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Base Load Power Hub (BLPH)

OTP – Hydrogen Fuel Cell Package

Document Number: 123A90-PML-COM-PRO-03062

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1 INTRODUCTION

1.1 Project Overview

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.2 Project Location

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



Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map



Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile is located on coordinates E 590719.1, N 5841602.3 and is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.3 Project Concept

All components included in the BLPH will be integrated onshore on a topside and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

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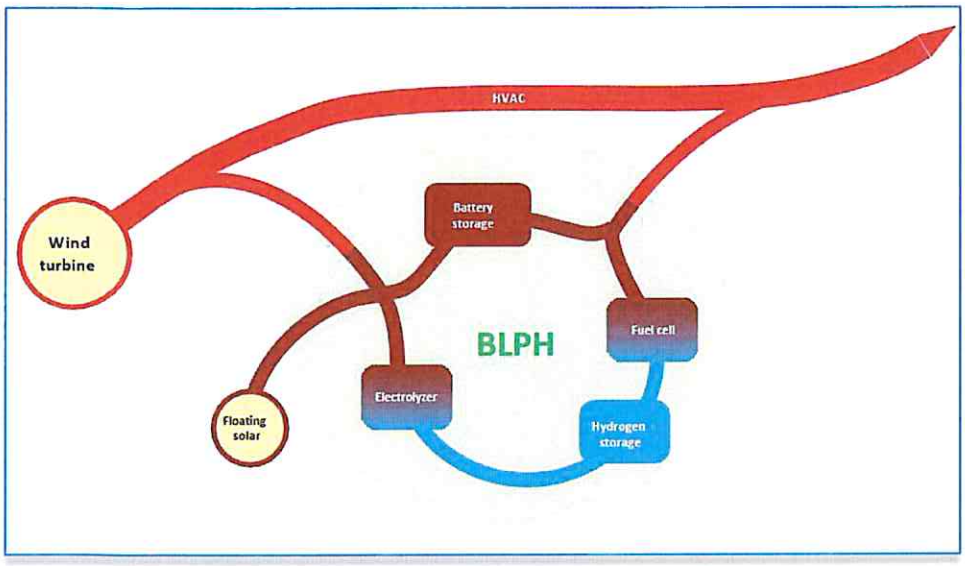


Figure 3 - BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.
The purpose of the BLPH is to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

2 DOCUMENT SCOPE

The purpose of this document is to describe the dedicated Commissioning procedure together with the detailed test steps to be implemented for the preparation and execution of the operation testing of the Hydrogen Fuel Cell Package

The document will cover all related test steps to be performed at both the onshore Worksite construction yard and the offshore SITE.

3 OTP SUMMARY

3.1 Test Objective

The operating test of the Hydrogen Fuell Cell system is executed to ensure that the system is started up in a safe and controlled manner and to verify the correct operation according to the project requirements.

Aim of this document is to provide the sequence and appropriate actions to verify the safety systems of the system along with ability for the system to produce electrical power.

Please note that Pre-commissioning activities are described in detail in the method statement document K559-2254-CWIWP4202202-J99-009 as well as in the Vendor SAT procedure K559-2254-CWIWP4202202-J99-001. For the sake of completeness, these activities will be mentioned here as part of necessary steps but will not be part of the OTP.

Activities shall be developed as follows:

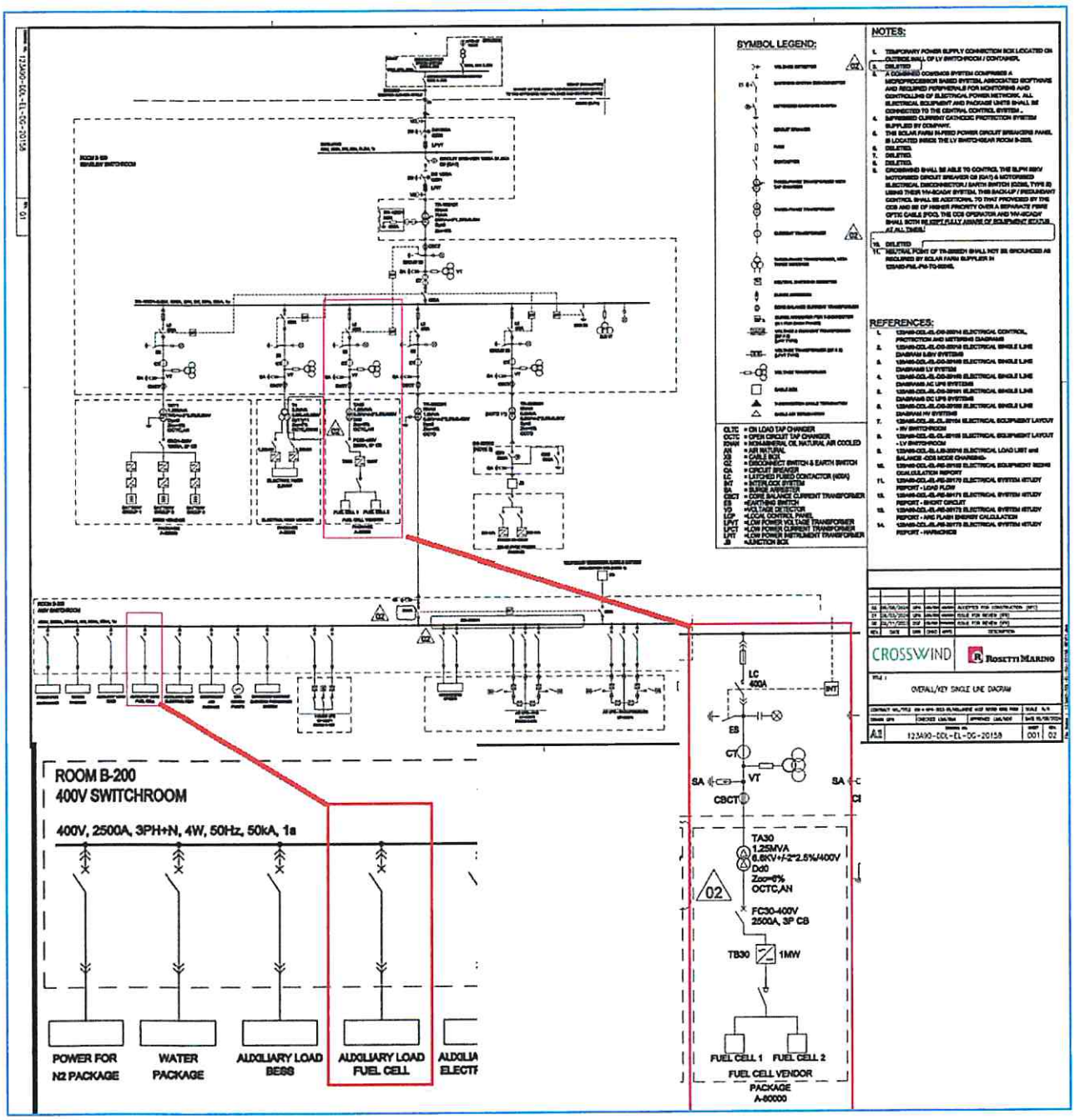
- Onshore pre-commissioning and commissioning activities at Contractor site (WORKSITE)
  - PHASE 1: Pre-commissioning (powered) activities including the following (NOT PART OF THIS OTP):
    - Leak Testing of modified H2 heater manifold assembly and coolant system leak test.
    - Aux first power on
    - Collant System fill and degas
  - PHASE 2: Pre-commissioning (powered) activities including the following (NOT PART OF THIS OTP):
    - IO test (package internal)
    - Platform communication check
    - Testing of 6.6 kV Trafo
    - Software upgrades testing
    - H2 supply check
    - External interface checks
    - Software upgrade testing
  - PHASE 3: Vendor SAT & Integrated function test of Hydrogen Fuel Cell package.

