Ships using Fuel Cells

January 2022

Rule Note
NR 547 DT R01 E

Marine & Offshore
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BUREAU VERITAS MARINE & OFFSHORE

GENERAL CONDITIONS

1. INDEPENDENCE OF THE SOCIETY AND APPLICABLE TERMS

1.1 The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2 The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not, in any circumstances, involve monitoring or exhaustive verification.

1.3 The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, designer, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of the above listed being relieved from any of their expressed or implied obligations as a result of the interventions of the Society.

1.4 Only the Society is qualified to apply and interpret its Rules.

1.5 The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6 Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the Rules applicable at the time of entering into the relevant contract for the performance of the Services.

1.7 The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1 **"Certificate(s)"** means classification or statutory certificates, attestations and reports following the Society's intervention.

2.2 **"Certification"** means the activity of certification in application of national and international regulations or standards ("Applicable Referential"), in particular by delegation from different governments that can result in the issuance of a Certificate.

2.3 **"Classification"** means the classification of a Unit that can result or not in the issuance of a classification Certificate with reference to the Rules. Classification (or Certification as defined in clause 2.2) is an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules and/or to Applicable Referential for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.4 **"Client"** means the Party and/or its representative requesting the Services.

2.5 **"Conditions"** means the terms and conditions set out in the present document.

2.6 **"Industry Practice"** means international maritime and/or offshore industry practices.

2.7 **"Intellectual Property"** means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8 **"Parties"** means the Society and Client together.

2.9 **"Party"** means the Society or the Client.

2.10 **"Register"** means the public electronic register of ships updated regularly by the Society.

2.11 **"Rules"** means the Society's classification rules (available online on veristar.com), guidance notes and other documents. The Society's Rules take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12 **"Services"** means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, maritime labour certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board. The Services are carried out by the Society according to the Rules and/or the Applicable Referential and to the Bureau Veritas' Code of Ethics. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

2.13 **"Society"** means the classification society **'Bureau Veritas Marine & Offshore SAS'**, a company organized and existing under the laws of France, registered in Nanterre under number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14 **"Unit"** means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1 Subject to the Services requested and always by reference to the Rules, and/or to the Applicable Referential, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enter the Unit's class in the Society's Register;
- survey the Unit periodically in service to note whether the requirements for the maintenance of class are met.

The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

3.2 The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1 The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit for surveys; and (iii) inform the Society in due time of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2 Certificates are only valid if issued by the Society.

4.3 The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

4.4 The Society may at times and at its sole discretion give an opinion on a design or any technical element that would 'in principle' be acceptable to the Society. This opinion shall not presume on the final issuance of any Certificate nor on its content in the event of the actual issuance of a Certificate. This opinion shall only be an appraisement made by the Society which shall not be held liable for it.

5. ACCESS AND SAFETY

5.1 The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawing, etc. required for the performance of the Services must be made available in due time.

5.2 The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1 The provision of the Services by the Society, whether complete or not, involves, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2 Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interest equal to twelve (12) months LIBOR plus two (2) per-cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold Certificates and other documents and/or to suspend or revoke the validity of Certificates.

6.3 In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to resolve the dispute.

7. LIABILITY

7.1 The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall defend, release, save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2 Except in case of wilful misconduct of the Society, death or bodily injury caused by the Society's negligence and any other liability that could not be, by law, limited, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cent (150%) of the price paid by the Client to the Society for the Services having caused the damage. This limit applies to any liability of whatsoever nature and howsoever arising, including fault by the Society, breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3 All claims shall be presented to the Society in writing within three (3) months of the completion of Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1 The Client shall defend, release, save, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services (including for damages arising out of or in connection with opinions delivered according to clause 4.4 above) except for those claims caused solely and completely by the gross negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1 The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2 The Services shall be automatically and immediately terminated in the event the Client can no longer establish any form of interest in the Unit (e.g. sale, scrapping).

