)               2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                        220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                 110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                        220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)            0.14        0.15
0.28
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)      0.31        0.31
0.69
Fb:    Allow Bend (ASD): .6*Fxc (MPa)               132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                       110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS

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Stiff Ring Req'd? 0.001 Not Req'd 0.001 Cone OK 0.002 Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	31.94	0.00	35.94
V:	Vertical Axial Loading (KN)	6.68	0.00	4.05
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.43	0.44	0.12
fb:	Bending Strss - M/Sx (MPa)	16.72	17.36	4.14
fb':	Localized Bending Stress (MPa)	28.97	28.97	10.42
fh':	Hoop Stress (MPa)	15.37	0.00	5.53
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	17.15	17.80	4.26
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	46.12	46.78	14.68

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```
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.130	PASS	0.134	PASS	0.036	PASS
Check 2: Stot1 / Ft	0.112	PASS	0.113	PASS	0.036	PASS
Check 3: fh' < Fh	0.139	PASS	0.000	PASS	0.055	PASS
Stiff Ring Req'd?	0.139	Not Req'd	0.134	Cone OK	0.055	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 60 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                        0.04        0.00
0.30
V:     Vertical Axial Loading (KN)                      0.83        0.00
1.39
Sx:    Section Modulus (cm^3)                          750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                   98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.08        0.09
0.09
fb:    Bending Strss - M/Sx (MPa)                       0.05        0.05
0.16
fb':   Localized Bending Stress (MPa)                   0.16        0.16
0.36
fh':   Hoop Stress (MPa)                                0.08        0.00
0.19
```

```
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.14        0.14
0.25
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.30        0.30
0.61
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     26.75        0.00
30.31
V:     Vertical Axial Loading (KN)                    8.33        0.00
5.35
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
```

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```
Ax:    Cross Sectional Area (sq cm)                    156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.53        0.55
0.16
fb:    Bending Strss - M/Sx (MPa)                       14.00       14.54
3.49
fb':   Localized Bending Stress (MPa)                   24.56       24.56
8.94
fh':   Hoop Stress (MPa)                                13.03        0.00
4.74
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              14.54       15.09
3.65
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        39.10       39.66
12.59
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.110	PASS	0.114	PASS	0.031	PASS
Check 2: Stot1 / Ft	0.095	PASS	0.096	PASS	0.030	PASS
Check 3: fh' < Fh	0.118	PASS	0.000	PASS	0.047	PASS
Stiff Ring Req'd?	0.118	Not Req'd	0.114	Cone OK	0.047	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 70 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
```

E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.03	0.00	0.21
V:	Vertical Axial Loading (KN)	0.91	0.00	1.51
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.09	0.09	0.10
fb:	Bending Strss - M/Sx (MPa)	0.04	0.04	0.11
fb':	Localized Bending Stress (MPa)	0.15	0.15	0.30
fh':	Hoop Stress (MPa)	0.08	0.00	0.16
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.13	0.13	0.21
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	0.28	0.28	0.50
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 70 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	20.53	0.00	23.49
V:	Vertical Axial Loading (KN)	10.49	0.00	7.25
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.67	0.70	0.22
fb:	Bending Strss - M/Sx (MPa)	10.75	11.16	2.70
fb':	Localized Bending Stress (MPa)	19.29	19.29	7.15
fh':	Hoop Stress (MPa)	10.23	0.00	3.79
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	11.42	11.85	2.92
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	30.71	31.15	10.08
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.086	PASS	0.090	PASS	0.024	PASS
Check 2: Stot1 / Ft	0.074	PASS	0.075	PASS	0.024	PASS
Check 3: fh' < Fh	0.093	PASS	0.000	PASS	0.038	PASS
Stiff Ring Req'd?	0.093	Not Req'd	0.090	Cone OK	0.038	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 80 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.01	0.00	0.11
V:	Vertical Axial Loading (KN)	0.95	0.00	1.58
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.10	0.10	0.10
fb:	Bending Strss - M/Sx (MPa)	0.02	0.02	0.06
fb':	Localized Bending Stress (MPa)	0.13	0.13	0.23
fh':	Hoop Stress (MPa)	0.07	0.00	0.12
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)              0.11        0.12
0.16
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        0.25        0.25
0.38
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.001	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.001	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     13.04        0.00
15.16
V:     Vertical Axial Loading (KN)                   14.49        0.00
11.10
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                     0.93        0.96
0.33
fb:    Bending Strss - M/Sx (MPa)                    6.83        7.09
1.74
```

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```
fb':   Localized Bending Stress (MPa)                    13.10       13.10
5.09
fh':   Hoop Stress (MPa)                                  6.95        0.00
2.70
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                7.75        8.05
2.08
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          20.85       21.15
7.17
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.059	PASS	0.061	PASS	0.017	PASS
Check 2: Stot1 / Ft	0.051	PASS	0.051	PASS	0.017	PASS
Check 3: fh' < Fh	0.063	PASS	0.000	PASS	0.027	PASS
Stiff Ring Req'd?	0.063	Not Req'd	0.061	Cone OK	0.027	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 90 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65
```

```
M:     Overturning Moment (KN-m)                          0.00        0.00
0.00
V:     Vertical Axial Loading (KN)                        0.96        0.00
1.60
Sx:    Section Modulus (cm^3)                            750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                      98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.10        0.10
0.10
fb:    Bending Strss - M/Sx (MPa)                         0.00        0.00
0.00
fb':   Localized Bending Stress (MPa)                     0.11        0.11
0.15
fh':   Hoop Stress (MPa)                                  0.06        0.00
0.08
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.10        0.10
0.10
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.21        0.21
0.25
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.001	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.001	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
```

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```
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                        0.00        0.00
0.00
V:     Vertical Axial Loading (KN)                     35.49        0.00
32.04
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                  156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        2.27        2.36
0.97
fb:    Bending Strss - M/Sx (MPa)                       0.00        0.00
0.00
fb':   Localized Bending Stress (MPa)                   3.83        3.83
2.36
fh':   Hoop Stress (MPa)                                2.03        0.00
1.25
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                  1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                          220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                   110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                  2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              2.27        2.36
0.97
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        6.10        6.19
3.33
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.017	PASS	0.018	PASS	0.008	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.008	PASS
Check 3: fh' < Fh	0.018	PASS	0.000	PASS	0.012	PASS
Stiff Ring Req'd?	0.018	Not Req'd	0.018	Cone OK	0.012	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Stack Deflection Lift Angle = 0 Deg
Load Combination Dead Weight

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
11.500	0.0	0.5	0.0	0.5	4.0	0.120	Pass
11.467	0.0	0.5	0.0	0.5	3.8	0.120	Pass
11.385	0.0	0.4	0.0	0.4	3.4	0.120	Pass
11.257	0.0	0.3	0.0	0.3	2.8	0.120	Pass
11.128	0.0	0.3	0.0	0.3	2.1	0.121	Pass
11.000	0.0	0.2	0.0	0.2	1.5	0.121	Pass
10.699	0.0	0.0	0.0	0.0	52.7	0.000	Pass
10.400	0.0	-0.2	0.0	0.2	52.7	0.003	Pass
8.400	0.0	-1.2	0.0	1.2	52.7	0.023	Pass
7.667	0.0	-1.5	0.0	1.5	52.7	0.028	Pass
6.456	0.0	-1.6	0.0	1.6	52.7	0.030	Pass
6.123	0.0	-1.6	0.0	1.6	52.7	0.030	Pass
5.789	0.0	-1.5	0.0	1.5	52.7	0.028	Pass
5.456	0.0	-1.4	0.0	1.4	52.7	0.027	Pass
5.137	0.0	-1.4	0.0	1.4	52.7	0.026	Pass
5.000	0.0	-1.3	0.0	1.3	52.7	0.026	Pass
4.863	0.0	-1.3	0.0	1.3	52.7	0.025	Pass
3.100	0.0	-0.9	0.0	0.9	52.7	0.017	Pass
2.450	0.0	-0.7	0.0	0.7	52.7	0.013	Pass
1.385	0.0	-0.4	0.0	0.4	52.7	0.007	Pass
1.275	0.0	-0.4	0.0	0.4	52.7	0.007	Pass
1.165	0.0	-0.3	0.0	0.3	52.7	0.006	Pass
0.950	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
0.350	0.0	-0.1	0.0	0.1	52.7	0.001	Pass
0.305	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.153	0.0	0.0	0.0	0.0	52.7	0.000	Pass
0.000	0.0	0.0	0.0	0.0	0.8	0.063	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dy^2 + Dz^2)
Ratio = Dres / Limit

Lifting Reactions Summary - Dead Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	13924	19324
10.0	14158	19089
20.0	14402	18846
30.0	14671	18576
40.0	14991	18256
50.0	15406	17842
60.0	16005	17243
70.0	17029	16218
80.0	19398	13850
90.0	33248	0

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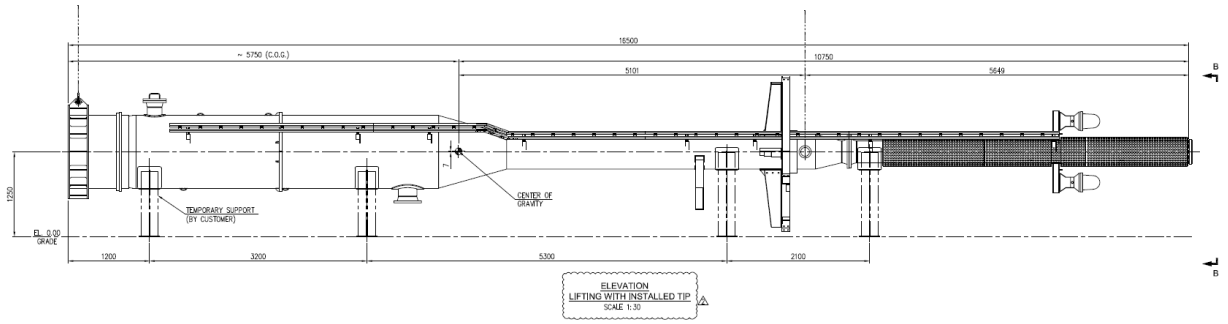
Lifting Reactions Summary - Dead + Impact Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

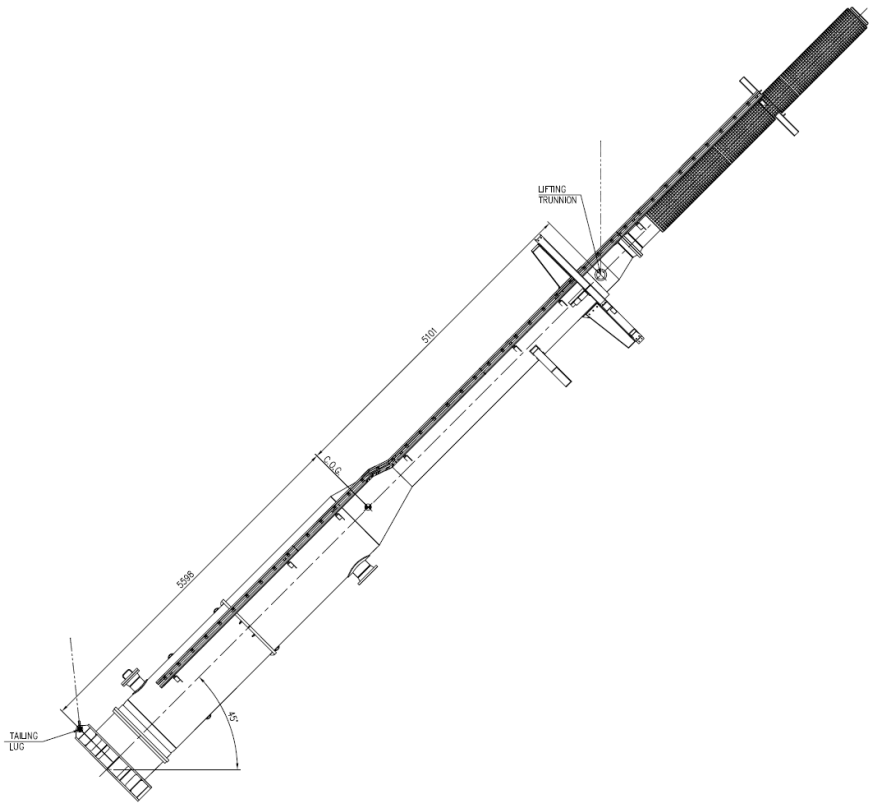
Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	20885	28986
10.0	21237	28634
20.0	21602	28269
30.0	22007	27865
40.0	22487	27384
50.0	23108	26763
60.0	24008	25864
70.0	25544	24328
80.0	29097	20775
90.0	49871	0

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C- LIFTING ANALYSIS CONFIGURATION WITH INSTALLED TIP

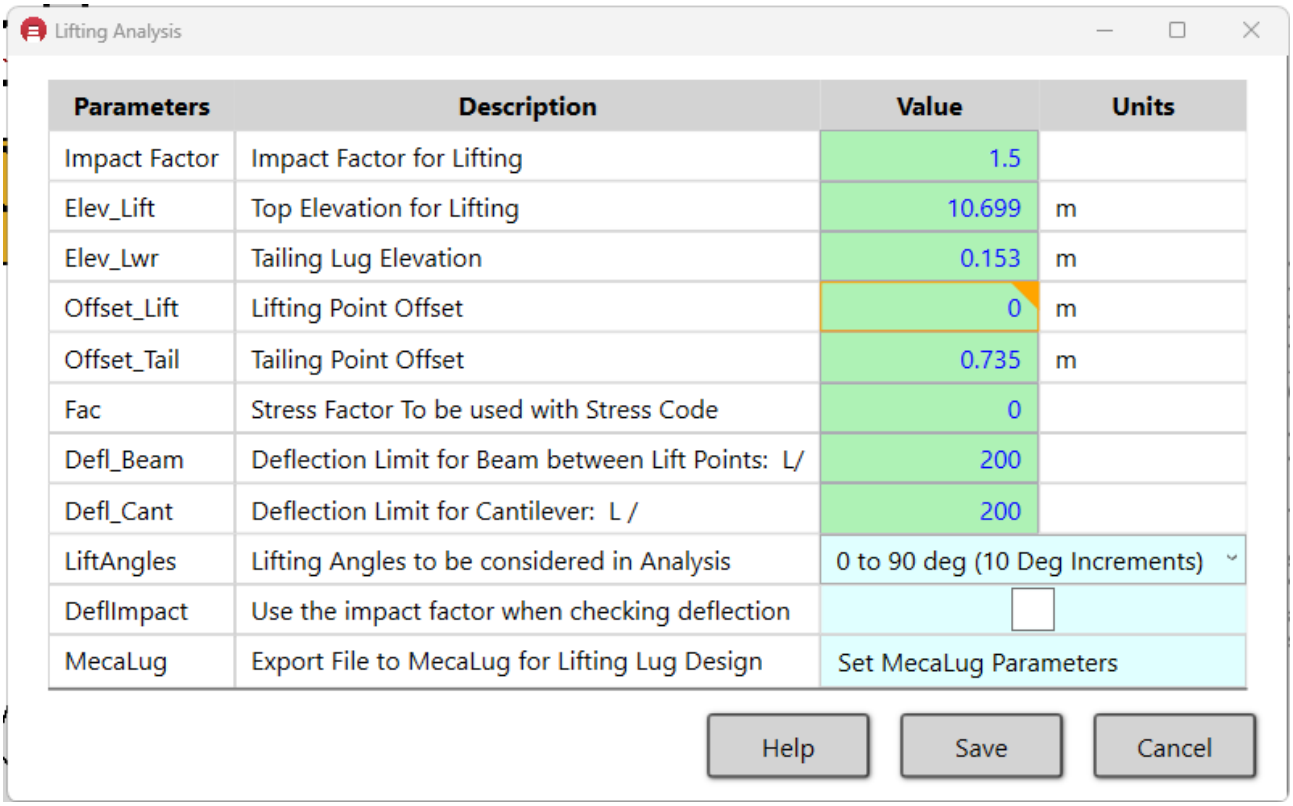
The configuration for the lifting is shown here after.





Differently than what analyzed in the annex D, here the tip will be installed before lifting.

A specialized model has been developed to analyze the lifting phases. For safety, the top platform is assumed to be fully assembled during the lift. In practice, some components will be added later to avoid potential conflicts with the lifting hardware.



MecaStack v5630

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Calculations Prepared by:
Date: Dec 04, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Vent Cross wind-20241204-00.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height = 16.50 m Top of Stack Elevation = 16.5 m

Grade Elevation = 0.00 m Bottom of Stack = 0.0 m

All elevations are based upon the bottom of stack being at 0 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
16.5	0.3238	16.5	6.0	16.5	0.0
11.385	0.3238	11.5	10.0	11.5	3.0
11.0	0.5080			0.305	0.0
6.456	0.5080				
5.456	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
16.5	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		-10.00	206.84	195121	1.53E-05	137.89	8000	517.11
11.5	A-516-60	80.00	204.66	199333	1.20E-05	117.90	7849	413.68
		-10.00	220.63	202705	1.15E-05	117.90	7849	413.68
0.446	S275J0	80.00	239.00	207692	1.20E-05	101.79	7849	356.33
		-10.00	275.00	210000	1.20E-05	117.14	7849	410.03

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
11.500	8.400	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	2.450	0.950	0.0000	758.00	Oper
External insulation	3.100	0.350	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	0.950	0.000	200.0	Dead

Nozzles:

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Num	Description	Elevation	Nominal Diameter	Schedule	Outer Diameter	Thickness	Tilt	Orien-tation	Proj-ection
		m			mm	mm	Deg	Deg	mm
1	1N	5.000	10 inch [254.0 mm]	Std	273.1	9.3	0.0	180.0	200.0
2	HW	1.275	8 inch [203.2 mm]	Std	219.1	8.2	0.0	0.0	200.0

Num	Description	Repad Width	Repad Thickness	Flange Spec	Flange Radial Width	Flange Thickness	Nozzle Loads
		mm	mm		mm	mm	
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx	Fy	Fz	Mx	My	Mz	Local/ Global	Load Applied	Load Type	Check WRC 107
		KN	KN	KN	KN-m	KN-m	KN-m				
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC	FyC	FzC	MxC	MyC	MzC	|	Ver	Shear	Mom	Mbase
			KN	KN	KN	KN-m	KN-m	KN-m	|	KN	KN	KN-m	KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	|	14.46	16.42	7.89	89.99

Equivalent Nozzle Loads Applied on Stack:
Ver = Stack Vertical Load considered at Nozzle Elev: Fy
Shear = Stack Shear Load considered at Nozzle Elev: [Fx^2+Fz^2]^0.5
Mom = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
Mbase = Est Mom at base if no Support: Mom + Shear*Elev
Provided only to evaluate the impact of the load on overall stack

Helical Strakes: (3 Vanes 120 deg apart assumed)

ElTop	= Top Strake Elevation	= 16.5 m
ElBot	= Bottom Strake Elevation	= 11.0 m
Pitch	= Strake Pitch (One complete wrap)	= 1.6190 m
Width	= Strake Width	= 32.4 mm
Thick	= Strake Thickness	= 3.2 mm
OD	= Outer Diameter of Stack and Insulation (If Applicable)	= 323.8 mm
ShapeFac	= Strake Shape Factor (Applied to bare stack shell)	= 1.40
SO	= Stand-off from OD of shell to strake	= 0.0 mm
Len	= Pitch Length: [(PI*(OD+2*SO+2*Width))^2+(Pitch^2)]^0.5	= 2.028 m

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```
Area      = Total Painted Area (3 vanes): (2*Width*Len*3*Wraps)            = 92.932 sq
cm
Wraps     = Total Number of Wraps (Top elev - Bot elev)/ Pitch             = 3.40
WtUni     = Estimated Linear Weight of Strakes and Clips: Wt/(ElTop-ElBot) = 4.54 kg/m
Wt        = Estimated total Wt of Strakes and Clips: 1.5*(Area/2)*Thick*Dens= 25.0 kg

Type      = Type of Baseplate                                              = Chair
                                                                             Continuous
Plate
SupType   = Type of Support                                                = Rigid Steel
Base
Friction  = Coefficient of Friction for Support                            = 0.300
BasisBolt = Basis for Bolt Design                                          = Brownell &
Young
Nbolt     = Number of Bolts                                                = 16
Dbolt     = Nominal Bolt Diameter                                          = 27.0 mm
Dbh       = Bolt Hole Diameter                                             = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                                    = 3.0 mm
CAplt     = Corrosion Allowance on Plates                                  = 0.0 mm
ID        = Inside Diameter of Baseplate                                   = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                              = 1270.0 mm
OD        = Outer Diameter of Baseplate                                    = 1385.0 mm
Tb        = Thickness of Bottom Plate                                      = 25.0 mm
Tt        = Thickness of Top Plate                                         = 25.0 mm
Fw        = Fillet Weld Size                                               = 5.0 mm
Fwu       = Weld Ultimate Tensile Strength                                 = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                                     = 1
Hg        = Height of Anchor Chair                                         = 305.0 mm
Tg        = Thickness of Gusset                                            = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                         = S275J0
Dens      = Material Density                                               = 7849 Kg/m^3
Temp      = Design Temperature                                             = 21.11 Deg C
Fy        = Minimum Yield Stress                                           = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                        = 410030.5
KPa
Sa        = Allowable Tensile Stress                                       = 117141.7
KPa
E         = Modulus of Elasticity                                          = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                               = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                                      = False
Matl      = Bolt Material Specification                                    = Gr. 8.8
Fu        = Ultimate Tensile Stress                                        = 800548.8
KPa
Fy        = Yield Stress                                                   = 640440.4
KPa
Fproof    = Proof Stress                                                   = 544374.4
KPa
Eb        = Modulus of Elasticity                                          = 202705497.9
KPa
```

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```
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile                    = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                                    = 800.55 MPa
PreStress = Pretension Stress on Bolt                                       = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                        = Rectangular
Pt        = Plate Washer Thickness                                          = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                          = 90.0 mm
Pl        = Length of Washer Parallel to Shell                              = 100.0 mm
Pdh       = Bolt Hole Diameter                                              = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 11.44 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                         = 323.8 mm
Do        = Outside Diameter of Flange                                      = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange                    = 25.4 mm
Dbc       = Bolt Circle Diameter                                            = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle                     = 54.0 mm
Tf        = Thickness of Flange                                             = 31.8 mm
Tw        = Fillet Weld Size                                                = 6.0 mm
Gus       = Gussets                                                         = False
Db        = Nominal Bolt Diameter                                           = 22.2 mm
Nb        = Number of Bolts                                                 = 12
BMatl     = Bolt Material                                                   = Gr 8 (US)
Fu        = Ultimate Bolt Tensile Stress                                    = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                  = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                    = 60.00 %
Fw        = Tensile Stress of Weld                                          = 413.68 MPa
FMatl     = Flange Material                                                 = A-36
Fyf       = Yield Stress of Flange                                          = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                                 = 193742.33
MPa
```

Design Codes

```
Stress Criteria:  Eurocde 3 - Design of Steel structures:  Part 3-2: Towers, masts and
chimneys
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)       = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters         = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset                = False

Lifting Criteria:

Impact    = Impact Factor                                                   = 1.50
Lift_El   = Elevation of Lifting Point                                      = 10.699 m
UprOff    = Longitudinal Offset for Lifting Lug point from Lift Elev to Lift Eye= 0.0000
m
Tail_El   = Elevation of Tailing Point                                      = 0.153 m
LwrOff    = Radial Offset for Tailing Lug point from Ctr Line to Tail Pt    = 0.7350 m
SF        = Stress Factor of Safety                                         = 0.000
Defl_Beam = Deflection Limit between Lifting Points:  L /                   = 200.0
Defl_Cant = Deflection Limit for Cantilevers:         L /                   = 200.0
Defl_Impact= Consider Impact loading for deflection check?                   = False
```

Check Stack for 0 to 90 Deg in 10 Deg increments

Damping Criteria:

Structural Damping Criteria:
Criteria: ASME STS-1-2021
Stack Type: UnLined
Support: ELASTIC

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

Log Decrement Damping = 2 * PI * Bs

Aerodynamic Damping Criteria:
(Only used in Along wind analysis, Not considered for vortex shedding)

Criteria: EN 1994-1-4

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
16.500	13.452	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
13.452	11.500	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
11.500	11.467	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.467	11.385	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.385	11.257	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.257	11.128	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
11.128	11.000	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
11.000	10.699	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.699	10.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.400	8.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
8.400	6.456	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.456	6.123	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.123	5.789	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
5.789	5.456	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
5.456	5.137	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
5.137	5.000	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
5.000	4.863	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
4.863	3.100	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
3.100	2.450	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
2.450	1.385	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
1.385	1.275	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
1.275	1.165	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
1.165	0.950	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal

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0.950	0.446	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.446	0.350	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.350	0.305	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.305	0.153	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5
0.153	0.000	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	6

Section Props - If a number is shown, then the section contains something unusual (Breach, nozzle, stiffeners, etc..) and so the properties were calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0
6	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Weight Summary (Lifting)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	5.604	2458.5	24110
Ladders	9.950	69.2	679
Platforms	10.400	319.3	3132
Helical Strakes	13.750	25.0	245
Baseplate	0.127	389.0	3815
Structural Flange(s)	11.440	58.0	569
Nozzle(s)	3.537	53.2	521
General Attachment Uniform)	1.725	82.5	809
General Attachment Concentrated	0.950	200.0	1961
Total	5.299	3654.7	35841

Cylindrical Shells Wt: (Wt = 2458.5 kg, El COG = 5.604 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
16.500	11.500	14.000	0.3238	6.0	8000	239.6	47.92	239.6
11.500	11.385	11.443	0.3238	10.0	7849	6.3	77.38	8.9
11.385	11.000	11.193	0.4159	10.0	7849	27.2	100.09	38.5
11.000	6.456	8.728	0.5080	10.0	7849	393.0	122.80	558.0
6.456	5.456	5.956	0.7874	10.0	7849	134.7	191.69	191.7
5.456	0.446	2.951	1.0668	10.0	7849	916.5	260.59	1305.6
0.446	0.305	0.376	1.0668	10.0	7849	25.8	260.59	36.7
0.305	0.000	0.153	1.0668	10.0	7849	79.5	260.59	79.5

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Total	5.604					1822.5		2458.5

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 9.950 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	11.500	8.400	9.950	22.32	69.2
Total			9.950		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 10.400 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	10.400	319.3
Total					10.400	319.3

Helical Strakes Wt: (Wt = 25.0 kg, El COG = 13.750 m)

El Top m	El Bot m	El COG m	Lin Wt kg/m	TOt Wt kg
16.500	11.000	13.750	4.54	25.0
Total		13.750		25.0

Baseplate Wt: (Wt = 389.0 kg, El COG = 0.127 m)

Description	Elevation COG m	Weight kg
Bottom Plate	0.013	192.0
Top Plate	0.293	120.2
Gussets	0.153	61.1
Washers	0.153	15.6
Total	0.127	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 11.440 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
11.440	482.6	31.8	0.0	0.0	0.0	25.1	7.9	11.440	2	58.0
Total					0.0	25.1	7.9	11.440		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

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Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 3.537 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	5.000	273.1	-3.99	12.06	7.36	16.85	0.00	5.000	32.27
2	1.275	219.1	-2.53	8.51	2.65	12.26	0.00	1.275	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	3.537	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 1.725 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	3.100	0.350	1.725	30.00	82.5
Total	0.000	0.000	1.725		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 0.950 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	0.950	0.000	200.0
Total	0.950		200.0

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Impact Load	I

Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	I
3	Dead Weight		X	0.000	0	1.0	
4	Dead Weight + Impact	X		0.000	0	1.0	1.0

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

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Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
9	Upper Lift Point	10.6990	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Free	Free
30	Lower Lift Point	0.1530	0.7350	0.0000	Free	Fixed	Free	Free	Free	Free

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
16.500	13.452	4	Dead Weight + Impact	Buckling	0.000	PASS
13.452	11.500	4	Dead Weight + Impact	Buckling	0.059	PASS
11.500	11.467	4	Dead Weight + Impact	Buckling	0.089	PASS
11.467	11.385	4	Dead Weight + Impact	Buckling	0.090	PASS
11.385	11.257	4	Dead Weight + Impact	Buckling	0.093	PASS
11.257	11.128	4	Dead Weight + Impact	Buckling	0.070	PASS
11.128	11.000	4	Dead Weight + Impact	Buckling	0.056	PASS
11.000	10.699	4	Dead Weight + Impact	Buckling	0.046	PASS
10.699	10.400	4	Dead Weight + Impact	Buckling	0.053	PASS
10.400	8.400	4	Dead Weight + Impact	Buckling	0.031	PASS
8.400	6.456	4	Dead Weight + Impact	Buckling	0.066	PASS
6.456	6.123	4	Dead Weight + Impact	Buckling	0.129	PASS
6.123	5.789	4	Dead Weight + Impact	Buckling	0.069	PASS
5.789	5.456	4	Dead Weight + Impact	Buckling	0.045	PASS
5.456	5.137	4	Dead Weight + Impact	Buckling	0.032	PASS
5.137	5.000	4	Dead Weight + Impact	Buckling	0.032	PASS
5.000	4.863	4	Dead Weight + Impact	Buckling	0.035	PASS
4.863	3.100	4	Dead Weight + Impact	Buckling	0.033	PASS
3.100	2.450	4	Dead Weight + Impact	Buckling	0.030	PASS
2.450	1.385	4	Dead Weight + Impact	Buckling	0.027	PASS
1.385	1.275	4	Dead Weight + Impact	Buckling	0.020	PASS
1.275	1.165	4	Dead Weight + Impact	Buckling	0.020	PASS
1.165	0.950	4	Dead Weight + Impact	Buckling	0.018	PASS
0.950	0.446	4	Dead Weight + Impact	Buckling	0.015	PASS
0.446	0.350	4	Dead Weight + Impact	Buckling	0.009	PASS
0.350	0.305	4	Dead Weight + Impact	Buckling	0.008	PASS
0.305	0.153	4	Dead Weight + Impact	Buckling	0.005	PASS
0.153	0.000	4	Dead Weight + Impact	Buckling	0.001	PASS
0.000	0.000	0			0.000	PASS

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
16.500	0.00	0.00	0.00	0.00	0.00	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.58	0.00	0.00	7.67	7.67	0.00	130.14	24.57	1.958	1.384	0.059	0.004	0.059
11.500	9.65	0.00	0.00	12.86	12.86	0.00	145.11	71.07	1.990	1.612	0.089	0.008	0.089
11.467	9.78	0.00	0.00	13.03	13.03	0.00	145.11	71.07	1.990	1.612	0.090	0.008	0.090
11.385	10.17	0.00	0.00	13.56	13.56	0.00	145.11	71.07	1.990	1.612	0.093	0.009	0.093

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```
11.257  10.81 0.00  0.00 10.03 10.03  0.00 143.11  50.11 1.980 1.505 0.070 0.005  0.070
11.128  11.49 0.00  0.00  7.84  7.84  0.00 141.19  37.29 1.970 1.440 0.056 0.003  0.056
11.000  12.19 0.00  0.00  6.38  6.38  0.00 139.35  28.85 1.961 1.397 0.046 0.002  0.046
10.699  13.98 0.00  0.00  7.32  7.32  0.00 139.35  28.85 1.961 1.397 0.053 0.003  0.053
10.400   8.12 0.00  0.00  4.25  4.25  0.00 139.35  28.85 1.961 1.397 0.030 0.001  0.030
 8.400  16.77 0.00  0.00  8.78  8.78  0.00 139.35  28.85 1.961 1.397 0.063 0.004  0.063
 6.456  33.40 0.00  0.00 17.48 17.48  0.00 139.35  28.85 1.961 1.397 0.125 0.017  0.125
 6.123  35.51 0.00  0.00  9.79  9.79  0.00 147.09  15.58 2.000 1.329 0.067 0.004  0.067
 5.789  37.30 0.00  0.00  6.34  6.34  0.00 147.09  10.00 2.000 1.301 0.043 0.002  0.043
 5.456  38.78 0.00  0.00  4.46  4.46  0.00 145.82   7.41 1.994 1.288 0.031 0.001  0.031
 5.137  39.86 0.00  0.00  4.57  4.57  0.00 145.82   7.41 1.994 1.288 0.031 0.001  0.031
 5.000  40.20 0.00  0.00  5.00  5.00  0.00 145.82   7.41 1.994 1.288 0.034 0.001  0.034
 4.863  40.40 0.00  0.00  4.65  4.65  0.00 145.82   7.41 1.994 1.288 0.032 0.001  0.032
 3.100  36.61 0.00  0.00  4.21  4.21  0.00 145.82   7.41 1.994 1.288 0.029 0.001  0.029
 2.450  32.12 0.00  0.00  3.70  3.70  0.00 145.82   7.41 1.994 1.288 0.025 0.001  0.025
 1.385  20.84 0.00  0.00  2.40  2.40  0.00 145.82   7.41 1.994 1.288 0.016 0.000  0.016
 1.275  19.41 0.00  0.00  2.44  2.44  0.00 145.82   7.41 1.994 1.288 0.017 0.000  0.017
 1.165  17.89 0.00  0.00  2.06  2.06  0.00 145.82   7.41 1.994 1.288 0.014 0.000  0.014
 0.950  14.75 0.00  0.00  1.70  1.70  0.00 145.82   7.41 1.994 1.288 0.012 0.000  0.012
 0.446   5.15 0.00  0.00  0.59  0.59  0.00 176.89   7.68 1.974 1.281 0.003 0.000  0.003
 0.350   3.20 0.00  0.00  0.37  0.37  0.00 176.89   7.68 1.974 1.281 0.002 0.000  0.002
 0.305   2.27 0.00  0.00  0.15  0.15  0.00 176.89 183.33 1.974 2.000 0.001 0.000  0.001
 0.153   0.92 0.00  0.00  0.06  0.06  0.00 176.89 183.33 1.974 2.000 0.000 0.000  0.000

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 0 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 0.00 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev     w       l     Cxb  Cx  Dwk   ax    Fyk    Lxo    Lpx    Lx     Xx  s_xRcr  s_xRk
s_xRd
  m              m              mm          MPa                              MPa     MPa
MPa
------ ------ ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
```

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```
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 1.00 3.7 0.427 220.63 0.300 1.033 0.250 1.000 3532.85 220.63
147.09
 5.789 160.2 10.6275 1.0 1.00 4.1 0.403 220.63 0.300 1.004 0.281 1.000 2785.52 220.63
147.09
 5.456 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 5.137 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 5.000 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 3.100 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 2.450 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.385 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.275 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.165 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.950 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.446 145.5 10.6275 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.350 145.5 10.6275 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
```

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```
   w     = Length Param:  l/(r*t)^0.5  [D.1]     Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]       Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]              Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]     s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                      s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]        fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.20	-0.03	0.00	-0.03	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.53	-0.54	-0.09	7.56	7.47	0.00	130.14	24.57	1.958	1.384	0.057	0.004	0.057
11.500	9.50	-0.67	-0.07	12.66	12.59	0.00	145.11	71.07	1.990	1.612	0.087	0.008	0.087
11.467	9.63	-0.84	-0.09	12.83	12.75	0.00	145.11	71.07	1.990	1.612	0.088	0.008	0.088
11.385	10.02	-0.87	-0.09	13.35	13.26	0.00	145.11	71.07	1.990	1.612	0.091	0.009	0.091
11.257	10.65	-0.91	-0.08	9.88	9.80	0.00	143.11	50.11	1.980	1.505	0.069	0.005	0.069
11.128	11.31	-0.95	-0.07	7.73	7.66	0.00	141.19	37.29	1.970	1.440	0.054	0.003	0.054
11.000	12.01	-1.03	-0.07	6.29	6.22	0.00	139.35	28.85	1.961	1.397	0.045	0.002	0.045
10.699	13.76	3.46	0.22	7.21	7.43	0.00	139.35	28.85	1.961	1.397	0.053	0.003	0.053
10.400	7.90	2.22	0.14	4.13	4.27	0.00	139.35	28.85	1.961	1.397	0.031	0.001	0.031
8.400	17.27	1.54	0.10	9.04	9.14	0.00	139.35	28.85	1.961	1.397	0.066	0.005	0.066
6.456	34.29	1.16	0.07	17.95	18.02	0.00	139.35	28.85	1.961	1.397	0.129	0.018	0.129
6.123	36.48	0.99	0.05	10.06	10.11	0.00	147.09	15.58	2.000	1.329	0.069	0.005	0.069
5.789	38.36	0.83	0.03	6.52	6.55	0.00	147.09	10.00	2.000	1.301	0.045	0.002	0.045
5.456	39.93	0.64	0.02	4.59	4.61	0.00	145.73	7.41	1.993	1.288	0.032	0.001	0.032
5.137	41.09	0.49	0.01	4.71	4.72	0.00	145.76	7.41	1.993	1.288	0.032	0.001	0.032
5.000	41.47	0.32	0.01	5.15	5.16	0.00	145.78	7.41	1.993	1.288	0.035	0.001	0.035
4.863	41.72	-0.31	-0.01	4.80	4.79	0.00	145.86	7.41	1.994	1.288	0.033	0.001	0.033
3.100	38.57	-1.14	-0.03	4.44	4.40	0.00	145.98	7.41	1.994	1.288	0.030	0.001	0.030
2.450	34.35	-1.78	-0.05	3.95	3.90	0.00	146.10	7.41	1.995	1.288	0.027	0.001	0.027
1.385	23.60	-2.22	-0.06	2.71	2.65	0.00	146.32	7.41	1.996	1.288	0.018	0.000	0.018
1.275	22.22	-2.35	-0.07	2.79	2.72	0.00	146.38	7.41	1.996	1.288	0.019	0.000	0.019
1.165	20.76	-2.47	-0.07	2.39	2.31	0.00	146.49	7.41	1.997	1.288	0.016	0.000	0.016
0.950	17.74	-3.25	-0.10	2.04	1.94	0.00	146.87	7.41	1.999	1.288	0.013	0.000	0.013
0.446	8.45	-3.47	-0.10	0.97	0.87	0.00	180.06	7.68	1.987	1.281	0.005	0.000	0.005
0.350	6.56	-3.52	-0.11	0.76	0.65	0.00	181.20	7.68	1.991	1.281	0.004	0.000	0.004
0.305	5.67	-3.59	-0.06	0.38	0.32	0.00	179.63	183.33	1.985	2.000	0.002	0.000	0.002
0.153	0.91	1.04	0.02	0.06	0.08	0.00	173.73	183.33	1.961	2.000	0.000	0.000	0.000

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 10 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 1.04 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

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Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3526.39	220.63	147.09
5.789	160.2	10.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.282	1.000	2780.35	220.63	147.09
5.456	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2295.30	218.59	145.73
5.137	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.49	218.63	145.76
5.000	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.40	218.67	145.78
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2300.98	218.79	145.86
3.100	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2306.35	218.97	145.98
2.450	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2311.80	219.16	146.10
1.385	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.302	0.979	0.308	0.995	2321.33	219.48	146.32
1.275	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2324.11	219.58	146.38
1.165	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.996	2328.73	219.73	146.49
0.950	145.5	10.6275	1.0	1.02	4.6	0.383	220.63	0.305	0.979	0.307	0.999	2345.46	220.30	146.87

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 0.446 145.5 10.6275 1.0 1.05 4.6 0.383 275.00 0.312 0.979 0.332 0.982 2496.62 270.09
180.06
 0.350 145.5 10.6275 1.0 1.07 4.6 0.383 275.00 0.316 0.979 0.329 0.988 2537.56 271.79
181.20
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.318 0.979 0.340 0.980 2381.90 269.45
179.63
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.279 0.979 0.340 0.948 2381.90 260.59
173.73

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

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   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.40	-0.07	0.00	-0.07	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.37	-1.06	-0.18	7.21	7.03	0.00	130.14	24.57	1.958	1.384	0.054	0.003	0.054
11.500	9.07	-1.33	-0.13	12.08	11.95	0.00	145.11	71.07	1.990	1.612	0.082	0.007	0.082
11.467	9.19	-1.65	-0.17	12.24	12.08	0.00	145.11	71.07	1.990	1.612	0.083	0.007	0.083
11.385	9.56	-1.71	-0.17	12.74	12.56	0.00	145.11	71.07	1.990	1.612	0.087	0.008	0.087
11.257	10.16	-1.80	-0.15	9.43	9.28	0.00	143.11	50.11	1.980	1.505	0.065	0.004	0.065
11.128	10.79	-1.88	-0.14	7.37	7.23	0.00	141.19	37.29	1.970	1.440	0.051	0.003	0.051
11.000	11.46	-2.03	-0.13	6.00	5.87	0.00	139.35	28.85	1.961	1.397	0.042	0.002	0.042
10.699	13.13	6.94	0.44	6.88	7.32	0.00	139.35	28.85	1.961	1.397	0.053	0.003	0.053
10.400	7.44	4.49	0.29	3.89	4.18	0.00	139.35	28.85	1.961	1.397	0.030	0.001	0.030
8.400	17.23	3.16	0.20	9.02	9.22	0.00	139.35	28.85	1.961	1.397	0.066	0.005	0.066
6.456	34.11	2.40	0.15	17.85	18.01	0.00	139.35	28.85	1.961	1.397	0.129	0.018	0.129
6.123	36.30	2.08	0.10	10.01	10.11	0.00	147.09	15.58	2.000	1.329	0.069	0.005	0.069
5.789	38.20	1.75	0.06	6.49	6.56	0.00	147.09	10.00	2.000	1.301	0.045	0.002	0.045
5.456	39.81	1.38	0.04	4.58	4.62	0.00	145.63	7.41	1.993	1.288	0.032	0.001	0.032
5.137	41.02	1.09	0.03	4.70	4.73	0.00	145.68	7.41	1.993	1.288	0.032	0.001	0.032
5.000	41.43	0.74	0.02	5.15	5.17	0.00	145.72	7.41	1.993	1.288	0.035	0.001	0.035
4.863	41.71	-0.50	-0.02	4.80	4.78	0.00	145.88	7.41	1.994	1.288	0.033	0.001	0.033
3.100	39.28	-2.13	-0.06	4.52	4.46	0.00	146.12	7.41	1.995	1.288	0.030	0.001	0.030
2.450	35.47	-3.39	-0.10	4.08	3.98	0.00	146.35	7.41	1.996	1.288	0.027	0.001	0.027
1.385	25.56	-4.25	-0.12	2.94	2.82	0.00	146.72	7.41	1.998	1.288	0.019	0.000	0.019
1.275	24.28	-4.51	-0.14	3.05	2.91	0.00	146.83	7.41	1.999	1.288	0.020	0.000	0.020
1.165	22.92	-4.75	-0.14	2.64	2.50	0.00	147.02	7.41	2.000	1.288	0.017	0.000	0.017
0.950	20.11	-6.28	-0.19	2.31	2.13	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.446	11.42	-6.72	-0.20	1.31	1.11	0.00	181.69	7.68	1.993	1.281	0.006	0.000	0.006
0.350	9.65	-6.82	-0.21	1.11	0.90	0.00	182.89	7.68	1.998	1.281	0.005	0.000	0.005
0.305	8.80	-6.95	-0.11	0.59	0.48	0.00	180.49	183.33	1.988	2.000	0.003	0.000	0.003
0.153	0.86	2.06	0.03	0.06	0.09	0.00	171.68	183.33	1.952	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
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Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 20 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 2.06 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3519.35	220.63	147.09
5.789	160.2	10.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2774.62	220.63	147.09
5.456	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2290.86	218.44	145.63
5.137	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.26	218.52	145.68
5.000	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2295.04	218.59	145.72
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2302.06	218.82	145.88

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 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.301 0.979 0.309 0.993 2312.42 219.18
146.12
 2.450 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2322.73 219.53
146.35
 1.385 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.998 2339.11 220.09
146.72
 1.275 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.90 220.25
146.83
 1.165 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2351.88 220.52
147.02
 0.950 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2381.01 220.63
147.09
 0.446 145.5 10.6275 1.0 1.07 4.6 0.383 275.00 0.318 0.979 0.328 0.991 2555.37 272.54
181.69
 0.350 145.5 10.6275 1.0 1.09 4.6 0.383 275.00 0.323 0.979 0.325 0.998 2598.22 274.34
182.89
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.323 0.979 0.340 0.985 2381.90 270.74
180.49
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.264 0.979 0.340 0.936 2381.90 257.52
171.68

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
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Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41

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3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.59	-0.10	0.00	-0.10	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.10	-1.55	-0.26	6.64	6.38	0.00	130.14	24.57	1.958	1.384	0.049	0.003	0.049
11.500	8.35	-1.94	-0.20	11.14	10.94	0.00	145.11	71.07	1.990	1.612	0.075	0.006	0.075
11.467	8.47	-2.41	-0.24	11.28	11.04	0.00	145.11	71.07	1.990	1.612	0.076	0.006	0.076
11.385	8.81	-2.50	-0.25	11.74	11.49	0.00	145.11	71.07	1.990	1.612	0.079	0.006	0.079
11.257	9.36	-2.62	-0.22	8.69	8.47	0.00	143.11	50.11	1.980	1.505	0.059	0.004	0.059
11.128	9.95	-2.74	-0.20	6.79	6.59	0.00	141.19	37.29	1.970	1.440	0.047	0.002	0.047
11.000	10.56	-2.96	-0.19	5.53	5.34	0.00	139.35	28.85	1.961	1.397	0.038	0.002	0.038
10.699	12.10	10.33	0.66	6.34	7.00	0.00	139.35	28.85	1.961	1.397	0.050	0.003	0.050
10.400	6.75	6.76	0.43	3.54	3.97	0.00	139.35	28.85	1.961	1.397	0.028	0.001	0.028
8.400	16.65	4.81	0.31	8.72	9.02	0.00	139.35	28.85	1.961	1.397	0.065	0.005	0.065
6.456	32.85	3.70	0.24	17.19	17.43	0.00	139.35	28.85	1.961	1.397	0.125	0.017	0.125
6.123	34.98	3.23	0.15	9.65	9.80	0.00	147.09	15.58	2.000	1.329	0.067	0.004	0.067
5.789	36.84	2.76	0.10	6.26	6.36	0.00	147.09	10.00	2.000	1.301	0.043	0.002	0.043
5.456	38.44	2.22	0.07	4.42	4.49	0.00	145.51	7.41	1.992	1.288	0.031	0.001	0.031
5.137	39.66	1.78	0.05	4.54	4.59	0.00	145.59	7.41	1.992	1.288	0.032	0.001	0.032
5.000	40.08	1.28	0.04	4.98	5.02	0.00	145.65	7.41	1.993	1.288	0.034	0.001	0.034
4.863	40.39	-0.54	-0.02	4.65	4.63	0.00	145.89	7.41	1.994	1.288	0.032	0.001	0.032
3.100	38.73	-2.93	-0.09	4.46	4.37	0.00	146.24	7.41	1.996	1.288	0.030	0.001	0.030
2.450	35.44	-4.76	-0.14	4.08	3.94	0.00	146.58	7.41	1.997	1.288	0.027	0.001	0.027
1.385	26.66	-6.01	-0.17	3.07	2.89	0.00	147.07	7.41	2.000	1.288	0.020	0.000	0.020
1.275	25.52	-6.40	-0.20	3.21	3.01	0.00	147.09	7.41	2.000	1.288	0.020	0.000	0.020
1.165	24.30	-6.75	-0.20	2.80	2.59	0.00	147.09	7.41	2.000	1.288	0.018	0.000	0.018
0.950	21.79	-8.99	-0.27	2.51	2.24	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
0.446	13.94	-9.63	-0.29	1.60	1.31	0.00	182.72	7.68	1.998	1.281	0.007	0.000	0.007
0.350	12.34	-9.78	-0.29	1.42	1.13	0.00	183.33	7.68	2.000	1.281	0.006	0.000	0.006
0.305	11.58	-9.96	-0.16	0.77	0.61	0.00	180.92	183.33	1.990	2.000	0.003	0.000	0.003

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0.153 0.80 3.01 0.05 0.05 0.10 0.00 170.17 183.33 1.946 2.000 0.001 0.000 0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 30 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 3.01 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35

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 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.298 1.033 0.251 1.000 3511.20 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.298 1.004 0.282 1.000 2767.86 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.989 2285.49 218.26
145.51
 5.137 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2289.20 218.39
145.59
 5.000 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2291.86 218.48
145.65
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2302.39 218.84
145.89
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.302 0.979 0.309 0.994 2317.71 219.36
146.24
 2.450 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.997 2332.66 219.87
146.58
 1.385 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2354.28 220.60
147.07
 1.275 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2360.63 220.63
147.09
 1.165 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2371.24 220.63
147.09
 0.950 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2410.51 220.63
147.09
 0.446 145.5 10.6275 1.0 1.09 4.6 0.383 275.00 0.322 0.979 0.326 0.997 2592.22 274.08
182.72
 0.350 145.5 10.6275 1.0 1.10 4.6 0.383 275.00 0.326 0.979 0.323 1.000 2631.20 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.325 0.979 0.340 0.987 2381.90 271.38
180.92
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.253 0.979 0.340 0.928 2381.90 255.26
170.17

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11

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11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.76	-0.13	0.00	-0.13	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	2.75	-2.00	-0.33	5.88	5.54	0.00	130.14	24.57	1.958	1.384	0.043	0.002	0.043
11.500	7.39	-2.50	-0.25	9.85	9.60	0.00	145.11	71.07	1.990	1.612	0.066	0.004	0.066
11.467	7.49	-3.10	-0.31	9.98	9.67	0.00	145.11	71.07	1.990	1.612	0.067	0.005	0.067
11.385	7.79	-3.22	-0.33	10.38	10.06	0.00	145.11	71.07	1.990	1.612	0.069	0.005	0.069
11.257	8.28	-3.37	-0.29	7.69	7.40	0.00	143.11	50.11	1.980	1.505	0.052	0.003	0.052
11.128	8.80	-3.53	-0.26	6.01	5.75	0.00	141.19	37.29	1.970	1.440	0.041	0.002	0.041
11.000	9.34	-3.81	-0.24	4.89	4.65	0.00	139.35	28.85	1.961	1.397	0.033	0.001	0.033
10.699	10.71	13.58	0.87	5.60	6.47	0.00	139.35	28.85	1.961	1.397	0.046	0.002	0.046
10.400	5.87	8.98	0.57	3.07	3.65	0.00	139.35	28.85	1.961	1.397	0.026	0.001	0.026
8.400	15.53	6.48	0.41	8.13	8.54	0.00	139.35	28.85	1.961	1.397	0.061	0.004	0.061
6.456	30.54	5.05	0.32	15.99	16.31	0.00	139.35	28.85	1.961	1.397	0.117	0.015	0.117
6.123	32.54	4.44	0.21	8.98	9.18	0.00	147.09	15.58	2.000	1.329	0.062	0.004	0.062
5.789	34.31	3.84	0.14	5.83	5.97	0.00	147.09	10.00	2.000	1.301	0.041	0.002	0.041
5.456	35.83	3.14	0.09	4.12	4.22	0.00	145.35	7.41	1.991	1.288	0.029	0.001	0.029

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 5.137  37.03   2.58  0.07  4.24  4.31  0.00 145.47   7.41 1.992 1.288 0.030 0.001 0.030
 5.000  37.45   1.94  0.06  4.65  4.71  0.00 145.55   7.41 1.992 1.288 0.032 0.001 0.032
 4.863  37.77  -0.40 -0.01  4.35  4.33  0.00 145.88   7.41 1.994 1.288 0.030 0.001 0.030
 3.100  36.92  -3.47 -0.10  4.25  4.14  0.00 146.34   7.41 1.996 1.288 0.028 0.001 0.028
 2.450  34.24  -5.82 -0.18  3.94  3.76  0.00 146.79   7.41 1.998 1.288 0.026 0.001 0.026
 1.385  26.84  -7.44 -0.21  3.09  2.87  0.00 147.09   7.41 2.000 1.288 0.020 0.000 0.020
 1.275  25.87  -7.94 -0.25  3.25  3.00  0.00 147.09   7.41 2.000 1.288 0.020 0.000 0.020
 1.165  24.84  -8.38 -0.25  2.86  2.61  0.00 147.09   7.41 2.000 1.288 0.018 0.000 0.018
 0.950  22.69 -11.26 -0.34  2.61  2.27  0.00 147.09   7.41 2.000 1.288 0.015 0.000 0.015
 0.446  15.92 -12.09 -0.36  1.83  1.47  0.00 183.33   7.68 2.000 1.281 0.008 0.000 0.008
 0.350  14.54 -12.27 -0.37  1.67  1.30  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.305  13.88 -12.52 -0.20  0.92  0.73  0.00 181.17 183.33 1.991 2.000 0.004 0.000 0.004
 0.153   0.71   3.87  0.06  0.05  0.11  0.00 168.95 183.33 1.941 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 40 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 3.87 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev     w       l     Cxb  Cx  Dwk   ax     Fyk    Lxo    Lpx    Lx     Xx   s_xRcr  s_xRk
s_xRd
  m              m              mm           MPa                              MPa      MPa
MPa
------ ----- ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
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11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.298 1.033 0.251 1.000 3501.05 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.298 1.004 0.283 1.000 2759.32 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2278.52 218.02
145.35
 5.137 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.989 2283.78 218.20
145.47
 5.000 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.990 2287.38 218.32
145.55
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2301.72 218.81
145.88
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2322.33 219.51
146.34
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2342.01 220.19
146.79
 1.385 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000 2367.79 220.63
147.09
 1.275 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2375.45 220.63
147.09
 1.165 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.27 220.63
147.09
 0.950 145.5 10.6275 1.0 1.06 4.6 0.383 220.63 0.315 0.979 0.301 1.000 2436.51 220.63
147.09
 0.446 145.5 10.6275 1.0 1.10 4.6 0.383 275.00 0.325 0.979 0.324 1.000 2618.16 275.00
183.33
 0.350 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2652.15 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.327 0.979 0.340 0.988 2381.90 271.76
181.17
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.244 0.979 0.340 0.922 2381.90 253.42
168.95

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
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Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
16.500	0.00	-0.90	-0.15	0.00	-0.15	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	2.30	-2.38	-0.40	4.93	4.53	0.00	130.14	24.57	1.958	1.384	0.035	0.001	0.035
11.500	6.20	-2.98	-0.30	8.26	7.96	0.00	145.11	71.07	1.990	1.612	0.055	0.003	0.055

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11.467	6.28	-3.70	-0.38	8.38	8.00	0.00	145.11	71.07	1.990	1.612	0.055	0.003	0.055
11.385	6.54	-3.84	-0.39	8.71	8.32	0.00	145.11	71.07	1.990	1.612	0.057	0.003	0.057
11.257	6.95	-4.02	-0.34	6.45	6.11	0.00	143.11	50.11	1.980	1.505	0.043	0.002	0.043
11.128	7.38	-4.20	-0.31	5.04	4.74	0.00	141.19	37.29	1.970	1.440	0.034	0.001	0.034
11.000	7.84	-4.54	-0.29	4.10	3.81	0.00	139.35	28.85	1.961	1.397	0.027	0.001	0.027
10.699	8.98	16.63	1.06	4.70	5.77	0.00	139.35	28.85	1.961	1.397	0.041	0.002	0.041
10.400	4.81	11.15	0.71	2.52	3.23	0.00	139.35	28.85	1.961	1.397	0.023	0.001	0.023
8.400	13.91	8.17	0.52	7.28	7.80	0.00	139.35	28.85	1.961	1.397	0.056	0.004	0.056
6.456	27.24	6.47	0.41	14.26	14.67	0.00	139.35	28.85	1.961	1.397	0.105	0.012	0.105
6.123	29.05	5.75	0.27	8.01	8.28	0.00	147.09	15.58	2.000	1.329	0.056	0.003	0.056
5.789	30.66	5.03	0.18	5.21	5.39	0.00	147.09	10.00	2.000	1.301	0.037	0.001	0.037
5.456	32.06	4.20	0.13	3.69	3.82	0.00	145.13	7.41	1.990	1.288	0.026	0.001	0.026
5.137	33.19	3.53	0.10	3.80	3.90	0.00	145.29	7.41	1.991	1.288	0.027	0.001	0.027
5.000	33.59	2.76	0.09	4.17	4.26	0.00	145.40	7.41	1.991	1.288	0.029	0.001	0.029
4.863	33.91	-0.02	0.00	3.90	3.90	0.00	145.82	7.41	1.994	1.288	0.027	0.001	0.027
3.100	33.87	-3.68	-0.11	3.90	3.79	0.00	146.43	7.41	1.997	1.288	0.026	0.001	0.026
2.450	31.87	-6.49	-0.20	3.67	3.47	0.00	146.99	7.41	2.000	1.288	0.024	0.001	0.024
1.385	26.07	-8.41	-0.24	3.00	2.75	0.00	147.09	7.41	2.000	1.288	0.019	0.000	0.019
1.275	25.29	-9.00	-0.28	3.18	2.90	0.00	147.09	7.41	2.000	1.288	0.020	0.000	0.020
1.165	24.47	-9.54	-0.29	2.82	2.53	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
0.950	22.74	-12.97	-0.39	2.62	2.23	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
0.446	17.26	-13.95	-0.42	1.99	1.57	0.00	183.33	7.68	2.000	1.281	0.009	0.000	0.009
0.350	16.13	-14.17	-0.43	1.86	1.43	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	15.60	-14.46	-0.23	1.04	0.81	0.00	181.33	183.33	1.992	2.000	0.004	0.000	0.004
0.153	0.59	4.61	0.07	0.04	0.11	0.00	167.87	183.33	1.937	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 50 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 4.61 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
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16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.297 1.033 0.252 1.000 3487.22 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.297 1.004 0.283 1.000 2747.53 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.312 0.987 2268.68 217.69
145.13
 5.137 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.311 0.988 2275.89 217.93
145.29
 5.000 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2280.57 218.09
145.40
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.34 218.73
145.82
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.06 219.64
146.43
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 0.999 2350.92 220.49
146.99
 1.385 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2380.08 220.63
147.09
 1.275 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.90 220.63
147.09
 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2403.65 220.63
147.09
 0.950 145.5 10.6275 1.0 1.07 4.6 0.383 220.63 0.318 0.979 0.299 1.000 2460.50 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.327 0.979 0.323 1.000 2637.58 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.330 0.979 0.321 1.000 2666.38 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.328 0.979 0.340 0.989 2381.90 272.00
181.33
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.235 0.979 0.340 0.916 2381.90 251.81
167.87
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   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.02	-0.17	0.00	-0.17	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	1.79	-2.69	-0.45	3.84	3.39	0.00	130.14	24.57	1.958	1.384	0.026	0.001	0.026
11.500	4.82	-3.36	-0.34	6.43	6.09	0.00	145.11	71.07	1.990	1.612	0.042	0.002	0.042
11.467	4.89	-4.18	-0.42	6.51	6.09	0.00	145.11	71.07	1.990	1.612	0.042	0.002	0.042
11.385	5.09	-4.34	-0.44	6.78	6.34	0.00	145.11	71.07	1.990	1.612	0.044	0.002	0.044
11.257	5.41	-4.55	-0.39	5.02	4.63	0.00	143.11	50.11	1.980	1.505	0.032	0.001	0.032
11.128	5.74	-4.75	-0.35	3.92	3.58	0.00	141.19	37.29	1.970	1.440	0.025	0.001	0.025
11.000	6.10	-5.13	-0.33	3.19	2.86	0.00	139.35	28.85	1.961	1.397	0.021	0.000	0.021
10.699	6.99	19.54	1.25	3.66	4.91	0.00	139.35	28.85	1.961	1.397	0.035	0.001	0.035
10.400	3.61	13.35	0.85	1.89	2.75	0.00	139.35	28.85	1.961	1.397	0.020	0.000	0.020
8.400	11.80	9.98	0.64	6.18	6.82	0.00	139.35	28.85	1.961	1.397	0.049	0.003	0.049
6.456	23.00	8.05	0.51	12.04	12.56	0.00	139.35	28.85	1.961	1.397	0.090	0.009	0.090
6.123	24.55	7.24	0.34	6.77	7.11	0.00	147.09	15.58	2.000	1.329	0.048	0.002	0.048
5.789	25.95	6.43	0.23	4.41	4.64	0.00	147.09	10.00	2.000	1.301	0.032	0.001	0.032
5.456	27.18	5.49	0.17	3.13	3.29	0.00	144.77	7.41	1.988	1.288	0.023	0.001	0.023
5.137	28.20	4.73	0.13	3.23	3.36	0.00	145.00	7.41	1.989	1.288	0.023	0.001	0.023
5.000	28.57	3.87	0.12	3.55	3.67	0.00	145.13	7.41	1.990	1.288	0.025	0.001	0.025
4.863	28.87	0.71	0.02	3.32	3.34	0.00	145.68	7.41	1.993	1.288	0.023	0.001	0.023
3.100	29.60	-3.42	-0.10	3.41	3.30	0.00	146.47	7.41	1.997	1.288	0.023	0.001	0.023
2.450	28.32	-6.59	-0.20	3.26	3.06	0.00	147.09	7.41	2.000	1.288	0.021	0.000	0.021
1.385	24.26	-8.77	-0.25	2.79	2.54	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
1.275	23.71	-9.44	-0.30	2.98	2.68	0.00	147.09	7.41	2.000	1.288	0.018	0.000	0.018
1.165	23.11	-10.04	-0.30	2.66	2.36	0.00	147.09	7.41	2.000	1.288	0.016	0.000	0.016
0.950	21.86	-13.92	-0.42	2.52	2.10	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.446	17.81	-15.03	-0.45	2.05	1.60	0.00	183.33	7.68	2.000	1.281	0.009	0.000	0.009
0.350	16.98	-15.28	-0.46	1.95	1.49	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	16.58	-15.61	-0.24	1.10	0.86	0.00	181.43	183.33	1.992	2.000	0.005	0.000	0.005
0.153	0.46	5.21	0.08	0.03	0.11	0.00	166.86	183.33	1.933	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 60 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 5.21 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

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Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	0.98	3.7	0.427	220.63	0.295	1.033	0.252	1.000	3465.91	220.63	147.09
5.789	160.2	10.6275	1.0	0.98	4.1	0.403	220.63	0.295	1.004	0.284	1.000	2729.15	220.63	147.09
5.456	145.5	10.6275	1.0	0.98	4.6	0.383	220.63	0.295	0.979	0.313	0.984	2253.00	217.16	144.77
5.137	145.5	10.6275	1.0	0.98	4.6	0.383	220.63	0.296	0.979	0.312	0.986	2262.98	217.50	145.00
5.000	145.5	10.6275	1.0	0.99	4.6	0.383	220.63	0.297	0.979	0.312	0.987	2268.98	217.70	145.13
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.25	218.52	145.68
3.100	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.996	2327.81	219.70	146.47
2.450	145.5	10.6275	1.0	1.03	4.6	0.383	220.63	0.306	0.979	0.306	1.000	2358.83	220.63	147.09
1.385	145.5	10.6275	1.0	1.04	4.6	0.383	220.63	0.310	0.979	0.304	1.000	2390.74	220.63	147.09
1.275	145.5	10.6275	1.0	1.04	4.6	0.383	220.63	0.311	0.979	0.303	1.000	2400.68	220.63	147.09

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 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.313 0.979 0.302 1.000 2417.14 220.63
147.09
 0.950 145.5 10.6275 1.0 1.08 4.6 0.383 220.63 0.320 0.979 0.298 1.000 2483.05 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2651.95 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.331 0.979 0.321 1.000 2675.50 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.329 0.979 0.340 0.990 2381.90 272.14
181.43
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.227 0.979 0.340 0.910 2381.90 250.30
166.86

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68

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 0.305 1.00 2.11 0.500 0.274 1.118 0.818  0.000 0.000 1.0000  0.00 3660.74 275.00 183.33
 0.153 1.00 2.11 0.500 0.274 1.118 0.818  0.000 0.000 1.0000  0.00 3660.74 275.00 183.33

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.11	-0.18	0.00	-0.18	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	1.23	-2.92	-0.49	2.62	2.14	0.00	130.14	24.57	1.958	1.384	0.016	0.000	0.016
11.500	3.30	-3.65	-0.37	4.40	4.03	0.00	145.11	71.07	1.990	1.612	0.028	0.001	0.028
11.467	3.34	-4.54	-0.46	4.46	4.00	0.00	145.11	71.07	1.990	1.612	0.028	0.001	0.028
11.385	3.48	-4.71	-0.48	4.64	4.16	0.00	145.11	71.07	1.990	1.612	0.029	0.001	0.029
11.257	3.70	-4.93	-0.42	3.43	3.01	0.00	143.11	50.11	1.980	1.505	0.021	0.000	0.021
11.128	3.93	-5.16	-0.38	2.68	2.31	0.00	141.19	37.29	1.970	1.440	0.016	0.000	0.016
11.000	4.17	-5.57	-0.36	2.18	1.83	0.00	139.35	28.85	1.961	1.397	0.013	0.000	0.013
10.699	4.78	22.58	1.44	2.50	3.95	0.00	139.35	28.85	1.961	1.397	0.028	0.001	0.028
10.400	2.32	15.86	1.01	1.22	2.23	0.00	139.35	28.85	1.961	1.397	0.016	0.000	0.016
8.400	9.22	12.20	0.78	4.83	5.61	0.00	139.35	28.85	1.961	1.397	0.040	0.002	0.040
6.456	17.86	10.11	0.65	9.35	10.00	0.00	139.35	28.85	1.961	1.397	0.072	0.006	0.072
6.123	19.09	9.23	0.43	5.26	5.69	0.00	147.09	15.58	2.000	1.329	0.039	0.001	0.039
5.789	20.21	8.35	0.31	3.43	3.74	0.00	147.09	10.00	2.000	1.301	0.025	0.001	0.025
5.456	21.22	7.33	0.22	2.44	2.66	0.00	144.09	7.41	1.985	1.288	0.018	0.000	0.018
5.137	22.07	6.51	0.18	2.53	2.71	0.00	144.42	7.41	1.986	1.288	0.019	0.000	0.019
5.000	22.39	5.57	0.17	2.78	2.96	0.00	144.59	7.41	1.987	1.288	0.020	0.000	0.020
4.863	22.67	2.15	0.06	2.61	2.67	0.00	145.31	7.41	1.991	1.288	0.018	0.000	0.018
3.100	24.05	-2.33	-0.07	2.77	2.70	0.00	146.36	7.41	1.996	1.288	0.018	0.000	0.018
2.450	23.50	-5.78	-0.17	2.70	2.53	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
1.385	21.26	-8.14	-0.23	2.44	2.21	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
1.275	20.93	-8.87	-0.28	2.63	2.35	0.00	147.09	7.41	2.000	1.288	0.016	0.000	0.016
1.165	20.58	-9.52	-0.29	2.37	2.08	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.950	19.83	-13.73	-0.41	2.28	1.87	0.00	147.09	7.41	2.000	1.288	0.013	0.000	0.013
0.446	17.31	-14.93	-0.45	1.99	1.54	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.350	16.79	-15.21	-0.46	1.93	1.47	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	16.54	-15.56	-0.24	1.10	0.86	0.00	181.42	183.33	1.992	2.000	0.005	0.000	0.005
0.153	0.31	5.65	0.09	0.02	0.11	0.00	165.86	183.33	1.929	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
```

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```
   UR1    = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2    = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 70 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 5.65 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	0.97	3.7	0.427	220.63	0.292	1.033	0.254	1.000	3426.29	220.63	147.09
5.789	160.2	10.6275	1.0	0.97	4.1	0.403	220.63	0.292	1.004	0.286	1.000	2694.56	220.63	147.09
5.456	145.5	10.6275	1.0	0.97	4.6	0.383	220.63	0.292	0.979	0.315	0.980	2222.90	216.14	144.09
5.137	145.5	10.6275	1.0	0.97	4.6	0.383	220.63	0.293	0.979	0.314	0.982	2237.41	216.63	144.42

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```
 5.000 145.5 10.6275 1.0 0.98 4.6 0.383 220.63 0.294 0.979 0.313 0.983 2245.19 216.89
144.59
 4.863 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2276.90 217.97
145.31
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2323.12 219.54
146.36
 2.450 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2362.43 220.63
147.09
 1.385 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2396.78 220.63
147.09
 1.275 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2407.95 220.63
147.09
 1.165 145.5 10.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2425.85 220.63
147.09
 0.950 145.5 10.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2502.67 220.63
147.09
 0.446 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.329 0.979 0.322 1.000 2659.72 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.331 0.979 0.320 1.000 2677.92 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.328 0.979 0.340 0.990 2381.90 272.13
181.42
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.219 0.979 0.340 0.905 2381.90 248.79
165.86

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00

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5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.16	-0.19	0.00	-0.19	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	0.62	-3.06	-0.51	1.33	0.82	0.00	130.14	24.57	1.958	1.384	0.006	0.000	0.006
11.500	1.68	-3.83	-0.39	2.23	1.84	0.00	145.11	71.07	1.990	1.612	0.013	0.000	0.013
11.467	1.70	-4.75	-0.48	2.26	1.78	0.00	145.11	71.07	1.990	1.612	0.012	0.000	0.012
11.385	1.77	-4.93	-0.50	2.35	1.85	0.00	145.11	71.07	1.990	1.612	0.013	0.000	0.013
11.257	1.88	-5.17	-0.44	1.74	1.30	0.00	143.11	50.11	1.980	1.505	0.009	0.000	0.009
11.128	1.99	-5.40	-0.39	1.36	0.97	0.00	141.19	37.29	1.970	1.440	0.007	0.000	0.007
11.000	2.12	-5.84	-0.37	1.11	0.74	0.00	139.35	28.85	1.961	1.397	0.005	0.000	0.005
10.699	2.43	27.00	1.73	1.27	3.00	0.00	139.35	28.85	1.961	1.397	0.021	0.001	0.021
10.400	1.00	19.95	1.28	0.53	1.80	0.00	139.35	28.85	1.961	1.397	0.013	0.000	0.013
8.400	6.03	16.12	1.03	3.16	4.19	0.00	139.35	28.85	1.961	1.397	0.030	0.001	0.030
6.456	11.56	13.93	0.89	6.05	6.94	0.00	139.35	28.85	1.961	1.397	0.050	0.003	0.050
6.123	12.38	13.00	0.60	3.41	4.02	0.00	147.09	15.58	2.000	1.329	0.027	0.001	0.027
5.789	13.14	12.08	0.44	2.23	2.67	0.00	146.14	10.00	1.995	1.301	0.018	0.000	0.018
5.456	13.85	11.01	0.33	1.59	1.93	0.00	142.24	7.41	1.975	1.288	0.014	0.000	0.014
5.137	14.47	10.15	0.28	1.66	1.94	0.00	142.78	7.41	1.978	1.288	0.014	0.000	0.014
5.000	14.72	9.17	0.29	1.83	2.11	0.00	143.01	7.41	1.979	1.288	0.015	0.000	0.015
4.863	14.94	5.58	0.17	1.72	1.89	0.00	143.96	7.41	1.984	1.288	0.013	0.000	0.013
3.100	16.67	0.89	0.03	1.92	1.95	0.00	145.53	7.41	1.992	1.288	0.013	0.000	0.013
2.450	16.78	-2.72	-0.08	1.93	1.85	0.00	146.74	7.41	1.998	1.288	0.013	0.000	0.013
1.385	16.26	-5.20	-0.15	1.87	1.72	0.00	147.09	7.41	2.000	1.288	0.012	0.000	0.012
1.275	16.16	-5.96	-0.19	2.03	1.85	0.00	147.09	7.41	2.000	1.288	0.013	0.000	0.013
1.165	16.05	-6.65	-0.20	1.85	1.65	0.00	147.09	7.41	2.000	1.288	0.011	0.000	0.011

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 0.950  15.80 -11.06 -0.33  1.82  1.48  0.00 147.09   7.41 2.000 1.288 0.010 0.000 0.010
 0.446  14.81 -12.32 -0.37  1.70  1.33  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.350  14.60 -12.61 -0.38  1.68  1.30  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.305  14.50 -12.98 -0.20  0.97  0.76  0.00 181.13 183.33 1.991 2.000 0.004 0.000 0.004
 0.153   0.16   5.92  0.09  0.01  0.10  0.00 164.80 183.33 1.924 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 80 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.92 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000

          Since Nratio <= 0.1 then Secondary Moments need not be considered.
```

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35

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 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.94 3.7 0.427 220.63 0.285 1.033 0.258 1.000 3320.16 220.63
147.09
 5.789 160.2 10.6275 1.0 0.93 4.1 0.403 220.63 0.283 1.004 0.291 0.994 2601.54 219.21
146.14
 5.456 145.5 10.6275 1.0 0.93 4.6 0.383 220.63 0.283 0.979 0.321 0.967 2140.75 213.36
142.24
 5.137 145.5 10.6275 1.0 0.94 4.6 0.383 220.63 0.285 0.979 0.319 0.971 2164.72 214.17
142.78
 5.000 145.5 10.6275 1.0 0.95 4.6 0.383 220.63 0.286 0.979 0.318 0.972 2174.95 214.51
143.01
 4.863 145.5 10.6275 1.0 0.96 4.6 0.383 220.63 0.291 0.979 0.315 0.979 2217.21 215.94
143.96
 3.100 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.989 2286.54 218.30
145.53
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.998 2339.99 220.12
146.74
 1.385 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.309 0.979 0.305 1.000 2379.24 220.63
147.09
 1.275 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2392.46 220.63
147.09
 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2410.95 220.63
147.09
 0.950 145.5 10.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2505.46 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2647.01 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.329 0.979 0.322 1.000 2660.00 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.327 0.979 0.340 0.988 2381.90 271.69
181.13
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.210 0.979 0.340 0.899 2381.90 247.20
164.80

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57

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11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.18	-0.20	0.00	-0.20	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	0.00	-3.11	-0.52	0.00	-0.52	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
11.500	0.00	-3.88	-0.39	0.00	-0.39	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.467	0.00	-4.83	-0.49	0.00	-0.49	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.385	0.00	-5.01	-0.51	0.00	-0.51	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.257	0.00	-5.25	-0.45	0.00	-0.45	0.00	143.11	50.11	1.980	1.505	0.000	0.000	0.000
11.128	0.00	-5.49	-0.40	0.00	-0.40	0.00	141.19	37.29	1.970	1.440	0.000	0.000	0.000
11.000	0.00	-5.93	-0.38	0.00	-0.38	0.00	139.35	28.85	1.961	1.397	0.000	0.000	0.000
10.699	0.00	53.76	3.44	0.00	3.44	0.00	139.35	28.85	1.961	1.397	0.025	0.001	0.025
10.400	0.00	40.04	2.56	0.00	2.56	0.00	139.35	28.85	1.961	1.397	0.018	0.000	0.018
8.400	0.00	36.15	2.31	0.00	2.31	0.00	139.35	28.85	1.961	1.397	0.017	0.000	0.017