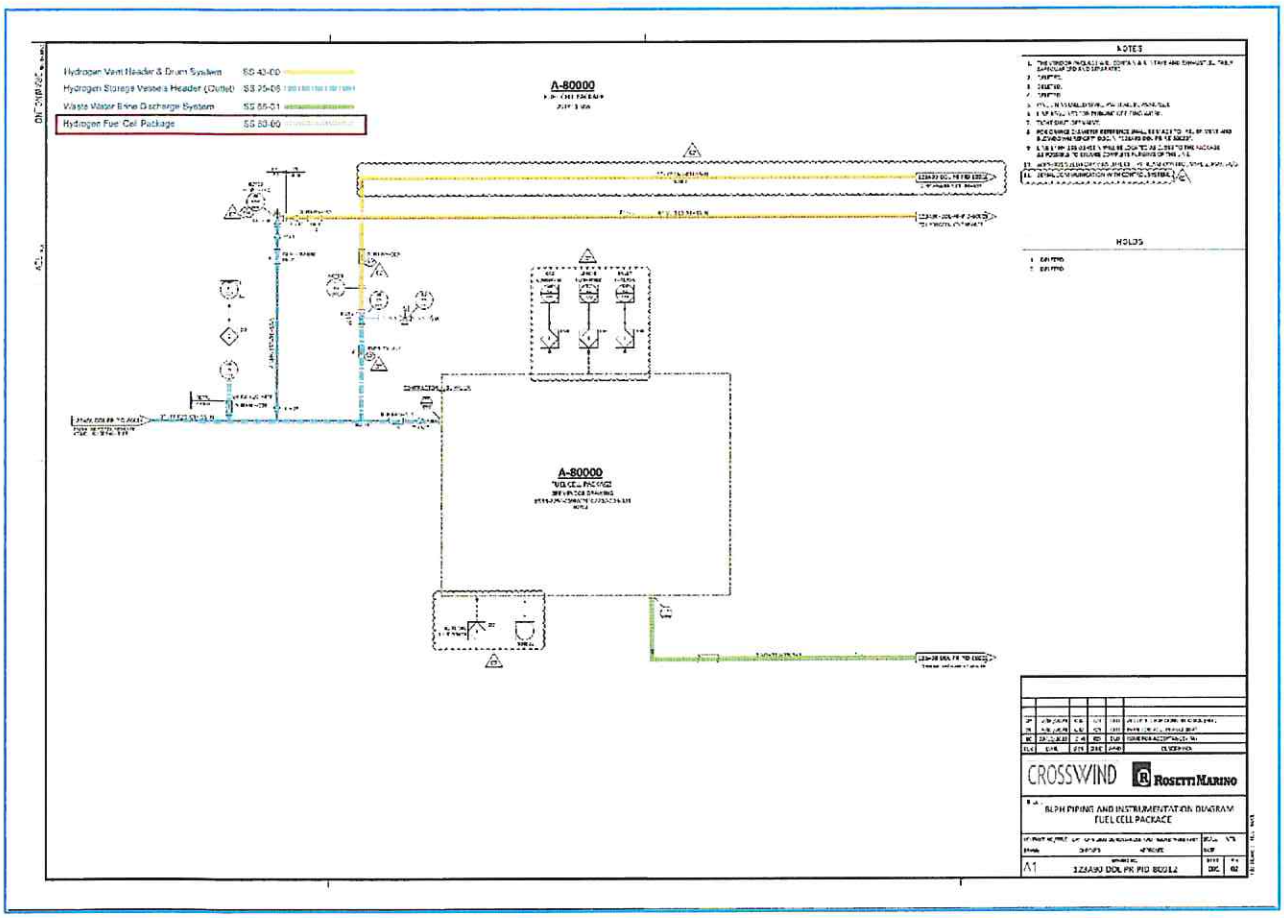
- Offshore commissioning (SITE)
  - PHASE 4: Integrated function test of Hydrogen Fuel Cell package (OFFSHORE).

PHASES 1 – 2 are covered by and contained within the vendor Method Statement. PHASES 3 - 4 are included within this OTP document, and the Vendor SAT procedure.

3.2 System Boundary Limits

See below the interested systems and subsystems on the Overall Single Line Diagram





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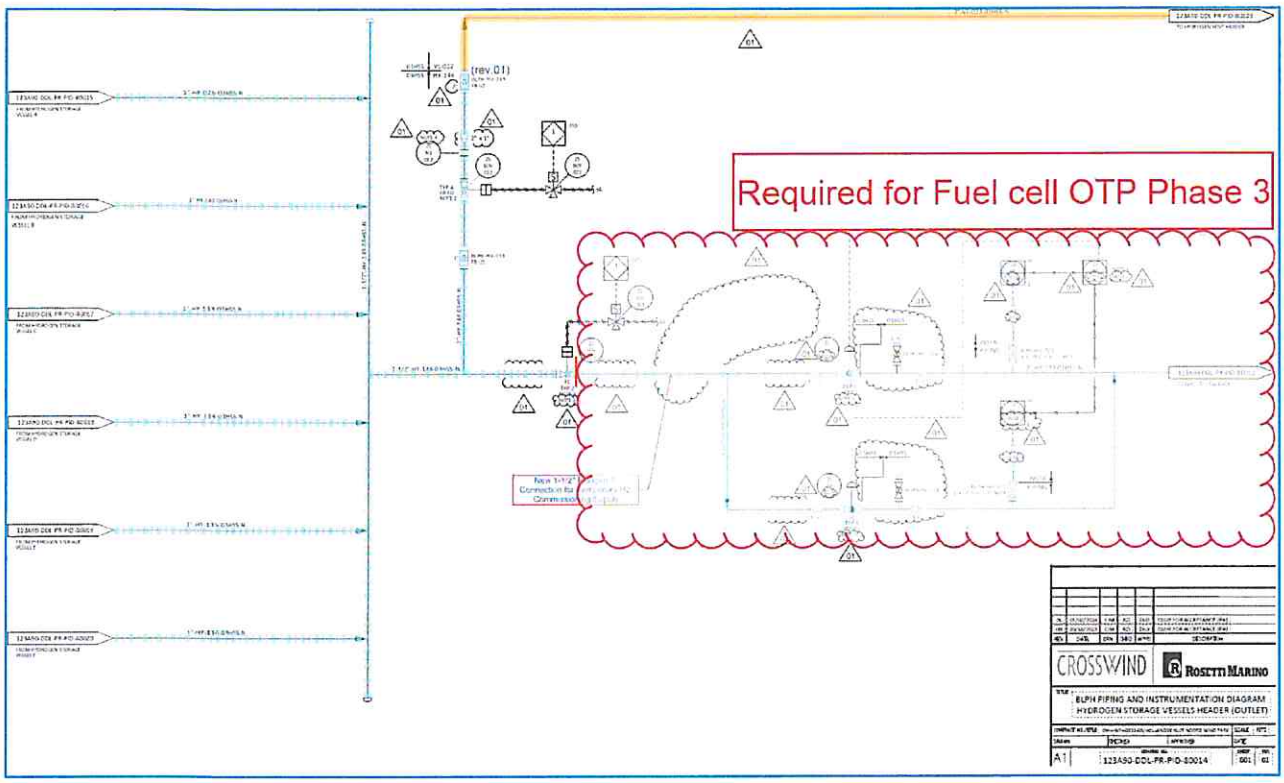


Figure 4 – OTP System Boundary Limits

3.3 Test and System Description

Proceeding with this OTP is confirmation that the following system:

- 80-00 Hydrogen Fuel Cell

That all equipment is installed in accordance with the following vendor documents:

- K559-2254-CG-PHI-001 Commissioning Philosophy
- ELO-INN-PBH-DWG-0005 General Arrangement Drawing
- ELO-ELE-BPH-DWG- 0005 Electrical Single Line Diagram Power Distribution
- ELO-INN-BPH-CKT-0006 Alarm warning list
- ELO-INN-BPH-DWG-0008 Process Flow Diagrams
- K559-2254-EL-ELL-002 BLPH - Electrical Load List (CCS MODE 2(A) 'HOT STANDBY')
- K559-2254-EL-ELL-003 BLPH - Electrical Load List (CCS MODE 3(C) 'DISCHARGING')
- K559-2254-EL-ELL-004 BLPH - Electrical Load List (CCS MODE 4(A) 'COLD STANDBY')
- K559-2254-EL-ELL-005 BLPH - Electrical Load List (CCS MODE 4A(D) 'EMERGENCY MODE (Island))
- K559-2254-EL-ELL-006 BLPH - Electrical Load List (CCS MODE 5(D) 'POWER OUT (Blackout))
- K559-2254-PR-PHI-001 - Main process control philosophy

3.4 Safety Devices

- Appropriate Personnel Protective Equipment (PPE) and safety equipment e.g., safety shoes, hand gloves, helmet, earplugs etc. are available and must be used in line with the site requirements.
- For entry into the 40' container standard PPE as stated above must be worn. Phones are not permitted within the 40' container.
- Access to the 10' transformer container is not permitted during operation and the container is to be double locked, the second lock being controlled by the CONTRACTOR.
  This is in addition to all normal PPE in line with site requirements.
- Warning safety signs are to be posted with restricted access to essential personnel only.
- Adequate firefighting equipment must be present at site.

3.4.1 HSE Management

- All necessary safety precautions must be taken to avoid any risk of personnel injury.
- All personnel involved in this operational test shall be competent for the tasks they will be required to undertake
- Place safety / warning signs and segregate the entire area with barrier tapes (safety barriers) of a colour distinguished (blue and white) from those used for construction activities
- Restrict access into area only to authorized personnel
- Conduct "Toolbox Talk" with all personnel prior to starting test work
- Appropriate Personnel Protective Equipment (PPE) and safety equipment e.g. safety shoes, hand gloves, helmet, earplugs etc. are available and must be used in line with the site requirements. Flame retardant coveralls should be worn.
- ATEX Field radios or Walkie-Talkies will be required for communication during testing.
- Portable gas detectors to be used by all personnel after H2 introduction.
- All activities carried out on the project shall be performed in accordance with the "Permit to Work" system Doc. PRO-HSE-23
- Electrical and mechanical isolations are to be assured as per Doc. PRO-HSE-08 and "Commissioning and start-up operation" procedure.
- Observe and enforce all international codes and regulations to safeguard personnel, plant and environment.
- Ensure that the working area is clean, tidy, well illuminated and that access and escape routes are free from obstructions.