9.3 The Classification granted to the concerned Unit and the previously issued Certificates shall remain valid until the date of effect of the termination notice issued, or immediately in the event of termination under clause 9.2, subject to compliance with clause 4.1 and 6 above.

9.4 In the event where, in the reasonable opinion of the Society, the Client is in breach, or is suspected to be in breach of clause 16 of the Conditions, the Society shall have the right to terminate the Services (and the relevant contracts associated) with immediate effect.

10. FORCE MAJEURE

10.1 Neither Party shall be responsible or liable for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2 For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts.

11. CONFIDENTIALITY

11.1 The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, will be treated as confidential except where the information:

- is properly and lawfully in the possession of the Society;
- is already in possession of the public or has entered the public domain, other than through a breach of this obligation;
- is acquired or received independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure).

11.2 The Parties shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3 Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4 Without prejudice to sub-clause 11.1, the Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1 Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2 The Intellectual Property developed by the Society for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain the exclusive property of the Society.

13. ASSIGNMENT

13.1 The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to any third party without the prior written consent of the other Party.

13.2 The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1 Invalidity of one or more provisions does not affect the remaining provisions.

14.2 Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3 In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1 These Conditions shall be construed in accordance with and governed by the laws of England and Wales.

15.2 Any dispute shall be finally settled under the Rules of Arbitration of the Maritime Arbitration Chamber of Paris ("CAMP"), which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be Paris (France). The Parties agree to keep the arbitration proceedings confidential.

15.3 Notwithstanding clause 15.2, disputes relating to the payment of the Society's invoices may be submitted by the Society to the *Tribunal de Commerce de Nanterre*, France, or to any other competent local Court, at the Society's entire discretion.

16. PROFESSIONAL ETHICS

16.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including but not limited to US sanctions and EU sanctions) and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection (https://personaldataprotection.bureauveritas.com/privacypolicy).

Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2 In addition, the Client shall act consistently with the Bureau Veritas' Code of Ethics and, when applicable, Business Partner Code of Conduct both available at https://group.bureauveritas.com/group/corporate-social-responsibility/operational-excellence.

RULE NOTE NR 547

NR 547
Ships using Fuel Cells

January 2022

Section 1 General

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Section 5 Fuel Cell Power Installation

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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:

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

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

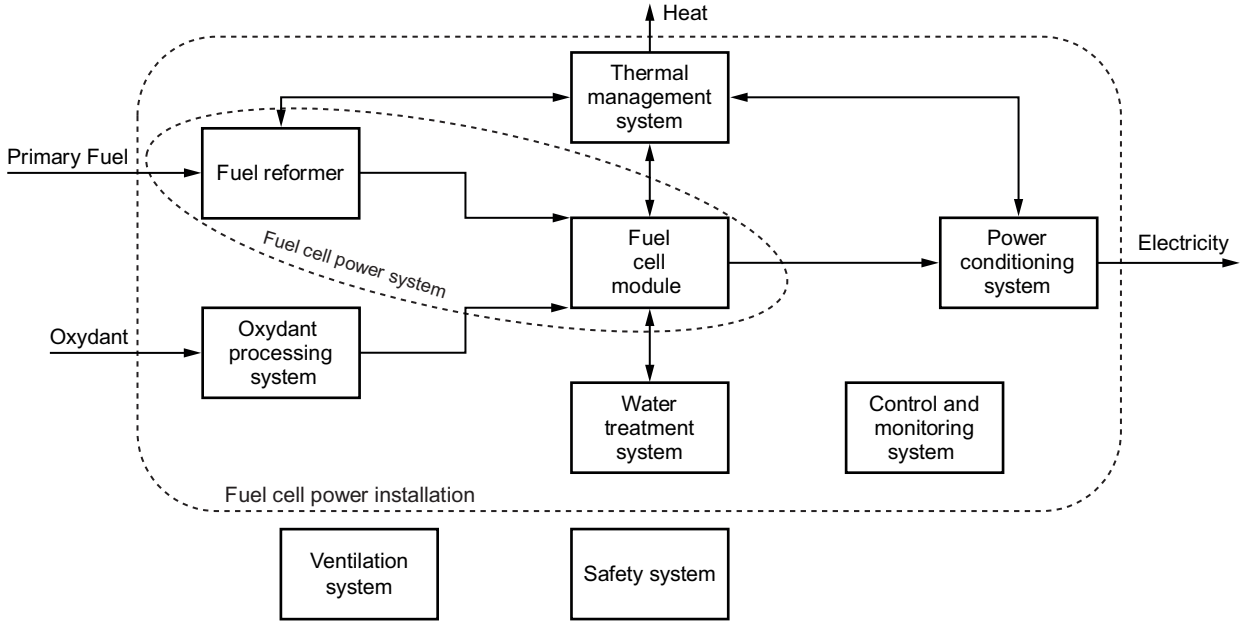
1.2 Application

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 Administration of the State whose flag the ship is entitled to fly is to be contacted to define the approval process and the conditions in which the use of the concerned fuel could 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, Ch 2, Sec 3, [2]. Alternative arrangements which would deviate from these requirements are to be given special consideration by the Society and, when deviating from SOLAS requirements, be included in the alternative design demonstration to be approved by the Flag Administration.

Table 1 : Documentation to be submitted

No.	I/A **(1)**	Documents **(2)**
1	A	General arrangement of the fuel cell spaces, with description of the classification of hazardous areas and dangerous areas with respect to primary fuel toxicity, when relevant
2	I	Description of the different operating configurations of the fuel cell power installation, with indication of the power developed by each component
3	I	Risk analysis (see Sec 2, [1.1])
4	I	Risk analysis follow-up report
5	A	Testing program and results / type approval reference of the installation components
6	A	Specification of the control, monitoring and safety systems, including emergency shutdown (ESD) and fire, liquid fuel and gas detection and fire-extinguishing systems
7	A	Diagram of the gas piping system located in the fuel cell spaces, including double wall piping or duct system
8	A	Material, thickness and joints of the fuel piping
9	A	Diagram of the inert gas piping system
10	A	Diagram of the ventilation system in fuel cell spaces, and sizing justification
11	A	Diagram of the oxidant processing, supply and exhaust system
12	A	Diagram of the gas detection system
13	I	Instrumentation list
14	I	Safety certificates for electrical equipment located in hazardous spaces or zones, where applicable
15	A	Design data and sizing calculation of the fuel piping systems
16	I	Primary and reformed fuel characteristics (storage pressure, temperature, Lower Explosivity Limit (LEL), toxicity, corrosivity and any other important safety related characteristics)
17	A	Diagram of the production (if applicable), treatment, supply and outlet piping systems of the safety and transitory gases
18	A	Diagram of the auxiliary piping systems and associated tanks if any
19	I	Operating manual of the fuel cell power installation, including: • Procedures for start, stop and emergency stop of gas utilization equipment • Steps to be taken in case of gas detection in fuel cell spaces, in double wall pipes or ducts or in ventilation hoods or casings
20	I	Procedures for maintenance of fuel consumers, other gas related equipment (including detectors verification and calibration), and other fuel cell power system components including the steps to be taken prior to servicing the units
21	A	Procedure for testing gas monitoring/ detection systems
22	I	Procedure for checking the gas tightness of the fuel system
23	A	Program of installation onboard testing
24	A	Fuel cell power installation reliability assessment **(3)**
25	A	Fire Control Plan

(1) A = to be submitted for approval
I = to be submitted for information

(2) Diagrams are to include also, where applicable, the local and remote control systems and automation systems

(3) If used for propulsion or essential services (See Sec 5, [2.1])

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 service feature **fuelcell** as defined in NR467, Pt A, Ch 1, Sec 2, [4.13.2] and subject to compliance with the requirements of [1.3.2].