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```
 6.456   0.00 33.92  2.17  0.00  2.17  0.00 139.35  28.85 1.961 1.397 0.016 0.000 0.016
 6.123   0.00 32.98  1.53  0.00  1.53  0.00 134.09  15.58 1.934 1.329 0.011 0.000 0.011
 5.789   0.00 32.04  1.17  0.00  1.17  0.00 129.16  10.00 1.909 1.301 0.009 0.000 0.009
 5.456   0.00 30.96  0.93  0.00  0.93  0.00 124.44   7.41 1.885 1.288 0.007 0.000 0.007
 5.137   0.00 30.09  0.84  0.00  0.84  0.00 124.44   7.41 1.885 1.288 0.007 0.000 0.007
 5.000   0.00 29.09  0.91  0.00  0.91  0.00 124.44   7.41 1.885 1.288 0.007 0.000 0.007
 4.863   0.00 25.45  0.77  0.00  0.77  0.00 124.44   7.41 1.885 1.288 0.006 0.000 0.006
 3.100   0.00 20.68  0.62  0.00  0.62  0.00 124.44   7.41 1.885 1.288 0.005 0.000 0.005
 2.450   0.00 17.01  0.51  0.00  0.51  0.00 124.44   7.41 1.885 1.288 0.004 0.000 0.004
 1.385   0.00 14.50  0.42  0.00  0.42  0.00 124.44   7.41 1.885 1.288 0.003 0.000 0.003
 1.275   0.00 13.73  0.43  0.00  0.43  0.00 124.44   7.41 1.885 1.288 0.003 0.000 0.003
 1.165   0.00 13.03  0.39  0.00  0.39  0.00 124.44   7.41 1.885 1.288 0.003 0.000 0.003
 0.950   0.00  8.55  0.26  0.00  0.26  0.00 124.44   7.41 1.885 1.288 0.002 0.000 0.002
 0.446   0.00  7.27  0.22  0.00  0.22  0.00 149.63   7.68 1.862 1.281 0.001 0.000 0.001
 0.350   0.00  6.98  0.21  0.00  0.21  0.00 149.63   7.68 1.862 1.281 0.001 0.000 0.001
 0.305   0.00  6.60  0.10  0.00  0.10  0.00 163.59 183.33 1.919 2.000 0.001 0.000 0.001
 0.153   0.00  6.02  0.09  0.00  0.09  0.00 163.59 183.33 1.919 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 90 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 6.02 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev    w      l     Cxb  Cx  Dwk   ax    Fyk   Lxo   Lpx    Lx    Xx  s_xRcr  s_xRk
s_xRd
  m             m             mm          MPa                              MPa     MPa
MPa
------ ----- ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
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11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.60 3.7 0.427 220.63 0.200 1.033 0.323 0.912 2119.71 201.14
134.09
 5.789 160.2 10.6275 1.0 0.60 4.1 0.403 220.63 0.200 1.004 0.363 0.878 1671.31 193.74
129.16
 5.456 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.137 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.000 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 4.863 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 3.100 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 2.450 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.385 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.275 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.165 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.950 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.446 145.5 10.6275 1.0 0.60 4.6 0.383 275.00 0.200 0.979 0.439 0.816 1429.14 224.44
149.63
 0.350 145.5 10.6275 1.0 0.60 4.6 0.383 275.00 0.200 0.979 0.439 0.816 1429.14 224.44
149.63
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.200 0.979 0.340 0.892 2381.90 245.39
163.59
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.200 0.979 0.340 0.892 2381.90 245.39
163.59

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
```

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l = Distance between stiffeners

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Structural Flange Analysis, Angle = 0 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 0 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M          = Moment on Flange                                              = 9775.9 N-m
V          = Vertical Load on Flange (- is compression, + is tension)      = 0 N
S          = Shear Load on Flange                                          = 3887 N

Ds         = Outer Diameter of Shell                                       = 323.8 mm
Do         = Outside Diameter of Flange                                    = 482.6 mm
Dbc        = Bolt Circle Diameter                                          = 431.8 mm
Tf         = Thickness of Flange                                           = 31.8 mm
Tw         = Fillet Weld Size                                              = 6.0 mm

Db         = Nominal Bolt Diameter                                         = 22.2 mm
Nb         = Number of Bolts                                               = 12
Fu         = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                  = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb         = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys        = Yield Stress of Shell                                         = 215.81 MPa
Fw         = Tensile Stress of Weld                                        = 413.68 MPa
Fyc        = Yield Stress of Flange                                        = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E          = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 7547 N
Ab         = Nominal Area of Bolt                                          = 3.879 sq cm
Km         = Stiffness of Material                                         = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                             = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby        = Bolt Yield Stress                                             = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 6866 N
Fact       = Actual force on bolt                                          = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.075

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 124964 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144438 N
Ratio      = Fb / Fbcomb                                                   = 0.865
```

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```
Sh        = Shear on Bolt                                          = 324 N
Sallow    = Allowable Shear on Bolt                                = 92281 N
Ratio     = Sh / Sallow                                            = 0.004

Check Welding
Iw        = Bending Moment of Inertia for Weld                     = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                       = 22621.48
cm^4
Aw        = Area of Weld                                           = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                     = 13993.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw            = 124.11 MPa
Ratio     = Fba / Sw                                               = 0.113

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                           = 87.6 mm
Lg        = Gross Flange area for each bolt                        = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area             = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge              = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                       = 54.0 mm
A         = Distance from Bolt CL to Flange OD                     = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole             = 42.9 mm
Rho       = Calculated Parameter                                   = 3.377
Beta      = Calulcated Parameter                                   = 5.6865
Alpha'    = Alpha where treq'd is minimum                          = 1
Tc        = Required thickness to develop load w/no prying         = 10.3 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 8.2 mm
Ratio     = Treqd / Tf                                             = 0.257
```

Structural Flange Analysis, Angle = 10 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 10 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 9627.4 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -674 N
S         = Shear Load on Flange                                   = 3826 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa
```

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```
Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 7376 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 6710 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.073

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 124934 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144439 N
Ratio     = Fb / Fbcomb                                              = 0.865

Sh        = Shear on Bolt                                            = 319 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw        = Area of Weld                                             = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                       = 13858.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw              = 124.11 MPa
Ratio     = Fba / Sw                                                 = 0.112

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                             = 87.6 mm
Lg        = Gross Flange area for each bolt                          = 113.0 mm
```

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```
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 5.8251
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 10.2 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 8.1 mm
Ratio     = Treqd / Tf                                                  = 0.254
```

Structural Flange Analysis, Angle = 20 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 20 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 9186.3 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -1328 N
S         = Shear Load on Flange                                        = 3651 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 6981 N
Ab        = Nominal Area of Bolt                                        = 3.879 sq cm
```

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```
Km          = Stiffness of Material                                          = 5922221.21
N/mm
Kb          = Stiffness of Bolt                                              = 1238416.78
N/mm
CC          = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)         = 0.173
Fby         = Bolt Yield Stress                                              = 896316.8
KPa
Fproof      = Bolt Proof Stress (0.85*Fby)                                   = 761869.3
KPa
Aroot       = Bolt Root Area                                                 = 2.705 sq cm
Fi          = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}               = 123659 N
K           = Coefficient of Thread Friction                                 = 0.000
Tb          = Bolt Torque to Produce Preload: K*Fi*Db                        = 0.00 N-m
Fmin        = Min. Force to keep Flange in Compression                       = 6351 N
Fact        = Actual force on bolt                                           = 91479 N
Ratio       = Enough Pre-load to keep Joint in Compression:  Fmin / Fact     = 0.069

Fb          = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi           = 124866 N
Fballow     = Allowable Bolt Tensile Load (Pure Tension)                     = 152464 N
Fbcomb      = Allowable Bolt Tensile Load (Tens & Shear)                     = 144439 N
Ratio       = Fb / Fbcomb                                                    = 0.864

Sh          = Shear on Bolt                                                  = 304 N
Sallow      = Allowable Shear on Bolt                                        = 92281 N
Ratio       = Sh / Sallow                                                    = 0.003

Check Welding
Iw          = Bending Moment of Inertia for Weld                             = 11310.74
cm^4
Jw          = Polar Moment of Inertia for Weld                               = 22621.48
cm^4
Aw          = Area of Weld                                                   = 86.303 sq
cm
Fba         = Weld Stress due to Axial & Bending                             = 13303.0 KPa
Sw          = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                    = 124.11 MPa
Ratio       = Fba / Sw                                                       = 0.107

Design Flange: NO GUSSETS
Ln          = Net Flange area at each bolt                                   = 87.6 mm
Lg          = Gross Flange area for each bolt                                = 113.0 mm
Delta       = Ratio of net area(@bolt line) & gross area                     = 0.7753
A'          = Distance from Flange OD to Bolt Hole Edge                      = 12.7 mm
B           = Distance from Bolt CL to Pipe OD                               = 54.0 mm
A           = Distance from Bolt CL to Flange OD                             = 25.4 mm
B'          = Distance from Pipe OD to edge of Bolt Hole                     = 42.9 mm
Rho         = Calculated Parameter                                           = 3.377
Beta        = Calulcated Parameter                                           = 6.1714
Alpha'      = Alpha where treq'd is minimum                                  = 1
Tc          = Required thickness to develop load w/no prying                 = 9.9 mm
Alpha       = Ratio mom@ BL to Mom @ stem line                               = 0
Q           = Prying Force per bolt                                          = 0 N
Treq'd      = Required Flange Thickness                                      = 7.8 mm
Ratio       = Treqd / Tf                                                     = 0.247
```

Structural Flange Analysis, Angle = 30 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 30 Deg , Load # 4

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Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 8466.2 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -1942 N
S	= Shear Load on Flange	= 3364 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 6374 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 5799 N
Fact	= Actual force on bolt	= 91479 N
Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.063
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 124761 N

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```
Fballow   = Allowable Bolt Tensile Load (Pure Tension)          = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)          = 144439 N
Ratio     = Fb / Fbcomb                                         = 0.864

Sh        = Shear on Bolt                                       = 280 N
Sallow    = Allowable Shear on Bolt                             = 92281 N
Ratio     = Sh / Sallow                                         = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                  = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                    = 22621.48
cm^4
Aw        = Area of Weld                                        = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                  = 12343.3 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw         = 124.11 MPa
Ratio     = Fba / Sw                                            = 0.099

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                        = 87.6 mm
Lg        = Gross Flange area for each bolt                     = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area          = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge           = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                    = 54.0 mm
A         = Distance from Bolt CL to Flange OD                  = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole          = 42.9 mm
Rho       = Calculated Parameter                                = 3.377
Beta      = Calulcated Parameter                                = 6.7874
Alpha'    = Alpha where treq'd is minimum                       = 1
Tc        = Required thickness to develop load w/no prying      = 9.5 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                    = 0
Q         = Prying Force per bolt                               = 0 N
Treq'd    = Required Flange Thickness                           = 7.5 mm
Ratio     = Treqd / Tf                                          = 0.236
```

Structural Flange Analysis, Angle = 40 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 40 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                    = 7488.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -2497 N
S         = Shear Load on Flange                                = 2977 N

Ds        = Outer Diameter of Shell                             = 323.8 mm
Do        = Outside Diameter of Flange                          = 482.6 mm
Dbc       = Bolt Circle Diameter                                = 431.8 mm
Tf        = Thickness of Flange                                 = 31.8 mm
Tw        = Fillet Weld Size                                    = 6.0 mm

Db        = Nominal Bolt Diameter                               = 22.2 mm
Nb        = Number of Bolts                                     = 12
Fu        = Ultimate Bolt Tensile Stress                        = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu        = 393.00 MPa
```

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```
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys       = Yield Stress of Shell                                         = 215.81 MPa
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
Fyc       = Yield Stress of Flange                                        = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E         = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 5573 N
Ab        = Nominal Area of Bolt                                          = 3.879 sq cm
Km        = Stiffness of Material                                         = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                             = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby       = Bolt Yield Stress                                             = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 5070 N
Fact      = Actual force on bolt                                          = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.055

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 124622 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144439 N
Ratio     = Fb / Fbcomb                                                   = 0.863

Sh        = Shear on Bolt                                                 = 248 N
Sallow    = Allowable Shear on Bolt                                       = 92281 N
Ratio     = Sh / Sallow                                                   = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw        = Area of Weld                                                  = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                            = 11008.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                   = 124.11 MPa
Ratio     = Fba / Sw                                                      = 0.089
```

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```
Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 7.8052
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 8.9 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 7.0 mm
Ratio     = Treqd / Tf                                                  = 0.221
```

Structural Flange Analysis, Angle = 50 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 50 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 6283.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -2975 N
S         = Shear Load on Flange                                        = 2497 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509
```

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```
BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N          = 4603 N
Ab         = Nominal Area of Bolt                                             = 3.879 sq cm
Km         = Stiffness of Material                                            = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                                = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)           = 0.173
Fby        = Bolt Yield Stress                                                = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                     = 761869.3
KPa
Aroot      = Bolt Root Area                                                   = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}                 = 123659 N
K          = Coefficient of Thread Friction                                   = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                          = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                         = 4188 N
Fact       = Actual force on bolt                                             = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact       = 0.046

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi             = 124455 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                       = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                       = 144439 N
Ratio      = Fb / Fbcomb                                                      = 0.862

Sh         = Shear on Bolt                                                    = 208 N
Sallow     = Allowable Shear on Bolt                                          = 92281 N
Ratio      = Sh / Sallow                                                      = 0.002

Check Welding
Iw         = Bending Moment of Inertia for Weld                               = 11310.74
cm^4
Jw         = Polar Moment of Inertia for Weld                                 = 22621.48
cm^4
Aw         = Area of Weld                                                     = 86.303 sq
cm
Fba        = Weld Stress due to Axial & Bending                               = 9339.3 KPa
Sw         = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                      = 124.11 MPa
Ratio      = Fba / Sw                                                         = 0.075

Design Flange: NO GUSSETS
Ln         = Net Flange area at each bolt                                     = 87.6 mm
Lg         = Gross Flange area for each bolt                                  = 113.0 mm
Delta      = Ratio of net area(@bolt line) & gross area                       = 0.7753
A'         = Distance from Flange OD to Bolt Hole Edge                        = 12.7 mm
B          = Distance from Bolt CL to Pipe OD                                 = 54.0 mm
A          = Distance from Bolt CL to Flange OD                               = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                       = 42.9 mm
Rho        = Calculated Parameter                                             = 3.377
Beta       = Calulcated Parameter                                             = 9.5125
Alpha'     = Alpha where treq'd is minimum                                    = 1
Tc         = Required thickness to develop load w/no prying                   = 8.0 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                                 = 0
Q          = Prying Force per bolt                                            = 0 N
Treq'd     = Required Flange Thickness                                        = 6.4 mm
Ratio      = Treqd / Tf                                                       = 0.200
```

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Structural Flange Analysis, Angle = 60 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 60 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 4887.9 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -3364 N
S	= Shear Load on Flange	= 1942 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 3493 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 3178 N
Fact	= Actual force on bolt	= 91479 N

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Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.035
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 124263 N
Fballow	= Allowable Bolt Tensile Load (Pure Tension)	= 152464 N
Fbcomb	= Allowable Bolt Tensile Load (Tens & Shear)	= 144439 N
Ratio	= Fb / Fbcomb	= 0.860
Sh	= Shear on Bolt	= 162 N
Sallow	= Allowable Shear on Bolt	= 92281 N
Ratio	= Sh / Sallow	= 0.002

Check Welding

Iw	= Bending Moment of Inertia for Weld	= 11310.74 cm^4
Jw	= Polar Moment of Inertia for Weld	= 22621.48 cm^4
Aw	= Area of Weld	= 86.303 sq cm
Fba	= Weld Stress due to Axial & Bending	= 7386.2 KPa
Sw	= Allowable Fillet Weld Stress: (ASD) 0.3*Fuw	= 124.11 MPa
Ratio	= Fba / Sw	= 0.060

Design Flange: NO GUSSETS

Ln	= Net Flange area at each bolt	= 87.6 mm
Lg	= Gross Flange area for each bolt	= 113.0 mm
Delta	= Ratio of net area(@bolt line) & gross area	= 0.7753
A'	= Distance from Flange OD to Bolt Hole Edge	= 12.7 mm
B	= Distance from Bolt CL to Pipe OD	= 54.0 mm
A	= Distance from Bolt CL to Flange OD	= 25.4 mm
B'	= Distance from Pipe OD to edge of Bolt Hole	= 42.9 mm
Rho	= Calculated Parameter	= 3.377
Beta	= Calulcated Parameter	= 12.6293
Alpha'	= Alpha where treq'd is minimum	= 1
Tc	= Required thickness to develop load w/no prying	= 7.0 mm
Alpha	= Ratio mom@ BL to Mom @ stem line	= 0
Q	= Prying Force per bolt	= 0 N
Treq'd	= Required Flange Thickness	= 5.5 mm
Ratio	= Treqd / Tf	= 0.175

Structural Flange Analysis, Angle = 70 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 70 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 3343.5 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -3650 N
S	= Shear Load on Flange	= 1328 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm

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```
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu             = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy               = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 2277 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 2071 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.023

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 124052 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.859

Sh        = Shear on Bolt                                            = 111 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.001

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw        = Area of Weld                                             = 86.303 sq
cm
```

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```
Fba       = Weld Stress due to Axial & Bending                    = 5208.8 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw           = 124.11 MPa
Ratio     = Fba / Sw                                              = 0.042

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                          = 87.6 mm
Lg        = Gross Flange area for each bolt                       = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area            = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge             = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                      = 54.0 mm
A         = Distance from Bolt CL to Flange OD                    = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole            = 42.9 mm
Rho       = Calculated Parameter                                  = 3.377
Beta      = Calulcated Parameter                                  = 19.5326
Alpha'    = Alpha where treq'd is minimum                         = 1
Tc        = Required thickness to develop load w/no prying        = 5.7 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                      = 0
Q         = Prying Force per bolt                                 = 0 N
Treq'd    = Required Flange Thickness                             = 4.5 mm
Ratio     = Treqd / Tf                                            = 0.141
```

Structural Flange Analysis, Angle = 80 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 80 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                      = 1697.6 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -3825 N
S         = Shear Load on Flange                                  = 674 N

Ds        = Outer Diameter of Shell                               = 323.8 mm
Do        = Outside Diameter of Flange                            = 482.6 mm
Dbc       = Bolt Circle Diameter                                  = 431.8 mm
Tf        = Thickness of Flange                                   = 31.8 mm
Tw        = Fillet Weld Size                                      = 6.0 mm

Db        = Nominal Bolt Diameter                                 = 22.2 mm
Nb        = Number of Bolts                                       = 12
Fu        = Ultimate Bolt Tensile Stress                          = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu          = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy            = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                          = 60.00 %
Eb        = Modulus of Elasticity for Bolt                        = 202705.50
MPa

Fys       = Yield Stress of Shell                                 = 215.81 MPa
Fw        = Tensile Stress of Weld                                = 413.68 MPa
Fyc       = Yield Stress of Flange                                = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy            = 194.22 MPa
E         = Modulus of Elasticity of Flange                       = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt        = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters      = 10.00
```

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```
Spmax     = Maximum bolt spacing: Bspace*Db                              = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                         = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N      = 992 N
Ab        = Nominal Area of Bolt                                         = 3.879 sq cm
Km        = Stiffness of Material                                        = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                            = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)       = 0.173
Fby       = Bolt Yield Stress                                            = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                 = 761869.3
KPa
Aroot     = Bolt Root Area                                               = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}             = 123659 N
K         = Coefficient of Thread Friction                               = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                      = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                     = 902 N
Fact      = Actual force on bolt                                         = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact   = 0.010

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi         = 123830 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                   = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                   = 144440 N
Ratio     = Fb / Fbcomb                                                  = 0.857

Sh        = Shear on Bolt                                                = 56 N
Sallow    = Allowable Shear on Bolt                                      = 92281 N
Ratio     = Sh / Sallow                                                  = 0.001

Check Welding
Iw        = Bending Moment of Inertia for Weld                           = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                             = 22621.48
cm^4
Aw        = Area of Weld                                                 = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                           = 2873.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                  = 124.11 MPa
Ratio     = Fba / Sw                                                     = 0.023

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                 = 87.6 mm
Lg        = Gross Flange area for each bolt                              = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                   = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                    = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                             = 54.0 mm
A         = Distance from Bolt CL to Flange OD                           = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                   = 42.9 mm
Rho       = Calculated Parameter                                         = 3.377
Beta      = Calulcated Parameter                                         = 45.2309
Alpha'    = Alpha where treq'd is minimum                                = 1
Tc        = Required thickness to develop load w/no prying               = 3.7 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                             = 0
Q         = Prying Force per bolt                                        = 0 N
```

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```
Treq'd    = Required Flange Thickness                                  = 3.0 mm
Ratio     = Treqd / Tf                                                 = 0.093
```

Structural Flange Analysis, Angle = 90 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 90 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                           = 0.0 N-m
V         = Vertical Load on Flange (- is compression, + is tension)   = -3884 N
S         = Shear Load on Flange                                       = 0 N

Ds        = Outer Diameter of Shell                                    = 323.8 mm
Do        = Outside Diameter of Flange                                 = 482.6 mm
Dbc       = Bolt Circle Diameter                                       = 431.8 mm
Tf        = Thickness of Flange                                        = 31.8 mm
Tw        = Fillet Weld Size                                           = 6.0 mm

Db        = Nominal Bolt Diameter                                      = 22.2 mm
Nb        = Number of Bolts                                            = 12
Fu        = Ultimate Bolt Tensile Stress                               = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu               = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                 = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                               = 60.00 %
Eb        = Modulus of Elasticity for Bolt                             = 202705.50
MPa

Fys       = Yield Stress of Shell                                      = 215.81 MPa
Fw        = Tensile Stress of Weld                                     = 413.68 MPa
Fyc       = Yield Stress of Flange                                     = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                 = 194.22 MPa
E         = Modulus of Elasticity of Flange                            = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt             = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters           = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                            = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                       = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N    = 0 N
Ab        = Nominal Area of Bolt                                       = 3.879 sq cm
Km        = Stiffness of Material                                      = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                          = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)     = 0.173
Fby       = Bolt Yield Stress                                          = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                               = 761869.3
KPa
Aroot     = Bolt Root Area                                             = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}           = 123659 N
K         = Coefficient of Thread Friction                             = 0.000
```

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```
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                    = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                   = 0 N
Fact      = Actual force on bolt                                       = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi       = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                 = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                 = 144440 N
Ratio     = Fb / Fbcomb                                                = 0.856

Sh        = Shear on Bolt                                              = 0 N
Sallow    = Allowable Shear on Bolt                                    = 92281 N
Ratio     = Sh / Sallow                                                = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                         = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                           = 22621.48
cm^4
Aw        = Area of Weld                                               = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                         = 450.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                = 124.11 MPa
Ratio     = Fba / Sw                                                   = 0.004

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                               = 87.6 mm
Lg        = Gross Flange area for each bolt                            = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                 = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                  = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                           = 54.0 mm
A         = Distance from Bolt CL to Flange OD                         = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                 = 42.9 mm
Rho       = Calculated Parameter                                       = 3.377
Beta      = Calulcated Parameter                                       = 0
Alpha'    = Alpha where treq'd is minimum                              = 0
Tc        = Required thickness to develop load w/no prying             = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                           = 0
Q         = Prying Force per bolt                                      = 0 N
Treq'd    = Required Flange Thickness                                  = 0.0 mm
Ratio     = Treqd / Tf                                                 = 0.000
```

Conical Transition Analysis, Angle = 0 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63

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```
E:     Modulus of Elasticity (MPa)                    202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                      117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                              412.65      412.65
412.65

M:     Overturning Moment (KN-m)                          10.17        0.00
12.19
V:     Vertical Axial Loading (KN)                         0.00        0.00
0.00
Sx:    Section Modulus (cm^3)                            750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                       98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.00        0.00
0.00
fb:    Bending Strss - M/Sx (MPa)                         13.56       13.94
6.38
fb':   Localized Bending Stress (MPa)                     15.66       15.66
9.23
fh':   Hoop Stress (MPa)                                   8.30        0.00
4.90
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                     2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                     3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                13.56       13.94
6.38
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          29.21       29.60
15.62
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.102	PASS	0.105	PASS	0.048	PASS
Check 2: Stot1 / Ft	0.071	PASS	0.072	PASS	0.038	PASS
Check 3: fh' < Fh	0.075	PASS	0.000	PASS	0.044	PASS
Stiff Ring Req'd?	0.102	Not Req'd	0.105	Cone OK	0.048	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 0 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	33.40	0.00	38.78
V:	Vertical Axial Loading (KN)	0.00	0.00	0.00
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.00	0.00	0.00
fb:	Bending Strss - M/Sx (MPa)	17.48	18.15	4.46
fb':	Localized Bending Stress (MPa)	29.54	29.54	10.93
fh':	Hoop Stress (MPa)	15.67	0.00	5.80
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	17.48	18.15	4.46
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	47.03	47.69	15.39
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.132	PASS	0.137	PASS	0.037	PASS
Check 2: Stot1 / Ft	0.114	PASS	0.116	PASS	0.037	PASS
Check 3: fh' < Fh	0.142	PASS	0.000	PASS	0.058	PASS
Stiff Ring Req'd?	0.142	Not Req'd	0.137	Cone OK	0.058	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 10 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	10.02	0.00	12.01
V:	Vertical Axial Loading (KN)	0.84	0.00	0.95
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.09	0.09	0.06
fb:	Bending Strss - M/Sx (MPa)	13.35	13.73	6.29
fb':	Localized Bending Stress (MPa)	15.52	15.52	9.18
fh':	Hoop Stress (MPa)	8.23	0.00	4.87
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)             13.44       13.81
6.35
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       28.95       29.33
15.53
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.101	PASS	0.104	PASS	0.048	PASS
Check 2: Stot1 / Ft	0.070	PASS	0.071	PASS	0.038	PASS
Check 3: fh' < Fh	0.075	PASS	0.000	PASS	0.044	PASS
Stiff Ring Req'd?	0.101	Not Req'd	0.104	Cone OK	0.048	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     34.29        0.00
39.93
V:     Vertical Axial Loading (KN)                    1.54        0.00
0.83
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.10        0.10
0.03
fb:    Bending Strss - M/Sx (MPa)                    17.95       18.64
4.59
```

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```
fb':   Localized Bending Stress (MPa)                    30.50       30.50
11.31
fh':   Hoop Stress (MPa)                                 16.17        0.00
6.00
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               18.05       18.74
4.62
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         48.55       49.24
15.93
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.136	PASS	0.142	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.119	PASS	0.039	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.060	PASS
Stiff Ring Req'd?	0.147	Not Req'd	0.142	Cone OK	0.060	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 20 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone        Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65
```

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```
M:     Overturning Moment (KN-m)                          9.56        0.00
11.46
V:     Vertical Axial Loading (KN)                        1.65        0.00
1.88
Sx:    Section Modulus (cm^3)                           750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                     98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.17        0.17
0.12
fb:    Bending Strss - M/Sx (MPa)                        12.74       13.10
6.00
fb':   Localized Bending Stress (MPa)                    14.91       14.91
8.85
fh':   Hoop Stress (MPa)                                  7.91        0.00
4.69
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               12.91       13.27
6.12
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         27.81       28.18
14.97
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.097	PASS	0.100	PASS	0.046	PASS
Check 2: Stot1 / Ft	0.067	PASS	0.068	PASS	0.036	PASS
Check 3: fh' < Fh	0.072	PASS	0.000	PASS	0.043	PASS
Stiff Ring Req'd?	0.097	Not Req'd	0.100	Cone OK	0.046	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small        Cone       Large
Ht:    Height of Cone (mm)                                0.0      1000.0
0.0
OD:    Outer Diameter (mm)                              508.0         0.0
1066.8
```

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```
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       34.11        0.00
39.81
V:     Vertical Axial Loading (KN)                      3.16        0.00
1.75
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                  156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.20        0.21
0.05
fb:    Bending Strss - M/Sx (MPa)                      17.85       18.54
4.58
fb':   Localized Bending Stress (MPa)                  30.51       30.51
11.35
fh':   Hoop Stress (MPa)                               16.18        0.00
6.02
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                  1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                          220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                   110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                  2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)             18.06       18.75
4.63
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       48.57       49.26
15.98
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.136	PASS	0.142	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.119	PASS	0.039	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.060	PASS
Stiff Ring Req'd?	0.147	Not Req'd	0.142	Cone OK	0.060	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 30 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	8.81	0.00	10.56
V:	Vertical Axial Loading (KN)	2.41	0.00	2.74
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.24	0.25	0.18
fb:	Bending Strss - M/Sx (MPa)	11.74	12.07	5.53
fb':	Localized Bending Stress (MPa)	13.84	13.84	8.25
fh':	Hoop Stress (MPa)	7.34	0.00	4.38
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	11.98	12.32	5.70
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	25.83	26.17	13.95

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```
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.091	PASS	0.093	PASS	0.043	PASS
Check 2: Stot1 / Ft	0.063	PASS	0.063	PASS	0.034	PASS
Check 3: fh' < Fh	0.067	PASS	0.000	PASS	0.040	PASS
Stiff Ring Req'd?	0.091	Not Req'd	0.093	Cone OK	0.043	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       32.85        0.00
38.44
V:     Vertical Axial Loading (KN)                      4.81        0.00
2.76
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                 156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.31        0.32
0.08
fb:    Bending Strss - M/Sx (MPa)                      17.19       17.85
4.42
fb':   Localized Bending Stress (MPa)                  29.57       29.57
11.03
fh':   Hoop Stress (MPa)                               15.68        0.00
5.85
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                 1596.11     1596.11
760.05
```

```
Fhc:   Hoop Comp - Fys (MPa)                          220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                   110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                  2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)             17.50       18.17
4.51
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       47.08       47.75
15.54
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.132	PASS	0.137	PASS	0.038	PASS
Check 2: Stot1 / Ft	0.114	PASS	0.116	PASS	0.038	PASS
Check 3: fh' < Fh	0.142	PASS	0.000	PASS	0.058	PASS
Stiff Ring Req'd?	0.142	Not Req'd	0.137	Cone OK	0.058	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 40 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      7.79        0.00
9.34
V:     Vertical Axial Loading (KN)                    3.10        0.00
3.53
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
```

```
Ax:    Cross Sectional Area (sq cm)                      98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.31        0.32
0.23
fb:    Bending Strss - M/Sx (MPa)                        10.38       10.68
4.89
fb':   Localized Bending Stress (MPa)                    12.36       12.36
7.40
fh':   Hoop Stress (MPa)                                  6.55        0.00
3.92
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               10.70       11.00
5.11
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         23.06       23.36
12.51
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.081	PASS	0.083	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.056	PASS	0.057	PASS	0.030	PASS
Check 3: fh' < Fh	0.059	PASS	0.000	PASS	0.036	PASS
Stiff Ring Req'd?	0.081	Not Req'd	0.083	Cone OK	0.039	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small        Cone       Large
Ht:    Height of Cone (mm)                                0.0      1000.0
0.0
OD:    Outer Diameter (mm)                              508.0         0.0
1066.8
T:     Thickness (mm)                                    10.0        10.0
10.0
Fys:   Yield Stress (MPa)                               220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                   202705.50   202705.50
202705.50
```

```
Sa:    Allowable Axial Stress (MPa)                    117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                            412.65      412.65
412.65

M:     Overturning Moment (KN-m)                        30.54        0.00
35.83
V:     Vertical Axial Loading (KN)                       6.48        0.00
3.84
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                   156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.41        0.43
0.12
fb:    Bending Strss - M/Sx (MPa)                       15.99       16.60
4.12
fb':   Localized Bending Stress (MPa)                   27.71       27.71
10.38
fh':   Hoop Stress (MPa)                                14.70        0.00
5.51
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              16.40       17.03
4.24
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        44.12       44.74
14.62
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.124	PASS	0.129	PASS	0.036	PASS
Check 2: Stot1 / Ft	0.107	PASS	0.108	PASS	0.035	PASS
Check 3: fh' < Fh	0.133	PASS	0.000	PASS	0.055	PASS
Stiff Ring Req'd?	0.133	Not Req'd	0.129	Cone OK	0.055	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 50 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 50 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	6.54	0.00	7.84
V:	Vertical Axial Loading (KN)	3.70	0.00	4.20
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.38	0.39	0.27
fb:	Bending Strss - M/Sx (MPa)	8.71	8.96	4.10
fb':	Localized Bending Stress (MPa)	10.50	10.50	6.32
fh':	Hoop Stress (MPa)	5.57	0.00	3.35
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	9.09	9.35	4.37
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	19.59	19.84	10.69
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.069	PASS	0.071	PASS	0.033	PASS
Check 2: Stot1 / Ft	0.047	PASS	0.048	PASS	0.026	PASS
Check 3: fh' < Fh	0.050	PASS	0.000	PASS	0.030	PASS
Stiff Ring Req'd?	0.069	Not Req'd	0.071	Cone OK	0.033	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	27.24	0.00	32.06
V:	Vertical Axial Loading (KN)	8.17	0.00	5.03
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.52	0.54	0.15
fb:	Bending Strss - M/Sx (MPa)	14.26	14.81	3.69
fb':	Localized Bending Stress (MPa)	24.98	24.98	9.41
fh':	Hoop Stress (MPa)	13.25	0.00	4.99
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75

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```
Stot:  Total Stress Check 1: fa + fb (MPa)                  14.78       15.35
3.84
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)            39.76       40.33
13.25
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                      132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                              110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.112	PASS	0.116	PASS	0.032	PASS
Check 2: Stot1 / Ft	0.096	PASS	0.098	PASS	0.032	PASS
Check 3: fh' < Fh	0.120	PASS	0.000	PASS	0.050	PASS
Stiff Ring Req'd?	0.120	Not Req'd	0.116	Cone OK	0.050	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 60 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small         Cone        Large
Ht:    Height of Cone (mm)                            0.0        385.0
0.0
OD:    Outer Diameter (mm)                          323.8          0.0
508.0
T:     Thickness (mm)                                10.0         10.0
10.0
Fys:   Yield Stress (MPa)                           220.63       220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50    202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90       117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65       412.65
412.65

M:     Overturning Moment (KN-m)                      5.09         0.00
6.10
V:     Vertical Axial Loading (KN)                    4.18         0.00
4.75
Sx:    Section Modulus (cm^3)                       750.3        750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583       98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.42         0.44
0.30
fb:    Bending Strss - M/Sx (MPa)                     6.78         6.97
3.19
```

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```
fb':   Localized Bending Stress (MPa)                    8.32        8.32
5.06
fh':   Hoop Stress (MPa)                                 4.41        0.00
2.68
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               7.20        7.41
3.49
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        15.52       15.72
8.55
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.054	PASS	0.056	PASS	0.026	PASS
Check 2: Stot1 / Ft	0.038	PASS	0.038	PASS	0.021	PASS
Check 3: fh' < Fh	0.040	PASS	0.000	PASS	0.024	PASS
Stiff Ring Req'd?	0.054	Not Req'd	0.056	Cone OK	0.026	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     23.00        0.00
27.18
```

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```
V:     Vertical Axial Loading (KN)                          9.98        0.00
6.43
Sx:    Section Modulus (cm^3)                             1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                       156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                            0.64        0.66
0.19
fb:    Bending Strss - M/Sx (MPa)                          12.04       12.50
3.13
fb':   Localized Bending Stress (MPa)                      21.43       21.43
8.13
fh':   Hoop Stress (MPa)                                   11.36        0.00
4.31
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                      1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                               220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                        110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                      2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                               220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                 12.68       13.17
3.32
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)           34.11       34.59
11.46
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                      132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                              110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.096	PASS	0.099	PASS	0.028	PASS
Check 2: Stot1 / Ft	0.083	PASS	0.084	PASS	0.028	PASS
Check 3: fh' < Fh	0.103	PASS	0.000	PASS	0.043	PASS
Stiff Ring Req'd?	0.103	Not Req'd	0.099	Cone OK	0.043	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 70 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small        Cone       Large
Ht:    Height of Cone (mm)                                0.0       385.0
0.0
OD:    Outer Diameter (mm)                              323.8         0.0
508.0
```

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```
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      3.48        0.00
4.17
V:     Vertical Axial Loading (KN)                    4.54        0.00
5.16
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.46        0.47
0.33
fb:    Bending Strss - M/Sx (MPa)                     4.64        4.77
2.18
fb':   Localized Bending Stress (MPa)                 5.89        5.89
3.63
fh':   Hoop Stress (MPa)                              3.12        0.00
1.93
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                        220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                 110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                        220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)            5.10        5.24
2.51
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)     10.98       11.13
6.15
Fb:    Allow Bend (ASD): .6*Fxc (MPa)               132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                       110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.038	PASS	0.040	PASS	0.019	PASS
Check 2: Stot1 / Ft	0.027	PASS	0.027	PASS	0.015	PASS
Check 3: fh' < Fh	0.028	PASS	0.000	PASS	0.017	PASS
Stiff Ring Req'd?	0.038	Not Req'd	0.040	Cone OK	0.019	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	17.86	0.00	21.22
V:	Vertical Axial Loading (KN)	12.20	0.00	8.35
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.78	0.81	0.25
fb:	Bending Strss - M/Sx (MPa)	9.35	9.71	2.44
fb':	Localized Bending Stress (MPa)	17.12	17.12	6.59
fh':	Hoop Stress (MPa)	9.08	0.00	3.50
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	10.13	10.52	2.69
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	27.24	27.63	9.29
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25

```
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.077	PASS	0.079	PASS	0.023	PASS
Check 2: Stot1 / Ft	0.066	PASS	0.067	PASS	0.023	PASS
Check 3: fh' < Fh	0.082	PASS	0.000	PASS	0.035	PASS
Stiff Ring Req'd?	0.082	Not Req'd	0.079	Cone OK	0.035	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 80 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      1.77        0.00
2.12
V:     Vertical Axial Loading (KN)                    4.75        0.00
5.40
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.48        0.50
0.35
fb:    Bending Strss - M/Sx (MPa)                     2.35        2.42
1.11
fb':   Localized Bending Stress (MPa)                 3.28        3.28
2.10
fh':   Hoop Stress (MPa)                              1.74        0.00
1.12
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                2504.08     2504.08
1596.11
```

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Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	2.84	2.92	1.45
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	6.11	6.19	3.56
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.021	PASS	0.022	PASS	0.011	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.009	PASS
Check 3: fh' < Fh	0.016	PASS	0.000	PASS	0.010	PASS
Stiff Ring Req'd?	0.021	Not Req'd	0.022	Cone OK	0.011	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	11.56	0.00	13.85
V:	Vertical Axial Loading (KN)	16.12	0.00	12.08
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002

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```
CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          1.03        1.07
0.36
fb:    Bending Strss - M/Sx (MPa)                         6.05        6.28
1.59
fb':   Localized Bending Stress (MPa)                    11.97       11.97
4.79
fh':   Hoop Stress (MPa)                                  6.35        0.00
2.54
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                7.08        7.35
1.96
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         19.05       19.32
6.75
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.053	PASS	0.056	PASS	0.016	PASS
Check 2: Stot1 / Ft	0.046	PASS	0.047	PASS	0.016	PASS
Check 3: fh' < Fh	0.058	PASS	0.000	PASS	0.025	PASS
Stiff Ring Req'd?	0.058	Not Req'd	0.056	Cone OK	0.025	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 90 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small        Cone       Large
Ht:    Height of Cone (mm)                                0.0       385.0
0.0
OD:    Outer Diameter (mm)                              323.8         0.0
508.0
T:     Thickness (mm)                                    10.0        10.0
10.0
Fys:   Yield Stress (MPa)                               220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                   202705.50   202705.50
202705.50
```

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```
Sa:    Allowable Axial Stress (MPa)                    117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                            412.65      412.65
412.65

M:     Overturning Moment (KN-m)                         0.00        0.00
0.00
V:     Vertical Axial Loading (KN)                       4.83        0.00
5.49
Sx:    Section Modulus (cm^3)                           750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                     98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.49        0.50
0.35
fb:    Bending Strss - M/Sx (MPa)                        0.00        0.00
0.00
fb':   Localized Bending Stress (MPa)                    0.57        0.57
0.51
fh':   Hoop Stress (MPa)                                 0.30        0.00
0.27
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               0.49        0.50
0.35
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         1.06        1.07
0.86
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.004	PASS	0.004	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.003	PASS	0.003	PASS	0.002	PASS
Check 3: fh' < Fh	0.003	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.004	Not Req'd	0.004	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

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		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.00	0.00	0.00
V:	Vertical Axial Loading (KN)	36.15	0.00	32.04
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	2.31	2.40	0.97
fb:	Bending Strss - M/Sx (MPa)	0.00	0.00	0.00
fb':	Localized Bending Stress (MPa)	3.90	3.90	2.36
fh':	Hoop Stress (MPa)	2.07	0.00	1.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	2.31	2.40	0.97
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	6.21	6.30	3.33
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result

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Check 1: Stot / Fb	0.017	PASS	0.018	PASS	0.008	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.008	PASS
Check 3: fh' < Fh	0.019	PASS	0.000	PASS	0.012	PASS
Stiff Ring Req'd?	0.019	Not Req'd	0.018	Cone OK	0.012	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Stack Deflection Lift Angle = 0 Deg
Load Combination Dead Weight

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
16.500	0.0	-1.6	0.0	1.6	29.0	0.055	Pass
13.452	0.0	0.0	0.0	0.0	13.8	0.001	Pass
11.500	0.0	0.2	0.0	0.2	4.0	0.061	Pass
11.467	0.0	0.2	0.0	0.2	3.8	0.062	Pass
11.385	0.0	0.2	0.0	0.2	3.4	0.063	Pass
11.257	0.0	0.2	0.0	0.2	2.8	0.065	Pass
11.128	0.0	0.1	0.0	0.1	2.1	0.067	Pass
11.000	0.0	0.1	0.0	0.1	1.5	0.068	Pass
10.699	0.0	0.0	0.0	0.0	52.7	0.000	Pass
10.400	0.0	-0.1	0.0	0.1	52.7	0.002	Pass
8.400	0.0	-0.9	0.0	0.9	52.7	0.016	Pass
6.456	0.0	-1.2	0.0	1.2	52.7	0.023	Pass
6.123	0.0	-1.2	0.0	1.2	52.7	0.022	Pass
5.789	0.0	-1.1	0.0	1.1	52.7	0.022	Pass
5.456	0.0	-1.1	0.0	1.1	52.7	0.021	Pass
5.137	0.0	-1.0	0.0	1.0	52.7	0.020	Pass
5.000	0.0	-1.0	0.0	1.0	52.7	0.019	Pass
4.863	0.0	-1.0	0.0	1.0	52.7	0.019	Pass
3.100	0.0	-0.7	0.0	0.7	52.7	0.013	Pass
2.450	0.0	-0.5	0.0	0.5	52.7	0.010	Pass
1.385	0.0	-0.3	0.0	0.3	52.7	0.006	Pass
1.275	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
1.165	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
0.950	0.0	-0.2	0.0	0.2	52.7	0.004	Pass
0.446	0.0	-0.1	0.0	0.1	52.7	0.001	Pass
0.350	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.305	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.153	0.0	0.0	0.0	0.0	52.7	0.000	Pass
0.000	0.0	0.0	0.0	0.0	0.8	0.050	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dy^2 + Dz^2)
Ratio = Dres / Limit

Lifting Reactions Summary - Dead Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	17443	18398
10.0	17666	18174
20.0	17898	17943

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30.0	18155	17686
40.0	18459	17381
50.0	18854	16987
60.0	19425	16416
70.0	20400	15441
80.0	22655	13186
90.0	35841	0

Lifting Reactions Summary - Dead + Impact Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	26164	27597
10.0	26499	27262
20.0	26847	26914
30.0	27232	26529
40.0	27689	26072
50.0	28281	25480
60.0	29137	24624
70.0	30599	23162
80.0	33982	19779
90.0	53761	0

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D – LIFTING LUGS ANALYSIS

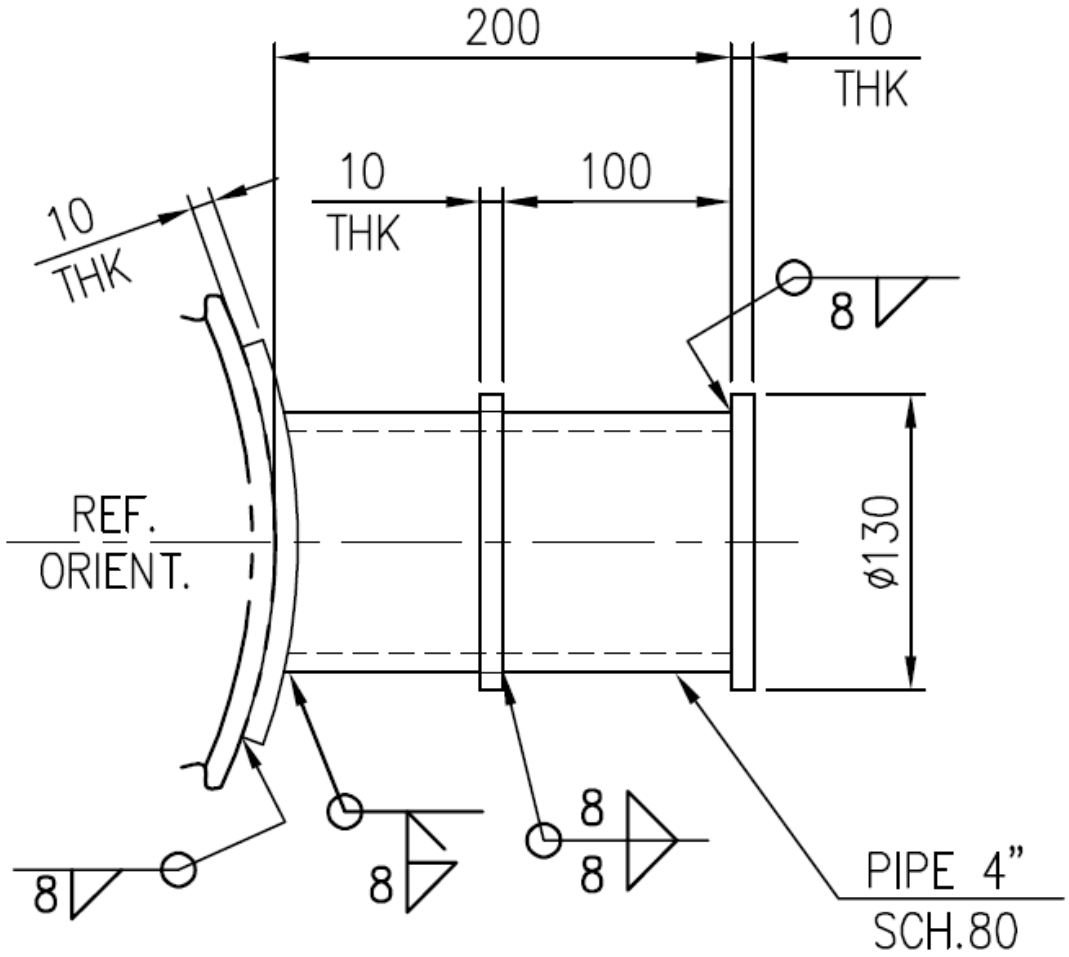
The desing of the liftign lugs is performed using the loads amplified by a contingency factor that safely envelope the results of both configuration of lifting. The loads are included in the drawing 1724000887-MAC-DD-00019_01 (23-0193-0530A_01) and they are reported hereafter.

LIFT ANGLE Deg.	LIFTING LOAD kN	TAILING LOAD kN
0	24.95	34.62
10	25.37	34.20
20	25.80	33.77
30	26.29	33.29
40	26.86	32.71
50	27.60	31.97
60	28.68	30.89
70	30.51	29.06
80	34.76	24.82
90	59.57	0.00

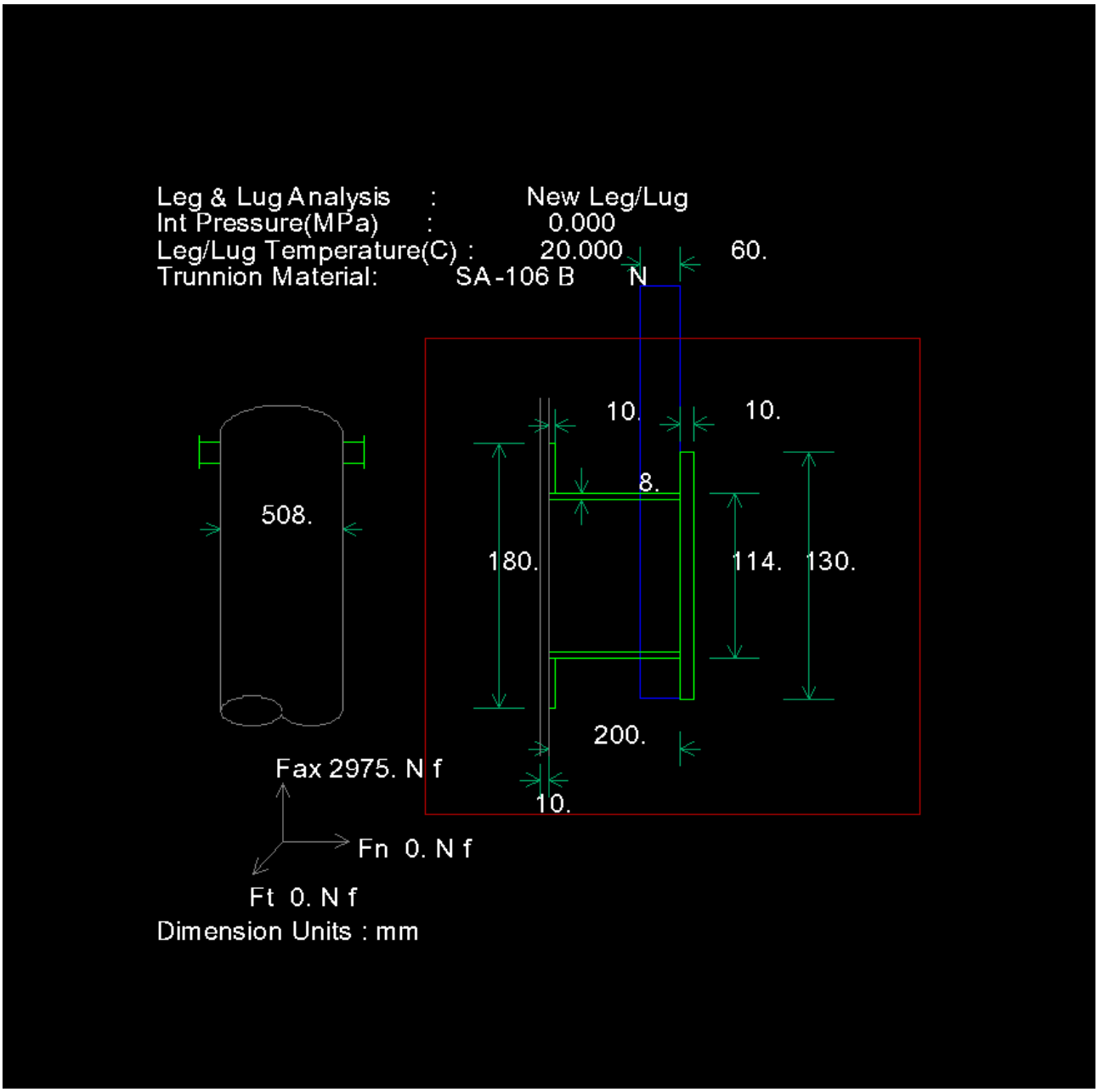
D.1 LIFTING TRUNNIONS

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The trunnion geoemtry is reported here after.



D.1.1 90° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                                0.00  MPa
Design Temperature for Attachment            TEMP      20.00  C
Vessel Outside Diameter                        OD     508.000  mm.
Vessel Wall Thickness                          Ts     10.0000  mm.
Vessel Corrosion Allowance                    Cas      0.0000  mm.
Vessel Material                                     SA-516 70
Vessel Material UNS Number                             K02700
Vessel Allowable Stress at Design               S     137.90  MPa
```

```
Analysis Type:                                        Trunnion

Empty Weight of Vessel                        Wemp       0.00  N f
Operating Weight of Vessel (vertical load )     W       0.00  N f

Trunnion Material                                    SA-106 B
Trunnion Material UNS Number                           K03006
Trunnion Yield Stress                           SY     241.32  MPa
Trunnion Outside Diameter                      TOD    114.300  mm.
Trunnion Thickness                            TTHK     8.0000  mm.
Trunnion Length                                 TL   200.0000  mm.
Bail/Sling Width                                TT    60.0000  mm.
Pad Outside Diameter                           POD    180.000  mm.
Pad Thickness                                 PTHK    10.0000  mm.
Ring Outside Diameter                          Rod     130.00  mm.
Ring Thickness                                Rthk      10.00  mm.
Trunnion Type                                        Hollow
Lift Orientation                                     Horizontal
Impact Factor                                Impfac       1.00

Force Along Vessel Axis                         Fax    2975.00  N f
Force Normal to Vessel                           Fn       0.00  N f
Force Tangential to Vessel                       Ft       0.00  N f
Perform WRC-107 Analysis on the Trunnion                 Yes

Occasional Load Factor (AISC A5.2)           Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((2975.00^2 + 0.00^2)^1/2) * 1.00
 = 2975.00 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 2975.00
 = 505955.12 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 505955 *1.000/ 66402.77
 = 7.62 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 2975.00 / 2671.61
 = 1.11 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
 = SBC / SBA + SSC / SSA
 = 7.62 / 159.27 + 1.11 / 96.53
 = 0.06 [Passed] UCHK, Must be less than 1.
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Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 2975.00 / 6858.00
 = 0.43 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                     VC          0.0  N f
Longitudinal Shear                        VL      -2975.0  N f
Circumferential Moment                    MC          0.0  N-mm 0.
Longitudinal Moment                       ML    -505955.1  N-mm 0.
Torsional Moment                          MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)

              |                   Stress Intensity Values at                                |
Type of       |                                                                             |
Stress   Load |       Au        Al        Bu        Bl        Cu        Cl        Du        Dl|
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Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	2.8	2.8	-2.8	-2.8	0.0	0.0	0.0	0.0
Circ. Bend. ML	6.7	-6.7	-6.7	6.7	0.0	0.0	0.0	0.0
Tot. Circ. Str.	9.4	-3.9	-9.4	3.9	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.8	0.8	-0.8	-0.8	0.0	0.0	0.0	0.0
Long. Bend. ML	10.5	-10.5	-10.5	10.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	11.3	-9.7	-11.3	9.7	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	0.8	0.8	-0.8	-0.8
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	0.8	0.8	-0.8	-0.8
Str. Int.	11.3	9.7	11.3	9.7	1.7	1.7	1.7	1.7

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	5.6	5.6	-5.6	-5.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	7.1	-7.1	-7.1	7.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	12.6	-1.5	-12.6	1.5	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	2.6	2.6	-2.6	-2.6	0.0	0.0	0.0	0.0
Long. Bend. ML	11.7	-11.7	-11.7	11.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	14.2	-9.1	-14.2	9.1	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	1.1	1.1	-1.1	-1.1
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	1.1	1.1	-1.1	-1.1
Str. Int.	14.2	9.1	14.2	9.1	2.1	2.1	2.1	2.1

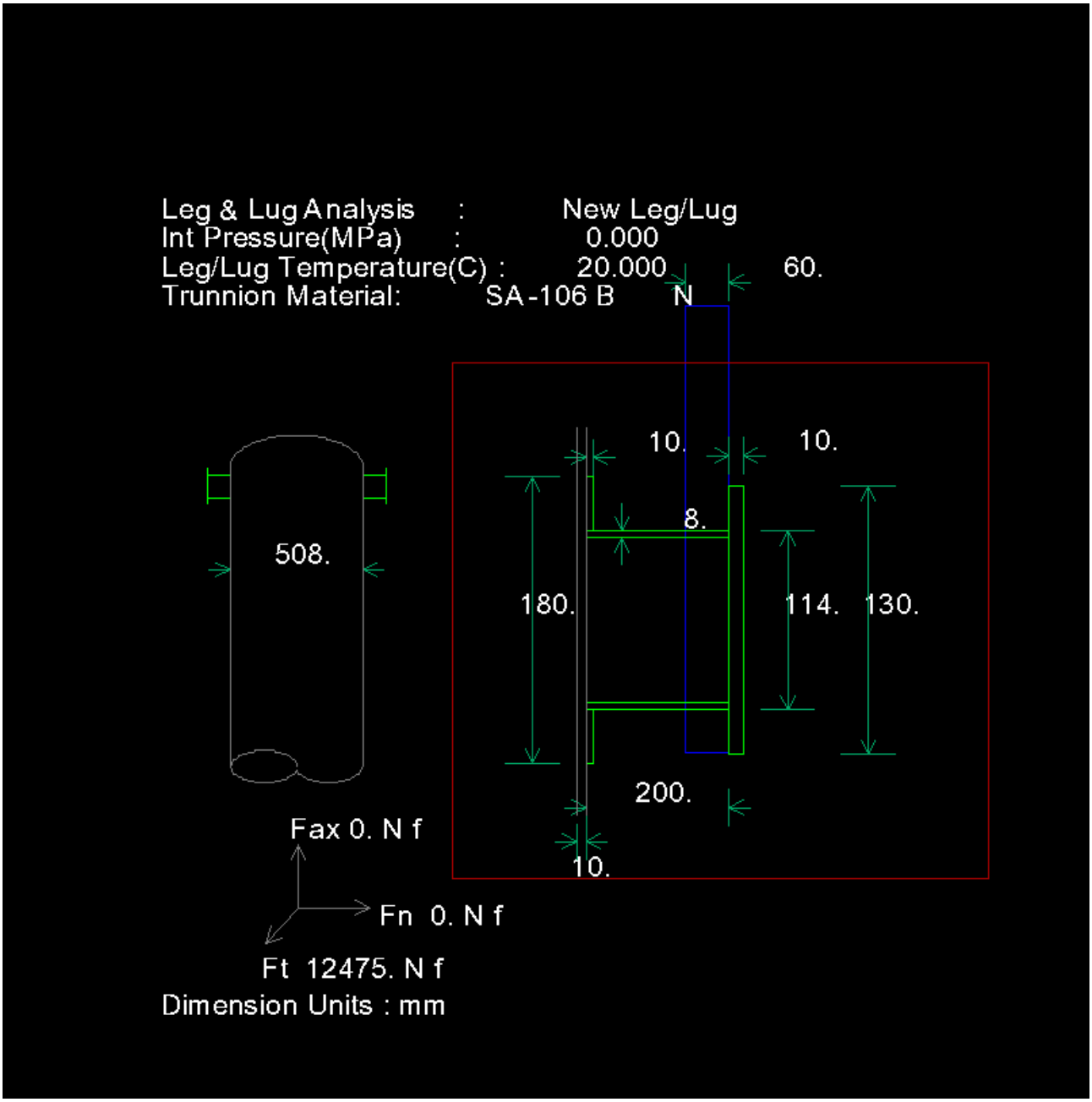
SUMMARY OF RESULTS:

Trunnion unity check value: 0.0594

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	7.62	159.27	Pass
Shear Stress (MPa)	1.11	96.53	Pass
Bearing Stress (MPa)	0.43	180.99	Pass

Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 11.32 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 14.24 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.1.2 0° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                                0.00  MPa
Design Temperature for Attachment           TEMP       20.00  C
Vessel Outside Diameter                       OD     508.000  mm.
Vessel Wall Thickness                         Ts     10.0000  mm.
Vessel Corrosion Allowance                   Cas      0.0000  mm.
```

```
Vessel Material                                    SA-516 70
Vessel Material UNS Number                           K02700
Vessel Allowable Stress at Design              S     137.90  MPa
Analysis Type:                                    Trunnion

Empty Weight of Vessel                      Wemp       0.00  N f
Operating Weight of Vessel (vertical load )    W       0.00  N f

Trunnion Material                                  SA-106 B
Trunnion Material UNS Number                         K03006
Trunnion Yield Stress                         SY     241.32  MPa
Trunnion Outside Diameter                    TOD    114.300  mm.
Trunnion Thickness                          TTHK     8.0000  mm.
Trunnion Length                               TL   200.0000  mm.
Bail/Sling Width                              TT    60.0000  mm.
Pad Outside Diameter                         POD    180.000  mm.
Pad Thickness                               PTHK    10.0000  mm.
Ring Outside Diameter                        Rod     130.00  mm.
Ring Thickness                              Rthk      10.00  mm.
Trunnion Type                                      Hollow
Lift Orientation                                   Horizontal
Impact Factor                             Impfac       1.00

Force Along Vessel Axis                       Fax       0.00  N f
Force Normal to Vessel                         Fn       0.00  N f
Force Tangential to Vessel                     Ft   12475.00  N f
Perform WRC-107 Analysis on the Trunnion              Yes

Occasional Load Factor (AISC A5.2)         Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((.00^2 + 12475.00^2)^1/2) * 1.00
 = 12475.00 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 12475.00
 = 2121610.00 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 2121610 *1.000/ 66402.77
 = 31.94 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 12475.00 / 2671.61
 = 4.67 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
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 = SBC / SBA + SSC / SSA
 = 31.94 / 159.27 + 4.67 / 96.53
 = 0.25 [Passed] UCHK, Must be less than 1.

Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 12475.00 / 6858.00
 = 1.82 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                      VC     -12475.0  N f
Longitudinal Shear                         VL          0.0  N f
Circumferential Moment                     MC    2121610.0  N-mm 0.
Longitudinal Moment                        ML          0.0  N-mm 0.
Torsional Moment                           MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)
```

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Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-3.5	-3.5	3.5	3.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-60.1	60.1	60.1	-60.1
Circ. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.0	0.0	0.0	0.0	-63.6	56.5	63.6	-56.5
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-5.5	-5.5	5.5	5.5
Long. Bend. MC	0.0	0.0	0.0	0.0	-33.7	33.7	33.7	-33.7
Long. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.0	0.0	0.0	0.0	-39.2	28.1	39.2	-28.1
Shear VC	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Str. Int.	6.9	6.9	6.9	6.9	63.6	56.5	63.6	56.5

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of	Stress Intensity Values at

Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-11.5	-11.5	11.5	11.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-121.2	121.2	121.2	-121.2
Circ. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.0	0.0	0.0	0.0	-132.7	109.7	132.7	-109.7
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-23.4	-23.4	23.4	23.4
Long. Bend. MC	0.0	0.0	0.0	0.0	-51.5	51.5	51.5	-51.5
Long. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.0	0.0	0.0	0.0	-74.9	28.1	74.9	-28.1
Shear VC	-4.4	-4.4	4.4	4.4	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-4.4	-4.4	4.4	4.4	0.0	0.0	0.0	0.0
Str. Int.	8.8	8.8	8.8	8.8	132.7	109.7	132.7	109.7

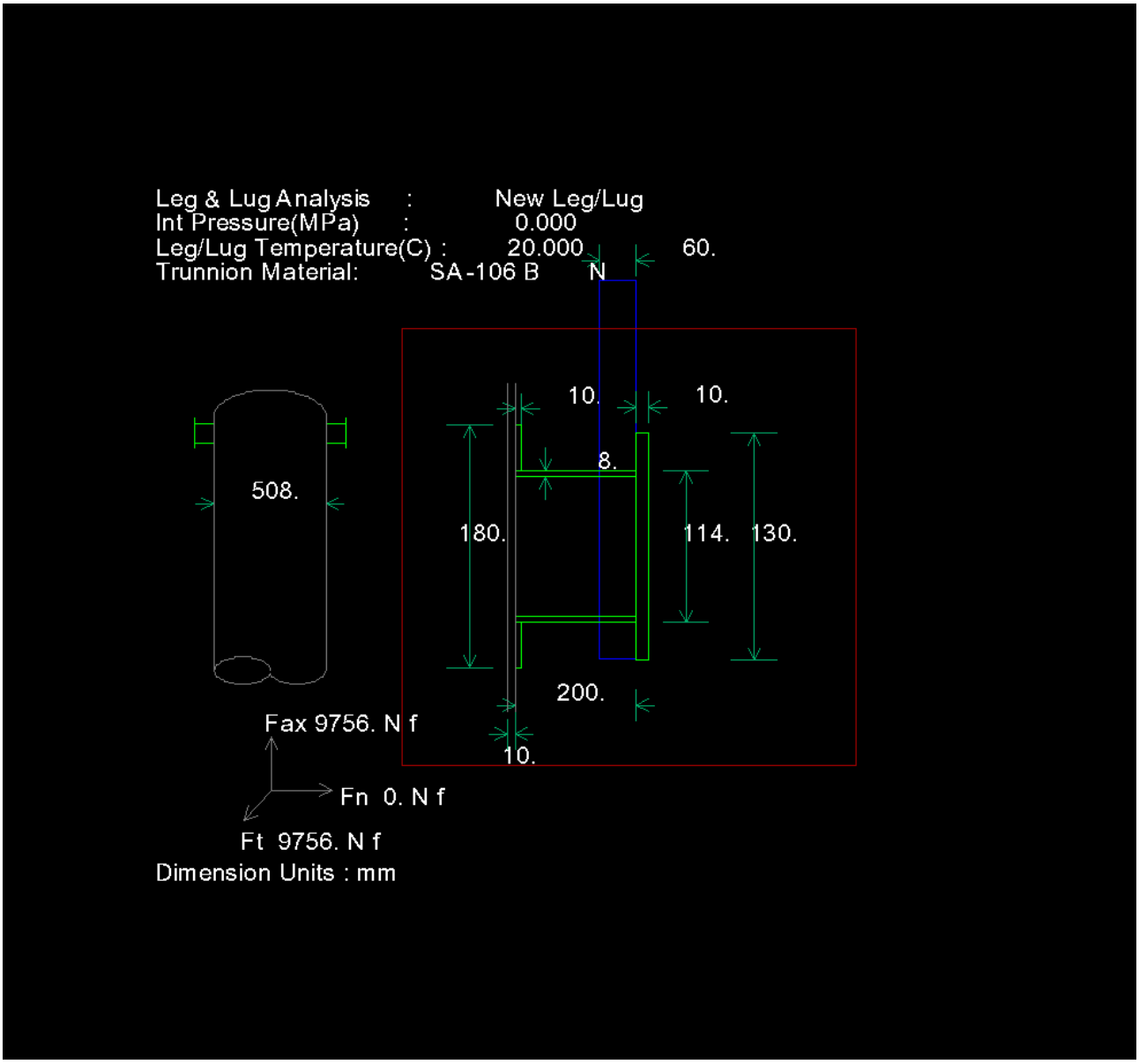
SUMMARY OF RESULTS:

Trunnion unity check value: 0.2489

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	31.94	159.27	Pass
Shear Stress (MPa)	4.67	96.53	Pass
Bearing Stress (MPa)	1.82	180.99	Pass

Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 63.60 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 132.71 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.1.3 45° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                                0.00  MPa
Design Temperature for Attachment            TEMP      20.00  C
Vessel Outside Diameter                        OD     508.000  mm.
Vessel Wall Thickness                          Ts     10.0000  mm.
Vessel Corrosion Allowance                    Cas      0.0000  mm.
Vessel Material                                     SA-516 70
Vessel Material UNS Number                             K02700
Vessel Allowable Stress at Design                S     137.90  MPa
```

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```
Analysis Type:                                        Trunnion

Empty Weight of Vessel                        Wemp       0.00  N f
Operating Weight of Vessel (vertical load )     W       0.00  N f

Trunnion Material                                    SA-106 B
Trunnion Material UNS Number                           K03006
Trunnion Yield Stress                           SY     241.32  MPa
Trunnion Outside Diameter                      TOD    114.300  mm.
Trunnion Thickness                            TTHK     8.0000  mm.
Trunnion Length                                 TL   200.0000  mm.
Bail/Sling Width                                TT    60.0000  mm.
Pad Outside Diameter                           POD    180.000  mm.
Pad Thickness                                 PTHK    10.0000  mm.
Ring Outside Diameter                          Rod     130.00  mm.
Ring Thickness                                Rthk      10.00  mm.
Trunnion Type                                        Hollow
Lift Orientation                                     Horizontal
Impact Factor                                Impfac       1.00

Force Along Vessel Axis                         Fax    9756.00  N f
Force Normal to Vessel                           Fn       0.00  N f
Force Tangential to Vessel                       Ft    9756.00  N f
Perform WRC-107 Analysis on the Trunnion             Yes

Occasional Load Factor (AISC A5.2)           Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((9756.00^2 + 9756.00^2)^1/2) * 1.00
 = 13797.07 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 13797.07
 = 2346452.50 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 2346452 *1.000/ 66402.77
 = 35.33 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 13797.07 / 2671.61
 = 5.16 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
 = SBC / SBA + SSC / SSA
 = 35.33 / 159.27 + 5.16 / 96.53
 = 0.28 [Passed] UCHK, Must be less than 1.
```

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```
Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 13797.07 / 6858.00
 = 2.01 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                     VC      -9756.0  N f
Longitudinal Shear                        VL      -9756.0  N f
Circumferential Moment                    MC    1659192.5  N-mm 0.
Longitudinal Moment                       ML   -1659192.5  N-mm 0.
Torsional Moment                          MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)

              |                   Stress Intensity Values at                                |
Type of       |                                                                             |
Stress   Load |       Au        Al        Bu        Bl        Cu        Cl        Du        Dl|
```

Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	-47.0	47.0	47.0	-47.0
Circ. Memb. ML	9.1	9.1	-9.1	-9.1	0.0	0.0	0.0	0.0
Circ. Bend. ML	21.8	-21.8	-21.8	21.8	0.0	0.0	0.0	0.0
Tot. Circ. Str.	30.9	-12.7	-30.9	12.7	-49.7	44.2	49.7	-44.2
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-4.3	-4.3	4.3	4.3
Long. Bend. MC	0.0	0.0	0.0	0.0	-26.3	26.3	26.3	-26.3
Long. Memb. ML	2.7	2.7	-2.7	-2.7	0.0	0.0	0.0	0.0
Long. Bend. ML	34.4	-34.4	-34.4	34.4	0.0	0.0	0.0	0.0
Tot. Long. Str.	37.1	-31.7	-37.1	31.7	-30.7	22.0	30.7	-22.0
Shear VC	-2.7	-2.7	2.7	2.7	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	2.7	2.7	-2.7	-2.7
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-2.7	-2.7	2.7	2.7	2.7	2.7	-2.7	-2.7
Str. Int.	38.1	32.1	38.1	32.1	50.1	44.5	50.1	44.5

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-9.0	-9.0	9.0	9.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-94.8	94.8	94.8	-94.8
Circ. Memb. ML	18.3	18.3	-18.3	-18.3	0.0	0.0	0.0	0.0
Circ. Bend. ML	23.2	-23.2	-23.2	23.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	41.5	-4.9	-41.5	4.9	-103.8	85.8	103.8	-85.8
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-18.3	-18.3	18.3	18.3
Long. Bend. MC	0.0	0.0	0.0	0.0	-40.3	40.3	40.3	-40.3
Long. Memb. ML	8.5	8.5	-8.5	-8.5	0.0	0.0	0.0	0.0
Long. Bend. ML	38.2	-38.2	-38.2	38.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	46.7	-29.8	-46.7	29.8	-58.6	22.0	58.6	-22.0
Shear VC	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	3.5	3.5	-3.5	-3.5
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-3.5	-3.5	3.5	3.5	3.5	3.5	-3.5	-3.5
Str. Int.	48.4	30.2	48.4	30.2	104.0	85.9	104.0	85.9

SUMMARY OF RESULTS:

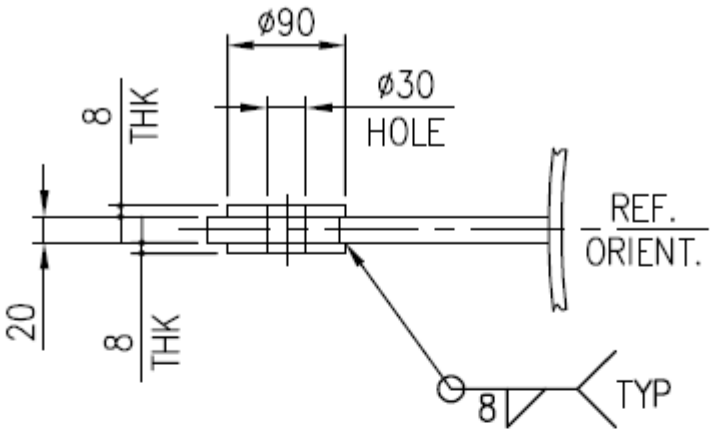
Trunnion unity check value: 0.2753

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	35.33	159.27	Pass
Shear Stress (MPa)	5.16	96.53	Pass
Bearing Stress (MPa)	2.01	180.99	Pass

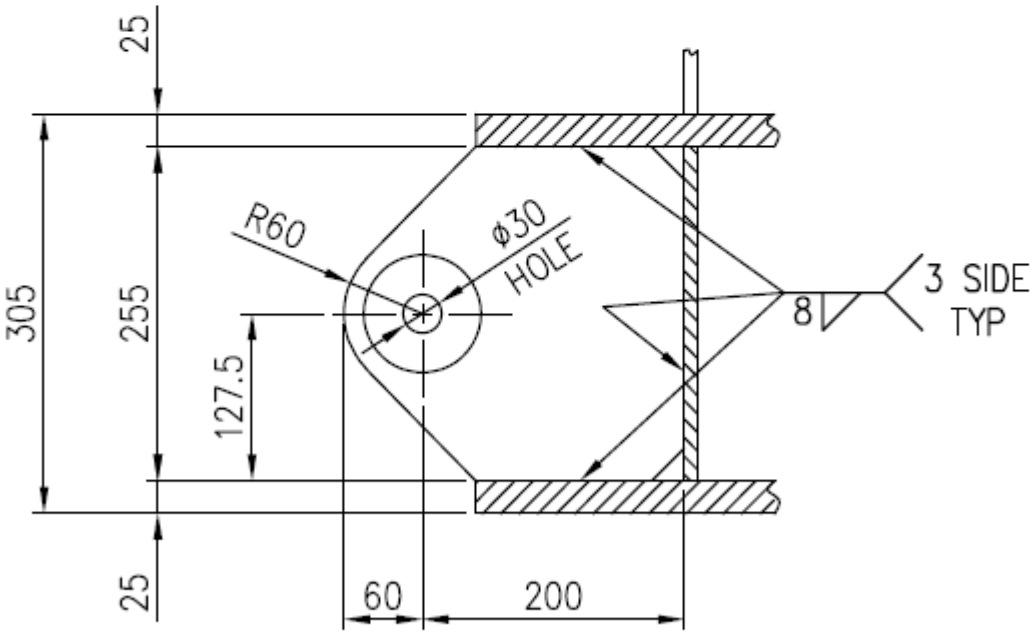
Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 50.12 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 104.04 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.2 TAILING LUG

The tailng lug is obtained by one hole on one of the gusset of the base plate as shown below.



PLAN VIEW



ELEVATION

TAILING LUG DETAIL

The maximum load from the analysis is at 0° and it is 34.62 kN. Considering the stiffnes of the basbearing e ring the only relevant check is related to the bearing strenght of the bolt. Copnsidering EN 1993-3 for the verification the following is the formula for the strenght.

Bearing strength of bolts

The bearing resistance of the bolt $F_{b,Rd}$ should be verified against the applied shear load $F_{v,Ed}$ in accordance with *EN1993-1-8 Table 3.4*:

$F_{b,Rd} = k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t / \gamma_{M2}$

where:

- f_u is the ultimate tensile strength of the connected plate
- d is the nominal diameter of the bolt.
- t is the thickness of the connected plate.
- γ_{M2} is the partial safety factor for the resistance of bolts in accordance with *EN1993-1-8 §2.2(2) Table 2.1* and the National Annex. The recommended value in EN1993-1-8 is $\gamma_{M2} = 1.25$.

The coefficient k_1 is:

for edge bolts: $k_1 = \min(2.8 \cdot e_2/d_0 - 1.7, 1.4 \cdot p_2/d_0 - 1.7, 2.5)$
for inner bolts: $k_1 = \min(1.4 \cdot p_2/d_0 - 1.7, 2.5)$

where e_2 is the distance between the center of the edge bolt and the end of the plate measured perpendicular to the load transfer direction, p_2 is the distance between the centers of neighboring bolts measured perpendicular to the load transfer direction, and d_0 is the diameter of the bolt hole.

The coefficient α_b is:

$\alpha_b = \min(\alpha_d, f_{ub}/f_u, 1.0)$

for end bolts: $\alpha_d = e_1/(3 \cdot d_0)$
for inner bolts: $\alpha_d = p_1/(3 \cdot d_0) - 1/4$

where e_1 is the distance between the center of the end bolt and the end of the plate measured parallel to the load direction, p_1 is the distance between the centers of neighboring bolts measured parallel to the load direction, and d_0 is the diameter of the bolt hole.

