Ballard Power Systems Europe A/S
Majsmarken 1
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Denmark

Revision history		
Rev.	**Date.**	**Description**
001	11/08/2023	First Issue

Document Title:	**BLPH Project - Type Approval Certificates**
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Requsition Number:	n/a
Customer:	CrossWind C.V., Rotterdam, The Netherlands

TYPE APPROVAL CERTIFICATE

Certificate No:
TAE00004GG
Revision No:
2

This is to certify:

That the Fuel Cell

with type designation(s)
FCwave

Issued to
Ballard Power Systems Europe A/S
Hobro, Nordjylland, Denmark

is found to comply with
DNV rules for classification – Ships

Application :

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV.

Issued at **Hamburg** on **2023-07-14**
This Certificate is valid until **2027-05-31**.
DNV local unit: **Denmark CMC**

Approval Engineer: **Sven Lellesch**

for **DNV**

Olaf Drews
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.

Product description

FCwave™ is a PEM fuel cell power module with rated power of 200 kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinet. The system, lower and upper cabinet, each have individual serial numbers and can be replaced during the service lifetime of the product.

The fuel for the system is pressurized gaseous hydrogen. The hydrogen storage system is not part of Ballard Power Systems Europe scope and therefore not part of the type approval. Oxidant for the reaction is drawn from ambient air and compressed in the internal compressors to feed the fuel cell stacks.
From the stacks, the module will deliver up to 720V direct current to the output of the system. It acts as a load follower electrically. The system needs power from external power source such as the vessels power system to start up, but when running it self-powers the internal Balance of Plant components. The controller and safety system require 24 VDC continuously from the vessels power system to function.
The system requires external water cooling to remove excess heat from the exothermic reaction in the fuel cells. The heat transfer is done with the integrated heat exchanger. The heat can be used in shipboard systems or disposed of as the customer desires. The fuel cells used in the system are Low Temperature PEM fuel cells. Temperatures in the system are below 100°C. The Fuel cell system is built into a cabinet. The cabinet has an ingress protection of IP44. The system is designed to be installed inside a fuel cell installation room. FCwave™ follows the gas safe machinery space concept as per IGF Code.

System Data

Control System Hardware and Software Version

Software	2.X.X	Dated 01/06 2023
Firmware	4.0.4.0	Dated 24/11 2021 (Deif AS)

Safety System Hardware and Software Version

Software	1.1.0	Dated 01/06 2023
Firmware	4.4	01/27 2022 (Siemens)

Independent Safety triggered by

Hydrogen concentration measurement inside fuel cell
External E Stop
Heat Detection inside fuel cell
Smoke Detection inside fuel cell
Ventilation Air Flow inside fuel cell

Interfaces to vessel

Are to be coordinated for each installation
Fuel Cell installation Room and Room requirements
Vessel control system
24VDC safety power supply
24VDC power supply
DC input/output
H2 supply
Low temperature cooling supply
High temperature cooling supply
H2 Enclosure ventilation outlet
Process exhaust outlet
H2 Enclosure ventilation Inlet
Process air inlet
Water drain

Application/Limitation

Fuel cell of type FCwave™ is approved for application as per DNV-RU-SHIP Pt.6 Ch.2 Sec.3.

Installation room
The fuel cell space (H2 enclosure as part of the FCwave™ cabinet) is not equipped with A60 insulation and is not equipped with a fire extinguishing system as indicated in MSC.1/Circ.1647 para 3.1.2 and 3.3.1. Additional installation room requirements shall be defined in the detailed design phase for the vessel.

The installation room is regarded as non-hazardous space.
The free volume of the installation room shall not be less than 10m³.
Gas detection is recommended for the fuel cell installation room and in the ventilation exhaust.

The FCwave™ does not provide an emergency stop button. Adequate and accessible emergency stop buttons shall be provided and integrated to the FCwave™ emergency stop circuit.
Access to the installation room during operation shall be limited to trained service technicians and crew that have received Ballard fuel cell training. Unrestricted access to the installation room can be permitted when all fuel cell modules are powered off and otherwise deemed permissible.

Hydrogen supply
Supply piping to each cabinet shall be carried out as double walled piping following the IGF Code principles.
Each FCwave™ cabinet shall be provided with a shut-off valve with a closing time of less than 2 seconds.
The hydrogen mass flow to each FCwave™ must be restricted by suitable means in all operation scenarios to 4.9g/s.
The dimension (diameter and length) of the hydrogen supply piping from shut-off valve to module interface plate shall not exceed 5000 cm³ as per Integration Manual.

Ventilation
The fuel cell space (H2 enclosure as part of the FCwave™ cabinet) is designed with area classification according to IEC 60079-10:2020, at least suitable for zone 2 installation.
In all cases process air and ventilation exhaust must remain separated, combination of multiple systems exhaust of the same type only. If process and/or ventilation exhausts are combined from multiple systems, they must be equipped with separate isolation dampers, which must close if the module are not operating.
The integration to the vessel shall ensure the exhaust from FC modules (ventilation air) is led to a safe location free of any spark or ignition source.

