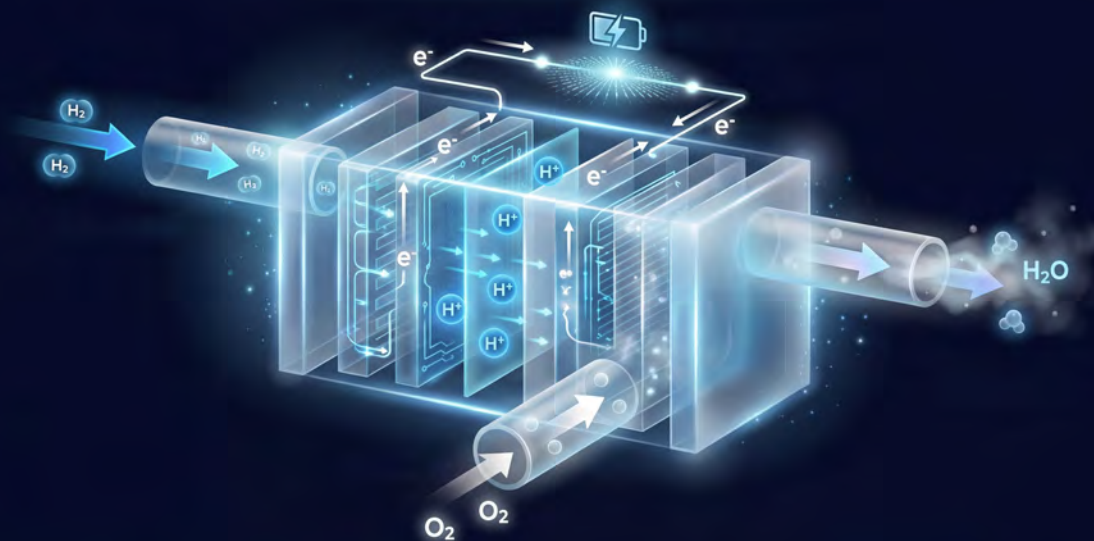


SHIPS USING **FUEL CELLS**

NR547 R02

EDITION NOVEMBER 2026



BUREAU VERITAS MARINE & OFFSHORE RULE NOTE

NR547 R02 NOVEMBER 2026

NR547 DT R02 November 2026 replaces the former edition January 2022.

The PDF electronic version of this document available on the Bureau Veritas Marine & Offshore website <https://marine-offshore.bureauveritas.com/> is the official version and shall prevail if there are any inconsistencies between the PDF version and any other available version.

This document is provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

© 2026 BUREAU VERITAS - All rights reserved





RULE NOTE NR547 SHIPS USING FUEL CELLS

Section 1	General
Section 2	Risk Assessment
Section 3	Arrangement On Board and Control of Atmosphere
Section 4	Materials
Section 5	Fuel Cell Power Installation
Section 6	Fire Safety
Section 7	Electrical Systems
Section 8	Control, Monitoring and Safety Systems
Section 9	On-Board Testing
Section 10	Survey at Work and Certification

Table of Content

Section 1 General

1	Scope	5
1.1	General	
1.2	Application	
1.3	Classification notation	
1.4	Documentation to be submitted	
1.5	Definitions	
1.6	References	

Section 2 Safety Assessment

1	General	10
1.1	Hazard identification and risk analysis	
1.2	Limitation of explosion consequences	
1.3	Limitation of toxicity consequences	

Section 3 Arrangement On Board and Control of Atmosphere

1	Arrangement on board	12
1.1	Primary fuel	
1.2	Fuel cell spaces location and access	
1.3	Fuel cell spaces arrangement	
2	Control of atmosphere	13
2.1	Fuel cell space concepts	
2.2	Ventilated fuel cell spaces	
2.3	Inerted fuel cell spaces	
2.4	Ventilation openings and duct arrangement	

Section 4 Materials

1	General requirements	15
1.1	Equipment and components	
1.2	Fuel cell power system	
1.3	Piping systems	

Section 5 Fuel Cell Power Installation

1	General requirements	16
1.1	Principles	
2	Availability of power for propulsion or essential services	16
2.1	General	
3	Piping arrangements for fuel cell power system	16
3.1	General	
3.2	Double Block and Bleed arrangement	
3.3	Reformed fuel piping	
3.4	Buffer tanks	
4	Fuel reformer system	18
4.1	General	
5	Inert gas and transitory gas	18
5.1	General	
6	Exhaust gas and exhaust air outlets	18
6.1	General	
7	Other systems	18
7.1	General	

Table of Content

Section 6 Fire Safety

1	General requirements	19
1.1	General	
2	Fire and explosion protection	19
2.1	General	
3	Fire extinguishing	19
3.1	General	
4	Fire detection	19
4.1	General	

Section 7 Electrical Systems

1	Electrical systems and equipment	20
1.1	General	
1.2	Fuel cell connection	
1.3	Power conditioning system	
1.4	Fuel cell management system	
2	Hazardous areas	20
2.1	General	
2.2	Area classification	

Section 8 Control, Monitoring and Safety Systems

1	General	22
1.1	General requirements	
2	Gas or vapour detection	22
2.1	General	
3	Ventilation performance in ventilated spaces	22
3.1	General	
4	Pressure in inerted fuel cell spaces	23
4.1	General	
5	Control of a safe atmosphere	23
5.1	General	
6	Bilge wells	23
6.1	General	
7	Fuel cell power installation monitoring	23
7.1	General	
8	Emergency shutdown push buttons	24
8.1	General	
9	Fuel supply remote emergency stop	24
9.1	General	
10	Actions of the alarm system and safety system	24
10.1	Gas or vapour detection	
10.2	Loss of ventilation	
10.3	Loss of inert gas	
10.4	Loss of fuel cell coolant	
10.5	Liquid detection	
10.6	Fire detection	
10.7	Fuel cell power system	
10.8	Emergency shutdown push buttons	

Table of Content

	11	Alarms and safety actions	25
		11.1 Alarms	
		11.2 Safety actions	
Section 9		On-Board Testing	
	1	General	27
		1.1 Application	
		1.2 Piping	
	2	Spaces containing fuel cell power systems	27
		2.1 General	
		2.2 Ventilated fuel cell space and ducts	
		2.3 Inerted fuel cell space and ducts	
		2.4 Hot spot verification	
	3	Fuel cell power system	27
		3.1 Scope of the tests	
	4	Fuel cell as essential service	28
		4.1 Scope of the tests	
Section 10		Survey at Work and Certification	
	1	General	29
		1.1 Principles	
		1.2 Environmental tests	
	2	Fuel cell modules	29
		2.1 Type approval	
		2.2 Production testing	
	3	Fuel cell power system	29
		3.1 Type approval	
		3.2 Production testing	
	4	Reformer	30
		4.1 Type approval	
		4.2 Production testing	
	5	Integrated fuel cell systems	31
		5.1 Type approval	
		5.2 Production testing	
	6	Certification	31
		6.1 General	

Section 1 General

1 Scope

1.1 General

1.1.1 This Rule Note provides requirements for the arrangement and installation of fuel cell power systems on board ships, for delivery of electrical and / or thermal energy.

1.1.2 This Rule Note is applicable to fuel cell power systems used for auxiliary or main electric power systems on board ships. It includes requirements for the design and installation of fuel cell power systems and the spaces containing such installations. The main components of a fuel cell power system in the scope of this Rule Note are defined in Fig 1.

1.1.3 This Rule Note includes detailed requirements for:

- the installation from primary fuel supply (including reformer if any) to the exhaust gas system
- associated safety, monitoring and control systems

Requirements for testing and certification are defined in Sec 9 and Sec 10.

1.1.4 Fuel storage, preparation (except pre-reforming and reforming) and distribution outside of the fuel cell power installation are not detailed in this Rule Note.

1.1.5 The following primary fuels are considered in the scope of the present Rule Note:

- ammonia
- hydrogen
- liquid petroleum gas
- methyl or ethyl alcohol
- natural gas.

Other fuels may be considered by the Society on a case-by-case basis.

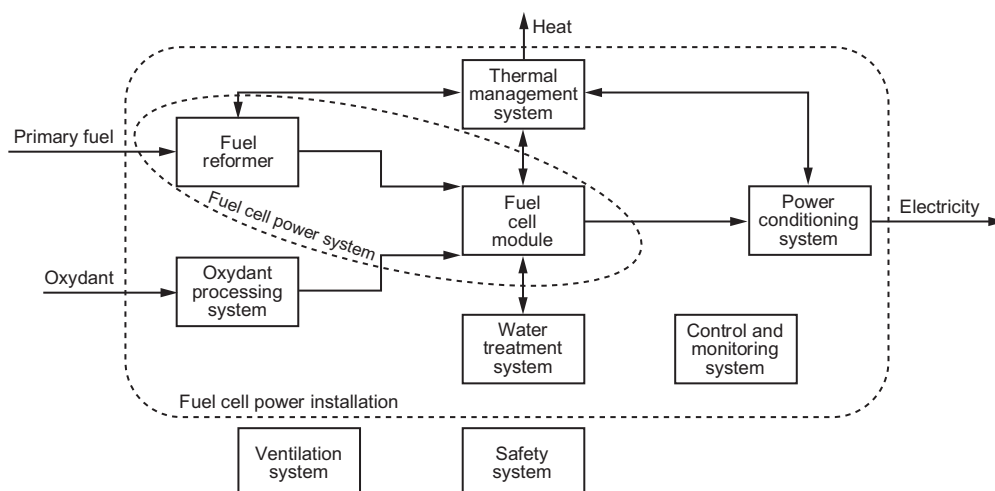
1.2 Application

1.2.1 Use of primary fuel

The arrangement of fuel storage, treatment and handling systems of ships using low-flashpoint liquid fuel or gases as primary fuel and falling within the scope of SOLAS Convention are to comply with the requirements of IMO IGF Code and Flag Administration, as applicable.

The Flag Administration is to be consulted to define the approval process and the conditions in which the use of the concerned fuel may be envisaged. The equivalence of the alternative design is to be demonstrated to, and approved by, the Flag Administration.