Therefore, based on the equations above, the bearing resistance of the bolt $F_{b,Rd}$ is not affected by the distances e_1, p_1, e_2, p_2 when the following conditions are satisfied:

for edge bolts: $e_1 \geq 3.0 \cdot d_0$ and $e_2 \geq 1.5 \cdot d_0$
for inner bolts: $p_1 \geq 3.75 \cdot d_0$ and $p_2 \geq 3.0 \cdot d_0$

Being:

α_b=1

K1=2.5

FU=430 FOR s275 jr

D= 27 MM

T= 20 MM

Hence the resistance is :

$$F_b = 1 \cdot 2.5 \cdot 430\ MPa \cdot 27\ mm \cdot 20\ mm \frac{1}{1.25} = 464\ kN$$

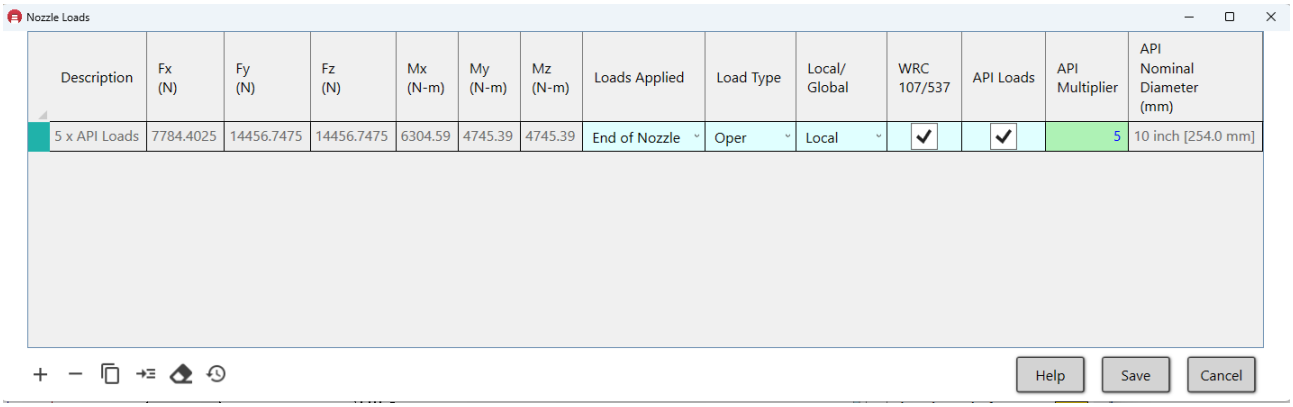
Considering a factoe LRFD action of $35\ kN \cdot 1.5 = 52.5\ kN$

The verification is passed.

E – MISCELLANEUS CALC – DERATING CALCULATION OF THE INLET FLANGE N1 AS PER UG 44(B)

The flange is loaded by the followings external loads:

Nozzle 1N's loads have been calculated with a factor of 5 times the value from API 537.



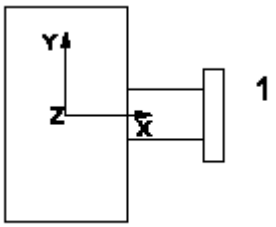


Figure 9 Nozzle 1N loads

As per Ug-44(b) due to the external loads the flange shall be derated to P_D as follow:

$$P_D = \min\left(P_R;\ F_M P_R + P_R - \frac{(16\ M_E + 4\ F_E G)}{\pi\ G^3} \right)$$

To respect the equation:

$$16\ M_E + 4\ F_E\ G\ \leq\ \pi\ G^3\ [\ (P_R - P_D) + (F_M\ P_R)]$$

Being

P_R flange pressure rating at 80°C for flange group 1 (material SA-350 LF2) is 18.42 bar

F_M as per taable UG-44-1 equal to 1.2 for ASME B16.5 Flange #150 less than NPS 12

M_E External moment resultant equal to:

$$M_E = \sqrt{M_Y^2 + M_Z^2} = 4.75\ kNm\ \cdot \sqrt{2} = 6.72\ kNm$$

F_E External tensile axiale force equal to $F_X = 7.78\ kN$

G is the mean gasket diameter (gasket reaction) equal to $G = (D_i + D_o)\frac{1}{2} = (273.05 + 339.73)mm\frac{1}{2} = 306.39\ mm$

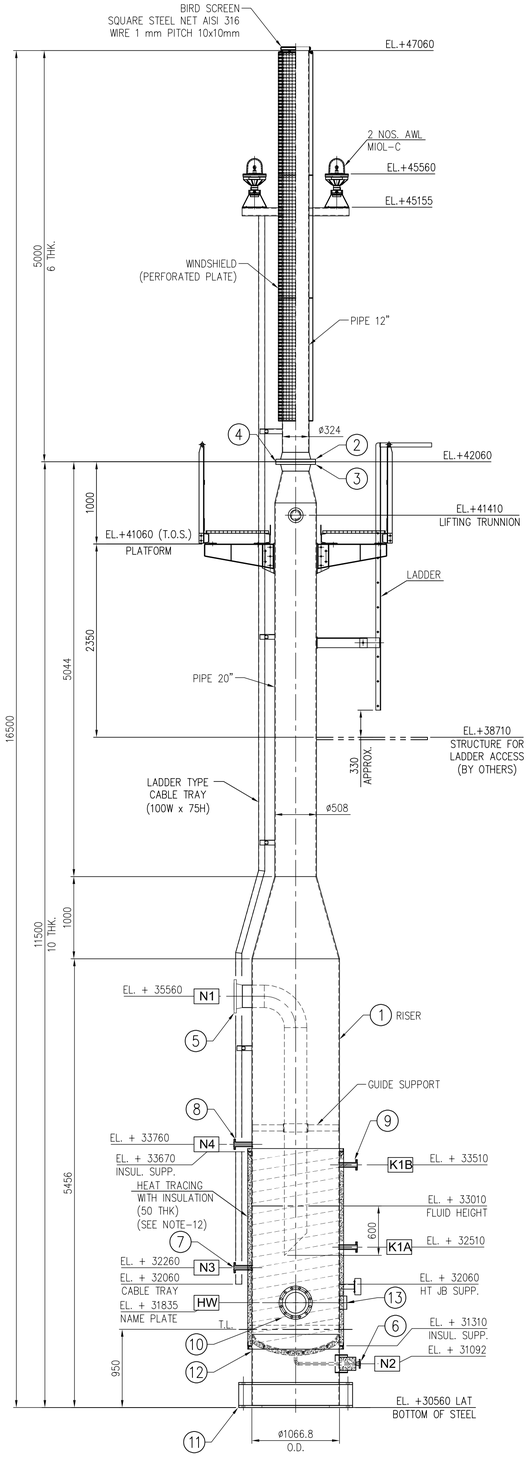
Accordingly, the derated pressure of the flange is :

$$P_D = \min\left(18.42\ barg;\ \ 1.2\ \cdot 18.42\ barg + \ \ 18.42\ barg - \frac{16\ \cdot 6.72\ kNm + 4\ \cdot 7.78\ kN\ \cdot 0.306\ m}{\pi\ 0.306^3\ m^3}\ \frac{1}{100}\frac{barg}{kPa}\right)$$
$$= \min(\ 18.42\ barg\ ; 27.52\ barg) = 18.42\ barg$$

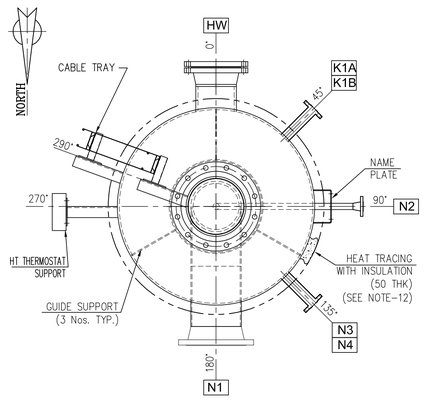
There is no change in the pressure-temperature rating of the flange due to the external loads hence the flange doesn't have to be derated.

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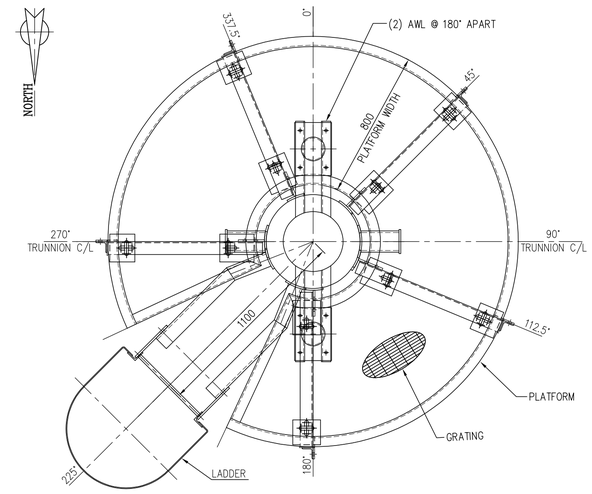


ELEVATION
SCALE 1:36
(FOR TRUE ORIENTATION REFER PLAN VIEWS)

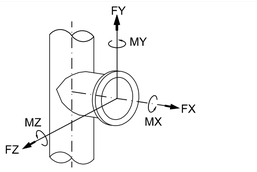


PLAN

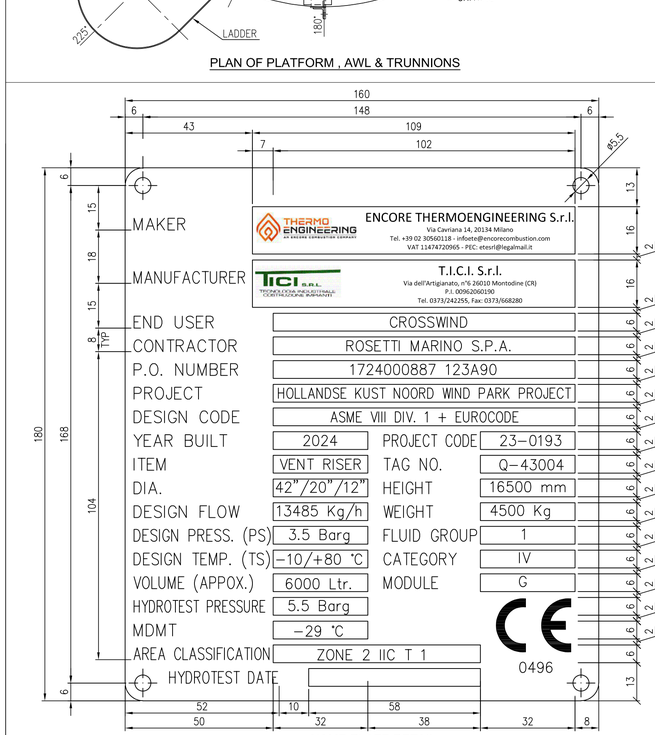
PLATFORM, AWL & TRUNNION NOT SHOWN FOR CLARITY



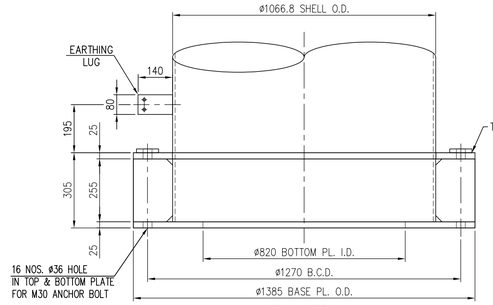
PLAN OF PLATFORM , AWL & TRUNNIONS



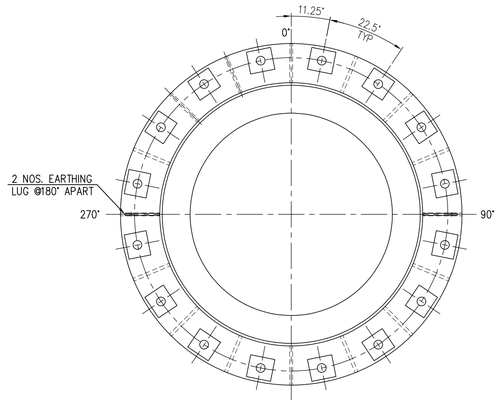
NOZZLE LOADS						
	LOADS [kN]			MOMENTS [kN x m]		
	FX	FY	FZ	MX	MY	MZ
INLET N1 (10")	7.78	14.45	14.45	6.31	4.74	4.74



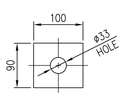
NAME PLATE DETAIL



ELEVATION
ANCHOR CHAIR DETAIL
SCALE 1:12



PLAN VIEW



WASHER DETAIL

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
LIFTING DRAWING - HYDROGEN VENT	1724000887-MAC-DD-00019
-	-

MATERIAL LIST

ITEM	Q.TY	DESCRIPTION	DIMENSION	MATERIALS
1	1	RISER SHELL	42" (1066.8) OD. x 10 THK	A516 GR.60/EQUIV
	1	RISER SHELL	20" (508) OD. x 10 THK	A516 GR.60/EQUIV
		VENT TIP SHELL	12" (323.9) OD. x 6 THK	AISI 316
2	1	VENT TIP FLANGE	ø12" 150# WNRF ASME B16.5	AISI 316L
3	1	RISER OUTLET FLANGE	ø12" 150# WNRF ASME B16.5	A350 GR LF2
4	1	GASKET	ø12" 150#, SPIRAL WOUND	NOTE-10
5	1	VENT INLET FLANGE	ø10" 150# WNRF, SCH.40 ASME B16.5	A350 GR LF2
5A	1	VENT INLET PIPE (DIP PIPE)	ø10" SCH.40 (SMLS)	A333 GR.6
6	1	DRAIN CONNECTION FLANGE	ø1" 150# WNRF, SCH. 80 ASME B16.5	A350 GR LF2
7	1	SWAN NECK CONNECTION FLG.	ø1" 150# LWNRF ASME B16.5	A350 GR LF2
8	1	FILLING LINE FLANGE	ø1" 150# LWNRF ASME B16.5	A350 GR LF2
9	2	LEVEL TRANSMITTER CONNECTION	ø1" 150# LWNRF ASME B16.5	A350 GR LF2
10	1	HAND HOLE FLANGE	ø8" 150# WNRF, SCH.40 ASME B16.5	A350 GR LF2
11	1	ANCHOR CHAIR	-	S275J0 or EQUIV.
12	1	SKIRT SHELL	42" (1066.8) OD.	S275J0 or EQUIV.
13	1	NAMEPLATE	-	AISI 316L

NOZZLES LIST

POS.	Q'TY	SIZE	RATING	FLANGE	SERVICE	PROJECTION FROM RISER C/L
N1	1	10"	150#	WNRF	VENT INLET FROM V-43001 W/ DIP PIPE	750
N2	1	1"	150#	WNRF	DRAIN	800
N3	1	1"	150#	LWNRF	SWAN NECK CONNECTION	750
N4	1	1"	150#	LWNRF	FILLING LINE	750
K1A/B	2	1"	150#	LWNRF	LEVEL TRANSMITTER	750
HW	1	8"	150#	WNRF	HAND HOLE W/ BLIND	750

LOADS AT THE BASE

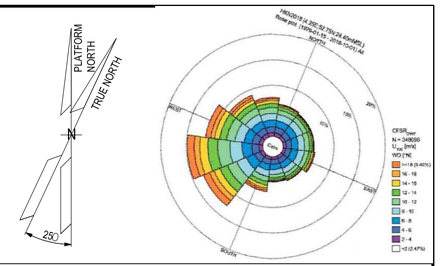
		Vertical [kN]	Shear [kN]	Moment [kN]
DEAD LOAD	DL	-27.66	0.00	0.00
DEAD LOAD CONTENT	DL_O	-17.06	0.00	0.00
LIVE LOAD ON PLATFORM	LL	-13.34	0.00	0.00
NOZZLE LOADS	NL	4.97	24.63	134.99
THERMAL	TL	0.00	0.00	0.00
WIND LOAD	WL	0.00	28.845	235.65
WAVE AND CURRENT LOADS	HL	0.00	-6.99	-55.95

THESE ARE THE RESULTANT FORCES AND THE SHEAR AND MOMENT CAN OCCUR IN ANY DIRECTION.

SHEAR = RESULTANT SHEAR: (FX^2 + FZ^2)^0.5

MOMENT = RESULTANT MOM: (MX^2 + MZ^2)^0.5

VERTICAL LOAD IS POSITIVE UPWARD



NOTES

GENERAL NOTES:

1. ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3. ALL WELDING SHALL BE CONTINUOUS WITH CATHETUS EQUAL TO MINIMUM THK. TO BE WELDED.
4. REFERRING TO MAJOR AXIS FLANGE HOLES SHALL BE SYMMETRICALLY DISPOSED WITH EXCEPTION OF PILOTS FLANGES.
5. ALL FLANGES <= 24" ARE ACCORDING TO ASME B16.5 WITH FINISHING 125 AARH.
6. FOR SURFACE TREATMENT PLEASE REFER TO THE DOCUMENT NO. 1724000887-MAT-PRO-00010 (23-0193-0030).
7. MAIN COMPONENT WEIGHTS (APPROX.):
   RISER WEIGHT : 3950 kg (INCLUDING PLATFORM & LADDER)
   VENT TIP : 450 kg
8. FOR WIRING DIAGRAM (JB AND HT) REFER DOCUMENT NO. 1724000887-MAC-DG-00007 (23-0193-0170)
9. DELETED.
10. GASKET SHALL BE STAINLESS STEEL, SPIRAL WOUND, GRAPHITE FILLED, EPOXY-COATED CARBON STEEL CENTERING RING AND STAINLESS STEEL INNER RING.
11. FOR RISER CONSTRUCTION DETAILS REFER DRAWING NO. 1724000887-MAC-DD-00005 (23-0193-131).
12. HEAT TRACING CABLES AND INSULATION SUPPORTS ARE IN ETE SCOPE OF WORK. INSULATION SUPPLY & INSTALLATION BY OTHERS.

NAME PLATE NOTES:

a. ALL DIMENSIONS ARE IN mm, UNLESS OTHERWISE STATED.
b. NAMEPLATE MATERIAL : AISI 316L
   NAMEPLATE THK. : 2 mm
   TEXT COLOR : BLACK
   TEXT ENGRAVED
C. NAMEPLATE WILL BE FIXED ON VENT RISER REFER TO DOC. 1724000887-MAC-DD-00005 (23-0193-0131).

DESIGN DATA

DESCRIPTION	VALUES
DESIGN CODE	ASME VIII DIV. 1 + EUROCODE
MAX. GAS FLOW	13485 kg/h
AMBIENT TEMPERATURE	-8.4 / +25 °C
OPERATING PRESSURE	ATM barg
DESIGN TEMPERATURE	-10 / +80 °C
DESIGN PRESSURE	3.5 barg
CORROSION ALLOWANCE	3 mm (FOR CARBON STEEL ONLY)
HYDROTEST PRESSURE	5.5 barg
AREA CLASIFICATION	ZONE 2 IIC T 1
MDMT	-29 °C
FLUID GROUP	1
CATEGORY	IV
MODULE	G
SEISMIC	N/A
WIND VELOCITY	28 m/s
TYPE OF FLUID	HYDROGEN GAS
WELDING EFFICIENCY	0.85
RADIOGRAPHY	SPOT RT

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	19/11/24

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0101

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
04	13-11-2024	SCB	VT	AL	ACCEPTANCE FOR CONSTRUCTION
03	10-10-2024	SCB	VT	AL	ACCEPTANCE FOR CONSTRUCTION
02	05-09-2024	SCB	VT	AL	ACCEPTANCE FOR CONSTRUCTION
01	30-07-2024	SCB	VT	AL	ISSUED FOR REVIEW
00	03-06-2024	RJS	SCB	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE :
HYDROGEN VENT
GENERAL ARRANGEMENT
INCLUDING FOUNDATION LOADS

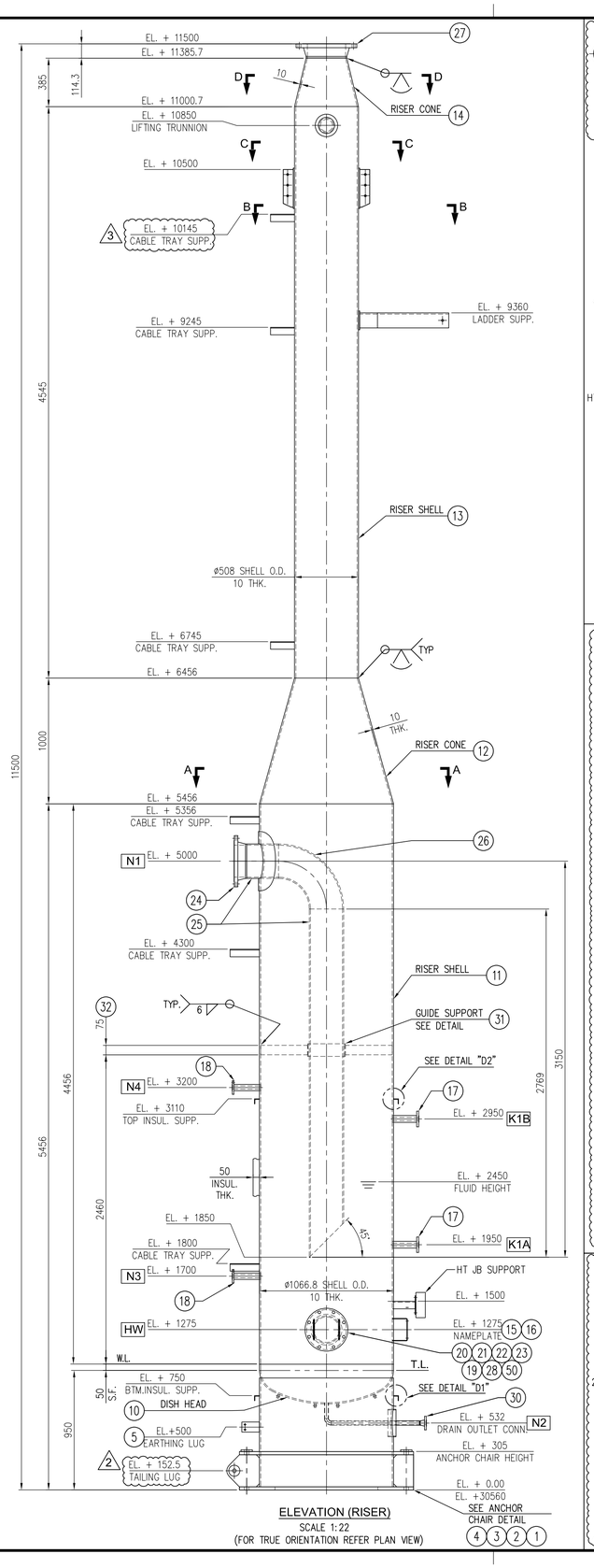
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:36

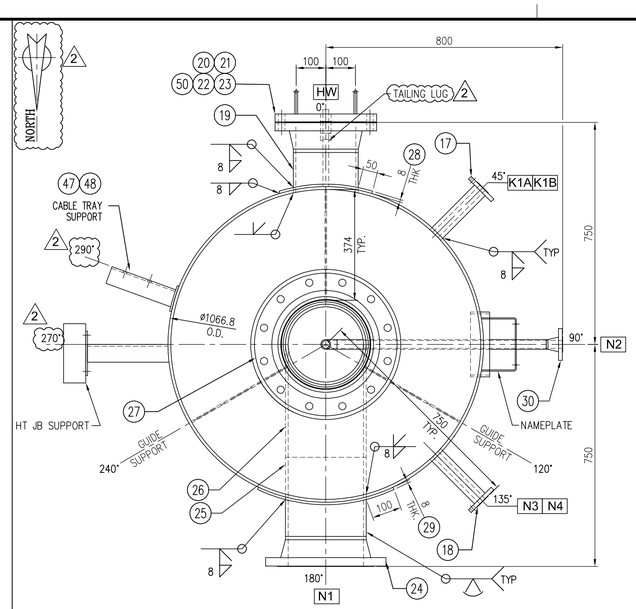
DRAWN RJS | CHECKED SCB | APPROVED AL | DATE 03/06/24

A1 | DRAWING NO. 1724000887-MAC-DA-00003 | SHEET 001 | REV. 04

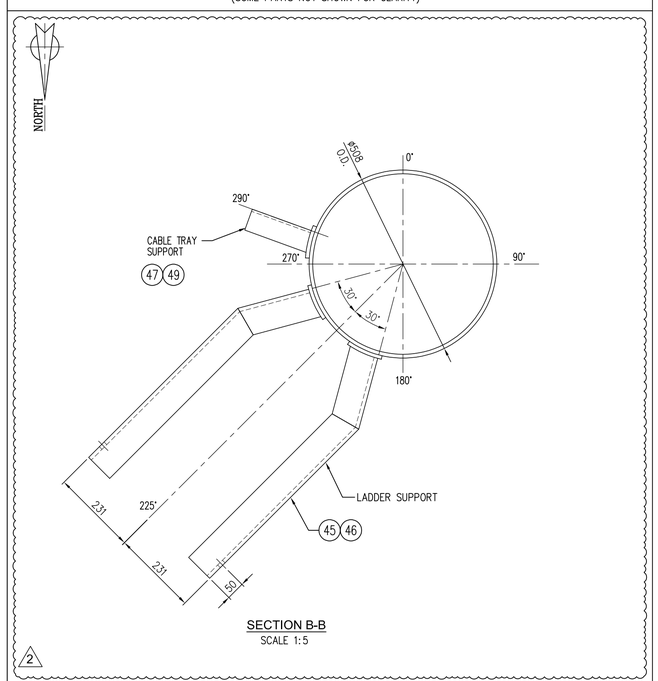
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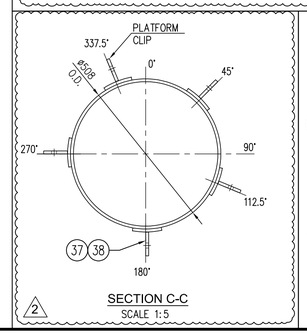




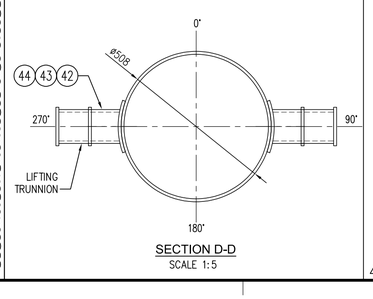
SECTION A-A
SCALE 1:10
(SOME PARTS NOT SHOWN FOR CLARITY)



SECTION B-B
SCALE 1:5



SECTION C-C
SCALE 1:5



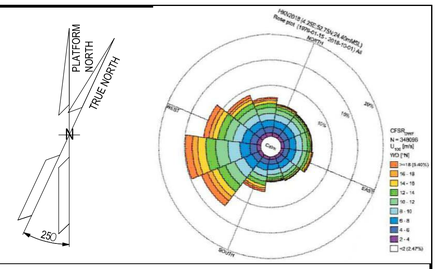
SECTION D-D
SCALE 1:5

BILL OF MATERIAL (RISER)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL	PED
1	1	BOTTOM ANCHOR PLATE	25 THK x 1385 O.D. x 820 I.D.	S275 J0	–
2	1	TOP ANCHOR PLATE	25 THK x 1385 O.D. x 1070 I.D.	S275 J0	–
2 3	15	GUSSET PLATE	12 THK x 159 x 255	S275 J0	–
4	16	WASHER PLATE	15 THK x 90 x 100	S275 J0	–
5	2	EARTHING LUG	6 THK x 80 x 140	AISI 304	–
6	1	SKIRT SHELL	10 THK x 865 LG. x 3320 (ROLL TO 1066.8 O.D.)	S275 J0	–
7	1	SLEEVE PIPE	8", SCH.20 (6.35 THK) x 97 LG.	A333 GR.6	–
8	1	PIPE (N2) (SMLS)	1", SCH.80 (4.55) x 1000 LG. (CUT TO SUIT)	A333 GR.6	ASME/EN
9	1	ELBOW	1", SCH.80 (4.55), 90DEG LR, BW.	A420 WPL6	ASME/EN
10	1	DISH END	2:1 ELLIPSOIDAL HEAD, 50 S.F. 12 THK (BEFORE FORMING) x 1066.8 O.D.	A516 Gr.60 /EQUIV.	ASME/EN
11	1	RISER SHELL	10 THK x 4456 LG. x 3320 (ROLL TO 1066.8 O.D.)	A516 Gr.60 /EQUIV.	ASME/EN
12	1	CONE	ø1066.8 LARGE O.D. x ø508 SMALL OD x 10 THK x 1000 HEIGHT.	A516 Gr.60 /EQUIV.	ASME/EN
13	1	RISER SHELL	10 THK x 4545 LG. x 1565 (ROLL TO 508 O.D.)	A516 Gr.60 /EQUIV.	–
14	1	CONE	ø508 LARGE O.D. x ø323.8 SMALL OD x 10 THK x 385 HEIGHT.	A516 Gr.60 /EQUIV.	–
15	1	NAMEPLATE SUPPORT	4 THK x 210 x 385	A516 Gr.60 /EQUIV.	ASME/EN
16	4	RIVETS	ø5	AISI 316	–
17	2	FLANGE FOR K1A & K1B	ø1" 150# LWNRF x 230 LG. ASME B16.5	A350 GR LF2	ASME/EN
18	2	FLANGE FOR N3 & N4	ø1" 150# LWNRF x 230 LG ASME B16.5	A350 GR LF2	ASME/EN
19	1	PIPE (HW) (SMLS)	8", SCH.40 (8.18 THK) x 122 LG. (CUT TO SUIT)	A333 GR.6	ASME/EN
20	1	FLANGE (HW)	8", SCH.40 (8.18 THK) x 150#, WNRF	A350 GR LF2	ASME/EN
21	1	FLANGE (HW)	8" x 150#, BLRF	A350 GR LF2	ASME/EN
22	1	GASKET (HW)	8", 150# SPIRAL WOUND ASME B16.20	SEE NOTE-9	ASME/EN
23	8	STUD BOLT + 2 NUT FOR (HW)	M20 x 110 LG.	A193 GR. B7/ SA194 GR.2H (HDG)	ASME/EN
24	1	FLANGE (N1)	10", SCH.40 (9.27 THK) x 150#, WNRF	A350 GR LF2	ASME/EN
25	1	PIPE (N1) (SMLS)	10", SCH.40 (9.27 THK) x 3200 LG. (CUT TO SUIT)	A333 GR.6	ASME/EN
26	1	ELBOW	10", SCH.40 (9.27), 90DEG LR, BW.	A420 WPL6	ASME/EN
27	1	FLANGE (RISER OUTLET)	12", SCH.STD (10 THK) x 150#, WNRF	A350 GR LF2	–
28	1	REPAD PLATE (HW)	8 THK x 50 WIDTH (CUT TO SUIT INNER OUTER ELLIPTICAL HOLES)	A516 Gr.60 /EQUIV.	ASME/EN
29	1	REPAD PLATE (N1)	8 THK x 100 WIDTH (CUT TO SUIT INNER OUTER ELLIPTICAL HOLES)	A516 Gr.60 /EQUIV.	ASME/EN
30	1	FLANGE (N2)	1", SCH.80 (4.55 THK) x 150#, WNRF	A350 GR LF2	ASME/EN
31	1	GUIDE SUPP. PLATE	6 THK x 100 LG. x 924 (ROLL TO 300 O.D.)	A516 Gr.60 /EQUIV.	ASME/EN
32	3	GUIDE SUPP. RIBS	6 THK x 75 x 375	A516 Gr.60 /EQUIV.	ASME/EN
3 33		DELETED			–
33A		DELETED			–
3 34		DELETED			–
3 35	2	INSUL. SUPP. ANGLE	L50x50x4 x 3666 LG. (ROLL TO 1146.8 O.D.)	S275 J0	ASME/EN
36	25	SQUARE NUT	M16	A194 GR. 2H (HDG)	–
37	5	PLATFORM CLEAT PAD	10 THK x 100 x 320	A516 Gr.60 /EQUIV.	–
38	5	PLATFORM CLEAT	10 THK x 80 x 300	A516 Gr.60 /EQUIV.	–
39	1	JB SUPP. PAD	6 THK x 90 x 90	A516 Gr.60 /EQUIV.	ASME/EN
40	1	JB SUPP. ANGLE	L60x60x6 x 197 LG.	S275 J0	–
41	1	JB SUPP. PLATE	6 THK x 150 x 150	S275 J0	–
42	2	TRUNNION PLATE	10 THK x ø130	S275 J0	–
43	2	TRUNNION PAD	10 THK x ø180	S275 J0	–
44	2	TRUNNION PIPE	4", SCH.80 (8.56 THK) x 196 LG.	A333 GR.6	–
2 44A	2	TRUNNION STOPPER	10 THK x ø130 O.D. x ø116 I.D.	S275 J0	
45	2	LADDER CLIP	L120x80x10 x 800 LG.	S275 J0	–
46	2	LADDER CLIP PAD	6 THK x 111 x 150	A516 Gr.60 /EQUIV.	–
47	6	CABLE TRAY SUPP. PAD	6 THK x 90 x 90	A516 Gr.60 /EQUIV.	ASME/EN
48	3	CABLE TRAY SUPP.	L60x60x6 x 232 LG.	S275 J0	–
49	3	CABLE TRAY SUPP.	L60x60x6 x 188 LG.	S275 J0	–
50	2	HANDLE (HW)	ø10 ROD x 300 LG.	S275 J0	ASME/EN
51	2	CONNECTION PLATE	6 THK x 30 x 80	S275 J0	–
52	2	HEX BOLT	M10 x 30 LG.	CS (HDG)	–
53	2	HEX NUT	M10 (H=D)	CS (HDG)	–
54	1	TAILING LUG	20 THK x 255 x 260	S275 J0	
2 55	2	TAILING LUG COLLAR PLATE	8 THK x ø90 O.D. x ø30 I.D.	S275 J0	

BILL OF MATERIAL (TIP, WINDSHIELD & BIRD SCREEN)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL	PED
101	1	FLANGE (VENT TIP)	ø12", (6 THK) x 150#, WNRF	AISI 316L	–
102	1	GASKET (VENT TIP CONN.)	ø12", 150# SPIRAL WOUND ASME B16.20	SEE NOTE-9	–
103	12	STUD BOLT + 2 NUT FOR VENT TIP FLG.	M24 x 135 LG.	A193 Gr. B7 SA194 Gr. 2H (HDG)	–
104	1	VENT TIP SHELL	ø12", 6 THK x 4886 LG.	AISI 316	–
105	5	WINDSHIELD SUPP. RING PL.	6 THK x ø416 O.D. x ø328 I.D.	AISI 316	–
106	1	WINDSHIELD & BIRD SCREEN SUPP. RING PL.	6 THK x ø416 O.D. x ø328 I.D. (SEE DETAIL)	AISI 316	–
107	8	NUT	M12	AISI 316	–
108	2	PERFORATED SHEET METAL	2 THK x 1491 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
109	1	PERFORATED SHEET METAL	2 THK x 973 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
110	1	PERFORATED SHEET METAL	2 THK x 139 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
111	1	PERFORATED SHEET METAL	2 THK x 375 LG. x 1314 (ROLL TO 420 O.D.)	AISI 316	–
112	1	BIRD SCREEN MTG. RING PL.	6 THK x ø416 O.D. x ø336 I.D. (SEE DETAIL)	AISI 316	–
113	1	BIRD SCREEN HOLDING SHELL	6 THK x 60 LG. x 1075 (ROLL TO 348 O.D.)	AISI 316	–
114	1	BIRD SCREEN STIFFENER RING	6 THK x 25 LG. x 1119 (ROLL TO 362 O.D.)	AISI 316	–
115	1	BIRD SCREEN	SQUARE STEEL NET WIRE, 1MM PITCH 10x10MM	AISI 316	–
116	8	HEX BOLT	M12 x 35 LG.	AISI 316	–
117	4	AWL SUPP.	UPN100 x 471 LG.	AISI 316	–
118	2	LIFTING LUG	10 THK x 90 x 145	AISI 316	–
119	2	CABLE TRAY SUPP.	L60x60x6 x 295 LG.	AISI 316	–
6 120	1	SPIRAL VENTURI SEAL	12"-SVS-9	AISI 316	–



NOTES

GENERAL NOTES :

1 – ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2 – ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3 – ALL WELDING SHALL BE CONTINUOS WITH CATHETUS EQUAL TO MINIMUN THK. TO BE WELDED.
4 – UNLESS OTHERWISE STATED, FLANGES WILL HAVE BOLT HOLES STRADDLING CENTERLINE.
5 – FOR SURFACE TREATMENT PLEASE REFER TO THE DOCUMENT NO. 1724000887-MAT-PRO-00010 (23-0193-0030).
6 – THE FACES OF FLANGES SHALL BE SMOOTH FINISH. SMOOTH FINISH SHALL BE ACHIEVED IN ACCORDANCE WITH ASME B16.5.
7 – FLANGE UP TO 24" SHALL COMPLY WITH ASME B16.5.
8 – REINFORCING PADS SHALL BE PROVIDED WITH ONE ¼" NPT TELLTALE HOLE. TWO-PIECE REINFORCING PADS SHALL BE PROVIDED WITH TWO TELLTALE HOLES (ONE PER SEGMENT). AFTER TESTING, THE TELLTALE HOLE SHALL BE PLUGGED. REINFORCING PADS SHALL NOT BE LOCATED ON THE WELDED SEAMS.
9 – GASKET SHALL BE STAINLESS STEEL, SPIRAL WOUND, GRAPHITE FILLED, EPOXY-COATED CARBON STEEL CENTERING RING AND STAINLESS STEEL INNER RING.
10 – WELDING FOR BIRD SCREEN (ITEM 114) SHALL BE DONE AFTER PROPER INSERTION OF ITEM 115 BETWEEN ITEM 113 AND 114
11 – RISER TOTAL NET WEIGHT: 3300 kg.
TIP TOTAL NET WEIGHT: 450 kg.
CABLE TRAY & ACCESSORIES NET WEIGHT: 90 kg.
PLATFORM & LADDER NET WEIGHT: 650 kg. (INCLUDING GRATING)
12 – BASE PLATE HOLE SHALL BE USED AS TAILING LUG FOR LIFTING OF RISER.
13 – SUITABLE CUTOUTS SHALL BE TAKEN INTO WINDSHIELD FOR WELDING OF AWL SUPPORT & CABLE TRAY SUPPORTS TO TIP SHELL.

HOLDS

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.

Sign	Date
Giuseppe Cavallo	21/11/24

THERMO ENGINEERING — AN ANSALDO ENERGIA COMPANY

ETE JOB	23-0193
ETE DWG NR.	23-0193-0131

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

CROSSWIND — ROSETTI MARINO

TITLE :

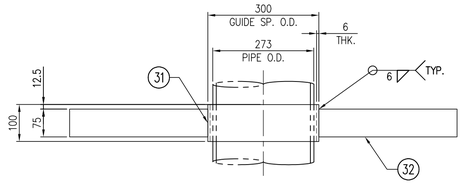
HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK		SCALE 1:22	
DRAWN RJ	CHECKED SCB	APPROVED AL	DATE 02-08-24
A1	DRAWING NO. 1724000887-MAC-DD-00005	SHEET 001	REV. 03

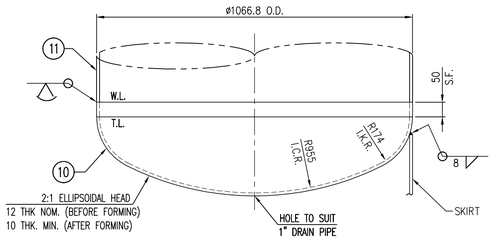
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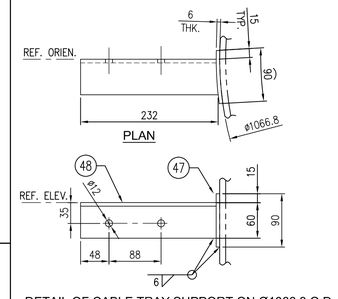
REV. 03



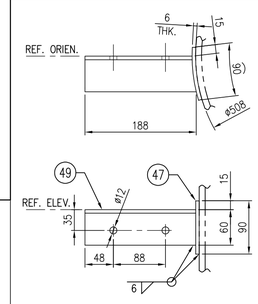
DETAIL OF GUIDE SUPPORT FOR NOZZ. "N1"



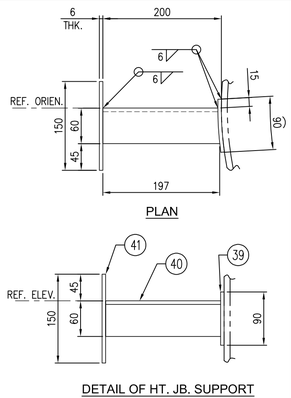
1066.8 O.D. DISH END DETAIL



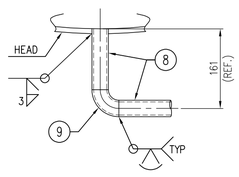
DETAIL OF CABLE TRAY SUPPORT ON Ø1066.8 O.D.



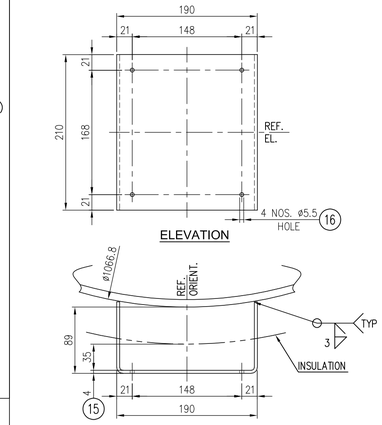
DETAIL OF CABLE TRAY SUPPORT ON Ø508 O.D.



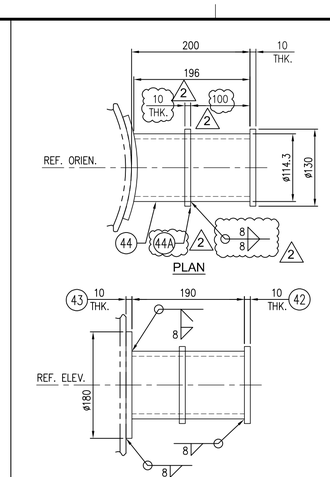
DETAIL OF HT. JB. SUPPORT

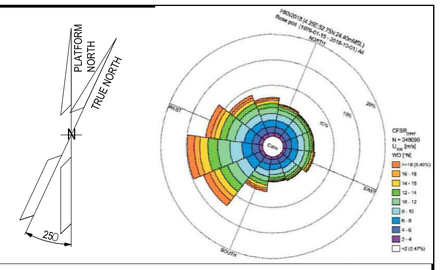


1" DRAIN DETAIL
SCALE 1:6

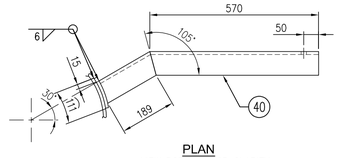


SCALE 1:4

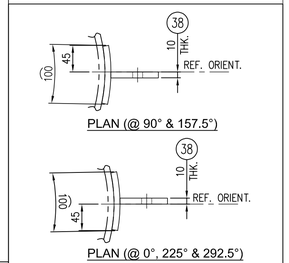




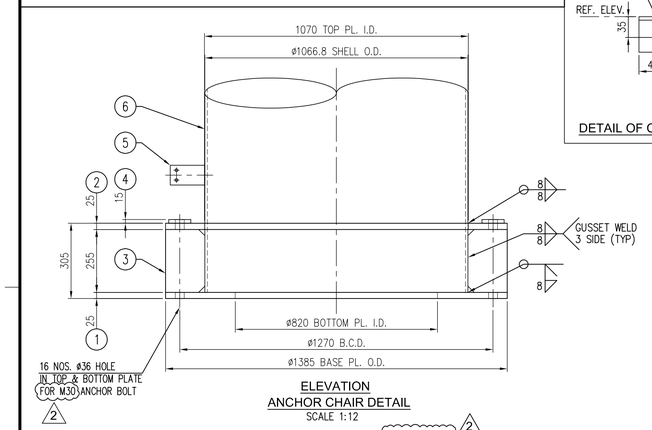
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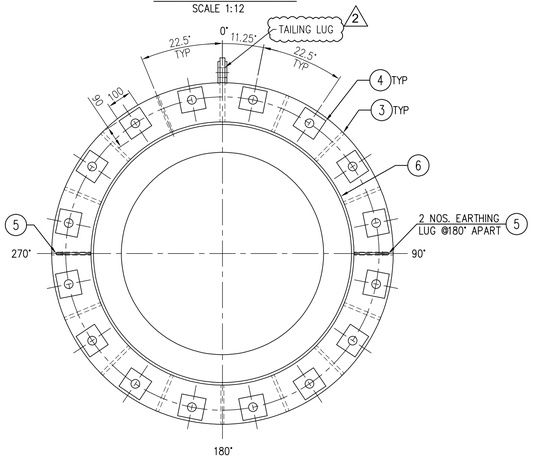
DETAIL OF LADDER SUPPORT

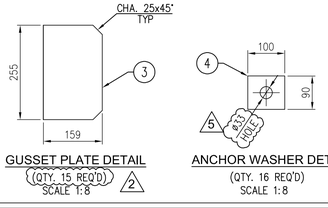


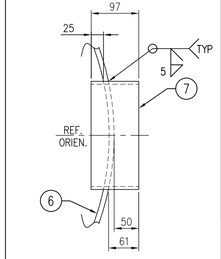
SCALE 1:5



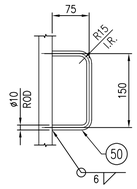
ELEVATION
ANCHOR CHAIR DETAIL
SCALE 1:12



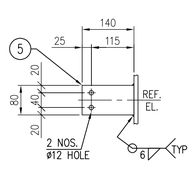




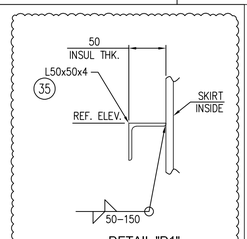
8" PIPE SLEEVE DETAIL
(FOR NOZZLE N2)
SCALE 1:6



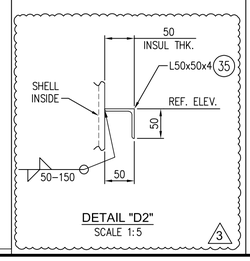
DETAIL OF HANDLE (HW)
SCALE 1:6



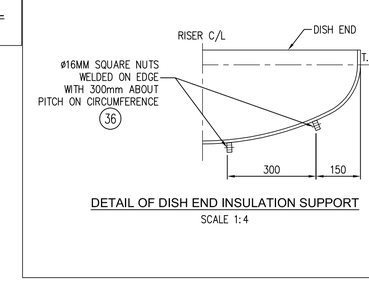
EARTHING LUG DETAIL
SCALE 1:8

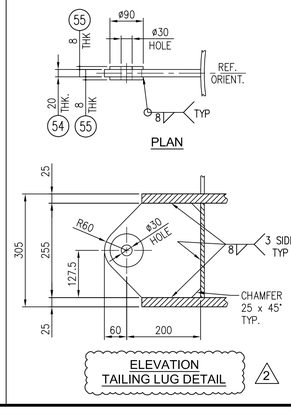


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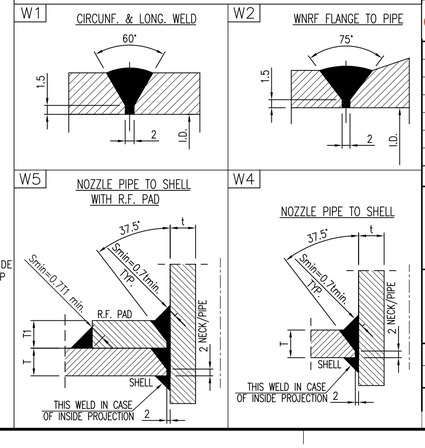


3 DELETED





WELDING DETAILS



REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

THERMO ENGINEERING — AN ENCONE COMBUSTION COMPANY

ETE JOB 23-0193

ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

TITLE :

HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:22

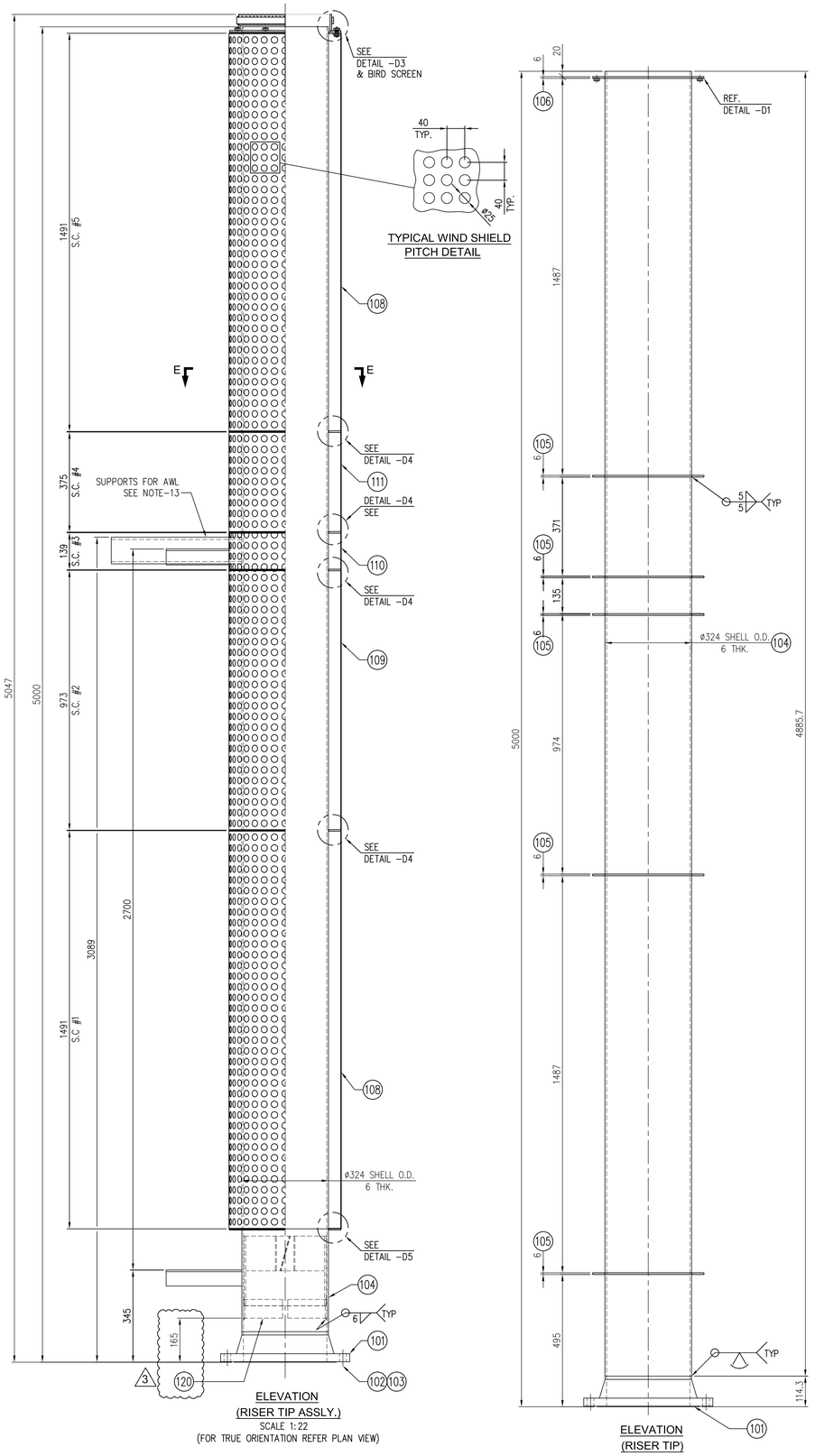
DRAWN RJ | CHECKED SCB | APPROVED AL | DATE 02-08-24

A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 002 | REV. 03

File Name : 1724000887-MAC-DD-00005_03

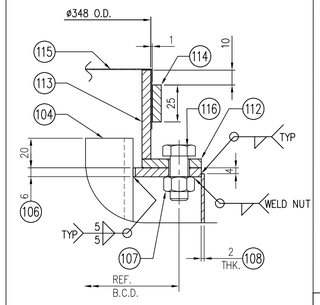
DRAWING NO. 1724000887-MAC-DD-00005_03

REV. 03

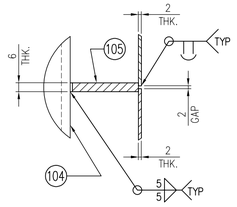


ELEVATION
(RISER TIP ASSLY.)
SCALE 1:22
(FOR TRUE ORIENTATION REFER PLAN VIEW)

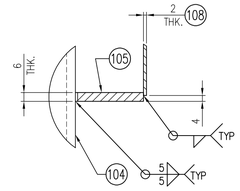
ELEVATION
(RISER TIP)



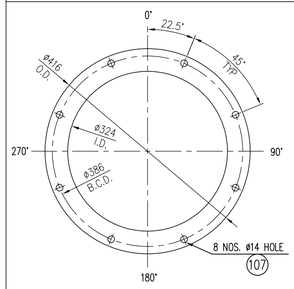
SECTIONAL DETAIL-D3
SCALE 1:2



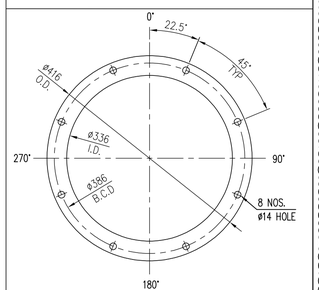
SECTIONAL DETAIL-D4
SCALE 1:2



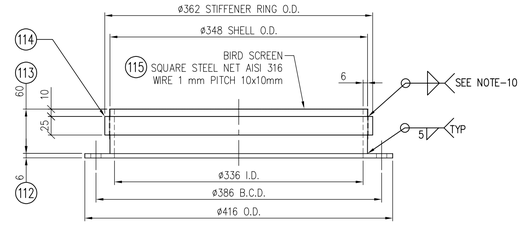
TYPICAL SECTIONAL DETAIL-D5
SCALE 1:2



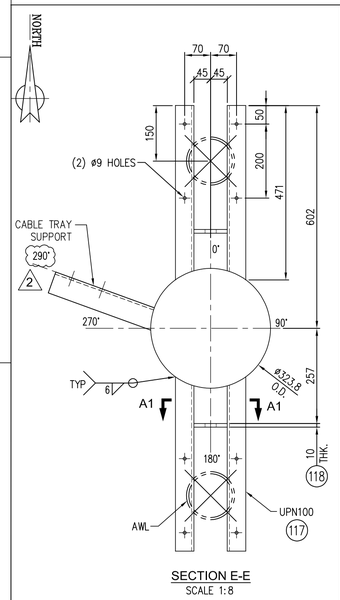
DETAIL OF ITEM (106)
SCALE 1:6



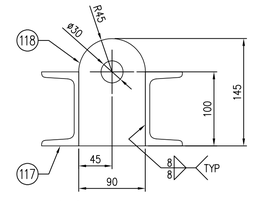
DETAIL OF ITEM (112)
SCALE 1:6



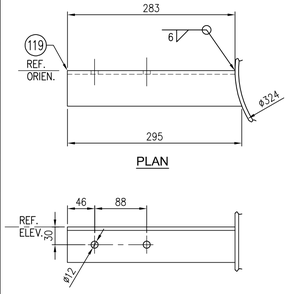
BIRD SCREEN ASSY. DETAIL
SCALE 1:4



SECTION E-E
SCALE 1:8

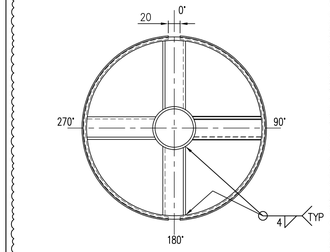


SECTION "A1-A1"
SCALE 1:4

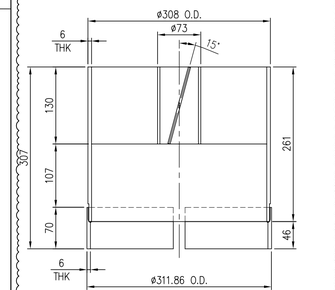


PLAN

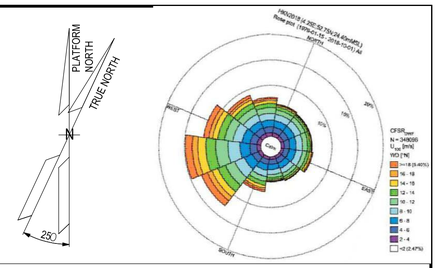
CABLE TRAY SUPPORT



PLAN VIEW



DETAIL OF VENTURI SEAL (120)
SCALE 1:6



NOTES

03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
REV.	DATE	DRN	CHKD	APPD	DESCRIPTION

THERMO ENGINEERING — AN ENCORE CORPORATION COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

TITLE :

HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

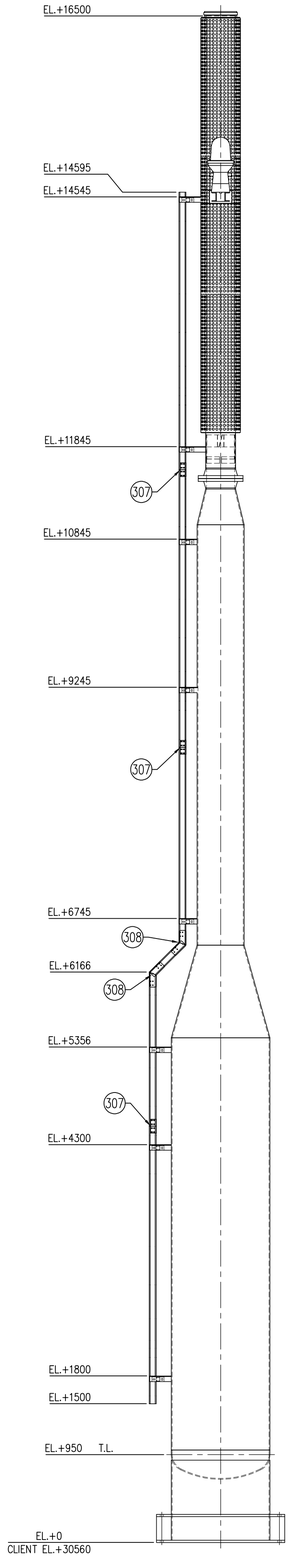
CONTRACT NO./TITLE CW-1-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK			SCALE 1:22
DRAWN RJ	CHECKED SCB	APPROVED AL	DATE 02-08-24

A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 003 | REV. 03

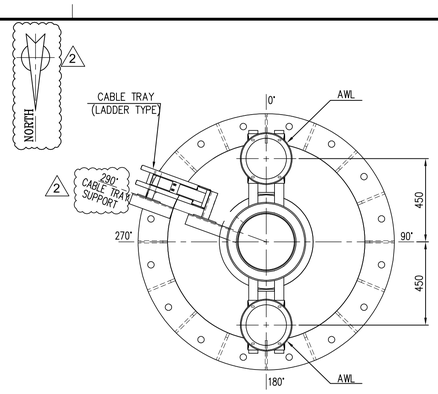
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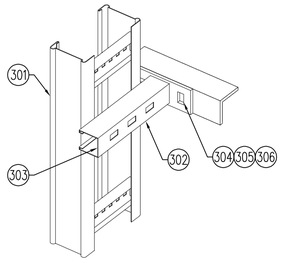
REV. 03



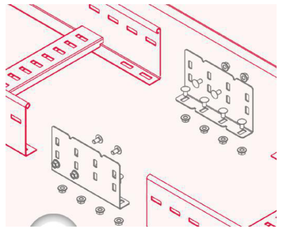
ELEVATION
SCALE 1:32
(REFER THIS VIEW ONLY FOR CABLE TRAY DETAIL)



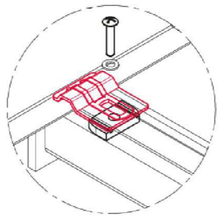
PLAN VIEW
SCALE 1:16
(REFER THIS VIEW ONLY FOR CABLE TRAY)



TYP. CABLE TRAY SUPPORT ARRANGEMENT



TYP. CABLE TRAY JOINT DETAIL
PART NO. 307,313,314



Profili e mensole / Channels and brackets:
UR1

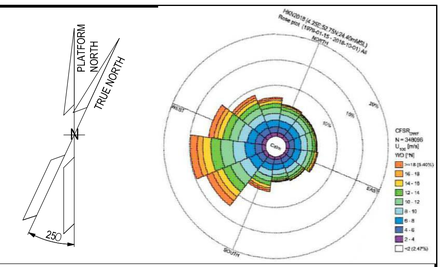
TYP. CABLE TRAY FIXING DETAILS
PART NO. 309,310,311,312



TYP. HINGE JOINT DETAIL
PART NO. 308,313,314

BILL OF MATERIAL (CABLE TRAY)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL
301	14 mtr	CABLE TRAY 100x75	(B2 Z 01B3C100HH10)	HOT DIP GALV.
302	8	58 UR1 SINGLE BRACKET	(A0 Z 58S7R100MU)	HOT DIP GALV.
303	16	PLUG FOR BRACKET FOR UR1	(A0 P 4TXXI040N)	LDPE
304	16	HEX. HEAD BOLT	M10 X 30LG.	CS (HDG)
305	16	HEX. HD. NUT	M10	CS (HDG)
306	16	WASHER	M10	CS (HDG)
307	8	CABLE TRAY JOINT	JOINT (B2 Z 60A4H025M)	HOT DIP GALV.
308	4	VERTICAL HINGE JOINT	(B2 Z 63A5H025M)	HOT DIP GALV.
309	16	NUT FOR CABLE TRAY	M8 (D0C25S08X40 Z)	HOT DIP GALV.
310	16	CABLE TRAY LOCKING DEVICE	(B2 X 84XXXO40M)	HOT DIP GALV.
311	16	WIDE CROWNED HEAD SCREW	M8 (D0C13L08X20 D)	HOT DIP GALV.
312	16	PLANE WASHER	M8 (D0C36S08X17 Z)	HOT DIP GALV.
313	160	ROUND HEAD SCREW WITH SQ. NECK	M6 (D0C10A06X15 E)	HOT DIP GALV.
314	160	FLANGED HEX. NUT	M6 (D0C16S06 E)	HOT DIP GALV.
315	14 mtr	SELF LOCKING COVER	100x15 (B2 Z 05Q3P100D)	HOT DIP GALV.
316	10	EARTHING BAR FOR COVERS EQUIPOTENTIAL CONNECTION W/2 NOS. M6 SCREW	(A3 R 62X1X015M)	HOT DIP GALV.



NOTES

				ETE JOB	23-0193
				ETE DWG NR.	23-0193-0131
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
REV.	DATE	DRN	CHKD	APPD	DESCRIPTION

CROSSWIND

ROSETTI MARINO

TITLE :

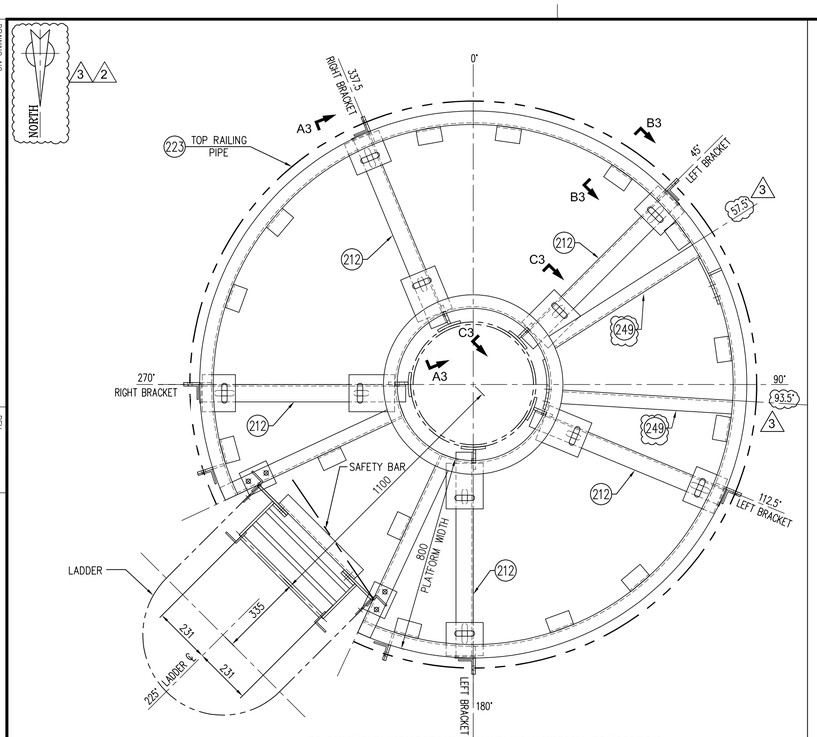
HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK			SCALE 1:22
DRAWN RJ	CHECKED SCB	APPROVED AL	DATE 02-08-24
A1	DRAWING NO. 1724000887-MAC-DD-00005	SHEET 004	REV. 03

File Name : 1724000887-MAC-DD-00005_03

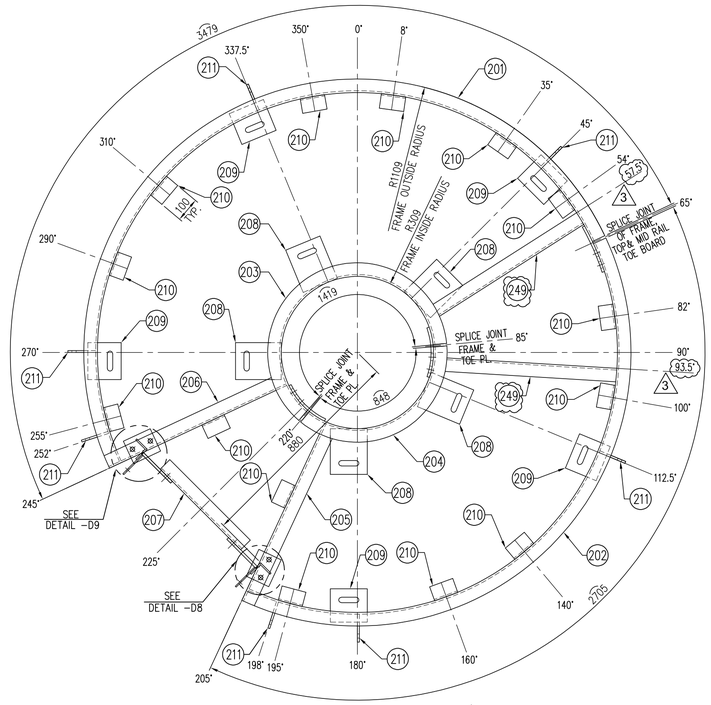
DRAWING NO. 1724000887-MAC-DD-00005_03

REV. 03



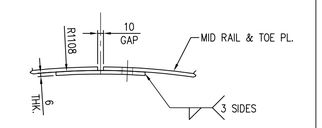
PLAN OF PLATFORM ASSEMBLY AT EL. +41060 (T.O.S.) 2

SCALE 1:12



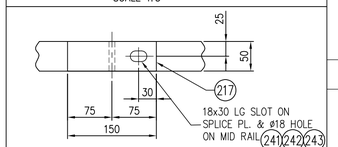
PLATFORM FRAME DETAIL 2

SCALE 1:12



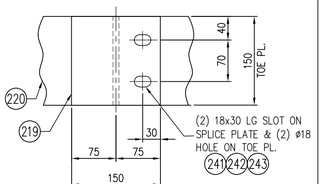
PLAN OF MID RAIL & TOE PL. SPLICE DETAIL

SCALE 1:5



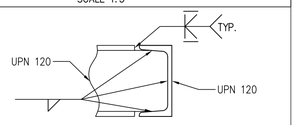
ELEVATION OF MID RAIL SPLICE DETAIL

SCALE 1:5



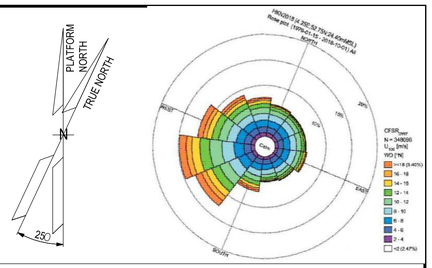
ELEVATION OF TOE PL. SPLICE DETAIL

SCALE 1:5



TYPICAL FRAME CONNECTION DETAIL

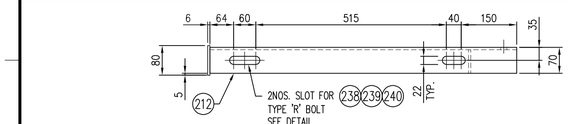
SCALE 1:5



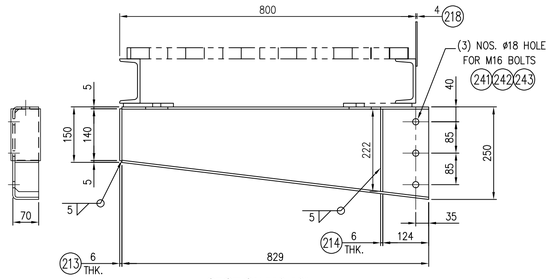
NOTES

GENERAL NOTES :

1 – ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE STATED.
2 – ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3 – BOLTS, NUTS AND WASHERS ARE HOT DIP GALVANIZED.
4 – DIMENSION "S" OF NON-DIMENSIONED FILLET WELDS SHALL AT LEAST BE EQUAL TO 0.8 TIMES THE MINIMUM THICKNESS OF THE SMALLEST ELEMENTS TO BE WELDED.
5 – ALL WELDS SHALL BE CONTINUOUS UNLESS OTHERWISE STATED.
6 – PAINTING CYCLES SHALL BE IN ACCORDANCE WITH DOCUMENT No.23-0193-0030.
7 – A SPARE OF 10% OF NUTS, BOLTS, WASHERS WILL BE SUPPLIED.
8 – No. OF SEPARATIONS OF GRATINGS SHALL BE VERIFIED BY MANUFACTURER.
9 – EACH PANEL OF GRATING WILL BE PROVIDED WITH A MINIMUM OF 4 GRATING CLAMPS.
10 – GRATINGS SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123.
11 – STEEL ASTM A10011/A1011M GRADE 36 [250] TYPE 1 OR EUROPEAN EQUIVALENT (S235 JR EN 10025).
13 – PLATFORMS & LADDER TOTAL WEIGHT : 650 Kg (GRATINGS INCLUDED).