1.3.2 Prior to the assignment of the additional service feature **fuelcell** and with respect to the primary fuel considered, granting of at least one of the following additional service feature is mandatory:

- **LNGfuel** or **CNGfuel** for fuel cell using natural gas as primary fuel
- **LPGfuel** for fuel cell using liquid petroleum gas as primary fuel
- **methanolfuel** for fuel cell using methyl or ethyl alcohol as primary fuel
- **ammoniafuel** for fuel cell using ammonia 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 service features are given in NR467, Pt A, Ch 1, Sec 2, [4.13] 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

1.4.1 Documentation to be submitted for granting the notation **fuelcell** is listed in Tab 1.

The list of documents requested is intended as a guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

1.5 Definitions

1.5.1 Exhaust air

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

1.5.2 Exhaust gas

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

1.5.3 Fuel cell

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

1.5.4 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.

1.5.5 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.

1.5.6 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.

1.5.7 Fuel cell space

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

1.5.8 Fuel cell stack

Fuel cell stack is an 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.

1.5.9 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.

1.5.10 Gas consumer

Gas consumer means any unit (a reformer or a fuel cell stack) within the fuel cell space using a gas as fuel

1.5.11 Lower explosivity limit (LEL)

LEL means the lower explosivity limit.

1.5.12 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.

1.5.13 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.

1.5.14 Primary fuel

Primary fuel is fuel supplied to fuel cell power system.

1.5.15 Process air

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

1.5.16 Reformed fuel

Reformed fuel is hydrogen rich gas generated in fuel reformer.

1.5.17 Safety gas

Safety gas is the gas injected in the fuel supply system for inerting purposes.

1.5.18 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.

1.5.19 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.

1.5.20 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, in accordance with NR467, Pt C, Ch 1, Sec 1, [1.1.3].

1.5.21 Ventilation air

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

1.5.22 Water treatment system

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

1.6 References

1.6.1 The followings documents are used as references:

NR216 : Rules on materials and welding for the classification of marine units

NR320 : Certification scheme of materials and equipment for the classification of marine units

NR467 : Rules for the classification of steel ships

NR529 : Gas fuelled ships

NI647 : LPG-fuelled ships

NR670 : Methyl/ethyl alcohol fuelled ships

NR671 : Ammonia-fuelled ships.

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).

1.2 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 occur
- 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 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 spaces in which toxic products may be encountered, their volumes and the associated consequences. Release of toxic products is not to:

- provoke health effects 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 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 suitable for the intended application with the range of process fluids and conditions expected during both normal operation and fault management

2 Fuel cell power system

2.1 General

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

2.1.2 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.

3 Piping systems

3.1 General

3.1.1 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.

3.1.2 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, Ch 1, Sec 10.

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

3.1.4 Components in contact with hydrogen in the reformed fuel are to be made of materials compatible with this element, in particular with respect to embrittlement and hydrogen attack phenomena. The demonstration of the suitability of materials is to be performed by tests according to recognized standards (e.g. ISO 11114-4:2017).

3.2 Classes of reformed fuel piping systems

3.2.1 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 certification of fittings.

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

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

Table 1 : Classes of reformed fuel piping systems

Piping system	Design conditions		Class of the reformed fuel piping		
	Design pressure	Design temperature	Single wall arrangement	Double wall arrangement	
				Inner pipe	Outer pipe
Low pressure lines	P = 10 bar **(1)**	any	I	II	II
High pressure lines	P > 10 bar	any	I	I	II
(1) The design pressure is not to be taken less than 10 bar					