Figure 1 : Fuel cell power system components



1.2.2 Use of fuel cell as an electrical source of power

The fuel cell system design is to comply with the requirements of NR467, Pt C, Ch2, Sec 3, [2]. Alternative arrangements which would deviate from these requirements are to be given special consideration by the Society. When deviating from SOLAS requirements, those arrangements are to be included in the alternative design demonstration to be approved by the Flag Administration.

1.3 Classification notation

1.3.1 Ships fitted with a fuel cell system and complying with the requirements of this Rule Note are assigned the additional class notation **FUELCELL** as defined in NR467, Pt A, Ch 1, Sec 2, [6.17] and subject to compliance with the requirements of [1.3.2].

1.3.2 Prior to the assignment of the additional class notation **FUELCELL** and with respect to the primary fuel considered, assignment of at least one of the following additional class notation is mandatory:

- **AMMONIAFUEL** for fuel cell using ammonia as primary fuel
- **HYDROGENFUEL** for fuel cell using hydrogen as primary fuel
- **LNGFUEL** or **CNGFUEL** for fuel cell using natural gas as primary fuel
- **LPGFUEL** for fuel cell using liquid petroleum gas as primary fuel
- **METHANOLFUEL** or **ETHANOLFUEL** for fuel cell using methyl or ethyl alcohol as primary fuel
- **LFPFUEL** for fuel cell using low flashpoint or gaseous primary fuels other than the fuels mentioned above.

Requirements for assignment of the above additional class notations are given in NR467, Pt A, Ch 1, Sec 2, [6.17] and in the relevant Rules published by the Society.

The primary fuel or fuels used by the fuel cell are to be indicated in a memoranda (see [1.1.5] for the list of primary fuels that may be considered).

1.4 Documentation to be submitted

1.4.1 Documentation to be submitted for the assignment of the additional class notation **FUELCELL** is listed in Tab 1.

Table 1 : Documentation to be submitted

No.	I/A (1)	Documents	Particulars
1	A	General arrangement of the fuel cell spaces	Including, when relevant: <ul style="list-style-type: none"> hazardous areas with associated categorisation toxic areas
2	I	Primary and reformed fuel characteristics	Including, when relevant, storage pressure, temperature, Lower Explosivity Limit (LEL), toxicity, corrosivity and any other important safety related characteristics
3	A	Hazardous area and toxic area plan	When relevant
4	I	Safety concept	
5	I	Risk assessment and follow-up report of the recommendations	See Sec 2
6	I	Specification and type-approval reference of the installation components	
7	A	Specification of the control, monitoring and safety systems for each fuel cell power installation	
8	A	Diagram of the liquefied and gaseous fuel gas piping system	Including venting system
9	A	Arrangement of the double piping or duct system	
10	A	Material, thickness and joints of the fuel piping	
11	A	Design data and sizing calculation of the fuel piping systems	
12	A	Diagram of the inert gas piping system	
13	A	Diagram of the ventilation system in fuel cell spaces	Including ventilation duct arrangement in adjacent zones and sizing justification
14	A	Diagram of the oxidant processing, supply and exhaust system	
15	A	Diagram of the gas detection system	
16	A	Instrumentation list	
17	I	List of electrical equipment located in hazardous areas and respective safety certificates	
(1) A= to be submitted for approval; I= to be submitted for information			

No.	I/A (1)	Documents	Particulars
18	A	Diagram of the production, treatment, supply and outlet piping systems of the transitory gases	When relevant
19	I	Procedure for maintenance of the fuel cell power installation	Including the steps to be taken prior to servicing the units
20	I	Documents and information related to the operation of the fuel cell power installation	Including indication of the power developed by each component
21	A	Details of fire-extinguishing appliances and systems related to the fuel cell power installation	
22	A	Details of insulation	
(1) A= to be submitted for approval; I= to be submitted for information			

1.5 Definitions

1.5.1 Essential services

Essential services are defined in NR467, Pt A, Ch 1, Sec 1 [1.2.1] and specified in NR467, Pt C, Ch 2, Sec 1, [3.11].

1.5.2 Exhaust air

Exhaust air is the exhaust from cathode side of fuel cell.

1.5.3 Exhaust gas

Exhaust gas is the exhaust from reformer or anode side of fuel cell.

1.5.4 Fuel cell

Fuel cell is a source of electrical power in which the chemical energy of a fuel is converted directly into electrical and thermal energy by electrochemical oxidation.

1.5.5 Fuel cell management system

A fuel cell management system is an electronic system associated with a fuel cell power system which monitors and/or manages its state by controlling its environment, and which provides communication between the fuel cell power system and other macro-system controllers, such as a power management system (PMS).

1.5.6 Fuel cell module

Fuel cell module is an assembly of one or more fuel cell stacks, their electrical connections, and means for monitoring and/or control.

Note 1: A fuel cell module comprises the following main components: one or more fuel cell stack(s), a piping system for conveying fuels, oxidants and exhausts, electric connections for the power delivered by the stack(s) and means for monitoring, control or both. Additionally, a fuel cell module can include: means for conveying additional fluids (e.g. cooling media, inert gas), means for detecting normal and abnormal operating conditions, enclosures or pressure vessels and module ventilation systems, and the required electronic components for module operation and power conditioning.

1.5.7 Fuel cell power installation

Fuel cell power installation is the fuel cell power system and other components and systems required to supply electrical power to the ship. It may also include ancillary systems for the fuel cell operation.

1.5.8 Fuel cell power system

Fuel cell power system is the group of components which may contain fuel or hazardous vapours, fuel cell(s), fuel reformers, if fitted, and associated piping systems.

1.5.9 Fuel cell room

Fuel cell room is a machinery space dedicated to the fuel cell power system or parts of these. The fuel cell power system may be arranged in an enclosure acting as the fuel cell space or not. In the latter case, the fuel cell room is also a fuel cell space.

1.5.10 Fuel cell space

Fuel cell space is a space limited by structural boundaries or an enclosure containing fuel cell power systems or parts of these. A fuel preparation room including a reformer is considered as a fuel cell space.

1.5.11 Fuel cell stack

Fuel cell stack means the assembly of cells, separators, cooling plates, manifolds and supporting structure that electrochemically converts, typically, hydrogen rich gas and air reactants to D.C. power, heat, water and other reaction products.

1.5.12 Fuel reformer

Fuel reformer is the arrangement of all related fuel-reforming equipment for processing gaseous or liquid primary fuels to reformed fuel feeding fuel cells. Intermediate steps of reforming (e.g. removal of heavy gases from the primary fuel) are also included. The reforming equipment, if fitted, may be an integrated part of the fuel cell or arranged as an independent unit with reformed fuel piping connected to the fuel cell.

1.5.13 Gas consumer

Gas consumer means any unit (a reformer, a fuel cell module or a group of fuel cell modules acting jointly) within the fuel cell space using a gas as fuel.

1.5.14 Integrated fuel cell system

Integrated fuel cell system means portable equipment provided in an enclosure complying with the requirements associated to a fuel cell space. This enclosure contains at minimum the fuel cell power systems and may contain part or all the associated balance of plant.

1.5.15 Lower explosivity limit (LEL)

LEL means the lower explosive limit (4,0% concentration in volume for H₂).

1.5.16 Liquid fuel consumer

Liquid fuel consumer means any unit (a reformer or a fuel cell stack) within the fuel cell space using a fuel in liquid form.

1.5.17 Oxidant processing system

Oxidant processing system meters, conditions, processes and may pressurize the incoming oxidant (generally air) supply, with pressure, temperature, hygrometry, purity and flow rate within the ranges accepted by the fuel cell module.

1.5.18 Primary fuel

Primary fuel is fuel supplied to fuel cell power system.

1.5.19 Process air

Process air is air supplied to the reformer and/or the cathode side of the fuel cell.

1.5.20 Reformed fuel

Reformed fuel is hydrogen rich gas generated in fuel reformer.

1.5.21 Same type of equipment

Two equipment are considered of the same type when they do not substantially differ in design and construction characteristics such as those listed below, as relevant:

- Cell technology (Proton exchange membrane, Solid oxyde, alkaline...)
- Rated power at beginning of life
- Fuel and oxydant composition range
- Fuel flow rate at rated power
- Fuel pressure
- Rated current
- Operating voltage
- Heat management system
- Coolant system
- Fuel cell space protection (ventilated or inerted enclosure)
- Transitory gas may not be necessary, depending on fuel cell technology.

1.5.22 Thermal management system

Thermal management system assist in heating the power train during start-up, provides cooling and heat rejection for thermal equilibrium within fuel cell power system, and may provide for the recovery of excess heat.

1.5.23 Transitory gas

Transitory gas is the gas able to be injected in the fuel supply system when system is changing from one state to another. Transitory gas may not be necessary, depending on fuel cell technology.

1.5.24 Unacceptable loss of power

Unacceptable loss of power means that it is not possible to sustain or restore normal operation of the propulsion machinery in the event of one of the essential auxiliaries becoming inoperative.