PLAN



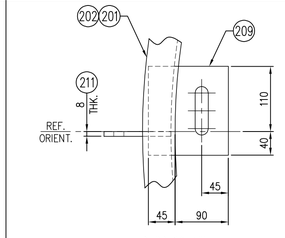
SECTION "A3-A3"

PLATFORM SUPPORT BRACKET DETAIL

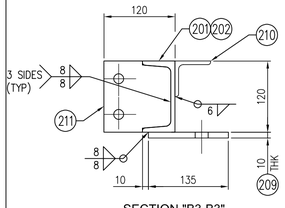
3 NOS. LEFT BRACKET (OPPOSITE)

2 NOS. RIGHT BRACKET (AS SHOWN)

SCALE 1:8

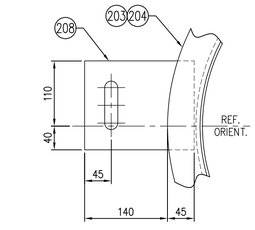


PLAN VIEW

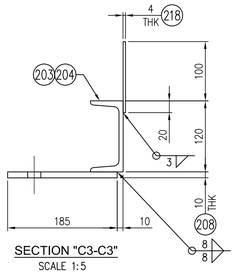


SECTION "B3-B3"

SCALE 1:5

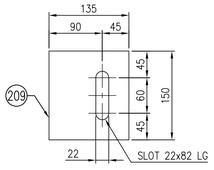


PLAN VIEW



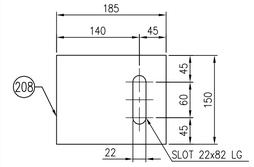
SECTION "C3-C3"

SCALE 1:5



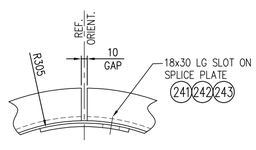
DETAIL OF PART NO. 209

SCALE 1:5

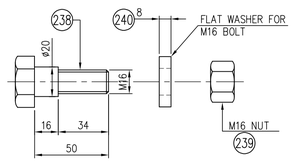


DETAIL OF PART NO. 208

SCALE 1:5

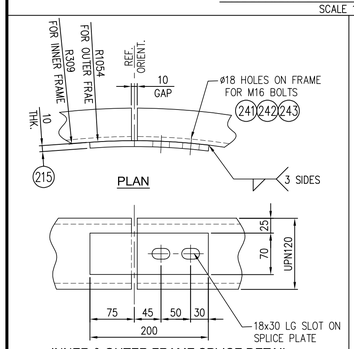


PLAN



BOLT TYPE 'R' DETAIL

(SCALE 1:2)



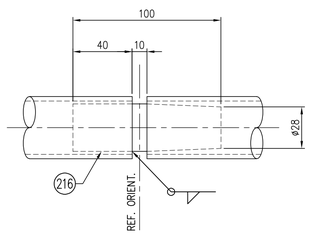
PLAN

INNER & OUTER FRAME SPLICE DETAIL

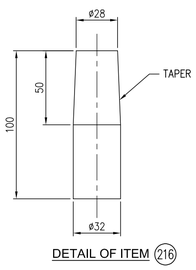
(1 SPLICE @ EXTERNAL FRAME)

(2 SPLICE @ INTERNAL FRAME)

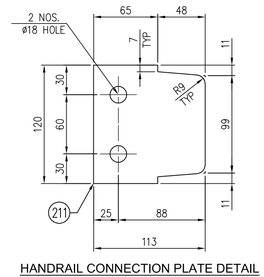
SCALE 1:5



TOP RAIL SPLICE DETAIL

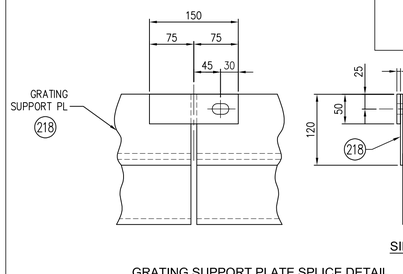


DETAIL OF ITEM 216



HANDRAIL CONNECTION PLATE DETAIL

SCALE 1:3

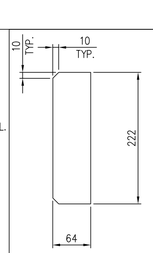


GRATING SUPPORT PLATE SPLICE DETAIL

(2 @ INTERNAL FRAME)

SCALE 1:5

SIDE VIEW



DETAIL OF PART NO. 214

SCALE 1:5

	ETE JOB	23-0193
THERMO ENGINEERING AN ENGIE THERMATHEN COMPANY	ETE DWG NR.	23-0193-0131

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

CROSSWIND

ROSETTI MARINO

TITLE :

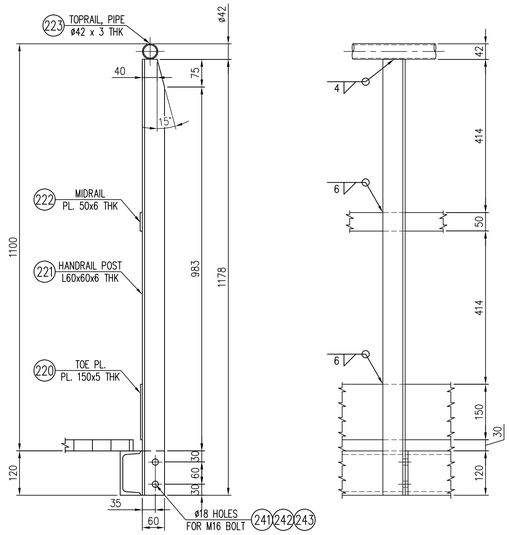
HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE	CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK		SCALE 1:22
DRAWN RJ	CHECKED SCB	APPROVED AL	DATE 02-08-24

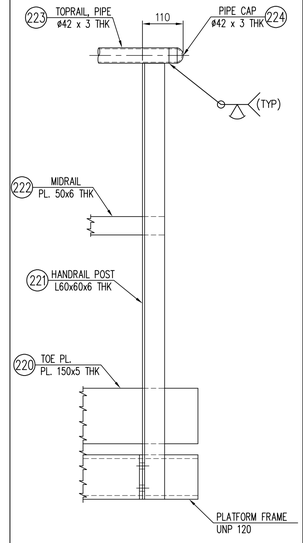
A1	DRAWING NO. 1724000887-MAC-DD-00005	SHEET 005	REV. 03

File Name : 1724000887-MAC-DD-00005_03

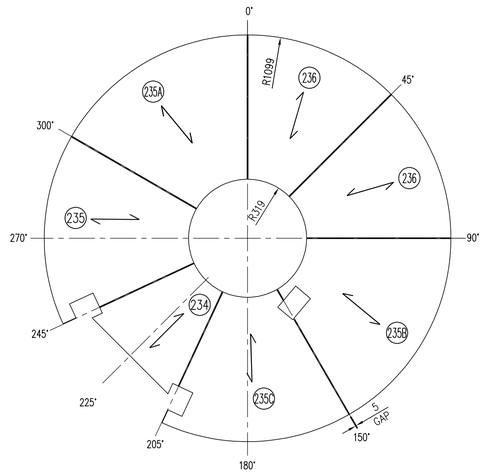
DRAWING NO. 1724000887-MAC-DD-00005_03 REV. 03



TYPICAL HANDRAIL DETAIL
(TYP. @ 5 PLCS.)
SCALE 1:8



TYPICAL HANDRAIL END DETAIL
(TYP. @ 2 PLCS.)
SCALE 1:8

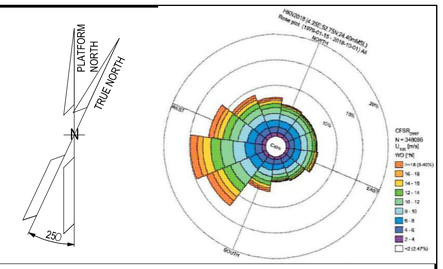


GRATING FOR PLATFORM DETAIL
(SCALE 1:16)

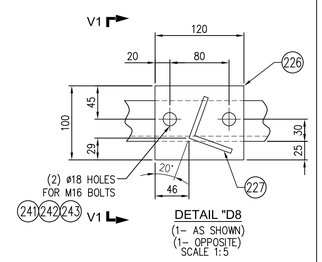
1

BILL OF MATERIAL (PLATFORM)

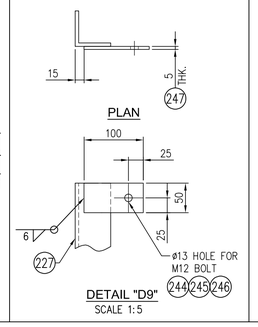
ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL
201	1	PLATFORM FRAME	UPN 120 x 3479 LG.	EN10025 S275 J0
202	1	PLATFORM FRAME	UPN 120 x 2705 LG.	EN10025 S275 J0
203	1	PLATFORM FRAME	UPN 120 x 1419 LG.	EN10025 S275 J0
204	1	PLATFORM FRAME	UPN 120 x 848 LG.	EN10025 S275 J0
205	1	PLATFORM FRAME	UPN 120 x 793 LG.	EN10025 S275 J0
206	1	PLATFORM FRAME	UPN 120 x 793 LG.	EN10025 S275 J0
207	1	PLATFORM FRAME	UPN 120 x 462 LG.	EN10025 S275 J0
208	5	CONNECTION PLATE (BRACKET)	10 THK x 185 x 150	EN10025 S275 J0
209	5	CONNECTION PLATE (BRACKET)	10 THK x 135 x 150	EN10025 S275 J0
210	14	GRATING SUPP. ANGLE	60 x 60 x 6 THK x 100 LG.	EN10025 S275 J0
211	7	CONNECTION PLATE (HANDRAIL POST)	8 THK x 113 x 120 LG.	EN10025 S275 J0
212	3R+2L	SUPPORT BRACKET	6 THK x 829 LG. (SEE DETAIL)	EN10025 S275 J0
213	5	BRACKET END PLATE	6 THK x 80 x 140 LG.	EN10025 S275 J0
214	5	BRACKET GUSSET	6 THK x 64 x 222 LG.	EN10025 S275 J0
215	1EX/2IN	SPLICE PL. (INNER/OUTER FRAME)	6 THK x 70 x 200 LG.	EN10025 S275 J0
216	1	SPLICE PL. (TOP RAIL)	ø32 ROD x 100 LG.	EN10025 S275 J0
217	3	SPLICE PL. (GRATING SUPP. PL.& MIDRAIL)	6 THK x 50 x 150 LG.	EN10025 S275 J0
218	1	GRATING SUPP. PL.	4 THK x 120 x 1950 LG.	EN10025 S275 J0
219	1	SPLICE PL. (TOE PLATE)	6 THK x 150 x 150 LG.	EN10025 S275 J0
220	1	TOE PLATE	5 THK x 150 x 7300 LG. (CUT TO SUIT)	EN10025 S275 J0
221	7	HANDRAIL POST	60 x 60 x 6 THK x 1178 LG.	EN10025 S275 J0
222	1	MID RAIL	6 THK x 50 x 7300 LG.	EN10025 S275 J0
223	1	TOP RAIL	ø42 x 3 THK x 7500 LG.	EN10025 S275 J0
224	2	TOP RAIL PIPE CAP	ø1.1/4" (42) x 3 THK, ASME B16.9	CS
225	2	PLATFORM STEP OVER SUPP. CLIP	10 THK x 120 x 167 LG.	EN10025 S275 J0
226	2	SAFETY GATE HANDRAIL BASE PL.	10 THK x 100 x 120 LG.	EN10025 S275 J0
227	2	SAFETY GATE HANDRAIL	60 x 60 x 6 THK x 1090 LG.	EN10025 S275 J0
228	1	PIPE (SAFETY BAR)	ø1" (33.4) x SCH.STD x 800 LG.	EN10025 S275 J0
229	1	PIPE (SAFETY BAR)	ø1" (33.4) x SCH.STD x 70 LG.	EN10025 S275 J0
230	1	PIPE (SAFETY BAR)	ø1" (33.4) x SCH.STD x 122 LG.	EN10025 S275 J0
231	2	END PLATE	3 THK x ø27	EN10025 S275 J0
232	1	ROD	ø22 x 125 LG.	EN10025 S275 J0
233	1	STOP PLATE	6 THK x 40 x 250 LG.	EN10025 S275 J0
234	1	GRATING	MESH 30x50, PL.30x5 THK, 0.26~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235	1	GRATING	MESH 30x50, PL.30x5 THK, 0.51~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235A	1	GRATING	MESH 30x50, PL.30x5 THK, 0.56~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235B	1	GRATING	MESH 30x50, PL.30x5 THK, 0.56~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
235C	1	GRATING	MESH 30x50, PL.30x5 THK, 0.51~ M² (IN 1 PANELS)	SEE NOTE,8,9,10,11
236	2	GRATING	MESH 30x50, PL.30x5 THK, 0.42~ M² (IN 2 PANELS)	SEE NOTE,8,9,10,11
236A		DELETED		
237	32	GRATING FIXING CLAMPS	STAPLE & CLAMP, WITH M8 x 60LG. HEX. HED. BOLT + 2 SQ. NUT (SEE DETAIL)	CS
238	10	BOLT TYPE 'R' (SEE DETAIL)	M16 x 50 LG.	8.8
239	10	HEX. HEAD NUT	M16 (H=D)	8
240	10	WASHER	8 THK FOR M16 BOLT	CS
241	46	HEX. HEAD BOLT	M16 x 50 LG.	8.8
242	46	HEX. HEAD NUT	M16 (H=D)	8
243	46	FLAT WASHER	M16	CS
244	2	HEX. HEAD BOLT	M12 x 40 LG.	8.8
245	2	HEX. HEAD NUT	M12 (H=D)	8
246	2	FLAT WASHER	M12	CS
247	2	LADDER CLIP	6 THK x 50 x 100	EN10025 S275 J0
248	1	BANDING PLATE	3 THK x 185 x 1500 LG. (CUT TO SUIT)	EN10025 S275 J0
3	249	2	PLATFORM FRAME	UPN 120 x 690 LG.	EN10025 S275 J0



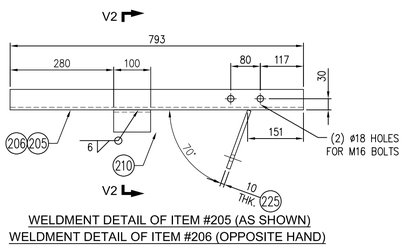
NOTES



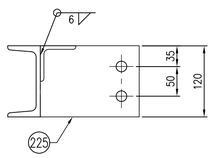
DETAIL "D8"
(1– AS SHOWN)
(1– OPPOSITE)
SCALE 1:5



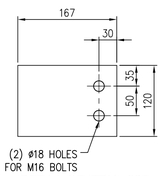
DETAIL "D9"
SCALE 1:5



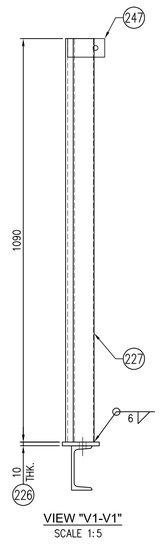
WELDMENT DETAIL OF ITEM #205 (AS SHOWN)
WELDMENT DETAIL OF ITEM #206 (OPPOSITE HAND)



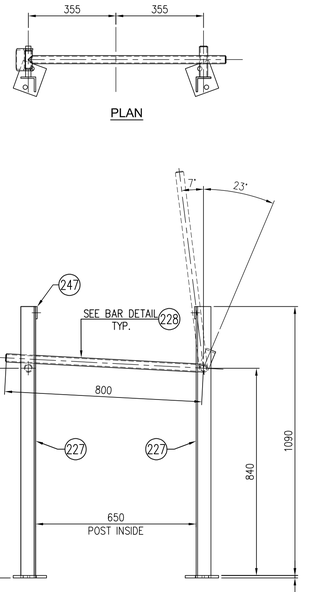
VIEW "V2-V2"
SCALE 1:5



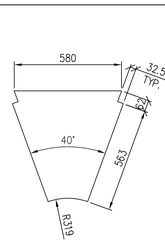
DETAIL OF ITEM #225
SCALE 1:5



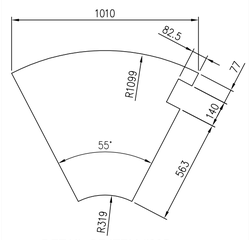
VIEW "V1-V1"
SCALE 1:5



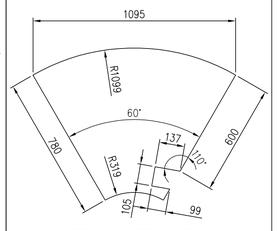
ELEVATION
SAFETY BAR TYPICAL DETAIL



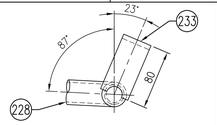
DETAIL OF ITEM #234
(SCALE 1:16)



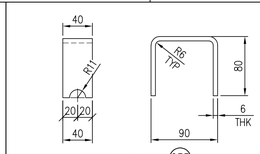
DETAIL OF ITEM #235
(SCALE 1:16)



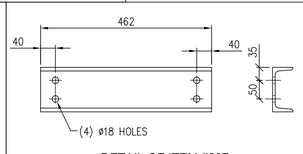
DETAIL OF ITEM #235B
(SCALE 1:16)



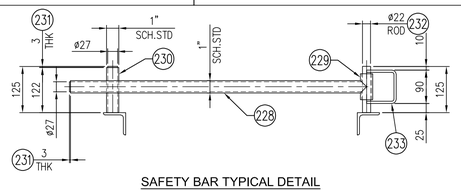
SAFETY BAR TYPICAL DETAIL



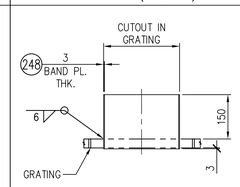
DETAIL PART 233



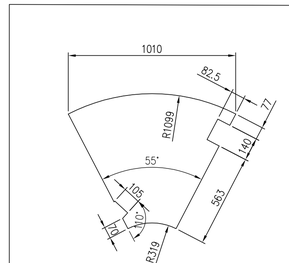
DETAIL OF ITEM #207
(SCALE 1:8)



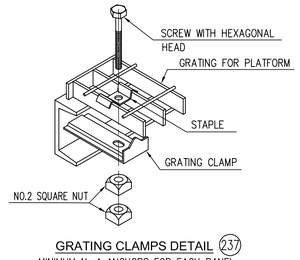
SAFETY BAR TYPICAL DETAIL



TYPICAL CUTOUT BANDING DETAIL



DETAIL OF ITEM #235C
(SCALE 1:16)



GRATING CLAMPS DETAIL 237
MINIMUM No.4 ANCHORS FOR EACH PANEL

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION

THERMO ENGINEERING — AN ENGLOBE CORPORATION COMPANY

ETE JOB 23-0193
ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

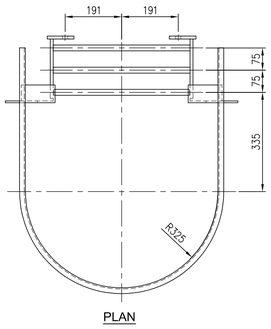
TITLE :
HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:22
DRAWN RJ | CHECKED SCB | APPROVED AL | DATE 07-08-24
A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 006 | REV. 03

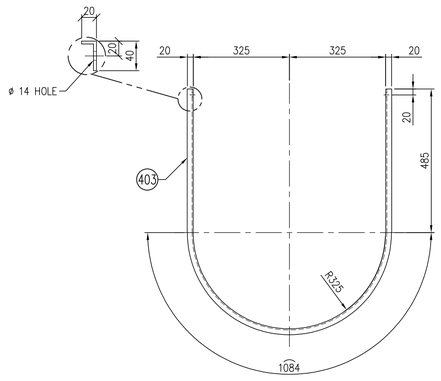
File Name : 1724000887-MAC-DD-00005_03

DRAWING NO. 1724000887-MAC-DD-00005_03

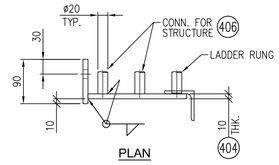
REV. 03



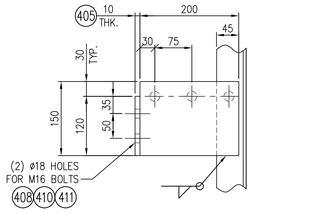
PLAN



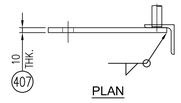
SECTION "A4-A4"



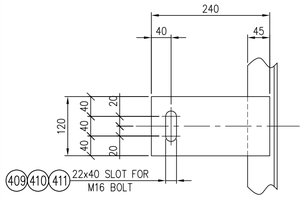
PLAN



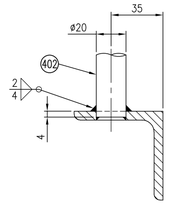
DETAIL #1



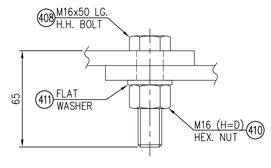
PLAN



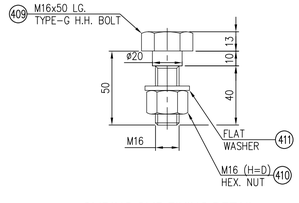
DETAIL #2



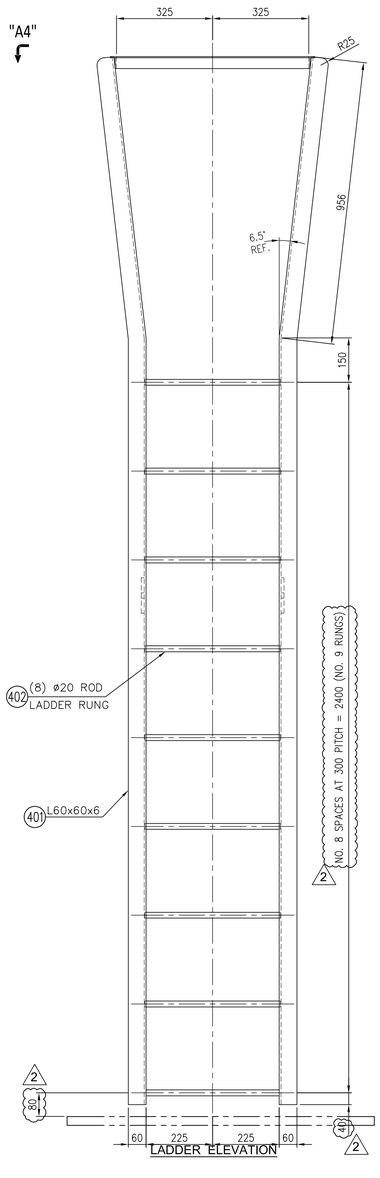
RUNGS WELDING DETAIL



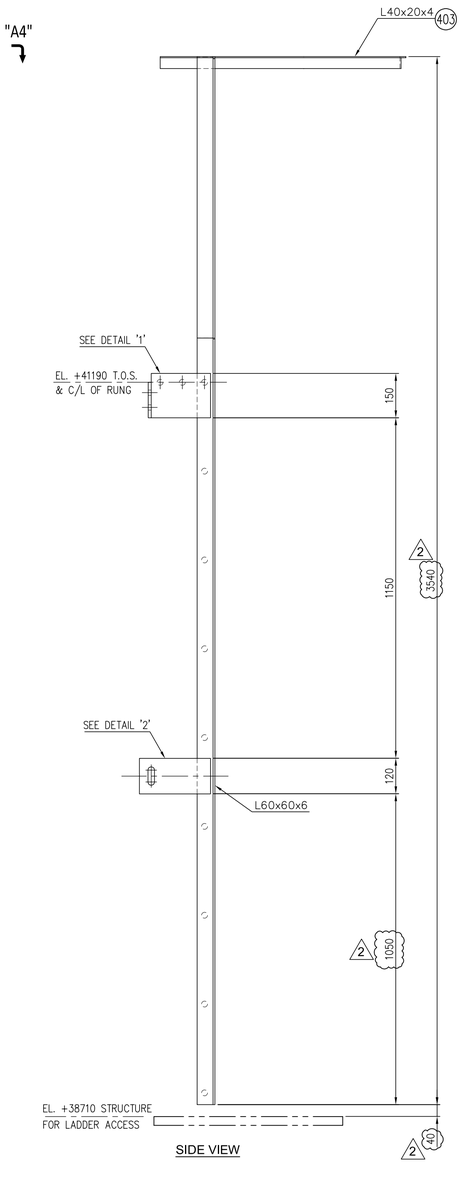
FIXED CLIP FIXING DETAIL



SLIDING CLIP FIXING DETAIL
(TYPE G BOLT)



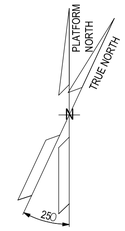
LADDER ELEVATION

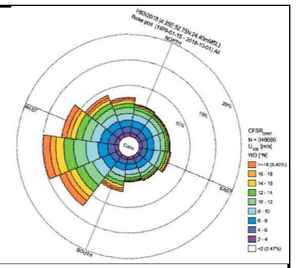


SIDE VIEW

BILL OF MATERIAL (LADDER)

ITEM	QTY	DESCRIPTION	DIMENSION	MATERIAL
401	2	LADDER STRINGER	L 60x60x6 x 3540 LG.	S275 J0
402	9	LADDER RUNG	ROD ø20 x 458 LG.	S275 J0
403	1	TOP HOOP	L 40x20x4 x 2055 LG.	S275 J0
404	2	LADDER CLIP (FIXED)	10 THK x 150 x 200 LG.	S275 J0
405	2	LADDER CLIP (FIXED)	10 THK x 90 x 120 LG.	S275 J0
406	2	CONN. STRUCT. RUNG	ROD ø20 x 462 LG.	S275 J0
407	2	LADDER CLIP (SLIDING)	10 THK x 120 x 240 LG.	S275 J0
408	4	HEXAGONAL HEAD BOLTS	M16 x 50 LG.	8.8
409	2	TYPE-G HEXAGONAL HEAD BOLTS (SEE DETAIL)	M16 x 65 LG.	8.8
410	6	HEXAGONAL NUTS	M16 (H=D)	8
411	6	FLAT WASHER	FOR M16 BOLT	CARBON STEEL





NOTES

03	06-11-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
02	08-10-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
01	05-09-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
00	02-08-2024	RJ	SCB	AL	ISSUED FOR INFORMATION
REV.	DATE	DRN	CHKD	APPD	DESCRIPTION

THERMO ENGINEERING — AN ENGIE COMPANY

ETE JOB 23-0193

ETE DWG NR. 23-0193-0131

CROSSWIND

ROSETTI MARINO

TITLE :

HYDROGEN VENT
DETAILED DRAWING WITH PART LIST

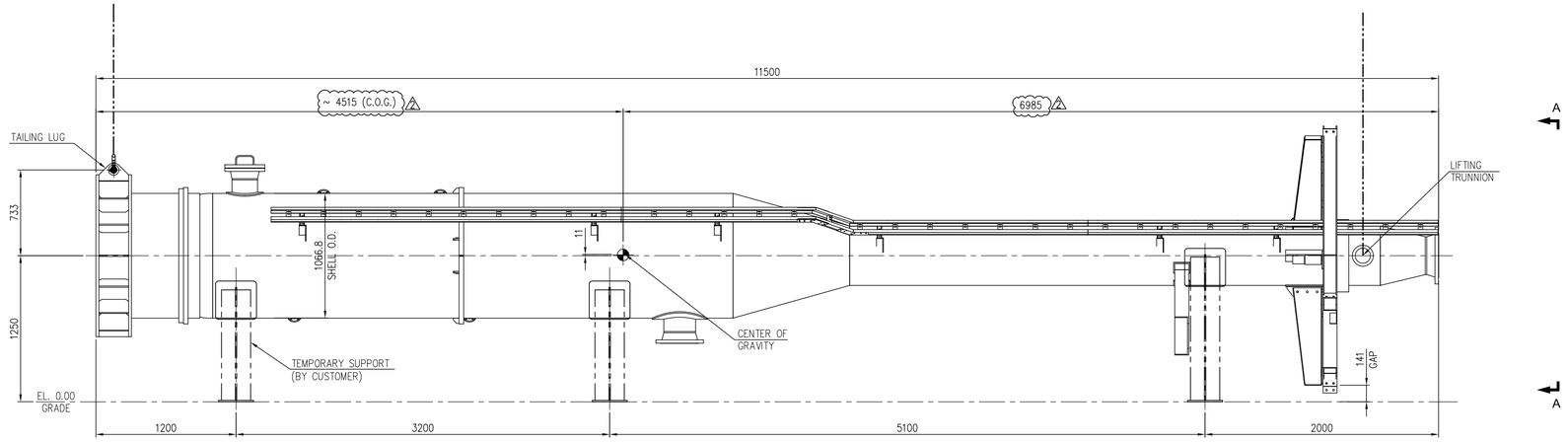
CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:22

DRAWN RJ | CHECKED SCB | APPROVED AL | DATE 02-08-24

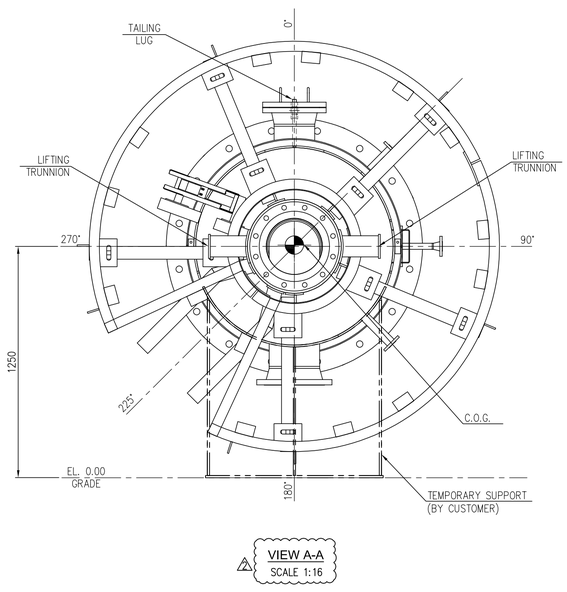
A1 | DRAWING NO. 1724000887-MAC-DD-00005 | SHEET 007 | REV. 03

File Name : 1724000887-MAC-DD-00005_03

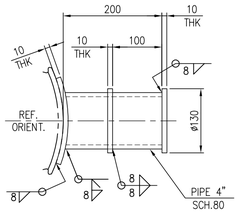
DRAWING NO. 1724000887-MAC-DD-00019_02 REV. 02



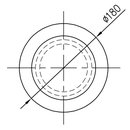
ELEVATION
⚠2 LIFTING WITHOUT INSTALLED TIP
SCALE 1:25



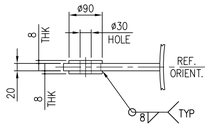
⚠2 VIEW A-A
SCALE 1:16



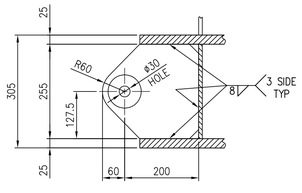
ELEVATION
LIFTING TRUNNION DETAIL



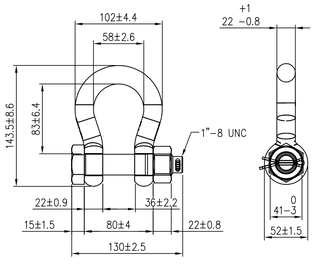
SIDE VIEW



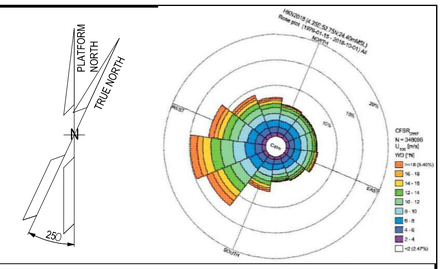
PLAN VIEW



ELEVATION
TAILING LUG DETAIL



SHACKLE DETAIL
GREEN PIN® BOW SHACKLE BN
GROUP : G-4163
PART : GPGHMB22
WLL :6.5t



NOTES

GENERAL NOTES:

1. ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3. DELETED..
4. THE LIFTING TRUNNIONS ARE PROVIDED TO LIFT THE ASSEMBLY IN FULLY DRESSED CONDITION.
5. VENT TIP, HANDRAIL, LADDER AND GRATINGS SHALL BE INSTALLED IN VERTICAL POSITION OF EQUIPMENT.
6. TOTAL LIFTING WEIGHT APPROX. : 4050 KG. (WITH 10% CONTINGENCY)

ROSETTI MARINO	
1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED
NOTE: Approval doesn't relieve the supplier from mandatory compliance with contractual documents and specifications. Comments made do not imply acceptance of any cost or delivery impact.	
Sign	Date
Giuseppe Cavallo	09/12/24

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

THERMO ENGINEERING — AN ENCOMP COMPANY | ETE JOB 23-0193 | ETE DWG NR. 23-0193-0530A

CROSSWIND | ROSETTI MARINO

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

TITLE : HYDROGEN VENT LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

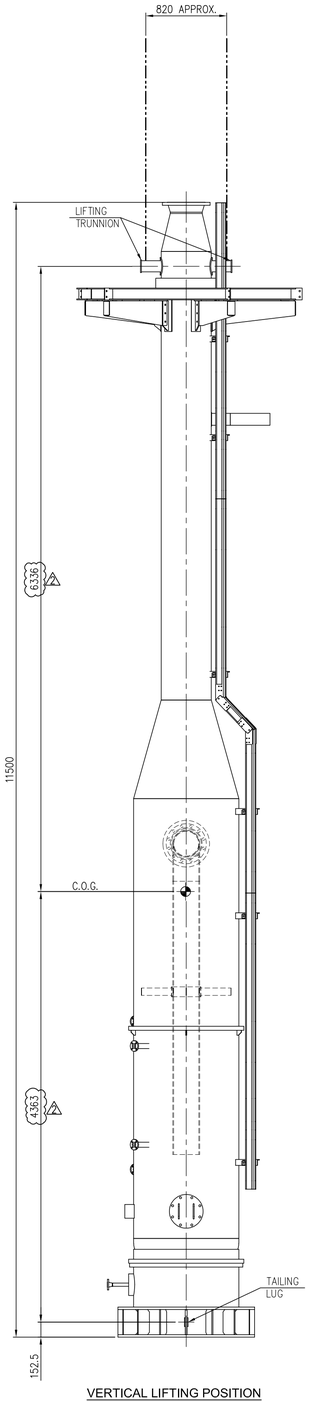
DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 001 | REV. 02

File Name : 1724000887-MAC-DD-00019_02

DRAWING NO. 1724000887-MAC-DA-00003_02

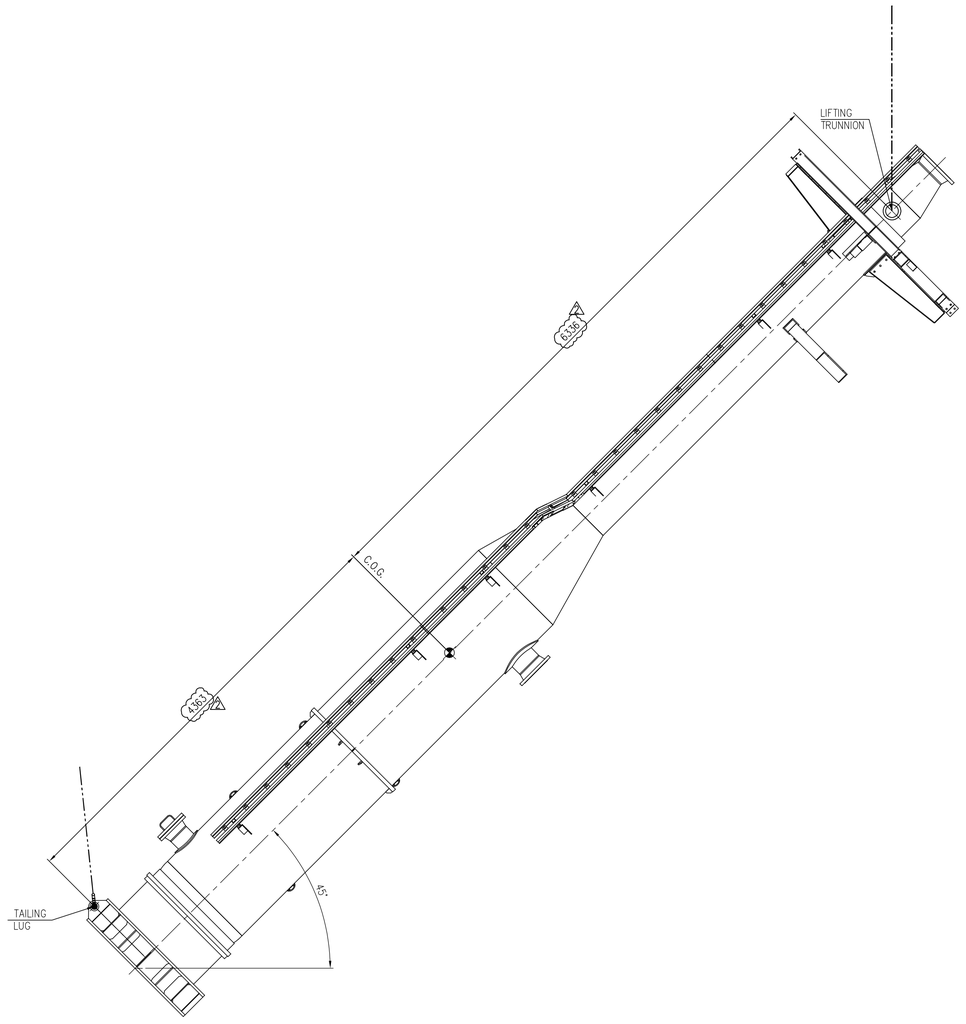
REV. 02



VERTICAL LIFTING POSITION

SCALE 1:30

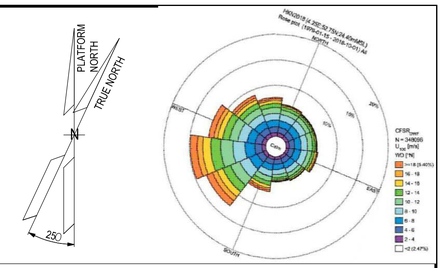
VIEW ROTATED FOR LIFTING TRUNNION CLARIFICATION



LIFTING VIEW AT 45° POSITION

SCALE 1:40

LIFT ANGLE Deg.	LIFTING LOAD kN	TAILING LOAD kN
0	24.95	34.62
10	25.37	34.20
20	25.80	33.77
30	26.29	33.29
40	26.86	32.71
50	27.60	31.97
60	28.68	30.89
70	30.51	29.06
80	34.76	24.82
90	59.57	0.00



NOTES

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY

ETE JOB 23-0193

ETE DWG NR. 23-0193-0530A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE : HYDROGEN VENT LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

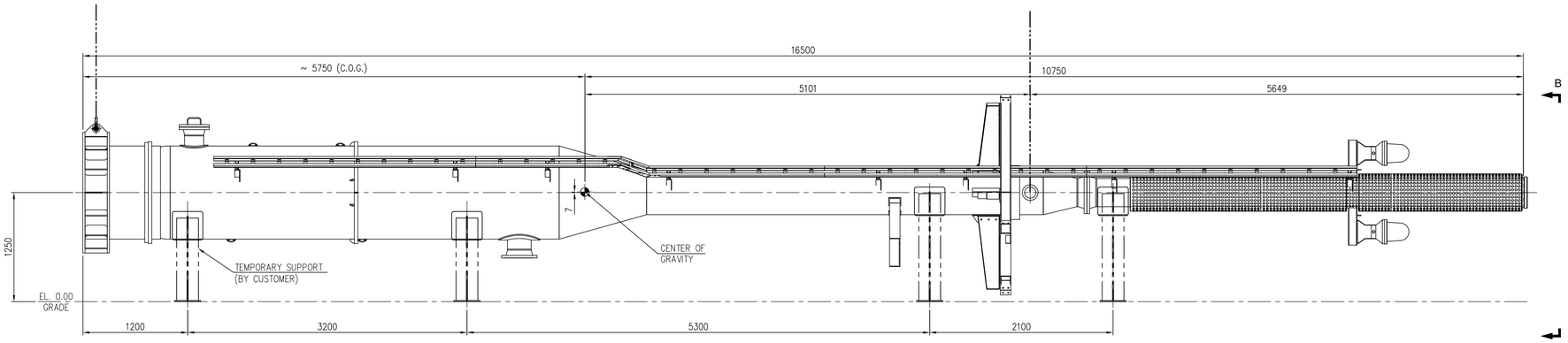
DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 002 | REV. 02

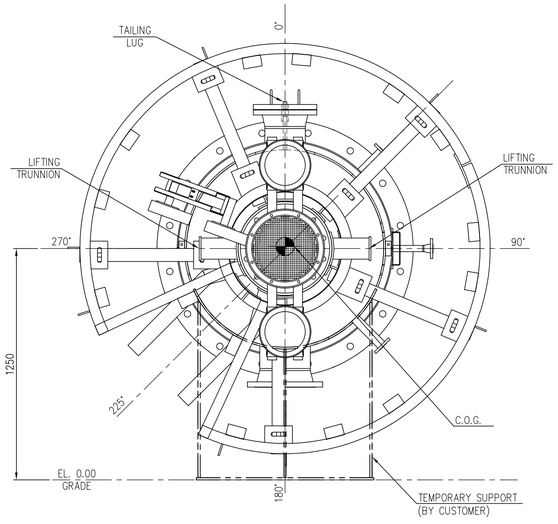
File Name : 1724000887-MAC-DA-00003_02

DRAWING NO. 1724000887-MAC-DD-00019_02

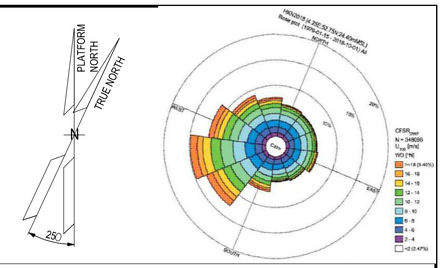
REV. 02



ELEVATION
LIFTING WITH INSTALLED TIP
SCALE 1:30



VIEW B-B
SCALE 1:16



NOTES

GENERAL NOTES:

1. ALL DIMENSION ARE IN mm UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS ARE IN mm UNLESS OTHERWISE STATED.
3. DELETED..
4. THE LIFTING TRUNNIONS ARE PROVIDED TO LIFT THE ASSEMBLY IN FULLY DRESSED CONDITION.
5. VENT TIP, HANDRAIL, LADDER AND GRATINGS SHALL BE INSTALLED IN VERTICAL POSITION OF EQUIPMENT.
6. TOTAL LIFTING WEIGHT APPROX. : 4600 KG. (WITH 10% CONTINGENCY)

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY

ETE JOB	23-0193
ETE DWG NR.	23-0193-0530A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE :
HYDROGEN VENT
LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

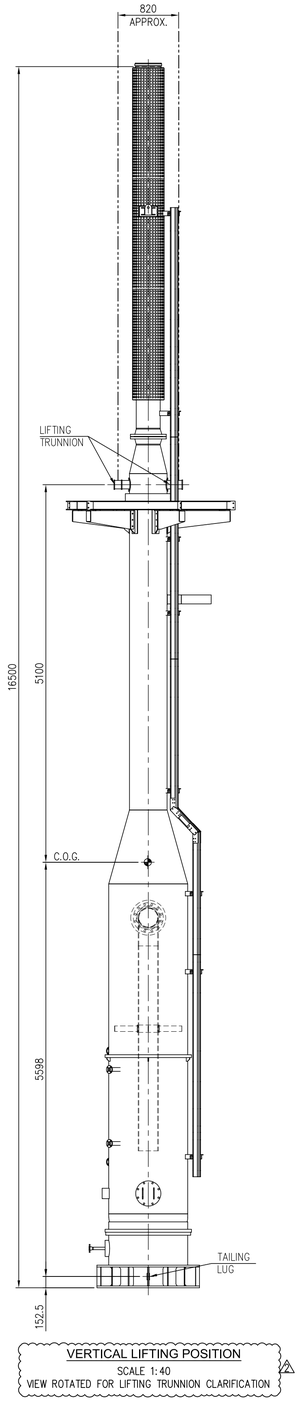
DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 001 | REV. 02

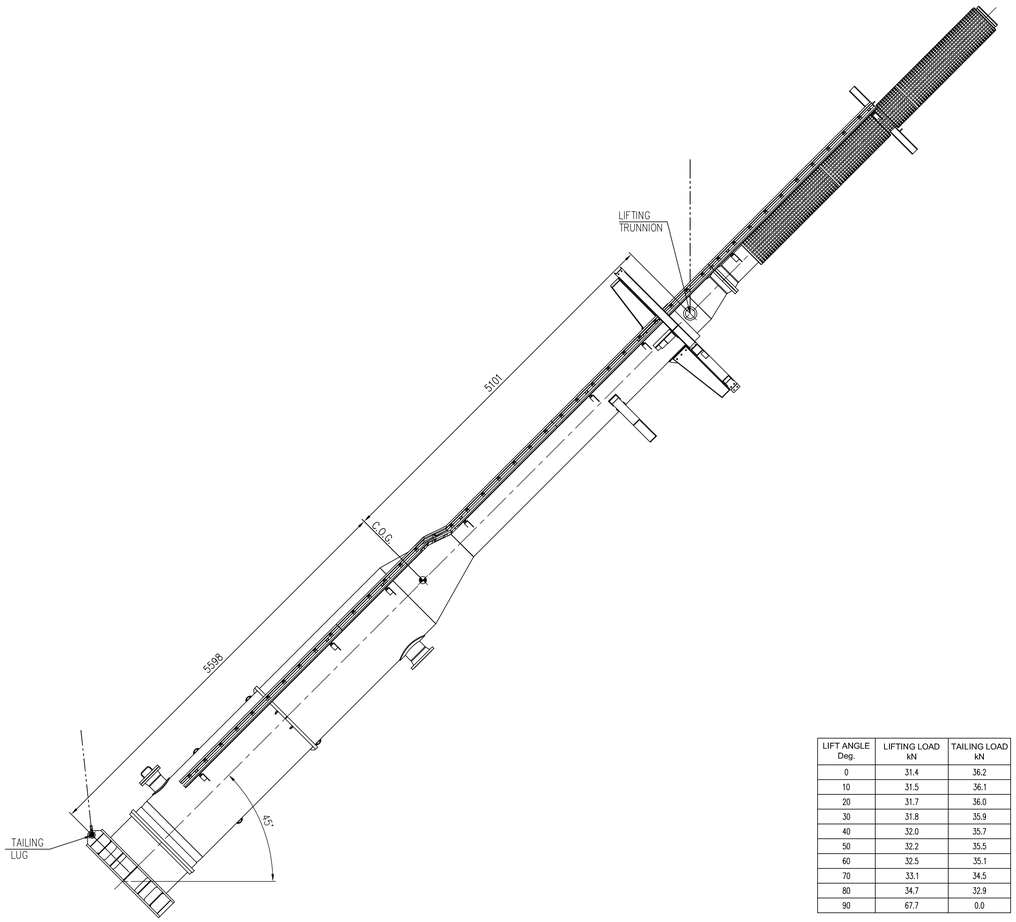
File Name : 1724000887-MAC-DD-00019_02

DRAWING NO. 1724000887-MAC-DD-00019_02

REV. 02

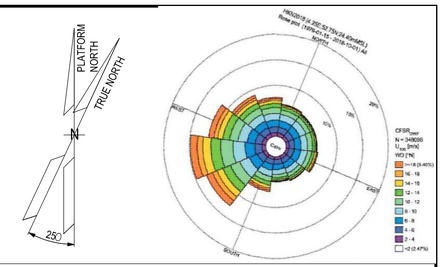


VERTICAL LIFTING POSITION
SCALE 1:40
VIEW ROTATED FOR LIFTING TRUNNION CLARIFICATION



LIFT ANGLE Deg	LIFTING LOAD kN	TAILING LOAD kN
0	31.4	36.2
10	31.5	36.1
20	31.7	36.0
30	31.8	35.9
40	32.0	35.7
50	32.2	35.5
60	32.5	35.1
70	33.1	34.5
80	34.7	32.9
90	67.7	0.0

LIFTING VIEW AT 45° POSITION
SCALE 1:40



NOTES

REFERENCE DOCUMENT	No.
MECHANICAL CALCULATION - HYDROGEN VENT	1724000887-MAC-CA-00004
DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	1724000887-MAC-DD-00005
GENERAL ARRANGEMENT - HYDROGEN VENT	1724000887-MAC-DA-00003
-	-

THERMO ENGINEERING — AN ENCORE COMBUSTION COMPANY

ETE JOB	23-0193
ETE DWG NR.	23-0193-0530A

REV.	DATE	DRN	CHKD	APPD	DESCRIPTION
02	15-11-2024	SCB	RV	AL	ACCEPTED FOR CONSTRUCTION
01	20-09-2024	SCB	RV	AL	ISSUED FOR REVIEW
00	05-08-2024	SCB	RV	AL	ISSUED FOR REVIEW

CROSSWIND

ROSETTI MARINO

TITLE : HYDROGEN VENT LIFTING DRAWING

CONTRACT NO./TITLE CW-I-WP4-2023-05/HOLLANDSE KUST NOORD WIND PARK | SCALE 1:30

DRAWN SCB | CHECKED RV | APPROVED AL | DATE 05/08/24

A1 | DRAWING NO. 1724000887-MAC-DD-00019 | SHEET 001 | REV. 02

File Name : 1724000887-MAC-DD-00019_02

Base Load Power Hub (BLPH)
Hydrogen Vent Q-43004

INSTALLATION OPERATING AND MAINTENANCE MANUAL (IOM)
Document Number: 1724000887-MAC-MAN-00017

Document Class: 3

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
2	MINOR COMMENTS - REVISE AND RESUBMIT - WORK MAY PROCEED
3	MAJOR COMMENTS – REJECTED – DO NOT PROCEED
4	APPROVAL NOT REQUIRED

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Sign	Date
Giuseppe Cavallo	21/01/25

Rev.	Date	Description	Prepared	Reviewed	Approved
03	20/12/2024	Issue for Information (IFI)	SI		
02	29/11/2024	Issue for Information (IFI)	SI		
01	24/10/2024	Issue for Information (IFI)	S		
00	19/09/2024	Issue for Information (IFI)	S		

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Revision / Change Log

Rev.	Description
00	Issue for Information (IFI)
01	Issue for Information (IFI)
02	Issue for Information (IFI)
03	Issue for Information (IFI)

HOLDS LIST

No.	Description
1	
2	
3	
4	

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Attachment 1
Self-regulating and power limiting heating cable systems -- Installation and Maintenance Manual

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1.1 INTRODUCTION

1.1.1PROJECT 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.

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.

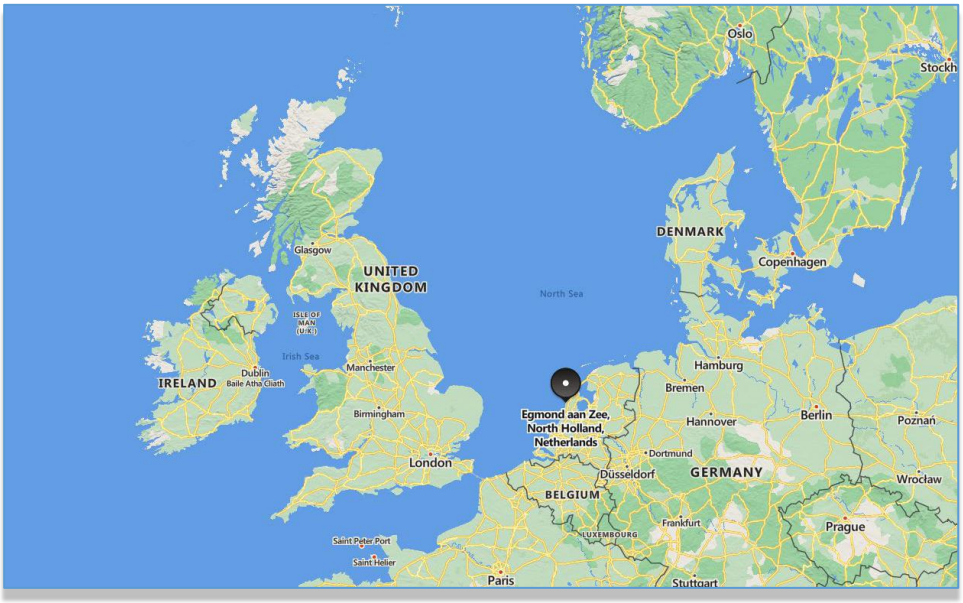


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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 located on coordinates E 590719.1, N 5841602.3 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 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.

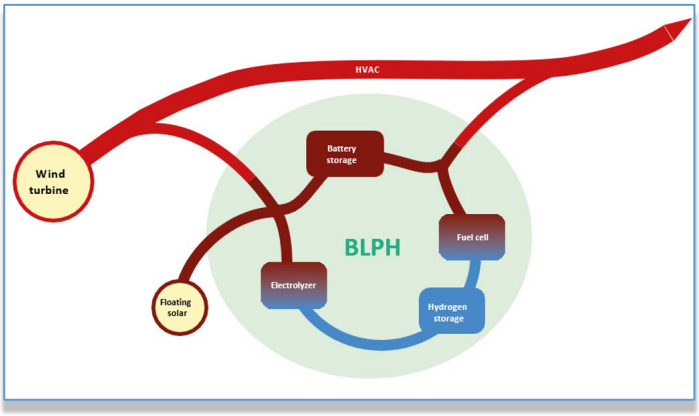


Figure 3 – BLPH Concept

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 s 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

This Document describes the instruction, operation and maintenance details of the Hydrogen Vent.

2.1 REFERENCES DOCUMENTS

REFERENCE DRAWINGS

To the present manual are enclosed the following reference drawings:

Drawing No.	Rev.	Description	Notes
1724000887-MAC-DA-00003	02	GENERAL ARRANGEMENTS DRAWINGS, INCLUDING FOUNDATION LOADS-HYDROGEN VENT	NA
1724000887-MAC-DD-00005	01	DETAILED DRAWING WITH PART LIST - HYDROGEN VENT	NA
1724000887-MAC-CA-00004	02	MECHANICAL CALCULATION – HYDROGEN VENT	NA

TECHNICAL SPECIFICATIONS

To the present manual are enclosed the following technical specifications :

Specification No.	Rev.	Description	Notes
123A90-DDL-MAC-MR-50042-MR FOR VENT	00	MATERIAL REQUISITION FOR HYDROGEN VENT – Q-43004	NA
123A90-DDL-MAC-DS-50044-TDS	00	TECHNICAL DATASHEET – HYDROGEN VENT PACKAGE	NA

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	CROSSWIND
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
PROJECT ITEM:	HYDROGEN VENT
MAKER (ETE):	ENCORE THERMO ENGINEERING SRL
BESS	BATTERY ENERGY STORAGE SYSTEM
BLPH	Base Load Power Hub
BTV	Self regulating cable
CNR	National Research Council
COD	Codification
DA	General arrangement drawing

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DDL	Deliverables Document List
DEP.	Department
DS	Datasheet
EDMS	Engineering data management system
EN	European norm
EPA	Environmental Protection agency
ETS	Electronic Thermostat
HKN	Hollandse Kust Noord
HTV	Self regulating cable
IEEE	Institute of electrical and electronics engineers
IOM	Installation operating and maintenance manual
JBM	Integrated power tee connection
JBU	Junction box for modular system
LP	Liquid penetrant
MDMT	Minimum Design Metal Temperature
MR	Material requisition
NGC	Next generation controller
NPS	Nominal pipe size
OSHA	Occupational safety and health administration
VooW	Van Oord Offshore Wind
VPL	Power limiting cable
WP	Work package

Table 1 - Definitions and Abbreviations

2.3 PROJECT DATA

DESIGN CODE	ASME VIII DIV.1 + EUROCODE
MAX. GAS FLOW	13485 kg/h
AMBIENT TEMPERATURE	-8.4/+25°C
OPERATING PRESSURE	ATM barg
DESIGN TEMPERATURE	-10/ +80°C
DESIGN PRESSURE	3.5 barg
CORROSION ALLOWANCE	3mm (for carbon steel only)
HYDROTEST PRESSURE	5.5 barg
AREA CLASSIFICATION	ZONE 2 IIC T 1
MDMT	-29°C
FLUID GROUP	1
CATEGORY	IV
MODULE	G
SEISMIC	N/A
WIND VELOCITY	28 m/s
TYPRE OF FLUID	HYDROGEN GAS
WELDING EFFICIENCY	0.85
RADIOGRAPHY	

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3. VENT TIP

3.1 GENERAL INTRODUCTION

The Vent Tips described in the present manual are used to guarantee the gas high combustion efficiency.
These tips are passive systems, i.e. without parts in motion.

3.2 OPERATION PRINCIPLES

The vent tips type SVT are equipment indifferently used for continuous or discontinuous service, for vent systems that does not foresee the primer of the flame even in the presence of any flammable gas.
In any case, the tips are carried out with highly refractory steels, selected to guarantee continuously the flame presence at their exit without that it causes any damages to the equipment.
In case that the flame presence on the tip is not acceptable, it will be necessary to foresee particular systems that guarantee the extinguishing of the flame.

3.3 APPLICABLE CODES, STANDARDS, AND REGULATIONS

The planning activities and the carrying out of the vent tips type SVT are done in compliance with the following rules and procedures:

Process design	:	API RP 521
Materials	:	ASTM – UNI
Welding procedures	:	ASME IX

3.4 GUARANTEES

The described documents within the present manual are covered by functional and construction guarantee for the whole period foreseen in the contract of supply.

To be noted that these guarantees will be declined in case that Encore Thermoengineering has not been contacted for the foreseen verifications after the installation, for the start-up and for the first commissioning operation.

Furthermore, to be noted that to maintain the validity of the foreseen guarantee, any possible intervention for modification or tampering with the supplied products, it should be obligatory to agree with Encore Thermoengineering which will authorize the intervention by written.

3.5 CONSTRUCTION FEATURES

The materials for the carrying out of the vent tips type SVT are selected on the base of the specific needs deriving from the process conditions.
For a detailed determination of the materials used and for the building features please refer to the drawings enclosed.
In general, the vent tips type SVT are made of a flanged connection to allow the installation to the conduct of gas feeding (riser), of a vertical shell complete with windshield, and with systems for the detection of the flame (optional).

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The vent tips type SVT do not suffer for the use weather conditions except the limits indicated in the technical specification enclosed to the present manual.

3.6 REQUIRED UTILITIES

There are not required utilities for the correct use of the equipment.
If there is the need to prevent air infiltration in the system upstream of the tip, the entire system should be kept fluxed with a quantity of inert gas directly proportional to the dimensions of the tip and of its accessories.
For these quantities refer to the enclosed technical specification

3.7 TYPES AND CODIFICATION

The specific features of vent tips type SVT can be deduced from the table below.
This on the base of the identification abbreviation of the tip written on the drawing and on the plate of the equipment.

TE-	COD 1	SVT	COD 2

	Codification tag	Description
COD 1	-	Vent tip inlet connection diameter in inches

	Figure position											Accessories
COD 2	1	2	3	4	5	6	7	8	9	10	11	
Nr. 0=NO	x											Nr. of thermocouples for control of the tip flame
Inch 0=NO		x										Extinguisher inlet connection diameter
Inch 0=NO			x									Sample relieving flange diameter
Nr. 0=NO				x								Connections quantity for sample relieving
1=SI 0=NO					x							Refractory inner coating
Nr. 0=NO						x						Anti-noise shell
												Nr. of thermocouples for flame alarm inside the tip

Example: TE-12"- SVT-3/1.5/0/0//0/1
Vent tip diameter 12" with 3 thermocouples for tip flame detection, with extinguisher inlet diameter of 1.1/2”, without sample relieving, without internal refractory lining, with one thermocouple for flame detection inside the tip.

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3.8 OPERATING PROCEDURES

3.8.1 – INSTRUCTION FOR RECEIVING AND STORING OF THE MATERIALS:
Materials are supplied completed of packing necessary to preserve the quality of the good.
Once received the unit, check the state of the packing and of the delivered good and proceed to its storing according to the following:
Vent tip: in covered area

- Electric and instrumental accessories: in closed area
- Mechanical accessories: in covered area

3.8.2 – INSTRUCTION FOR INSTALLATION:
After taking the materials out of the packing install them following this procedure:

- accurately clean the line to eliminate the possible present deposits.
- Install the vent tip through the special connection flange putting between the proper gasket, being sure to follow the correct positioning foreseen on the drawing and assembly schemes.
- Install the different control accessories through the proper connections and proceed to their electric or pneumatic connection.

For the assembly indications of the accessories refer to the enclosed manuals of installation, use and maintenance of the single component.
Connect, if it is foreseen, the snuffing line to the corresponding flanged connection putting between the right gaskets.
Check all connections.
3.8.3 – INSPECTION AFTER INSTALLATION
After the installation and before proceeding to the starting of the system, it is necessary to carry out the following checks:

- Check that all the equipment and the accessories are connected in the proper way.
- Check that all electric connections are carried out correctly. At this point we advise to do a blank test of all the foreseen accessories to check the right correspondence of the signals.

3.8.4 – UTILIZATION
Ended up the described checks, the equipment is ready to be used in the limits of use indicated in the technical specification.
3.8.4.1 – START-UP PROCEDURES
No procedure is necessary for the start-up.
3.8.4.2 – PROGRAMMED SHUT-DOWN PROCEDURES
No procedure is necessary for the programmed shut-down.
3.8.4.3 - EMERGENCY SHUT-DOWN PROCEDURES
No procedure is necessary for the emergency shutdown.
3.8.4.4 – NORMAL OPERATION PROCEDURES
No procedure is necessary for the normal use.
In any case if one of these events happens:

- Discharge in emergency of elevated quantity of fluid.
- accidental primer and stabilization of the flame on the exit opening of the tip or inside it.
- Explosion inside the tip or the conveying pipe of the gases

We recommend carrying out an accurate check of the tip and of its components.

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3.9 INSPECTION AND MAINTENANCE

To guarantee the correct functioning of the supplied equipment and to avoid permanent damages on them, it is necessary to plan periodical interventions of maintenance according to what is reported below.
The good knowledge of those indications and the regular carrying out of the inspections and the maintenance activities allow to avoid operating mistakes and sudden stops of the equipment.
It is advisable to read carefully this section and do not hesitate to contact our technical offices if the instructions are not clear or exhaustive enough.
The inspection and maintenance schemes indicate the interval of intervention, which we recommend to follow.
These indications are to be considered the minimal to do.
Running the plant these schemes can be improved for what concerns the interval and also adding other check and maintenance activities.

Encore Thermoengineering is not responsible for possible damages to persons or things caused by the bad installation, incorrect use of the equipment or by the non-carrying out of the inspection and maintenance activity.

MAINTENANCE CALENDAR				
Intervention Object	Intervention description	Reference document	Tools	Frequency (months)
Tip shell and windshield	Check that they are free of oxidation and buckling and well preserved If necessary, clean accurately	1724000887-MAC-DD-00005	Various spanners Inox brush Pulivapor Detergents Acids for cleaning	12
Seal flanges and connections	Check and grease the bolts and nuts of the connections Check the sealing and the tightening of the joints Substitute the sealing gaskets	1724000887-MAC-DD-00005	Various spanners Grease Spare parts	12

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4. SELF SUPPORTING TYPE FLARE RISER

4.1 GENERAL INTRODUCTION

The Riser is carried out with pipes of thickness and diameter fixed with the process dimensioning, according to the capacities to handle and their chemical-physical conditions and following a structural calculation of mechanical stability specific of each single job.
The quality of the material is fixed in relation to the features of the process and of mechanical resistance and in compliance with the client requests.
The Riser is calculated from the structural point of view to be self-supporting.

4.2 OPERATION PRINCIPLES

The Riser is planned and carried out to allow the flow of fluids to be kept under the conditions specified by the client from the inlet point up to the top tip.
The height of the Riser is calculated according to law and good technique, to limit the fall-out of polluting substances and of radiation to the ground within the requested limits.

4.3 APPLICABLE CODES, STANDARDS AND REGULATIONS

The planning activities and the carrying out of the Riser are done in compliance with the following rules and procedures:

Process design	:	API RP 520
	:	API RP 521
	:	OSHA
	:	EPA
Mechanical design	:	CNR-UNI 10012/1973
	:	CNR-UNI 10011/1985
	:	CNR-UNI 10027/1985
	:	UBC Code
	:	AISC Code
Materials	:	ASTM – UNI -EN
Welding procedures	:	DIN EN ISO 15614-1

4.4 GUARANTEE

The described documents within the present manual are covered by functional and construction guarantee for the whole period foreseen in the contract of supply.

To be noted that these guarantees will be no more valid in case during erection, commissioning and start-up activities (if Thermoengineering qualified and skilled engineers would not be required in accordance with the contractual rates) the recommendation of this operating manual are not strictly observed.

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Furthermore, to be noted that to maintain the validity of the foreseen guarantee, any possible intervention for modification or tampering with the supplied products, it should be obligatory to agree with Thermoengineering which will authorize the intervention by written.

4.5 CONSTRUCTIVE FEATURES AND UTILIZATION LIMITS

The Riser is supplied in prefabricated (pre-engineered) parts (trunks) to assemble on site through welded couplings.
The trunks of the riser do not suffer for the weather conditions of use except the limits deriving from the used material, from the superficial treatments and from the chemical features of the process flux.

Normally in the first part (low part) are applied all the nozzles for the process and instrument connection, manhole, hand hole, etc.
The building features and the materials used are noticeable from the drawings enclosed.

4.6 OPERATING PROCEDURES

4.6.1 – INSTRUCTION FOR RECEIVING AND STORING OF THE MATERIALS:
The materials are supplied completed of the necessary packing to preserve the quality of the good.
Once received the unit, check the state of the packing and of the good supplied and store it in a covered area.

4.6.2 – INSTRUCTION FOR INSTALLATION:
In case of supply in more parts, each single part is supplied loose to be assembled in the yard as follows:

- Through flanged couplings for small diameters
- Through welding for big diameters

The trunks are given completely prefabricated (pre-engineered) and completed of supports for stairs, platforms, and other accessories.
The choice of the step of prefabrication and of assembly completion before the positioning of the Riser has to be done on the base of the assembly needs and of the means at disposal for the lifting and the moving of the materials.
Particular care has to be taken for the stays connection and for their pre-tension, which has to be done according to what is foreseen in the proceeding enclosed
The lifting and material handling must be done only after having spotted and checked the lifting and slinging points of the materials.

4.6.3 – INSPECTION AFTER INSTALLATION
At the end of the installation and before starting the system it will be necessary to do some checks as:

- Check that all the accessories are properly connected
- Check that all the bolted connections have been carried out correctly.
- Check the welding carried out on site through non-destructive checks (Rx, LP, etc.)

It is advisable to ask for the attendance of a Thermoengineering technician to assist to the described verifications and the start-up operation in order to maintain valid the foreseen guarantee (see chapter 4 guarantee).

4.6.4 – UTILIZATION

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4.6.4.1 – START-UP PROCEDURES
No particular procedure is necessary for the start-up.
4.6.4.2 – PROGRAMMED SHUT-DOWN PROCEDURES
No particular procedure is necessary for the programmed shut-down.
4.6.4.3 - EMERGENCY SHUT-DOWN PROCEDURES
No particular procedure is necessary for the emergency shut-down.
4.6.4.4 – NORMAL OPERATION PROCEDURES
No particular procedure is necessary for the normal operation.

4.7 INSPECTION AND MAINTENANCE

To guarantee the correct functioning of the supplied equipment and to avoid permanent damages on them, it is necessary to plan periodical interventions of maintenance according to what is reported below.
The good knowledge of those indications and the regular carrying out of the inspections and the maintenance activities allow to avoid operating mistakes and sudden stops of the equipment.
It is advisable to read carefully this section and do not hesitate to contact our technical offices if the instructions are not clear or exhaustive enough.
The inspection and maintenance schemes indicate the interval of intervention, which we recommend to follow.
These indications are to be considered the minimal to do.
Running the plant these schemes can be improved for what concerns the interval and also adding other check and maintenance activities.

Encore Thermoengineering is not responsible for possible damages to persons or things caused by the bad installation, incorrect use of the equipment or by the non-carrying out of the inspection and maintenance activity.

MAINTENANCE CALENDAR				
Intervention object	Intervention description	Reference document	Particular tools	Frequency (months)
Connections sealing	Check and grease the tie-rods and nuts of all connections Check and grease the foundation tie-rods. Tightening of the joints	1724000887-MAC-DD-00005	Various spanners Grease	12

5. VERTICAL LIQUID SEAL

5.1 GENERAL REFUSAL

The vertical seal is carried out with tubes or sheets of thickness and diameter fixed with the process dimensioning, according to the capacities to handle and their chemical-physical conditions and following a structural calculation of mechanical stability specific of each single job.
The quality of the material is fixed in relation to the features of the process and of mechanical resistance requested by the project.
The water seal is fixed to the foundation and directly coupled to the vertical pipe of the vent-hole flare.

5.2 OPERATION PINCIPLES

The aim of the specific liquid seal is:

- To keep the waste gas pressure under a certain value in the system upstream of water seal.
- To prevent the air entrance in the system caused by the different pressures and temperatures upstream of water seal.
- To avoid the burn back into the system during no flow or very low gas flow rate

When the value waste gas pressure is under a certain value the waste gas cannot overcome the barrier made of water .
When the pressure of the waste gas exceeds the water head, the waste gas overcome the barrier of liquid and it vents to the flare.
The high of the water head is fixed according to the needs of the process and the guidelines of the international rules.

5.3 APLLICABLE CODES, STANDARDS AND REGULATIONS

The planning activities and the carrying out of the water seal are done in compliance with the following rules and procedures:

Process design	:	API RP 520
	:	API RP 521
	:	ASME VIII Division 1 & 2
	:	SHELL DEP.
Mechanical design	:	CNR-UNI
	:	ASME VIII Division 1 & 2
	:	UBC Code
	:	AISC Code
Materials	:	ASTM – UNI
Welding procedures	:	ASME IX

5.4 GUARNTEE

The described documents within the present manual are covered by functional and construction guarantee for the whole period foreseen in the contract of supply.

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To be noted that these guarantees will be no more valid in case during erection, commissioning and start-up activities (if Thermoengineering qualified and skilled engineers would not be required in accordance with the contractual rates) the recommendation of this operating manual are not strictly observed.

Furthermore, to be noted that to maintain the validity of the foreseen guarantee, any possible intervention for modification or tampering with the supplied products, it should be obligatory to agree with Thermoengineering which will authorize the intervention by written.

5.5 CONSTRUCTION FEATURES:

The liquid seal is supplied in a single piece completely prefabricated and tested ready to be assembled in the yard through welded to flare riser.
The equipment does not suffer for the weather conditions of use except the limits deriving from the used material, from the superficial treatments and from the chemical features of the process flux.
Normally on the water seal are applied all the connection nozzles to the process tubes, the nozzles for the connection of the control instruments, and accessories.
The building features and the materials used are noticeable from the drawings and the technical specification enclosed.
The water seal drum is supplied without any water refilling and automatically discharge system.
In order to guarantee a correct functionality, we suggest foreseeing an automatic hydraulic refilling system in function of the inside liquid level measurement of water seal.
Furthermore, it is suggested to install an open syphon to evacuate the liquid in excess. In this case it will be necessary to consider a min. total height of syphon equal to 1.5-time maximum flare pressure drop at max. gas discharge case from the top of the syphon (at the same level to the normal liquid level inside of water seal, to syphon bottom.
For other arrangements of this devices, we suggest contacting Thermoengineering.

5.6 REQUIRED UTILITIES

To keep the system safe, it is necessary to check and to refill, if necessary, the liquid (water and glycol (50%)) every six months, considering that the liquid consumption is 0,12 l/h..
It is also necessary to put in constantly a certain quantity of inert gas (N2 CO2 etc.) or combustible gas to guarantee an oxygen concentration of less than 6% inside the riser and so to prevent the production of potentially explosive mixtures.
The "purge" gas has to be put in the water seals. As "purge" gas it is not advisable to use steam or gas with high dew point, because it is necessary to take into account that the gas volume put in, could change considerably due to the gas cooling inside the system.

5.7 OPERATING PROCEDURES

5.7.1 INSTRUCTION FOR RECEIVING AND STORING OF THE MATERIALS :

The materials are supplied completed of the necessary packing to preserve the quality of the good.
Once received the unit, check the state of the packing and of the good supplied and store it in a covered area, even if there are not particular contra-indications for the storage of the good in an open area, considering to protect the flange faces.

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5.7.2 INSTRUCTION FOR INSTALLATION:

The liquid seal is normally supplied completely pre-assembled and ready to be installed after the fastening to the ground foundation through the proper screws.

The rising and the material handling has to be done only after having spotted and checked the raising and slinging points of the equipment.

The connection with the pipe is carried out as follows:

- Through flanged couplings
- Through direct welding over the reduction cone

Once placed, it is necessary to clean accurately the tank before the installation of all the foreseen accessories.

All the services to the water seal (gas entrance, level controls, etc.) have to be connected to the water seal through the proper flanged connections putting the proper gaskets and taking into account the special instructions for each single component.

5.7.3 INSPECTION AFTER INSTALLATION

At the end of the installation and before starting the system it will be necessary to do some checks as:

- Check that all the accessories are properly connected
- Check that all the bolted connections have been carried out correctly.
- Check the welding carried out in yard through non-destructive checks (Rx, Lpt, etc.)

5.7.4 UTILIZATION

START-UP PROCEDURES

- Clean accurately the tank and fill it up to the working level.
- Carry on a seal test of all connections and equipment connected to the liquid seal.

All the system of control, drainage and warming up of the liquid have to be tested in order to work in complete safety.

PROGRAMMED SHUT-DOWN PROCEDURES

During the planned stop has to be scheduled the carrying out of the following procedure:

- Emptying of the tank and accurate cleaning
- Interception of the gas entrance lines and services through blind plates

EMERGENCY SHUT-DOWN PROCEDURES

During the emergency stop it has to be carried out the same procedure as for the planned stop.

NORMAL OPERATION PROCEDURES

No procedure is necessary for the normal operation of the seal because the checks of levels and fluid temperature (if foreseen) have been automatically carried out. Periodically and according to the type of plant where the seal is installed, it has to be foreseen a cleaning of the liquid through the proper inside weir.

For this operation proceed as follows:

- Acting on the on-off and drainage valves restore the liquid inside the level indicator.
- Restore the original level.

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5.8 INSPECTION AND MAINTENANCE

To guarantee the correct functioning of the supplied equipment and to avoid permanent damages on them, it is necessary to plan periodical interventions of maintenance according to what is reported below. The good knowledge of those indications and the regular carrying out of the inspections and the maintenance activities allow to avoid operating mistakes and sudden stops of the equipment. It is advisable to read carefully this section and do not hesitate to contact our technical offices if the instructions are not clear or exhaustive enough. The inspection and maintenance schemes indicate the interval of intervention, which we recommend to follow. These indications are to be considered the minimal to do. Running the plant these schemes can be improved for what concerns the interval and also adding other check and maintenance activities.

Encore Thermoengineering is not responsible for possible damages to persons or things caused by the bad installation, incorrect use of the equipment or by the non-carrying out of the inspection and maintenance activity.

MAINTENANCE CALENDAR				
Intervention object	Intervention description	Reference document	Particular tools	Frequency (months)
Connections sealing	Check and grease the tie-rods and nuts of all connections Check and grease the foundation tie-rods. Check the connections of the services	1724000887-MAC-DD-00005	Various spanners Grease	12
Seal vessel	the liquid consumption is based on the assumption of the refilling of water and glycol every 6 months	1724000887-MAC-DS-00004	na	6

nVent

RAYCHEM

Self-regulating and power limiting heating cable systems

Installation and Maintenance Manual



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Register for your extended warranty on nVent.com/RAYCHEM.

ATEX/UKEX

	Certificate No	Code
BTV	SGS20ATEX0048X (BAS21UKEX0497X)	Ⓔx II 2 G Ex 60079-30-1 eb IIC T6 Gb Ⓔx II 2 D Ex 60079-30-1 tb IIIC T80°C Db or Ⓔx II 2 G Ex 60079-30-1 eb mb IIC T6 Gb Ⓔx II 2 D Ex 60079-30-1 mb tb IIIC T80°C Db Tmin –60°C
QTVR	SGS20ATEX0050X (BAS21UKEX0498X)	Ⓔx II 2 G Ex 60079-30-1 eb IIC T4 Gb Ⓔx II 2 D Ex 60079-30-1 tb IIIC T130°C Db or Ⓔx II 2 G Ex 60079-30-1 eb mb IIC T4 Gb Ⓔx II 2 D Ex 60079-30-1 mb tb IIIC T130°C Db Tmin –60°C
XTV(R)	SGS20ATEX0049X (BAS21UKEX0499X)	Ⓔx II 2 G Ex 60079-30-1 eb IIC T* Gb Ⓔx II 2 D Ex 60079-30-1 tb IIIC T**°C Db or Ⓔx II 2 G Ex 60079-30-1 eb mb IIC T* Gb Ⓔx II 2 D Ex 60079-30-1 mb tb IIIC T**°C Db Tmin –60°C (* ** see schedule)
KTV	SGS20ATEX0051X (BAS21UKEX0500X)	Ⓔx II 2 G Ex 60079-30-1 eb IIC T226°C(T2) Gb Ⓔx II 2 D Ex 60079-30-1 tb IIIC T226°C Db or Ⓔx II 2 G Ex 60079-30-1 eb mb IIC T226°C(T2) Gb Ⓔx II 2 D Ex 60079-30-1 mb tb IIIC T226°C Db Tmin –60°C (* ** see schedule)
HTV	PTB21ATEX1003X (BAS21UKEX0649X)	Ⓔx II 2 G Ex 60079-30-1 eb IIC T* Gb Ⓔx II 2 D Ex 60079-30-1 tb IIIC T**°C Db or Ⓔx II 2 G Ex 60079-30-1 eb mb IIC T* Gb Ⓔx II 2 D Ex 60079-30-1 mb tb IIIC T**°C Db Tmin –60°C (* ** see schedule)
VPL	SGS20ATEX0045X (BAS21UKEX0503X)	Ⓔx II 2 G Ex 60079-30-1 eb IIC T* Gb Ⓔx II 2 D Ex 60079-30-1 tb IIIC T**°C Db or Ⓔx II 2 G Ex 60079-30-1 eb mb IIC T* Gb Ⓔx II 2 D Ex 60079-30-1 mb tb IIIC T**°C Db Tmin –60°C (* ** see schedule)

IECEx

	Certificate No	Code
BTV	IECEx BAS 20.0011X	Ex 60079-30-1 eb IIC T6 Gb Ex 60079-30-1 tb IIIC T80°C Db or Ex 60079-30-1 eb mb IIC T6 Gb Ex 60079-30-1 mb tb IIIC T80°C Db Tmin –60°C
QTVR	IECEx BAS 20.0013X	Ex 60079-30-1 eb IIC T4 Gb Ex 60079-30-1 tb IIIC T130°C Db or Ex 60079-30-1 eb mb IIC T4 Gb Ex 60079-30-1 mb tb IIIC T130°C Db Tmin –60°C
XTV(R)	IECEx BAS 20.0012X	Ex 60079-30-1 eb IIC T* Gb Ex 60079-30-1 tb IIIC T**°C Db or Ex 60079-30-1 eb mb IIC T* Gb Ex 60079-30-1 mb tb IIIC T**°C Db Tmin –60°C (* ** see schedule)

	Certificate No	Code
KTV	IECEx BAS 20.0014X	Ex 60079-30-1 eb IIC T226°C(T2) Gb Ex 60079-30-1 tb IIIC T226°C Db or Ex 60079-30-1 eb mb IIC T226°C(T2) Gb Ex 60079-30-1 mb tb IIIC T226°C Db Tmin –60°C (* ** see schedule)
HTV	IECxPTB21.0007X	Ex 60079-30-1 eb IIC T* Gb Ex 60079-30-1 tb IIIC T**°C Db or Ex 60079-30-1 eb mb IIC T* Gb Ex 60079-30-1 mb tb IIIC T**°C Db Tmin -60°C (* ** see schedule)
VPL	IECEx BAS 20.0008X	"Ex 60079-30-1 eb IIC T* Gb Ex 60079-30-1 tb IIIC T**°C Db or Ex 60079-30-1 eb mb IIC T* Gb Ex 60079-30-1 mb tb IIIC T**°C Db Tmin –60°C (* ** see schedule)"

EAC Ex

Product name in SAP	Certificate No	Code
BTV CABLE	TC RU C-BE. МЮ62.B.00054/18	1Ex e IIC T6 Gb X 1Ex e mb II C T6 Gb X Ex tb IIIC T80°C Db X Ex tb mb IIIC T80°C Db X Ta –60°C…+56°C IP66
QTVR CABLE	TC RU C-BE. МЮ62.B.00054/18	1Ex e IIC T4 Gb X 1Ex e mb IIC T4 Gb X Ex tb IIIC T130°C Db X Ex tb mb IIIC T130°C Db X Ta –60°C…+56°C IP66
XTV CABLE	TC RU C-BE. МЮ62.B.00054/18	1Ex e IIC T* Gb X 1Ex e mb IIC T* Gb X Ex tb IIIC T* Db X Ex tb mb IIIC T* Db X Ta –60°C…+56°C IP66
KTV CABLE	TC RU C-BE. МЮ62.B.00054/18	1Ex e IIC 226°C (T2) Gb X 1Ex e mb IIC 226°C (T2) Gb X Ex tb IIIC T226°C Db X Ex tb mb IIIC T226°C Db X Ta –60°C…+56°C IP66
HTV CABLE	ЕАЭС RU C-BE. АЖ58.B.01728/21	1Ex e mb 60079-30-1 IIC 180°C (T3)…215°C (T2) Gb X Ex tb 60079-30-1 IIIC 180°C … 215°C Db X
VPL CABLE	TC RU C-BE. МЮ62.B.00054/18	1Ex e IIC T* Gb X 1Ex e mb IIC T* Gb X Ex tb IIIC T* Db X Ex tb mb IIIC T* Db X Ta –60°C…+56°C IP66

BSA cables are EAC certified to TR CU 004/2011

WARNING: As with any electrical equipment or wiring installation operating at line voltages, heating cable and component damage or incorrect installation that allows the penetration of moisture or contamination can lead to electrical tracking, arcing and potential fire hazard.

Do not connect heating cable conductors together or this will result in a short circuit.

Any unconnected heating cable end must be sealed with a nVent approved end seal.

To prevent fire or explosion in hazardous areas, verify that the maximum sheath temperature of the heating cable is below the auto-ignition temperature of the gases in the area. For further information, see design documentation.

The purchaser should make the manufacturer aware of any external effects to which the equipment may be subject.