Before starting work on any of the activities in this OTP it is the responsibility of the persons performing the work to:

- Familiarize themselves with the plant/equipment to be worked on
- Ensure they are aware of all other work activities that are taking place, or due to take place
- If necessary, re-plan any situation/activity
- Ensure proper communications between parties involved in the execution of the OTP
- Read the relevant Vendor documentation for the equipment covered by this OTP and observe any special requirements and limitations recommended or imposed by Vendor
- Verify that all personnel involved in the implementation of this procedure are familiar with its content as well as the associated safety requirements (Toolbox Talk)

3.5 Acceptance Criteria

- Before Power ON:

Visual inspection and verification are a crucial step to identify any obvious issues with the installation, such as loose connections, missing components, or damage to the equipment.

Crosschecking the installation with engineering documentation ensures that the installation is done correctly and according to the manufacturer's guidelines. These steps can help identify any missing or incorrect components, and wrong connections - – Refer to Vendor SAT chapters 7.1, through 7.4

All package ITRs to be completed & RFC issued for sub-system 80-00.

Apply padlocks on all necessary Breakers per LoTo Procedure.

Applicable locations:
- AC Power Distribution (BA20+UC50)
- Control System, Container #1 (LA01+UC20)
- Coolant Skid Cabinet, Container #1 (HE01+UC30
- DCDC Cabinets #1-6 (+UC01 to +UC06)
- Control System, Container #2 (LA01+UC31)
- Power Conversion Output, Container #2 (BA30+DA03)

See Ballard produced document "BLPH Project – Electrical Single Line Diagrams" – BPSE-ELE-BPH-DWG-00005

Powering ON the unit is an essential step to verify that the equipment is functioning correctly. Observing if everything is OK and any alarm will help detect possible errors or malfunctions.

Phase 1 (Not in the OTP) will prove correct (NOT PART OF THIS OTP):
- All piping (H2 and cooling) installed correctly.
- All cooling systems are filled correctly.
- Energization of the AUX circuits is successful; all the subsystems are working according to specification.
- All necessary Software updates are performed, and the package internal communication is proven successful.
- The safety critical functions integrated in the Hydrogen Fuel Cell package are working according to specification.

Phase 2 (Not in the OTP) will prove correct (NOT PART OF THIS OTP):
- All necessary Software updates are performed, and the package internal communication is proven successful.
- Functionality checks of the Package VFDs.
- The communication with the EMCS/PCS.
- The installation and functionality of the 6.6kv Trafo.

Phase 3 will prove correct:
- Completion of the Vendor SAT procedure.
- Functionality of the Hydrogen Fuell Cell package in coordination with Required Associated Subsystems packages on BLPH. (ONSHORE)

Phase 4 will prove correct:
- Functionality of the Hydrogen Fuel Cell package in coordination with the other packages on BLPH (OFFSHORE).

Performing the steps in this OTP as per engineering documents is crucial to ensure that the equipment is operating correctly and that it meets the desired design specifications. Observing the results will help identify any issues that may arise during the operation.

Overall, following these steps shall provide a comprehensive and effective way to verify the equipment installation and functionality.

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4 DOCUMENTS REFERENCES AND ABBREVIATIONS

4.1 Reference Documents

4.1.1 Company Documents and Standards

Document ID	Document Title
[1] K559-2254-CG-PHI-001	Commissioning Philosophy
[2] K559-2254-EL-ELL-002	BLPH Electrical Load List (CCS MODE 2(A) 'HOT STANDBY')
[3] K559-2254-EL-ELL-003	BLPH Electrical Load List (CCS MODE 3(C) 'DISCHARGING')
[4] K559-2254-EL-ELL-004	BLPH Electrical Load List (CCS MODE 4(A) 'COLD STANDBY')
[5] K559-2254-EL-ELL-005	BLPH Electrical Load List (CCS MODE 4A(D) 'EMERGENCY MODE (Island))
[6] K559-2254-EL-ELL-006	BLPH Electrical Load List (CCS MODE 5(D) 'POWER OUT (Blackout))
[7] K559-2254-PR-PHI-001	Main process control philosophy

Table 1: Company Documents and Standards

Note – These documents were produced in FEED and made available to RM for info. They have subsequently been superseded by Detailed Design, similar or same deliverables.

4.1.2 Project Documents

Document ID	Document Title
[1] 123A90-PML-PM-LIS-01001	Master Document Register
[2] 123A90-PML-PM-PL-00001	Project Execution Plan
[3] 123A90-PML-QHSE-PL-00001	Project HSE Plan
[4] 123A90-PRO-HSE-23	RM Yard Permit To Work Procedure
[5] 123A90-PML-COM-PL-03002	Mechanical Completion & Commissioning Exec. Plan
[6] 123A90-PML-COM-PRO-03007	Commissioning Strategy
[7] 123A90-PML-COM-LIS-03011	System/Sub-Systems List
[8] 123A90-PML-COM-LIS-03012	System/Sub-System Boundary Limit Diagrams
[9] 123A90-PML-COM-PRO-03038	Leak Test Procedure
[10]123A90-PML-COM-SP-03032	Pre-Commissioning Functional Test Sheet Template Collection (ITR-B)
[11]123A90-PML-COM-SP-03014	Commissioning TDS - Temporary Equipment & Facilities
[12]123A90-PML-COM-PRO-03019	OTP – Onshore Performance & Integrated Test Procedure
[13]123A90-PML-COM-LIS-03034	Inhibit-Override Register

Document ID	Document Title
[14]123A90-PML-COM-LIS-03035	PSV Calibration Register
[15]123A90-PML-COM-PRO-03036	OTP - Black Start Procedure
[16]123A90-PML-COM-LIS-03024	Commissioning Spare Parts and Consumables List
[17]123A90-PML-COM-PRO-03022	Initial offshore START-UP procedures
[18]123A90-PML-COM-SP-03057	Worksite WEF (Work Execution Flow Scheme)
[19]123A90-PML-COM-SP-03058	Site WEF (Work Execution Flow Scheme)
[20]123A90-PML-COM-RE-03001	Commissioning Final Dossier (ITR-B)
[21]123A90-PML-QHSE-PRO-00116	Flushing and Cleaning Procedures
[22]123A90-PML-QHSE-SP-00118	Mechanical Completion Check Sheet Template Collection (ITR-A)
[23]123A90-PML-QHSE-RE-00115	Mechanical Completion Final Dossier (ITR-A)
[24]123A90-PML-QHSE-PRO-00117	Punch list Management Procedure
[25]123A90-PML-COM-PRO-03041	OTP - Hydrogen Storage & Venting Systems
[26]123A90-PML-COM-PRO-03042	OTP - Sea Water Intake & Fresh Water Treatment Systems
[27]123A90-PML-COM-PRO-03043	OTP - Instrument Air System
[28]123A90-PML-COM-PRO-03055	OTP - Nitrogen Generation System
[29]123A90-PML-COM-PRO-03044	OTP - HVAC Systems
[30]123A90-PML-COM-PRO-03045	OTP - HV Switchgear & 66 kV Transformer Systems
[31]123A90-PML-COM-PRO-03046	OTP - 6.6 kV Switchgear & Transformer Systems
[32]123A90-PML-COM-PRO-03047	OTP - LV Switch Board & LV Distribution Board Systems
[33]123A90-PML-COM-PRO-03048	OTP - Lighting & Small Power Systems
[34]123A90-PML-COM-PRO-03049	OTP - Electrical Heat Tracing Systems
[35]123A90-PML-COM-PRO-03050	OTP - UPS Systems
[36]123A90-PML-COM-PRO-03051	OTP - Data Network Systems
[37]123A90-PML-COM-PRO-03052	OTP - Telecom & Surveillance Systems
[38]123A90-PML-COM-PRO-03053	OTP - Navaid System
[39]123A90-PML-COM-PRO-03054	OTP - F&G and ESD C&E Logics
[40]123A90-PML-QHSE-PRO-00120	Proverlis Management Procedure
[41]123A90-PML-COM-PRO-03056	OTP – Document Template
[42]123A90-DDL-IN-RE-40095	Process Control Logics Description

Table 2: Reference Project Deliverables

4.1.3 Vendor Documents

Document ID	Document Title
[1] K559-2254-CWIWP4202202-C06-001Rev007	Electrical Single Line Diagram
[2] K559-2254-CWIWP4202202-B01-001Rev009	General Arrangement
[3] K559-2254-CWIWP4202202-N01-001Rev001	Integration Manual
[4] K559-2254-CWIWP4202202-N01-002Rev002	Operators Manual
[5] K559-2254-CWIWP4202202-E03-007Rev001	Electrical Interface Document
[6] K559-2254-CWIWP4202202-K03-001Rev001	Performance Test Results (FAT)
[7] K559-2254-CWIWP4202202-J99-001-Rev003	SAT Procedure
[8] K559-2254-CWIWP4202202-C08-001Rev004	Control Philosophy & Block Logic Diagrams
[9] K559-2254-CWIWP4202202-J99-009	Method Statement

Table 3: Company Key Reference Documentation

4.2 Acronyms and Abbreviations

Acronyms / Abbreviations	Description
BLPH	BaseLoad Power Hub
CO	Carbon monoxide
EMCS	Electrical Monitoring & Control System
ESD	Emergency Stop Devices
FAT	Factory Acceptance Test
FTE	Full Time Employees
F&G	Fire and Gas
PPE	Personal Protective Equipment
ITR	Inspection & Test Record
LOTO	Lock Out Tag Out
OTP	Operational Test Procedure
PCS	Power Conversion System
SAT	Site Acceptance Test
SOC	State Of Charge

Table 1: Acronyms and Abbreviations

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5 OTP AT ONSHORE WORKSITE

This chapter refer to the activities on the Contractor worksite (construction yard).