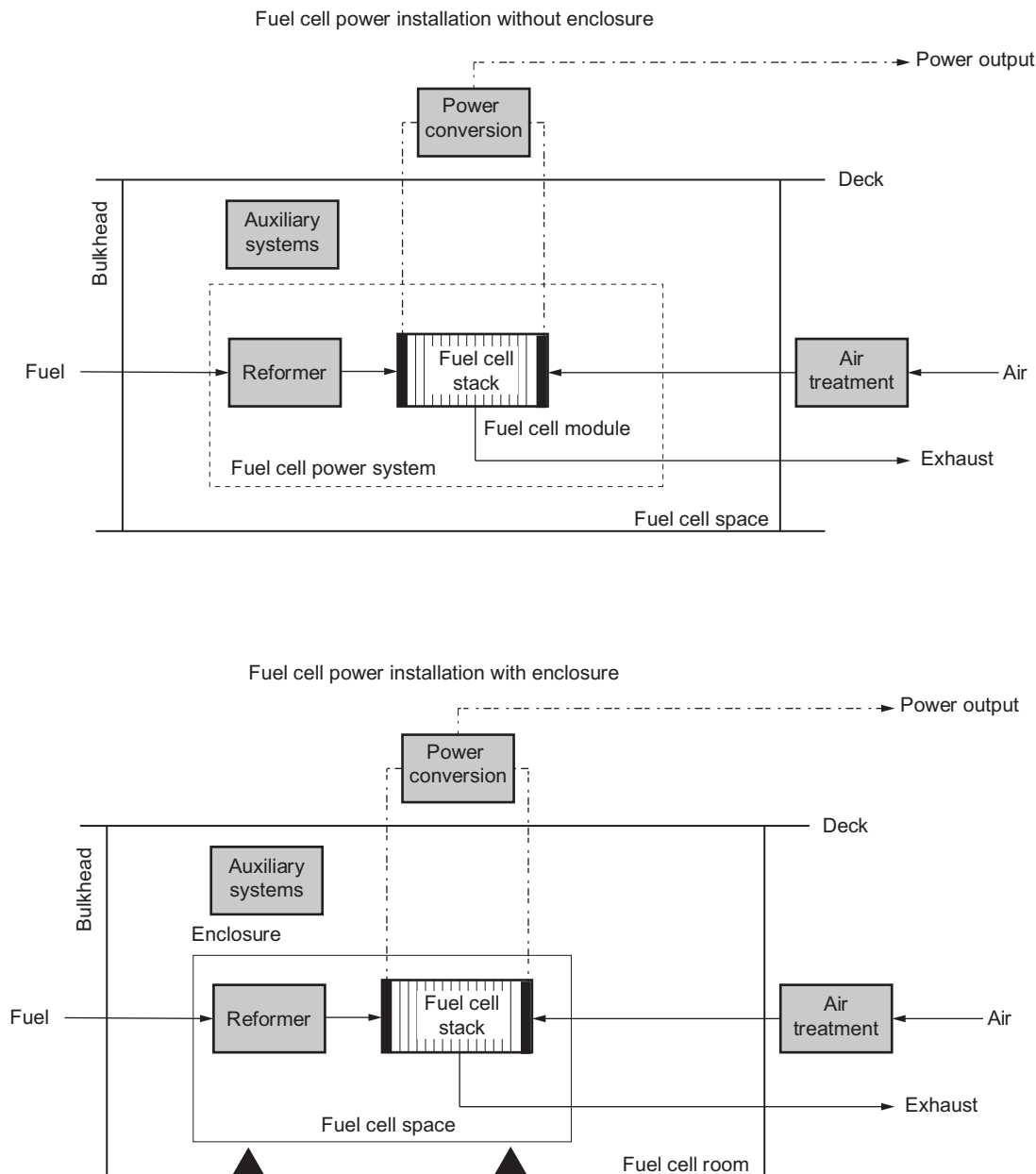
1.5.25 Ventilation air

Ventilation air is air used to ventilate the fuel cell space.

1.5.26 Water treatment system

Water treatment system provides the treatment and purification of recovered or added water for use within the fuel cell power systems.

Note 1: Typical arrangements for a fuel cell power installation are shown in Fig 2.

Figure 2 : Typical arrangements for a fuel cell power installation

1.6 References

1.6.1 Bureau Veritas Rules for Classification and Rule Notes

The followings documents are used as references:

- NR216 Rules on materials and welding for the classification of marine units
- NR467 Rules for the Classification of steel ships
- NR529 Gas fuelled ships
- NR647 LPG-fuelled ships
- NR670 Methanol and ethanol fuelled ship
- NR671 Ammonia-fuelled ships
- NR678 Hydrogen-fuelled ships.

1.6.2 IMO documents

This Rule Note incorporates requirements, printed in *italic type*, from IMO Circular MSC.1/Circ.1647 “Interim Guidelines for the safety of ships using fuel cell power installations”, which are applicable for Classification purposes.

Section 2

Safety Assessment

1 General

1.1 Hazard identification and risk analysis

1.1.1 A risk assessment is to be conducted in order to ensure that any risks arising from the use of the fuel cell power installation affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed. Consideration is to be given to the hazards associated with installation, operation, and maintenance, following any foreseeable failure.

1.1.2 Hazards are to be identified using acceptable and recognised hazard identification techniques. The following hazards are to be considered, as a minimum: loss of function, component damage, operational and environment-related influences, electrical faults, unwanted chemical reactions, toxicity, auto-ignition of fuels, fire, explosion, short-term power failure (blackout). The effects of the following are to be considered:

- the ship's operational profile
- the ship's operational status
- modes of operation
- environmental conditions
- dependencies - power, fuel, air, cooling, heating, data, human input
- environmental impact and failures - human error, supply failure, system, machinery
- equipment and component failure, random, systematic, common cause.

1.1.3 The risks are to be analysed using acceptable and recognised risk analysis techniques. The analysis is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary. If mitigation solutions are operational, details of risks, and the means by which they are mitigated, are to be included in the operating manual.

1.1.4 This risk assessment is to include, at least:

- an HAZID study covering the fuel cell spaces
- an HAZOP study for the fuel cell power system
- an FMECA analysis if the fuel cell power installation is to be used for essential services.

Note 1: Relevant international standards are to be followed, such as IEC 61882:2016 Hazard and operability studies (HAZOP studies) and IEC 60812:2018 Failure modes and effects analysis (FMEA and FMECA).

1.1.5 Use of high-temperature fuel cell power systems with reformed fuel temperatures above the self-ignition temperature is to be subject to special consideration within the risk assessment. See Sec 3, [1.3.8].

1.1.6 The period before safety shutdown in case of loss of ventilation or inert gas pressure in the fuel cell space is to be subject to special consideration within the risk assessment. See Sec 8, [10.2] and Sec 8, [10.3].

1.1.7 For any risk assessment carried out in the scope of the present Rules, a detailed follow-up report of actions and mitigation measures taken in response to any analysis findings is to be submitted to the Society.

This report is to include especially the monitoring and control options mentioned in Sec 8, [1.1.1].

The mitigation measures and provisions corresponding to the outcomes of the risk assessment and studies are to be taken, addressed and implemented in the ship design and shown on the drawings which are listed in Sec 1, [1.4].

1.2 Limitation of explosion consequences

1.2.1 The risk analysis is to identify the spaces in which explosive mixtures may be encountered, their volumes, their probability of explosion and the associated consequences. An explosion in any space containing any potential sources of release and potential ignition sources is not to:

- cause damage to or disrupt the proper functioning of equipment / systems located in any space other than that in which the incident occurs
- damage the ship in such a way that flooding of water below the main deck or any progressive flooding occurs
- damage work areas or accommodation in such a way that people who stay in such areas under normal operating conditions are injured

- disrupt the proper functioning of control stations and switchboard rooms for necessary power distribution
- damage life-saving equipment or associated launching arrangements
- disrupt the proper functioning of fire-fighting equipment located outside the explosion- damaged space, or
- affect other areas in the vessel in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise
- prevent access to life-saving appliances (LSA) or impede escape routes.

Note 1: Double wall fuel pipes are not considered as potential sources of release.

1.2.2 An explosion analysis is required for ventilated fuel cell spaces. It may also be required for other gas hazardous spaces, as a result of the risk assessment. Explosion analyses are to demonstrate that, for the worst case scenario, the maximum pressure built-up in case of explosion does not exceed the design pressure of the space, taking into account the venting arrangement and the explosion pressure relief devices, where provided.

1.3 Limitation of toxicity consequences

1.3.1 The risk analysis is to identify the areas and spaces where toxic products may be encountered, their volumes and the associated consequences. Release of toxic products is not to:

- provoke health effect for people who stay in work areas or accommodation under normal operating conditions
- prevent access to life-saving appliances (LSA) or impede escape routes
- induce an unacceptable contamination of the environment.

Section 3 Arrangement On Board and Control of Atmosphere

1 Arrangement on board

1.1 Primary fuel

1.1.1 Primary fuel storage, preparation and distribution outside of the fuel cell spaces are to comply with the requirements detailed in the corresponding Rule Note:

- NR529 for natural gas
- NR647 for liquid petroleum gas
- NR670 for methyl or ethyl alcohol
- NR671 for ammonia
- NR678 for hydrogen
- NR529, Ch 1, Sec 1, [1.2.2] for low flashpoint or gaseous primary fuels other than the fuels mentioned above.

1.1.2 Fuel cell spaces and associated equipment and systems (e.g. ventilation systems) are to comply with the requirements applicable to machinery spaces with an engine fuelled with the primary fuel as detailed in the Rule Notes listed in [1.1.1].

1.2 Fuel cell spaces location and access

1.2.1 *Fuel cell spaces are to be arranged outside accommodation spaces, service spaces, machinery spaces of category A and control stations.*

1.2.2 *Where an independent and direct access to the fuel cell spaces from the open deck cannot be arranged, access to fuel cell spaces is to be through an airlock complying with NR529, Ch 2, Sec 8.*

1.2.3 *An airlock is not required if access to the space is not required and not possible (eg: integrated fuel cell system) before the equipment inside is safely shut down, isolated from the fuel system, drained of leakages and the inside atmosphere is confirmed gas-free. In this case, the following provisions are to be implemented, as a minimum:*

- *all controls required for safe operation and gas freeing of the equipment and space are to be provided for remote operation from outside the space*
- *all parameters required for safe operation and gas freeing are to be remotely monitored and alarms are to be given*
- *the space openings are to be equipped with an interlock preventing operation with the space open*
- *the spaces are to be provided with suitable fuel leakage collection and draining arrangements for remote operation from outside the space*
- *provisions are to be made so that the fuel equipment inside can be isolated from the fuel system, drained of fuel and purged safely for maintenance.*

1.3 Fuel cell spaces arrangement

1.3.1 *Fuel cell spaces containing fuel reformers are also to comply with the requirements relevant for the primary fuel, especially considering the piping arrangements.*

1.3.2 Equipment in a fuel cell space is to be limited to those related to the fuel cell power systems. Fuel storage systems, including buffer storage of primary or reformed fuels are not to be located inside a fuel cell space.

1.3.3 *Sources of ignition are to be minimized to reduce the probability of explosions.* Incinerators, inert gas generators or other oil fired boilers are not to be located within a fuel cell space.