Specific conditions of use

The following limiting temperatures for the end seals, splices and power connections shall not be exceeded:
+110°C for the S-20 and E-20
+260°C for the E-40 and S-40
+150°C for the C-150-E, S-150 and E-150
+151°C for the E-100, E-100-L and JBS-100
+155°C for the JBM-100 and T-100
+110°C for the C25-21 and C25-100
+180°C for the C25-100-METAL/C3/4-100-METAL

The E-100, E-100-L, JBM-100, JBM-100-L, JBS-100, JBS-100-L and T-100 have limiting temperatures based on an internal component in these accessories. When located on a pipe or other work piece surface, a maximum pipe temperature of 250°C will not cause the limiting temperatures of 151°C or 155°C to be exceeded

The end seals, splices and power connections have the following associated ambient temperatures:
–60°C to +56°C for the E-20 and S-20
–60°C to +56°C for the E-40 and S-40
–55°C to +56°C for the T-100, JBM-100, JBS-100, JBU-100 and E-100
–40°C to +56°C for the JBS-100-L, JBM-100-L, and JBU-100-L
–55°C to +55°C for the C-150-E, S-150 and E-150
–40°C to +40°C for the E-100-L
–55°C to +110°C for the C25-21 and C25-100
–60°C to +180°C for the C25-100-METAL / C3/4-100-METAL / C25-100-METAL-NP / C3/4-100-METAL-NP / C25-100-METAL-SS

- The assembly of glands, splices and end terminations shall be carried out in accordance with the manufacturing instructions.
- The heating element supply circuit must include an electrical protection device in conformity with Clause 4.4 of IEC 60079-30-1. For the JBM-100-L, JBU-100-L and JBS-100-L this shall be limited to 20 A maximum when used at ambient temperatures above 40°C.
- The minimum installation temperature of the heating cables is –60°C. The minimum bending radii at specific temperatures are shown on the next pages of this document.
- The supply to the heating unit must be terminated in a suitably certified terminal enclosure.
- At ambient temperatures above 40°C temperature resistant power cable suitable for temperatures above 90°C and metal glands must be used.
- The minimum installation temperature for E-20 and S-20 is –20°C.
- The installer is to carry out a dielectric strength test on Ex equipment in which the C25-21, C25-100 and C25-100-METAL / C3/4-100-METAL / C25-100-METAL-NP / C3/4-100-METAL-NP / C25-100-METAL-SS connection kit is fitted. No dielectric breakdown shall occur. (Alternatively, an insulation resistance test may be undertaken in accordance with IEC 60079-30-2)

Rated Voltage

BTV1, QTVR1, KTV1, XTV(R)1, HTV1, VPL1: 110 V, 120 V
BTV2, QTVR2, KTV2, XTV(R)2, HTV2, VPL2: 230 V, 277 V, VPL4: 400 V, 480 V

	BSA	BTV	QTVR	XTV	XTVR	KTV	HTV	VPL
Min. Bending Radius (mm)								
−60°C ≤ T < −20°C	35	35	35	51	51	26	25	19
−20°C ≤ T < −10°C	30	30	30	35	35	20	20	15
−10°C ≤ T < 0°C	25	25	25	25	25	15	15	15
0°C ≤ T < +10°C	20	20	20	20	20	15	15	15
T ≥ +10°C	10	12	12	12	12	12	13	12
Minimum Installation Temperature	−60°C	−60°C	−60°C	−60°C	−60°C	−60°C	−60°C	−60°C

	BSA	BTV	QTVR	XTV	XTVR	KTV	HTV	VPL
Max. continuous operating Temp °C (energized)	65	65	110	121	150	150	205	See table below
Max. intermittent exposure Temp °C (1000 h cumulative, energized/ de-energized)	85	85	110	250	***250	250	**260	–
Max. continuous exposure Temp °C (de-energized)	65	65	110	160	160	160	205	260
Self-limiting Temperature in accordance with IEC/EN 60079-30-1		T6	T4	T3 (T2: 20XTV2, 15/ 20XTV1)	T3 (T2: 20XTVR2, 15/ 20XTVR1)	T2	T3 (T2: 20HTV, 28HTV2)	T*
Power Limiting Temperature (*By design)	–	–	–	–	–	–	–	T*

** 2000 hours for HTV, for durations applicable to other exposure temperatures between 205°C and 260°C, contact nVent.
*** 2000 hours for XTVR

Maximum continuous operating temperature table (heating cable energized)

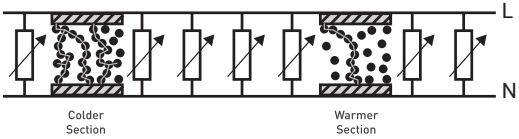
Cable	110 V	230 V	254 V	277 V	400 V	480 V
5VPL1-CT	235°C	–	–	–	–	–
10VPL1-CT	215°C	–	–	–	–	–
15VPL1-CT	190°C	–	–	–	–	–
20VPL1-CT	150°C	–	–	–	–	–
5VPL2-CT	–	230°C	225°C	225°C	–	–
10VPL2-CT	–	210°C	200°C	195°C	–	–
15VPL2-CT	–	180°C	145°C	105°C	–	–
20VPL2-CT	–	150°C	–	–	–	–
5VPL4-CT	–	–	–	–	230°C	230°C
10VPL4-CT	–	–	–	–	215°C	205°C
15VPL4-CT	–	–	–	–	195°C	160°C
20VPL4-CT	–	–	–	–	150°C	150°C

1. GENERAL INFORMATION

Use of the manual

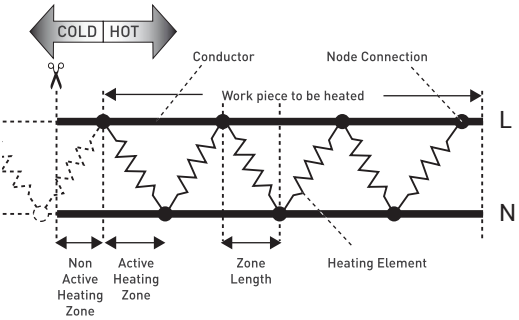
The Installation and Maintenance manual is for nVent RAYCHEM self-regulating and power limiting heating cable systems on thermally insulated pipes and vessels only.
For information regarding other applications contact your nVent representative.

BSA, BTV, QTVR, XTV(R), KTV, HTV self regulating heating cables



- Power output varies with temperature.
  As pipe temperature increases, power output decreases.
- At high temperatures, the polymer expands, reducing the number of the conductive paths, and thus reducing current flow.
- At low temperatures, there are many conductive paths, allowing current to flow between the conductors.

VPL power limiting heating cables



Important

For the nVent warranty to apply, the instructions that are included in this manual and product packages must be followed. The installation must be compatible with local requirements applicable to electric heat- tracing systems.

2. HEATING CABLE SELECTION

The design of electrical resistance heat tracing systems shall be overseen by persons knowledgeable of heat tracing following the design methodology for explosive atmospheres as specified by the manufacturer.

Check the design specification to make sure the proper heating cable is installed on each pipe or vessel. Refer to nVent product literature and the TraceCalc software to select the proper heating cable for each thermal, chemical, electrical and mechanical environment.

Heat tracing system design documentation

The heat tracing system documentation shall be retained for each heat tracing system and shall be available while the system is in use.

3. HEATING CABLE INSTALLATION

Persons involved in the installation and testing of electric heat tracing systems shall be suitably trained in all special techniques required. Installation shall be carried out under the supervision of a qualified person

De-energise all power circuits before installation or servicing

The insulation resistance of the heating cable shall be measured and recorded after installation and shall not be less than 100 Megaohms

3.1 Heating cable storage

- Keep ends of heating cable and kit components dry before and during installation
- Temperature range: –40°C to +60°C
- Protect the heating cable from mechanical damage

3.2 Pre-installation checks

Check materials received:

- Review the heating cable design and compare the list of materials to the catalogue numbers of heating cables and electrical components received to confirm that proper materials are on site. The heating cable type is printed on its outer jacket.
- Temperature exposure must not exceed that specified in nVent product literature. Exceeding these limits will impair product performance. Check that expected exposure is within these limits.
- Ensure that the heating cable voltage rating is suitable for the service voltage available.
- Do not energize cable when it is coiled or on the reel.
- Inspect heating cable and components for in-transit damage. An insulation resistance test (see section 8) on each reel is recommended.

Check piping to be traced:

- Ensure all pressure testing is complete and pipework has final paint coating.
- Walk the system and plan the routing of the heating cable on the pipe.
- Check pipework against specification drawing. If different consult design authority.
- Inspect piping for burrs, rough surfaces, sharp edges etc. which could damage the heating cable. Smooth off or cover with layers of glass cloth tape or aluminium foil.

3.3 Heating cable handling

Heating cable handling tips:

- Paint and pipe coatings must be dry to the touch before heating cable installation.
- When pulling the heating cable, avoid:
  - sharp edges
  - excessive pulling force
  - kinking and crushing
  - walking on it, or running over it with equipment

Heating cable pulling tips:

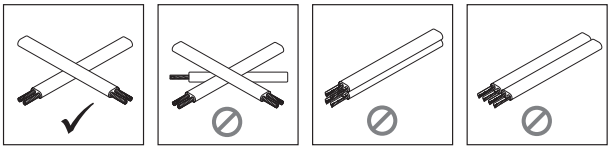
- Use a reel holder that pays out smoothly with little tension.
- Keep heating cable strung loosely but close to the pipe being traced to avoid interference with supports and equipment.
- Pay out designed length and mark (i.e. with fixing tape) on cable while still on reel.

- Leave the appropriate amount of heating cable at all power connection, splice, tee and end seal locations.
  (Refer to component installation instructions)
  - Add additional heating cable to trace the fittings and supports or for spiralling as required by the design specifications, or consult nVent product literature for design.
- Protect all heating cable ends from moisture, contamination and mechanical damage or other interference if left exposed before component installation.

3.4 Heating cable attachment recommendations

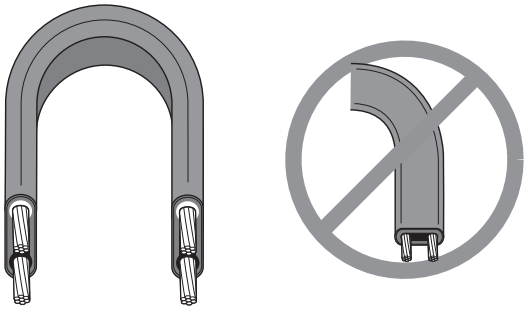
- The heating cable may be installed straight, spiralled or in multiple runs as required by the design specification, nVent product literature or TraceCalc software.
  - Do not use metal attachments, vinyl electrical tape or duct tape as heating cable damage may result.
  - Self-Regulating technology allows for the multiple overlapping of the heating cable on to itself.
- Power Limiting technology dictates that the heating cable can be overlapped only once on to itself. If VPL cables are installed parallel to each other, please allow for minimum 15 mm clearance.

For VPL heating cable only:



- Fix in place with a minimum of two wraps the appropriate self-adhesive glass cloth tape (see figure 1) or plastic cable ties at 300 mm intervals and additionally where necessary.
- Plastic cable ties must have a temperature rating that matches the system exposure temperature.
- The heating cable's minimum bend radius must not be exceeded (refer to p. 6)

Bend the cable only in upright position



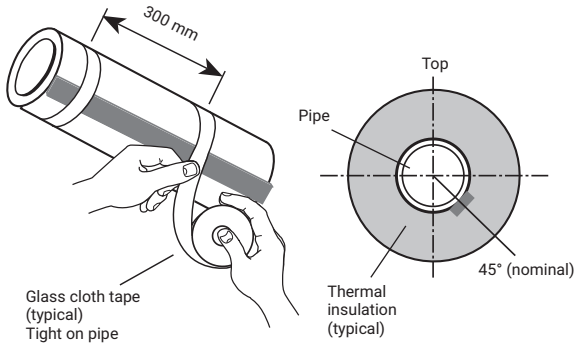
- The heating cable does not bend easily in the flat plane.
  Do not force such a bend, as the heating cable may be damaged.

3.4.1 Straight tracing

- Straight trace the pipe unless the design calls for spiralling (see 3.4.2).
- On horizontal pipes fix on lower quadrant as shown in Figure 1 and not on bottom of pipe.

- To prevent overheating, be sure the location of the power limiting heating cable is planned so that the active heating zone will not extend into the component. Read the kit installation instructions and plan the component location before permanently attaching the cable to the pipe. Ensure that the active heating zones are located where heat is required i.e. on the pipe.
- Thermally insulate and weatherproof to specification.

Figure 1

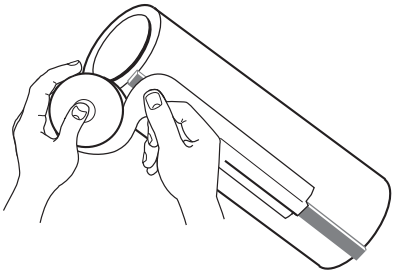


nVent attachment tapes:

GT66 Self-adhesive glass cloth tape
General purpose tape. Not for stainless-steel surfaces or for installation temperatures <4°C.

GS54 Self-adhesive glass cloth tape
Recommended for use on stainless-steel and cupro-nickel surfaces or for installation temperatures <4°C.

Figure 2



ATE-180 Aluminium tape

Use only if the design requires it.

ATE-180 improves the heat transfer and increases the power output of the heating cable.

Attach the heating cable to the pipe as shown in Figure 2.

3.4.2 Spiral tracing

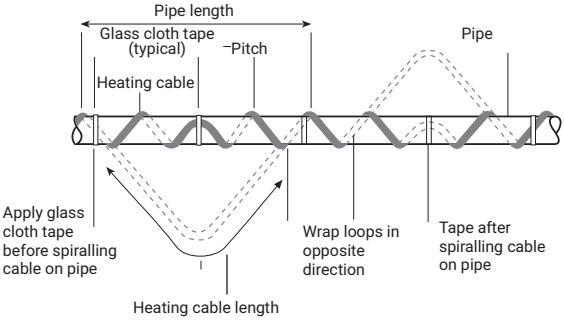
- Alternative spiralling methods are shown in Figures 2a and 2b.
- Only spiral heating cable on pipe when called for by design.
- To prevent overheating, be sure the location of the power limiting heating cable is planned so that the active heating zone will not extend into the component. Read the kit installation instructions and plan the component location before permanently attaching the cable to the pipe. Ensure that the active heating zones are located where

Spiral pitch table (mm).

NB	NPS	Spiral Ratio				
(mm)	(inches)	Metres of cable per metre of pipe				
		1.1	1.2	1.3	1.4	1.5
25	1	250	170	140	110	100
32	1¼	310	210	170	140	130
40	1½	350	240	190	160	140
50	2	430	300	240	200	180
65	2½	520	360	290	240	210
80	3	630	430	350	290	260
90	3½	720	490	390	330	290
100	4	800	560	440	370	330
125	5	990	680	550	460	400
150	6	1180	810	650	550	480
200	8	1520	1050	840	710	620

Example:
For pipe of 80 mm NB (3" NPS) requiring 1.3 metres of heating cable per metre of pipe, pitch is 350 mm.

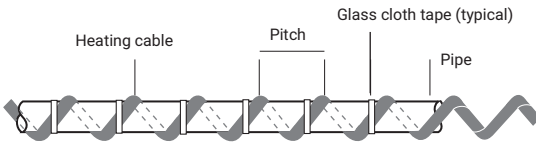
Figure 2a



Heating cable length = pipe length x spiral ratio
Refer to design specification for spiral ratio

Step 1 Make starting loop as shown
Step 2 Grasp loop and wind around pipe
Step 3 Space evenly and attach to pipe.
Thermally insulate and weatherproof to specification

Figure 2b



Refer to design specification for spiral pitch
Mark the pipe at the spiral pitch or use a simple length gauge
Fix the heating cable as installation progresses
Thermally insulate and weatherproof to specification

3.5 Cutting the heating cable

- Cut the heating cable to length after it is attached to the pipe. Before cutting it, confirm the tracing allowance as per Sections 3.3 and 3.6.
- nVent RAYCHEM heating cable can be cut to length without affecting the heat output per metre.

3.6 Typical installation details

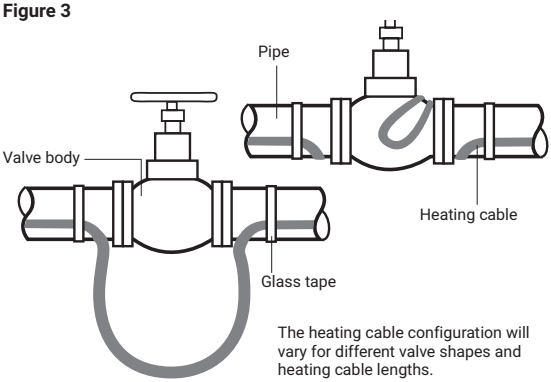
- Typical installation details for fixing heating cable to pipe fittings are shown hereafter.

General notes:

- Trace pipe fittings as shown to allow easy maintenance.
- Consult the design specification or nVent product literature or TraceCalc software for the tracing requirements for fittings and supports.
- Follow the recommendations for cutting and stripping heating cables; they are included in the component installation instructions.

3.6.1 Valve

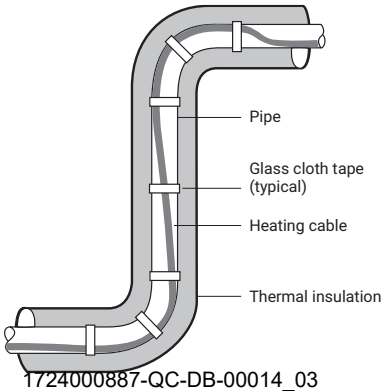
Figure 3



- Refer to design specification for additional heating cable length.
- Fix with self-adhesive glass cloth tape.
- Thermally insulate and weatherproof to specification (including valve stem).

3.6.2 Elbow

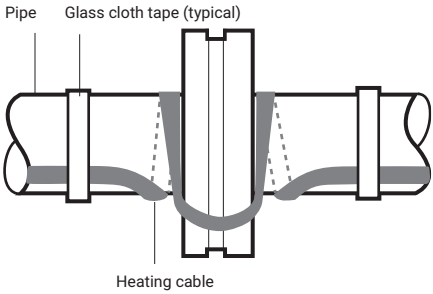
Figure 4



- Fix heating cable to outside (long) radius of elbow
- Fix with self-adhesive glass cloth tape
- Thermally insulate and weatherproof to specification

3.6.3 Flange

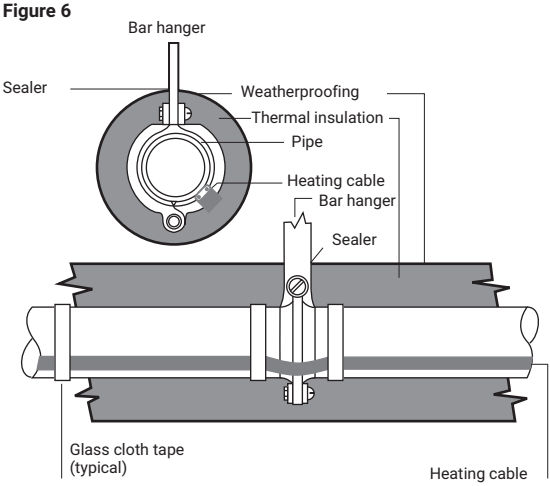
Figure 5



- Additional heating cable is 2-3 times diameter of pipe (typical)
- Fix with self-adhesive glass cloth pipe
- Thermally insulate and weatherproof to specification

3.6.4 Pipe bar hanger

Figure 6

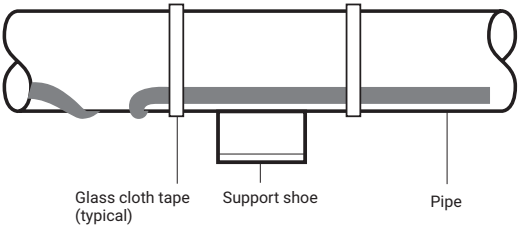


- Do not clamp heating cable with support. Heating cable must be over the support
- No additional heating cable is required for bar or rod pipe hangers unless called for in the design specification, then use loop length specified
- Fix with self-adhesive glass cloth tape
  Thermally insulate and weatherproof to specification

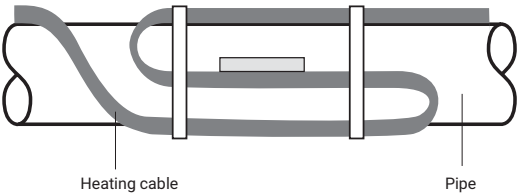
3.6.5 Pipe support shoe

Figure 7

Side view



Bottom view



- Refer to design specification for additional heating cable length
- Fix with self-adhesive glass cloth tape
- Thermally insulate and weatherproof to specification

4. COMPONENTS INSTALLATION

General notes:

Select the required components from nVent product literature or use the TraceCalc software.

nVent RAYCHEM component kits (including power connections, splices and end seals) must be used to satisfy Standards and Approval Body requirements.

Installation instructions included in the kit must be followed, including those for preparation of the heating cable conductors for connections. Before assembly, use the guide given in the instructions to ensure that the kit is correct for the heating cable and environment.

- nVent RAYCHEM self-regulating and power limiting heating cables are parallel circuit design. Do not twist the conductors together as this will result in a short circuit.

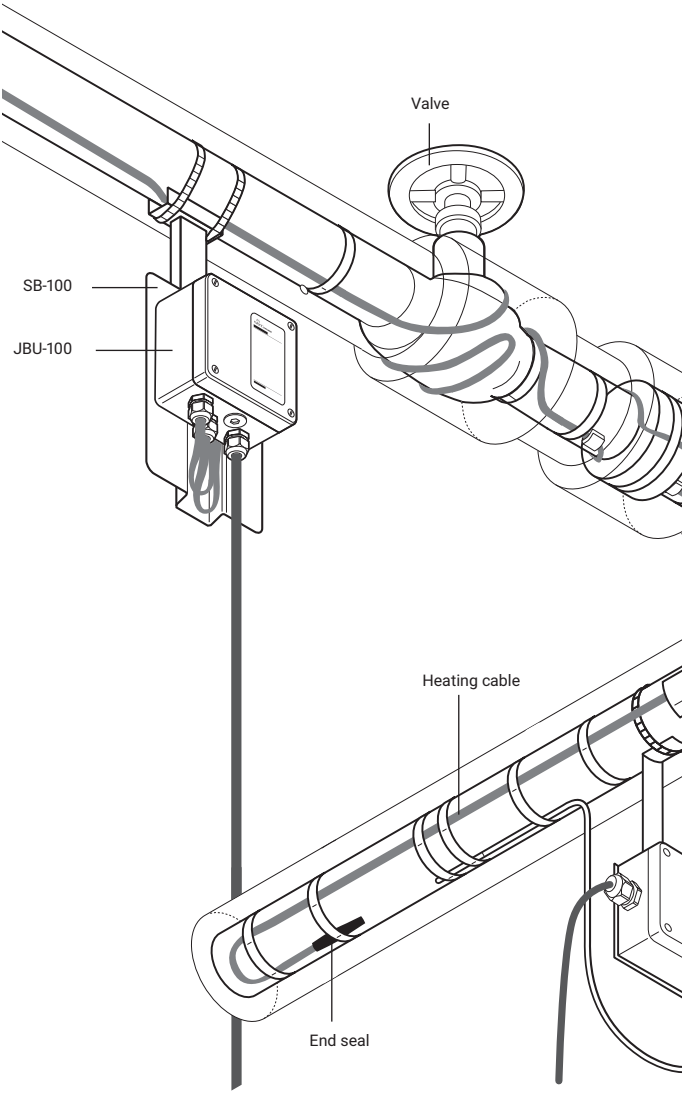
4.1 Components required

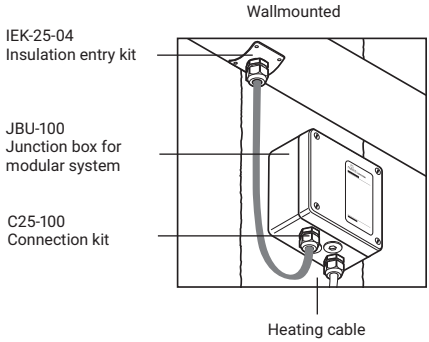
- For the installation of all components refer to the relevant component installation instructions.
- Required for each heating cable run:
  Power connection and insulation entry kit
  End seal.
- As required:
  Splice. Tee-splice. Junction box. Three connection kits and three insulation entry kits. Accessories (pipe straps, fixing tape, support brackets, labels, etc.).

4.2 Typical systems installation

Below components are not suitable for BSA. You can find the solutions for BSA in DOC2210 or contact your local nVent representative.

Figure 8a




Wallmounted
IEK-25-04
Insulation entry kit
JBU-100
Junction box for
modular system
C25-100
Connection kit
Heating cable

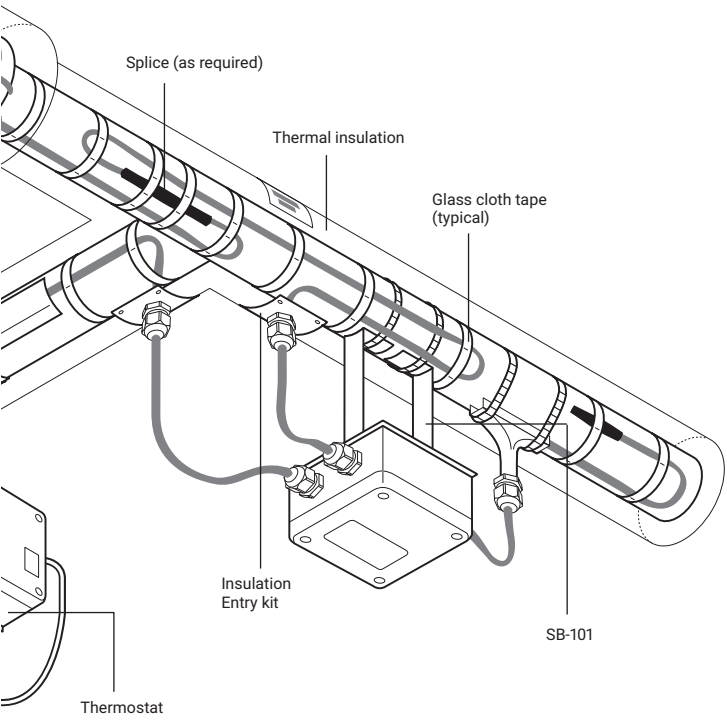
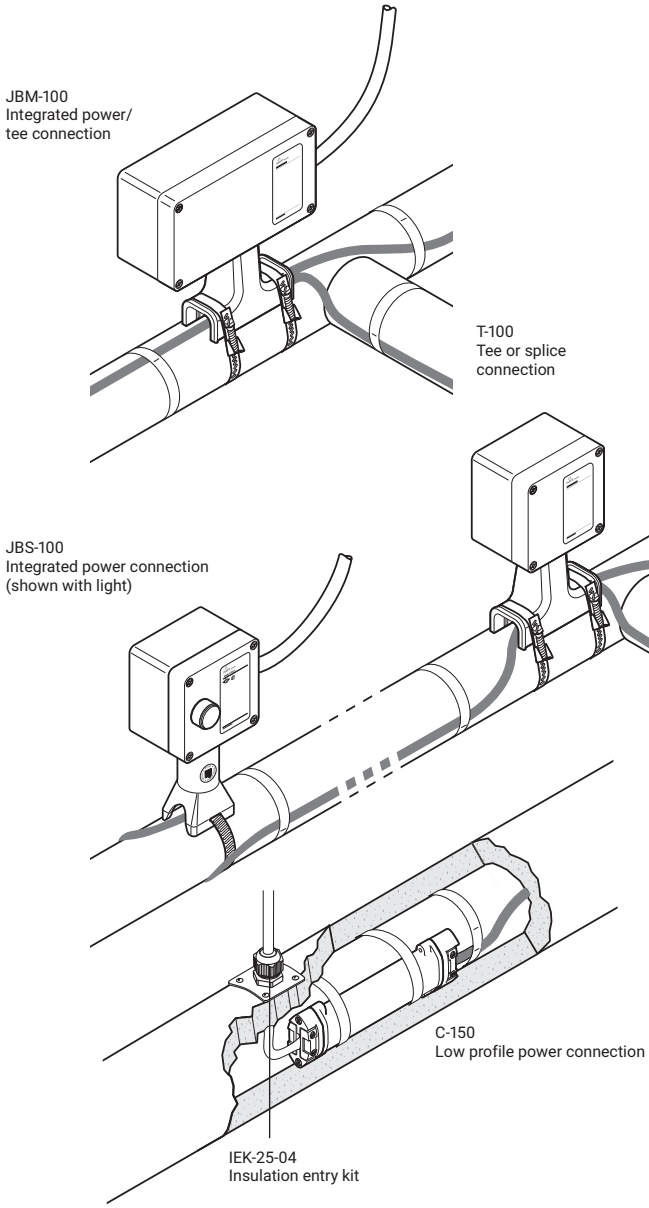
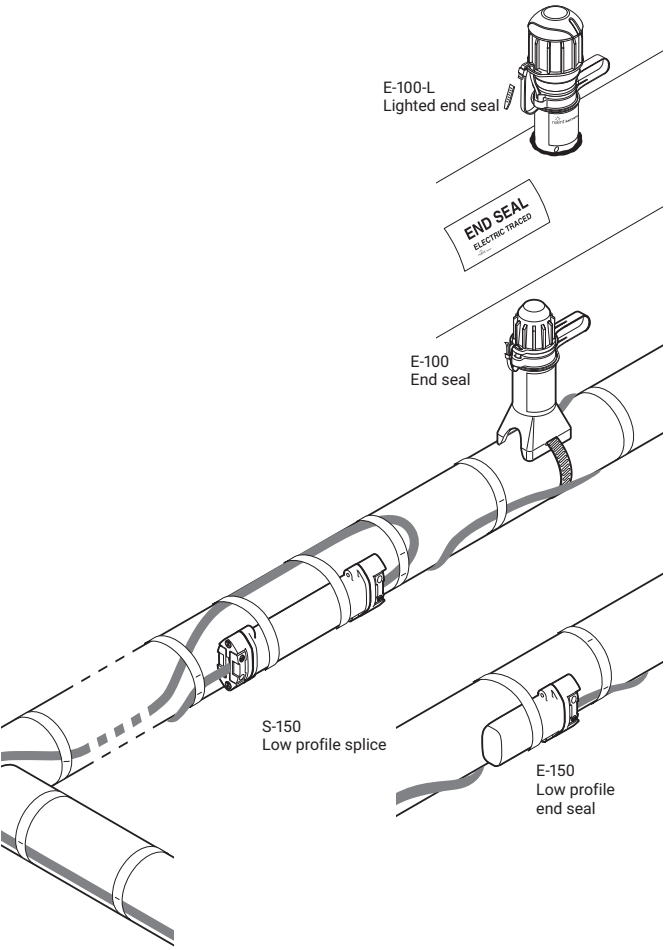

Splice (as required)
Thermal insulation
Glass cloth tape
(typical)
Insulation
Entry kit
SB-101
Thermostat

Figure 8b

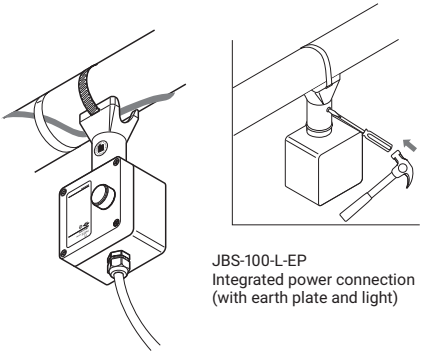

JBM-100
Integrated power/
tee connection
T-100
Tee or splice
connection
JBS-100
Integrated power connection
(shown with light)
C-150
Low profile power connection
IEK-25-04
Insulation entry kit


E-100-L
Lighted end seal
END SEAL
ELECTRIC TRACED
E-100
End seal
S-150
Low profile splice
E-150
Low profile
end seal

4.3 Component installation hints

- On horizontal pipes locate junction boxes below pipe wherever possible. Pinch out drainhole in the stand when installing upside down.
- Locate junction boxes for easy access but not exposed to mechanical abuse.
- Position junction boxes so that power cable and heating cable entries do not point upwards.

Figure 9a



JBS-100-L-EP
Integrated power connection
(with earth plate and light)

- Fix lids in place where access not required.
- Confirm junction box stopping plugs are correct for application and fixed firmly in place.
- Route heating cable from junction box to insulation entry so as to avoid possible mechanical damage.
  - Do not strain heating cable as it exits/enters junction boxes and insulation entries.
- Ensure heating cable is fixed above pipe straps such as used for junction box support brackets.
- Fix all low profile components (e.g. heatshrink end seals) in place with self-adhesive glass cloth tape.

5. THERMOSTATS

- In temperature-sensitive applications, thermostatic control may be necessary. If maximum temperature is a concern, consult your nVent representative for design assistance.
- nVent RAYCHEM control and monitoring products are designed for use with Self-Regulating and Power-Limiting heat-tracing systems. Thermostats, controllers and control and monitoring systems are available. Compare features of these products in the table below. For additional information on each product, refer to product datasheets or contact your nVent representative.
- Follow the installation instructions supplied with the thermostat. Use the proper wiring diagram for the heating cable layout and control method desired.

	Mechanical Thermostats	ETS-05	NGC-20	Elexant 40x0i	NGC-30	NGC-40
Control						
Ambient sensing	X	X	X	X	X	X
Line sensing	X	X	X	X	X	X
Pasc			X	X	X	X
Monitoring						
Ambient temperature		X	X	X	X	X
Pipe Temperature		X	X	X	X	X
Ground Fault			X	X	X	X
Current			X	X	X	X
Voltage			X	X	X	X
Location						
Pipe mount		X	X	X		
Field Mount		X	X	X	X	X
Substation				X	X	X

- Controllers shall meet the requirements from clause 4.5.3 in IEC/IEEE 60079-30-1.

6. THERMAL INSULATION AND MARKING

6.1 Pre-insulation checks

- Visually inspect the heating cable and components for correct installation and damage. (See Section 10 if damaged.)
- Insulation resistance (Megger) testing (as per Section 8) is recommended prior to covering the pipe with thermal insulation.

6.2 Insulation installation hints

- Correct temperature maintenance requires properly installed and dry thermal insulation.
- Thermally insulate and weatherproof to design specification.
- Check insulation type and thickness against the design specification.
- To minimize potential heating cable damage, insulate as soon as possible after tracing.
- Check that all pipework, including fittings, wall penetrations and other areas, have been completely insulated.
- Ensure that heating cable is not damaged during installation of cladding for example by drills, self tapping screws and sharp edges of cladding.
- Check that all insulation entry kits are fitted correctly and sealed.
- Ensure that all places where valve stems, support brackets, thermostat capillaries, etc exit the cladding are sealed.

6.3 Marking

- For power limiting heating cable install label: LAB-I-35 as shown (typical) in figures 10a & 10b

Figure 10a

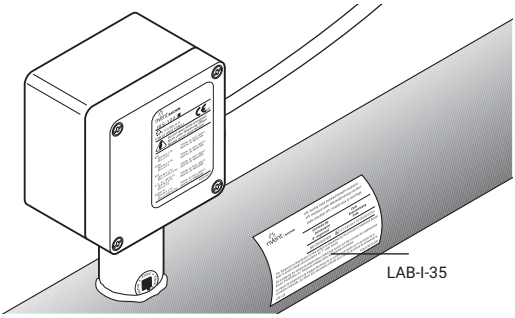
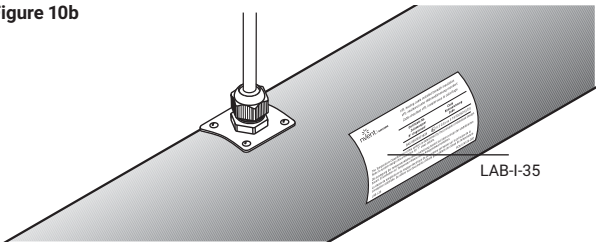
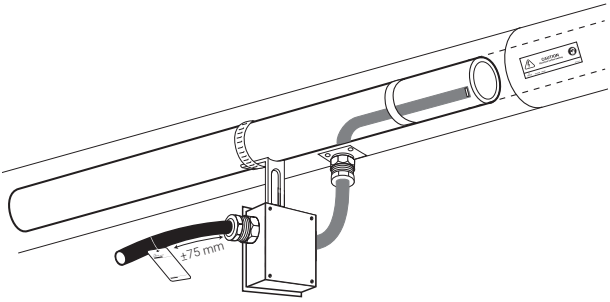


Figure 10b



- The presence of the heating cables shall be made evident by the posting of warning labels or caution labels (“Electric Traced”) on the cladding. Labels are to be applied at maximum 3 meter intervals and on alternate locations along the circuit.
- Install “Electric Traced” signs along piping at suitable intervals (3 m intervals recommended) on alternate sides as a warning.
- Mark on outside of insulation the location of heating cable components.

Figure 10c



7. POWER SUPPLY AND ELECTRICAL PROTECTION

In the event of an earth fault or over current interruption, the device shall not be reset until the cause of the trip has been investigated by qualified personnel

7.1 Electrical loading

Size overcurrent protective devices according to the design specification or applicable nVent product literature. If devices other than those specifically identified are used, consult the nVent representative for the appropriate sizing information.

7.2 Ground fault equipment protection is required for each circuit

The metal sheath/braid of the heating cable must be connected to a suitable earthing terminal

7.3 Residual current (earth fault) protection

nVent insists on the use of a 30 mA residual current device to provide maximum safety and protection. However, where there is a marked increase in nuisance tripping, a maximum 300 mA residual current device may be used.

For heating cables installed in a hazardous area, the use of residual current devices is normally a condition of their approval.

8. HEATING CABLE TESTING

8.1 Recommendations

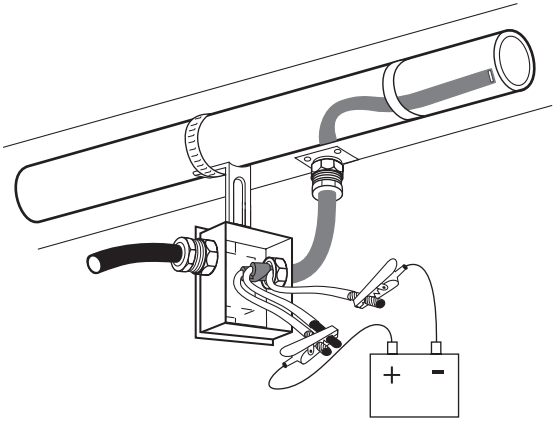
nVent recommends insulation resistance test before installing heating cable; before installing thermal insulation; prior to initial start-up; and as part of the periodic maintenance.
(see Section 9.2).

8.2 Test method

After completing heating cable installation, the insulation resistance between the conductors and the braid should be checked (see Figure 11) using a 2500 VDC megger. Minimum readings should be 100 MegaOhms regardless of the heating cable length. The installer should record the original values for each circuit on the installation record sheet
(see page 33). If a thermostat is installed, it should be bypassed.

Figure 11

Test between heating cable and braid



Capacitance test method

This method uses capacitance measurement (nF) to approximate the location of a fault where the heating cable has been severed. It also gives an estimate of total heating cable length in a non-severed circuit. This reading must be taken at the power connection and will only work when the heating cable has passed IR testing. This information is used to calculate the heating cable output per linear metre or to determine if the maximum length has been exceeded.

Record the capacitance reading from one end of the heating cable. The capacitance reading should be measured between both bus wires twisted together (positive lead) and the braid (negative lead).

Multiply the measured capacitance with the heating cable's capacitance factor as listed in the following table.

Example:

20HTV2-CT

Recorded capacitance = 16.9 nF

Capacitance factor = 2.96 m/nF
Fault location = 16.9 nF x 2.96 m/nF
= 50 m from reading location

As an alternative, capacitance values from both the front and back end can be used. The ratio of one capacitance value taken from one end (A) divided by the sum of both A and B (A + B) and then multiplied by 100 yields the distance from the first end, expressed as a percentage of the heating circuit length.

Heating cable capacitance factors (m/nF)

Cable catalog number	Capacitance factor	Cable catalog number	Capacitance factor
3BTV1-CR	2.29	20XTVR2-CT	2.71
3BTV2-CT	2.29	5XTVR1-CT	3.08
5BTV1-CR	2.29	10XTVR1-CT	2.68
5BTV2-CT	2.29	15XTVR1-CT	2.68
8BTV1-CR	1.68	20XTVR1-CT	2.77
8BTV2-CT	1.68	5KTV1-CT	3.29
10BTV1-CR	1.68	5KTV2-CT	3.38
10BTV2-CT	1.68	8KTV1-CT	3.14
10QTVR1-CT	1.43	8KTV2-CT	3.2
10QTVR2-CT	1.43	15KTV1-CT	2.96
15QTVR2-CT	1.01	15KTV2-CT	3.02
15QTVR1-CT	1.01	20KTV1-CT	2.83
20QTVR1-CT	1.01	20KTV2-CT	3.08
20QTVR2-CT	1.01	3HTV1-CT	3.2
4XTV2-CT-T3	3.29	3HTV2-CT	3.51
5XTV1-CT-T3	3.29	5HTV1-CT	3.2
5XTV2-CT-T3	3.38	5HTV2-CT	3.38
8XTV2-CT-T3	3.38	8HTV1-CT	2.80
10XTV1-CT-T3	3.14	8HTV2-CT	3.38
10XTV2-CT-T3	3.26	10HTV1-CT	2.8
12XTV2-CT-T3	3.26	10HTV2-CT	3.2
15XTV1-CT-T3	2.96	12HTV1-CT	2.93
15XTV2-CT-T3	3.02	12HTV2-CT	3.14
20XTV1-CT-T2	2.83	15HTV1-CT	2.83
20XTV2-CT-T2	3.08	15HTV2-CT	2.99
3XTVR2-CT	3.57	20HTV1-CT	2.65
5XTVR2-CT	3.51	20HTV2-CT	2.96
8XTVR2-CT	3.11	28HTV2-CT	2.56
10XTVR2-CT	3.20	All VPL-CT	2.86
12XTVR2-CT	2.99		
15XTVR2-CT	2.87		

9. OPERATION, MAINTENANCE AND PIPE REPAIRS

Caution: Consult the heat tracing system documentation prior to maintenance/repair/modification.

9.1 Heating cable operation

- Temperature exposure must not exceed that specified in nVent product literature. Exceeding those limitations will shorten the service life and may permanently damage the heating cable.
- Pipe insulation must be complete and dry to maintain the correct temperature.

9.2 Inspection and maintenance

- Visual inspection: Exposed heating cable and pipe insulation should be checked periodically to make sure that no physical damage has occurred.
- Upon completion of maintenance/repair/modification, the insulation resistance of the heating cable shall be measured and recorded and shall not be less than 100 Megaohms
- Meggering: The system should be meggered regularly. When meggering the insulation resistance from the main supply panel, it is recommended that the test is performed between L/N (together) and PE. Freeze protection systems should be meggered before the winter months each year (see section 8). Temperature maintenance systems should be tested at least twice a year. Function testing of electrical protection and temperature control systems should be carried out at regular intervals.
- The Periodic Inspection Record on the following pages should be filled out during maintenance of each circuit in your system.

9.3 Piping systems repair and maintenance

- After maintenance/repair/modification, test the operation of the earth-fault device of each affected circuit or equivalent.
- Isolate heating cable circuit.
- Protect the heating cable from mechanical or thermal damage during pipe repair work.
- Check heating cable installation after pipe repairs and restore thermal insulation following the recommendations in Section 6. Check correct functioning of electrical protection systems.

10. HEATING CABLE DAMAGE

- Do not repair damaged heating cable.
  Remove entire damaged section and splice in a new length using the appropriate nVent RAYCHEM splice kits.
- Replace damaged heating cable at once.
  Damage allowing moisture and contamination to enter the heating cable may result in arcing earth faults and potential fire hazards.
- Heating cable exposed to fire or flame may cause further fire damage if powered.
  Remove from service at once and replace before re-use.

11. TROUBLESHOOTING GUIDE

- Refer to the Troubleshooting guide on pages 34-37.
  If the problem persists after following the guide procedures, contact your nVent representative immediately.

INSTALLATION RECORD SHEET

INSTALLATION RECORDS FOR:		CIRCUIT NO.							
Circuit breaker number									
Drawing reference number									
Megger test on pipe before insulating (bypass thermostat if applicable)	Reading								
	Initial								
	Date								
Megger test after insulating (bypass thermostat if applicable)	Reading								
	Initial								
	Date								
Circuit voltage	Panel								
	Connection terminals								
Insulation complete and sealed	Initial								
	Date								
Locations of low profile components are marked on the cladding	Initial								
	Date								

REMARKS & COMMENTS:

INSPECTION AND MAINTENANCE RECORD SHEET

MAINTENANCE CHECKS FOR:		CIRCUIT NO.					MONTH:		YR.:
No signs of overheating, moisture, or corrosion, etc.	Initial								
	Date								
In connection systems Heating cable and cable glands tight Connection terminals tight Earth connection tight Insulation in good condition	Initial								
	Date								
Thermostats set properly and capillaries are protected	Initial								
	Date								

Megger test (bypass thermostat if applicable)	Reading									
	Initial									
	Date									
Circuit voltage	Panel									
	Connection terminals									
All boxes and thermostats have been firmly closed	Initial									
	Date									
Locations of low profile components are marked on the cladding	Initial									
	Date									

REMARKS & COMMENTS:

Troubleshooting guide

A Symptom: Overcurrent protection trips or blows
Probable Causes:

1 Electrical fault at
- a damaged heating cable
- b faulty splices or tees
- c end seal
- d connection

2 Circuit oversized

3 Start-up below design temperature

4 Defective electrical protection

B Symptom: RCD trips
Probable Causes:

1 Earth fault at:
- a damaged heating cable
- b faulty splices or tees
- c end seal
- d connection

2 Excessive moisture in:
- a junction boxes
- b splices and tees
- c end seals

3 High leakage currents due to a combination of excessive lengths of power cable and heating cable.

4 Mains borne disturbances

5 Defective RCD

Corrective Actions

1 Investigate and remedy (see note 1):

2 Resize or redesign within Technical Databook Guidelines. (If larger protection is required, ensure supply cables are compatible).

3 a redesign for lower start-up temperatures
b preheat pipe from alternative heat source to within exposure temperatures given in Product Data Sheets
c Energize part of circuit followed by remainder (e.g. in sequence

4 Replace

Corrective Actions

1 Investigate and remedy (see note 1):

2 Dry out and reseal or remake immediately. Perform insulation resistance test. (10 MΩ minimum)

3 Redesign

4 Redesign distribution, guidance is available from nVent

5 Replace

C Symptom: No power output.
Probable Causes

1 Loss of supply voltage due to:
- a overcurrent or residual current protection operating
- b loose terminals in junction box
- c loss of supply cable continuity (e.g., open circuited from damage)

2 Control thermostat is connected in the normally open position

3 High resistance connection at:
- a junction box terminals
- b splices and tees

D Symptom: Low pipe temperature.
Probable Causes:

1 Wet thermal insulation

2 Design error

3 Incorrect setting or operation of controls e.g., thermostats.

4 Heating cable has been exposed to excessive temperature beyond rating.

Note:
Locate faults by the following steps:

1. Visually inspect the power connections, splices and end seals for correct installation.
2. Look for signs of damage at:
   a) Valves, pumps, flanges and supports.
   b) Areas where repairs or maintenance work has been carried out.
3. Look for crushed or damaged insulation and cladding along the pipe.

Corrective Actions

1 Restore supply voltage
   a following A and B (page 29)
   b re-tighten terminals
      NB: If excessive heating has occurred due to high resistance, replace terminals or crimps
   c locate damage and repair

2 Reconnect to normally closed position

3 Locate and remedy by:
   a re-tighten
   b repair
      NB: If excessive heating has occurred due to high resistance, replace terminals or crimps

Corrective Actions

1 Remove and replace with dry insulation of correct specification and ensure complete weatherproofing

2 a check with competent authority for design conditions
   b modify to meet nVent recommendations

3 Repair or reset to correct level of operation

4 Replace

4. If after 1, 2 and 3 above the fault has not been located, then either:
   a) Consult nVent for further assistance.
   b) Where local practices and conditions allow (e.g., non hazardous areas) isolate one section of heating cable from another by cutting in half and testing (e.g., Insulation Resistance) both halves until general area of damage is found. Remove insulation and expose fault.

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2.2.3 Material test certificates

SEE ATTACHED NEXT PAGE

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CERTIFICATI MATERIALI
Material Certificates

DOC. NR. 23 – 0193 - HYDROGEN VENT

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NR. ORDINE CLIENTE *Client PO No.*	23 – 0193-OA24-00100 REV. 0
DATA ORDINE *P.O. Date*	25.07.2024
DENOMINAZIONE IMPIANTO *Plant Description*	23 – 0193 HYDROGEN VENT
DESTINAZIONE IMPIANTO *Plant Destination*	HOLLAND
NR. DI PAGINE DEL DOCUMENTO *Total document pages*	2

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 31/10/2024

CROSSWIND
31/10/24

REV *Rev.*	DATA *Date*	DESCRIZIONE *Description*	COMP. *Prepared*	CONTR. *Checked*	APPROV. *Approved*
0	31.10.2024	PRIMA EMESSIONE / First emission	M.D.	M.D.	G.D.

CERTIFICATI MATERIALI
Material Certificates

DOC. NR. 23 – 0193 - HYDROGEN VENT

DISEGNO DI RIFERIMENTO : **1724000887-MAC-DA-00003_03 "HYDROGEN VENT"_Vent Tip**

Reference drawing

*I certificati sotto riportati ed allegati si riferiscono ai soli componenti principali dell'item, di fornitura T.i.c.i. srl e coprono l'intero scopo di fornitura.

**Certificates below listed and attached only refer to the main components of the item, supplied by T.i.c.i. srl and they are valid for the entire scope of supply.*

DWG *Item*	DESCRIZIONE *Description*	MATERIALE *Material*	ALLEGATO *Attachment*	MILL CERTIF. No. *Mill Certificate No.*	No. COLATA *Heat No.*	FORNITORE *Manufacturer*	COD. INTERNO *Internal code n°*
1	VENT TIP SHELL – 12" 6THK	AISI316	A	630768-EN	821154	AVESTA POLARIT STAINLESS	T24/126
2	VENT TIP FLANGE – 12" #150 WNRF ASME B16.5	AISI316L	B	7097/24	72542	FAD FLANGE	R24/492(A)

xCROSS KIND 31/10/24

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 31/10/2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

A

AvestaPolarit STAINLESS

Avesta

QCM. Hans Pernäng

CERTIFICATE - ZEUGNIS - CERTIFICAT

1/1

EN 10204-3.1.B

Date - Datum	Load - Ladung - Chargem No	Cert.No - Zeugnis No
2002-04-03	IT2A-0326	630768-EN

Your order - Ihre Bestellung - Votre commande: 501782

Avesta order - Auftrag - Ordre: 200602

Invoice - Rechnung - Facture: 246105

Purchaser - Besteller - Acheteur:
AVESTAPOLARIT S.P.A.
VIA ROSSINI, 5

IT-21058 SOLBIATE-OLONA
ITALY

Dest.
AVESTAPOLARIT S.P.A.

Requirements - Anforderungen - Exigences:
ASTM A 240-01
ASME SA-240 2001
NF A 36-209 (05.90)
UNI 7500 (DEC 1975)
TRB 100, AD 2000 W2, W10 & DIN 17441 (02.97)

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 31/10/24

Product - Erzeugnisform - Produit:
Cold Rolled Stainless, Coil
finish 2B, cut edge

Grade - Werkstoff - Nuance:
Avesta 17-11-2L
TYPE 316/TYPE 316L/Z3 CND 17-11-02/X2 CRNIMO 1712/1.4404

Brand mark / Herstellerzeichen / Signe du producteur	Inspectors stamp / Abname - Stempel / Estamp de l'expert	Melting process / Erschmelzungsart / Procédé de fusion
AvestaPolarit	AJA A	E + AOD

Extent of delivery - Lieferumfang - Etendue de livre

Item Pos Poste	Pcs Anzahl Nombre	kg	Dimensions - Abmessungen - Dimensions mm	Heat No Schmelze Nr Coulée No	Lot No Los Nr Lot Nr
5	1	9050	6.00 2000 ØEST. 273 ØEST. 323	821154	002

Chemical composition - Chemische Zusammensetzung - Composition chimique

	C	Si	Mn	P	S	Cr	Ni	Mo	Nb	Cu	Co	N	B
Heat	.019	.55	1.12	.026	.001	17.51	11.17	2.05	.006	.31	.17	.046	.0009

Test results - Prüfergebnisse - Résultats d'essais (1N/mm 2= 1 MPa) F = Front -- Anfang - Début B = Back - Ende - Fin T = Transverse - Quer - Travers

	Test Ref Probe Ref Eprouv Ref	Temp °C	Rp 0.2 N/mm²	Rp 1.0 N/mm²	R_m N/mm²	A5 %	2" %	HB HB
Min		+20	255	285	550	45	40	
Max					640			217
	F T	+20	282	313	594	58	58	150
	B T		274	309	583	58	58	147

Mechanical properties conform to the limits in DIN 17441 (07.85)
Corrosion acc. ASTM A 262-E, EN ISO 3651-2A: Satisfactory
Heat treatment: Material temperature 1100 cel / Quenched
Steel grade verification (spectroscopic): OK
Insp. and gauge measurement: Satisfactory
Approved acc. AD 2000 Merkblatt W0 & W0/TRD 100 by TÜV Nord e.V. with renounce of countersignment

AvestaPolarit STAINLESS
CERTIFICATO CONFORME ALL'ORIGINALE

×CROSSWIND 31/10/24 R

COPIA CONFORME ALL'ORIGINALE
F.lli PINATO & C. sas

AvestaPolarit AB (Publ)
Avesta
S-774 80 AVESTA
SWEDEN
Regoffice: Stockholm Sweden
Telephone : (0)226 814 18
Telefax : (0)226 813 16
Telex no : 7030 AVESTA S
Reg no : 556001-8748
V.A.T no : SE556001874801

This material is found to comply with order requirements

Authorized Inspector

ISO9002 Registration FM 20032

ISO 14001

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITÀ

B

FAD FLANGE ACCIAIO & DERIVATI s.p.a.

SEDE LEGALE: VIA BONESCHI 1 - 20040 CAMBIAGO (MI) ITALIA
TEL. +39 02 959420 FAX: +39 02 95942323 INTERNET: www.fadflange.it - E-MAIL: info@fadflange.it
CAPITALE SOCIALE / SHARE EQUITY € 3.000.000,00 REG.IMP. MONZA BRIANZA /C.F. 03840080158
PARTITA IVA / V.A.T. NO. IT 00763360968 - REA MI/875057 - N.MECCANOGRAFICO MI 100012

CERTIFICATO PROVE MATERIALI N.7097/24

1- 1

Test certificate - Certificat d'epreuves - Werksabnahmezeugnis
EN 10204 / 3.1

CLIENTE / Customer - Client - Kunde:
F.I.R.A.S. DI CROCE SRL
VIA GALVANI, 24/26
20019 SETTIMO MILANESE MI ITALIA

DATA / Date - Date - Datum: 10/09/2024
COMMESSA / Mill order / Conf. de commande / Kontr: 2415568
ORDINE / Order / Commande / Auftrag: 24/GR/2231/4693
D.D.T. / Delivery note / Bulletin de livraison / Lieferschein: 7.097

CODICE Line code / Code / Kode	COLATA Heat / Coulée / Schmelze	CERTIFICATO ORIGINE Certificate of origin / Certificat d'usine / Werkszeugnis	NORMA / MAT. / DESCRIZIONE Standard / Material / Description / Norme / Matériél / Description / Standard / Werkstoff / Gegenstand	POS.ORD. Item order / Pos. de comm / Auftragsline	QUANTITA Quantity / Quantité / Stückzahl
	72542	ASO	F.FLG.ASME B16.5 A/SA182F316L WN 150 12" S.20 RF	1	1

ANALISI CHIMICA / Chemical analysis / Analyse chemique / Chemische zusammensetzung

C %	Mn %	P %	S %	Si %	Cr %	Ni %	Mo %	Ti %	Cu %	Nb %	N %	V %	Al %	Sn %	CE %	5
0,019	1,820	0,031	0,001	0,470	16,610	10,180	2,140	0,004	0,400	0,067	0,069	0,066	0,000	0,008	0,000	

B %	Ca %	H2 %	O2 %	W %	Sb %	As %	Fe %	Co %	PRE %	%	%	%
0,004	0,001	0,000	0,000	0,059	0,002	0,005	0,000	0,121	0,0000			

CARATTERISTICHE MECCANICHE / Mechanical test / Epreuves mecaniques / Mechanische eigenschaften

MPA Tensile strenght / Rupture / Zugfestigkeit	MPA Yield point / Limite elastique / Streckgrenze	4D % Elongation / Allongement / Dehnung	Reduction of area / Striction % / Einschnürung	HB Hardness / Dureté / Harte		Impact test / Resilience / Kerbschlagzähigkeit			(1)	(2)	(3)	4
510,0	257,0	52,0	62,0	165	165	10/10 KV -50°C	168	171 170 J	B	D	X	X

P = 1

CODICE Line code / Code / Kode	COLATA Heat / Coulée / Schmelze	CERTIFICATO ORIGINE Certificate of origin / Certificat d'usine / Werkszeugnis	NORMA / MAT. / DESCRIZIONE Standard / Material / Description / Norme / Matériél / Description / Standard / Werkstoff / Gegenstand	POS.ORD. Item order / Pos. de comm / Auftragsline	QUANTITA Quantity / Quantité / Stückzahl
	567388	CLARRA	F.FLG.ASME B16.5 A/SA182F304L WN 300 2" S.STD RF	2	3

ANALISI CHIMICA / Chemical analysis / Analyse chemique / Chemische zusammensetzung

C %	Mn %	P %	S %	Si %	Cr %	Ni %	Mo %	Ti %	Cu %	Nb %	N %	V %	Al %	Sn %	CE %	5
0,017	1,490	0,039	0,026	0,440	18,190	8,040	0,000	0,000	0,000	0,000	0,087	0,000	0,000	0,000	0,000	

B %	Ca %	H2 %	O2 %	W %	Sb %	As %	Fe %	Co %	PRE %	%	%
0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,150	0,0000		

CARATTERISTICHE MECCANICHE / Mechanical test / Epreuves mecaniques / Mechanische eigenschaften

MPA Tensile strenght / Rupture / Zugfestigkeit	MPA Yield point / Limite elastique / Streckgrenze	4D % Elongation / Allongement / Dehnung	Reduction of area / Striction % / Einschnürung	HB Hardness / Dureté / Harte		Impact test / Resilience / Kerbschlagzähigkeit			(1)	(2)	(3)	4
608,0	319,0	62,0	70,0	163	163	10/10 KV -50°C	173	165 172 J	B	D	X	X

P = 2

NACE MR 0103 ED16

Material manufactured in accordance with PED 2014/68/UE PAR.4.3 under quality assurance system ISO 9001 cert. 206967 issued by Bureau Veritas

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
Review Witness
Date: 31/10/24

CROSSWIND
31/10/24 R

1 PRODUZIONE ACCIAIO / Steel production / Production acier / Staal produktion: A - COLATO E ELABORATO AL FORNO ELETTRICO / Steel made by electric furnace / Produit au four électrique / Ausgangsstahl im elektrischen.

2 TRATT. TERMICO / Heat treatment / Traitement thermique / Wärmebehandlung: A - NORMALIZZATO / Normalized / Normalisé / Normalgeglüht.

4 K - CONTROLLO VISIVO E DIMENSIONALE SODDISFACENTE / Satisfactory visual and dimensional check / Inspection et contrôle dimensionnel satisfaisant / Abschließende und maßkontrolle bestanden.

- I VALORI DELLE ANALISI CHIMICHE SONO RIPRESI DAL CERTIFICATO DI FONDERIA / Chemical analysis values are taken from mill certificate / Les valeurs de l'analyse chimique sont pris du certificat de coulée / Die werte der analysen sin vom original werkszeugnis entnommen.

RESP. CONTROLLO CERTIFICATI / Issued by / Cert. contrôle / Zeugnisausstellung: T.I.C.I. S.R.L. Via dell'Artigianato, 5 26010 MONTODINE (CR) P.I. 00962080190 - TEL. 0373-242255 DENTI MARTA RESP. QUALITÀ

ENTE UFFICIALE DI COLLAUDO / Inspection authority / Service inspection officiel / Abnahme verein

CAPO COLLAUDO / Chief Inspector / Chef de la réception / Chef der abnahmeabteilung

F.I.R.A.S. di CROCE s.r.l.

COPIA CONFORME ALL'ORIGINALE

CERTIFICATI MATERIALI
Material Certificates

DOC. NR. 23 – 0193 - HYDROGEN VENT

CLIENTE *Client*	ENCORE THERMOENGINEERING s.r.l.
NR. ORDINE CLIENTE *Client PO No.*	23 – 0193-OA24-00100 REV. 0
DATA ORDINE *P.O. Date*	25.07.2024
DENOMINAZIONE IMPIANTO *Plant Description*	23 – 0193 HYDROGEN VENT
DESTINAZIONE IMPIANTO *Plant Destination*	HOLLAND
NR. DI PAGINE DEL DOCUMENTO *Total document pages*	2

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 24/10/2024

☒ REVIEW ☐ WITNESS
ON BEHALF OF RTG
A. DELLA PINA DATE 24 OTT 2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

REV *Rev.*	DATA *Date*	DESCRIZIONE *Description*	COMP. *Prepared*	CONTR. *Checked*	APPROV. *Approved*
0	23.10.2024	PRIMA EMESSIONE / First emission	M.D.	M.D.	G.D.

CERTIFICATI MATERIALI
Material Certificates

DOC. NR. 23 – 0193 - HYDROGEN VENT

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 24/10/2024

DISEGNO DI RIFERIMENTO : **1724000887-MAC-DA-00003_03**
"HYDROGEN VENT"

Reference drawing

*I certificati sotto riportati ed allegati si riferiscono ai soli componenti principali dell'item, di fornitura T.i.c.i. srl e coprono l'intero scopo di fornitura.
**Certificates below listed and attached only refer to the main components of the item, supplied by T.i.c.i. srl and they are valid for the entire scope of supply.*

DWG *Item*	DESCRIZIONE *Description*	MATERIALE *Material*	ALLEGATO *Attachment*	MILL CERTIF. No. *Mill Certificate No.*	No. COLATA *Heat No.*	FORNITORE *Manufacturer*	COD. INTERNO *Internal code n°*
1	RISER SHELL 42" X 10THK	A516 GR. 60	A	617262	NSAA02	METINVEST	SC24/76
1	RISER SHELL 20" X 10THK	ASTM A333	B	B 19901/1	1810276	ARCELOR MITTAL	T24/123
3	RISER OUTLET FLANGE 12" #150 WNRF ASME B16.5	A350 GR LF2	C	7405/24	816536	FAD FLANGE	R24/494
5	VENT INLET FLANGE 10" #150 WNRF SCH.40 ASME B16.5	A350 GR LF2	C	7405/24	285700	FAD FLANGE	R24/491
5A	VENT INLET PIPE 10" SCH40	A333 GR.6	D	1543/EXP/R/20	886752	ALCHEMIA S.A.	T24/125
6	DRAIN CONNECTION FLANGE 1" #150 WNRF SCH.80 ASME B16.5	A350 GR LF2	C	7405/24	77780	FAD FLANGE	R24/493
7	SWAN NECK CONNECTION FLANGE 1" #150 LWNRF ASME B16.5	A350 GR LF2	E	CER-5315/24	BH0727	FIL-PEMTO S.P.A.	R24/480
8	FILLING LINE FLANGE 1" #150 LWNRF ASME B16.5	A350 GR LF2	E	CER-5315/24	BH0727	FIL-PEMTO S.P.A.	R24/480
9	LEVEL TRANSMITTER CONNECTION FLANGE 1" #150 LWNRF ASME B16.5	A350 GR LF2	E	CER-5315/24	BH0727	FIL-PEMTO S.P.A.	R24/480
10	HAND HOLE FLANGE 8" #150 WNRF SCH.40 ASME B16.5	A350 GR LF2	C	7405/24	460712	FAD FLANGE	R24/489
11	ANCHOR CHAIR 25THK	S355J2+N	F	22378	N242498043	NLMK VERONA S.P.A.	SC24/76
12	SKIRT SHELL 42" 10THK	A516 GR. 60	A	617262	NSAA02	METINVEST	SC24/76

☒REVIEW ☐WITNESS
ON BEHALF OF RPG
DELLA PINA DATE 24 OTT 2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

SC24/76

CERTIFICATO DI CONTROLLO 3.1 / INSPECTION CERTIFICATE 3.1 - EN 10204:2004

A04/A05

METINVEST
METINVEST TRAMETAL SPA

A01
Società per azioni con socio unico soggetta a direzione e coordinamento di Metinvest B.V
Registered office: Via XII Ottobre 1, 5° piano - 16121 Genova, Italy
Phone +39 010 5762911 - Fax +39 010 5762990
Works: Via E. Fermi, 44 - 33058 San Giorgio di Nogaro UD, Italy
Phone +39 0431 629989 - Fax +39 0431 629985
Cap. Soc. Euro 300.120.000,00 i.v.
C.F., P.IVA e Iscr. Reg. Imp. GE 05956630965 - REA 437720/GE
http://trametal.metinvestholding.com

(A) PROCESSO DI ELABORAZIONE / STEELMAKING PROCESS: E = ELECTRIC ; BO = BASIC OXYGEN
(B) STATO DI FORNITURA / DELIVERY CONDITION: AR = GREZZO DI LAMINAZIONE / AS ROLLED ;
N° = LAMINAZIONE A TEMPERATURA CONTROLLATA / NORMALIZING ROLLING ;
N = NORMALIZZATO / NORMALIZED at 910°C, 1,5 min/mm ; ARIA CALMA / STILL AIR;
R = RICOTTO / ANNEALED;
N+R = NORMALIZZATO + RINVENUTO / NORMALIZED + TEMPERED
(C) TRATTAMENTO TERMICO DEL CAMPIONE / HEAT TREATMENT OF SAMPLE:
N = 910°C, 1,5 min/mm ; ARIA CALMA / STILL AIR
R = 650°C, 1,5 min/mm ; ARIA CALMA / STILL AIR
(D) Ceq_1 = C + Mn/6 ; Ceq_2 = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 ;
Pcm = C + Si/30 + (Mn + Cu + Cr)/20 + Ni/60 + Mo/15 + V/10 + B*5
(1) POSIZIONE / LOCATION: 1 = TESTA / TOP ; 2 = PIEDE / BOTTOM
(2) POSIZIONE / LOCATION: C = CUORE / 1/2 THICKNESS ; P = PELLE / SURFACE ; "D" = SPESSORE / THICKNESS
(3) DIREZIONE / DIRECTION: L = LONGITUDINALE / LONGITUDINAL ; T = TRASVERSALE / TRANSVERSE
(4) FORMA DEL PROVINO / SHAPE OF TEST PIECE: P = PRISMATICO / PRISMATIC ; C = CILINDRICO / CYLINDRICAL
(5) ESITO PROVA DI PIEGA / RESULT: OK = COMPLYING ; NO = NOT COMPLYING

SACMO CORE THERMOENGINEERING S.r.l.
QC Inspection
☐ Review ☐ Witness

A06 Cliente / Customer

Date: 24/10/2024

EUSIDER HEAVY PLATES SPA

Via Tortona 25
00000 Milano 20144 IT
MI

EUSIDER HEAVY PLATES — COPIA CONFORME ALL'ORIGINALE

A03 N° Certificato / Certificate no.	A04 Data / Date
617262	03/07/2024
A08 N° Ordine Trametal / Works order	**A07 N° Ordine cliente / Customer's order**
32402441	204120
DDT	**del / date**
BOL 32412815	02/07/2024
Pratica / File no.	
del / date	

B06 Marcatura di prodotto / Marking of the product
LAMIERA/ORDINE/N° INFORNAMENTO/DIMENSIONI/QUALITÀ/MARCHIO DEL PRODUTTORE
PLATE/ORDER/INTERNAL N°/DIMENSIONS/STEEL GRADE/MANUFACTURER'S MARK

B01/B02/B03

Prodotto / Product	Lamiere / Hot rolled plates
Qualità / Steel grade	A516GR60MT/LTV
Normativa / Specification	ASTM

DDT.81155767
N.1 FOGLIO 10X2500X12000

B07 ITEM	B07 LAMIERA PLATE	B07 N° INFORN. INTERNAL NUMBER	B09/B11 DIMENSIONI [mm] DIMENSIONS	B12 MASSA TEORICA [t] THEORICAL WEIGHT	B07 LOTTO BATCH NO.	C70 PROCESSO ELAB. (A) STEELMAKING PROCESS	B04 STATO FORNITURA LAMIERA (B) DELIVERY CONDITION	C00 CAMPIONE SAMPLE	B05 TRATT. CAMPIONE (C) HEAT TREATMENT	C00 CAMPIONE PWHT SAMPLE	B05 PWHT TEMPERATURA INIZIO °C BEGINNING TEMPERATURE	VELOCITA' RISCALDO C/h HEATING RATE	TEMPERATURA TRATTAMENTO °C TEMPERATURE TREATMENT	HOLDING TIME PERMANENZA Min	VELOCITA' RAFFREDDAMENTO °C/h COOLING RATE	TEMPERATURA FINE °C END TEMPERATURE	N° CICLI / CYCLES	C00 CAMPIONE Q+T SAMPLE	B05 Q+T TEMPERATURA (Q) °C TEMPERATURE	HOLDING TIME PERMANENZA (Q) Min	COOLING RAFFREDDAMENTO	TEMPERATURA (T) °C TEMPERATURE	HOLDING TIME PERMANENZA (T) Min	COOLING RAFFREDDAMENTO
7	NSAA000403A	1961847	10.00X2480X12000	2,34	799483	BO	N	GG870																	
7	NSAA000403B	1961847	10.00X2480X12000	2,34	799483	BO	N	GG870																	
7	NSAA020302B	1961870	10.00X2480X12000	2,34	799487	BO	N	GG874																	
7	NSAA020303A	1961854	10.00X2480X12000	2,34	799488	BO	N	GG875																	
7	NSAA020303B	1961854	10.00X2480X12000	2,34	799488	BO	N	GG875																	
7	NSAA020402A	1961841	10.00X2480X12000	2,34	799477	BO	N	GG864																	
7	NSAA020402B	1961841	10.00X2480X12000	2,34	799477	BO	N	GG864																	
7	NSAA020403A	1961834	10.00X2480X12000	2,34	799478	BO	N	GG865																	
7	NSAA020403B	1961834	10.00X2480X12000	2,34	799478	BO	N	GG865																	
7	NSAA020404A	1961837	10.00X2480X12000	2,34	799479	BO	N	GG866																	
7	NSAA020404B	1961837	10.00X2480X12000	2,34	799479	BO	N	GG866																	

C71/C92 COMPOSIZIONE CHIMICA DI COLATA / HEAT CHEMICAL ANALYSIS

B07 COLATA HEAT	C71 C %	C72 Mn %	C73 Si %	C74 P %	C75 S %	C76 Cu %	C77 Ni %	C78 Cr %	C79 Mo %	C80* Al %	C81 V %	C82 Nb %	C83 Ti %	C84 Sn %	C85 Ca %	C86 N %	C87 B %	C88 H %	C89 Ceq1 % (D)	C90 Ceq2 % (D)	C91 Pcm % (D)
A51660LTV Min 0,00 - 12,50		0,60	0,15																		
A51660LTV Max 0,00 - 12,50	0,21	0,90	0,40	0,025	0,025																
Ordine Min 7																					
Ordine Max 7	0,15	1,10	0,30			0,100															
NSAA00	0,11	0,88	0,18	0,014	0,002	0,010	0,030	0,040	0,010	0,027	0,001	0,001	0,003	<0.005	0,0000	0,0035	0,0003	0,0001	0,26	0,27	0,17
NSAA02	0,11	0,89	0,22	0,009	0,003	0,020	0,030	0,020	0,010	0,027	0,001	0,002	0,003	<0.005	0,0000	0,0035	0,0003	0,0001	0,26	0,27	0,17

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00502660197 Tel. 0373-242255
DENTI MARTA
RESP. QUALITA'

REVIEW WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 24 OTT 2024

A

			PROVA DI TRAZIONE TENSILE TEST									PROVA DI RESILIENZA IMPACT TEST - CHARPY V-NOTCH TEST						PROVA DI PIEGA BEND TEST				PROVA DI DUREZZA HARDNESS TEST				PROVA DI STRIZIONE Z% TEST	
C00		C01	C01	C02	C03	C11	C12		C13	C14	C10	C41	C02	C03	C01	C42	C43	C02	C51	C52	C50	C01	C30	C31	C32	C53	C54
CAMPIONE SAMPLE	SPESSORE LAMIERA PLATE THICKNESS	POSIZIONE (1) LOCATION	POSIZIONE (2) LOCATION	DIREZIONE (3) ORIENTATION	TEMPERATURA [°C] TEST TEMPERATURE	YIELD STRENGTH ReH [Mpa]	TENSILE STRENGTH Rm [Mpa]	ReH/Rm	ELONGATION A%	PROOF/YIELD STRENGTH Rp 0,2 [Mpa]	SHAPE OF TEST PIECE FORMA PROVINO (4)	LARGHEZZA [mm] WIDTH	DIREZIONE (3) ORIENTATION	TEMPERATURA [°C] TEST TEMPERATURE	POSIZIONE (2) LOCATION	INDIVIDUAL VALUES SINGOLI VALORI (J)	MEDIA (J) MEAN VALUE	DIREZIONE (3) ORIENTATION	MANDRINO MANDREL	ANGOLO [°] ANGLE	ESITO (5) RESULT	POSIZIONE (2) LOCATION	METODO TEST METHOD	SINGOLI VALORI INDIVIDUAL VALUES	MEDIA MEAN VALUE	Z% VALORE MEDIO Z% MEAN VALUE Z% SINGOLI VALORI Z% INDIVIDUAL VALUES	Z% VALORE MEDIO Z% MEAN VALUE
A51660LTV Min 0.00 - 20.00					20		415		21,0	220																	
A51660LTV Max 0.00 - 20.00					20		550																				
A51660LTV Min 0.00 - 25.00													L	-51			18										
ORDINE Min 7													L	-50		14	27										
GG864	10,00	2	P	T	20		434		36,5	313	P	7,50	L	-50	P	143 127 137	136						HB	139 123 134	132		
GG864	10,00	2	P	T	300					232	C	7,50	T	-50	P	57 62 79	66										
GG865	10,00	2	P	T	20		428		39,9	336	P	7,50	L	-50	P	178 138 151	156						HB	137 126 128	131		
GG865	10,00	2	P	T	300					245	C	7,50	T	-50	P	70 94 66	77										
GG866	10,00	2	P	T	20		434		34,5	324	P	7,50	L	-50	P	162 155 180	166						HB	132 142 120	131		
GG866	10,00	2	P	T	300					239	C	7,50	T	-50	P	82 90 77	83										
GG870	10,00	2	P	T	20		424		35,3	321	P	7,50	L	-50	P	132 150 155	146						HB	140 148 134	141		
GG870	10,00	2	P	T	300					220	C	7,50	T	-50	P	74 82 70	75										
GG874	10,00	2	P	T	20		423		35,7	335	P	7,50	L	-50	P	171 128 146	148						HB	135 145 141	140		
GG874	10,00	2	P	T	300					247	C	7,50	T	-50	P	63 59 73	65										
GG875	10,00	2	P	T	20		427		38,8	335	P	7,50	L	-50	P	138 146 169	151						HB	135 141 148	141		
GG875	10,00	2	P	T	300					233	C	7,50	T	-50	P	99 82 71	84										

C10

ASME SA-370 FIG. 3 AND FIG. 10 / 11 - SAMPLE TAKEN AFTER PLATE HEAT TREATMENT. Elongation in 8" for thk ≤ 20mm, in 2" for thk > 20mm. IMPACT TEST IN ACC. TO ASTM A20 OPTION S5

D02-D50 CONTROLLO ULTRASONORO / ULTRASONIC EXAMINATION

D02	D03	D04	D05	D06	D07
APPARECCHIATURA EQUIPMENT	N° SERIE SERIAL NO	CONDIZIONI SUPERFICIALI SURFACE CONDITIONS	ACCOPPIANTE COUPLANT	MODALITÀ OPERATIVE PROCEDURE	TARATURA CALIBRATION
GILARDONI RDG2000	RDG2000-053188003	GREZZO DI LAMINAZIONE AS ROLLED	ACQUA WATER	IN ACCORDO ALLA SPECIFICA ACCORDING TO SPECIFICATION	IN ACCORDO ALLA SPECIFICA ACCORDING TO SPECIFICATION

B07 LAMIERA PLATE	D08 SONDE PROBE	D09 DIAMETRO DIAMETER MM	D10 FREQUENZA FREQUENCE MHz	D11 ANGOLO Angle °	D12 NORMA DI RIFERIMENTO STANDARD SPECIFICATION	D13 CLASSE DI ACCETTABILITÀ ACCEPTANCE SPECIFICATIONS	D14 ESITO RESULT	D15 INDICAZIONI INDICATIONS	D16 RETICOLO RETICLE	D17 BORDI EDGES
NSAA020402A		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020402B		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020403A		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020403B		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020404A		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020404B		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA000403A		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA000403B		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020302B		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020303A		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50
NSAA020303B		mm 20	5 MHz	0	ASME-SA578/B		OK	NO INDICATIONS FOUND	mm 225x225	50

D18	D19	D20
NOTE REMARKS: ENCORE THERMOENGINEERING S.r.l. QC Inspection	ENTE ISPETTIVO INSPECTOR	FIRMA SIGNATURE
By ..... ☒ Review ☐ Witness Date: 24/10/2024 T.I.C.I. S.R.L. Via dell'Artigianato, 6 26010 MONTODINE (CR) P.I. 00962060190 - TEL. 0373-242255 DENTI MARTA RESP. QUALITA'	☒ REVIEW ☐ WITNESS ON BEHALF OF RTG A. DELLABRINA DATE 24 OTT 2024	METINVEST TRAMETAL S.p.a. F. Andrian III Liv. EN ISO 9712

Z01						
ITEM		TOLLERANZA DI SPESSORE TOLERANCE ON THICKNESS	TOLLERANZE DI LARGHEZZA TOLERANCE ON WIDTH	TOLLERANZE DI LUNGHEZZA TOLERANCE ON LENGTH	CONDIZIONI SUPERFICIALI SURFACE FINISH	PLANARITÀ FLATNESS
7		EN 10029 CL.C	-0+100 MM	-0+200 MM	EN 10163/2 CL B2	EN 10029 CL. N

CERTIFICHIAMO che le lamiere elencate sono conformi alla prescrizione dell'ordine, che i controlli della marcatura, dell'aspetto superficiale e dimensionale hanno dato esito positivo.
WE CERTIFY that the above mentioned plates are consistent with the order prescriptions: marking, inspection and measurement without objection.
DICHIARIAMO CHE LE LAMIERE SONO STATE CONTROLLATE IN ACCORDO ALLA NORMATIVA VIGENTE E CHE LE RADIAZIONI IONIZZANTI NON ECCEDONO IL VALORE DEL FONDO NATURALE.
WE DECLARE THAT THE PLATES WERE CONTROLLED ACCORDING TO STANDARD AND RADIATION DO NOT EXCEED THE NATURAL RADIATION.