5.1 Planning and Manpower

5.1.1 Planned tasks with estimated manpower

Estimated manpower for the different phases of the OTP are:

- 2 Vendor FTE.
- 1 Commissioning Supervisor from Company
- 1 Commissioning Supervisor from Contractor
- 1 Operator from EMCS vendor
- 1 Operations Engineer from Company.

5.1.2 Pre-Commissioning duration estimate:

- **PHASE 1:** 12 days approx. (Not in the OTP)
- **PHASE 2:** 12 days approx. (Not in the OTP)

5.1.3 Test duration estimate

The test duration should be as follows:

- **PHASE 3:** 3 days approx.
- **PHASE 4:** 2 days approx.

If necessary, the estimated time can be extended in order to complete all required pre-commissioning and commissioning activities.

5.1.4 Vendor Assistance

Vendor Ballard will lead and/or supervise the onshore commissioning activities. For offshore commissioning Ballard will provide remote support.

5.1.5 Summary of interface signals to be tested:

Please refer to the following documents;

- **BPSE-INN-BPH-REG-00006** – Modbus Table
- **BPSE-INN-BPH-OTH-00012** - BLPH - FC Package Modbus Table

5.2 OTP Test Requirements – Onshore WORKSITE

5.2.1 Pre-Commissioning Achievement

Prior to commencement of commissioning activities, the relevant pre-commissioning documentation be fully signed.

5.2.2 Commissioning Achievement

The commissioning achievement will be the full successful operation, functionality and integration of the Hydrogen Fuel Cell package installed on BLPH.

5.2.3 Status of Required Associated Subsystems

- PHASE 3

Subsystems required RFC for Commissioning of the Hydrogen Fuel Cell Package

- 83-00 400V Switchboard SG200N1
- 83-00 Auxiliary power supply
- 83-20 Distribution board
- 88-00: Earthing System
- 83-99: Temporary Yard 400/230V Main and auxiliary power supplies
- 87-00: EMCS
- 87-10: PCS
- 82-00: MV 6.6 kV Switchboard (SG-100D1)
- 82-10: Power Transformer 1.25 MVA
- 82-99: MV 6.6 kV Temporary Yard Supply Integrated Test
- 70-00: F&G Control System
- 79-00: Emergency Shutdown Systems (SIS)
- 25-01 to 25-08 (Partial): Hydrogen Storage Vessels & Header
- 43-00: Hydrogen Vent Header and Drum System
- 55-01: Waste Water Brine Discharge System

- PHASE 4

- Subsystems required RFC for OFFSHORE Commissioning of the Hydrogen Fuel Cell Package
- 83-00 400V Switchboard SG200N1
- 83-00 Auxiliary power supply
- 83-20 Distribution board
- 88-00: Earthing System
- 87-00: EMCS
- 87-10: PCS
- 82-00: MV 6.6 kV Switchboard (SG-100D1)
- 82-10: Power Transformer 1.25 MVA
- 70-00: F&G Control System
- 79-00: Emergency Shutdown Systems (SIS)
- 25-01 to 25-08: Hydrogen Storage Vessels & Header
- 43-00: Hydrogen Vent Header and Drum System
- 55-01: Waste Water Brine Discharge System
- 81-20: Power Transformer 7 MVA (TR-100AD1)
- 81-10: GIS 66 kV (HNA6-AFA70)
- 81-00: 66 kV Subsea Cable

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5.2.4 Special Tools & Test Equipment

The following special tool and Test Equipment are required:

S.No.	DESCRIPTION	QTY
1	General PPE	3
2	Various tools for electrical wiring	1
3	Various tools for mechanical installation	1
4	H2 Sniffer - Sewerin Snooper Mini H2	1
5	Pressure sensor - Fluke 700RG07 500PSIG	1
6	Test gas - Formier gas 5% hydrogen	1
7	Sniffer test station - Sewerin SPE-HG	1
8	Pressure regulator	1
9	Pressure relief valve	1
10	Smoke generator for fire detector test	1
11	H2 test gas for detector test	1
12	Coolant pumping/filling equipment	1
13	CE multitester	1
14	Multimeter	1

- H2 Sniffer - Sewerin Snooper Mini H2, Detection instrument to sniff/locate source of potential leaks.
- Pressure sensor - Fluke 700RG07 500PSIG, measuring device to accurately adjust and monitor gas pressure during leakage test.
- Test gas - Formier gas 5% hydrogen. Test gas for pressurizing pipework where the 5% hydrogen acts as tracer agent for sniffing
- Sniffer test station - Sewerin SPE-HG. Test instrument that emits a reference gas to check the correct function of the Snooper Mini H2 sniffer.
- Pressure regulator, Test gas pressure regulator for pressurizing the DUT.
- Pressure relief valve, Safety valve to ensure safe pipework pressurization during test.

TESTING & MEASUREMENT INSTRUMENT USED			
Type	Serial N.	Calibration certificate	Validity

5.2.5 Commissioning Spare Parts

HOLD 2

5.2.6 Temporary Facilities

Phase 3: Temporary emergency stop and/or fire and gas detection may be required if deemed necessary after suitable risk assessment. This will depend on the availability of interacting sub-systems.

If a temporary H2 connection is provided by Rosetti to ensure testing can progress this will be subject to a separate risk assessment & permit for installation/operation.

5.3 OTP Description – Onshore WORKSITE

5.3.1 OTP Test Preparation

Step	Description	Result	Verified by	Date
1	System Ready for Commissioning Certificate (RFC) is issued and approved.	✓		04.07.25
2	No Mechanical Completion or Pre-commissioning punch list 'A' items are outstanding against the system to be commissioned.	✓		"
3	Factory Acceptance Test Procedure has been carried out successfully (refer to Doc. K559-2254-CWIWP4202202-K03-001Rev001)	✓		"
4	All personnel involved in the implementation of this procedure are familiar with its content as well as with associated safety requirements (Toolbox Talk to be conducted before initiation of activities).	✓		"
5	A final walkdown of the system has been completed, to ensure that the system and the area are ready for commissioning.	✓		"
6	Check that areas are free for work and escape routes are clear of any obstructions.	✓		"
7	All safety barriers and warning signs have been installed.	✓		"
8	Ensure that proper communications have been established between parties involved in the implementation of the procedure.	✓		"
9	Verify availability of test equipment and spares as per section 5.2.	✓		"
10	With reference to Commissioning Temporary equipment & Facilities (refer on Doc. 123A90-PML-COM-SP-03014), check that power is available to any temporary equipment or test equipment (if any).	✓		"
11	System(s) isolations as per LOTO procedure defined within HSSE Permits to Work and Commissioning procedures duly prepared and approved	✓		"
12	All yard personnel have been duly notified by dedicated LUN (Livening Up Notification) that the system(s) is ready for commissioning.	✓		"

Step	Description	Result	Verified by	Date

5.3.2 Electrical Preparation

Step	Description	Result	Verified by	Date
1	Check related punch list 'B' items and confirm acceptability for start of commissioning activities.	✓		4-7-25
2	Verify that all relevant associated systems / subsystems are completed.	✓		"
3	Check that grounding and bonding are in accordance with applicable documents.	✓		"
4	Verify and confirm the correct circuit breaker protection settings according to latest protection study revision.	✓		"
5	Verify and confirm the completion of the final connections between the LV 400V Switchboard and the FC, the MV 6.6kV and FC, and the EMCS.	✓		"
6	Assess the need for additional temporary F&G or E-Stop protection during ONSHORE phases and implement necessary changes.	✓		"

5.3.3 Mechanical Preparation

Step	Description	Result	Verified by	Date
1	Check the correct flow direction of the valves.	✓		4-07-25
2	Confirm leak testing is complete and documented.	✓		"
3	Ensure package PSV setpoints are correct for the designed operating pressure.	✓		"
4	Ensure all unnecessary isolations are removed and package is ready to receive hydrogen.	✓		"

5.3.4 Instrument Preparation

Step	Description	Result	Verified by	Date
1	Check related punch list 'B' items and confirm acceptability for start of commissioning	✓		4-7-25

Step	Description	Result	Verified by	Date
	activities.			
2	Verify that all relevant associated systems / subsystems are ready.	✓		4-7-25
3	Check Inhibit and Override register has been prepared and validated.	✓		"
4	Verify that relevant equipment/ components are available and in operation for start of commissioning activities.	✓		"
5	Verify availability of test equipment as per section 5.2.4.	✓		"

5.3.5 Piping Preparation

Step	Description	Result	Verified by	Date
1	Ensure Process Water drain connection is correctly connected to the Rosetti system	✓		4-7-25
2	Ensure H2 supply connection is correctly connected from the Rosetti system	✓		4-7-25
3	Review Rosetti flange management and confirm all interface connections have been torqued and leak tested with details recorded and signed for.	✓		4-7-25
4	Ensure Blind flange/ positive isolation is in place at test boundary.	✓		4-7-25

5.3.6 Additional Discipline Preparation

Not applicable.

5.4 Test Steps – Onshore WORKSITE - PHASES 1-2 (NOT PART OF THIS OTP)

The previous chapters must be successfully performed prior to commissioning of the Hydrogen Fuel Cell Package.