1.3.4 All components containing fuel are to be protected against mechanical damage.

1.3.5 *Fuel cell spaces are to be designed to safely contain fuel leakages and be provided with suitable leakage detection systems.* Liquid leakages are to be collected at the most probable leak location (eg pump sealing arrangements, flanges) and are to be shielded from ignition sources. The containment means are to have a sufficient capacity to collect the maximum volume of fluid anticipated to leak.

1.3.6 *Fuel cell spaces are to be arranged to avoid the accumulation of hydrogen-rich gas by having simple geometrical shape and no obstructing structures in the upper part.* Large fuel cell spaces are to be arranged with a smooth ceiling sloping up towards the ventilation outlet. Ceiling under deck covering support structure is not acceptable.

1.3.7 *Fuel cell space boundaries are to be gastight towards other enclosed spaces in the ship.*

1.3.8 Surface temperature of components and pipes in the fuel cell space is to be below the self-ignition temperature of the primary or reformed fuel used.

High-temperature fuel cell power systems with reformed fuel temperatures above the self-ignition temperature are to be subject to special consideration by risk analysis.

1.3.9 A bilge system is to be provided in order to remove liquid from the fuel cell spaces. This system is to comply with the relevant requirement for the primary fuel. See Sec 1, [1.3.2]. This system is also to be able to maintain the fuel cell space pressure if used when the fuel cell power system is in operation.

1.3.10 Provision are to be made to facilitate cleaning, inspection and maintenance of the components of the fuel cell power installation. Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

2 Control of atmosphere

2.1 Fuel cell space concepts

2.1.1 A fuel cell space is to be protected by an external boundary enclosing components where fuel is fed. The inside of this enclosure is to be either ventilated in accordance with [2.2] or inerted in accordance with [2.3].

2.2 Ventilated fuel cell spaces

2.2.1 *Fuel cell spaces are to be equipped with an effective mechanical ventilation system to maintain an underpressure in the complete space, taking into consideration the density of potentially leaking fuel gases.*

2.2.2 *For fuel cell spaces on open deck, overpressure ventilation may be considered.*

2.2.3 *The ventilation rate in fuel cell spaces is to be sufficient to dilute the average gas / vapour concentration below 25% of LEL in all maximum probable leakage scenarios owing to technical failures.*

2.2.4 *Any ducting used for the ventilation of fuel cell spaces is not to serve any other space.* If the fuel cell space boundary is an enclosure situated in a fuel cell room, ventilation inlet from the fuel cell room may be accepted provided it is demonstrated that this space is non-hazardous and that the risk of gas backflow in the space is prevented.

2.2.5 *Ventilation ducts from spaces containing reformed fuel piping or release sources are to be designed and arranged such that any possibility for gas to accumulate is avoided.* For this purpose, they are to run continuously upward from the ventilated space up to the ventilation outlet, without small radii of curvatures.

2.2.6 *Two or more fans are to be installed for the ventilation of the fuel cell space providing 100% redundancy upon loss of one fan. 100% ventilation capacity is also to be supplied from the emergency source of power.*

2.2.7 *In case of failure of one fan, automatic change-over to another fan is to be provided and indicated by an alarm.*

2.2.8 *Ventilation air inlets for fuel cell spaces are to be taken from areas which, in the absence of the considered inlet, would be non-hazardous.*

2.2.9 *Ventilation air inlets for non-hazardous enclosed spaces are to be taken from non-hazardous areas located at least 1,5 m away from the boundaries of any hazardous area.*

2.2.10 *Ventilation air outlets from a fuel cell space are to be located in an open area which, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.*

2.2.11 Fans are to be of a non-sparking type as defined in NR467, Pt C, Ch 4, Sec 1, [3.32].

2.2.12 Electric motors for ventilation fans are not to be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

2.2.13 The number and power of the ventilation fans are to be such that the full required ventilation capacity remains available after failure of a fan with a separate circuit from the main switchboard or emergency switchboard or of a group of fans with common circuit from the main switch-board or emergency switchboard.

2.2.14 *Air inlet and outlet openings are to be provided with fail safe automatic closing fire dampers which are to be remotely operable from outside the fuel cell space.*

2.2.15 The ventilation systems are to be designed and arranged such as to avoid dangerous gas concentration in the vicinity of potential ignition sources. Suitable analyses (e.g. CFD calculations) or tests are to be performed, assuming a credible worst-case scenario and taking into account:

- the fuel cell power
- the ventilation fan capacity
- the position of the ventilation inlets and outlets
- the distribution of the ventilation flows.

2.3 Inerted fuel cell spaces

2.3.1 Permanent inerting may be accepted for atmospheric control of a fuel cell space, provided the requirements of the present Sub-article are complied with.

2.3.2 *A fuel cell space is not to be possible to enter during inerting or when inerted and sealing arrangements are to ensure that leakages of inert gas to adjacent spaces are prevented.*

2.3.3 The inerting system is to comply with the relevant requirements of NR467, Pt C, Ch 4, Sec 15, [13], NR529, Ch 3, Sec 11 and NR529, Ch 3, Sec 12.

2.3.4 *The pressure of inerting media is always to be kept positive towards surrounding spaces and monitored.*

2.3.5 *Any change in the pressure, indicating a breach of the external outer boundary of fuel cell space, or a breach of the boundary with a space where fuel is flowing (e.g. fuel cell stack, reformer) is to activate a controlled shut-off of the fuel supply.*

2.3.6 *Fuel cell space is to be equipped with a mechanical ventilation to evacuate the inerting agent.*

2.3.7 Means are to be provided to prevent access to the inerted fuel cell space except when the space is completely ventilated by fresh air and the fuel supply is interrupted and depressurized or purged.

2.3.8 *The inerting system is to be not operable under ongoing maintenance or inspection.*

2.3.9 In case of important variations of temperature during the transition between phases of fuel cell power installation, pressure inside the fuel cell space is to be kept in a range suitable to keep the tightness of the fuel cell space.

2.4 Ventilation openings and duct arrangement

2.4.1 Ducts are to be gastight and made of a corrosion-resisting material or their interior surfaces are to be painted with corrosion-resistant paint.

2.4.2 The ventilation inlet for the double wall piping or duct is to be located in a non-hazardous area in the open air away from ignition sources. The inlet opening is to be fitted with a suitable wire mesh guard and protected from ingress of water.

2.4.3 Where the inlet duct passes through a more hazardous space, the duct is to be gastight and have over-pressure relative to this space.

2.4.4 The ventilation outlet from the duct is to be located in an open area which, in the absence of the considered outlet would be the same or lesser hazard than the ventilated space.

2.4.5 If release of toxic product may occur, the ventilation outlet is to be fitted at a minimum distance of 3 m from areas traversed by people. This distance can be increased based on the risk assessment (see Sec 2, [1.3.1]) or the other applicable rules (eg: ammonia).

Section 4 Materials

1 General requirements

1.1 Equipment and components

1.1.1 All equipment and components within the fuel cell power installation are to be made of materials, including filler materials for welding, suitable for the intended application with the range of process fluids and conditions expected during both normal operation and fault management.

1.2 Fuel cell power system

1.2.1 Materials of the fuel cell power system are to be in accordance with the requirements of NR216 unless otherwise agreed.

1.2.2 *The use of combustible materials within the fuel cell power system is to be kept to a minimum* (e.g. electrical isolation purposes) and is subject to the approval of the Society.

1.3 Piping systems

1.3.1 Materials used for primary or reformed fuel piping are to meet the requirements mentioned in Sec 1, [1.3.2] and NR467, Pt C, Ch 1, Sec 10 as relevant.

1.3.2 Use of material other than steel in fuel cell spaces

Fuel pipes and their valves and fittings made of materials other than steel may be accepted in fuel cell spaces too small to be entered provided it cannot cause any release of flammable/toxic fluid outside the enclosure in case of failure.

A Quantitative Risk Assessment (QRA) is to be performed to demonstrate an equivalent safety level.

1.3.3 Materials for fuel cell power installation piping containing other fluids than the primary or reformed fuel are to be in accordance with NR467, Pt C, Ch1, Sec 10.

1.3.4 Materials and welding of fuel piping systems are to comply with the provisions of NR216.

1.3.5 Components in contact with hydrogen in the reformed fuel are to be made of material compatible with hydrogen use, in particular with respect to embrittlement and hydrogen attack phenomena. 304/304L and 316/316L austenitic stainless steel may be used. Other materials may be approved upon special consideration. The demonstration of the suitability of materials is to be performed by tests according to a recognized standard accepted by the Society (e.g. ISO 11114-1:2017 or 11114-4:2017).

1.3.6 Piping systems are subdivided into three classes, denoted as class I, class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings.

Piping classes I, II and III are to be determined in accordance with the provisions of NR678, Ch 1, Sec 5, Tab 1 for reformed fuel piping systems and in accordance with NR678, Ch 1, Sec 5, Tab 2 for all vent pipes and open ended lines, including:

- venting lines from “bleed” valves and
- purging lines from gas consumers.

1.3.7 Where the reformed fuel piping system is of a material susceptible to stress corrosion cracking in the presence of a salt-laden atmosphere, adequate measures to avoid this occurring are to be taken by considering material selection, protection of exposure to salty water and/or readiness for inspection.

A protective coating is to be applied on fuel pipes made in steel grade 304L and located on the open deck. Fuel pipes made in steel grade 316L are not required to be coated.

The selection of the coating system is the responsibility of the Shipyard and the Shipowner based on the recommendations of the coating manufacturer.

Section 5 Fuel Cell Power Installation

1 General requirements

1.1 Principles

1.1.1 Fuel cell power installations are to be designed for automatic operation and equipped with all the monitoring and control facilities required for safe operation of the system.

1.1.2 Fuel cell power installations are to be designed and tested in accordance with the relevant recommendations of IEC 62282-2-100: 2020 and 62282-3-100: 2019.

1.1.3 Systems whose failure is detrimental to the proper operation of the fuel cell power system are to be at least duplicated or designed in such a way that a safe situation can be reached, for the fuel cell power system and for the ship (e.g. refrigeration, water supply).