Approval Conditions
For each delivery to DNV class the following documentation of the fuel cell power installation is to be submitted for approval:

Fuel cell power installation
- Reference to this type approval certificate
- Documents according to DNV RU-SHIP, Pt. 6 Ch. 2 Sec. 3, table 3 for Fuel cell power installation
- G060 Structural fire protection drawing
- G200 Fixed fire protection drawing
- MAN002 Integration Manual

The Type Approval covers hardware and software listed under product description.

When the type approved software is revised (affecting all future deliveries) DNV is to be informed by forwarding updated software version documentation. If the changes are judged to affect functionality for which rule requirements apply a new functional type test may be required and the certificate may have to be renewed to identify the new software version.

Product certificate
Each delivery of the application system is to be certified according to Pt.6, Ch.2, Sec. 3. The certification test is to be performed at the manufacturer of the application system before the system is shipped to the yard. After certification, the clause for application software control will be put into force

Application software control
All changes in software are to be recorded as long as the system is in use on board. Documentation of major changes are to be forwarded to DNV for evaluation and approval before implemented on board

Type Approval documentation

Tests carried out

Marking of product
The components shall be marked for traceability to the Type Approval.

Periodical assessment
For retention of the Type Approval, a periodical assessment as per DNV-CP-0338 Sec.4 shall be performed by a DNV Surveyor in order to verify that the conditions for the Type Approval are complied with.
To check the validity of this certificate, please look it up in https://approvalfinder.dnv.com.

Certificate No: LR23327644TA
Issue Date: 27/07/2023
Expiry Date: 26/07/2028

Type Approval Certificate

This is to certify that the undernoted product(s) has/have been tested with satisfactory results in accordance with the relevant requirements of the Lloyd's Register Type Approval System.

Manufacturer	**Ballard Power Systems Europe A/S**
Address	Majsmarken 1, Hobro, 9500, Denmark
Type	Fuel Cell Module
Description	FCwave™ is a PEM fuel cell power module with rated power of 200 kW for marine applications. The system is comprised of an enclosure with an internal separate lower and upper cabinet. The system, lower and upper cabinet, each have individual serial numbers and can be replaced during the service lifetime of the product. The fuel for the system is pressurized gaseous hydrogen. The hydrogen storage system is not part of Ballard Power Systems Europe scope and therefore not part of the type approval. Oxidant for the reaction is drawn from ambient air and compressed in the internal compressors to feed the fuel cell stacks. From the stacks, the module will deliver up to 720V DC to the output of the system. It acts as a load follower electrically. The system needs power from external power source such as the vessels power system to start up, but when running it self-powers the internal Balance of Plant components. The controller and safety system require 24V DC continuously from the vessels power system to function. The system requires external water cooling to remove excess heat from the exothermic reaction in the fuel cells. The heat transfer is done with the integrated heat exchanger. The heat can be used in shipboard systems or disposed of as the customer desires. The fuel cells used in the system are Low Temperature PEM fuel cells. Temperatures in the system are below 100°C. The Fuel cell system is built into a cabinet. The cabinet has an ingress protection of IP 44. The system is designed to be installed inside a fuel cell installation room.

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Type Approval Certificate

FCwave™ follows the gas safe machinery space concept as per IGF Code.

Trade Name

FCwave™

Application

Marine, Offshore and Industrial applications for use in environmental categories ENV1, as defined in Lloyd's Register Type Approval System, Test Specification Number 7, Fuel Cell Modules, January 2023.

Specified Standard

-Manufacturer's specification
-IACS UR E10 Rev. 8 / 2021 as applicable

Ratings

-Maximum rated output power: 200kW
-Operating voltage: 350 – 720V DC
-Rated current: 2 x 300A or 1 x 550A

Other Conditions

The Fuel Cell Module is approved subject to the following conditions:

- A risk assessment specific to fuel cell power installations is to be carried out for each installation on board.The risk assessment is to evaluate risks related to the safe operation of the ship and as such is to address the safety of the fuel cell power installation itself and, where the fuel cell installation provides power for propulsion of the ship or other essential services, the dependability of the fuel cell power installation.
- The Fuel Cell Module shall only be used in accordance with the manufacturer's instructions and recommendations.
- The Fuel Cell Module shall be installed and maintained in accordance with the applicable rules, regulations, and standards for marine applications.
- The Fuel Cell Module shall be operated and monitored in accordance with the relevant safety requirements.
- The Fuel Cell Module shall be subject to periodic inspections and maintenance, in accordance with the manufacturer's recommendations and applicable rules and regulations.

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Certificate No: LR23327644TA
Issue Date: 27/07/2023
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Type Approval Certificate

Type Approval does not eliminate the need for normal inspection and survey procedures required by the Rules and Regulations.
If the specified standards are amended during the validity of this certificate, the product is to be re-approved prior to it being supplied to vessels to which the amended standards apply.

This certificate is not valid for equipment, the design, ratings or operating parameters of which have been varied from the specimen tested. The manufacturer should notify Lloyd's Register EMEA of any modification or changes to the equipment in order to obtain a valid Certificate.

The Design Appraisal Document HPC2262032/JM/PH and its supplementary Type Approval Terms and Conditions form part of this Certificate.

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