Z06		
FULLY KILLED FINE GRAIN STEEL HARDNESS IN ACC. TO NACE MR 0103		
Z07	Z03 ENTE COLLAUDO / INSPECTION BODY	Z02
PRODUCED FROM CONTINOUS CAST SLAB AND HAVE A MINIMUN REDUCTION RATIO OF 3 TO 1. ACC. TO ASTM ED. 2023. FULLY KILLED, FINE GRAIN STEEL. Value of Mn maximun in derogation permitted up to 1.50% Issued in agreement with TÜV SÜD Industrie Service GmbH. QS approved acc. to PED, Annex I, Para. 4.3 by Notified Body 0036 (Certification no. DGR-0036-QS-W 847 2003 / MUC-03).	TIMBRO DELL'ISPETTORE STAMP OF THE INSPECTION REPRESENTATIVE	METINVEST TRAMETAL S.p.a. F. Andrian CQ Manager

☒ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 24 OTT 2024

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-212255
RESP. QUALITA'

F.I.R.A.S. DI CROCE SRL P.O. 24/GR/2231/139 TAL JOB N°424005033 OUR DDT N°402401956 OF 20/09/24
N° 1 MT 6,46 HEAT 1810276 DIMENSIONS 508 x 9,53 ITEM 3 T24/123

Manufacturer: ArcelorMittal Tubular Products Roman S.A. STEFAN CEL MARE STR, BL 15, SC. A, PARTER I ROMAN, NEAMT ROMANIA	**MILL TEST CERTIFICATE** according to EN 10204/3.1/2004 -	Page 1/5 B 19901/1 28.07.2020	ArcelorMittal

Buyer: T.A.L. S.P.A.con socio unico VIA G. DI VITTORIO, 6, ZONA IND., 29017 FIORENZUOLA D'ARDA (PIACENZA) ITALY	SEAMLESS STEEL LINE PIPES	Total weight: 13.297 tons - lbs	Total Length: 113.50 meters - feets	Pieces 18	Bundles -
Buyer's reference PO NO. OF200147	**Standard:** API 5L ed.46-2018-PSL 1; ISO 3183-2019; ASTM A 333/A 333M-2018; ASME SA 333/SA 333M-2017; ASME B16.25-2017; ANSI/NACE MR 0103/ISO 17945-2015; NACE MR 0175/ISO 15156-1&2-2015;				
Contract 50004527	**Dimensions:** 508.00 x 9.53 mm -	**Schedule:** STD/20	Length: 5.50 - 7.00 m -		-

Item	Item Client
9	-

Hydro Test:	Bar	PSI	MPa	Time(sec)
	122	-	12.2	5

Steel Grade: X52/6/L360 -

Chemical Analysis(%)

Heat	Bulletin No.	Product Req.		C	Mn	Si	S	P	Cr	Ni	Cu	Mo	V	Nb	Ti	B
			Max	0.28	1.35	-	0.025	0.025	0.30	0.40	0.40	0.12	0.080	0.020	-	0.0010
			Min	-	0.29	0.10	-	-	-	-	-	-	-	-	-	-
1810237		Heat analysis		0.14	1.21	0.21	0.003	0.007	0.12	0.07	0.14	0.01	0.060	0.000	0.003	0.0004
1810275		Heat analysis		0.13	1.20	0.20	0.003	0.007	0.12	0.07	0.10	0.02	0.062	0.002	0.003	0.0005
1810276		Heat analysis		0.13	1.25	0.21	0.003	0.011	0.13	0.06	0.10	0.01	0.073	0.003	0.002	0.0003
1810237	20-583	Product analysis		0.15	1.22	0.22	0.003	0.007	0.13	0.08	0.13	0.01	0.060	0.000	0.003	0.0003
1810237	20-583	Product analysis		0.14	1.22	0.22	0.003	0.006	0.13	0.08	0.13	0.01	0.060	0.000	0.003	0.0003
1810275	18-470	Product analysis		0.14	1.22	0.22	0.003	0.008	0.13	0.07	0.10	0.02	0.065	0.003	0.002	0.0003
1810275	18-470	Product analysis		0.14	1.21	0.21	0.003	0.008	0.12	0.07	0.10	0.02	0.064	0.003	0.002	0.0003
1810276	18-279	Product analysis		0.14	1.26	0.23	0.003	0.012	0.13	0.07	0.10	0.01	0.074	0.003	0.001	0.0003
1810276	18-279	Product analysis		0.14	1.26	0.23	0.003	0.011	0.13	0.06	0.10	0.01	0.074	0.003	0.001	0.0003

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

We state on our sole responsibility that the delivered products are in conformity with the order requirements.

REVIEW ☐ WITNESS
ON BEHALF OF RINA
DELEGATA DATE 24 OTT 2024

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024
Quality Control Representative

Approved by QUALITY1 on 06/08/20

B 1 OF 5

Formular 12A rev 9

F.I.R.A.S. DI CROCE SRL P.O. 24/GR/2231/139 TAL JOB N°424005033 OUR DDT N°402401956 OF 20/09/24
N° 1 MT 6,46 HEAT 1810276 DIMENSIONS 508 x 9,53 ITEM 3

Manufacturer:
ArcelorMittal Tubular Products Roman S.A.
STEFAN CEL MARE STR, BL 15, SC. A, PARTER I
ROMAN, NEAMT ROMANIA

MILL TEST CERTIFICATE
according to EN 10204/3.1/2004

Page 2/5
B 19901/1
28.07.2020

ArcelorMittal

Buyer: T.A.L. S.P.A.con socio unico
VIA G. DI VITTORIO, 6, ZONA IND., 29017
FIORENZUOLA D'ARDA (PIACENZA)
ITALY

SEAMLESS STEEL LINE PIPES

Total weight:	Total Length:	Pieces	Bundles
13.297 tons - lbs	113.50 meters - feets	18	-

Standard: API 5L ed.46-2018-PSL 1; ISO 3183-2019; ASTM A 333/A 333M-2018; ASME SA 333/SA 333M-2017; ASME B16.25-2017; ANSI/NACE MR 0103/ISO 17945-2015; NACE MR 0175/ISO 15156-1&2-2015;

Buyer's [redacted] PO N° [redacted]
Contract 50004527

Dimensions: 508.00 x 9.53 mm
Schedule: STD/20
Length: 5.50 - 7.00 m

Item	Item Client
9	-

Hydro Test:	Bar	PSI	MPa	Time(sec)
	122	-	12.2	5

Steel Grade: X52/6/L360

Chemical Analysis(%)

Heat	Bulletin No.	Product Req.		Nb + Ti + V
			Max	0.150
			Min	-
1810237		Heat analysis		0.063
1810275		Heat analysis		0.067
1810276		Heat analysis		0.078
1810237	20-583	Product analysis		0.063
1810237	20-583	Product analysis		0.063
1810275	18-470	Product analysis		0.070
1810275	18-470	Product analysis		0.069
1810276	18-279	Product analysis		0.078
1810276	18-279	Product analysis		0.078

$CEpcm = C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5B$ $CE_S = C+Mn/6$ $CE_{IIW} = C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15$

REVIEW WITNESS
ON BEHALF OF RTG
A. DELLA PINA-DATE 24 OTT 2024

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
Review Witness
Date: 24/10/2024
Quality Control Representative

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-24255
DENTI MARTA
RESP. QUALITA'

We state on our sole responsibility that the delivered products are in conformity with the order requirements.

Formular 12A rev 9

Approved by QUALITY1 on 06/08/20

(B) 2 of 5

F.I.R.A.S. DI CROCE SRL P.O. 24/GR/2231/139 TAL JOB N°424005033 OUR DDT N°402401956 OF 20/09/24
N° 1 MT 6,46 HEAT 1810276 DIMENSIONS 508 x 9,53 ITEM 3

Manufacturer:
ArcelorMittal Tubular Products Roman S.A.
STEFAN CEL MARE STR, BL 15, SC. A, PARTER I
ROMAN, NEAMT ROMANIA

MILL TEST CERTIFICATE
according to EN 10204/3.1/2004

Page 3/5
B 19901/1
28.07.2020

ArcelorMittal

Buyer: T.A.L. S.P.A.con socio unico
VIA G. DI VITTORIO, 6, ZONA IND., 29017
FIORENZUOLA D'ARDA (PIACENZA)
ITALY

SEAMLESS STEEL LINE PIPES

Total weight:	Total Length:	Pieces	Bundles
13.297 tons - lbs	113.50 meters feets	18	-

Standard: API 5L ed.46-2018-PSL 1; ISO 3183-2019; ASTM A 333/A 333M-2018; ASME SA 333/SA 333M-2017; ASME B16.25-2017; ANSI/NACE MR 0103/ISO 17945-2015; NACE MR 0175/ISO 15156-1&2-2015;

Buyer's reference: PO NO: OF200147
Contract 50004527

Dimensions: 508.00 x 9.53 mm | Schedule: STD/20 | Length: 5.50 - 7.00 m

Item	Item Client
9	-

Hydro Test:	Bar	PSI	MPa	Time(sec)
	122	-	12.2	5

Steel Grade: X52/6/L360

Tensile Test

Heat	Orientation	Length mm	Length inch	Width/Diameter mm	Width/Diameter inch	Thickness mm	Thickness inch	Section mm²	Section inch²	Mechanical test Bulletin No.	YS MPa	YS (PSI:1000)	UTS MPa	UTS (PSI:1000)	E %	YS/UTS max: -
1810237	Longitudinal Flat	50.8	-	40.00	-	10.60	-	424.0	-	20-2043	418.00	-	526.00	-	42.60	0.79
1810237	Longitudinal Flat	50.8	-	40.00	-	10.70	-	428.0	-	20-2043	422.00	-	531.00	-	42.80	0.79
1810275	Longitudinal Flat	50.8	-	40.00	-	10.40	-	416.0	-	20-1998	397.00	-	503.00	-	41.80	0.79
1810275	Longitudinal Flat	50.8	-	40.00	-	10.60	-	424.0	-	20-1998	402.00	-	511.00	-	42.30	0.79
1810276	Longitudinal Flat	50.8	-	40.00	-	10.30	-	412.0	-	20-1998	401.00	-	507.00	-	41.20	0.79
1810276	Longitudinal Flat	50.8	-	40.00	-	10.00	-	400.0	-	20-1998	398.00	-	502.00	-	39.70	0.79

Impact Test

Heat	Impact Test Bulletin No.	Orientation	Size (mm)	Temp. (°C)	Req.KV (min. J)	KV values (J)			Req.Avr. (min. J)	Avr. fracture energy (J)	KCU min:-J/cm² T:°C			Shear Area min. %			Lateral Expansion min. mm		
1810237	20-2775	Longitudinal	10x7.5x55	-48	11.0	190	146	202	14.0	179	-	-	-	95	95	100	1.71	1.29	1.77
1810275	20-2750	Longitudinal	10x7.5x55	-48	11.0	254	222	240	14.0	239	-	-	-	100	100	100	2.27	2.00	2.18
1810276	20-2750	Longitudinal	10x7.5x55	-48	11.0	206	238	248	14.0	231	-	-	-	100	100	100	1.90	2.15	2.24

Hardness Test

Heat	Hardness Test Bulletin No.	HB max.-	HV 10 max.-	HV 10 max.- OD	Midwall	ID	End A	End B	HRC max.22
1810237	20-1712	-	-	-	-	-	-	-	-
1810275	20-1663	-	-	-	-	-	-	-	-
1810276	20-1663	-	-	-	-	-	-	-	-

We state on our sole responsibility that the delivered products are in conformity with the order requirements.

Formular 12A rev.9

REVIEW ON BEHALF OF A. DELLA PINA DATE 24 OTT 2024
Quality Control Representative

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By.....
Review Witness
Date: 24/10/2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

Approved by QUALITY1 on 06/08/20

THIS DOCUMENT IS REPRODUCED BY A COMPUTERIZED SYSTEM AND IS CONFORM TO THE ORIGINAL

F.I.R.A.S. DI CROCE SRL P.O. 24/GR/2231/139 TAL JOB N°424005033 OUR DDT N°402401956 OF 20/09/24
N° 1 MT 6,46 HEAT 1810276 DIMENSIONS 508 x 9,53 ITEM 3

Manufacturer:
ArcelorMittal Tubular Products Roman S.A.
STEFAN CEL MARE STR, BL 15, SC. A, PARTER I
ROMAN, NEAMT ROMANIA

MILL TEST CERTIFICATE
according to EN 10204/3.1/2004
-

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B 19901/1
28.07.2020

ArcelorMittal

Buyer: T.A.L. S.P.A.con socio unico
VIA G. DI VITTORIO, 6, ZONA IND., 29017
FIORENZUOLA D'ARDA (PIACENZA)
ITALY

SEAMLESS STEEL LINE PIPES

Total weight:	Total Length:	Pieces	Bundles
13.297 tons - lbs	113.50 meters - feets	18	-

Standard: API 5L ed.46-2018-PSL 1; ISO 3183-2019; ASTM A 333/A 333M-2018; ASME SA 333/SA 333M-2017; ASME B16.25-2017; ANSI/NACE MR 0103/ISO 17945-2015; NACE MR 0175/ISO 15156-1&2-2015;

Buyer's reference: PO NO.: OF200147

Contract 50004527

Dimensions: 508.00 x 9.53 mm
-

Schedule: STD/20

Length: 5.50 - 7.00 m
-

-
-

Item	Item Client
9	-

Hydro Test:	Bar	PSI	MPa	Time(sec)
	122	-	12.2	5

Steel Grade: X52/6/L360
-

Technological/Microstructure Test

Heat	Flattening Test Bulletin No.	Flattening Test
1810237	20-2375	OK
1810275	20-2287	OK
1810275	20-2287	OK
1810276	20-2287	OK
1810276	20-2287	OK

☐ REVIEW ☐ WITNESS
ON BEHALF OF RTG
A. BELLAFINA DATE 24 OTT 2024

Heat

Heat	Pieces	Length (m)	Weight (kg)
1810237	1	-	-
1810275	8	-	-
1810276	9	-	-

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024

I.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

We state on our sole responsibility that the delivered products are in conformity with the order requirements.

Quality Control Representative

Approved by QUALITY1 on 06/08/20

B
4 OF 5

Formular 12A rev 9

F.I.R.A.S. DI CROCE SRL P.O. 24/GR/2231/139 TAL JOB N°424005033 OUR DDT N°402401956 OF 20/09/24
N° 1 MT 6,46 HEAT 1810276 DIMENSIONS 508 x 9,53 ITEM 3

Manufacturer:
ArcelorMittal Tubular Products Roman S.A.
STEFAN CEL MARE STR, BL 15, SC. A, PARTER I
ROMAN, NEAMT ROMANIA

MILL TEST CERTIFICATE
according to EN 10204/3.1/2004

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B 19901/1
28.07.2020

ArcelorMittal

Buyer: T.A.L. S.P.A.con socio unico
VIA G. DI VITTORIO, 6, ZONA IND., 29017
FIORENZUOLA D'ARDA (PIACENZA)
ITALY

SEAMLESS STEEL LINE PIPES

Total weight:	Total Length:	Pieces	Bundles
13.297 tons - lbs	113.50 meters - feets	18	-

Standard: API 5L ed.46-2018-PSL 1; ISO 3183-2019; ASTM A 333/A 333M-2018; ASME SA 333/SA 333M-2017; ASME B16.25-2017; ANSI/NACE MR 0103/ISO 17945-2015; NACE MR 0175/ISO 15156-1&2-2015;

Buyer's reference: PO NO. : OE200147

Contract 50004527

Dimensions: 508.00 x 9.53 mm
-

Schedule: STD/20

Length: 5.50 - 7.00 m
-

-
-

Item	Item Client
9	-

Hydro Test:

Bar	PSI	MPa	Time(sec)
122	-	12.2	5

Steel Grade: X52/6/L360
-

Remarks PIPES IN COMPLIANCE WITH PED: 2014-68-EU/15.05.2014, ANNEX 1, SECTION 4.3.
Manufacturing process – hot rolling.
Hot finished, steel is fully killed and produced by electric furnace, source G300706.
Visual inspection and dimensional check without objection.
Heat treatment: normalizing at temperature 890-940°C, time soaking 25 min.
Hydrostatic test hold for 5 sec. no leakage noticed.
The products was manufactured, sampled, tested, marked and inspected in accordance with the Standards, the supplementary requirements, and any other requirements designated in the purchase order, and has been found to meet such requirements.

☑ REVIEW ☐ WITNESS
ON BEHALF OF ERG
A. DELLA PINA DATE 24 OTT 2024

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☑ Review ☐ Witness
Date: 24/10/2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 8
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

We state on our sole responsibility that the delivered products are in conformity with the order requirements.

Quality Control Representative

Formular 12A rev 9

Approved by QUALITY1 on 06/08/20

TAL SPA - THIS DOCUMENT IS REPRODUCED BY A COMPUTERIZED SYSTEM AND IS CONFORM TO THE ORIGINAL

FAD FLANGE ACCIAIO & DERIVATI s.p.a.

SEDE LEGALE: VIA BONESCHI , 1 - 20040 CAMBIAGO (MI) ITALIA
TEL : +39 02 959420 FAX : + 39 02 95942323 INTERNET: www.fadflange.it - E-MAIL: info@fadflange.it
CAPITALE SOCIALE / SHARE EQUITY € 3.000.000,00 REG.IMP. MONZA BRIANZA /C.F. 03840080158
PARTITA IVA / V.A.T. No. IT 00763980968 - REA 1975057 - N.MECCANOGRAFICO MI 100012

CERTIFICATO PROVE MATERIALI N.7405/24

Test certificate - Certificat d'epreuves - Werksabnahmezeugnis
EN 10204 / 3.1

CLIENTE / Customer - Client - Kunde
F.I.R.A.S. DI CROCE SRL

VIA GALVANI, 24/26

20019 SETTIMO MILANESE MI ITALIA

DATA / Date - Date - Datum 19/09/2024
COMMESSA / Mill order / Comf. de commande / Komm 2415807
ORDINE / Order / Commande / Auftrag 24/GR/2231/131
D.D.T. / Delivery note / Bulletin de livraison / Lieferschein 7.405

CODICE	COLATA	CERTIFICATO ORIGINE	NORMA / MAT. / DESCRIZIONE	POS.ORD.	QUANTITA
Line code / Code / Kode	Heat / Coulé / Schmelze	Certificate of origin / Certificat d'usine / Werkszeugniss	Standard / Material / Description / Norme / Matériél / Description / Standard / Werkstoff / Gegenstand	Item order / Pos. de comm / Auftragsiabe	Quantity / Quantité / Stückzahl
	77780	RIVA	F.FLG.ASME B16.5 A/SA350LF2-1 WN 150 1" S.XS RF	1	1

ANALISI CHIMICA / Chemical analysis / Analyse chemique / Chemische zusammensetzung

C %	Mn %	P %	S %	Si %	Cr %	Ni %	Mo %	Ti %	Cu %	Nb %	N %	V %	Al %	Sn %	CE %
0,150	0,950	0,011	0,005	0,200	0,140	0,060	0,020	0,006	0,160	0,002	0,010	0,002	0,026	0,000	0,360

B %	Ca %	H2 %	O2 %	W %	Sb %	As %	Fe %	Co %	PRE %
0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,0000

CARATTERISTICHE MECCANICHE / Mechanical test / Epreuves mechaniques / Mechanische eigenscharte

MPA Tensile stranght / Rupture / Zugfestigkeit	MPA Yield point / Limite elasticite / Streckgrenze	4D % Elongation / Allongement / Dehnung	Reduction of area / Striction % / Einschnürung	HB Hardness / Dureté / Harte	Impact test / Resilence / Kerbschlagzähigkeit	1	2	3	4
521,0	319,0	35,0	66,0	158	158 10/10 KV -50°C 55 50 47 J	A	A	X	X

R24/493

CODICE	COLATA	CERTIFICATO ORIGINE	NORMA / MAT. / DESCRIZIONE	POS.ORD.	QUANTITA
Line code / Code / Kode	Heat / Coulé / Schmelze	Certificate of origin / Certificat d'usine / Werkszeugniss	Standard / Material / Description / Norme / Matériél / Description / Standard / Werkstoff / Gegenstand	Item order / Pos. de comm / Auftragsiabe	Quantity / Quantité / Stückzahl
	460712	abs	F.FLG.ASME B16.5 A/SA350LF2-1 WN 150 8" S.STD RF	2	1

ANALISI CHIMICA / Chemical analysis / Analyse chemique / Chemische zusammensetzung

C %	Mn %	P %	S %	Si %	Cr %	Ni %	Mo %	Ti %	Cu %	Nb %	N %	V %	Al %	Sn %	CE %
0,187	1,150	0,010	0,003	0,230	0,060	0,060	0,010	0,002	0,140	0,002	0,008	0,005	0,021	0,008	0,411

B %	Ca %	H2 %	O2 %	W %	Sb %	As %	Fe %	Co %	PRE %
0,000	0,001	0,000	0,000	0,000	0,000	0,005	0,000	0,007	0,0000

CARATTERISTICHE MECCANICHE / Mechanical test / Epreuves mechaniques / Mechanische eigenscharte

MPA Tensile stranght / Rupture / Zugfestigkeit	MPA Yield point / Limite elasticite / Streckgrenze	4D % Elongation / Allongement / Dehnung	Reduction of area / Striction % / Einschnürung	HB Hardness / Dureté / Harte	Impact test / Resilence / Kerbschlagzähigkeit	1	2	3	4
502,0	329,9	70,1	64,3	144 155	10/10 KV -50°C 41 36 45 J	A	A	X	X

R24/489

CODICE	COLATA	CERTIFICATO ORIGINE	NORMA / MAT. / DESCRIZIONE	POS.ORD.	QUANTITA
Line code / Code / Kode	Heat / Coulé / Schmelze	Certificate of origin / Certificat d'usine / Werkszeugniss	Standard / Material / Description / Norme / Matériél / Description / Standard / Werkstoff / Gegenstand	Item order / Pos. de comm / Auftragsiabe	Quantity / Quantité / Stückzahl
	265431	ABS	F.FLG.ASME B16.5 A/SA350LF2-1 BL 150 8" RF	3	1

ANALISI CHIMICA / Chemical analysis / Analyse chemique / Chemische zusammensetzung

C %	Mn %	P %	S %	Si %	Cr %	Ni %	Mo %	Ti %	Cu %	Nb %	N %	V %	Al %	Sn %	CE %
0,193	1,160	0,011	0,003	0,180	0,050	0,070	0,010	0,003	0,120	0,003	0,006	0,005	0,021	0,005	0,412

B %	Ca %	H2 %	O2 %	W %	Sb %	As %	Fe %	Co %	PRE %
0,000	0,001	0,000	0,000	0,000	0,000	0,004	0,000	0,008	0,0000

CARATTERISTICHE MECCANICHE / Mechanical test / Epreuves mechaniques / Mechanische eigenscharte

MPA Tensile stranght / Rupture / Zugfestigkeit	MPA Yield point / Limite elasticite / Streckgrenze	4D % Elongation / Allongement / Dehnung	Reduction of area / Striction % / Einschnürung	HB Hardness / Dureté / Harte	Impact test / Resilence / Kerbschlagzähigkeit	1	2	3	4
507,0	334,0	70,7	66,7	141 156	10/10 KV -50°C 40 46 38 J	A	A	X	X

CODICE	COLATA	CERTIFICATO ORIGINE	NORMA / MAT. / DESCRIZIONE	POS.ORD.	QUANTITA
Line code / Code / Kode	Heat / Coulé / Schmelze	Certificate of origin / Certificat d'usine / Werkszeugniss	Standard / Material / Description / Norme / Matériél / Description / Standard / Werkstoff / Gegenstand	Item order / Pos. de comm / Auftragsiabe	Quantity / Quantité / Stückzahl
	285700	ABS	F.FLG.ASME B16.5 A/SA350LF2-1 WN 150 10" S.STD RF	4	1

ANALISI CHIMICA / Chemical analysis / Analyse chemique / Chemische zusammensetzung

C %	Mn %	P %	S %	Si %	Cr %	Ni %	Mo %	Ti %	Cu %	Nb %	N %	V %	Al %	Sn %	CE %
0,187	1,150	0,011	0,002	0,210	0,090	0,070	0,020	0,003	0,090	0,003	0,007	0,003	0,028	0,006	0,412

B %	Ca %	H2 %	O2 %	W %	Sb %	As %	Fe %	Co %	PRE %
0,000	0,001	0,000	0,000	0,000	0,001	0,003	0,000	0,009	0,0000

CARATTERISTICHE MECCANICHE / Mechanical test / Epreuves mechaniques / Mechanische eigenscharte

MPA Tensile stranght / Rupture / Zugfestigkeit	MPA Yield point / Limite elasticite / Streckgrenze	4D % Elongation / Allongement / Dehnung	Reduction of area / Striction % / Einschnürung	HB Hardness / Dureté / Harte	Impact test / Resilence / Kerbschlagzähigkeit	1	2	3	4
500,0	324,9	69,2	63,1	144 147	10/10 KV -50°C 39 43 50 J	A	A	X	X

R24/491

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date 21/10/2024

☐ REVIEW ☐ WITNESS
ON BEHALF OF RZG
A. DE LA PINA DATE 24 OTT 2024

(1) PRODUZIONE ACCIAIO / Steel production / Stahl produktion: A - COLATO E LAMINATO AL FORNO ELETTRICO / Killed steel made by electric furnace / Acier calmé produit au four électrique / Beruhigter Stahl im elektrofen. B - ELABORATO AL FORNO ELETTRICO / Made by electric furnace / Produit au four électrique / Ausgearbeitet im elektrofen.

(2) TRATT. TERMICO / Heat treatment / Traitment terrmique / Warmebehandlung: A - NORMALIZZATO / Normalized / Normalisé / Normalgeglüht. B - NORMALIZZATO E RINVENUTO / Normalized and tempered / Normalisé et revenu / Normalisiert angelassen. C - BONIFICATO / Quenched and tempered / Etuvé / Harten und anlassen. D - SOLUBILIZZATO / Solution treat and quench / Schebilisé / Lösungsgeglüht.

(3) X - CERTIFICATO SECONDO ASME SA 9 ED. 21 ACL

(4) X - CONTROLLO VISIVO E DIMENSIONALE SODDISFACENTE / Satisfactory visual and dimensional check / Inspection et contrôle dimensional satisfaisant / Besichtigung und maasskontrolle bestanden.

- I VALORI DELLE ANALISI CHIMICHE SONO RICAVATI DAL CERTIFICATO DI FERRERIA / Chemical analysis values are taken from mill certificate / Le valeur de certificat ont été obtenus par le certificat d'usine / Der werte das zeugnisses ein vom original werksabnahmezeugniss erhalten.

(5) Cr+Mo+V = 0 ; Mn+Cr+Mo+V = 5 ; Cu+Ni = 15

X MADE MR 01-75 ED. 15

(5) DOUBLE CERTIFICATION: C.S:A/SA105/SA350LF2 - S.S:A/SA182F316/316L & A/SA182F304/304L

RESP. CONTROLLO CERTIFICATI / Issued by / Cert. contrôle / Zeugnis-prüfengnant

ENTE UFFICIALE DI COLLAUDO / Inspection authority / Service inspection officiel / Abnahme veseln

CAPO COLLAUDO / Chief inspector / Chef de la reception / Chef de abnahmestellung

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242355
DENTI MARTA
RESP. QUALITA'

1 of 2

CERTIFICATO PROVE MATERIALI N.7405/24

Test certificate - Certificat d'epreuves - Werksabnahmezeugniss
EN 10204 / 3.1

FAD FLANGE ACCIAIO & DERIVATI s.p.a.

SEDE LEGALE: VIA BONESCHI , 1 - 20040 CAMBIAGO (MI) ITALIA
TEL +39 02 959420 FAX : + 39 02 95942323 INTERNET: www.fadflange.it - E-MAIL: info@fadflange.it
CAPITALE SOCIALE / SHARE EQUITY € 3.000.000,00 REG.IMP. MONZA BRIANZA /C.F. 03840060158
PARTITA IVA / V.A.T. No. IT 00763960968 - REA MI975057 - N.MECCANOGRAFICO MI 100012

CLIENTE / Customer - Client - Kunde
F.I.R.A.S. DI CROCE SRL

VIA GALVANI, 24/26

20019 SETTIMO MILANESE MI ITALIA

DATA / Date - Date - Datum 19/09/2024
COMMESSA / Mill order / Conf. de commande / Komm 2415807
ORDINE / Order / Commande / Auftrag 24/GR/2231/131
D.D.T. / Delivery note / Bulletin de livraison / Lieferschein 7.405

CODICE Line code Code Kode	COLATA Heat Coule Schmelze	CERTIFICATO ORIGINE Certificate of origin Certificat d'usine Werkszeugniss	NORMA / MAT. / DESCRIZIONE Standard / Material / Description Norme / Matériel / Description Standard / Werkstoff / Gegenstand	POS.ORD. Item order Pos. de comm Auftragslabe	QUANTITA Quantity Quantité Stückzahl
	816536	ABS	F.FLG.ASME B16.5 A/SA350LF2-1 WN 150 12" S.STD RF	5	2

ANALISI CHIMICA / Chemical analysis / Analyse chimique / Chemische zusammensetzung

C %	Mn %	P %	S %	Si %	Cr %	Ni %	Mo %	Tl %	Cu %	Nb %	N %	V %	Al %	Sn %	CE %
0,188	1,190	0,010	0,004	0,200	0,100	0,080	0,020	0,003	0,120	0,001	0,005	0,003	0,028	0,012	0,424

B %	Ca %	H2 %	O2 %	W %	Sb %	As %	Fe %	Co %	PRE %
0,000	0,002	0,000	0,000	0,000	0,000	0,006	0,000	0,010	0,0000

CARATTERISTICHE MECCANICHE / Mechanical test / Epreuves mecaniques / Mechanische eigenschaften

MPA Tensile strenght Rupture Zugfestigkeit	MPA Yield point Limite elastiche Streckgrenze	4D % Elongation Allongement Dehnung	Reduction of area Striction % Einschnürung	HB Hardness Dureté Harte		Impact test Resilience Kerbschlagzähigkeit				1	2	3	4
511,9	334,9	62,7	66,2	143	153	10/10 KV	-50°C	43	36 48 J	A	A	X	X

R24/494-492

NACE MR 0103 ED16

Material manufactured in accordance with PED 2014/68/UE PAR.4.3 under quality assurance system ISO 9001 cert. 206967 issued by Bureau Veritas

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 24/10/2024

☒ REVIEW ☐ WITNESS
ON BEHALF OF RTA
A. DELL'ERBA DATE 24 OTT 2024

(1) PRODUZIONE ACCIAIO / Steel production / Production acier / Stahl produktion
A - CALMATO E COLATO AL FORNO ELETTRICO / Killed steel made by electric furnace / Acier calmé produit au four électrique / Beruhigt stahl abgearbeitet im elektroofen.
B - RAFFINATO AL FORNO ELETTRICO / Made by electric furnace / Produit au four électrique / Ausgearbeitet im elektroofen.

(2) TRATT. TERMICO / Heat treatment / Traitement termique / Warmebehandlung
A - NORMALIZZATO / Normalised / Normalisé / Normalgeglüht.
B - NORMALIZZATO E RINVENUTO / Normalised and tempered/ Normalisé et revenu / Normalisiert angelassen.
C - BONIFICATO / Quenched and tempered / Trempé / Harten und anlassen.
D - SOLUBILIZZATO / Solution treat and quench / Schlußbild / Lösungsgeglüht.

(3) X - CERTIFICATO SECONDO ASME SA II ED. 21 ADD.

(4) X - CONTROLLO VISIVO E DIMENSIONALE SODDISFACENTE / Satisfactory visual and dimensional check / Inspection et controle dimensionnel satisfesant / Besichtigung und massenkontrolle bestanden.
- I VALORI DELLE ANALISI CHIMICHE SONO RICAVATI DAL CERTIFICATO DI FERRERIA / Chemical analysis values are taken from mill certificate / Le valeurs de certificat ont été obtenus par le certificat d'usine / Die werte des zeugnisses sin vom original werkszeugnismaterial erhalten.

(5) DOUBLE CERTIFICATION: C.S.: A/SA182F316/316L & A/SA182F304/304L

RESP. CONTROLLO CERTIFICATI Issued by Cert. cmbible Zeugnisaustellungsort	ENTE UFFICIALE DI COLLAUDO Inspection authority Service inspection officiel Abnahme Verein	CAPO COLLAUDO Chief inspector Chef de la reception Chef der abnahmeabteilung
T.I.C.I. S.R.L. Via dell'Artigianato, 6 26010 MONTODINE (CR) P.I. 00962060190 - TEL. 0373-242255 DENTI MARTA RESP. QUALITA'	F.I.R.A.S. DI CROCE s.r.l.	

COPIA CONFORME ALL'ORIGINALE

T24/125

alchemia
ALCHEMIA S.A.
Oddział Walcownia Rur Batory
w Chorzowie
ul. Dyrekcyjna 6
41-506Chorzów
POLAND
(A01)(A04)

(A03)

ŚWIADECTWO ODBIORU No 1543/EXP/R/20

CERTYFICAT DE RECEPTION INSPECTION CERTIFICATE
ABNAHMEPRÜFZEUGNIS СЕРТИФИКАТ

(A02) Acc. to EN 10204:2004 type 3.1
/nr normy/

Strona Page Page Seite Страница 1/2

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....

(A08) Zamawiający T.A.L.
Acheteur-Customer-Besteller-Заказчик

☐ review ☐ Witness

(A06) Adres wysyłkowy
Adresse-Address-Versandadresse-Адрес получателя

(A07) Nr zamówienia klienta
Numéro de la commande du client Purchaser's order No Kundenbestellnummer
No заказа

(A08.04) Nr potwierdzenia
Date de la commande Manuf. Order No Werksauftragsnummer
Приказ №

PL/ABR/19/01838/H2000395
OF 200224

4329003/20

Wyszczególnienie zamówienia:
Specyfication de la commande-Order Specification-Spizifikation der Bestellung-Спецификация заказа

Wyrób i wymagania dodatkowe (stan obr. termicz., mech. itp.) Produit et prescriptions supplémentaires (traitement thermique et usinage) Product and any supplementary requirements (Heat and mechanical treatment etc.) Erzeugnis und Zusätzliche Anforderungen (therm und mechan. Bearbeitung usw.) Продукта и дополнительные требования (состояние терм. и механобраб. и пр.)	Wymiar wyrobu Dimensions du produit Product dimensions Masse des Erzeugnisses Размер продукта	Oznaczenie stali Désignation del'acier Steel designation Stahlbezeichnung Марка стали	Wytop Coulée Heat Abstich Плавка	Sztuk Pieces Pièces Stück Штук	mb ft (c. mtr.) c. mtr. 1. M пог. м	kg lb (kg) кг
(B01.B03) Hot rolled seamless steel pipes acc.to API 5L - PSL1/18/EN ISO 3183 : 2012/ A1:2018 - PSL1/ ASTM A333/A333M/18/ A999/ A999M/18/ ASME SA 333/ SA999/ SEC.II.PART.A/19. Outside diameter tolerances +/- 0,75 % . Bevelled ends acc. to API - 5L . Outside surface lacquered. Normalized 910 °C/20'. Pipes hot finished > 850 °C and cooled in still air. Melting proces of the steel :E. Fully killed. Charge material of Polish origin.	(B09) 10,750" x 0,365" (273 x 9,27 mm) 7 - 11,8 m	(B02) 6/X52/L360	(B07) 886752	(B08) 26	(B15) 232,35	(B13) 14502

☒ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 24 OTT. 2024

Kontrolę techniczną powyższego zamówienia przeprowadził Oddział Technicznej Kontroli. Wyniki badań podano niżej.
Le controle technique de la cde exécuté par le Service de Controle. Les resultats des essais sont indiqués ci-après.
The technical investigation of this order has been executed by the Works Control. Results of tests are as follows.
Die technische Prüfung obiger Bestellung wurde von der Fabrikationskontrolle durchgeführt. Die Ergebnisse der Proben sind nachstehend angeführt.
Технический контроль вышеупомянутого заказа произвел Отдел Технического Контроля. Результат испытания представлен ниже.

1. SKŁAD CHEMICZNY - COMPOSITIO CHIMIQUE – CHEMICAL COMPOSITION – CHEMISCHE ZUSAMMENSETZUNG
(C71-C92) ХИМИЧЕСКИЙ СОСТАВ

Wytop Coulée Heat Abstich Плавка	C	Mn	Si	P	S	Cr	Ni	Cu
(B07) 886752 control anal. control anal.	0,14	1,26	0,23	0,010	0,004	0,09	0,09	0,18
	0,15	1,28	0,24	0,010	0,005	0,09	0,09	0,18
	0,16	1,28	0,24	0,010	0,004	0,09	0,09	0,18
	Al	Mo	V	Ti	Nb	N	Ceq	
	0,035	0,04	0,05	0,000	0,001	0,008	0,40	
	0,035	0,04	0,05	0,000	0,001	0,011	0,42	
	0,035	0,04	0,05	0,000	0,001	0,011	0,42	

Approved by QUALITY1 on 23/03/20

TAL SPA - THIS DOCUMENT IS REPRODUCED BY A COMPUTERIZED SYSTEM AND IS CONFORMAL THE ORIGINAL

Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962080190 - TEL. 0373-24225
DENTI MARTA
RESP. QUALITA'

F.I.R.A.S. DI CROCE SRL P.O. 24/GR/2231/1 TAL JOB N°424005123 OUR DDT N°202405445 OF 23/09/24
N° 1 MT 8.94 HEAT 886752 DIMENSIONS 273 x 9,27 ITEM 1

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness

2. BADANIA MECHANICZNE – ESSAIS MECANIQUES – MECHANICAL TESTS – MECHANISCHE UNTERSUCHUNGEN
МЕХАНИЧЕСКИЕ ИСПЫТАНИЯ
Date: 24/10/2024

Nr wytopu lub próby No de la coulée ou De l'eprouvette Heat No Or. Tests No Abstich Oder Probe No № плавки или пробы	$Rt_{0,5}$ MPa min 360	Rm MPa min 460	A 2" % min 30,0	Z %	Badanie udarności Impact Impact test Kerbschlagprobe Испытание на удар acc. to ASTM E23 KV(10x10mm) (L) min 27J/-53 °C (C40,C41,C02) Wartość pojedyncza / Valeurs individuelles / Individual values / Einzelwerte / Единственный результат	Średnia / Moyenne / Mean / Mittel / Среднее	Twardość Dureté Hardness Härte Твердость acc.to NACE MR 0175/ISO 15156-2/15 AN.A.P. 2.1.2 and NACE-MR 0103/ISO 17945/15 P.13.1 MAX 22 HRC/ 237 HB (C30)	°C MPa min
(B07.C02.C00)	(C11)	(C12)	(C13)	(C50-69)	(C42)	(C43)	(C31)	(C50-C69)
Test size: 1½" 86752/6031 L	413	552	40,1		100% Shear area 300 - 209 - 202	204	163 HB 163 HB	
886752/6032	401	544	40,1					

3. INNE BADANIA – AUTRES ESSAIS – OTHER TESTS – ANDERE UNTERSUCHUNGEN – ДРУГИЕ ИСПЫТАНИЯ
(D51-D99)
Guarantee grain size acc.to ASTM E 112 min. 8.
(Z04)

BADANIA TECHNOLOGICZNE – ESSAIS TECHNOLOGIQUES – TECHNOLOGICAL TESTS – TECHNOLOGISCHE PRÜFUNGEN
ТЕХНОЛОГИЯ ИССЛЕДОВАНИЯ

Flattening test - positive results
Each pipes has been hydrostatically tested by pressure 20,5 MPa - positive results - time 5 s

Powierzchnię i wymiary zbadano w 100% - Surface et dimensions ont été controlés et 100% - Surface and dimensions tested at 100%
Oberfläche und Abmessungen geprüft zu 100% - Наружный осмотр и проверка измерений произведены в 100% - positive results

4. BADANIA NIENISZCZĄCE - Essais Non Destructifs – Non Destructive Tests – Zerstörungsfreie Prüfungen - Неразрушающий Контроль (D03-D50)

Numery rur - Le nombre de tubes - Numbers of tubes - Nummern von Rühren - Номера трубок

5. UWAGI DODATKOWE – Additional Remarks – Autresobservations – Andere Bemerungen- Дополнительные примечания (Z05-Z99)
Approved acc. to AD2000-Merkblatt W0 by TÜV NORD Systems GmbH & Co. KG. Certified acc. to Pressure Equipment Directive 2014/68/UE annex I, sec 4.3 by the Certification body for pressure equipment of the TÜV NORD Systems GmbH & Co. KG, reg.-no. 0045. Certificate No 07/203/9120/WP/0888/19R1 and Certificate No 07/202/9120/WZ/0888/19/R1 and ISO 9001/TUV Certificat No 04-100 950250-001.

(Z01)Niniejszym potwierdzamy, że wyżej wymieniony materiał został zbadany i spełnia warunki potwierdzenia zamówienia - Par la présente je confirme que le material susmentionne a été examine et il remplit les conditions de la confirmation de commande.- We hereby certify, that the material described above has been tested and complies with the terms of the order.- Es wird bestaetigt, dass das oben genannte Material gepreuft wurde und den Bedingungen der Bestellung entspricht.- Подтверждаем, что вышеуказанный материал был протестирован и соответствует условиям подтверждения договора.

(D01)Cechowanie – Marquage – Marking – Kennzeichnung – Обозначен
Acc. to API 5L / X52/ PSL1 /Monogram API5L/ ISO 3183/ L360/ PSL1/A333/A999/ SA333 /SA999/ 6.

(D51-D99)Na podstawie wyżej przeprowadzonych prób material zwolniono – Sur la base des essais si-dessus le material est dliv-According to the carried out tests the material relensed – Untersuchungen wurde das Material freigegeben – На основании вышеописанных Испытаний признан годным.

Kontrola Jakości Contrôle de Fabrication Control of Manufacture Fubrikationskontrolle Технический контроль (Z03)	Dyrekcja Direction Management Direktion Дирекция (Z05)	(Z02)
KJ 21/634 SPECJALISTA Z ZAKRESU KONTROLI JAKOŚCI Halina Rehmet	Kierownik Działu Kontroli Jakości i Nadzoru Technologicznego Barbara Czyż	dn. 19.03. 2020 r. 1543/EXP/R/20 Strona Page Page Seite Страница 2/2

REVIEW ☐ WITNESS
ON BEHALF OF RTG
A. BELLARINA DATE 24 OTT 2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

F.I.R.A.S. di CROCE s.r.l.

COPIA CONFORME ALL'ORIGINALE

B 2 of 2

TAL SPA - THIS DOCUMENT IS REPRODUCED BY A COMPUTERIZED SYSTEM AND IS CONFORM TO THE ORIGINAL

Approved by QUALITY1 on 23/03/20

FIL-PEMTO s.p.a.
Valvole & raccordi
Sede di: 21042 CARONNO PERTUSELLA (Varese)
Via Asiago, 1880 - Telefax 02.9657200
Telefono 02.9657141 (r.a.)

CERTIFICATO DI COLLAUDO 3.1 EN 10204:2004

INSPECTION CERTIFICATE CERTIFICAT DE RECEPTION

COMPANY WITH QUALITY SYSTEM CERTIFIED BY RINA - ISO 9001 -

MATERIALE: - *MATERIAL:* - *MATERIEL:*
SA350LF2 CL.1

CLIENTE - *CUSTOMER* - *CLIENT*
F.I.R.A.S. DI CROCE SRL
VIA GALVANI 24/26
SETTIMO MILANESE

ORDINE - *ORDER* - *COMMANDE*
ORD.24/GR/2231/131

SIGLA PRODUTTORE FLANGE *MARK SIGLE* NOV

N° CER-5315/24
DATE 12/09/2024
BOLLA DI CONSEGNA - *DELIVERY NOTE - BORDEREAU LIVRAISON* N° 6866
12/09/2024 pag. 1 di 1

ANALISI CHIMICA: - CHEMICAL COMPOSITION - COMPOSTION CHIMIQUE

Colata *Heat* *Coulée*	QTY	DESCRIZIONE PRODOTTO *PRODUCT DESCRIPTION* DESCRIPTION DE PRODUIT	C %	Si %	Mn %	S %	P %	Ni %	Cr %	Mo %	Al %	N %	Cu %	Ti %	V %	Nb %	C.Eq.
BH0727	4	FLANGE A350LF2 ANSI 150 LWN RF 1" Lg.228,6	0.190	0.20	1.02	0.003	0.007	0.08	0.12	0.03	0.030	0.000	0.10	0.002	0.002	0.000	0,402

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024

CARATTERISTICHE MECCANICHE - *MECHANICAL TESTS - ESSAIS MECANIQUES*

Acciaieria *Steel manufactory* *Fournisseur*	Colata *Heat* *Culée*	Provetta / Test specimen: Sez. mm *Sect. mm*	Lung. mm *Lenght. mm*	Forma *Shape*	Sez.	Rottura *Tensile str.* Resistence N/mm^2	Snervamento *Yield point* Limite él. N/mm^2	Allungamento *E longation* Allongem %	Contrazione *Red. of area* Contraction %	Durezza *Hardness* Dureté Hb	Resilienza - *Impact Value - Resilience - Joule/cm^2*: TIPO *Type*	1.	2.	3.	Media	°C
O.R.I. MARTIN S.P.A.	BH0727	12,50	50	◯	T	562	391	30.1	52.7	171-172	KV	52	55	56	55	-46

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

☐ REVIEW ☐ WITNESS
ON BEHALF OF RRG
A. DELLA PINA DATE 24 OTT 2024

F.I.R.A.S. di CROCE s.r.l.

COPIA CONFORME ALL'ORIGINALE

MANUFACTURED IN ACCORDANCE WITH ORDER AND SPECIFICATIONS

STEEL PROCESS INFORMATION:
SUPPLY STATEMENT:

ADDITIONAL TEST RESULT

Note:
DIMENSION FLANGES ACCORDING TO ASME/ANSI B16.5 Ed.2020 AND EN1092-1 Ed 2018
ASME II PART A ED.2019 - ACCORDING TO NACE MR 01-75 - MR01-03 /ISO15156
ACCORDING TO PED 2014/68/UE FULLY KILLED FINE GRAIN

TRATTAMENTO TERMICO *HEAT TREATMENT - TRAITMENT TERMIQUE*
NORMALIZED AT 920 °C
AND COOLED IN STILL AIR

CONTROLLO VISIVO E DIMENSIONALE *VISUAL AND DIMENSIONAL CONTROL*
SATISFACTORY

UFFICIO CONTROLLO QUALITA' *QUALITY CONTROL DEPARTMENT*
FIL- PEMTO S.p.A.

ENTE COLLAUDATORE (RESPONSABILE COLLAUDO) *INSPECTION AUTHORITY (INSPECTOR)*

480 + 481

NLMK Verona

CE 0036 08
DOP NO. 302-CPR-01/07/2013EN 10025-1

Numero di certificato / Mill test certificate A03: 22378
Data / Date Z02: 17/06/24
Certificato di collaudo / Inspection report A02: EN 10204:2004 3.1

AZIENDA CON SISTEMA DI GESTIONE PER LA QUALITÀ CERTIFICATO ISO 9001 DA DNV
QUALITY SYSTEM CERTIFIED ISO 9001 BY DNV
Copia Conforme all'Originale / Certified Copy of the Original

Cliente / Customer A06:
EUSIDER HEAVY PLATES SPA
VIA TORTONA 25
20144 MILANO (MI)

Nostra conferma n./riga / Manufacturer's works order number A08: 62799/ 670
Ordine cliente / Purchaser order A07: 204216
D.D.T. n. / Delivery note A10: 6754
Data / Date: 19/06/24

Colata n. / Heat n. B07: N242498043
N. unità collaudo / Identification samole C00: 44003283
Lamiera capostipite / Identification sample C00: N2424980430A111
Prodotto / Product B01: Lamiera Bordo Grezzo
Stato di fornitura / Delivery condition B04: +N

Norma / Standard B14: EN 10025-2:2019
Acciaio / Steel grade B02: S355J2+N
Scheda n. / Identification nr B07: N2424980430A121
Dimensioni / Sizes (mm / Inches) B09: 25,0 x 2450 x 6500 mm
Pezzi / Pieces B08: 1
Massa teorica / Theorical mass t B12: 0,000
Massa effettiva / Actual mass t B13: 3,375

Acciaio prodotto B.O.F. - Materiale esente da radioattività e da mercurio / Steel produced by B.O.F. - Radioactivity free/Mercury free C70

Analisi chimica % C71	C	Mn	Si	P	S	Cr	Ni	Mo	Al	Cu	Nb	V	Ti	N ppm	Ceq
Chemical composition %	0,16	1,49	0,23	0,013	0,0020	0,03	0,02	0,002	0,027	0,03	0,020	0,024	0,002	67	0,42

Prove di trazione / Tensile test C15

B05 Trattamento provino Specimen Treatment	C03 Temperatura di esecuzione Test Temperature °C	C01 Posizione prelievo Position of test pieces	C02 Senso prelievo Direction of the test pieces	Tratto utile / Gauge length 5,65 x √So C14: C12 Tensile Strenght Rm MPa	C11 Yield point Reh MPa	C13 Elongation A %
+N	+20	2	T	530	412	29

Prova di resilienza / Impact test C40

B05 Trattamento provino Specimen Treatment	C03 Temperatura di esecuzione Test Temperature °C	C44 Posizione prelievo Position of test pieces	C45 Senso prelievo Direction of the test pieces	C42 Provino Specimen 10X10 $KV_2$1 J	C42 Provino Specimen 10X10 $KV_2$2 J	C42 Provino Specimen 10X10 $KV_2$3 J	C43 Provino Specimen 10X10 KV_2X J
+N	-20	2	L	205	214	219	213

C31 Durezza Hardness HBW 2,5/187,5	C51 Trazione sullo spessore TTP (Z%) 1	C51 Trazione sullo spessore TTP (Z%) 2	C51 Trazione sullo spessore TTP (Z%) 3	C51 Trazione sullo spessore TTP (Z%) X	C53 Prova di piega - Bend test

DDT.81154077
N.1 FOGLIO 25X2500X6000

EUSIDER HEAVY PLATES COPIA CONFORME ALL'ORIGINALE

REVIEW ☒ WITNESS ☐
ON BEHALF OF RTG ENCORE THERMOENGINEERING S.r.l.
QC Inspection
DELLA PINA DATE 24 OTT 2024 By

Altre prove / Other test D02:
Controllo ultrasuoni / Ultrasonic test
Prove inclusionali / Inclusional test

Specifica cliente / Customer supplementary requirements C06:
☐ Review ☐ Witness
Date 24/10/2024

Marcatura e identificazione, aspetto della superficie, forma e caratteristiche dimensionali soddisfacenti / Marking and identification, surface appearance, shape and dimensional properties satisfactory D01
Marking: NLMK VERONA, identification nr, Steel grade, Sizes

Tolleranze dimensionali e di forma / Dimensione and shape tolerances D01:
EN 10029 CLASSE A
Interne NLMK
EN 10029
EN 10029 CL N

Condizione superficiale / Surface condition D01:
EN 10163-1-2:2005 A1

We hereby certify that the material has been made and tested in accordance with the specification(s) mentioned in the purchase order Z01

Note: 2,=2 mm to skin

Ente collaudatore / Inspection body Z03:

Preparato controllo qualità / Issued by quality control A05:
MATTEO ALDEGHERI

Verificato responsabile controllo qualità / Checked by quality control Z01:
ALESSANDRA LISSIGNOLI

(C01-C44) Posizione prelievo / Specimen location :

(B05) Trattamento provino / Specimen treatment : Laminazione di normalizzazione / Normalizing rolling

(B04) Stato di fornitura / Delivery condition : Laminazione di normalizzazione / Normalizing rolling

(C02-C45) Direction of the test pieces: L:longitudinal T:transverse S:thickness

2.2.4 Visual and Dimensional reports

SEE ATTACHED NEXT PAGE

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TICI S.R.L. TECNOLOGIA INDUSTRIALE COSTRUZIONE IMPIANTI	**CERTIFICAZIONE ISPETTIVA** **VERBALE DI CONTROLLO VISIVO E DIMENSIONALE** ***Inspection Certificates*** ***Visual & Dimensional Test Report***	**Mod. Rev. 0** 13/10/2009 Pag. 1 di 1

CLIENTE *Client*	ENCORE THERMOENGINEERING s.r.l.	IMPIANTO *Plant*	HYDROGEN VENT
N°ORDINE *P.o. No.*	23 – 0193-OA24-00100 REV. 0		
DATA ORDINE *PO Date*	25.07.2024	COD. COMMESSA *Internal Job No.*	23 – 0193 ROSETTI MARINO

LOCALITA' COLLAUDO *Inspection location*	T.I.C.I MONTODINE (CR) - ITALY	DATA *Date*	31.10.2024
IDENTIFICAZIONE COMPONENTE *Component identification*	**HYDROGEN VENT_VENT TIP**		
	DWG: **1724000887-MAC-DA-00003_03**		
PROCEDURE DI COLLAUDO *Test procedures*	ASME V – ASME IX		

Si certifica che sui componenti elencati, in relazione ai documenti di riferimento, alle relative procedure sopra indicate, sono stati eseguiti i seguenti collaudi:
We hereby certify that in relation of the described components, to the mentioned reference documents, in accordance with the listed test procedures, the following test has been executed:

DESCRIZIONE *Description*	DATA *Date*	ESITO *Result*		AZIONI *Actions*				TIPO *Type*	
		Positivo *Positive*	Negativo *Negative*	Accettato *Accepted*	Riparare *Repair*	Scartato *Rejected*	Ripetere *Repet*	Totale *Total*	Parziale *Partial*
CONTROLLO VISIVO E DIMENS. – Fit-up *Visual and Dimensional Inspection – Fit-up*	26.10.2024	OK							
CONTROLLO TRACCIABILITA' MATERIALI Check of material identification	26.10.2024	OK							
CONTROLLO VISIVO SALDATURE *Welding Visual Inspection*	30.10.2024	OK							
CONTROLLO VISIVO E DIMENS. PRIMA DELLA VERNICIATURA *Visual and Dimensional Inspection Before release to painting*	31.10.2024	OK							

	Note	*Notes:*

ISPETTORE *Inspector*	DATA *Date*	FIRMA *Signed*	
T.I.C.I. Q.A.	31.10.2024	MARTA DENTI	By .....
CLIENTE *Client*	31/10/2024		Date: 31/10/2024
COMMITTENTE *Client*			
ENTE INCARICATO *Inspection Authority*			

ENCORE THERMOENGINEERING S.r.l
QC Inspection
T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
00962080190 - TEL. 0375 242255
DENTI MARTA
RESP. QUALITA'

CROSSWIND
31/10/24 W/R

TICI S.R.L. TECNOLOGIA INDUSTRIALE COSTRUZIONE IMPIANTI	**CERTIFICAZIONE ISPETTIVA** **VERBALE DI CONTROLLO VISIVO E DIMENSIONALE** ***Inspection Certificates*** ***Visual & Dimensional Test Report***	**Mod. Rev. 0** 13/10/2009 Pag. 1 di 1

CLIENTE *Client*	ENCORE THERMOENGINEERING s.r.l.	IMPIANTO *Plant*	HYDROGEN VENT
N°ORDINE *P.o. No.*	23 – 0193-OA24-00100 REV. 0		
DATA ORDINE *PO Date*	25.07.2024	COD. COMMESSA *Internal Job No.*	23 – 0193 ROSETTI MARINO

LOCALITA' COLLAUDO *Inspection location*	T.I.C.I MONTODINE (CR) - ITALY	DATA *Date*	19/11/2024
IDENTIFICAZIONE COMPONENTE *Component identification*	**HYDROGEN VENT**		
	DWG: **1724000887-MAC-DA-00003_03**		
PROCEDURE DI COLLAUDO *Test procedures*	ASME V – ASME IX		

Si certifica che sui componenti elencati, in relazione ai documenti di riferimento, alle relative procedure sopra indicate, sono stati eseguiti i seguenti collaudi:
We hereby certify that in relation of the described components, to the mentioned reference documents, in accordance with the listed test procedures, the following test has been executed:

DESCRIZIONE *Description*	DATA *Date*	ESITO *Result*		AZIONI *Actions*				TIPO *Type*	
		Positivo *Positive*	Negativo *Negative*	Accettato *Accepted*	Riparare *Repair*	Scartato *Rejected*	Ripetere *Repet*	Totale *Total*	Parziale *Partial*
CONTROLLO VISIVO E DIMENS. – *Visual and Dimensional Inspection*	19/11/2024	OK							

	Note	*Notes:*

ISPETTORE ***Inspector***	DATA ***Date***	FIRMA ***Signed***	TIMBRO *Stamp*
T.I.C.I. Q.A.	19.11.2024	**MARTA DENTI**	T.I.C.I. S.R.L. Via dell'Artigianato, 6 26010 MONTODINE (CR) P. I. 00962060190 - TEL. 0373-242255 DENTI MARTA RESP. QUALITA'
CLIENTE *Client*	19.11.2024	LINARI STEFANO	ROSETTI MARINO
COMMITTENTE *Client*	19.11.2024	ANGELO D'ONGIA	ENCORE THERMOENG.
ENTE INCARICATO *Inspection Authority*			

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☒ Witness
Date: 19/11/2024

× CROSSWIND
19/11/24 W/R

delucchi
ZINCHERIA A CALDO

AZIENDA CON SISTEMA DI GESTIONE QUALITÀ CERTIFICATO DA DNV GL = ISO 9001 =

Membro di alz

AGA

HIQUALIZINC

DICHIARAZIONE DI CONFORMITA'
Inspection certificate

Numero: D0982/24 number:	Data: 19/11/2024 date:
Commessa/e n° Production order no.	2406104

Spett.le/Dear Sirs

Cliente/customer: RACCHETTI ALFREDO ARNALDO

Indirizzo/address: VIA MILANO, 43 LOC. CAVATIGOZZI
CREMONA (CR)

Ordine/order: _____ Referente/Person in charge: _____

tel 0372 491104 fax _____

Il materiale/material

da noi ricevuto nelle seguenti date/received on the following dates: 18/11/2024

con Vostri d.d.t. numero-data/with your document number -date: D00849 - 18/11/2024

Descrizione/description: **PROT. 452/24 TICI - unica entrata RIF. ROSETTI MARINO**
GRIGLIATO BORDATO MAGLIA 30x50 - 30x5
N. 07 PEZZI DI VARIE MSIURE SAG.

Spedito il giorno/sent on: 19/11/2024 **con d.d.t. numero**/with document no. 6074

è stato zincato in conformità alle seguenti norme:
has been hot dip galvanized in according the following standards:

UNI EN ISO 1461

Le caratteristiche del rivestimento rilevate soddisfano quanto prescritto dalle norme indicate. *Qualità provata HiQualiZinc.*
Tested specifications satisfy requirements stated by the standards. *Proven quality HiQualiZinc.*

Trezzano Rosa, lì 19/11/2024

Firma RQA/Signature RQA

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 19/11/2024

delucchi S.p.A.

20060 TREZZANO ROSA (MI) - ITALIA – via Bologna 9 - zona ind.
tel. +39(0)2 90960474 - fax +39(0)2 90968181
http://www.bisolzinco.it /ita/gruppo/delucchi
delucchi@bisolzinco.it

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
PEC: tici.srl@pec.it - SDI: J6URR1W

TICI S.R.L. TECNOLOGIA INDUSTRIALE COSTRUZIONE IMPIANTI	**CERTIFICAZIONE ISPETTIVA** **VERBALE DI CONTROLLO VISIVO E DIMENSIONALE** ***Inspection Certificates*** ***Visual & Dimensional Test Report***	**Mod. Rev. 0** 13/10/2009 Pag. 1 di 1

CLIENTE *Client*	ENCORE THERMOENGINEERING s.r.l.	IMPIANTO *Plant*	HYDROGEN VENT
N°ORDINE *P.o. No.*	23 – 0193-OA24-00100 REV. 0		
DATA ORDINE *PO Date*	25.07.2024	COD. COMMESSA *Internal Job No.*	23 – 0193 ROSETTI MARINO

LOCALITA' COLLAUDO *Inspection location*	T.I.C.I MONTODINE (CR) - ITALY	DATA *Date*	24.10.2024
IDENTIFICAZIONE COMPONENTE *Component identification*	**HYDROGEN VENT**		
	DWG: **1724000887-MAC-DA-00003_03**		
PROCEDURE DI COLLAUDO *Test procedures*	ASME V – ASME IX		

Si certifica che sui componenti elencati, in relazione ai documenti di riferimento, alle relative procedure sopra indicate, sono stati eseguiti i seguenti collaudi:
We hereby certify that in relation of the described components, to the mentioned reference documents, in accordance with the listed test procedures, the following test has been executed:

DESCRIZIONE *Description*	DATA *Date*	ESITO *Result*		AZIONI *Actions*				TIPO *Type*	
		Positivo *Positive*	Negativo *Negative*	Accettato *Accepted*	Riparare *Repair*	Scartato *Rejected*	Ripetere *Repet*	Totale *Total*	Parziale *Partial*
CONTROLLO VISIVO E DIMENS. – Fit-up *Visual and Dimensional Inspection – Fit-up*	16.10.2024	OK							
CONTROLLO TRACCIABILITA' MATERIALI Check of material identification	16.10.2024	OK		24 OTT 2024					
CONTROLLO VISIVO SALDATURE *Welding Visual Inspection*	23.10.2024	OK		24 OTT 2024					
CONTROLLO VISIVO INT. / EST. PRIMA DELLA PROVA IDRAULICA *Int. / Est. Visual and Dimensional Inspection Prior to Hydrostatic testing*	23.10.2024	OK		24 OTT 2024					
CONTROLLO VISIVO E DIMENS. PRIMA DELLA VERNICIATURA *Visual and Dimensional Inspection Before release to painting*	24.10.2024	OK		24 OTT 2024					

	Note	*Notes:*

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By: .....
Review ☐ Witness ☐

ISPETTORE *Inspector*	DATA *Date*	FIRMA *Signed*	
T.I.C.I. Q.A.	24.10.2024	MARTA DENTI	T.I.C.I. S.R.L. Via dell'Artigianato, 5 26010 MONTODINE (CR) P.I. 00962060190 - TEL. 0373 242255 DENTI MARTA RESP. QUALITA' Date: 24/10/2024
CLIENTE *Client*	24/10/2024		
COMMITTENTE *Client*	24 OTT 2024		OBO RTG
ENTE INCARICATO *Inspection Authority*			

REVIEW ☐ WITNESS ☒
ON BEHALF OF RTG
A. BELLAPINA DATE 24 OTT 2024

2.2.5 NDE reports and operators 'qualification

SEE ATTACHED NEXT PAGE

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Prüfzertifikat / Certificate

Für Einstellnormale zur Ferritgehaltmessung nach dem Magnetinduktiv-Verfahren

Die Ferritgehalte der unten aufgeführten Einstellnormale wurden durchVergleichsmessungen mit bei der Firma FISCHER vorhandenen Referenznormalen bestimmt. Die Referenznormale für Ferrit Nummer sind Schweißproben hergestellt von der Fa. Teledyne McKay (USA); die Referenznormale für den in Prozent angegeben Ferritgehalt sind gegossene Proben, hergestellt von der Firma Avesta (Schweden) und der Bergakademie Freiberg. Die Messung wurde mit dem magnetinduktiven Verfahren durchgeführt. Die nachstehenden Werte sind Mittelwerte aus 5 * 5 Einzelmessungen.
Für die Ferrit Nummer Werte sind die Referenznormale der Firma FISCHER rückführbar auf den Einstellnormalsatz vom Welding Institut in Abington (GB) Satz Nr.: 32 vom Mai 1980.
Die Garantiefehlergrenze beträgt +/- 5% des beschrifteten Wertes des Standards oder +/- 0,4 FN. Es gilt der größere Wert.

Calibration standards for calibration of ferrite measuring instruments using the magnetic induction method

The ferrite content of standards covered by this certification has been determined by comparative measurements against secondary master standards owned by
HELMUT FISCHER GmbH & Co. The WRC Ferrite Number (FN) secondary master standards were manufactured by Teledyne McKay Company (USA). The Teledyne Mc Kay secondary weld metal standards comprise of austenitic stainless steel weld metal which has been deposited using the submerged-arc strip cladding method. These WRC Ferrite Number (FN) secondary master standards are traceable to secondary weld metal standards supplied by the Welding Institute of Abington UK., standards set 32 dated May 1980.
The ferrite percent secondary master standards consists of cast samples manufactured by Avesta Company (Schweden) and the Bergakademie Freiberg (Germany). The comparative measurements were made using the magnetic induction method.
The certified standards value is a mean of 5*5 single measurements. The guaranteed uncertainty is the greater of ± 5% of the certified value or ± 0.4 FN.

CERTIFICATO DI CONTROLLO No:000089620 - ULTIMO LUGLIO 2024 - PROSSIMO: 10/07/2025

Set No.: NA - 0589	No.	FN(Ferrit No.)	Ferrit %
BASE			
	58673	10,2 FN	11,3 Fe%
	58674	39,9 FN	35,0 Fe%
	58675	123,5 FN	85,6 Fe%

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By ..... Review ☐ Witness
Date: 31/10/2024

Bitte beachten Sie die Hinweise zur Gewährleistung und zur Messmittelüberwachung auf der Rückseite
Please turn-over for more information about warranty and calibration standard inspection

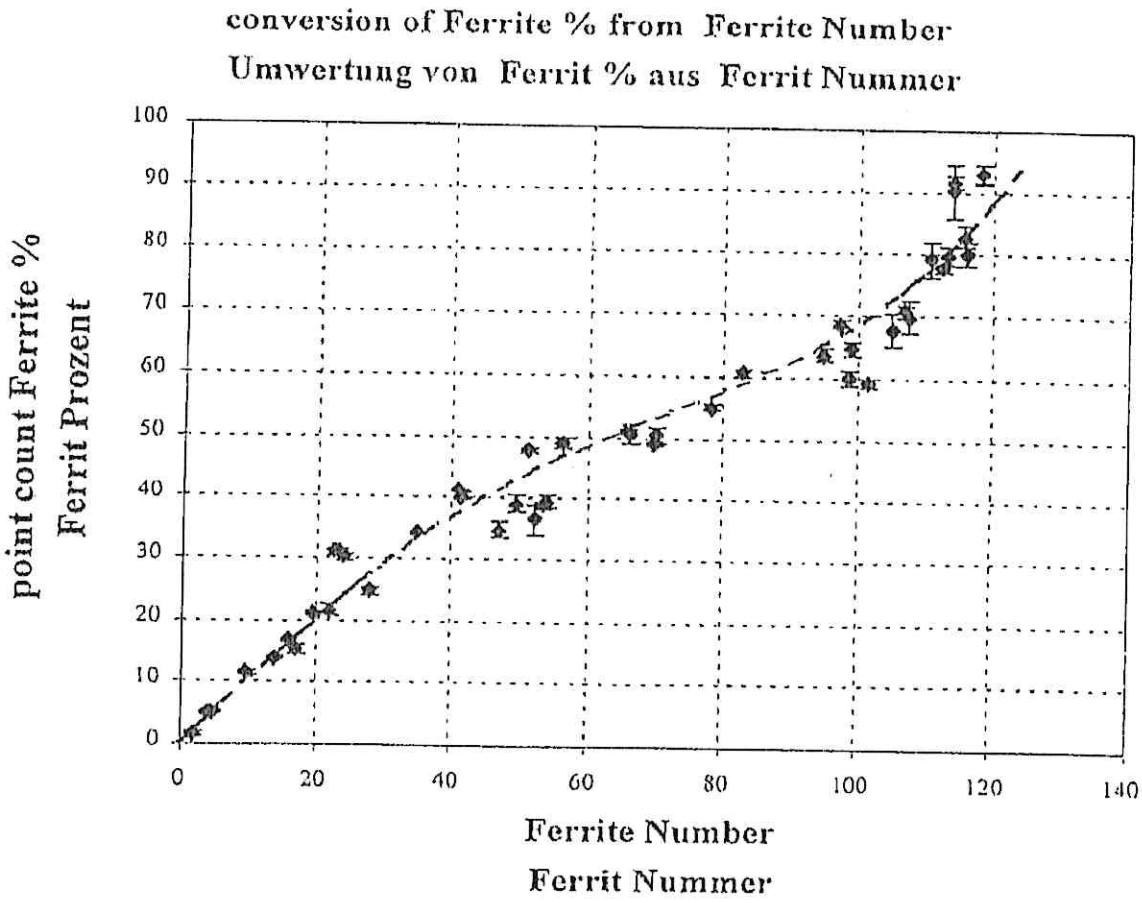
Datum / date: 10/07/2017

Unterschrift/ Signed:

HELMUT FISCHER GMBH + CO
Institut für Elektrotechnik und Messtechnik
D - 71050 Sindelfingen, Postfach 600161
Tel.(07031) 303-0, Fax (07031) 303 - 79

Physikalisches Versuchslabor/ Standards Department

ISO 9001



Gewährleistung: Unsere Garantie für die gelieferten Einstellnormale bezüglich herstellungs bedingter Mängel gilt für einen Zeitraum von 3 Monaten ab dem Datum der Lieferung.
Prüfmittelüberwachung: Wir empfehlen für die Prüfmittelüberwachung der hier zertifizierten Einstellnormale ein Intervall von 12 Monaten. (fachgerechte Anwendung vorausgesetzt)
Hinweis: Vor jeder Benutzung sollten die Einstellnormale visuell auf äußerliche erkennbare mechanische Beschädigungen wie Eindrücke, Korrosion oder Oberflächenverschmutzung, überprüft werden.
Wir empfehlen Ihnen, Einstellnormale zu ersetzen, sobald sie sichtbare Gebrauchsspuren aufweisen.
Die Firma HELMUT FISCHER übernimmt keine Haftung für Folgeschäden, welche von unsachgemäßer Anwendung der Einstellnormale herrühren.
Unsere Gewährleistung umfaßt nur den kostenlosen Umtausch beanstandeter Einstellnormale.

Note: These standards are subject to wear effects. For this reason the standards can only be guaranteed for a period of three month from the delivery date. This warranty covers manufacturing defects only.
We recommend that you return these standards to FISCHER annually for recertification.
Prior to each use inspect the standards for obvious mechanical defects, such as deep scratches, gouges, corrosion, contamination or other defects. Any standards showing mechanical defects should be replaced promptly.
If any new standards proves to be defective, we shall replace it with a new standard. This replacement shall be our exclusive remedy. In no event will we be liable for any special or consequential damages.
Our warranty only covers the even exchange of faulty calibration standards free of change.