1.1.4 Fuel cell power installations are to comply with the relevant requirements of NR467, Part C, Chapter 1 and NR467, Part C, Chapter 2.

1.1.5 Equipment is to be marked in accordance with NR467, Part C. Fuel pipes and all the other piping needed for operation and maintenance are to be colour marked in accordance with EN ISO 14726:2008 or other recognized standard acceptable by the Society.

2 Availability of power for propulsion or essential services

2.1 General

2.1.1 A FMEA is to be performed on the fuel cell power installation to demonstrate that failure of the control system will not result in the operation of the fuel cell being degraded beyond acceptable performance criteria. In addition, failure of one component of the fuel cell power installation, including auxiliary service, and/or safety actions is not to lead to an unacceptable loss of power.

2.1.2 If the power from the fuel cell is needed for restoration of power in a blackout or dead ship situation, the recovery arrangements are to be documented and approved in each case.

2.1.3 When the fuel cell is intended to be used for propulsion or essential services, a combination of several fuel cell power installations distributed in different fuel cell spaces and/or other sources of power is required.

2.1.4 The following requirements apply:

- each fuel cell space/machinery space is to be supplied by a separate gas fuel line
- additionally to what is given in Sec 8, Tab 1, automatic shutdown of the first fuel cell power system is to initiate the start of the second power system.

2.1.5 Filters that could impair the proper functioning of the system, fitted on fuel or air supply lines are to be arranged so that they can be cleaned without interrupting the fuel or air supply. For that purpose, two filters or strainers fitted in parallel, or one duplex type with a change over facility, may be accepted.

3 Piping arrangements for fuel cell power system

3.1 General

3.1.1 Single wall gas piping without casing may be accepted within the scope of the ventilated fuel cell space concept, in one of the following cases:

- on fuel cells supplied with gas at a pressure lower than or equal to 0,5 MPa when their nominal power does not exceeds 100 kW per module
- for gas pipes located in gastight GUV spaces / enclosures
- for venting pipes
- in fuel cell spaces too small to be entered when the spaces boundaries comply with the requirement given in [3.3.2].

3.1.2 Detection and alarm are to be provided at the exit of piping leaving the boundaries of the fuel cell power system when the presence of toxic or flammable products cannot be excluded.

3.1.3 The fuel supply line to each liquid fuel consumer is to be provided with a remotely operated shut-off valve.

3.2 Double Block and Bleed arrangement

3.2.1 Each gas consumer is to be provided with “double block and bleed” valves arrangement. These valves are to be arranged so that, when the safety system is activated, this will cause the shut-off valves that are in series to close automatically and the bleed valve to open automatically. In addition:

- the two shut-off valves are to be in series in the gas fuel pipe to the gas consuming equipment. The bleed valve is to be in a pipe that vents to a safe location in the open air that portion of the gas fuel piping that is between the two valves in series, or
- the function of one of the shut-off valves in series and the bleed valve can be incorporated into one valve body, so arranged that the flow to the gas utilization unit will be blocked and the ventilation opened.

3.2.2 The two shut-off valves are to be of the fail-to-close type, while the ventilation valve is to be fail-to-open.

3.2.3 The gas supply line to each consumer is to be equipped with one manually operated shutdown valve upstream of the double-block-and-bleed valves to ensure safe isolation during maintenance.

3.2.4 The double block and bleed valves are to also be used for normal stop of the gas consumer.

3.2.5 The automatic double block and bleed valves are to be capable of being manually operated.

3.2.6 The double block and bleed valves are to be contained, if necessary, in a gastight casing in order to create hazardous areas as limited as possible.

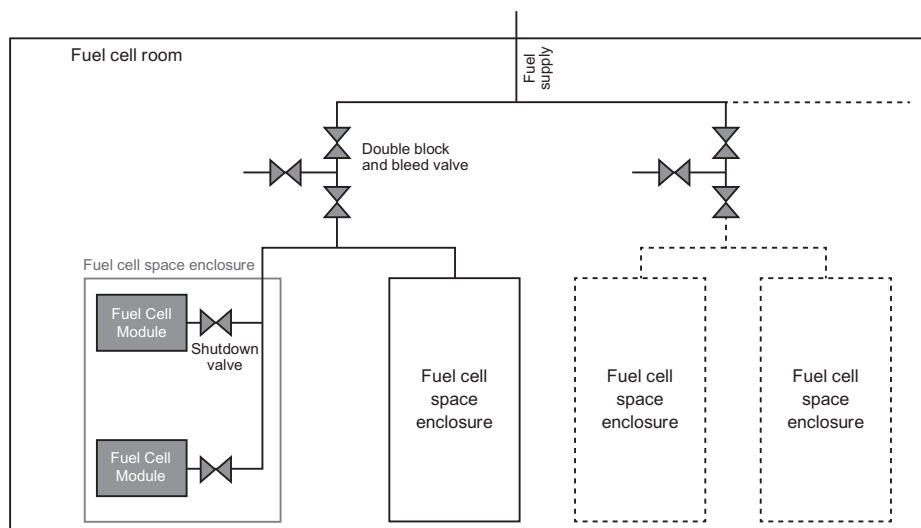
3.2.7 In cases of emergency shut down, the complete fuel supply branch downstream of the double block and bleed valve, if any, is to be automatically vented assuming reverse flow from the fuel cell power system to the pipe.

3.2.8 When fuel cell power systems are fitted in enclosures acting as fuel cell spaces in the same fuel cell room as shown in Fig 1, the double block and bleed valves arrangement can protect a group of gas consumer provided:

- control and monitoring system remains active, even for stopped gas consumers
- detection of a failure in one gas consumer, even stopped, is to lead to the safety shutdown of the group of gas consumers with the same double block and bleed valves arrangement.

Each gas consumer is to be fitted with a dedicated shutdown valve for normal stop.

Figure 1 : Fuel cell room



3.3 Reformed fuel piping

3.3.1 All piping containing reformed fuel for fuel cell power systems, where fitted, is to:

- not be led through enclosed spaces outside of a fuel cell space unless complying with the requirements of NR678 for hydrogen pipes in enclosed spaces
- be butt-welded as far as practicable
- be arranged to minimize the number of connections
- be provided with fixed hydrogen detectors capable of detecting a hydrogen leak in places where leakage of hydrogen may occur, such as valves, flanges and seals.

3.3.2 In a ventilated fuel cell space, reformed fuel piping is to be double-walled or fitted with a casing capable of safely containing any leakages, including pipe rupture. An arrangement where the casing is ventilated or nitrogen filled and monitored for pressure or alternatively able to efficiently detect gases showing a leakage in the fuel cell power system may be an acceptable solution. In this case, the earthing of the reformed fuel piping system is to be particularly considered in order to avoid the creation of static charges.

3.3.3 Reformed fuel piping is to meet the relevant requirements of NR678.

3.4 Buffer tanks

3.4.1 Buffer tanks are to be designed as a temporary reserve for the process and not as additional fuel storage. The buffer tank is to comply with requirements applicable to the corresponding primary fuel or reformed fuel.

4 Fuel reformer system

4.1 General

4.1.1 Fuel reformer systems are to be designed for automatic operation.

4.1.2 Burners installation and design are to comply with relevant requirements mentioned in NR529, Ch 3, Sec 3.

4.1.3 The recirculation of residual gas (e.g.: from the fuel cell modules, gas purifier...) to the reformer is to be protected by an automatic shut-off valve.

4.1.4 The fuel reformer system is to comply with the relevant requirements depending of the primary fuel (see Sec 1, [1.3.2]).

5 Inert gas and transitory gas

5.1 General

5.1.1 *Means to safely remove the primary and reformed fuel from the fuel cell power system are to be provided.*

5.1.2 Circulation of inert or transitory gases inside primary and reformed fuel pipes, as well as inside exhaust gases pipes is to be possible.

5.1.3 Inert gas and transitory gas are to be compatible with the fuel to be purged.

5.1.4 The inert or transitory gas subsystems are to be protected by a suitable means against contamination by primary or reformed fuel.

5.1.5 Inert gas and transitory gas piping from the fuel cell power systems are to be led separately from piping not dedicated to fuel cell power systems to the open air and are to be arranged as an outlet from a hazardous area.

6 Exhaust gas and exhaust air outlets

6.1 General

6.1.1 *Exhaust gases and exhaust air piping from the fuel cell power systems are to be gastight and are not to be combined with any ventilation except ventilation serving the fuel cell space and are to be led to a safe location in the open air.*

6.1.2 The process air exhaust system is to be made of a material resistant to condensate and so arranged as to prevent any backflow. Devices to drain condensate from the process air exhaust system are to be provided.

7 Other systems

7.1 General

7.1.1 *Auxiliary systems where primary or reformed fuel may leak directly into the system medium (e.g. lubricating oil, cooling water) are to be equipped with appropriate extraction and detection means fitted directly after the medium outlet from the system in order to prevent gas dispersion. Gas extracted from auxiliary systems media is to be vented to a safe location on the open deck.*

7.1.2 *A secondary containment of the coolant pipe is to be provided or the equipment within the fuel cell space is to be protected from a coolant release. Consideration is to be given to the safe removal of the coolant.*

7.1.3 Parts of the fuel cell power system sensitive to marine environment are to be sealed. Where fresh air is needed, filters and air dryers are to be provided in the oxydant processing system to meet the specification provided by the manufacturer.

Section 6 Fire Safety

1 General requirements

1.1 General

1.1.1 The recommendations in this chapter are additional to the requirements given in NR467, Part C, Chapter 4.

1.1.2 *The fuel cell space is to be regarded as a machinery space of category A according to NR467, Part C, Chapter 4 for fire protection purposes, except that the space is to be bounded by "A-60" class divisions.*

1.1.3 *Where [1.1.2] is deemed to be impracticable, on a case-by-case basis, the Society may approve alternative boundary designs that provide for an equivalent level of safety.*

If the fuel cell space boundary is an enclosure situated in a fuel cell room with no other equipment that may have a fire risk, structural boundaries of the fuel cell room with A-60 insulation is acceptable.