Please refer to the following documents for Phase 1-2 pre-commissioning Onshore activities:

- Method Statement, Doc No: K559-2254-CWIWP4202202-J99-009.
- SAT Procedure, Doc No: K559-2254-CWIWP4202202-J99-001

5.4.1 OTP Steps WORKSITE - PHASE 3

It is foreseen that previous sections are successfully performed.

Please refer to SAT document K559-2254-CWIWP4202202-J99-001 ***section 7 and 8*** for Phase 3 commissioning Onshore activities.

5.4.2 OTP Steps WORKSITE - PHASE 4

It is foreseen that previous sections are successfully performed.

In the following steps the functionality of the Hydrogen Fuel Cell package shall be tested for operation in all BLPH operating modes.

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Hydrogen Fuel Cell Integrated Testing ONSHORE

Step	Description	Result	Verified by	Date
Fuel Cell operating modes to be controlled from PCS via ECMS.				
1	Confirm on PCS that CCS operating mode is in "IDLE". Confirm Fuel Cell Package is in sleep mode.	✓	S. M	5-7-25
2	On PCS, change CCS operating mode to "IMPORT". Confirm no change at Fuel Cell package.	✓	"	"
3	On PCS, change CCS operating mode to "HOT STANDBY". Confirm Fuel Cell is now in Standby mode.	✓	"	"
4	Confirm H2 storage is available. This requires a reading of ≥ 20 barg on at least one of the following pressure transmitters: • 25-PT-035 • 25-PT-037 • 25-PT-040 • 25-PT-043 • 25-PT-046 • 25-PT-049	✓	"	"
NOTE: Pressure control via valves 25-PV-055A & 25-PV-055B should already be successfully tested via Hydrogen Venting & Storage OTP 123A90-PML-COM-PRO-03042				
5	On PCS, change CCS operating mode to "EXPORT". Confirm Fuel Cell status changes to running.	✓	"	5-7-25
6	Confirm that power output can be controlled via the EMCS over modbus. Test power output at increments of 0.25MW up to and including 1MW.	✓	"	"
7	On PCS, change CCS operating mode to "COLD STANDBY". Confirm Fuel Cell shuts down and returns to Sleep mode.	✓	"	"
8	On PCS, change CCS operating mode to "EMERGENCY (Island Mode)". Confirm Fuel Cell recommences discharge of power.	✓	"	14-7-25
9	On PCS, change CCS operating mode to "MAINTENANCE". Confirm Fuel Cell can only be operated locally.	✓	"	14-7-25

Step	Description	Result	Verified by	Date
10	On PCS, return CCS operating mode to "EXPORT". Initiate Fuel Cell F&G event via 1 of the 3 hydrogen detectors located inside the container and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters • Safe Torque Off of all Motor Drives	✓		05.7.25
11	On PCS, return CCS operating mode to "EXPORT". Operate the Fuel Cell Package Emergency Stop and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters • Safe Torque Off of all Motor Drives	✓		05.7.25

Full details of the EMCS HMI control graphics can be found in Document Number: **123A90-DDL-EL-SP-20039 Functional and Technical Design Specification, IDS and DDS for Electrical Monitoring and Control System (EMCS)**

Hydrogen Fuel Cell Integrated Testing ONSHORE Notes and Remarks

TESTING CARRIED OUT ALONGSIDE OIT OTP. FUEL CELL WAS RAMPED UP FROM 300KW TO 1MW AND THEN BACK DOWN TO 300KW. BEFORE DISCONNECTING. THE FUEL CELL WAS NOT USED BELOW 300KW DUE TO INSTABILITY OF THE BLPH CONTROL VALVES. DURING RAMP UP AND DOWN THE FUEL CELL WAS CONTROLLED IN 100KW INCREMENTS. PLEASE REFER TO THE OIT OTP FOR MORE INFORMATION.

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5.4.2.1 Hydrogen Fuel Cell Integrated Testing ONSHORE - Certifying Authority Table of Attendances

Name and Surname	Certifying Authority	Position	Signature
S. Mackhof			

5.4.2.2 Hydrogen Fuel Cell Integrated Testing ONSHORE - Final Signatures and Company Acceptance

Name and Surname	Company Representative	Position	Signature
S. Mackhof	CW	OPS ENGINEER	
Gedas Paulauskas	Ballard	Service Tech.	

5.5 Post-test Conditions

Throughout Phase 1 to 4, AUX power shall be maintained active to ensure monitoring of the package and functionality of its safety features.
All other sub-systems shall be de-energized and, if deemed necessary, LOTO.
No AUX power will be provided during sea transport.

5.6 Reinstatement and Preservation Tasks

Generally, the system/ sub-system shall be reinstated at its initial condition; and the following activities must be carried out as minimum:

- all inhibition performed for the test shall be removed (as per Inhibit / Override List)
- all equipment/devices shall be returned in healthy functional conditions.

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6 OTP AT SITE

6.1 Planning and Manpower

6.1.1 Offshore Site overview

It is expected that all pre-commissioning tests, systems energization and commissioning steps will have been successfully performed during the Onshore Phases.
Consequently, during the offshore SITE phase, the respective systems will be inspected prior to re-energization. No additional test steps will be required on these items of equipment, correct operation and functioning will be verified.

6.1.2 Planned tasks with estimated manpower

Estimated manpower for the entire duration of the Test:

- 1 Operations Engineer from Client
- 1 Commissioning representative from Client
- 1 operator from EMCS vendor
- 1 Supervisor from Contractor

6.1.3 Test duration estimate

The test duration should be as follows:

- 2 days approx.

If necessary, the estimated time can be extended to complete all required pre-commissioning and commissioning activities.

6.1.4 Vendor Assistance

- For offshore commissioning Ballard will provide remote support.

6.1.5 Items Postponed to C&E OTP

- Not Applicable

6.1.6 HOLDS

- Not Applicable

6.2 OTP Test Requirements – Offshore SITE

6.2.1 Pre-Commissioning Achievement

- Not applicable

6.2.2 Commissioning Achievement

The commissioning achievement will be the full successful operation, functionality and integration of the Hydrogen Fuel Cell package installed on BLPH.

The successful commissioning result, achieved during the WORKSITE commissioning phase for the functionality and safeguard of the Hydrogen Fuel Cell Package, will allow for a smoother commissioning phase of the offshore SITE.

- The systems and subsystems involved:
- 83-00 400V Switchboard SG200N1
- 83-00 Auxiliary power supply
- 83-20 Distribution board
- 88-00: Earthing System
- 87-00: EMCS
- 87-10: PCS
- 82-00: MV 6.6 kV Switchboard (SG-100D1)
- 82-10: Power Transformer 1.25 MVA
- 70-00: F&G Control System
- 79-00: Emergency Shutdown Systems (SIS)
- 25-01 to 25-08: Hydrogen Storage Vessels & Header
- 55-01: Waste Water Brine Discharge System
- 81-20: Power Transformer 7 MVA (TR-100AD1)
- 81-10: GIS 66 kV (HNA6-AFA70)
- 81-00: 66 kV Subsea Cable

6.2.3 Status of Required Associated Subsystems

The systems involved has been already energized and commissioned in WORKSITE Phase

6.2.4 Special Tools & Test Equipment

The following special tool and Test Equipment are required:

S.No.	DESCRIPTION	QTY
1	General PPE	3
2	Various tools for electrical wiring	1
3	Various tools for mechanical installation	1
4	H2 Sniffer - Sewerin Snooper Mini H2	1
5	Pressure sensor - Fluke 700RG07 500PSIG	1
6	Test gas - Formier gas 5% hydrogen	1
7	Sniffer test station - Sewerin SPE-HG	1
8	Pressure regulator	1
9	Pressure relief valve	1
10	Smoke generator for fire detector test	1
11	H2 test gas for detector test	1
12	Coolant pumping/filling equipment	1
13	CE multitester	1
14	Multimeter	1

- H2 Sniffer - Sewerin Snooper Mini H2, Detection instrument to sniff/locate source of potential leaks.
- Pressure sensor - Fluke 700RG07 500PSIG, measuring device to accurately adjust and monitor gas pressure during leakage test.
- Test gas - Formier gas 5% hydrogen. Test gas for pressurizing pipework where the 5% hydrogen acts as tracer agent for sniffing
- Sniffer test station - Sewerin SPE-HG. Test instrument the emits a reference gas to check the correct function of the Snooper Mini H2 sniffer.
- Pressure regulator, Test gas pressure regulator for pressurizing the DUT.

- Pressure relief valve, Safety valve to ensure safe pipework pressurization during test.

TESTING & MEASUREMENT INSTRUMENT USED			
Type	Serial N.	Calibration certificate	Validity

6.2.5 Consumable List

- Not applicable

6.2.6 Commissioning Spare Parts

HOLD 2

6.2.7 Temporary Facilities

- Not applicable

6.3 OTP Description – SITE

The SITE test will consist of a repeat of the onshore integration testing with the BLPH now installed situ to it's permanent connections. In the following steps the functionality of the Hydrogen Fuel Cell package shall be tested for operation in all BLPH operating modes.