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☑ Review ☐ Witness
Date: 31/10/2024

IRTEC SRL

Istituto di ricerche tecnologiche e collaudi

RAPPORTO DI PROVA / *Test report*	**RC240286**	**Data** / *Date*	**31/10/2024**
COMMESSA n° ***JOB No.***	**JC240194**	**PAGINA** / *Page*	1 / 2

CLIENTE *Customer*	**T.I.C.I. S.r.l.** 26010 MONTODINE – CR – ITALY Via DELL'ARTIGIANATO,6	**UTENTE** *User*	/

CON ORDINE / *With Order*	---	**DEL** / *dated*	///
RIFERIMENTO / *Reference*	---	**DEL** / *dated*	///
RICEZIONE / *Reception*	INTERVENTO ESTERNO	**DEL** / *dated*	31/10/2024
ACCETTAZIONE / *Acceptance*	---	**DEL** / *dated*	///

OGGETTO DELLE PROVE : *Object of the tests :*	**Controllo ferrite.** *Ferrite Control.*

IL CAMPIONE E' COSI' DESCRITTO DAL CLIENTE
The sample is as described by the customer

	DESCRIZIONE *Description*	**DIMENSIONI** *Dimension*	**DESCRIZIONE** *Description*	**COLATA N°** *Heat N°*	**CERTIFICATO** *Certificate*	**DATA** *Date*
MATERIALE *Material*	AISI 316 – L	Ø323,85	HYDROGEN VENT	---	---	---

ALTRE INFORMAZIONI : *Other features*	**JOB. 23 – 0193 – DWG N°.: 1724000887-MAC—DD-00005 REV. 5**

IL RAPPORTO CONTIENE LE SEGUENTI PROVE
Report is relative to the following tests

DESCRIZIONE *Description*	**METODO** *Method*	***CAMPIONE*** *Semple*	**PAGINA** *Sheet*	**PROVA** *Test*
PROVA di FERRITE / *Ferrite test*	**NDT-FE-04 E1 R0h**	**286**	**2**	**240286 - 1**

PROVE NON ACCREDITATE
(*) *Not Accredited Test*

VEDI DICHIARAZIONI NELLA PAGINA DI FINE DOCUMENTO
See statements on the end of document page

x CROSSWIND
31/10/24

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☑ Witness
Date: 31/10/204

ISPETTORE del CLIENTE / *Customer Inspector*	**ENTE di COLLAUDO** / *Inspection Agency*

IRTEC SRL

Istituto di ricerche tecnologiche e collaudi

RAPPORTO DI PROVA / *Test report*	**RC240286**	**Data** / *Date*	**31/10/2024**
COMMESSA n° ***JOB No.***	**JC240194**	**PAGINA** / *Page*	2 / 2

CONTROLLO FERRITE *Ferrite control*	**NDT-FE-04**	**PROVA** *Test*	**240286**

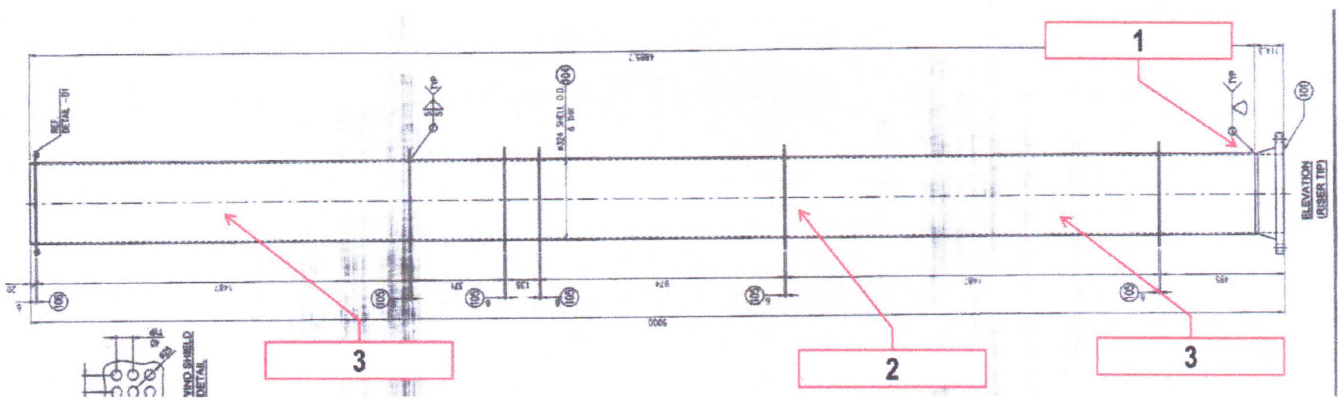
Inizio prova *Test date*	31/10/2024	**Fine prova** *Test end*	31/10/2024	**Temp. Prova** *Test temp.*	12,7°C	**Tec. qualificato** *Qualified tech.*	**VINCENZO SANTARCANGELO**

CAMPIONE N° *Sample n°*	**POSIZIONE** *Position*	**VALORI OTTENUTI** *Obtained Value*					**MEDIA** *Average*
286 - 1	**WELDING THO FLANGE SIDE OF WELD BY FERRITOSCOPE** FISCHER FMP30 S.N. 82618	**8,3**	**7,0**	**7,4**	---	---	**7,6**
286 - 2	**WELDING THO TUBE & TUBE SIDE OF WELD BY FERRITOSCOPE** FISCHER FMP30 S.N. 82618	**8,8**	**9,4**	**7,1**	---	---	**8,5**
286 - 3	**WELDING THO LONGITUDINAL TUBE SIDE OF WELD BY FERRITOSCOPE** FISCHER FMP30 S.N. 82618	**5,4**	**8,1**	**5,6**	---	---	**6,4**
NDT-FE-04 E1 R0h	**REQUISITI** / *Requirements*	**3 ÷ 12**					

DICHIARAZIONE di CONFORMITA' *Compliance statement*

I risultati di prova relativi ai misurandi nella tabella sopra riportata sono conformi ai requisiti previsti dalle norme di accettabilità sotto indicate sulla base della regola decisionale adottata e indicata nelle note finali.
The test results relating to the measurands in the table above comply with the requirements set by the acceptability standards indicated below on the basis of the decision rule adopted and indicated in the final notes.

NORME ACCETTABILITA' *Acceptability standards*: CUSTOMER REQUIREMENTS



CROSSWIND
31/10/24 W

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☑ Witness
Date: 31/10/2024

End Document

ISPETTORE del CLIENTE / *Customer Inspector*	**ENTE di COLLAUDO** / *Inspection Agency*

IRTEC SRL
SISTEMA DI QUALITA' CERTIFICATO ISO 9001:2015

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F.SANTI, 3
Tel. 02.90.96.15.41 • 2 - Fax 02.90.96.32.92
E-mail : info@irtecsrl.com Web: www.irtecsrl.com

REPORT No. REPORT	RC240274
COMMESSA JOB	JC240186
DATA DATE	2024/10/19
FOGLIO SHEET	1 DI OF 2

RC240274 JC240186 2024/10/19 10016 MODULO /FORM M-UT Rev. 0 UT TEST REPORT ***RAPPORTO DI PROVA UT***

CLIENTE *CUSTOMER*	***T.I.C.I. S.r.l.*** *– Via DELL'ARTIGIANATO,6 – 26010 MONTODINE – CR – ITALY* ***ROSETTI MARINO***	***ENTE DI COLLAUDO*** *INSPECTION AGENCY* //
COMMESSA *JOB*	*23 – 0193*	
OGGETTO *SUBJECT*	*ULTRASONIC EXAMINATION OF RISER SHELL & RISER BOTTOM : HYDROGEN VENT – DRAWING N°.: 1724000887 – MAC – DD – 00005*	
STADIO DI LAVORAZIONE *WORKING STAGE*	*FINISHED*	***SUPERFICIE*** *SURFACE* *MACHINED*
SPECIFICA *SPECIFICATION*	*EN1714 LIV.2 ACCEPTANCE CRITERIA: EN1712 LIV.2*	
APPARECCHIO *EQUIPMENT*	*Krautkramer USM 36 Serial Number 19027620*	
SONDE *TRANSDUCERS*	*Krautkramer*	***ACCOPPIAMENTO*** *COUPLING* *FYp Gel*

SONDE E TARATURA

TIPO *TYPE*	***FREQ.*** *FREQ. (MHz)*	***DIMENSIONI*** *DIMENSIONS (mm)*	***ONDE*** *WAVES (L - T)*	***ANGOLO*** *ANGLE (°)*	***BLOCCO DI CALIBRAZIONE*** *CALIBRATION BLOCK*	*Straight Beam: DGS diagram FBH Ø 3 mm*
SEB4	*4*	*Ø24*	*L*	*0*		

OPERATORE OPERATOR	Mr. ANDREA CAVALLO Level 2 UT – Certificate Bureau Veritas No. IND-23-02425-C					
NOTE REMARKS	EXTENT OF TESTING: 100% (*) Double crystal probe					
ESITO RESULT	**ACCETTABILE** ACCEPTABLE	☒	**RIPARARE** TO BE REPAIRED	☐	**SCARTARE** REJECTED	☐

POS.	MATERIALE	TYPE	Q.TY	RESULT
1	A516 Gr60	RISER SHELL	1	OK
2	A516 Gr60	BOTTOM	1	OK

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00992080190 - TEL. 0373-242255
PEC: tici.srl@pec.it - SDI: J6URRTW

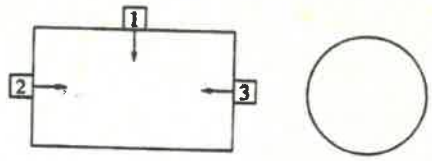
☑ REVIEW ☐ WITNESS
ON BEHALF OF RLG
A. DELLA PINA DATE 24 OTT 2024

ENCORE THERMOENGINEERING S.r.l.
QC Inspection

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE By ... Customer inspector	IL COLLAUDATORE ... The inspector
		☐ Review ☐ Witness Date: 24/10/2024	

RISER SHELL & BOTTON				
SONDA TRANSDUCER		FONDO SCALA FULL SCALE (mm)	AMPLIFICAZIONE (dB) AMPLIFICATION	
			TARATURA CALIBRATION	SCANSIONE SCANNING
1	SEB4	50	44	+6 dB
2	SEB4	50	44	+6 dB

SCAN POSITIONS



ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024

End Document

☑ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 24 OTT 2024

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customerinspector	IL COLLAUDATORE The inspector

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ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F.SANTI, 3
Tel. 02.90.96.15.41 • 2 - Fax 02.90.96.32.92
E-mail : info@irtecsrl.com Web: www.irtecsrl.com

REPORT No. REPORT	RC240273
COMMESSA JOB	JC240186
DATA DATE	2024/10/19
FOGLIO SHEET	1 DI OF 2

RC240273 JC240186 2024/10/19 10016 MODULO /FORM M-UT Rev. 0 UT TEST REPORT **RAPPORTO DI PROVA UT**

CLIENTE CUSTOMER	T.I.C.I. S.r.l. - Via DELL'ARTIGIANATO,6 – 26010 MONTODINE – CR – ITALY ROSETTI MARINO	**ENTE DI COLLAUDO** INSPECTION AGENCY	//
COMMESSA JOB	23 – 0193		
OGGETTO SUBJECT	ULTRASONIC EXAMINATION OF FLANGES & BLINDE : HYDROGEN VENT – DRAWING N°.: 1724000887 – MAC – DD – 00005		
STADIO DI LAVORAZIONE WORKING STAGE	FINISHED	**SUPERFICIE** SURFACE	MACHINED
SPECIFICA SPECIFICATION	EN1714 LIV.2 ACCEPTANCE CRITERIA: EN1712 LIV.2		
APPARECCHIO EQUIPMENT	Krautkramer USM 36 Serial Number 19027620		
SONDE TRANSDUCERS	Krautkramer	**ACCOPPIAMENTO** COUPLING	FYp Gel

SONDE E TARATURA

TIPO TYPE	FREQ. FREQ. (MHz)	DIMENSIONI DIMENSIONS (mm)	ONDE WAVES (L - T)	ANGOLO ANGLE (°)	BLOCCO DI CALIBRAZIONE CALIBRATION BLOCK	Straight Beam: DGS diagram FBH-Ø 3 mm
SEB4	4	Ø24	L	0		

OPERATORE OPERATOR	Mr. ANDREA CAVALLO Level 2 UT – Certificate Bureau Veritas No. IND-23-02425-C					
NOTE REMARKS	EXTENT OF TESTING: 100% (*) Double crystal probe					
ESITO RESULT	**ACCETTABILE** ACCEPTABLE	☒	**RIPARARE** TO BE REPAIRED	☐	**SCARTARE** REJECTED	☐

LIST OF THE EXAMINED ITEMS

POS.	HEAT	TYPE	DIMENSIONS	Q.TY	RESULT
1	460712	FLANGE SA350 LF2-1	8"	1	OK
2	285700	FLANGE SA350 LF2-1	10"	1	OK
3	816536	FLANGE SA350 LF2-1	12"	1	OK

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024

☒ REVIEW ☒ WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 24 OTT 2024

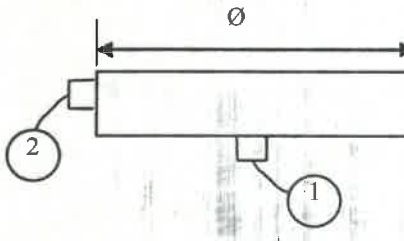
T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
PEC: tici.srl@pec.it - SDI: J6URRTW

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customerinspector	IL COLLAUDATORE The inspector

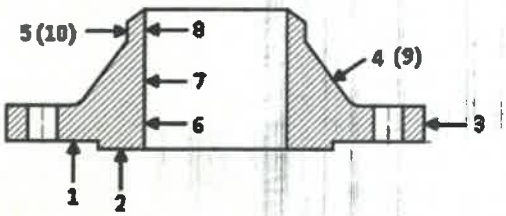
FLANGE SA350 LF2-1 – DN12" BLINDE				
SONDA TRANSDUCER		FONDO SCALA FULL SCALE (mm)	AMPLIFICAZIONE (dB) AMPLIFICATION	
			TARATURA CALIBRATION	SCANSIONE SCANNING
3	SEB4	50	44	+6 dB

FLANGE SA350 LF2-1 – DN10" & DN8"				
SONDA TRANSDUCER 1 & 2		FONDO SCALA FULL SCALE (mm)	AMPLIFICAZIONE (dB) AMPLIFICATION	
			TARATURA CALIBRATION	SCANSIONE SCANNING
1	SEB4	50	54	+6 dB
2	B4S	250	67	+6 dB
3	B4S	250	61	+6 dB
4	SEB4	50	60	+6 dB
5	MSEB4	25	40	+6 dB
9	MWB-45-4	100	66	+6 dB

SCAN POSITIONS



SCAN POSITIONS



ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024

☐ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. DELLA DINA DATE 24 OTT 2024

End Document

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	L'ISPETTORE DEL CLIENTE Customerinspector	IL COLLAUDATORE The inspector



BUREAU VERITAS 1828

BUREAU VERITAS

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO
PRS N° 076C

PROVE NON DISTRUTTIVE: Certificato di Qualifica Operatore
NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-23-02425-C

Si certifica la qualifica in Prove Non Distruttive al Livello 2
It certifies the qualification for Non-Destructive Testing at the level 2

Titolare del certificato / *Certificate holder*
Andrea Cavallo (ID # 6449)

Nato a / *born in*: Grottaglie (TA) Italy — Il / *on*: 2 Apr 1995

Per il metodo / *For the method*
Ultrasonic Testing (UT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)
APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / *For the sectors*
Pre- and in-service testing which includes manufacturing

Il presente certificato viene rilasciato in conformità alla Norma UNI EN ISO 9712:2012 e Regolamento Bureau Veritas IT-IND-REG-01_NDT.IND
This certificate is issued according to UNI EN ISO 9712:2012 and Bureau Veritas Rule IT-IND-REG-01_NDT.IND

Data ultima revisione / *Date last revision*: ---------- Emesso / *Issued*: 23 Jul 2023

Valido dal / *Valid from*: 23 Jul 2023 Scadenza / *Expiry date*: 22 Jul 2028

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☑ Review ☐ Witness
Date: 25/10/2023

Responsabile Tecnico di Schema
NDT Scheme Chief
Luca Rossi

Firma titolare del certificato
Signature of certificate holder

☑ REVIEW ☐ WITNESS
ON BEHALF OF RSC
A. BELLANINA DATE 25 OTT 202

to check the certificate: https://bvchecker.revo.network

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IND-F-044_NDT.IND Rev 06 del 13/10/2022

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ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI
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Tel. 02.90.96.15.41 • 2 - Fax 02.90.96.32.92
E-mail : info@irtecsrl.com Web: www.irtecsrl.com

REPORT No. REPORT	RC240275
RIF. REF.	JC240186
DATA DATE	2024/10/19
FOGLIO SHEET	1 DI 2 OF

RC240275 JC240186 2024/10/19 10016 MODULO / FORM M-MT Rev. 0 MT TEST REPORT RAPPORTO DI PROVA MT

CLIENTE / CUSTOMER	T.I.C.I. S.r.l. Via dell'Artigianato, 6 – 26010 Montodine (CR)	ENTE DI COLLAUDO / INSPECTION AGENCY	//
COMMESSA / JOB	ROSETTI MARINO 23 – 0193		
OGGETTO / SUBJECT	MAGNETIC PARTICLE EXAMINATION OF THE PLETE RISER BOTTOM HYDROGEN VENT - DRAWING N°.: 1724000887 – MAC – DD – 00005		
MATERIALE / MATERIAL	A516 Gr.60	SPESSORE / THICKNESS	10mm ÷ 12mm
STADIO DI LAVORAZIONE / WORKING STEP	AFTER WELDING	SUPERFICIE / SURFACE	AS WELDED BRUSCHED
SPECIFICA / SPECIFICATION	EN ISO 17638:2010 NDT-MT-10 YOKE MT EN ISO 17638_E2_R1		
Acceptability:	EN ISO 23278:2015		
APPARECCHIO / EQUIPMENT	DELTA FLUX IMPIANTI DF Y BT Matr. 1400120		

MAGNETIZZAZIONE CON GIOGO / YOKE MAGNETIZATION

CORRENTE / CURRENT
- ☒ **ALTERNATA** / ALTERNATING
- ☐ **RADDRIZZATA ½ ONDA** / RECTIFIED ½ WAVE

DISTANZA POLI / POLE SPACING: 80 ÷ 200 mm

INTENSITÀ DEL CAMPO / FIELD INTENSITY

Il giogo soddisfa i requisiti di / The yoke satisfies the requirements of:
ASME Sect. V Art. 7 - Paragraph T-762 (b)

RIVELATORE UMIDO / WET EXAMINATION MEDIUM

	PRODOTTO / PRODUCT	LOTTO / BATCH
KEROSENE / OIL	BW2	7260s USE BY:01/2027
ACQUA / WATER	//	//
LACCA DI CONTRASTO / SURFACE CONTRAST	WBL5	U230509s USE BY:04/2027

ILLUMINAZIONE / LIGTHING

☐ **NATURALE** / DAYLIGHT	//	
☒ **ARTIFICIALE** / ARTIFICIAL	1076 lux	
☐ **UV** / UV	//	

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 24/10/2024

☐ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 24 OTT 2024

NOTE / REMARKS: 100% CONTROL OF THE BOTTOM FORMING AREA

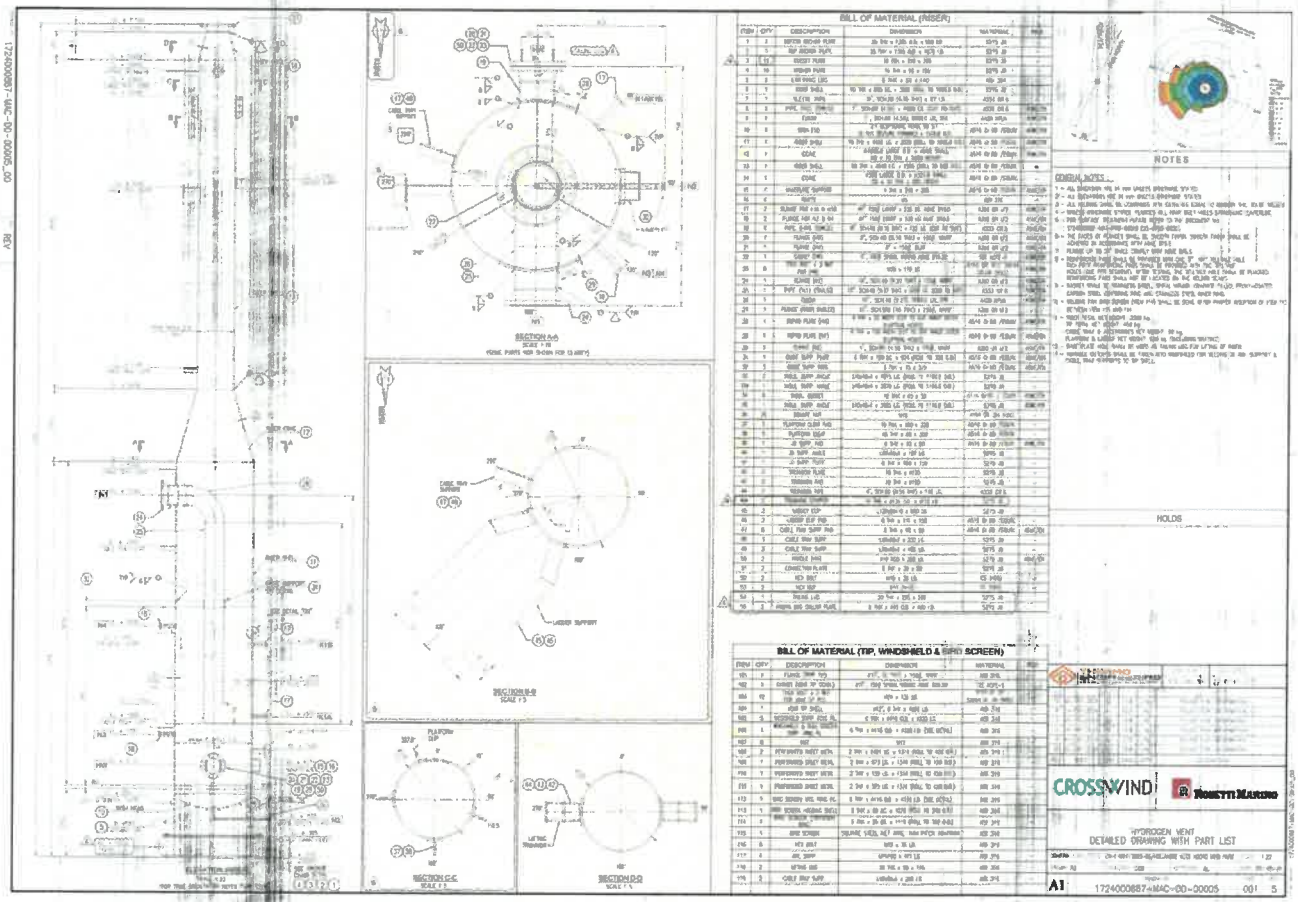
OPERATORE / OPERATOR: Cavallo-Andrea_EN-2_MT_Rina-20VE00144PN1_Scadenza13-02-2025_firma

ESITO / RESULT
- ☒ **SODDISFACENTE** / SATYSFACTORY
- ☐ **RIPARARE** / TO BE REPAIRED
- ☐ **SCARTARE** / REJECTED

Questo report è valido solo per la prova in oggetto. / This report applies only for the test in subject.

PROVE ESEGUITE DA / Test conducted by	PER IL LABORATORIO / For the laboratory	L'ISPETTORE DEL CLIENTE / Customer inspector	IL COLLAUDATORE / The inspector

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
0096206019 - TEL. 0373-242255
tici.srl@pec.it - SDI: J6URRTW



ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☐ **Review** ☐ **Witness**

Date: 24/10/2024

☑ REVIEW ☐ WITNESS
ON BEHALF OF RTG
A. DELLA PINA DATE 24 OTT 2024

End Document

PROVE ESEGUITE DA Test conducted by	PER IL LABORATORIO For the laboratory	**L'ISPETTORE DEL CLIENTE** Customer inspector	IL COLLAUDATORE The inspector

CERTIFICATO DI QUALIFICA DI OPERATORE PER CND

N. **20VE00144PN1**

Operatore	CAVALLO ANDREA		
Nato a	GROTTAGLIE (TA)	il	02/04/1995
Impiegato presso	CAVALLO ANDREA		
Con sede in	Fragagnano (TA)		

SI CERTIFICA che, a seguito degli esami sostenuti, l'operatore addetto alle prove non distruttive è qualificato al LIVELLO 2° in conformità alla norma UNI EN ISO 9712:2012 ed al Regolamento RINA RC/C 14,

nel metodo: **MAGNETOSCOPICO**

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 25/10/2024

per il/i settore/i:

Prova pre-servizio e in servizio di attrezzature, impianti e strutture

Il presente certificato è valido dal	14 Febbraio 2020	fino al	13 Febbraio 2025
Rilasciato a	GENOVA	il	14 Febbraio 2020

Filippo Lago
(Italy Welding & Pressure Equipment Certification Head)

Operatore

RINA Services S.p.A.
Via Corsica 12 - 16128 Genova

Questo certificato è composto di 1 pagina

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO
PRS N° 066 C
Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC
Signatory of EA, IAF and ILAC Mutual Recognition Agreements

I.R.T.E.C. srl
via F. Santi, 3
20056 Trezzo sull'Adda (Mi)
(Firma del Legale Rappresentante)
C.F. e P.IVA 02829820154

☒ REVIEW ☐ WITNESS
ON BEHALF OF RJ2G
AICELLA PINA DATE 25 OTT 2024

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI
TREZZO SULL'ADDA (MI)

ATTESTATO DI CERTIFICAZIONE
CERTIFICATION

No. 32

SI DICHIARA CHE THIS IS TO CERTIFY THAT	***LOREFICE NICOLÒ***
DIPENDENTE DELLA AN EMPLOYEE OF	IRTEC - ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI S.R.L. TREZZO SULL'ADDA
IN BASE ALLE CAPACITA' PERSONALI, ISTRUZIONE, ESAMI, ESPERIENZA ED IN ACCORDO CON QUANTO PRESCRITTO DA BY VERTUE OF HIS PERSONAL CAPABILITIES, INSTRUCTION, EXAMINATION, EXPERIENCE AND ACCORDING TO THE REQUIREMENTS OF	**IRTEC QUA-02 REV. 8 WRITTEN PRACTICE FOR PERSONNEL QUALIFICATION AND CERTIFICATION IN NON DESTRUCTIVE TESTING, PREPARED ON THE BASIS OF SNT-TC-1A RECOMMENDED PRACTICE, ED. 2016 + ASME BPVC.V-2019 – ARTICLE 1 APPENDIX III**
È QUALIFICATO AL LIVELLO IS QUALIFIED AS LEVEL	II (SECONDO) II (SECOND)
PER LA SEGUENTE TECNICA DI CONTROLLO NON DISTRUTTIVO FOR THE FOLLOWING NON DESTRUCTIVE TESTING TECHNIQUE	CONTROLLO MAGNETOSCOPICO (MT) MAGNETIC PARTICLE TESTING (MT)

☒ REVIEW ☐ WITNESS
ON BEHALF OF RINA
RINA DATE 25 OTT 2024

DATA DATE	13/01/2021
QUESTO ATTESTATO E' VALIDO FINO AL THIS CERTIFICATE IS VALID UP TO	31/01/2024

III Livello — Dott. Ing. G. Grossi
NDE LEVEL III — dott. Ing. G. GROSSI

IRTEC srl – TREZZO SULL'ADDA
General Manager Mrs. C. Salvi
13/01/2021

I.R.T.E.C. srl
via F. Santi, 3
20056 Trezzo sull'Adda (MI)
C.F. e P.IVA 02829820154
(Firma del Legale rappresentante)

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 25/10/2024

38CQO REV. 1

ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☒ Review ☐ Witness

Date: 25/10/2024

BUREAU VERITAS

ACCREDIA
PRS N° 0704

PROVE NON DISTRUTTIVE: Certificato di Qualifica Operatore
NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-22-01726-C

Si certifica la qualifica in Prove Non Distruttive al Livello2
It certifies the qualification for Non Destructive Testing at the level 2

Titolare del certificato / *Certificate holder*
Santarcangelo Vincenzo (ID # 4044)

Nato a / *born in*: Matera (MT) Il / *on*: 25 Apr 1960

Per il metodo / *for the method:*
Magnetic Testing (MT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)
APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / *for the sectors*:
Pre- and in-service testing which includes manufacturing

Il presente certificato viene rilasciato in conformità alla Norma UNI EN ISO 9712:2012 e Regolamento Bureau Veritas IT-IND-REG-01_NDT.IND
This certificate is issued according to UNI EN ISO 9712:2012 and Bureau Veritas Rule IT-IND-REG-01_NDT.IND

Data ultima revisione / *Date last revision*: ----------

Emesso / *issued*: 15 Jul 2022 Scadenza / *Expiry date*: 14 Jul 2027

Autorizzazione del datore di lavoro
Employer authorizing

Responsabile Tecnico di Schema
NDT Scheme Chief
Luca Rossi

Firma titolare del certificato
Signature of certificate holder

☒ REVIEW ☐ WITNESS
ON BEHALF OF: RTG
A. BELLAPINA DATE 25 OTT 2024

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IRTEC SRL
SISTEMA DI QUALITÀ CERTIFICATO ISO 9001:2015

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F. SANTI, 3 - Tel. 02.90.96.15.41 • 2 - Fax 02.90.96.32.92
E-mail: info@irtecsrl.com Web: www.irtecsrl.com

RADIOGRAPHIC EXAMINATION REPORT

Number: RA241029 **Date:** 24/10/2024
IRTEC Ref.: JA240399 Page 1 of 3
CUSTOMER Ref.: ROSETTI MARINO

Spett.
T.I.C.I. S.r.l.
Via DELL'ARTIGIANATO,6
26010 MONTODINE – CR – ITALY

Sample: HYDROGEN VENT – DRAWING N°.: 1724000887 – MAC – DD – 00005
WELDER'S NAME : RICCARDO SONCINI - STAMP: RS

Identification: 23-0193

Date of receipt: 23/10/2024

Test standards: ISO 17636-1:2022

Test procedures: 28-NDT-RT-E1 R2

Acceptance standards : ISO 10675 – 1 LIV.1 ED. 2021

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 25/10/2024

Material: A 516 Gr.60 **Weldings procedures/process:** ---
Area inspected: CROSSING WELDES **Surface condition:** AS WELDED
Examination coverage: SPOOT + 100% ON BUTT WELDED JOINT – WELDER : RS
Nominal Thickness: 10mm **Weld metal Thickness:** 12mm

Source: SMART EVO 300 COMET SN.514236 **Radiation energy:** X – Ray
Source Size (mm x mm): 3.0 **Activity (GBq):** ---

Films: AGFA D4 **Processing:** AUTOMATIC
Screens: Pb **Front (mm):** 0.05 **Back (mm):** 0.10

Radiographic Technique		Penetrameter		D(1)	ā(2)	SDF(3)	Tube parameters		Exposure	Films density		Sensitivity	
Technique (see Fig.)	Films	Type EN	Placement Side	mm	mm	mm	Voltage kV	Current mA	Time Min.	Min.	Max.	Required Wire N.	Obtained Wire N.
14	Single	10	F	1.088	12	1.100	200	3	1	2.6	2.8	W13	W13
14	Single	10	S	496	12	508	200	3	1	2.4	2.6	W13	W13

(1) Source-to-object distance (2) Distance from source side of object to the film (3) Sourcer-film distance

This test report concerns only the sample submitted to the test. If not otherwise indicated, the sampling operation were performed by the Customer.

Date/s of execution: 23/10/2024 **At:** TICI – MONTODINE – CR – ITALY
Note/s: ---

☒ REVIEW ☐ WITNESS
ON BEHALF OF RTG
A. DELLA PINA DATE 25 OTT 2024

Operator/s			Technical Manager	
Lorefice Nicolò RT LIV.II	Lev. II			

DESCRIPTION:

1	Cricche	Cracks	10	Eccesso di penetrazione	Eccess Penetration
2	Cricche di Cratere	Crater Cracks	11	Eccesso localizzato	Local protrusion
3	Pori e Porosità	Porosity	12	Colpi d'arco e spruzzi	Arc strikes and spatters
4	Tarli	Wormholes	13	Slivellamento	Misalignement
5	Inclusioni solide e cavità allungate	Solid inclusions and elongated cavities	14	Insellamento	Root concavity
			15	Sgocciolamento	Burn Through
6	Inclusioni di Rame	Copper Inclusions	16		
7	Incollature	Lack of Fusion	17		
8	Mancanza di penetrazione	Lack of Penetration	18	Difetto film	Process or film defect
9	Incisioni Marginali	Undercuts	19	Nessun difetto	No defect

AC=Acceptable NA=Not Acceptable

Film reference		Exp. Tec.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Judgment
23-0193		---																				---
C1	1 – 2	Fig. 14									X											AC
C1	3 – 4	Fig. 14																			X	AC
C2	1 – 2	Fig. 14					X															AC
C2	3 – 4	Fig. 14														X						AC
C	5 – 6	Fig. 14																			X	AC
C	7 – 8	Fig. 14																			X	AC
C	8 – 9	Fig. 14																			X	AC
C	9 – 10	Fig. 14			X							X										AC
C	11 – 12	Fig. 14																			X	AC

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 25/10/2024

ISO 17636-1:2022(E)

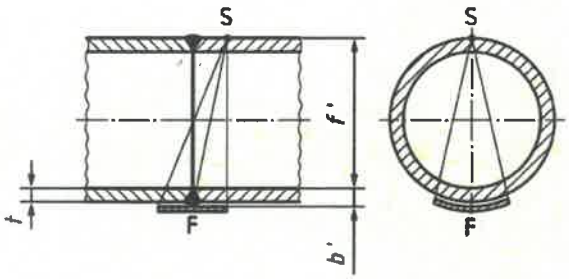
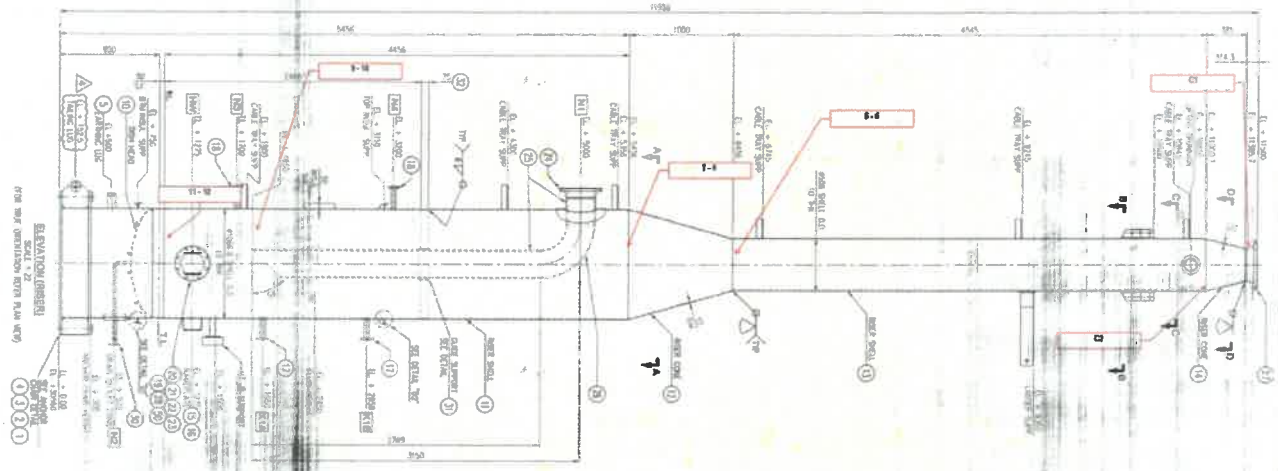


Figure 14 — Arrangement for testing of curved objects with the radiation source outside, located directly on the surface and evaluation of the wall next to the film with the IQI placed close to the film

☐ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. PELLA RINA DATE 25 OTT 2024



ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 25/10/2024

☒ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. BELLAVINA DATE 25 OTT 2024

End document

Operator/s			Technical Manager	
Lorefice Nicolò RT LIV. II SNT-TC-	Lev.			

ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☐ Review ☐ Witness

Date 25/10/2024

BUREAU VERITAS

ACCREDIA
PRS N° 076C

PROVE NON DISTRUTTIVE: Certificato di Qualifica Operatore
NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-20-03006-C

Si certifica la qualifica in Prove Non Distruttive al Livello 2
It certifies the qualification for Non Destructive Testing at the level 2

Titolare del certificato / *Certificate holder*
Lorefice Nicolò (ID # 7066)

Nato a / *born in*: Gela (CL) Il / *on*: 11 Nov 1993

Per il metodo / *for the method:*
Radiographic Testing (RT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)
APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / *for the sectors:*
Pre- and in-service testing which includes manufacturing

Il presente certificato viene rilasciato in conformità alla Norma UNI EN ISO 9712:2012 e Regolamento Bureau Veritas IT-IND-REG-01_NDT.IND
This certificate is issued according to UNI EN ISO 9712:2012 and Bureau Veritas Rule IT-IND-REG-01_NDT.IND

Data ultima revisione / *Date last revision*: ----------

Emesso / *issued*: 11 Dec 2020 Scadenza / *Expiry date*: 10 Dec 2025

Autorizzazione del datore di lavoro
Employer authorizing

IR TEC SRL

Firma titolare del certificato
Signature of certificate holder
Lorefice Nicolò

Responsabile Tecnico di Schema
NDT Scheme Chief
Luca Rossi

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☒ REVIEW ☐ WITNESS
ON BEHALF OF RTG
A. DELLA PINA DATE 25 OTT 2024



BUREAU VERITAS 1828

ACCREDIA

PRS N°0076

ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☐ Review ☐ Witness

Date: 25/10/2024

PROVE NON DISTRUTTIVE: Certificato di Qualifica Operatore

NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-24-02015-C

Si certifica la qualifica in Prove Non Distruttive al Livello 3

It certifies the qualification for Non-Destructive Testing at the level 3

Titolare del certificato / *Certificate holder*

Vincenzo Santarcangelo (ID # 4044)

Nato a / *born in*: Matera (MT) Italy — Il / *on*: 25 Apr 1960

Per il metodo-tecnica / *For the method-tecnique:*

Radiographic Testing / Film interpretation (RT/F-I)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)

APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / *For the sectors:*

Pre- and in-service testing which includes manufacturing (s)

(composed by product sector c-f-w-t-wp-m)

Il presente certificato viene rilasciato in conformità alla Norma UNI EN ISO 9712:2022 e Regolamento Bureau Veritas IT-IND-REG-01_NDT.IND

This certificate is issued according to UNI EN ISO 9712:2022 and Bureau Veritas Rule IT-IND-REG-01_NDT.IND

Emesso / *Issued*: 5 Jun 2024 — Valido dal / *Validity start date*: 6 Jun 2024

Data ultima revisione / *Date last revision*: ---------- — Scadenza / *Expiry date*: 5 Jun 2029

Responsabile Tecnico di Schema
NDT Scheme Chief
Luca Rossi

☑ REVIEW ☐ WITNESS
ON BEHALF OF
A. BELLAPINA DATE 25 OTT 2024

to check the certificate: https://bvchecker.revo.network

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IND-F-044_NDT.IND Rev 08 del 17/10/2023

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SISTEMA DI QUALITÁ CERTIFICATO ISO 9001:2015

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F. SANTI, 3
Tel. 02.90.96.15.41 ▯ 2 - Fax 02.90.96.32.92
E-mail: info@irtecsrl.com Web: www.irtecsrl.com

RAPPORTO DI PROVA n° / TEST REPORT No.	RC240280
COMMESSA n° / JOB No.	JC240186
DATA / DATE	25/10/2024
FOGLIO / SHEET	1 DI / OF 2

CLIENTE – Customer		COMMESSA – Job
T.I.C.I. S.r.l. – Via DELL'ARTIGIANATO,6 – 26010 MONTODINE – CR – ITALY		ROSETTI MARINO 23 – 0193
ITEM:	CLIENTE FINALE – End Customer	STAMPS:
---	ROSETTI MARINO	RICCARDO SONCINI – RS
OGGETTO – Object	DISEGNO – Drawing / OWNER DWG. N°.:	ITP STEP N°.:
100% PENETRANT TEST ONLY ON HYDROGEN VENT	DRAWING N°.: 1724000887 – MAC – DD – 00005	///
100% PENETRANT TEST ON WELDS HYDROGEN VENT		

CODICE – Code	PROCEDURA – Procedure	ACCETTABILITA' – Acceptance level
UNI EN ISO 3452-1	NDT PT 10 E2 R1 UNI EN ISO	UNI EN ISO 23277 LIVELLO. 1
///	///	///
MATERIALE – Material	DIMENSIONI – Dimensions	SPESSORE – Thickness
A516 Gr.60	SEE DWG.	THK 10mm ÷ 12mm
STATO DELLA SUPERFICIE - Surface condition		
☒ COME SALDATO - As welded	☒ SPAZZOLATO – Brushed	☐ LAVORATO DI MACCHINA - Machined
☐ MOLATO - Ground	☐ LAMINATO – Rolled	☐ GREZZO – Rough
ISPEZIONE - Inspection		
☒ LUCE BIANCA – White Ligth	☒ ILLUMINAMENTO - Illuminance 1076 Lx	TEMPERATURA SUPERFICIE / Surface Temperature: 16°C
☐ LUCE NERA – Black Ligth	☐ IRRAGIAMENTO - Irradiance	

TECNICA DI CONTROLLO – Control tecnique		PROCEDURA DI CONTROLLO - Procedure	
PENETRANTE - Penetrant		PULITURA DELLA SUPERFICIE / Surface cleaning	NDT K71B2p
☐ Fluorescente / Fluorescent ☒ A contrasto di colore / Color contrast			
Denominazione commerciale – Trade mark	NDT K71B2p	TEMPO DI ASCIUGATURA / Drying time	6 min
Lotto - Batch	240109ps		
PULITORE - Cleaner		APPLICAZIONE PENETRANTE / Penetrant application	SPRAY
Denominazione commerciale – Trade mark	NDT BC1		
Lotto - Batch	B240304s	TEMPO DI PENETRAZIONE / Penetration time	15 min
RILEVATORE - Developer			
Denominazione commerciale – Trade mark	NDT D112A	ASPORTAZIONE PENETRANTE / Penetrant removal	WATER AND CLOTHS
Lotto - Batch	240301W150s		
DESIGNAZIONE PRODOTTI – Products designations		TEMPO DI ASCIUGATURA / Drying time	10 min
II-A-e			
Note - Remarks		APPLICAZIONE RILEVATORE / Developer application	SPRAY
		TEMPO DI SVILUPPO / Developing time	10 ÷ 60 min

MATERIALE CONTROLLATO - Material verified

ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☐ Review ☒ Witness

Date: 25/10/2024

☐ REVIEW ☒ WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 25 OTT 2024

RISULTATO DELL'ESAME / Test result		
	☒	CONFORME – SATISFACTORY
	☐	NON CONFORME – UNSATISFACTORY

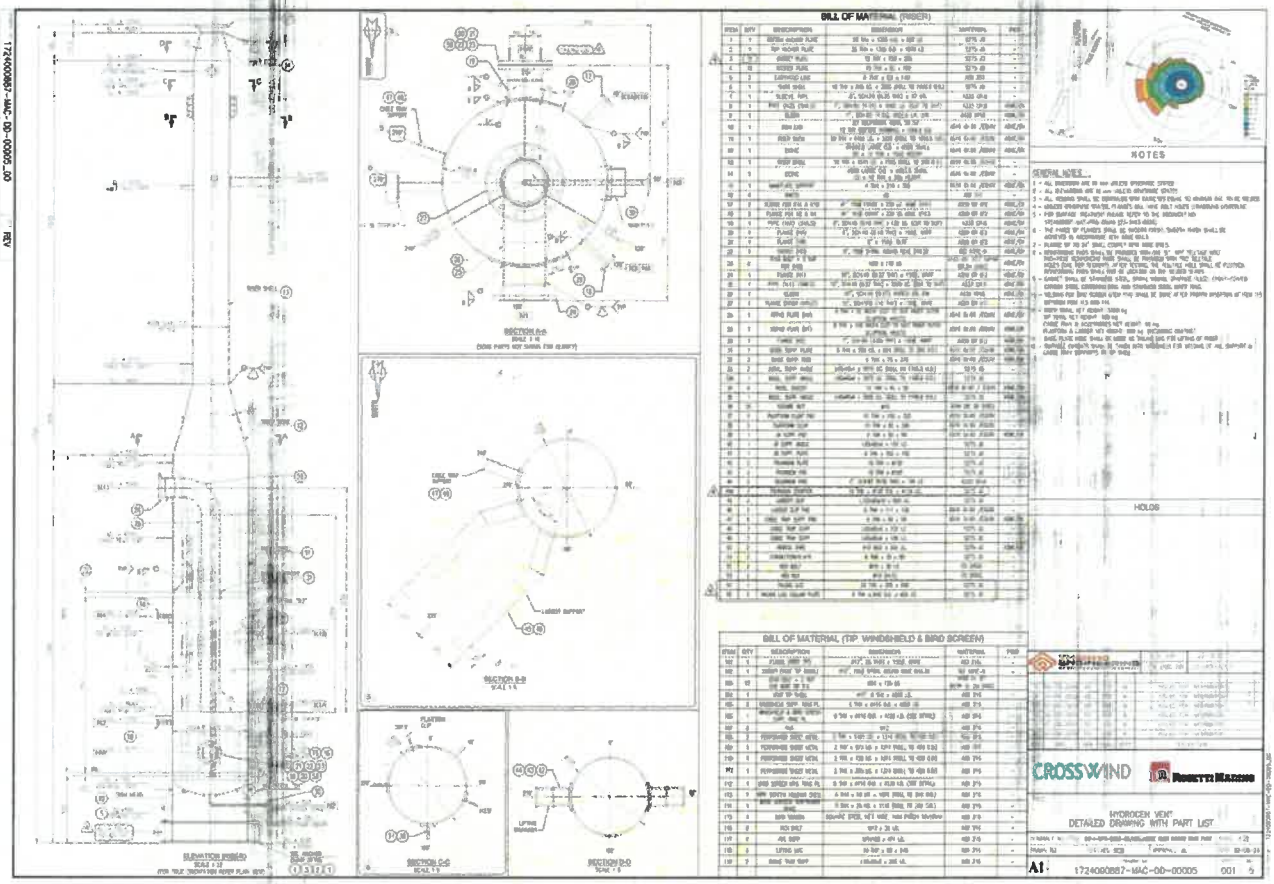
PROVE ESEGUITE DA / Test conducted by	CONTROLLO QUALITA' / Quality control	L'ISPETTORE DEL CLIENTE / Customer inspector	IL COLLAUDATORE / The inspector
LOREFICE NICOLO' PT IV Liv. UNI EN ISO 9712			

IRTEC SRL
SISTEMA DI QUALITÀ CERTIFICATO ISO 9001:2015

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI

20056 TREZZO S/A (MI) - VIA F. SANTI, 3
Tel. 02.90.96.15.41 ▯ 2 - Fax 02.90.96.32.92
E-mail: info@irtecsrl.com Web: www.irtecsrl.com

RAPPORTO DI PROVA n° / TEST REPORT No.	RC240280
COMMESSA n° / JOB No.	JC240186
DATA / DATE	25/10/2024
FOGLIO / SHEET	1 DI 2 / OF



ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☐ Review ☐ Witness

Date: 25/10/2024

☐ REVIEW ☒ WITNESS
ON BEHALF OF RTC
A. DELLA PINA DATE 25 OTT 2024

End Document

PROVE ESEGUITE DA / Test conducted by	CONTROLLO QUALITA' / Quality control	L'ISPETTORE DEL CLIENTE / Customer inspector	IL COLLAUDATORE / The inspector
LOREFICE NICOLO' RT IV Livello UNI EN ISO 9712			

ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI
TREZZO SULL'ADDA (MI)

ATTESTATO DI CERTIFICAZIONE
CERTIFICATION

No. 23

SI DICHIARA CHE
THIS IS TO CERTIFY THAT

LOREFICE NICOLÒ

DIPENDENTE DELLA
AN EMPLOYEE OF

IRTEC - ISTITUTO DI RICERCHE TECNOLOGICHE E COLLAUDI S.R.L. TREZZO SULL'ADDA

IN BASE ALLE CAPACITA' PERSONALI, ISTRUZIONE, ESAMI, ESPERIENZA ED IN ACCORDO CON QUANTO PRESCRITTO DA
BY VERTUE OF HIS PERSONAL CAPABILITIES, INSTRUCTION, EXAMINATION, EXPERIENCE AND ACCORDING TO THE REQUIREMENTS OF

IRTEC QUA-02 REV. 8
WRITTEN PRACTICE FOR PERSONNEL QUALIFICATION AND CERTIFICATION IN NON DESTRUCTIVE TESTING, PREPARED ON THE BASIS OF SNT-TC-1A RECOMMENDED PRACTICE, ED. 2016
+ ASME BPVC.V-2019-ARTICLE 1-APPENDIX III

E' QUALIFICATO AL LIVELLO
IS QUALIFIED AS LEVEL

II (SECONDO)
II (SECOND)

PER LA SEGUENTE TECNICA DI CONTROLLO NON DISTRUTTIVO
FOR THE FOLLOWING NON DESTRUCTIVE TESTING TECHNIQUE

CONTROLLO CON LIQUIDI PENETRANTI (PT)
LIQUID PENETRANT TESTING (PT)

☒ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. DELLA RINA DATE 25 OTT 2024

DATA DI RILASCIO DEL CERTIFICATO
DATE

13/01/2021

QUESTO ATTESTATO E' VALIDO FINO AL
THIS CERTIFICATE IS VALID UP TO

31/01/2024

III Livello
NDE LEVEL III

Dott. Ing. G. Grossi
dott. ing. G. GROSSI

IRTEC srl – TREZZO SULL'ADDA
General Manager Mrs. C. Salvi
13/01/2021

I.R.T.E.C. srl
via F. Santi, 3
20056 Trezzo sull'Adda (Mi)
C.F. e P.IVA 02829820154
(Firma del Legale rappresentante)

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 25/10/2024

38CQO REV.0



PRS N°0076

PROVE NON DISTRUTTIVE: Certificato di Qualifica Operatore

NON-DESTRUCTIVE TESTING: Operator Qualification Certificate

N° IND-24-02014-C

Si certifica la qualifica in Prove Non Distruttive al Livello 3

It certifies the qualification for Non-Destructive Testing at the level 3

Titolare del certificato / *Certificate holder*

Vincenzo Santarcangelo (ID # 4044)

Nato a / *born in*: Matera (MT) Italy — Il / *on*: 25 Apr 1960

Per il metodo-tecnica / *For the method-tecnique:*

Penetrant Testing (PT)

APPROVAZIONE PER ESECUZIONE DI PROVE NON DISTRUTTIVE secondo l'Allegato I paragrafo 3.1.3 della direttiva attrezzature a pressione 2014/68/UE PED (CEN/TR 15589 Route A)

APPROVAL FOR EXECUTION OF NON-DESTRUCTIVE TESTING as per Annex I paragraph 3.1.3 of pressure equipment directive 2014/68/UE PED (CEN/TR 15589 Route A)

Per i settori / *For the sectors*:

Pre- and in-service testing which includes manufacturing (s)

(composed by product sector c-f-w-t-wp-m)

Il presente certificato viene rilasciato in conformità alla Norma UNI EN ISO 9712:2022 e Regolamento Bureau Veritas IT-IND-REG-01_NDT.IND

This certificate is issued according to UNI EN ISO 9712:2022 and Bureau Veritas Rule IT-IND-REG-01_NDT.IND

Emesso / *Issued*: 5 Jun 2024 — Valido dal / *Validity start date*: 6 Jun 2024

Data ultima revisione / *Date last revision*: ---------- — Scadenza / *Expiry date*: 5 Jun 2029

☑ REVIEW ☐ WITNESS

ON BEHALF OF RDG

A. DELLA PINA DATE 25 OTT 2024

Responsabile Tecnico di Schema

NDT Scheme Chief

Luca Rossi

ENCORE THERMOENGINEERING S.r.l.

QC Inspection

By .....

☑ Review ☐ Witness

Date: 25/10/2024

to check the certificate: https://bvchecker.revo.network

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2.2.6 Hydrostatic reports

SEE ATTACHED NEXT PAGE

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TICI S.R.L. TECNOLOGIA INDUSTRIALE COSTRUZIONE IMPIANTI	OPERATING INSTRUCTION	IO REV. 0 as reported Sheet 1 of 1

HYDROSTATIC PRESSURE TEST

HYDRAULIC TEST REPORT N° 01

Item description:

HYDROGEN VENT

Document N°:	**1724000887-QC-PRO-00009**	REV01 25/10/2024
Test procedure N°:	**IO REV.0 as reported**	
Pressure gauge serial N°:	**26440**	
Test medium:	**WATER**	
Metal temperature:	**AMBIENT**	
Test pressure:	**5.5**	**bar**
Test time duration:	**1h**	
Visual exam. at pressure:	**POSITIVE**	
Test result:	**POSITIVE**	

Notes:

PRESSURE GAUGE SERIAL N°26440; CERTIFICATE N°FM/16380/24

ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☐ Review ☐ Witness

Date: 25/10/2024

☐ REVIEW ☑ WITNESS
ON BEHALF OF RINA
A. DELLA PINA DATE 25 OTT 2024

Supervisor	Signature	Date
M.D		25/10/2024

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
DENTI MARTA
RESP. QUALITA'

DNV ☑ Witnessed ☐ Reviewed And found acceptable
Date: 2024/10/25
Sign: CF-00220

Fratelli MAGNI s.r.l.

20122 MILANO (Milano) Via Larga,15
tel. 02 95.30.28.68/69/60
C.F./P.IVA IT00686490152
Web www.fratellimagni.com
Quality System Certified UNI EN ISO 9001:2015 (LL-C Cert. 390

By .....

☒ Review ☐ Witness

Date: 25/10/2024

RAPPORTO DI VERIFICA DELLA TARATURA

CERTIFICATE OF CALIBRATION

Spett. Ditta
Customer

SALP INOX SRL
VIA DEL CARROCCIO, 14
26012 CASTELLEONE (CR)

NUMERO: FM/I 6380/24
NUMBER

RICHIESTA: DDT N° 197 del 21.06.2024
APPLICATION *date*

OGGETTO:
Subject

Manometro: DN 100
Pressure gauge

campo scala 0 / 25 bar
range

Matricola: 26440
Serial number

Costruttore: FRATELLI MAGNI
Manufacturer

Classe di precisione: 1,0 %
Accuracy

Divisione minima: 0,25 bar
Scale interval

CONDIZIONI AMBIENTALI:
CALIBRATION CONDITIONS

Temperatura ambiente: 20 ± 1°C
Room temperature

Pressione atmosferica: 1005 ± 5 mbar
Atmospheric pressure

Umidità relativa: 65%
Relative umidity

CONDIZIONI DI TARATURA:
SYSTEM OF CALIBRATION

Posizione: verticale
Position *vertical*

Fluido: da -1 a +25 bar : aria
Fluid *from* *to* *air*

da 25 a +1100 bar : olio
from *to* *oil*

STRUMENTI DI RIFERIMENTO:
REFERENCE INSTRUMENTATION

- ☐ AEP Lab DDM n°309184
- ☐ Druck DPI 145: n°0453-97-02/490193
- ☐ Druck DPI 145: n°0453-97-02/891045
- ☐ AEP Lab DDM n°710317
- ■ Druck DPI 145: n°0453-97-02/589378
- ☐ AEP Lab DDM n°609609
- ☐ Druck CMO n° 4022377
- ☐ AEP Lab DDM n°B02319
- ☐ Druck DPI 145: n°0453-97-02/1376167
- ☐ AEP Lab DDM n°121415
- ☐ Bilancia Pesi S. BARNET 9189 6... n° 70...
  Balance Weights

CAMPO SCALA: *RANGE*	CERTIFICATO: *CERTIFICATE*	DATA: *DATE*	CENTRO TARATURA: *CALIBRATION CENTER*	
-1+2,5 bar g	LAT n° 227822P	05/10/2022	n°	93
-1+2,5 bar g	LAT n° 1095-23	28/03/2023	n°	238
0/10 bar g	LAT n° 1096-23	28/03/2023	n°	238
0/20 bar g	LAT n° 36323P	10/02/2023	n°	93
0/40 bar g	LAT n° 1097-24	28/03/2024	n°	238
0/50 bar g	LAT n° 36423P	10/02/2023	n°	93
0/70 bar g	LAT n° 0461/MP/2023	04/04/2023	n°	150
0/100 bar g	LAT n° 227922P	05/10/2022	n°	93
0/200 bar g	LAT n° 1098-23	28/03/2023	n°	238
0/700 bar g	LAT n° 228022P	05/10/2022	n°	93
10/1000 bar g	LAT n° 00.020	24/01/2000	n°	25

PRESSIONE NOMINALE (bar) *PRESSURE REFERENCE*	0,000	5,000	10,000	15,000	20,000	25,000
VALORE INDICATO (bar) Salita *MEASURED PRESSURE (bar) Raise*	0,000	4,900	9,873	14,853	19.825	24,857
VALORE INDICATO (bar) Discesa *MEASURED PRESSURE (bar) Decrease*	0,000	5,139	10,159	15,121	20,069	
ERRORE (%) Salita *DEVIATION (%) Raise*	0,000	0,400	0,508	0,588	0,700	0,572
ERRORE (%) Discesa *DEVIATION (%) Decrease*	0,000	-0,556	-0,636	-0,484	-0,276	

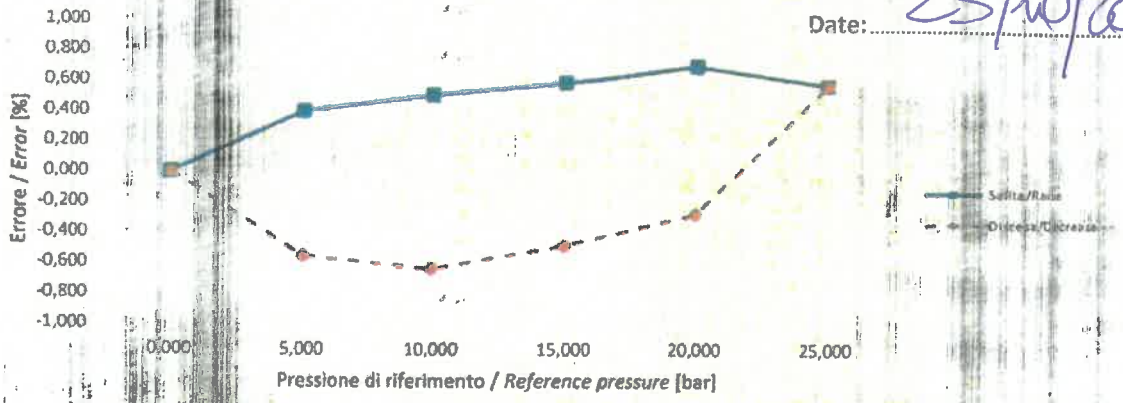
Lo strumento è stato picchettato ad ogni punto di misura
The instrument has been tapped at each measurement point

☒ REVIEW ☐ WITNESS
ON BEHALF OF RTG
A. DELLA PINA DATE 25 OTT 2024

Fratelli MAGNI s.r.l.

20122 MILANO (Milano) Via Larga,15
tel. 02 95.30.28.68/69/60
C.F./P.IVA IT00686490152
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Quality System Certified UNI EN ISO 9001:2015 (LL-C Cert. 3907094)

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness
Date: 25/10/2024



Max errore (massimo errore di indicazione) % f.s. = Emax = 0,70
Maximum error indication

I risultati di misura riportati nella presente dichiarazione sono stati ottenuti applicando la procedura (PR-09-01 Rev. 0) del Sistema Qualità Aziendale (UNI EN ISO 9001:2015 certificato LL-C n° 3907094).
The measurement results reported in this document have been determined according to the Quality System Procedure (PR-09-01 Rev.0) EN ISO 9001:2015 certificate LL-C n° 3907094

INCERTEZZA DEL PROCEDIMENTO DI TARATURA
THE CALIBRATION PROCEDURE UNCERTAINTY

Incertezza di misura del procedimento di taratura — **It = Ip + Is = 0,28 % f.s.**
The calibration procedure uncertainty

Ip = incertezza di misura dello strumento campione — **0,03 % f.s.**
measurement uncertainty of the standard instrument

Is = incertezza di indicazione dello strumento di taratura (risoluzione) calcolata come 1/4 della divisione minima sul % f.s. — **0,25 % f.s.**
indication of the instrument calibration uncertainty solution) calculated as 1/4 of minimum division % f.s

INCERTEZZA DELLO STRUMENTO IN TARATURA:
THE CALIBRATING INSTRUMENT UNCERTAINTY

Se si effettuano le opportune correzioni rispetto ad ogni punto di misura sulla base degli errori di indicazione sopra riportati, l'incertezza di misura Im dello strumento in taratura è pari a quella It del procedimento di taratura
The measurement uncertainty of the instrument to be calibrated Im is equal to that of the calibration procedure It, if you make the appropriate adjustments with respect to each measuring point on the basis of the errors indicated above

Nel caso non si effettuino correzioni ai valori misurati, l'incertezza Im di misura dello strumento in taratura, espressa come due volte lo scarto tipo, è pari:
On the contrary, if you do not make the appropriate adjustments to measured values, the measurement uncertainty of the instrument to be calibrated Im expressed as twice the standard deviation is equal to

Im = incertezza di misura dello strumento in taratura — **Im = $\sqrt{(It^2 + Emax^2)}$ = 0,75 % f.s.**
the measurement uncertainty of the instrument to be calibrated

☐ REVIEW ☐ WITNESS
ON BEHALF OF RTC
A. DELLA PINA DATE 25 OTT 2024

I documenti relativi ai campioni primari sono consultabili presso la ns. sede di Ornago.
The documents regarding to the primary standards are available at our site in Ornago.

NUMERO *NUMBER*	DATA RILASCIO *DATE OF ISSUE*	TECNICO *TESTED BY*	RESPONSABILE QUALITA' *QUALITY MANAGER*
FM/16380/24	18/07/2024	CORTI STEFANO	FRANCESCO GALBUSERA

I SERVIZI

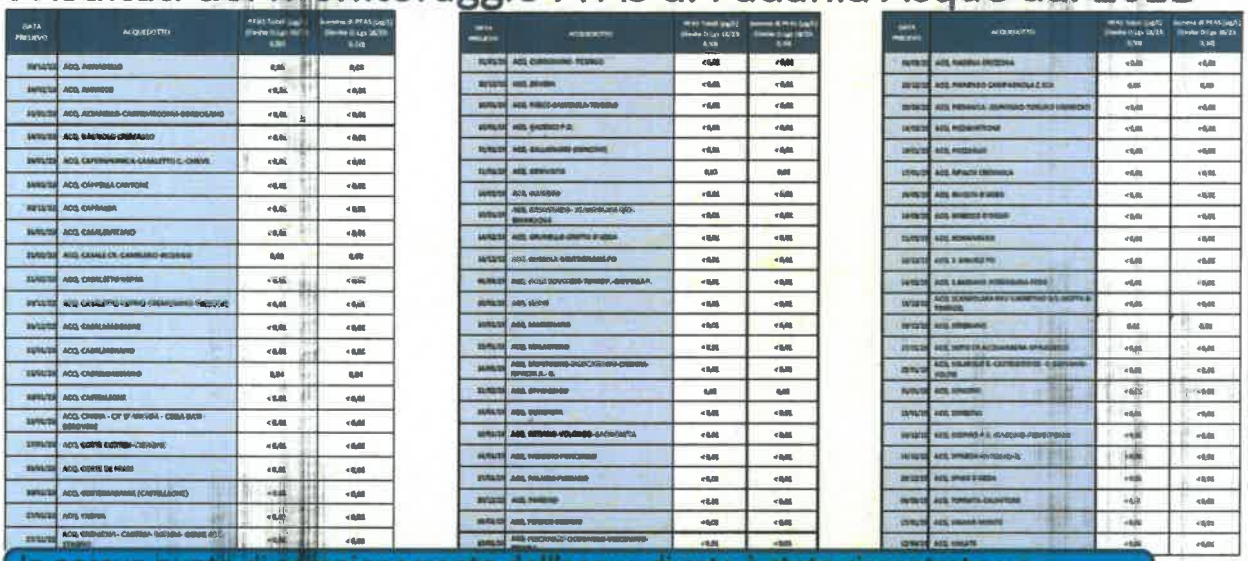
ANALISI ON-LINE

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
Review Witness
Date: 25/10/2024

TI TROVI IN: HOME / SERVIZI ON LINE / ANALISI ON-LINE

Selezionare il comune di interesse
Aggiornamento al 21/06/2024
NOTE PER LA CONSULTAZIONE DEI DATI:
1) La presente visualizzazione dei dati non ha valore di rapporto di prova, ma rappresenta una indicazione dei valori medi relativi agli ultimi 12 mesi di monitoraggio
2) Per l'acquedotto di Olmeneta selezionare il punto rete di Casalsigone nel comune di Pozzaglio.

I risultati del monitoraggio PFAS di Padania Acque dal 2022



In nessun punto di campionamento dell'acqua di rete è stato riscontrato un quantitativo di PFAS superiore rispetto a quanto indicato dal futuro limite di legge

7

Comune

Montodine

Punti di prelievo

F.P. - Via dei CAMPI

REVIEW WITNESS
ON BEHALF OF RTG
A. DELLA PINA DATE 25 OTT 2024

Parametro	Valore	Unità di misura	Limite max	Limite min	Valore guida
Temperatura	19,3	°C			
Cloro Attivo Libero (al prelievo)	0,03	mg/L			2
pH	8,1	unità pH	9,5	6,5	
Conducibilità Elettrica a 25°C	463	µS/cm			
Residuo Fisso	281	mg/L			
Bicarbonati	271	mg/L			
Ammoniaca	< 0,1	mg/L NH4	0,5		
Calcio	65	mg/L			
Magnesio	16,5	mg/L			

Parametro	Valore	Unità di misura	Limite max	Limite min	Valore guida
Potassio	1,14	mg/L			
Sodio	10	mg/L	200		
Durezza (da calcolo)	23	°F			
Fluoruri	0,06	mg/L	1.5		
Cloriti	< 10	µg/L	700		
Cloruri	1	mg/L	250		
Nitriti	< 0,05	mg/L	0.1		
Bromuri	< 0,05	mg/L			
Clorati	0,07	mg/L			
Nitrati	1	mg/L	50		
Fosfati (come P2O5)	0,26	mg/L			
Solfati	5	mg/L	250		
Arsenico	5	µg/L	10		
Cadmio	< 0,5	µg/L	5		
Cromo Totale	< 1	µg/L	50		
Rame	< 0,005	mg/L	1		
Ferro	< 5	µg/L	200		
Manganese	< 5	µg/L	50		
Nichel	< 1	µg/L	20		
Piombo	< 0,5	µg/L	10		
Vanadio	< 1	µg/L	50		
Zinco	< 5	µg/L			
Somma Tetracloroetilene-Tricloroetilene	< 1	µg/L	10		
Trialometani	5	µg/L	30		
Cloruro di Vinile	< 0,1	µg/L	0.5		
Benzene	< 0,1	µg/L	1		
1,2-Dicloroetano	< 0,1	µg/L	3		
Batteri Coliformi a 37°C	0	UFC/100 mL	0		
Escherichia Coli	0	UFC/100 mL	0		
Enterococchi intestinali	0	UFC/100 mL	0		
Conteggio delle colonie a 36°C	0	UFC/1 mL			
Conteggio delle colonie a 22°C	13	UFC/1 mL			

Dati aggiornati al 21/06/2024

ENCORE THERMOENGINEERING S.r
QC Inspection
By .....
☒ Review ☐ Witness
Date: 25/10/2024



padania acque S.p.A
Servizio Idrico Integrato provincia di Cremona

Padania Acque S.P.A.

☒ REVIEW ☐ WITNESS
ON BEHALF OF RINA
A. DELLA DINA DATE 25 OTT 2024

C.F., P.I. E R.I. CR: 00111860193
VIA MACELLO, 14 - 26100 CREMONA
R.E.A. DI CREMONA N. 133186
CAPITALE SOCIALE: € 33.749.473,16 I.V.

800 718 711
800 932 649
800 826 146

ENCORE THERMOENGINEERING S.r.l.
QC Inspection

By .....

☐ Review ☐ Witness

Date: 25/10/2024

SEGUICI

☑ REVIEW ☐ WITNESS
ON BEHALF OF RDC
A. DELLA FINA DATE 25 OTT 2024

2.2.7 Painting reports

SEE ATTACHED NEXT PAGE

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered an "NOT CONTROLLED" copy

unoprima

RAPPORTO DI VERNICIATURA - Painting report

Data / Date: 13/11/24 — Nr.: 926 24

CLIENTE / Customer	OGGETTO / Object	COMMESSA / Job
DB PROGETTI	N° 1 TIP IN S.S.	393

COMMITTENTE FINALE / Final costumer	PROGETTO / Project	CICLO VERNICIATURA / Painting System
ROSETTI MARINO	HOLLANDESE KUST	UPP 19 24 SYSTEM 6A

Date	Hour (From - To)	SSPC	ISO 8503-2	ISO 8502-6	ISO 8502-3
08/11/2024	08:50 - 10:20	SP16	MEDIUM G Rz 39,45µm	10,8 mg/m²	CLASS 1

TEMPERATURA AMBIENTE / Air temperature	UMIDITA' RELATIVA / Relative umidity	PUNTO DI RUGIADA / Dew point	TEMPERATURA SUPPORTO / Surface temperature
22°C	67%	15,3°C	21°C

VERNICIATURA - Painting

				Instrument Type
DATA APPLICAZIONE / *Application Date*	08/11/2024	11/11/2024	12/11/2024	//////////
ORA APPLICAZIONE(DALLE - ALLE) / *Application Hour (From - To)*	10:50 - 12:00	13:50 - 15:10	13:50 - 15:10	//////////
TEMPERATURA AMBIENTE / Air temperature	22°C	16°C	19°C	ELCOMETER 319 TOP SN ZF 29428
UMIDITA' RELATIVA / Relative Humidity	65%	47%	64%	ELCOMETER 319 TOP SN ZF 29428
PUNTO DI RUGIADA / Dew point	14,9°C	4,7°C	11,5°C	ELCOMETER 319 TOP SN ZF 29428
TEMPERATURA SUPPORTO / Surface temperature	19°C	16°C	19°C	ELCOMETER 319 TOP SN ZF 29428
METODO DI APPLICAZIONE / Application method	ROLLER / BRUSH CONVENTIONAL SPRAY	ROLLER / BRUSH CONVENTIONAL SPRAY	ROLLER / BRUSH CONVENTIONAL SPRAY	//////////
PRODOTTO VERNICIANTE / Paint product / Batch	EPOXY HEMPADUR 15570 224085032 - 224055078	EPOXY HB HEMPAPRIME MULTI 500 224075865-224056069	ACRYLIC HEMPEL'S 55088 044077024 - 044047082	//////////
COLORE / Color	GREY	GREY	RAL 9002	//////////
CONTROLLO FILM UMIDO µm / Wet film thickness check	125	175	150	ELCOMETER 3236 S.N. XB04087
D.F.T. RICHIESTO µm / D.F.T. required µm	50	100	75	//////////
DATA CONTROLLO SPESSORE SECCO / Dft checked date	09/11/2024	12/11/2024	13/11/2024	ISO 19840 - CORRECTION VALUE 10µm
NUMERO DI LETTURE SPESSORE ESEGUITE / NUMBER OF PERFORMED DFT READING	60	60	60	
D.F.T. MEDIO µm / D.F.T. average µm	112	250	341	ELCOMETER 456TOP Instrument S.N.: SG00559 Probe S.N.: ZC12732

NOTE / Remarks

* PAINTING APPLICATION AS PER INSTRUCTION OF PAINT MANUFACTURER
* ALL PARTS DEGREASED AS PER SSPC - SP1 BEFORE BLASTING
* BLOTTER TEST AS PER ASTM D4285 SATISFACTORY
* VISUAL TEST AFTER BLASTING AND PAINTING SATISFACTORY
* STRIPE COAT FOR ALL STEPS APPLIED BEFORE SPRAY PAINTING

ENDURE COATINGS S.r.l.
Inspection
By
Review
Witness

ISPETTORE UNOPRIMA / Unoprima Inspector	ISPETTORE CLIENTE / Customer Inspector	ISPETTORE COMMITTENTE FINALE / Final customer Inspector
DATA - Date	DATA - Date	Date: 13/11/2024 DATA - Date

UNOPRIMA SRL

x CROSSWIND 13/11/24 WIR

The certificate covers only external surface of TIP
19/11/24
ROSETTI MARINO SpA
Michele Sacchi
Quality Control Dept.

unoprima

RAPPORTO DI VERNICIATURA - Painting report

Data / Date: 18/11/24 — Nr.: 970 24

CLIENTE / Customer	OGGETTO / Object	COMMESSA / Job
TICI	STAIRS / HANDRAIL / STRUCTURES	393

COMMITTENTE FINALE / Final costumer	PROGETTO / Project	CICLO VERNICIATURA / Painting System
ROSETTI MARINO	HOLLANDESE KUST	UPP 19 24 SYSTEM 1B

Date	Hour (From - To)	ISO 8501-1	ISO 8503-2	ISO 8502-6	ISO 8502-3
13/11/2024	08:00 - 12:00	SA 2½	MEDIUM G Rz 65,21µm	10,3 mg/m²	CLASS 1

TEMPERATURA AMBIENTE / Air temperature	UMIDITA' RELATIVA / Relative umidity	PUNTO DI RUGIADA / Dew point	TEMPERATURA SUPPORTO / Surface temperature
19°C	62%	12,2°C	18°C

VERNICIATURA - Painting

				Instrument Type
DATA APPLICAZIONE / *Application Date*	13/11/2024	15/11/2024	16/11/2024	//////////
ORA APPLICAZIONE(DALLE - ALLE) / *Application Hour (From - To)*	14:10 - 17:00	15:30 - 17:10	10:30 - 12:00	//////////
TEMPERATURA AMBIENTE / Air temperature	17°C	19°C	11°C	ELCOMETER 319 TOP SN ZF 29428
UMIDITA' RELATIVA / Relative Humidity	62%	63%	55%	ELCOMETER 319 TOP SN ZF 29428
PUNTO DI RUGIADA / Dew point	10°C	11,5°C	2,7°C	ELCOMETER 319 TOP SN ZF 29428
TEMPERATURA SUPPORTO / Surface temperature	17°C	19°C	11°C	ELCOMETER 319 TOP SN ZF 29428
METODO DI APPLICAZIONE / Application method	ROLLER / BRUSH CONVENTIONAL SPRAY	ROLLER / BRUSH CONVENTIONAL SPRAY	ROLLER / BRUSH CONVENTIONAL SPRAY	//////////
PRODOTTO VERNICIANTE / Paint product / Batch	EPOXY RICH ZINC AVANTGUARD 750 044085900 - 044075619	EPOXY HB HEMPAPRIME MULTI 500 224075865-224056069	POLYURETHANE HEMPATHANE 55610 224017499-224046936	//////////
COLORE / Color	GREY	GREY	RAL 1023	//////////
CONTROLLO FILM UMIDO µm / Wet film thickness check	125	275	125	ELCOMETER 3236 S.N. XB04087
D.F.T. RICHIESTO µm / D.F.T. required µm	60	180	60	//////////
DATA CONTROLLO SPESSORE SECCO / Dft checked date	14/11/2024	16/11/2024	18/11/2024	ISO 19840 - CORRECTION VALUE 25µm
NUMERO DI LETTURE SPESSORE ESEGUITE / NUMBER OF PERFORMED DFT READING	60	60	60	
D.F.T. MEDIO µm / D.F.T. average µm	97	290	380	ELCOMETER 456TOP Instrument S.N.: SG00559 Probe S.N.: ZC29693

NOTE / Remarks

* PAINTING APPLICATION AS PER INSTRUCTION OF PAINTING MANUFACTURER
* ALL PARTS DEGREASED AS PER SSPC - SP1 BEFORE BLASTING
* BLOTTER TEST AS PER ASTM D4285 SATISFACTORY
* VISUAL TEST AFTER BLASTING AND PAINTING SATISFACTORY
* STRIPE COAT FOR ALL STRUCTURES APPLIED BEFORE SPRAY PAINTING

+CROSSWIND 19/11/24 WR

CONTROLLATO

By ..... Review ☐ Witness ☐

ISPETTORE UNOPRIMA / Unoprima Inspector / DATA - Date	ISPETTORE CLIENTE / Customer Inspector / DATA - Date	ISPETTORE COMMITTENTE FINALE / Final customer Inspector / DATA - Date
UNOPRIMA S.R.L.		ROSETTI MARINO SpA Michele Sacchi Quality Control Dept.