2 Fire and explosion protection

2.1 General

2.1.1 *Fuel cell spaces separated by a single bulkhead are to be designed to withstand the effects of a local gas explosion in either space, without affecting the integrity of the adjacent space and equipment within that space.*

2.1.2 *Failures leading to dangerous overpressure, e.g. gas pipe ruptures or blow out of gaskets, are to be mitigated by suitable explosion pressure relief devices and ESD arrangements.*

3 Fire extinguishing

3.1 General

3.1.1 A fixed fire-extinguishing system complying with NR467, Pt C, Ch 4, Sec 6 is to be provided for fuel cell spaces.

The Society may allow any alternative fire safety measures if the equivalence of the measure is demonstrated by a risk assessment considering the characteristics of fuels for use.

3.1.2 *The fixed fire-extinguishing system is to be suitable for use with the primary and reformed fuel and fuel cell technology proposed.*

3.1.3 *Before actuation of the fire extinguishing system, the fire dampers are to be closed automatically.*

4 Fire detection

4.1 General

4.1.1 *An approved fixed fire detection and fire alarm system complying with NR467, Pt C, Ch 4, Sec 15, [8] is to be provided. The type and arrangement is to be selected with due consideration of the fuels and combustible gases which may be present in fuel cell power installations.*

4.1.2 The fire detection system is to allow the remote identification of each individual detector. Alternatively, the detectors may be arranged in small separate sections if the type and arrangement does not induce delay in identifying the source of fire, the maximum extent of the section being the fuel cell space.

4.1.3 *Fuel cell spaces are to be fitted with suitable fire detectors. Smoke detectors alone are not considered sufficient for rapid detection of a fire.*

4.1.4 Before actuation of the fire-extinguishing system, the fuel supply is to be shut off automatically.

4.1.5 Required safety actions upon fire detection in the fuel cell space are given in Sec 8, Tab 1.

Section 7 Electrical Systems

1 Electrical systems and equipment

1.1 General

1.1.1 Electrical systems and equipment are to comply with the relevant requirements of NR467, Part C, Chapter 2. In particular, the electrical components of the fuel cell power installations are to be designed and constructed to operate under the environmental conditions on board as defined in NR467, Pt C, Ch 2, Sec 2, [1].

1.1.2 Cable penetrations are to be sealed against the passage of gas or vapour.

1.2 Fuel cell connection

1.2.1 The outgoing circuits on a fuel cell arrangement are to be provided with a switch disconnecter for isolating purposes. Contactors are not accepted as isolating devices.

1.2.2 It is to be ensured that the fuel cell can be disconnected from the electrical load at any load condition.

1.2.3 Means are to be provided for protection of the fuel cell power installation against overload, short circuits and flow of reverse current.

1.3 Power conditioning system

1.3.1 If a single power conditioning system is fed by more than one fuel cell power system, the fuel cell power systems are to be considered as pertaining to the same fuel cell power installation. Each fuel cell power system is to be fitted with a separate means of disconnection.

1.4 Fuel cell management system

1.4.1 If a single fuel cell management system manages more than one fuel cell power system, the fuel cell power systems are to be considered as pertaining to the same fuel cell power installation.

1.4.2 For fuel cell power system working with other equipment, fuel cells management system is to be provided with means to ensure coordinated shutdown or isolation to avoid dangerous operation.

2 Hazardous areas

2.1 General

2.1.1 Electrical equipment and wiring are not to be installed in hazardous areas unless essential for operational purposes or safety enhancement. Where electrical equipment, including components of fuel cell systems, is installed in hazardous areas, it is to comply with NR467, Pt C, Ch 2, Sec 2, [6] and NR467, Pt C, Ch 2, Sec 3, [10] according to the hazardous area classification.

2.1.2 Electrical equipment, including components of fuel cell systems installed in hazardous areas, is to be selected and installed in accordance with IEC 60079-10-1:2020 guidance and informative examples given in IEC 60092- 502:1999.

2.1.3 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2, and the different spaces are to be classified according to [2.2]. Alternatively, area classification according to IEC 60079-10-1:2020 may be applied with special consideration by the Society. All electrical equipment needs to comply with the resulting area classification.

2.1.4 The temperature class and equipment group specified in NR467, Pt C, Ch 2, Sec 3, Tab 15 are to be used for potential flammable atmosphere for certified safe equipment in accordance with IEC 60079-20-1:2020.

2.2 Area classification

2.2.1 Hazardous areas zone 0

This zone includes, but is not limited to, interiors of buffer tanks, reformers, pipes and equipment containing low-flashpoint fuel or reformed fuel, any pipework of pressure-relief or other venting.

Note 1: Additionally, instrumentation and electrical apparatus in contact with the gas or liquid gas are to be of a type suitable for zone 0.

Temperature sensors installed in thermo wells, and pressure sensors without additional separating chamber are to be of intrinsically safe type Ex-ia.

2.2.2 Hazardous areas zone 1

This zone includes, but is not limited to:

- *Areas on open deck, or semi-enclosed spaces on deck, within 3 m of any reformed fuel or purge gas outlets or fuel cell space ventilation outlets and around reformed fuel valves or flanges.*
- *Areas on open deck, or semi-enclosed spaces on deck, within 3 m of fuel cell exhaust air and exhaust gas outlets.*
- *Areas on open deck or semi-enclosed spaces on deck within 1.5 m of fuel cell space entrances, fuel cell space ventilation inlets and other openings into zone 1 spaces.*
- *Areas on open deck or semi-enclosed spaces within 3 m in which other sources of release of reformed fuel are located.*
- *Fuel cell spaces.*
- *Enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes whatever their arrangement.*

2.2.3 Hazardous areas zone 2

This zone includes, but is not limited to:

- *Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified above, if not otherwise specified.*
- *Airlocks.*

2.2.4 Ventilation ducts

Ventilation ducts are to have the same area classification as the ventilated space.

2.2.5 Fuel cell spaces

According to [2.2.2], fuel cell spaces are considered as hazardous zone 1 and all electrical equipment is to be certified for zone 1. The fuel cell stack itself is not considered a source of ignition if the surface temperature of the stack is kept below 300°C in all operating conditions and the fuel cell power system is capable of immediately isolating and de-energizing the fuel cell stack under every load and operating condition.,

Section 8 Control, Monitoring and Safety Systems

1 General

1.1 General requirements

1.1.1 The requirements given in this Section may be adapted on the basis of the risk assessment required in Sec 2. In particular, monitoring and control options are to be defined for systems not covered in this Section but for which the risk analysis shows significant risks.

1.1.2 *Safety related parts of the fuel cell control systems are to be designed to function independently from any other control and monitoring system.*

1.1.3 Separate sensors are to be arranged for the gas control and monitoring system and for the fuel safety system.

1.1.4 Gas detection functionality and fuel safety functionality for a fuel supply system inside fuel cell space can be implemented in a common system unit if the system is redundant.

1.1.5 The signals required to support the safety functions given in Tab 1 are to be hardwired, and arranged with section monitoring unless they are inherently fail safe. The requirement for hardwired signals is not applicable for signals sent to other systems for additional safety actions as specified in Tab 1.

1.1.6 The output signals required to perform the safety actions specified in Tab 1 are to be electrically independent from the fuel control system. This implies that the output signal is to be separate from any control section, and connected to e.g. separate solenoids and breaker terminals/coils.

2 Gas or vapour detection

2.1 General

2.1.1 Gas / vapour detection equipment is to be designed, installed and tested in accordance with a recognized standard accepted by the Society (e.g. ISO 26142:2010 for hydrogen detectors). The gas detection equipment is to be type-approved by the Society and suitable for all expected ambient conditions including air flow velocities.

2.1.2 *A permanently installed gas/vapour detection system is to be provided for:*

- fuel cell spaces,
- airlocks (if any),
- expansion tanks/degassing vessels in the auxiliary systems of the fuel cell power system where primary fuel or reformed fuel may leak directly into a system medium (e.g. cooling water),
- ducts around fuel pipes,
- the oxidant processing system exhaust pipe ,
- at ventilation inlets to accommodation spaces and machinery spaces if required based on the risk assessment,
- in GUV spaces and enclosures, and
- other enclosed or semi-enclosed spaces where primary/reformed fuel may accumulate.

2.1.3 *Two independent gas detectors located close to each other are required for redundancy reasons. If the gas detector is of the self-monitoring type, the installation of a single gas detector may be accepted.*

2.1.4 Gas / vapour detection is to be continuous without delay.

2.1.5 *The number of detectors in the fuel cell space is to be determined taking into account the size, layout and ventilation of the space. The detectors are to be located where gas / vapour may accumulate and/or in the ventilation outlets. Gas dispersal analysis or equivalent is to be used to find the best arrangement.*

3 Ventilation performance in ventilated spaces

3.1 General

3.1.1 Ventilation reduced below the required capacity is to trigger an alarm.

3.1.2 *In order to verify the performance of the ventilation system, a detection system of the ventilation flow and of the fuel cell space pressure is to be installed. A running signal from the ventilation fan motor is not sufficient to verify performance.*

4 Pressure in inerted fuel cell spaces

4.1 General

4.1.1 A detection system showing a proper value of the pressure of inert gas or any selected alternative method accepted by the Society is to be provided in inerted fuel cell spaces.

5 Control of a safe atmosphere

5.1 General

5.1.1 A monitoring equipment for toxic products, (e.g.: CO, methanol vapours, ammonia, ...) is to be provided inside any fuel cell space where primary or reformed fuel may be present. An alarm is to be triggered before the involved gas concentration reaches a level having potentially a negative impact on crew health.

As an alternative, in fuel cell spaces not normally accessible when the fuel cell is in operation, means are to be provided to ensure that the system is stopped and the space is continuously ventilated to ensure a gas concentration below the corresponding permissible exposure limit before entering.

5.1.2 In order to prevent the risk of anoxia:

- in fuel cell spaces normally accessible when the fuel cell system is in operation, oxygen concentration is to be monitored and oxygen concentration below 19% is to trigger an alarm
- in fuel cell spaces not normally accessible when the fuel cell system is in operation, means are to be provided to ensure a sufficient oxygen concentration before entry
- alternative means to prevent the risk of anoxia may be considered on a case-by-case basis.