6.3.1 OTP Test Preparation

Step	Description	Result	Verified by	Date
1	System Ready for Operation (RFO) Certificate is issued and approved.	✓		4-7-25
2	No blocking punch list items are outstanding against the system to be commissioned.	✓		"
3	System(s), (de)isolations as per LOTO procedure enclosed within commissioning Work Permits procedures prepared and approved	✓		"
4	Verify and confirm that all steps performed at WORKSITE of this procedure are completed without any pending issues that would prevent from proceeding with the offshore SITE PROCEDURE	✓		"

Step	Description	Result	Verified by	Date
5	All personnel involved in the implementation of this procedure are familiar with this procedure as well as with associated safety requirements (Toolbox Talk to be conducted before initiation of activities).	✓		4.7.25
6	A final walkdown after hook-up of the system has been completed, any preservation items have been removed and to ensure that the system and the area are ready for energization.	✓		"
7	Check that areas are free for work and escape routes are clear of any obstructions.	✓		"
8	Ensure that proper communications have been established between parties involved in the implementation of the procedure.	✓		"
9	Verify availability of test equipment and consumables as per chapters 6.2.4.	✓		"
10	All personnel have been duly notified during dedicated daily SIMOPS meetings that the system(s) is ready for operation.	✓		"

6.3.2 Electrical Preparation

Step	Description	Result	Verified by	Date
1	No blocking punch list items are outstanding against the system to be commissioned.	✓		4.7.25
2	Review and confirm no changes are required to be performed on existing protection settings.	✓		"

6.3.3 Mechanical Preparation

Step	Description	Result	Verified by	Date
1	No blocking punch list items are outstanding against the system to be commissioned.	✓		4.7.25
2	Ensure Fuel Cell package correctly connected to upstream H2 supply.	✓		"
3	Ensure Fuel Cell package correctly connected to downstream process waste water line.	✓		"

6.3.4 Instrument Preparation

Not applicable.

6.3.5 Piping Preparation

Not applicable

6.3.6 Additional Discipline Preparation

Not applicable.

6.4 OTP Test Steps – Offshore PHASE 4

The previous chapters must be successfully performed prior to final operational test of the Hydrogen Fuel Cell

6.4.1.1 Hydrogen Fuel Cell Integrated Testing OFFSHORE

Step	Description	Result	Verified by	Date
	Hydrogen Fuel Cell operating modes to be controlled from PCS via ECMS.			
1	Confirm on PCS that CCS operating mode is in "IDLE". Confirm Fuel Cell Package is in sleep mode.			
2	On PCS, change CCS operating mode to "IMPORT". Confirm no change at Fuel Cell package.			
3	On PCS, change CCS operating mode to "HOT STANDBY". Confirm Fuel Cell is now in Standby mode.			
4	Confirm H2 storage is available. This requires a reading of ≥ 20 barg on at least one of the following pressure transmitters: • 25-PT-035 • 25-PT-037 • 25-PT-040 • 25-PT-043 • 25-PT-046 • 25-PT-049			
	NOTE: Pressure control via valves 25-PV-055A & 25-PV-055B should already be successfully tested via Hydrogen Venting & Storage OTP 123A90-PML-COM-PRO-03042			
5	On PCS, change CCS operating mode to "EXPORT". Confirm Fuel Cell status changes to running.			
6	Confirm that power output can be controlled via the EMCS over modbus. Test power output at increments of 0.25MW up to and including 1MW.			
7	On PCS, change CCS operating mode to "COLD STANDBY". Confirm Fuel Cell shuts down and returns to Sleep mode.			
8	On PCS, change CCS operating mode to "EMERGENCY (Island Mode)". Confirm Fuel Cell recommences discharge of power.			

Step	Description	Result	Verified by	Date
9	On PCS, change CCS operating mode to "MAINTENANCE". Confirm Fuel Cell can only be operated locally.			
10	On PCS, return CCS operating mode to "EXPORT". Initiate Fuel Cell F&G event via 1 of the 3 hydrogen detectors located inside the container and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters Safe Torque Off of all Motor Drives			
11	On PCS, return CCS operating mode to "EXPORT". Operate the Fuel Cell Package Emergency Stop and confirm the following: • Safety trip of all 6 FC Wave modules. • All hydrogen safety valves are closed. • Safe Torque Off of all Power Converters Safe Torque Off of all Motor Drives			

6.4.1.2 Hydrogen Fuel Cell Integrated Testing OFFSHORE Notes and Remarks

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6.4.1.3 Hydrogen Fuel Cell Integrated Testing OFFSHORE - Certifying Authority Table of Attendances

Name and Surename	Certifying Authority	Position	Signature

6.4.1.4 Hydrogen Fuel Cell Integrated Testing OFFSHORE - Final Signatures and Company Acceptance

Name and Surname	Company Representative	Position	Signature
Name and Surename	**Certifying Authority**	**Position**	**Signature**

6.5 Post-test Conditions

After functional tests have been completed, system / sub-systems are left in healthy and safety condition and operational.

6.6 Reinstatement tasks

Generally, the system/ sub-system shall be reinstated at its initial condition; and the following activities must be carried out as minimum:

- all inhibition done for the test shall be removed (as per Inhibit / Override List)
- all equipment/devices shall be returned in healthy functional conditions.

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7 APPENDICES

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7.1 Vendor SAT Procedure

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7.2 Proverlis Summary System Reports

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7.3 Equipment Related Technical Queries

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7.4 As Built Documentation

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7.5 Management of Change – Summary Table of Tasks and Details of Affected Related Documentation

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Short Title	Megablock Site Acceptance Test
Full Title	Megablock Site Acceptance Test
Abstract	*Site acceptance test for verification of full Megablock system*

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Revision Record

Rev #	Description	Revised By	Date (dd-mm-yyyy)
-	Initial Release	RKN	28-05-2024
1	General updates	RKN	28-06-2024
1.1	General updates	TAN	18-09-2024
2	Update prior to release to CW	PBL	16-10-2024
3	Updates based on review with CW	RKN	19-11-2024
4	Updates based on review with CW	RKN	09-01-2025

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1.0 Executive Summary

This document outlines the recommended commissioning activities and site acceptance tests. These tests aim to verify correct installation, and that the system performance onsite matches the performance level shown during FAT. There should be no CAT A items outstanding prior to power up.

2.0 References

- Confirmation of Satisfactory SAT - Signature Page
- PWR008 Ballard commissioning document
- EN 60204 Electrical safety test 10ft
- EN 60204 Electrical safety test 40ft
- EN 60204 Electrical safety test Cng Pltfrm
- F07 & F08, Electrical safety SAT
- F10 Safety checklist
- SPC ID 0103 Cooling Circuit Pressure and Leak Test Procedure
- SPC ID 0104 H2 Leak Test Procedure
- SPC ID 0106 Noise Level Measurement Test Procedure
- SPC ID 0204 System pressure decay test template

3.0 Definitions and Acronyms

FC	FCwave™
H2	Hydrogen
FAT	Factory Acceptance Test
SAT	Site Acceptance Test
HT1	High temperature 1050kW cooling system 1
HT2	High temperature 1050kW cooling system 2
LT	Low temperature cooling system

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4.0 Objectives and Background

The tests in the document are based on the test matrix in document J99-02 (Aconex K559-2254-CWIWP4202202-J99-002-Rev002)

This document describes the witnessed Site Acceptance Tests. The tests do not include the internal testing that has been done to secure product maturity, mechanical and electrical connections have been done correctly.

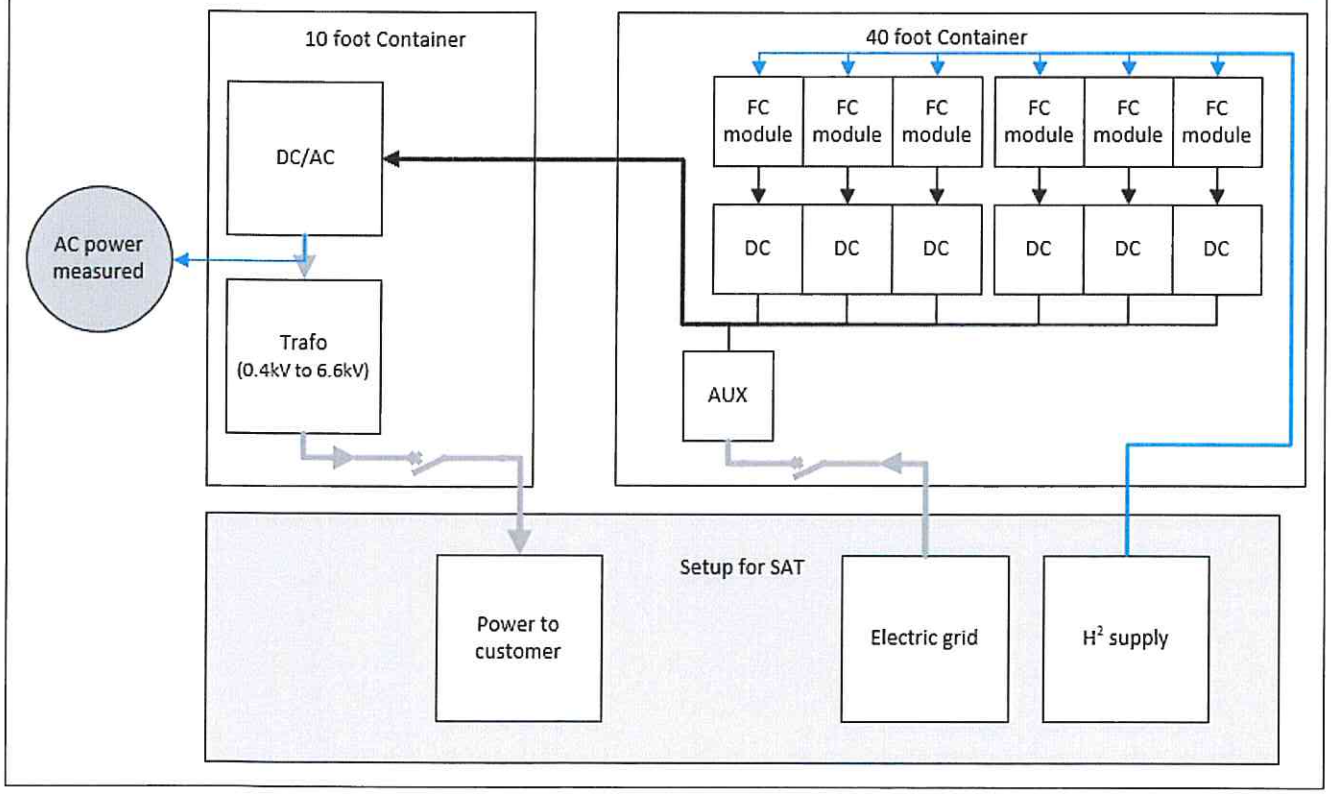
The SAT is not intended to replace an integration test. If third-party features are not yet ready for testing, those specific test cases will be temporarily excluded from the SAT and should be performed during integration testing. This will not affect the overall SAT signoff.