Date: 19/11/2024

unoprima

RAPPORTO DI VERNICIATURA - Painting report

Data / Date: 06/1124 — Nr.: 855 24

CLIENTE / Customer	OGGETTO / Object	COMMESSA / Job
TICI	N° 1 WATER SEAL + RISER TAG Q-43004	393

COMMITTENTE FINALE / Final costumer	PROGETTO / Project	CICLO VERNICIATURA / Painting System
ROSETTI MARINO	HOLLANDESE KUST	UPP 19 24 SYSTEM 1B

Date	Hour (From - To)	ISO 8501-1	ISO 8503-2	ISO 8502-6	ISO 8502-3
30/10/2024	08:00 - 10:00	SA 2½	MEDIUM G Rz 63,17µm	4,0mg/m²	CLASS 1

TEMPERATURA AMBIENTE / Air temperature	UMIDITA' RELATIVA / Relative umidity	PUNTO DI RUGIADA / Dew point	TEMPERATURA SUPPORTO / Surface temperature
19°C	62%	12,2°C	18°C

VERNICIATURA - Painting

				Instrument Type
DATA APPLICAZIONE / *Application Date*	30/10/2024	31/10/2024	04/11/2024	//////////
ORA APPLICAZIONE(DALLE - ALLE) / *Application Hour (From - To)*	13:00 - 15:05	10:00 - 12:00	09:40 - 11:50	//////////
TEMPERATURA AMBIENTE / Air temperature	24°C	22°C	18°C	ELCOMETER 319 TOP SN ZF 29428
UMIDITA' RELATIVA / Relative Humidity	52%	51%	53%	ELCOMETER 319 TOP SN ZF 29428
PUNTO DI RUGIADA / Dew point	13,6°C	11,4°C	8,4°C	ELCOMETER 319 TOP SN ZF 29428
TEMPERATURA SUPPORTO / Surface temperature	24°C	21°C	18°C	ELCOMETER 319 TOP SN ZF 29428
METODO DI APPLICAZIONE / Application method	ROLLER / BRUSH CONVENTIONAL SPRAY	ROLLER / BRUSH CONVENTIONAL SPRAY	ROLLER/BRUSH CONVENTIONAL SPRAY	//////////
PRODOTTO VERNICIANTE / Paint product / Batch	EPOXY RICH ZINC **AVANTGUARD 750** **044085900 - 044075619**	EPOXY HB **HEMPAPRIME MULTI 500** **224075865-224056069**	POLYURETHANE **HEMPATHANE 55610** **224017499-224046936**	//////////
COLORE / Color	GREY	GREY	RAL 9002	//////////
CONTROLLO FILM UMIDO µm / Wet film thickness check	125	275	125	ELCOMETER 3236 S.N. XB04087
D.F.T. RICHIESTO µm / D.F.T. required µm	60	180	60	//////////
DATA CONTROLLO SPESSORE SECCO / Dft checked date	**31/10/2024**	**04/11/2024**	**05/11/2024**	**ISO 19840 - CORRECTION VALUE 25µm**
NUMERO DI LETTURE SPESSORE ESEGUITE / NUMBER OF PERFORMED DFT READING	60	60	60	
D.F.T. MEDIO µm / D.F.T. average µm	**80**	**275**	**350**	ELCOMETER 456TOP Instrument S.N.: SG00559 Probe S.N.: ZC29693

NOTE / Remarks

* PAINTING APPLICATION AS PER INSTRUCTION OF PAINTING MANUFACTURER
* ALL PARTS DEGREASED AS PER SSPC - SP1 BEFORE BLASTING
* BLOTTER TEST AS PER ASTM D4285 SATISFACTORY
* VISUAL TEST AFTER BLASTING AND PAINTING SATISFACTORY
* STRIPE COAT FOR ALL STEPS APPLIED BEFORE SPRAY PAINTING

ROSETTI MARINO SpA
Alberto Renesto
Quality Control Dept.
APP 2735
8.11.24

IURI SALVI - UNOPRIMA NS 476

UNOPRIMA S.R.L. CONTROLLO QUALITÀ

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By

ISPETTORE UNOPRIMA / Unoprima Inspector	ISPETTORE CLIENTE / Customer Inspector	ISPETTORE COMMITTENTE FINALE / Final customer Inspector
DATA - Date	Review ☐ Witness ☒ DATA - Date: 02/11/2024	LUCA DEL CASTELLO for FOLKER on behalf of CROSSWIND DATA - Date 2024-11-08

Test Certificate

Certificat d'essai • Testzertifikat

elcometer®
www.elcometer.com

Certificate Number: 456-ZC29693-P

Probe Part Number: T456CFNF1R

Probe Type: Elcometer 456 Dual FNF Probe: Right Angle; Scale 1: 0-1500µm/0-60mils

Probe Serial Number: ZC29693

Measurement Date: 17/04/2023

The probe was calibrated using factory reference gauge Serial Number TG10156, using a smooth calibration, with the factory zero plate and the thickest certified foil listed below in accordance with Elcometer's Certification Procedure.

La Sonde a été étalonné à l'aide d'un étalonnage lisse, en utilisant une jauge de référance (Nr de Série TG10156),une plaque zéro et la feuille d'étalonnage certifié la plus epaisse qui est énumerés ci-dessous, selon les Procedures d'Etalonnage d'Elcometer.

Die Sonde wurde mit einem Referenz Gerat (Seriennummer TG10156) nach einer glatten Kalibrierermethode kalibriert, durch Einsetzen einer Nullplatte und der dickste zertifizierter Folie, die unten aufgelistet ist. Die Kalibriermethode wurde gemäß Elcometer's Zertifizierungsprotokolls.

Measurement Results: Ferrous • Resultats de Mesure: Ferreux • Messergebnisse: Eisenmetall

Foil / Substrate¹ Value • Valeur • Wert µm	mils	Serial Number²	Actual Measured Value¹ µm	mils		Allowable Value¹ µm	mils	
1480.0	58.27	TB07723	1479.8	58.26	±1%	1465.2 - 1494.8	57.69 - 58.85	Pass
744.0	29.29	TH11503	748.1	29.45	±3%	721.7 - 766.3	28.41 - 30.17	Pass
0.0	0.00	WE16274	0.0	0.00	±1µm	-1.0 - 1.0	-0.04 - 0.04	Pass

Measurement Results: Non Ferrous • Resultats de Mesure: Non-Ferreux • Messergebnisse: Nichteisenmetall

Foil / Substrate¹ Value • Valeur • Wert µm	mils	Serial Number²	Actual Measured Value¹ µm	mils		Allowable Value¹ µm	mils	
1480.0	58.27	TB07723	1480.4	58.28	±1%	1465.2 - 1494.8	57.69 - 58.85	Pass
744.0	29.29	TH11503	743.2	29.26	±3%	721.7 - 766.3	28.41 - 30.17	Pass
0.0	0.00	YF16048	-0.1	-0.01	±1µm	-1.0 - 1.0	-0.04 - 0.04	Pass

Signed on behalf of Elcometer Limited • Signé au nom d'Elcometer Limited • Unterzeichnet im Namen Elcometer Limited

Name:

Quality Manager • Responsable Qualité • Qualitätsbetriebsleiter

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☐ Review ☐ Witness

Date: 08/11/2024

¹ Measurements taken in microns, mils values are calculated using 1µm = 0.03937mil

² Certificate Number: 54212, 54212

LUCA DEL CASTELLO
on behalf of CROSSENS
2024-11-08
☐ W ☐ R ☐ M

ROSETTI MARINO SpA
Alberto Renesto
Quality Control Dept.

delucchi
ZINCHERIA A CALDO

AZIENDA CON SISTEMA DI GESTIONE QUALITÀ CERTIFICATO DA DNV GL = ISO 9001 =

Membro di alz

AGA

HIQUALIZINC

DICHIARAZIONE DI CONFORMITA'
Inspection certificate

Numero: D0982/24 number:	Data: 19/11/2024 date:
Commessa/e n° Production order no.	2406104

Spett.le/Dear Sirs

Cliente/customer: RACCHETTI ALFREDO ARNALDO

Indirizzo/address: VIA MILANO, 43 LOC. CAVATIGOZZI
CREMONA (CR)

Ordine/order: _____ Referente/Person in charge: _____

tel 0372 491104 fax _____

Il materiale/material

da noi ricevuto nelle seguenti date/received on the following dates: 18/11/2024

con Vostri d.d.t. numero-data/with your document number -date: D00849 - 18/11/2024

Descrizione/description: **PROT. 452/24 TICI - unica entrata RIF. ROSETTI MARINO**
GRIGLIATO BORDATO MAGLIA 30x50 - 30x5
N. 07 PEZZI DI VARIE MSIURE SAG.

Spedito il giorno/sent on: 19/11/2024 **con d.d.t. numero**/with document no. 6074

è stato zincato in conformità alle seguenti norme:
has been hot dip galvanized in according the following standards:

UNI EN ISO 1461

Le caratteristiche del rivestimento rilevate soddisfano quanto prescritto dalle norme indicate. *Qualità provata HiQualiZinc.*
Tested specifications satisfy requirements stated by the standards. *Proven quality HiQualiZinc.*

Trezzano Rosa, lì 19/11/2024

Firma RQA/Signature RQA

ENCORE THERMOENGINEERING S.r.l.
QC Inspection
By .....
☒ Review ☐ Witness
Date: 19/11/2024

delucchi S.p.A.

20060 TREZZANO ROSA (MI) - ITALIA – via Bologna 9 - zona ind.
tel. +39(0)2 90960474 - fax +39(0)2 90968181
http://www.bisolzinco.it /ita/gruppo/delucchi
delucchi@bisolzinco.it

T.I.C.I. S.R.L.
Via dell'Artigianato, 6
26010 MONTODINE (CR)
P.I. 00962060190 - TEL. 0373-242255
PEC: tici.srl@pec.it - SDI: J6URRTW

2.2.8 Survey reports

SEE ATTACHED NEXT PAGE

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ROSETTI MARINO	INSPECTION REPORT	Report No. IR-0887-ENC-02	SHEET 1 di 9
		Data *Date* ***19/11/2024***	Rev. *Rev.* ***00***

PROGETTO	CLIENTE	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
HOLLANDSE KUST NOORD WIND PARK	CROSSWIND	**123A90**	

FORNITORE/*Supplier*	No. Ordine/*P.O. No.*	OGGETTO/ *Object:*
ENCORE THERMOENGINEERING	*1724000887*	**Hydrogen Vent**

DESCRIZIONE DEL MATERIALE / *Material Description*					
POS. *Item*	**QUANTITA'** *Quantity*	**DESCRIZIONE** *Description*	**Nr. TAG S/N** *TAG No. S/N*	**TIPO DI ISPEZIONE** / *Kind of Inspection*	**ESITO** / *Result*
10	**1**	**Hydrogen Vent – Vent TIP 12", Length 5M Riser 20" Water Seal Included Cable Tray HDG Included**	**Q-43004**	**Visual and Final Inspection**	**Satisfactory with Note**
20	**1**	**Commissioning Spare Parts**	**-**	**Visual and Final Inspection**	**Satisfactory**
30	**1**	**2y Spare Parts**	**-**	**Visual and Final Inspection**	**Satisfactory**
50	**1**	**Heat Tracing System**	**-**	**Visual and Final Inspection**	**Satisfactory**
70	**2**	**Platform and Ladder**	**-**	**Visual and Final Inspection**	**Satisfactory**

DOCUMENTI APPLICABILI / *Applicable Documents*			
TITOLO DOCUMENTO / *Document Title*	**NUMERO DOCUMENTO** / *Document Number*	**REVISIONE** / *Revision*	**STATO DOCUMENTO** / *Document Status*
INSPECTION AND TEST PLAN	1724000887-QC-ITP-00002	02	1 - NO COMMENTS
GENERAL ARRANGEMENT INCLUDING FOUNDATION LOADS	1724000887-MAC-DA-00003	04	1 - NO COMMENTS
DETAILED DRAWING WITH PART LIST	1724000887-MAC-DD-00005	03	Under Review

DISTRIBUZIONE A: / *Distribution to:*	
☐ **GESTIONE FORNITURE** / *Supply Management Department*	☐ **CAPO COMMESSA** / *Project Manager*
☐ **PRODUZIONE** / *Production*	☒ **FORNITORE** / *Supplier*
☐ **PPLM** / *Project Procurement & Logistic Manager*	☐ **P.Q.M.**
☐ **MAGAZZINO** / *Warehouse*	☐ **P.E.M.**

ATTIVITA' ESEGUITE / *Activities Carried Out*

A – INTRODUZIONE / *Preliminary Introduction*

L' INCARICATO / *The person in charge*	IL RAPP. DEL CLIENTE / *Client's Representative*	IL FORNITORE / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

PROGETTO	CLIENTE	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
HOLLANDSE KUST NOORD WIND PARK	CROSSWIND	**123A90**	
FORNITORE/*Supplier* *ENCORE THERMOENGINEERING*	**No. Ordine/***P.O. No.* *1724000887*	**OGGETTO/** *Object:* **Hydrogen Vent**	

The inspector attended the inspection and test activities listed in the above tab and in accordance with applicable NOI 05 at the Sub-Vendor premises T.I.C.I. S.r.l., Montodine (CR) Italy on November 19th, 2024.

Attendees:
- Monica Denti - T.I.C.I. S.r.l. Representative
- Angelo Longoni - ENCORE THERMOENGINEERING SRL Representative
- Linari Stefano – SQL for ROSETTI MARINO
- Michele Sacchi – QC Painting for ROSETTI MARINO
- Pasquale Anacleto – On behalf Crosswind

The scope of inspection was to carry out the checks as per followings ITP Steps:
a. 4.1 Visual and dimensional check of the assembled Vessel (W)
b. 4.2 Painting inspection (final, dry film Thickness and color) (R) PARTE CARBON STEEL/L&P E PARTE STAINLESS STEEL → See **IR-0887-ENC-03**
c. 5.4 Check of name plate and marking (W)
d. 5.5 Spare parts check (type, quantity) (W)
e. 5.6 Completeness supply check according to the purchase order (W)

All tests gave satisfactory results.

Inspection Results: Satisfactory.

B –SCOPO DELL'ISPEZIONE / *Scope of Inspection*

DESCRIZIONE DEI TEST PRESENZIATI / *Description of witnessed tests*	**ESITO /** *Result*
ITP Step 4.1 Visual and dimensional check of the assembled Vessel	Satisfactory
ITP 4.2 Painting inspection (final, dry film Thickness and color) (R) PARTE CARBON STEEL/L&P E PARTE STAINLESS STEEL	Satisfactory with Note (see **IR-0887-ENC-03)**
ITP 5.4 Check of name plate and marking (W)	Satisfactory
ITP 5.5 Spare parts check (type, quantity) (W)	Satisfactory
ITP . 5.6 Completeness supply check according to the purchase order	Satisfactory

C –DETTAGLIO DEGLI STRUMENTI UTILIZZATI PER TEST E ISPEZIONE / *Details of Inspection and Test Instruments used*

NOME DELLO STRUMENTO *Equipment name*	**PRODUTTORE** *Manufacturer*	**MODELLO** *Model*	**PROSSIMA TARATURA** *Next calibration*
Pressure Gauge	**Fratelli Magni**	**S/N 26440**	**17/07/2025**

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO /
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PROGETTO	CLIENTE	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
HOLLANDSE KUST NOORD WIND PARK	CROSSWIND	**123A90**	

FORNITORE/*Supplier*	No. Ordine/*P.O. No.*	OGGETTO/ *Object:*
ENCORE THERMOENGINEERING	*1724000887*	**Hydrogen Vent**

D –ALLEGATI / *Attachments (***CERTIFICATI E TEST REPORT** */ Certificates and Test Reports)*

NUMERO DOCUMENTO / *Document Number*	DESCRIZIONE / *Description*	TIPO / *Type*	NR. PAGINE / *No. Pages*
Visual & Dimensional reports	Test report		1
ITP signed	ITP signed		1
Painting Certificates	Materials Certificates		2
1724000887-MAC-DA-00003	Dwg		1
1724000887-MAC-DD-00005	Dwg		7
Gratings Inspection Certificate	Test report		1
1724000887-MAC-DD-00019	Dwg		4

E – DETTAGLI ED ESITO DELL'ISPEZIONE */ Details and Results of Inspection*

POS. *Item*	BREVE DESCRIZIONE MATERIALE *Material brief description*	Q.TA' ODA *Order Q.ty*	Q.TA' TESTATA *Tested Q.ty*	ACCETTATO *Accepted*	DATA ACCETTAZIONE *Acceptance date*
10	HYDROGEN VENT	1	1	1	19/11/2024

F – CONCLUSIONI */ Conclusions*

Test Activities carried out with positive results
About DFT checks, has been satisfactory with note (see **IR-0887-ENC-03)**
The Lifting Drawing 1724000887-MAC-DD-00019 will be re issued in rev 02 within current week
Name plate will be installed within today 19/11/2024
Encore will supply cable tray; RM will complete installation of it between Stack and Tip.

Note:
is suggested, just before installation (on the part below the stack) and after the installation, to be performed painting touch up.

See pictures below of all details
Encore will deliver all materials next Monday 26th of November

Inspection Results: Satisfactory.

G – PUNTI IRRISOLTI */ Outstanding points*

None

H – STATO PACKING LIST / *Packing List Status*	☐ EMESSO / *Issued*	☒ NON EMESSO / *Not Issued*	DD/MM/YYYY **ULTIMA DATA UTILE** / *Last Date*

PUNCH LIST REPORT: VEDI ALLEGATO N° / *Refer to Attachment n° N/A*

REPORT FOTOGRAFICO (SE PRESENTE) / *Digital Pictures (if any)*

L' INCARICATO / *The person in charge*	IL RAPP. DEL CLIENTE / *Client's Representative*	IL FORNITORE / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO /
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PROGETTO	CLIENTE	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
HOLLANDSE KUST NOORD WIND PARK	CROSSWIND	**123A90**	
FORNITORE/*Supplier* *ENCORE THERMOENGINEERING*	**No. Ordine/***P.O. No.* *1724000887*	**OGGETTO/** *Object:* **Hydrogen Vent**	

MATERIAL IDENTIFICATION



TIP



CABLE TRAY OF TIP

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

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ROSETTI MARINO	INSPECTION REPORT	Report No. IR-0887-ENC-02	SHEET 5 di 9
		Data *Date* ***19/11/2024***	Rev. *Rev.* ***00***

PROGETTO	CLIENTE	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
HOLLANDSE KUST NOORD WIND PARK	CROSSWIND	**123A90**	
FORNITORE/*Supplier* *ENCORE THERMOENGINEERING*	**No. Ordine/***P.O. No.* *1724000887*	**OGGETTO/** *Object:* **Hydrogen Vent**	



LADDER and Platform



HANDRAILS

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO /
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STACK



STACK

L' INCARICATO / *The person in charge*	IL RAPP. DEL CLIENTE / *Client's Representative*	IL FORNITORE / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

PROGETTO	CLIENTE	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
HOLLANDSE KUST NOORD WIND PARK	CROSSWIND	**123A90**	
FORNITORE/*Supplier* *ENCORE THERMOENGINEERING*	**No. Ordine/***P.O. No.* *1724000887*	**OGGETTO/** *Object:* **Hydrogen Vent**	



HEAT TRACING



HEAT TRACING



HEAT TRACING



HEAT TRACING

L' INCARICATO / *The person in charge*	IL RAPP. DEL CLIENTE / *Client's Representative*	IL FORNITORE / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO /
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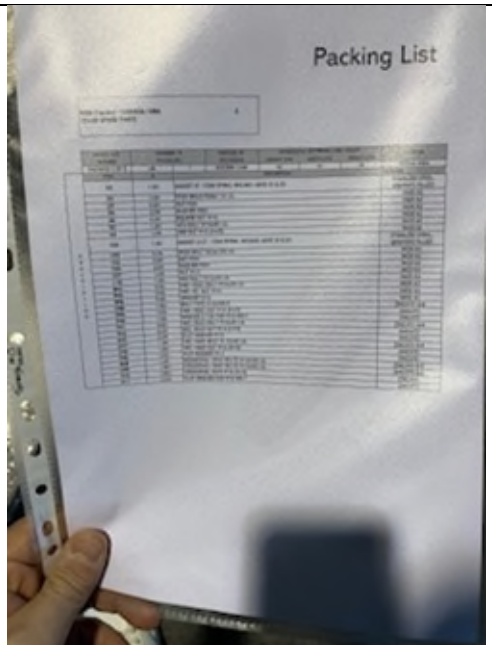
PROGETTO	CLIENTE	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
HOLLANDSE KUST NOORD WIND PARK	CROSSWIND	**123A90**	
FORNITORE/*Supplier* *ENCORE THERMOENGINEERING*	**No. Ordine/***P.O. No.* *1724000887*	**OGGETTO/** *Object:* **Hydrogen Vent**	



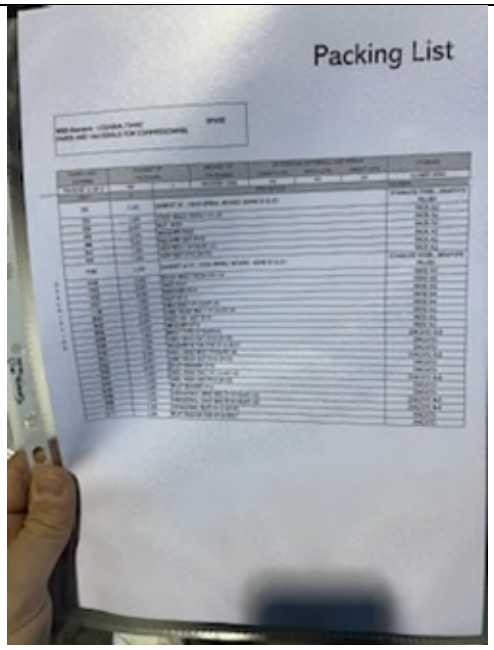
HEAT TRACING



CABLE TRAY



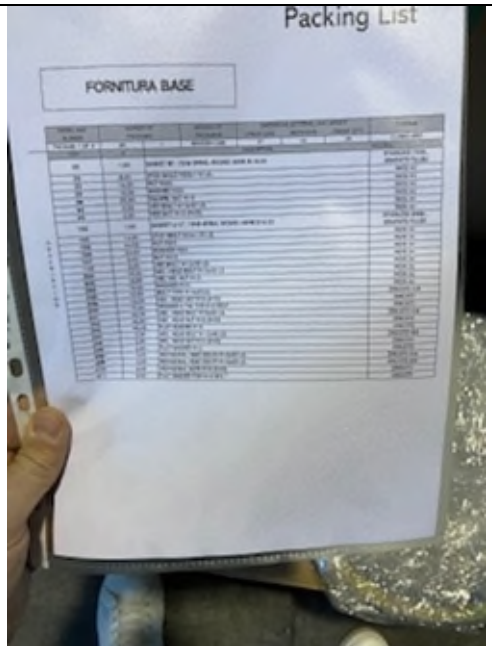
PKL 2Y SPARE PARTS



PKL COMMISSIONING SPARE PARTS

HYDROSTATIC TEST

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		



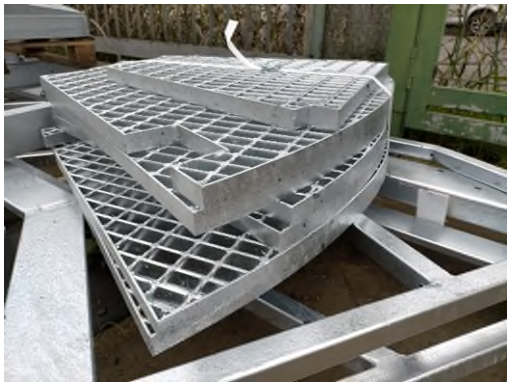
PKL ACCESSORIES



NAMEPLATE



Gratings



Gratings

NON VALIDO PER IL RILASCIO DELLA FORNITURA / *It is not valid for the supply's release*

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Stefano Linari Quality Control Dept.		

ROSETTI MARINO	INSPECTION REPORT	Report No. IR-ENC-0887-003	SHEET 1 of 11
		Data *Date 20/11/2024*	Rev. *Rev. 0*
PROGETTO *Project* **Base Load Power Hub (BLPH)**	**CLIENTE** *Client* CROSSWIND	**COMMESSA /** *Job* ***123A90***	**COMMESSA FORNITORE** / *Job Vendor* 23-0193
FORNITORE *Supplier: Encore Thermoengineering*	**No. Ordine** *P.O. No.* **1724000887 Rev.2**	**OGGETTO** *Object Hydrogen Vent*	

DESCRIZIONE DEL MATERIALE / *Material Description*

POS. *Item*	**QUANTITA'** *Quantity*	**DESCRIZIONE** *Description*	**Nr. TAG** *TAG No.*	**TIPO DI ISPEZIONE** / *Kind of Inspection*	**ESITO** / *Result*
10	1	TIP	Q-43004	Visual Check DFT	**Satisfactory with note**
70	1	Platform, ladder & handrails	Q-43004	Visual Check DFT	**Satisfactory**

DOCUMENTI APPLICABILI / *Applicable Documents*

TITOLO DOCUMENTO / *Document Title*	**NUMERO DOCUMENTO** / *Document Number*	**REVISIONE** / *Revision*	**STATO DOCUMENTO** / *Document Status*
INSPECTION AND TEST PLAN	1724000887-QC-ITP-00002	02	AFC
VALVES SURFACE PREPARATION AND PAINTING PROCEDURES	1724000887-MAT-PRO-00010	02	AFC

Remarks: None.

DISTRIBUZIONE A: / *Distribution to:*

☒**GESTIONE FORNITURE** / *Supply Management Department*	☒**CAPO COMMESSA** / *Project Manager*
☒**PRODUZIONE** / *Production*	☒**FORNITORE** / *Supplier*
☒**PPLM** / *Project Procurement & Logistic Manager*	☒**P.Q.M.**
☒**MAGAZZINO** / *Warehouse*	☒**P.E.M.**

ATTIVITA' ESEGUITE / *Activities Carried Out*

A - INTRODUZIONE / *Preliminary Introduction*

The present report refers to the inspection visit carried out 19/11/2024 at T.I.C.I. Srl factory, located in Via Dell'Artigianato 6 – 26010 Montodine (CR) , ITALY.
The following inspection activities were witnessed by Rosetti Marino and Crosswind as specified in the Notification of Inspection (Noi Nr. 05 Rev.05 of 08-11-2024) and in accordance with ITP (STEP 4.2) and Factory acceptance test procedure.
Attendees the test:

Michele Sacchi (Rosetti Marino QC Coating Inspector)
Stefano Linari (Rosetti Marino SQL)
Angelo Longoni (Encore Thermoengineering QC Dep.)
Pasquale Anacleto (behalf for Crosswind)
Area of concern
None

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35424		

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PROGETTO *Project*	CLIENTE *Client*	COMMESSA / *Job*	COMMESSA FORNITORE / *Job Vendor*
Base Load Power Hub (BLPH)	CROSSWIND	***123A90***	23-0193

FORNITORE *Supplier:*	No. Ordine *P.O. No.*	OGGETTO *Object*
Encore Thermoengineering	**1724000887 Rev.2**	*Hydrogen Vent*

B –SCOPO DELL'ISPEZIONE / *Scope of Inspection*

DESCRIZIONE DEI TEST PRESENZIATI / *Description of witnessed tests*	ESITO / *Result*
As per Inspection Notification follow the activities: • Visual inspection • DFT check TIP (Coating system 6A); Platform, ladder & handrails (Coating system 1) • Ral color (TIP RAL COLOR 9002 & Platform and ladder RAL COLOR 1023)	**Satisfactory**

C –DETTAGLIO DEGLI STRUMENTI UTILIZZATI PER TEST E ISPEZIONE / *Details of Inspection and Test Instruments used*

NOME DELLO STRUMENTO *Equipment name*	PRODUTTORE *Manufacturer*	MODELLO *Model*	PROSSIMA TARATURA *Next calibration*
Elcometer 456	**Elcometer**	**Model S Dual FNF Separate S\N ZM13936**	**03-01-2025**

Remarks:
None.

D –ALLEGATI / *Attachments (***CERTIFICATI E TEST REPORT** */ Certificates and Test Reports)*

NUMERO DOCUMENTO / *Document Number*	DESCRIZIONE / *Description*	TIPO / *Type*	NR. PAGINE / *No. Pages*
456-ZM13936-G	Certificate of Calibration	Certificate	1

Remarks:
None.

E – DETTAGLI ED ESITO DELL'ISPEZIONE */ Details and Results of Inspection*

All details has been highlighted in the test reports.

F – CONCLUSIONI */ Conclusions*

Test Activities Carried Out With Positive Results.

Note: During the DFT Check has been highlighted that the DFT (TIP piping under carter personal protection) does not reach the nominal THK. Anyway it can be accepted due to Stainless Steel material 316.
Reading Average THK. 80 micron.

G – PUNTI IRRISOLTI */ Outstanding points*

None.

H – STATO PACKING LIST / *Packing List Status*	☐ EMESSO / *Issued*	☒ NON EMESSO / *Not Issued*	DD/MM/YYYY **ULTIMA DATA UTILE** / *Last Date*

PUNCH LIST REPORT: VEDI ALLEGATO N° / *Refer to Attachment n° NOT APPLICABLE*

REPORT FOTOGRAFICO (SE PRESENTE) / *Digital Pictures (if any)*

L' INCARICATO / *The person in charge*	IL RAPP. DEL CLIENTE / *Client's Representative*	IL FORNITORE / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35424		

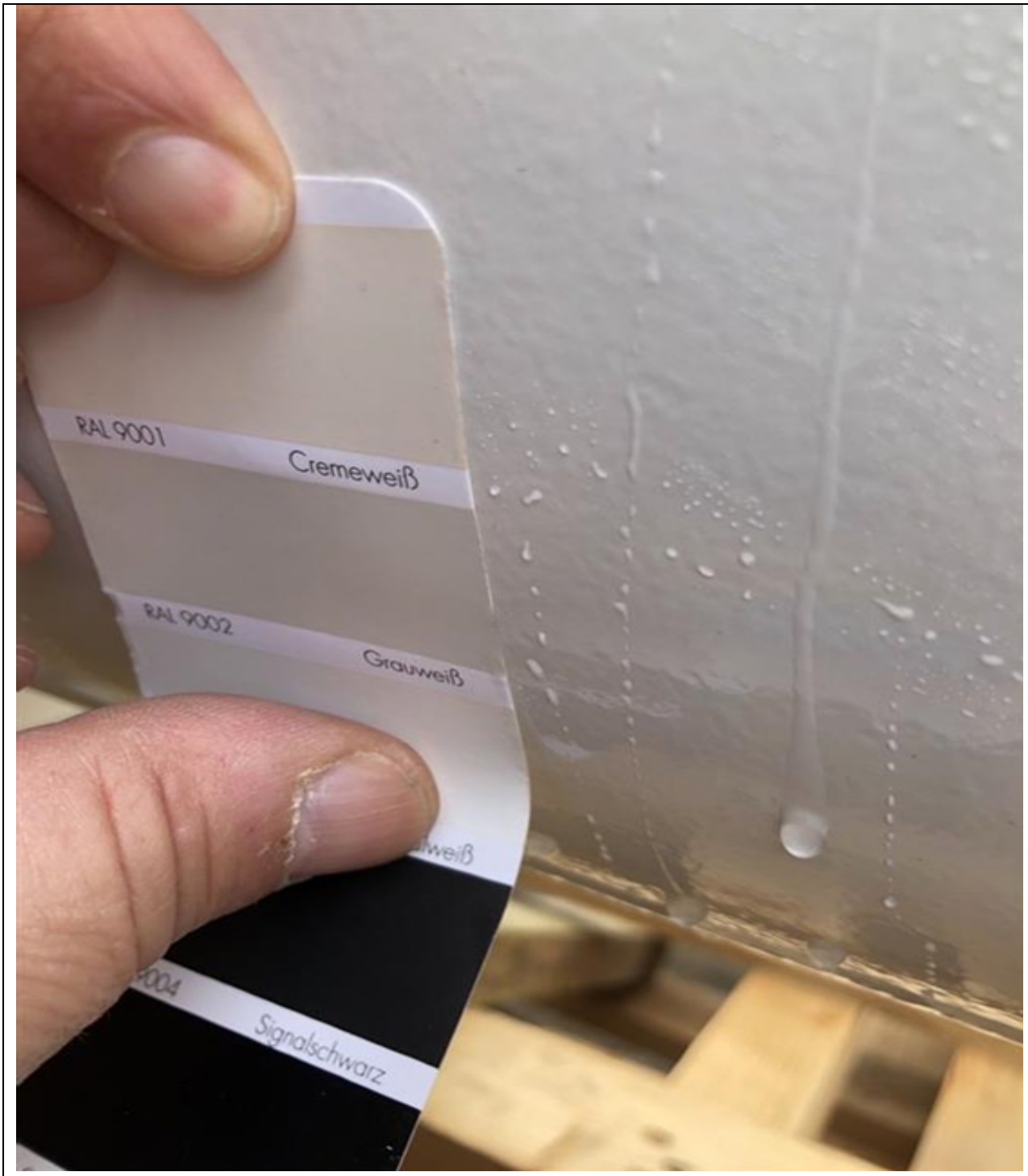
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Overview TIP external side

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35424		

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TIP Ral Color 9002

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35424		



Elcometer 456 Serial Number ZM13936



DFT Calibration

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35424		



DFT Check TIP external side S.S. Surface



DFT Check TIP external side S.S. Surface



DFT Check TIP external side S.S. Surface



DFT Check TIP external side S.S. Surface

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35424		

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO /
This document does not relieve the Supplier of the responsibility of any possible defects and/or misfunctioning arising during the utilisation.





Platform, ladder & Handerails

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35424		

QUESTO DOCUMENTO NON SOLLEVA IL FORNITORE DALLA RESPONSABILITA' DI EVENTUALI DIFETTI E/O MALFUNZIONAMENTI RILEVATI DURANTE L'USO /
This document does not relieve the Supplier of the responsibility of any possible defects and/or misfunctioning arising during the utilisation.



Platform, ladder & Handerails Ral Color 1023

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ROSETTI MARINO SpA Michele Secchi Quality Control Dept. NACE #35424		



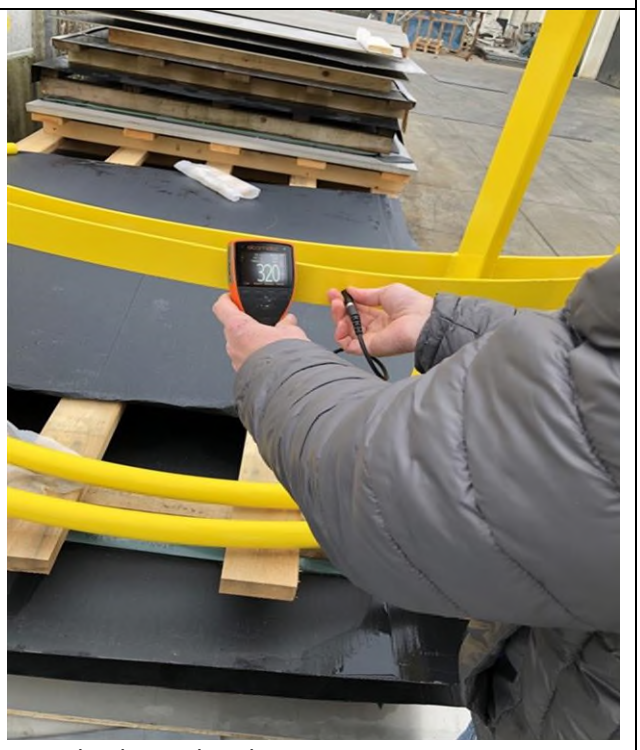
DFT Check Handerails



DFT Check Handerails



DFT Check Handerails



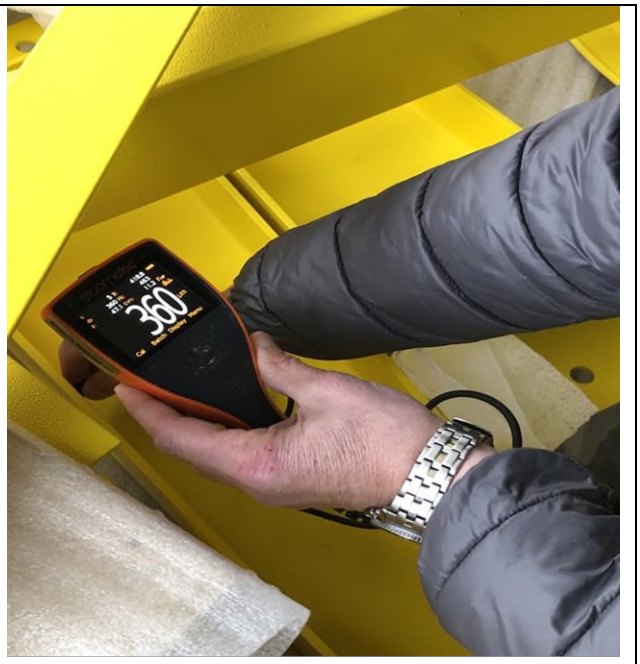
DFT Check Handerails

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35464		

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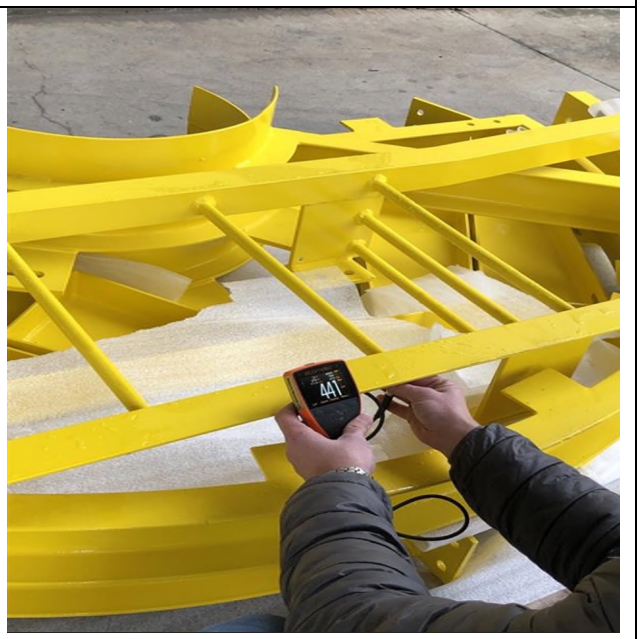
DFT Check Platform & ladder



DFT Check Platform & ladder



DFT Check Platform & ladder



DFT Check Platform & ladder

NON VALIDO PER IL RILASCIO DELLA FORNITURA / *It is not valid for the supply's release*

L' INCARICATO / *The person in charge*	**IL RAPP. DEL CLIENTE** / *Client's Representative*	**IL FORNITORE** / *Supplier*
ROSETTI MARINO SpA Michele Sacchi Quality Control Dept. NACE #35464		

Test Certificate
Certificat d'essai • Testzertifikat

elcometer®
www.elcometer.com

Certificate Number:
Numéro de Certificat:
Bescheinigungsnummer: 456-ZM13936-G

Instrument Part Number:
Code Article d'instrument:
Artikelnummer des Geräts: A456CFNFSS

Instrument Type:
Instrument Modèle:
Gerätetyp: Elcometer 456 Model S Dual FNF Separate
Elcometer 456 Modèle S Dual FNF à sonde séparée
Elcometer 456 Modell S mit separater Kombi-Sonde für Eisen und Nicht-Eisen (FNF)

Instrument Serial Number:
Instrument Numéro de Série:
Seriennummer des Geräts: ZM13936

Instrument PCB Serial Number:
Circuit Imprimé Numéro de Série:
Seriennummer der Leiterplatte: ZK23689-000

Measurement Date:
Date de Mesure:
Maß-datum: 03/01/2024

The instrument was calibrated using factory reference probe Serial Number UH11036 using a smooth calibration, with the factory zero plate and the thickest certified foil listed below in accordance with Elcometer's Certification Procedure.

L'instrument a été étalonné à l'aide d'un étalonnage lisse, en utilisant une Sonde de référance UH11036, une plaque zéro et la feuille d'étalonnage certifiée la plus épaisse qui sont énumérés ci-dessous, selon les Procédures d'Etalonnage d'Elcometer.

Das Gerät wurde mit einer Referenz-Sonde (Seriennummer UH11036) nach einer glatten Kalibriermethode kalibriert, durch Einsetzen einer Nullplatte und die dickste zertifizierter Folie, die unten aufgelistet ist. Die Kalibriermethode wurde gemäß Elcometer's Zertifizierungsprotokolls durchgeführt

Measurement Results: Ferrous • Resultats de Mesure: Ferreux • Messergebnisse: Eisenmetall

Foil / Substrate[1] Feuille d'Etalonnage / Substrat[1] Folie / Untergrund[1]			Actual Measured Value[1] Valeur mesurée exacte[1] Aktuelle Messwert[1]		Allowable Value[1] Valeur admissible[1] Zulässigen Wert[1]			
Value • Valeur • Wert		Serial Number[2] Numéro de Série[2] Seriennummer[2]						
µm	mils		µm	mils		µm	mils	
1488.0	58.58	UG13148	1487.0	58.54	±1%	1473.1 - 1502.9	58.00 - 59.17	Pass • Réussi • Bestanden
749.0	29.49	XL20243	751.7	29.59	±3%	726.5 - 771.5	28.60 - 30.37	Pass • Réussi • Bestanden
0.0	0.00	XC28006	0.0	0.00	±1µm	-1.0 - 1.0	-0.04 - 0.04	Pass • Réussi • Bestanden

Measurement Results: Non Ferrous • Resultats de Mesure: Non-Ferreux • Messergebnisse: Nichteisenmetall

Foil / Substrate[1] Feuille d'Etalonnage / Substrat[1] Folie / Untergrund[1]			Actual Measured Value[1] Valeur mesurée exacte[1] Aktuelle Messwert[1]		Allowable Value[1] Valeur admissible[1] Zulässigen Wert[1]			
Value • Valeur • Wert		Serial Number[2] Numéro de Série[2] Seriennummer[2]						
µm	mils		µm	mils		µm	mils	
1488.0	58.58	UG13148	1488.6	58.61	±1%	1473.1 - 1502.9	58.00 - 59.17	Pass • Réussi • Bestanden
749.0	29.49	XL20243	752.2	29.61	±3%	726.5 - 771.5	28.60 - 30.37	Pass • Réussi • Bestanden
0.0	0.00	YA00779	-0.1	0.00	±1µm	-1.0 - 1.0	-0.04 - 0.04	Pass • Réussi • Bestanden

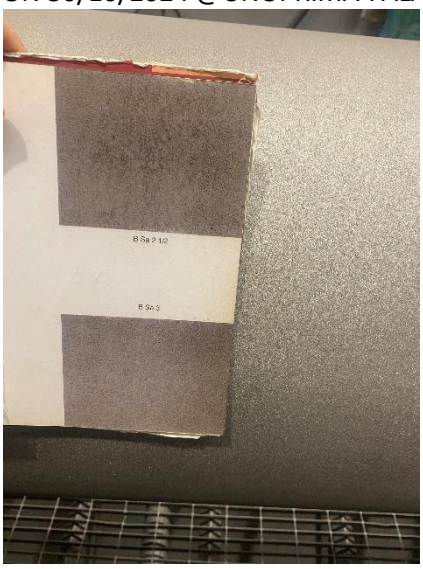
Signed on behalf of Elcometer Limited • Signé au nom d'Elcometer Limited • Unterzeichnet im Namen Elcometer Limited

Name:
Nom:
Name: A. Smith

Quality Manager • Responsable Qualité • Qualitätsbetriebsleiter

[1] Measurements taken in microns, mils values are calculated using 1µm = 0.03937mil
[1] Les valeurs sont prises en microns. Les valeurs en 'mils' sont calculées en utilisant 1µm = 0.03937mil
[1] Messwerte sind in Microns gezeigt. Um auf „mils" umzurechnen, benutzen Sie 1µm = 0.03937mil
[2] Certificate Number: 55613
[2] Numéro de Certificat: 55613
[2] Bescheinigungsnummer: 55613

PHOTOGRAPHIC REPORT OF PAINTING INSPECTION (SURFACE PREPARATION, PRIMER); CARBON STEEL PART ON 30/10/2024 @UNOPRIMA-PALAZZAGO (BG); JOB REF. PO -1724000887 Rev.2- HYDROGEN VENT; NOI03

















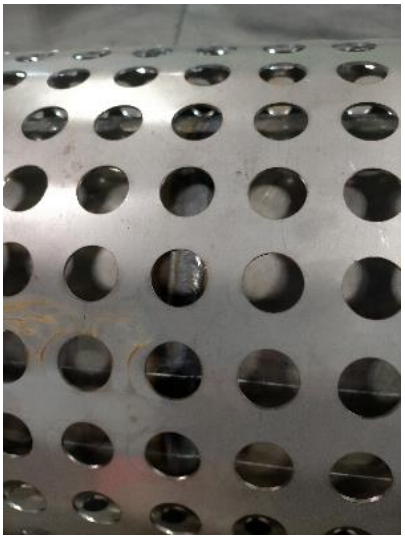




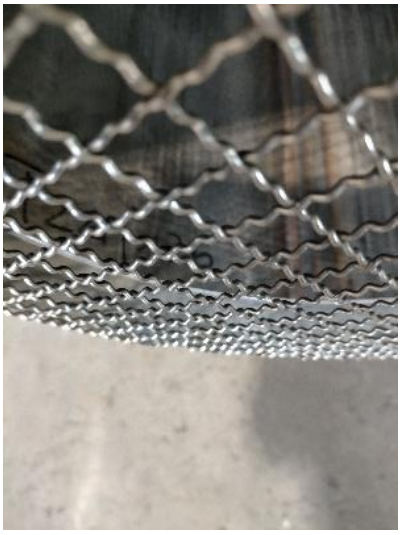
PHOTOGRAPHIC REPORT OF VISUAL AND DIMENSIONAL CHECK OF THE ASSEMBLED VESSEL (VENT TIP) BEFORE RELEASE TO PAINTING AND FERRITE CHECK ON STAINLESS STEEL PLATES, PIPES (VNT TIP ONLY) ON 31/10/2024 @TICI MONTODINE (BG); JOB REF. PO -1724000887 Rev.2- HYDROGEN VENT; NOI02








8.1


8.8




9.4


6.4




SDTE 61

2.2.9 Atex Certificates

SEE ATTACHED NEXT PAGE

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Base Load Power Hub (BLPH)

ATEX CERTIFICATION - HYDROGEN VENT

Document Number: 1724000887-MAC-LIS-00013

Document Class: 2

02	06/12/2024	Acceptance for construction (AFC)	SB	RV	ADL
01	25/10/2024	Acceptance for construction (AFC)	SB	RV	ADL
00	19/09/2024	Issue for Review (IFR)	SB	RV	ADL
Rev.	Date	Description	Prepared	Reviewed	Approved

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Acceptance for Construction (AFC)
02	Acceptance for Construction (AFC)

HOLDS LIST

No.	Description
1	
2	
3	
4	

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List of Attachments

Attachment 1

- ETS-05_Baseefa13ATEX0137 Issue 6

Attachment 2

- XTVR_SGS20ATEX0049X_Issue 4

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.

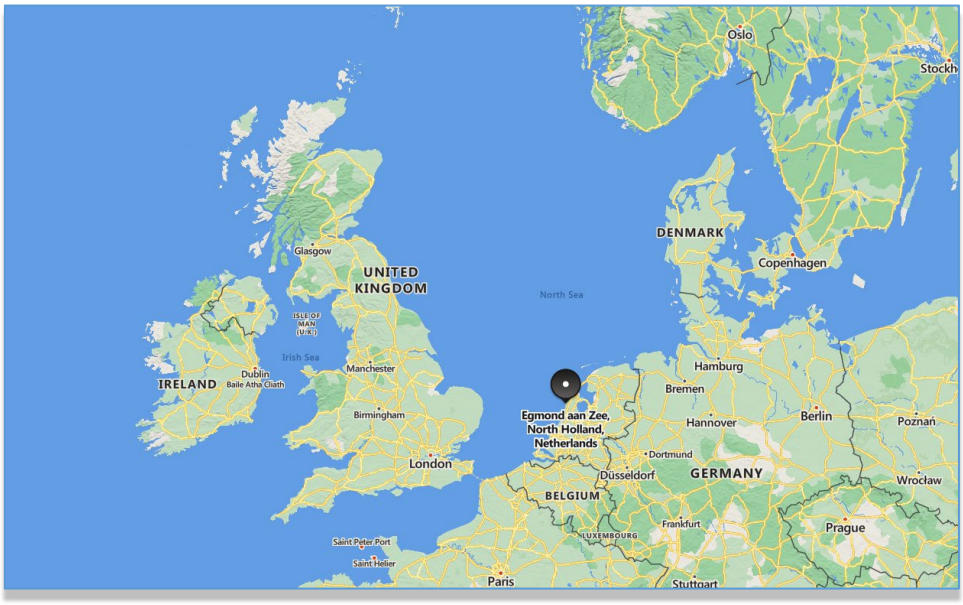


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

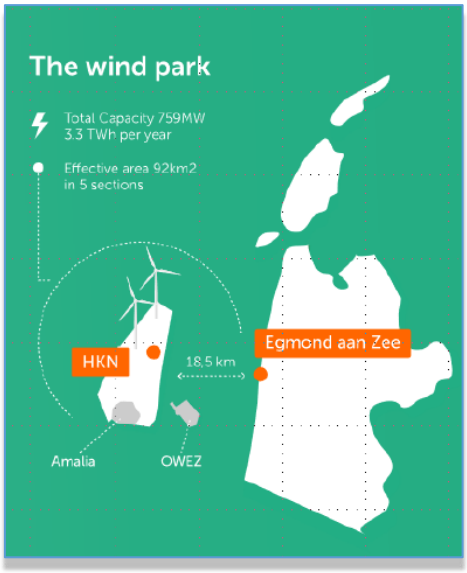


Figure 2 - Wind Park Details

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 located on coordinates E 590719.1, N 5841602.3 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.

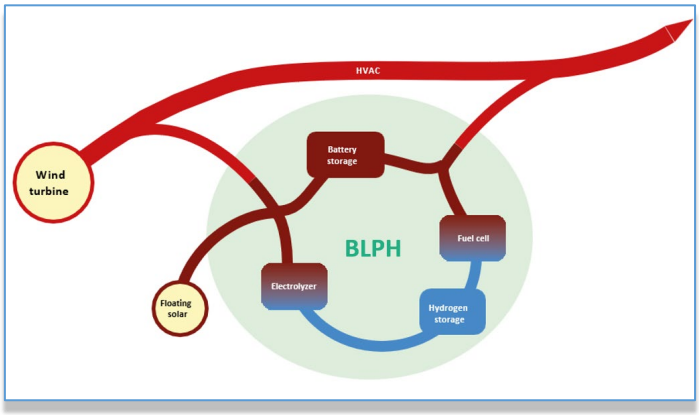


Figure 3 – BLPH Concept

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 s 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

This Document includes the Atex Certifications of the project as attachments

2.1 REFERENCES

To see Atex Register – Doc. No.: 1724000887-QC-LIS-00019_03

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	CROSSWIND
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Table 1 - Definitions and Abbreviations

1 # EU - TYPE EXAMINATION CERTIFICATE

2 **Equipment or Protective System Intended for use in Potentially Explosive Atmospheres Directive 2014/34/EU**

3 EU - Type Examination Certificate Number: **Baseefa13ATEX0137 Issue 6**

3.1 In accordance with Article 41 of Directive 2014/34/EU, EC-Type Examination Certificates referring to 94/9/EC that were in existence prior to the date of application of 2014/34/EU (20 April 2016) may be referenced as if they were issued in accordance with Directive 2014/34/EU. Supplementary Certificates to such EC-Type Examination Certificates, and new issues of such certificates, may continue to bear the original certificate number issued prior to 20 April 2016.

4 Product: **ETS-05 Electronic Thermostat**

5 Held by: **nVent Thermal Belgium NV**

6 Address: **Research Park Haasrode - Zone 2, Romeinse straat 14, B-3001 Leuven, Belgium**

7 This re-issued certificate extends EC Type Examination Certificate No. Baseefa13ATEX0137 to apply to product designed and constructed in accordance with the specification set out in the Schedule of the said certificate but having any variations specified in the Schedule attached to this certificate and the documents therein referred to.

8 SGS Fimko Oy, Notified Body number 0598, 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.

8.1 The original certificate was issued by SGS Baseefa Ltd (UK Notified Body 1180). It, and any supplements previously issued by SGS Baseefa Ltd have been transferred to the supervision of SGS Fimko Oy (EU Notified Body 0598). The original certificate number is retained.

The examination and test results are recorded in confidential Report No. **See Certificate History**

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0:2018 EN IEC 60079-7:2015+A1:2018 EN 60079-11:2012 EN 60079-18: 2015 EN 60079-31:2013

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:

Ex **See schedule**

SGS Fimko Oy Customer Reference No. **5034** Project File No. **20/0458**

This document is issued by the Company subject to their General Conditions for Certification Services accessible at hiip://www.sgs.com/en/Terms-and-Conditions.aspx . Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any holder of this document is advised that information contained herein reflects the Company's findings at the time of their intervention only and within the limits of Client's instructions, if any. It does not necessarily indicate that the equipment may be used in particular industries or circumstances. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. This document cannot be reproduced except in full, schedule included, without prior written approval of the Company. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law.

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Business ID 0978538-5 Member of the SGS Group (SGA SA)

Tuomas Hänninen
SGS Fimko Oy

13 # Schedule

14 ## Certificate Number Baseefa13ATEX0137 – Issue 6

15 Description of Product

The nVent ETS-05 Electronic Thermostat provides accurate temperature control for heating cables.

It comprises a plastic box with terminals inside for connection to the sensor and to the incoming user connections. Relay contacts are present to allow resistive loads of up to 230V a.c. at 32A to be controlled.

ETS-05-a1-bb-c
The supply range for the equipment is 99 to 121V a.c.
Supply & relay terminal block TB1 U_m = 253V. Rated current = 32A.
Relay terminal block TB3 (if present) U_m = 253V.

ETS-05-a1R-bb-c
The supply range for the equipment is 99 to 132V a.c. U_m = 253V.
Supply & relay terminal block TB1 Um = 253V. Rated current = 32A.
Relay terminal block TB3 (if present) Um = 253V.

ETS-05-a2-bb-c
The supply range for the equipment is 195 to 230V a.c. U_m = 253V.
Supply & relay terminal block TB1 Um = 253V. Rated current = 32A.
Relay terminal block TB3 (if present) Um = 253V.

ETS-05-a2R-bb-c
The supply range for the equipment is 195 to 277V a.c. U_m = 277V.
Supply & relay terminal block TB1 Um = 277V. Rated current = 32A.
Relay terminal block TB3 (if present) Um = 277V.

The options a bb & c affect the operational non-safety aspects:-
a = A (0°C to 49°C model)
H (0°C to 499°C model)
L (0°C to 199°C model)
bb = A (American market version)
= E (European market version)
= J (Japanese market version)
c = A (Alarm output model) Rated alarm output = 275V, 3A resistive.
= not present (Alarm output not present)

Sensor Connections - Terminal Block TB2

U_o = 5.88V
I_o = 29mA
P_o = 43mW
C_i =26nF
L_i = 0
U_i = 0

The capacitance and either the inductance or inductance to resistance ratio (L/R) of the load connected to hazardous area terminals must not exceed the following values:

GROUP	CAPACITANCE (µF)	INDUCTANCE (mH)	OR L/R RATIO (µH/ohm)
IIC	43	43	843
IIB	1000	172	3373
IIA	1000	345	6746

The above load parameters apply where:

1. The external circuit contains no combined lumped inductance L_i and capacitance C_i greater than 1% of the above values, or
2. The inductance and capacitance are distributed as in a cable, or
3. The external circuit contains either only lumped inductance or lumped capacitance in combination with a cable.

In all other situations e.g. the external circuit contains combined lumped inductance and lumped capacitance, up to 50% of each of the L and C values is allowed.

The equipment is marked:

Ⓔx II 2(1)G Ex eb ia mb [ia Ga] IIC T5 Gb -40ºC ≤ Ta ≤ +60ºC
Ⓔx II 2D Ex tb IIIC T100ºC Db

16 Report Number

See Certificate History.

17 Specific Conditions of Use

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.

Clause	Subject	Compliance
1.2.7	LVD type requirements	Standards require manufacturer's declaration, supplied.
1.2.8	Overloading of equipment (protection relays, etc.)	Covered by installation rules and manufacturer's instructions
1.4.1	External effects	The Purchaser should make the manufacturer aware of such issues. Covered in Instructions
1.4.2	Aggressive substances, etc.	The Purchaser should make the manufacturer aware of such issues. Covered in Instructions

19 Drawings and Documents

New drawings submitted for this issue of certificate:

Number	Sheet	Issue	Date	Description
RGD 1102-107	1	6	01/05/2021	ETS-05 nVent Certification Label

This drawing is held with IECEx BAS 13.0071 Issue 6.
Other applicable drawings are listed on Baseefa13ATEX0126 Issue 5.

20 Certificate History

Certificate No.	Date	Comments
Baseefa13ATEX0137	26 August 2014	The release of the prime certificate. The associated test and assessment against the requirements of EN60079-0: 2012, EN60079-7: 2007, EN60079-11: 2012, EN60079-18: 2009 & EN60079-31: 2013 is recorded in Report GB/BAS/ExTR14.0185/00 for Project 12/0565
Baseefa13ATEX0137 Issue 1	21 December 2016	This issue reflects the issue of Baseefa13ATEX0126 Issue 1. Report GB/BAS/ExTR16.0395/00, Project 16/0987

Certificate No.	Date	Comments
Baseefa13ATEX0137/2	28 February 2018	To permit the use of an alternative opto-coupler and the correction of the marking code. See report GB/BAS/ExTR18.0099/00 for project 17/0869.
Baseefa13ATEX0137/3	22 January 2019	To confirm the certificate is now held in the name of nVent Thermal Belgium BV, and to permit the label to show name of nVent Thermal Belgium BV. See GB/BAS/ExTR18.0125/00 for project 17/0864.
Baseefa13ATEX0137/4	8 April 2020	To permit the addition of a new variant model ETS-05-x3-x that has an increased voltage range of 195V to 277V, and an increased U_m of 277V. See report GB/BAS/ExTR20.0070/00 for project 20/0005.
Baseefa13ATEX0137 Issue 5	10 August 2020	This issue of the certificate incorporates previously issued primary & supplementary certificates into one certificate, permits the use of an alternative enclosure, and confirms the equipment meets the requirements of EN IEC 60079-0:2018, EN IEC 60079-7: 2015+A1:2018 and EN 60079-18: 2015. See report GB/BAS/ExTR20.0119/00 for project 20/0123.
Baseefa13ATEX0137 Issue 6	30 September 2021	This issue of the certificate permits the addition of models with alarm outputs and permits the introduction of a new model naming convention. See report GB/BAS/ExTR21.0172/00 for project 20/0458.
For drawings applicable to each issue, see original of that issue.		

1 # EU - TYPE EXAMINATION CERTIFICATE

2 **Equipment or Protective System Intended for use in Potentially Explosive Atmospheres Directive 2014/34/EU**

3	EU - Type Examination Certificate Number:	**SGS20ATEX0049X – Issue 4**
4	Product:	**XTV Range of Self-Regulating Trace Heating Systems**
5	Manufacturer:	**nVent Thermal LLC**
6	Address:	**899 Broadway Street, CA, 94063-3104, United States of America**

7 This re-issued certificate extends EU Type Examination Certificate No. **SGS20ATEX0049X** to apply to product designed and constructed in accordance with the specification set out in the Schedule of the said certificate but having any variations specified in the Schedule attached to this certificate and the documents therein referred to.

8 SGS Fimko Oy, Notified Body number 0598, 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. **See Certificate History**

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0:2018 EN IEC 60079-7:2015+A1:2018 EN 60079-18:2015+A1:2017 EN 60079-30-1:2017 EN 60079-31:2014

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 :

Ⓔx II 2 GD Ex 60079-30-1 eb IIC T* Gb or Ex 60079-30-1 eb mb IIC T* Gb Tmin -60°C
Ex 60079-30-1 tb IIIC T°C Db or Ex 60079-30-1 mb tb IIIC T**°C Db (*/** see schedule)**

SGS Fimko Oy Customer Reference No. **0865** Project File No. **23/0318**

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13 # Schedule

14 ## Certificate Number SGS20ATEX0049X – Issue 4

15 Description of Product

The XTV Range of Self-Regulating Trace Heating Systems is of the parallel circuit self-regulating type, rated at up to 277V, with power output up to 66W/m (20W/ft). The units have a maximum self-limiting temperature of 240°C. The systems are also suitable for applications at lower temperatures when used as part of a stabilised design. The limiting temperatures of the end seals, splices and power connections must be observed as part of the self-limiting or stabilised design.

Each trace heating system comprises:

- the active heating cable.
- an end seal for terminating the remote end of the unit.
- a cable gland for connecting the powered end of the unit to a suitable terminal enclosure, or alternative integrated power connection systems.

The active heating cable comprises two stranded copper conductors separated by a fluoropolymer spacer around which are wound, in a spiral, a number of carbon loaded polymer fibres, which form the active part of the heating cable. An extruded layer of fluoropolymer covers the fibres and serves to insulate the copper conductors from a conductive covering, which covers the basic heater. A protective anti-corrosion fluoropolymer sheath may be extruded over the conductive cover. In this arrangement the unit is designated the XTV-CT Range of Self-Regulating Trace Heating Systems.

The outer fluoropolymer sheath may optionally be omitted to form the XTV-C Range of Self-Regulating Trace Heating Systems.

The declared maximum withstand temperature for the range is 250°C and the minimum installation temperature is -60°C.

CABLE ACCESSORIES

END SEALS

The end seals for terminating the remote end of the unit may be the following types:

Types E-100-L or E-100, which are mechanical end seals incorporating an end cap which is filled with silicone grease sealant, covered by certificates Sira14ATEX3015X and PTB09ATEX1060U.

Types E-100-L-A or E-100-A, which are mechanical end seals incorporating an end cap which is filled with silicone grease sealant.

A Raychem Type E-40 heat shrink end seal kit.

Type E-150 mechanical end seals, covered by certificate DEKRA20ATEX0011U.

SPLICES AND JOINTS

The following splicing and jointing arrangements are provided:

A Raychem Type S-40 heat shrink splice kit for connecting lengths of active heating cable.

A Raychem T-100 tee connection system, certificate PTB20ATEX1008U, for connecting up to three heater cables.

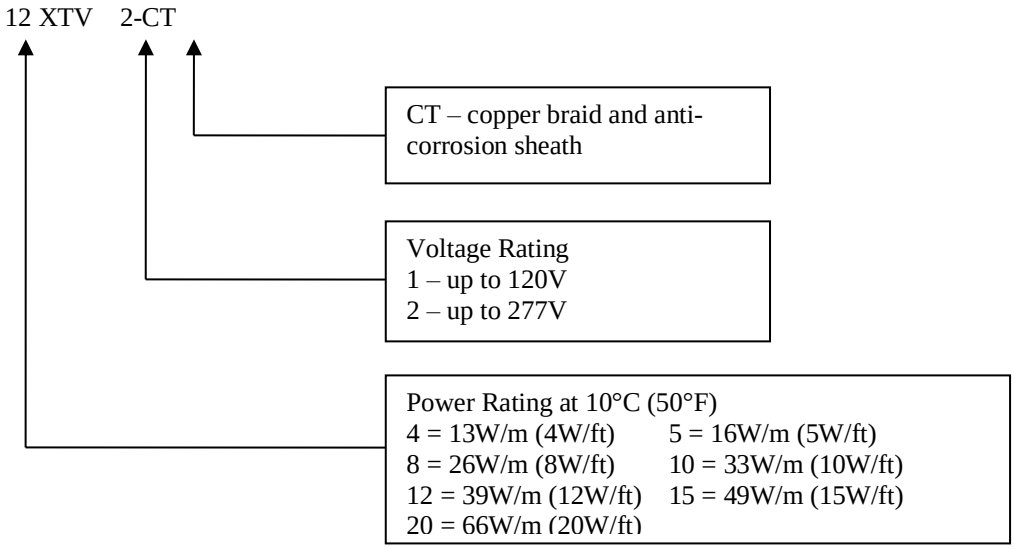
Type S-150 mechanical splice kit, covered by DEKRA20ATEX0011U.
POWER CONNECTIONS

Power connection may be achieved by the following means:

Connection Type	ATEX Certificate
JBM-100	PTB20ATEX1008U
JBS-100	PTB20ATEX1008U
JBU-100	PTB20ATEX1008U
C-150-E	DEKRA20ATEX0011U
C25-21 Connection Kit	Baseefa16ATEX0037U
C25-100 Connection Kit	Baseefa16ATEX0038U
C25-100-Metal / C3/4-100-Metal / C25-100-Metal-NP / C3/4-100-Metal-NP / C25-100-Metal-SS Kits	Baseefa16ATEX0039U

The C25-100-Metal / C3/4-100-Metal / C25-100-Metal-NP / C3/4-100-Metal-NP / C25-100-Metal-SS Kits include M25 or ¾ NPT gland to Sira01ATEX1270X and core sealer to Baseefa15ATEX0194U.

A number of power levels and voltages, up to the maximum specified, are included in the range. They are identified in the following manner:



The following temperature classes are assigned:

Output (W/ft)	**Type**	**Temperature Class**
4 , 8 & 12	XTV2	T3
5 & 10	XTV1 & XTV2	T3
15	XTV1	230°C (T2)
15	XTV2	T3
20	XTV1	230°C (T2)
20	XTV2	240°C (T2)

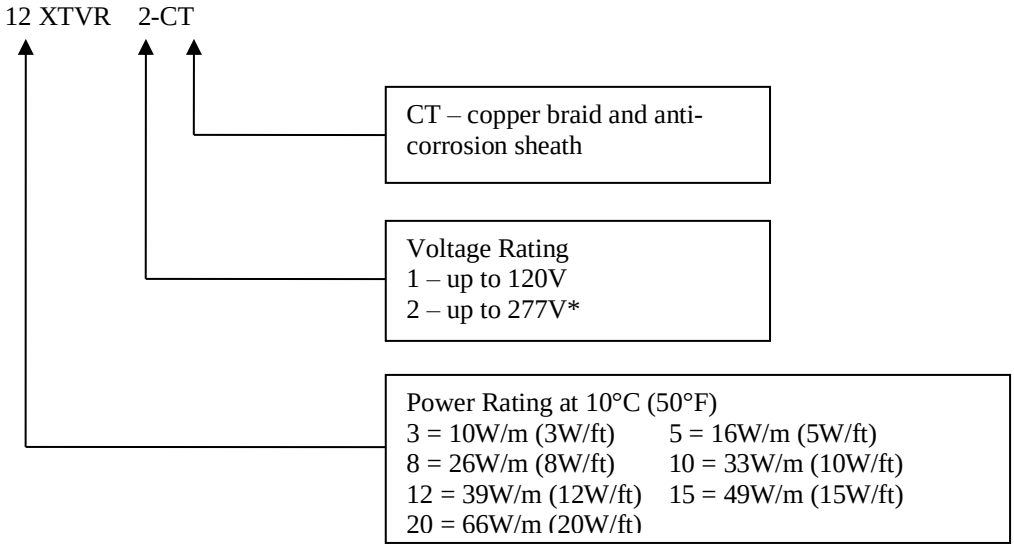
Any of the products in the range may be considered as part of a stabilised design system. In such a system the design is based upon the use of nVent proprietary software Trace calc Pro. The algorithm defined in this software may be used in additional design software. These designs may carry temperature classes other than those described above and are marked with the actual maximum temperature and the appropriate T class in parenthesis.

The minimum bending radii for XTV trace heating cable at specific temperatures are shown in the table below:

Temperature, T (°C)	Minimum Bending Radius (mm)
-60 ≤ T < -20	51
-20 ≤ T < -10	35
-10 ≤ T < 0	25
0 ≤ T < +10	20
T ≥ +10	12

XTVR

The *XTVR*-CT heating cables are equivalent to the *XTV*-CT heating cables apart from an increased maximum continuous operating temperature (maintain temperature) of +150°C (+302°F). The *XTVR*-CT heating cables have number of power levels and voltages, up to the maximum specified, are included in the range. They are identified in the following manner:



*The 20XTVR2-CT may also have an alternative maximum voltage of 240V.

The following temperature classes are assigned:

Output (W/ft)	Type	Temperature Class
3 & 8	XTVR2	180°C / T3
5	XTVR1 & XTVR2	180°C / T3
10	XTVR1 & XTVR2	200°C / T3
12	XTVR2	200°C / T3
15	XTVR2	200°C / T3
15	XTVR1	215°C / T2
20	XTVR1 & XTVR2	215°C / T2
20	XTVR2 at Max. 240V	200°C / T3

Any of the products in the range may be considered as part of a stabilised design system. In such a system the design is based upon the use of nVent proprietary software Trace calc Pro. The algorithm defined in this software may be used in additional design software. These designs may carry temperature classes other than those described above and are marked with the actual maximum temperature and the appropriate T class in parenthesis.

The minimum bending radii for the XTVR trace heating cable at specific temperatures are shown in the table below:

Temperature, T (°C)	Minimum Bending Radius (mm)
-60 ≤ T < -20	51
-20 ≤ T < -10	35
-10 ≤ T < 0	25
0 ≤ T < +10	20
T ≥ +10	12

16 Report Number

See Certificate History.

17 Specific Conditions of Use

1. The limiting temperatures for the end seals, splices and power connections are:

   260°C for the E-40 and S-40

   150°C for the C-150-E, S-150 and E-150

   151°C for the E-100, E-100-L and JBS-100

   155°C for the JBM-100 and T-100

   110°C for the C25-21 and C25-100

   180°C for the C25-100-Metal / C3/4-100-Metal

   The E-100, E-100-L, JBM-100, JBM-100-L, JBS-100, JBS-100-L and T-100 have limiting temperatures based on an internal component in these accessories. When located on a pipe or other work piece surface, a maximum pipe temperature of 250°C will not cause the limiting temperatures of 151°C or 155°C to be exceeded.

2. The end seals, splices and power connections have the following associated ambient temperatures.

   -60°C to +56°C for the E-40 and S-40

   -55°C to +56°C for the T-100, JBM-100, JBS-100, JBU-100 and E-100

   -40°C to +56°C for the JBS-100-L, JBM-100-L and JBU-100-L

   -55°C to +55°C for the C-150-E, S-150 and E-150

   -40°C to +40°C for the E-100-L

   -55°C to +110°C for the C25-21 and C25-100

   -60°C to +180°C for the C25-100-Metal / C3/4-100-Metal / C25-100-Metal-NP / C3/4-100-Metal-NP / C25-100-Metal-SS

3. The assembly of glands, splices and end terminations shall be carried out in accordance with the manufacturer's instructions.

4. The heating element supply circuit must include an electrical protection device in conformity with Clause 4.4 of EN 60079-30-1. For the JBM-100-L, JBU-100-L and JBS-100-L this shall be limited to 20A maximum when used at ambient temperatures above 40°C.

5. The minimum installation temperature is -60°C. The minimum bending radii at specific temperatures for the Type XTV units are shown in the table in the equipment description.

6. The supply to the heating unit must be terminated in a suitably certified terminal enclosure.

7. At ambient temperatures above 40°C temperature resistant power cable suitable for temperatures above 90°C and metal glands must be used.

8. When the E-100-L is used in ambient temperatures above 40°C metal nameplates must be used.

9. The installer is to carry out a dielectric strength test on Ex equipment in which the C25-21, C25-100 and C25-100-Metal / C3/4-100-Metal / C25-100-Metal-NP / C3/4-100-Metal-NP / C25-100-Metal-SS connection kit is fitted. No dielectric breakdown shall occur. (Alternatively, an insulation resistance test may be undertaken in accordance with EN 60079-30-2).

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
1.2.7	LVD type requirements
1.2.8	Overloading of equipment (protection relays, etc.)
1.4.1	External effects
1.4.2	Aggressive substances, etc.

19 Drawings and Documents

New drawings submitted for this issue of certificate:

None

Current drawings which remain unaffected by this issue:

Number	Sheet	Issue	Date	Description
2000003068[iii]		A	9/12/2022	Approvals Drawing for XTVR Heating Cable
2000003069[iii]		A	9/12/2022	XTVR Heater Units (European System)
906567[i]	1 of 1	P	05/21/21	C25-21, C25-100 and C25-100-METAL-XX, C3/4-100-METAL-XX Connection Kits
907826-A[iii]	1 of 1	F	01/22/21	XTV-C Label
906576-A[iii]	1 of 1	O	1/15/21	XTV Heater Units (European System)
906794-A[ii]	1 of 1	AA	03/30/20	Generic ATEX and IECEx Print Dwg for BTV-CT, QTVR-CT, XTV-CT, KTV-CT Heating Cables
906521-A[iii]	1 of 1	H	05/10/18	XTV-CT
907825-A[iii]	1 of 1	D	09/03/20	XTV-C
906817-A[iv]	1 of 1	L	08/11/20	ATEX Stabilised Design Labels
9242869[v]	1 & 2	O	12/09/19	LABL-JBM-100-L-E
9532687[v]	1 & 2	Q	12/09/19	LABL-JBM-100-L-EP
9621473[v]	1 & 2	O	12/09/19	LABL-JBS-100-L-E
9777523[v]	1 & 2	P	12/09/19	LABL-JBS-100-L-EP
9319676[v]	1 & 2	O	12/09/19	LABL-JBU-100-L-E
9735898[v]	1 & 2	O	12/09/19	LABL-JBU-100-L-EP
908758-A[vi]	1 & 2	A	3/20/20	E-40 Heat Shrinkable End Seal Kit Cut Back Dimensions
908782-A[iv]	1 of 1	A	3/20/20	S-40 Heat Shrinkable Splice Joint Kit Cut Back Dimensions for XTV and KTV

i) This drawing is common to IECEx BAS 16.0040U, IECEx BAS 16.0041U, IECEx 16.0042U, IECEx BAS 20.0008X, IECEx BAS 20.0009X, IECEx BAS 20.0011X, IECEx BAS 20.0012X, IECEx BAS 20.0013X, IECEx BAS 20.0014X, Baseefa16ATEX0037U, Baseefa16ATEX0038U, Baseefa16ATEX0039U,

SGS20ATEX0045X, SGS20ATEX0046X, SGS20ATEX0048X, SGS20ATEX0049X, SGS20ATEX0050X, SGS20ATEX0051X and is held with IECEx BAS 16.0040U.

ii) These drawings are common to IECEx BAS 20.0011X, IECEx BAS 20.0012X, IECEx BAS 20.0013X, IECEx BAS 20.0014X, SGS20ATEX0048X, SGS20ATEX0049X, SGS20ATEX0050X, SGS20ATEX0051X and are held with IECEx BAS 20.0011X.

iii) These drawings are common to IECEx BAS 20.0012X, SGS20ATEX0049X and are held with IECEx BAS 20.0012X.

iv) These drawings are common to IECEx BAS 20.0012X, IECEx BAS 20.0014X, SGS20ATEX0049X, SGS20ATEX0051X and are held with IECEx BAS 20.0012X.

v) These drawings are common to IECEx BAS 20.0008X, IECEx BAS 20.0011X, IECEx BAS 20.0012X, IECEx BAS 20.0013X, IECEx BAS 20.0014X, SGS20ATEX0045X, SGS20ATEX0048X, SGS20ATEX0049X, SGS20ATEX0050X, SGS20ATEX0051X and are held with IECEx BAS 20.0008X.

vi) These drawings are common to IECEx BAS 20.0008X, IECEx BAS 20.0012X, IECEx BAS 20.0014X, SGS20ATEX0045X, SGS20ATEX0049X, SGS20ATEX0051X and are held with IECEx BAS 20.0008X.

20 Certificate History

Certificate No.	Date	Comments
SGS20ATEX0049X	23 October 2020	The release of the prime certificate. The associated test and assessment against the requirements of EN 60079-0:2012+A11:2013, EN IEC 60079-7:2015+A1:2018, EN 60079-18:2015+A1:2017, EN 60079-30-1:2017 and EN 60079-31:2014 is documented in Test Report No. GB/BAS/ExTR20.0030/00.
SGS20ATEX0049X Issue 1	11 February 2021	To assess the XTV range of self-regulating trace heating systems against EN IEC 60079-0:2018, introduce the low profile power connection, splice and end seal kits, types C-150-E, S-150 and E-150 afforded DEKRA20ATEX0011U, minor amendments to the product description, to change the product name to "XTV Range of Self-Regulating Trace Heating Systems" and to amend the Specific Conditions of Use. The associated test and assessment is documented in Test Report No. GB/BAS/ExTR21.0005/00.
SGS20ATEX0049X Issue 2	7 July 2021	Minor drawing updates not affecting certification. Baseefa Certification Report GB/BAS/ExTR21.0060/00 refers.
SGS20ATEX0049X Issue 3	18 January 2023	To introduce the *XTVR*-CT heating cables. SGS Baseefa Certification Report GB/BAS/ExTR22.0182/00 refers.
SGS20ATEX0049X Issue 4	8 August 2023	To increase the temperature classification for the XTVR heating cables and to introduce an alternative maximum voltage 240V for the 20XTVR2-CT heating cable. SGS Certification Report GB/SGS/ExTR23.0071/00 refers.
For drawings applicable to each issue, see original of that issue.		