5.1.3 The monitoring and alarm systems required in [5.1.1] and [5.1.2] are to remain operational during any phase of operation of the fuel cell power system except when the fuel cell power system is completely purged from any hazardous gas and stopped.

6 Bilge wells

6.1 General

6.1.1 *Bilge wells in fuel cell spaces are to be provided with level sensors.*

7 Fuel cell power installation monitoring

7.1 General

7.1.1 As a general rule, the following parameters are to be monitored in accordance with the specification provided by the manufacturer. The detailed monitoring requirements may be adapted based the outcome of the risk assessments required in Sec 2, [1.1.1]:

- for fuel cell power system, fuel flow, temperature and pressure, cell voltage and cell voltage deviations, temperature in the stacks, electric current
- for oxidant processing system, oxidant flow, pressure and purity
- for thermal management system, cooling medium flow, level, pressure, temperature
- for water treatment system, water level, pressure and purity
- for exhaust system, temperature and gas detection
- parameters necessary to monitor lifetime/deterioration.

7.1.2 Fuel reformer units are to be equipped with all the indicating and control facilities required for assessment and control of the process. The chemical processes taking place within the unit and reformed fuel purity are to be monitored in accordance with the specifications provided by the manufacturer.

7.1.3 After shutdown, an automatic purge of the fuel reformer with inert gas is to occur.

7.1.4 *Means are to be provided to set a fuel cell power installation into a safe state for maintenance and shutdown.*

A local disconnection is not to lead to unsafe condition of the fuel cell power installation.

7.1.5 Filters on fuel or air supply lines are to be fitted with differential pressure monitoring.

8 Emergency shutdown push buttons

8.1 General

8.1.1 Emergency shutdown push buttons are to be arranged in the following locations as applicable:

- navigation bridge,
- onboard safety centre,
- engine control room,
- fire control station, and
- adjacent to the exit of the fuel cell space.

The activation device is to be arranged as a physical button, duly marked and protected against inadvertent operation. The emergency shutdown is to be handled by the safety system and be arranged with section monitoring.

8.1.2 Emergency shutdown push buttons are to be indicated in the Fire Control Plan.

9 Fuel supply remote emergency stop

9.1 General

9.1.1 The last primary fuel supply valve prior to the fuel cell power system is to be controlled by the fuel cell control system.

10 Actions of the alarm system and safety system

10.1 Gas or vapour detection

10.1.1 Gas / vapour detection in a fuel cell space above a gas or vapour concentration of 20% LEL is to cause an alarm.

10.1.2 Gas / vapour detection in a fuel cell space above a gas or vapour concentration of 40% LEL is to shut down the affected fuel cell power system and disconnect ignition sources and is to result in automatic closing of all valves required to isolate the leakage. If not certified for operation in zone 1 hazardous areas, the fuel cell stack are to be immediately electrically isolated and de-energized. Valves in the primary fuel system supplying liquid or gaseous fuel to the fuel cell space are to close automatically.

10.1.3 Gas / vapour detection in the fuel cell's exhaust above a gas or vapour concentration of 20% LEL is to cause an alarm. Gas / vapour detection above a gas or vapour concentration corresponding to a failure according to Manufacturer's specification is to shut down the affected fuel cell power system. Alternative means to detect a failure leading to H₂ release in the exhaust may be considered on a case-by-case basis.

10.1.4 Gas / vapour detection in the fuel cell's coolant supply tank above a gas or vapour concentration of 20% LEL is to cause an alarm.

10.1.5 In an inerted fuel cell space, immediate (emergency) shutdown of the fuel supply is not necessary in case of leakage detection. Instead, an automatic changeover to the other power supply systems and controlled shutdown of the fuel cell and the affected fuel supply system is to be initiated, to avoid damage to the fuel cell power system.

10.1.6 After gas or vapour detection, inert gas is to be injected in the primary and reformed fuel pipes and sent to the outside atmosphere.

10.2 Loss of ventilation

10.2.1 Loss of ventilation or loss of underpressure in a ventilated fuel cell space is to result in an automatic shutdown of the fuel cell by the process control within a limited period of time and isolation of the fuel supply. The period is to be considered on a case-by-case basis based on the risk analysis. After the period has expired, a safety shutdown is to be carried out.

10.2.2 Loss of ventilation in secondary enclosure of pipes for gaseous fuel is to trigger the closing of the related fuel valves by the normal process control.

10.3 Loss of inert gas

10.3.1 Loss of pressure in an inerted fuel cell space is to result in an automatic shutdown of the fuel cell by the process control within a limited period of time. The period is to be considered on a case by case basis based on the risk analysis. After the period has expired, a safety shutdown is to be carried out.

10.3.2 Loss of pressure in an inerted secondary enclosure of pipes for gaseous fuel is to trigger the closing of the related fuel valves by the normal process control.

10.4 Loss of fuel cell coolant

10.4.1 *Loss of fuel cell coolant is to result in an automatic shutdown of the fuel cell by the process control within a limited period of time.*

10.5 Liquid detection

10.5.1 *Detection of unintended liquid leakages is to trigger an alarm.(e.g. by the bilge high-level sensor)*

10.6 Fire detection

10.6.1 *Fire detection within the fuel cell space is to give audible and visual alarms, initiate automatic shutdown and isolation of the fuel supply.*

10.7 Fuel cell power system

10.7.1 *For fuel cell spaces rated as hazardous zone 1 where the fuel cell stack is not certified for operation in hazardous zone 1 and the surface temperature of the fuel cell stack exceeds 300°C, the fuel cell power system is to immediately shut down and isolate the affected fuel cell space.*

10.7.2 If limit values determined for the control process are exceeded in the fuel reformer or the fuel cell module, an alarm is to be activated and the fuel cell power system is to be shut down and inter-locked by an independent protective device.

10.7.3 If the determined process limit values for reformed fuel or oxidant gas purity are exceeded, an alarm is to be activated or the system is to be shut down. This requirement may be waived if it is demonstrated that no additional hazard can occur through impurities.

10.7.4 When a protective device or interlock causes a safety shutdown of the fuel cell power system, that condition is to be signaled in the navigation bridge and in the engine control room.

10.7.5 After a inert shutdown, an automatic purge of the fuel cell power system with inert gas is to occur. This requirement may be waived if it is demonstrated that no additional hazard can occur through the release of the remaining fuel.

10.8 Emergency shutdown push buttons

10.8.1 *Actuation of the fuel cell power system emergency shutdown push button is to interrupt the fuel supply to the fuel cell space and de-energize the ignition sources inside the fuel cell space.*

11 Alarms and safety actions

11.1 Alarms

11.1.1 Fuel cell power systems and fuel cell spaces are to be equipped with monitoring equipment and alarms as detailed in Tab 1. *Alarms additional to the ones required by Tab 1 may be required for unconventional or complex fuel cell power installations.*

11.1.2 Gas / vapour and liquid detection alarms are to be given both at the bridge, at the control location for bunkering and locally. If alarming depends on network communication, the functionality is to be handled by the separate network segment arranged for the fuel cell power installation safety functions.

11.1.3 Fuel gas safety alarms as specified in Tab 1 are to be given at the bridge. If alarming depends on network communication, the functionality is to be handled by the separate network segment arranged for the fuel installation safety functions.

11.2 Safety actions

11.2.1 Automatic inert actions are to be implemented as detailed in Tab 1. *Inert actions additional to those required by Tab 1 may be required for unconventional or complex fuel cell power installations (e.g. use of inert gas in fuel and exhaust pipes).*

Table 1 : Alarms and safety actions

Symbol convention X = Function is required; L = low; H = high; HH = high high	Monitoring		Automatic control	
Identification of system parameter	Alarm	Criteria	Shutdown of fuel supply to fuelcell space	Shutdown of ignition sources
GAS DETECTION				
Fuel cell space	H	20%LEL		
	HH	40%LEL	X	X (1)
Secondary enclosure of fuel pipes	H	20%LEL		
	HH	40%LEL	X	
Fuel cell exhaust	H	20%LEL		
	HH	(2)	X	
In other areas	H	20%LEL		
LIQUID DETECTION				
Bilge	H			
VENTILATION				
Fuel cell space	L	Reduced ventilation		
	X	Loss of ventilation or negative pressure	X (3)	
Secondary enclosure of fuel pipes	X	Loss of ventilation	X	
INERTING				
Fuel cell space	L	Loss of overpressure	X (3)	
Secondary enclosure of fuel pipes	L	Loss of overpressure	X	
OTHER				
Fire detection in fuel cell space	X		X (4)	X
System failure	X	Deviation of the process out of the limit values	(3)	
Emergency shutdown manually actuated	X		X	X
Airlock	X	more than one door moved from closed position		
	X	Loss of pressure or door open at loss of ventilation		
Failure of valve control actuating medium	X		X (5) (6)	
Control of atmosphere	X (7)	Detection of toxic gas or low level of oxygen		
Differential pressure across filters	H (8)			
Loss of fuel cell coolant	X		(3)	
Fuel cell stack surface temperature T > 300°C (9)	H	X	X	X
<p>(1) The fuel cell is to be automatically shutdown. If not certified for operation in zone 1 hazardous areas, the fuel cell stack is to be immediately electrically isolated and de-energized.</p> <p>(2) Concentration to be determined based on Manufacturer's specification</p> <p>(3) In addition, the fuel cell is to be automatically shutdown by process control</p> <p>(4) In addition, fire dampers are to close, ventilation is to shutdown and the fire extinguishing system is to be activated.</p> <p>(5) Time delayed as found necessary</p> <p>(6) Only double block and bleed valves to close.</p> <p>(7) Action to be completed depending on the gas detected</p> <p>(8) Local alarm</p> <p>(9) If fuel cell stack is not certified for zone 1</p> <p>Note 1: For primary fuel, reference is made to the relevant requirements, especially for gas detection (flammability, toxicity...). See Sec 1, [1.3.2].</p>				

Section 9 On-Board Testing

1 General

1.1 Application

1.1.1 The testing requirements in this Section are complementary to those required in NR467, Pt C, Ch 1, Sec 18 and those specific to the relevant primary fuel given in the corresponding Rule Note.