There should be no CAT A items outstanding prior to power up.

The scope of testing is:

- Visual Inspection of the delivered product (Tri-party walkaround)
- Verification of safety systems for the Megablock.
- Production of electrical power to the customer grid to verify performance.

Figure 1: Megablock System test overview



5.0 Note on Power Quality Measurements

The power quality measurements are indicative during SAT, as the measured power quality depends also on the customer load dissipating the produced power. Ballard is also not capable of measuring power quality on the 6.6kV bus, and any measurements are done on the 400V side of the output transformer. This results in lower measurements than on the medium voltage side of the output transformer, as the transformer inductance is an integral part of the harmonic dampening of the FC package.

Power quality measurements have been removed from pass/fail criteria.

6.0 Note on Electrical Load

The electrical load that is to dissipate the power generated by the FC package is not in Ballard scope. During step response tests and full load tests, it is required that it is present and able to absorb the power from the FC package.

7.0 Functional tests

7.1 F02 Visual inspection

7.1.1 Test

The test involves an examination of the paint job through visual inspection, assessing the overall build quality, and checking for any dents. The focus is also on evaluating the assembly quality to ensure compliance with weather resistance.

This test is superseded by the tri party walkaround.

7.1.2 Relevant Standard / document

- No reference

7.1.3 Brief Test Plan

- Visual inspection with customer of full system, meaning inside and outside container solution.
- Take comprehensive pictures of the full system and test setup, including close-ups of vital components, with timestamps for reference.

7.1.4 Pass/Fail criteria.

- Visual inspect with customer to review quality of full system.

7.1.5 Test Result

Table 1: Visual inspection – Test Result

Date tested	Item	Result	Pass/Fail	Notes
04/06/25	40' Container	ok	Pass	Peter Bleeker
04/06/25	10' Container	ok	Pass	Peter Bleeker
04/06/25	Cooling Skid	ok	Pass	Peter Bleeker

Peter Bleeker 09/06 '25

7.2 F07 Electrical safety test – 10-foot container

7.2.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

7.2.2 Relevant Standard / document

- EN 60204 Electrical safety test 10ft
- F07 & F08, Electrical safety SAT

7.2.3 Brief Test Plan

- According to EN 60204-1

7.2.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

7.2.5 Test Result

Table 2: Electrical safety test - Test results

Date tested	Item	Result	Pass/Fail	Notes
06/02/25	Grounding Continuity	OK	Pass	See test sheet
06/02/25	Isolation resistance	OK	Pass	See test sheet.

Pilo Blah 04/06 '25

Table 3: Electrical safety test - calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
	086 - 023	2025-06-04	Tests F07 & F08

7.3 F08 Electrical safety test – 40-foot container

7.3.1 Test

Follow designated standard to conduct electrical safety test, grounding continuity and high potential.

7.3.2 Relevant Standard / document

- EN 60204 Electrical safety test 40ft
- EN 60204 Electrical safety test Cng Pltfrm
- F07 & F08, Electrical safety SAT

7.3.3 Brief Test Plan

- According to EN 60204-1

7.3.4 Pass/Fail criteria.

- All relevant checks in EN 60204-1 chapter 18 passed.

7.3.5 Test Result

Table 4: Electrical safety test - Test Result

Date tested	Item	Result	Pass/Fail	Notes
06/02/25	Grounding Continuity	OU	Pass	See test sheet
06/02/25	Isolation Resistance	OU	Pass	See test sheet

Table 5: Electrical safety test - Calibration equipment

Unit	Equipment number	Calibration due date	Equipment used for
	086-003	2025-06-04	F08 & F07

Peter Blum
04/06/25

7.4 F10 Safety

7.4.1 Test

Conduct tests of safety inputs and outputs, including emergency stop buttons, smoke detectors, gas detectors and external connections.

7.4.2 Relevant Standard / document

- F10 Safety checklist

7.4.3 Brief Test Plan

- Trigger each safety input according to checklist.
  - Emergency pushbuttons
  - Smoke detectors test
  - H2 sensor test
  - External safety switches
  - External feedback

7.4.4 Pass/Fail criteria.

- Verified according to checklist.
- Each item triggers the correct alarm

7.4.5 Test Result

Table 6: Safety - Test Result

Date tested	Item	Result	Pass/Fail	Notes
19/02/2025	Emergency pushbuttons	✓	PASS	✓
19/02/2025	Smoke detectors	✓	PASS	✓
19/02/2025	H2 sensors	✓	PASS	✓
19/02/2025	External safety switches	✓	PASS	ADDED 120 OHM RESISTOR
19/02/2025	External feedback	✓	PASS	✓

Peter Black
P. Black

F. SCRIGNI
ROSETTA MARINO
04/00/25

Table 7: Safety – Calibration/Equipment

Unit	Equipment number	Calibration due date	Equipment used for
—	—	—	—

7.5 F18 H_2 Leakage test

7.5.1 Test procedure

All pipework and H2 instrumentation subassemblies must be inspected, recorded, verified and pass in accordance with the procedure in section 5.4 in *SPC ID 0104 H2 Leak Test Procedure Rev 002* prior to full system SAT.

System H2 leakage test is done system pressure decay test, according to section 5.5 in *SPC ID 0104 H2 Leak Test Procedure Rev 002*.

7.5.2 Pass/Fail criteria.

Pressure decay test with a maximum leakage no greater than specified in test procedure.

Result details are documented in the template *SPC ID 0204 System pressure decay test template*

Parameter	Value	Description
L_A [Nm^3/h]	**2,72 – 3,58 x10^{-3}**	**Maximum allowed pressure decay to pass pressure decay test, where L_A = L_S + L_Mu**
L_S [Nm^3/h]	0	Summarized expected leak rates of all components in the system (per design leak rate).
L_Mu [Nm^3/h]	2,72 – 3,58 x10^{-3}	Calculated accuracy of the measuring system, used to perform the test.
L_C [Nm^3/h]	2,7x10^{-5}	Maximum allowed leak rate for a given pipe section, where integrity/operability of the system may be maintained safely

7.5.3 Test Result

Table 8: H2 leakage - Test Result

Date tested	Item	Leakage rate L_1 [Nm^3/h]	Pass/Fail	Notes
19/2/25	H2 line 1	0	Pass	See test Sheet
19/2/25	H2 line 2	0	Pass	See test sheet
19/2/25	H2 line 3	0	Pass	See test Sheet
19/2/25	H2 line 4	0	Pass	See test sheet
19/2/25	H2 line 5	0	Pass	See test sheet
19/2/25	H2 line 6	0	Pass	See test Sheet

Dylan Bhell 04/06

8.0 Operational tests

Operations are done using operator HMI or remote HMI in normal operating mode.

8.1 O01 System Start/Stop - Normal low load operation.

8.1.1 Test

Fuel Cell system can start, deliver minimum power and perform controlled stop without faults. This test is based on DC power.

8.1.2 Relevant Standard / document

- No reference

8.1.3 Brief Test Plan

- All FC in standby
- Request 100kW DC
- Delay 120 seconds
- Request zero power
- Repeat with new preferred FC until all tested.

8.1.4 Pass/Fail criteria.

- Fuel Cell Package starts without faults.
- No persistent system alarms.
- Correct available power signal.
- DC Power output within +/-5% and stable in less than 60 seconds
- Fuel Cell Package stops without faults.
- Fuel Cell in stand-by in less than 120 seconds.