1.1.2 Additional testing may be required for unconventional or complex installations.

1.2 Piping

1.2.1 Piping systems are to be tested and examined in accordance with:

- NR678, Sec 12 for reformed fuel
- the corresponding Rule Note for primary fuel.

2 Spaces containing fuel cell power systems

2.1 General

2.1.1 The requirements in this article apply to fuel cell spaces or machinery spaces containing an enclosure acting as fuel cell space, as relevant.

2.1.2 As a minimum, the following equipment are to be checked:

- fixed fire detection and fire-extinguishing systems
- ventilation of spaces with reformers and/or fuel cells and airlocks, if any
- gas and leakage detection in spaces with reformers and/or fuel cells.

2.2 Ventilated fuel cell space and ducts

2.2.1 Ventilated fuel cell spaces and ducts are to be tested to verify that adequate ventilation and under pressure can be achieved. Ventilation rate at minimum flow is to be documented.

2.3 Inerted fuel cell space and ducts

2.3.1 Inerted fuel cell spaces and ducts are to be tested to verify that adequate inert atmosphere and overpressure can be achieved.

2.4 Hot spot verification

2.4.1 Compliance with the requirements of Sec 3, [1.3.8] is to be confirmed through thermal imaging scanning of equipment where hot surfaces may be expected. This verification is to be carried out with the fuel cell power installation under steady and normal operating conditions.

Thermal imaging measurements are to be performed:

- in accordance with a recognized methodology accepted by the Society
- with suitably calibrated equipment
- by qualified personnel.

The Society may require that the measurements be witnessed by a surveyor.

3 Fuel cell power system

3.1 Scope of the tests

3.1.1 The following operating modes, as applicable, are to be checked:

- start up and switch off of the fuel cell power installation
- normal load variations and proper functioning upon load shedding.

3.1.2 As a minimum, the following elements are to be checked:

- proper functioning of measurement systems
- alarms and safety actions for the fuel cell power system and its associated equipment
- automatic shutdown and fuel supply isolation
- purging of fuel cells and reformers
- proper response of the safety system, including emergency shutdown upon fault conditions.

4 Fuel cell as essential service

4.1 Scope of the tests

4.1.1 Functional and performance tests of the fuel cell power installations are to be performed at full load and under load variation according to the operating profile

4.1.2 The following operations are to be checked:

- fuel cell power installation recovery from blackout and/or dead ship condition
- propulsion capability when one of the essential power source (another fuel cell or other source of power) becomes inoperative
- interactions with other sources of power, including change-over with the emergency power source.

Section 10

Survey at Work and Certification

1 General

1.1 Principles

1.1.1 The manufacture, testing, and survey is to be in accordance with the applicable Rules for Classification, recognized standards accepted by the Society and the specific recommendations given in this Rule Note.

The general requirements for certification of fuel cell equipment are listed in Article [6].

1.1.2 Additional requirements for specific items regarding type approval and production testing are provided in Article [2] to Article [5]. The requirements for certification of equipment and piping are detailed:

- in the corresponding Rules Notes referenced in Sec 3, [1.1.1] for primary fuel
- in NR678 for reformed fuel.

Mixed fuels are to be considered on a case-by-case basis.

1.2 Environmental tests

1.2.1 Whenever environmental tests are required, equipment is to be tested based on the type test described in NR467, Pt C, Ch 3, Sec 6, Tab 1, as relevant, considering the environmental conditions given in NR467, Pt C, Ch 2, Sec 2.

2 Fuel cell modules

2.1 Type approval

2.1.1 Each type of fuel cell modules is to be type tested in accordance with IEC 62282-2-100:2020 or recognized standards acceptable to the Society. The scope of tests is to include at least the tests specified in Tab 1.

2.1.2 When a fuel cell module is intended to be used only in a specific fuel cell power system that is to be type-approved, only tests in Article [3] need to be performed.

2.2 Production testing

2.2.1 The routine tests as described in IEC 62282-2-100:2020 §6 of all fuel cell modules are to be witnessed by a Society's surveyor.

Table 1 : Type tests of fuel cell modules

N°	Test	Applicable testing standard	Other information
1	Visual inspection		
2	Environmental test	See [1.2]	Can be performed at fuel cell power system level
3	Gas leakage test	IEC 62282-2-100:2020 §5.3	
4	Normal operation test	IEC 62282-2-100:2020 §5.4	To be repeated after item 10
5	Pressure test		1,5 working pressure
6	Short-time rating test	IEC 62282-2-100 §5.7	If specified by manufacturer
7	Overpressure test	IEC 62282-2-100 §5.8	If the module is fitted with a pressure limiting device
8	Dielectric strength test	IEC 62282-2-100 §5.9	
9	Differential pressure test	IEC 62282-2-100 §5.10	
10	Flammable concentration test	IEC 62282-2-100 §5.13	For enclosed modules with ventilation
11	Abnormal operating conditions test	IEC 62282-2-100 §5.14	

3 Fuel cell power system

3.1 Type approval

3.1.1 Each type of fuel cell power system is to be type tested in accordance with IEC 62282-3-100:2019 or recognized standards acceptable to the Society. The scope of tests is to include at least the tests specified in Tab 2.

3.1.2 If a reformer is fitted, additional tests in Tab 3 are to be performed except if the equipment is already approved.

3.1.3 Fuel cell power systems are to be tested for type approval at works, when required. Tests carried out are to be witnessed by a Society's surveyor.

3.2 Production testing

3.2.1 The routine tests as described in IEC 62282-3-100:2019 §6 of all fuel cell power systems are to be witnessed by a Society's surveyor.

Table 2 : Type tests of fuel cell power system

N°	Test	Applicable testing standard	Remark
1	Visual inspection		
2	Environmental test	See [1.2]	
3	Leak test	IEC 62282-3-100: 2019 §5.4	
4	Pressure test	IEC 62282-3-100: 2019 §5.5	
5	Normal operation test	IEC 62282-3-100: 2019 §5.6	
6	Electrical overload test	IEC 62282-3-100: 2019 §5.7	
7	Shutdown test	IEC 62282-3-100: 2019 §5.8	
8	Exhaust gas temperature test	IEC 62282-3-100: 2019 §5.11	
9	Surface and component temperature test	IEC 62282-3-100: 2019 §5.12	
10	Wind test	IEC 62282-3-100: 2019 §5.13	If applicable
11	Rain test	IEC 62282-3-100: 2019 §5.14	If applicable
12	Emissions test	IEC 62282-3-100: 2019 §5.15	
13	Blocked condensate line test	IEC 62282-3-100: 2019 §5.16	
14	Condensate discharge test	IEC 62282-3-100: 2019 §5.17	
15	Electrical safety test	IEC 62282-3-100: 2019 §5.18	
16	EMC test	IEC 62282-3-100: 2019 §5.19	
17	Venting system leakage test	IEC 62282-3-100: 2019 §5.20	For hydrocarbon fuelled fuel cell

4 Reformer

4.1 Type approval

4.1.1 Each type of reformer is to be type tested. The scope of tests is to include at least the tests specified in Tab 3. When a reformer is intended to be used only in an integrated fuel cell power system, tests can be combined with those indicated in Tab 2.

Table 3 : Type tests of reformer

N°	Test	Applicable testing standard	Remark
1	Visual inspection		
2	Environmental test	See [1.2]	
3	Leak test	IEC 62282-3-100: 2019 §5.4	
4	Pressure test	IEC 62282-3-100: 2019 §5.5	
5	Operating characteristics test	IEC 62282-3-100: 2019 §5.9	Burners only
6	Automatic control tests	IEC 62282-3-100: 2019 §5.10	
7	Surface and component temperature test	IEC 62282-3-100: 2019 §5.12	
8	Wind test	IEC 62282-3-100: 2019 §5.13	If applicable
9	Rain test	IEC 62282-3-100: 2019 §5.14	If applicable
10	Electrical safety test	IEC 62282-3-100: 2019 §5.18	
11	EMC test	IEC 62282-3-100: 2019 §5.19	
12	Venting system leakage test	IEC 62282-3-100: 2019 §5.20	

4.2 Production testing

4.2.1 The routine tests as described in IEC 62282-3-100:2019 §6 of all fuel cell power systems are to be witnessed by a Society's surveyor.

5 Integrated fuel cell systems

5.1 Type approval

5.1.1 Each type of integrated fuel cell system is to be type tested. The scope of tests is to include at least the tests specified in Tab 2 and Tab 4. Depending on the configuration, tests may be performed at the system level or at the fuel cell power system level. For auxiliary equipment, type tests are to be performed according to relevant Society Rules if the equipment is not already approved.

Table 4 : Additional type tests for integrated fuel cell systems

N°	Test	Remark
1	Visual inspection	
2	Air filter performance	If fitted, see Sec 5, [7]
3	Enclosure tightness test	
4	Ventilation performance	For ventilated fuel cell space enclosure
5	Reduction/loss of ventilation	For ventilated fuel cell space enclosure
6	Inerting performance	For inerted fuel cell space enclosure
7	Loss of inerting	For inerted fuel cell space enclosure

5.2 Production testing

5.2.1 The routine tests as described in IEC 62282-3-100:2019 §6 of all fuel cell power systems are to be witnessed by a Society's surveyor. For auxiliary equipment, routine tests are to be performed according to relevant Society Rules.

6 Certification

6.1 General

6.1.1 Equipment is to be certified as listed in Tab 5.

Table 5 : Certification requirements

Item	Product certification				Remarks
	Design assessment/ approval	Raw material certificate	Examination and testing	Product certificate	
Fuel cell module	TA		X	C	
Fuel cell power system	TA		X	C	Reformer, if any, and fuel cell modules can be approved as part of the fuel cell power system without prior approval
Reformer	TA		X	C	
Integrated fuel cell system	TA		X	C	
Note 1: TA : Type Approval is required. C : Indicates that a BV product certificate is required with invitation of the Surveyor to attend the tests unless otherwise agreed, in addition to the manufacturer's document stating the results of the tests performed and/or compliance with the approved type as applicable. X : Indicates that examinations and tests are required.					



BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

© 2026 BUREAU VERITAS - All rights reserved



**BUREAU
VERITAS**

Shaping a World of Trust