8.1.5 Test Result

Table 9: System Start/Stop – Normal low load operation - Test Result

Date tested	Item	Result	Pass/Fail	Notes
14/6/25	FCwave 1	All pass criteria passed	pass	See below
14/6/25	FCwave 2	"	pass	"
14/6/25	FCwave 3	"	pass	"
14/6/25	FCwave 4	"	pass	"
16/6/25	FCwave 5	"	pass	"
16/6/25	FCwave 6	"	pass	"

Normal low load operation was tested during the conditioning of the modules on Sat June 14th + Monday June 16th.

Each FC module was ramped up from 0 - 200kw Output. All 6 modules exceeded 200 kw.

8.2 O09 Load Test – step response 0 to ~~35%~~ 40%

8.2.1 Test

Test step response by adding 35% load in one step from no load while measuring AC power quality.

8.2.2 Relevant Standard / document

- N/A

8.2.3 Brief Test Plan

- All FC in stand-by.
- Apply set point by requesting 350kW AC

8.2.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.2.5 Test Result

Table 10: Load Test - step response 0 to 35% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
04/07/2025	Step response 0-35%	—	Pass	—
	AC power quality		Indicative	

Gedas Paulauskas
Ballard

8.3 O10 Load Test – step response ~~35%~~ 40% to 70%

8.3.1 Test

Test step response by adding 35% load in one step to reach 70% load while measuring AC power quality.

8.3.2 Relevant Standard / document

- N/A

8.3.3 Brief Test Plan

- 3 FC running delivering 350kW AC steady state.
- 3 FC in stand-by
- Apply set point by requesting 700kW AC power.

8.3.4 Pass/Fail criteria.

- No persistent system alarms.

8.3.5 Test Result

Table 11: Load Test - step response 35% to 70% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/07/2025	Step response 35%-70%	—	Pass	—
	AC power quality		Indicative	

Gedas Pocelauskas
Ballard

8.4 O11 Load Test – step response 65% to 100%

8.4.1 Test

Test step response by adding 35% load in one step to reach full load while measuring AC power quality.

8.4.2 Relevant Standard / document

- N/A

8.4.3 Brief Test Plan

- 6 FC running delivering 650kW AC steady state.
- Apply set point by requesting 1000kW AC power.

8.4.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.4.5 Test Result

Table 12: Load Test - step response 65% to 100% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/07/2025	Step response 65%-100%	—	Pass	—
	AC power quality		Indicative	

Gedas Paulauskas
Ballard

8.5 O12 Load Test – 100% stability test - 1 hours.

8.5.1 Test

Test steady state at 100% load for 1 hours while measuring power quality.

This test is also dependent on the hydrogen supply for the system.

8.5.2 Relevant Standard / document

- N/A

8.5.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.

8.5.4 Pass/Fail criteria

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.5.5 Test Result

Table 13: Load Test – Steady state 100% load - Test Result

Date tested	Item	Result	Pass/Fail	Notes
3.7.25	Full load test	1000kw	Pass	—
	AC power quality		Indicative	

Gedas Pavlauskas
Ballard

8.6 O13 Load Test – step response 100% to 50%

8.6.1 Test

Test step response by removing 50% load in one step at full load while measuring power quality.

8.6.2 Relevant Standard / document

- N/A

8.6.3 Brief Test Plan

- 6 FC running delivering 1000kW steady state.
- Request 500kW AC.

8.6.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.6.5 Test Result

Table 14: Load Test - step response 100% to 50% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/07/2025	Step response 100%-50%	—	Pass	—
	AC power quality		Indicative	

Gedas Paulauskas
Ballard

8.7 O14 Load Test – step response 50% to 0%

8.7.1 Test

Test step response by removing 50% load in one step to no load while measuring AC power quality.

8.7.2 Relevant Standard / document

- N/A

8.7.3 Brief Test Plan

- 3-6 FC running delivering 500kW AC.
- Request 0% and apply set point.

8.7.4 Pass/Fail criteria.

- AC output: +/- 10% actual to curve at any time.
- No persistent system alarms.

8.7.5 Test Result

Table 15: Load Test - step response 50% to 0% - Test Result

Date tested	Item	Result	Pass/Fail	Notes
05/04/2025	Step response 50%-0%	—	Pass	—
	AC power quality	n/a	n/a	Unit not producing power

Gedas Paukauskas
Ballard

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	06/02/2025
Test location	40ft Container, RM Yard, Ravenna
Test performed by	PBL, MKD

Grounding continuity
EN 60204-1:2018 - Section 18.2.2 - Test 1
Test performed with a test current of 10A

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	Busbar to busbar	0,024	Ohm	0,01
	Module 1	0,018	Ohm	0,015
	DC/DC cabinet 1	0,023	Ohm	0,006
	Module 2	0,024	Ohm	0,011
	DC/DC cabinet 2	0,019	Ohm	0,006
	Module 3	0,026	Ohm	0,017
	DC/DC cabinet 3	0,016	Ohm	0,006
	Module 4	0,026	Ohm	0,02
	DC/DC cabinet 4	0,016	Ohm	0,008
	Module 5	0,024	Ohm	0,013
	DC/DC cabinet 5	0,017	Ohm	0,006
	Module 6	0,029	Ohm	0,017
	DC/DC cabinet 6	0,015	Ohm	0,005
	Control cabinet	0,021	Ohm	0,014
	Control cabinet right door	0,032	Ohm	0,048
	Lifting crane track, dolly	0,028	Ohm	0,008
	LT piping	0,031	Ohm	0,022
	Isolation transformer cover	0,039	Ohm	0,015
	Cable tray	0,019	Ohm	0,012

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	Busbar to busbar	0,019	Ohm	0,007
	Main DC/Acpoint 1	0,032	Ohm	0,031
	Main DC/Acpoint 2	0,024	Ohm	0,014
	Main DC/Acpoint 3	0,027	Ohm	0,011
	DC/AC conduncter point 1	0,037	Ohm	0,007
	DC/AC conduncter point 2	0,022	Ohm	0,009
	DC/AC conduncter point 3	0,023	Ohm	0,006
	LT coolant pipe	0,024	Ohm	0,014
	Cable tray	0,02	Ohm	0,007
	Main transforer grounding bolt	0,023	Ohm	0,009
	Main transformer chassis	0,02	Ohm	0,007
	Cable tray MV cables	0,022	Ohm	0,011

Name and date: Rhea Bhatt June 4th

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	06/02/2025
Test location	40ft Vontainer, RM Yard, Ravenna
Test performed by	PBL, MKD

Isolation resistance
EN 60204-1:2018 - Section 18.3
Test performed with a test voltage of 1000V

Main location	Location	Measurement FAT	Unit	Measurement SAT
40 ft container	L1-PE	> 999.9	MOhm	> 999.9
	Cooling skid L1	10,01	Mohm	12,11
	Colling skid L2	6,252	Mohm	5,21
	Cooling skid L3	12,81	Mohm	10,12
	AUX supply L1	251	Mohm	316
	AUX supply L2	337	MOhm	364
	AUX supply L3	237	Mohm	248

Main location	Location	Measurement FAT	Unit	Measurement SAT
10ft container	L1+L2+L3-PE on AC circuit	592	Mohm	Transformer connected, RM scope

Name and date: 

Title	F07 & F08 Electrical safety test - 40 ft and 10 ft container
Project	601456B CrossWind BLPH
Test date [DD-MM-YYYY]	06/02/2025
Test location	40ft container, RM Yard, Ravenna
Test performed by	PBL, MKD

Isolation resistance
EN 60204-1:2018 - Section 18.4
Test performed with a test voltage of 2500VAC

Main location	Location	Measurement FAT	Unit	Measurement SAT
40ft container	PE and L1	0	mA	0,6
	PE and L2	0	mA	0,6
	PE and L3	0	mA	0,6

Main location	Location	Measurement FAT	Unit	Measurement SAT
10 FT container	PE and L1	7,1	mA	Transformer connected, RM scope
	PE and L2	7,1	mA	Transformer connected, RM scope
	PE and L3	7	mA	Transformer connected, RM scope

Name and date: Peter Bell, Sun, 4th

BALLARD

Ballard Power Systems Europe A/S
Majsmarken 1
DK-9500 Hobro

Confirmation of Satisfactory H2 leakage test

Part No.	601456B-7002362 Incl sub-assemblies 601456B-7002973 601456B-7003716
Product name	FC PowerGen 1000kW
Serial No.	601456B

Ballard Power Systems Europe A/S confirms that the above-listed equipment has satisfactorily with comments undergone and passed the H2 leakage test according to

BLPH Project – SPC ID 0104 H2 Leak Test Procedure rev 02 Max 11,240 BARG < 1 hr dur

CrossWind C.V. acknowledges that the H2 leakage test for the above-listed equipment was witnessed and confirms that the test was performed satisfactorily with comments, and all agreed-upon specifications have been met

Signatures

Ballard Power Systems Europe A/S			
Signature:	Preben H 2		
Name:	PREBEN JENSEN		
Title:	SENIOR APPLICATION ENGINEER	Date:	19/2/25
CrossWind C.V.			
Signature:			
Name:			
Title:	Crosswind Commissioning Manager	Date:	
Inspector			
Signature:			
Name:	DAVE HUSGROVE		
Title:	Inspector for Crosswind	Date:	19/2/2025

Note: This document serves as formal confirmation that the H2 leakage test has been successfully completed and witnessed, with both parties in agreement on the satisfactory results. It should be signed by authorized representatives of both parties.