Table 2 : Classes of vent pipes and bleed lines

Design conditions		Class of the vent pipe		
Vent pipe design pressure	Vent pipe design temperature	Single wall arrangement	Double wall arrangement	
			Inner pipe	Outer pipe
P = 5 bar **(1)**	any	III	III	III
P > 5 bar and P ≤ 10 bar **(2)**	any	II	III	III
P > 10 bar **(2)**	any	I	II	III
(1) The design pressure of vent pipes and open ended lines is not to be taken less than 5 bar **(2)** The design pressure of vent pipes and open ended lines is not to be less than the maximum expected pressure, which is to be justified				

SECTION 4 GENERAL ARRANGEMENT

1 Primary fuel

1.1 General

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 Notes:

- NR529 for natural gas
- NI647 for liquid petroleum gas
- NR670 for methyl or ethyl alcohol
- NR671 for ammonia
- NR529, Part A 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 fueled with the primary fuel as detailed the Rule Notes listed in [1.1.1].

2 Fuel cell spaces

2.1 General

2.1.1 A fuel cell space containing fuel reformers is to comply with the requirements relevant for the primary fuel, especially considering the piping arrangements.

2.1.2 Fuel storage systems, including intermediate storage of primary or reformed fuels are not to be located inside a fuel cell space.

2.1.3 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.

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

2.1.5 A fuel cell space is 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 (e.g. 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.

2.1.6 A fuel cell space is 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.

2.1.7 Boundaries between fuel cell spaces and other enclosed spaces are to be gastight.

2.1.8 In general the surface temperature of components and pipes in the fuel cell space is never to be above the self-ignition temperature of the primary or reformed fuel used.

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

2.2 Bilge systems

2.2.1 A 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.

2.3 Arrangements for inspection and maintenance

2.3.1 Provisions 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.

3 Location and access

3.1 General

3.1.1 Fuel cell spaces are to be arranged outside accommodation spaces, service spaces, machinery spaces not dedicated to fuel cell power installation and control stations.

3.1.2 In general, access to the fuel cell space is to be direct from the open deck. If access is possible from another enclosed space of the ship, it is to be through an airlock which complies with NR529, [5.12].

3.1.3 An airlock is not required if access to the space is not required and not possible 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.

4 Ventilation ducts and double wall piping

4.1 General

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

4.1.2 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.

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

4.1.4 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.

4.1.5 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 or the other applicable rules (e.g. ammonia).

5 Atmospheric control of the fuel cell space

5.1 General

5.1.1 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 [5.2] or inerted in accordance with [5.3].

5.2 Ventilated fuel cell spaces

5.2.1 A ventilated fuel cell space is 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.

5.2.2 For a fuel cell space on open deck, overpressure ventilation may be considered.

5.2.3 The ventilation rate in a fuel cell space is to be sufficient to dilute the average gas / vapour concentration below 25% of the flammable range in all maximum probable leakage scenarios due to technical failures.

5.2.4 Any ducting used for the ventilation of a fuel cell space is not to serve any other space.

5.2.5 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.

5.2.6 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.

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

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

5.2.9 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.

5.2.10 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.

5.2.11 Fans are to be of a non-sparking type as defined in NR467, Pt C, Ch 4, Sec 1, [3.28].

5.2.12 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.

5.2.13 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 switchboard or emergency switchboard.

5.2.14 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.

5.2.15 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.

5.3 Inerted fuel cell spaces

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

5.3.2 It is not to be possible to enter the fuel cell space during inerting or when inerted. Sealing arrangements are to ensure that leakages of inert gas to adjacent spaces are prevented.

5.3.3 The inerting system is to comply with the relevant requirements of NR467, Pt C, Ch 4, Sec 15, [13] and NR529, 6.13 and 6.14.

5.3.4 The pressure of the inerting media is always to be kept positive and monitored.

5.3.5 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, etc.) is to activate a controlled shut-off of the fuel supply.

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

5.3.7 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.

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

5.3.9 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.

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 and IEC 62282-3.

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 fuel cell power installation reliability assessment is to be performed in order to ensure that the availability of power is at least equivalent to the level required for ships equipped with an internal combustion engine. 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.

Note 1: Relevant international standards are to be followed, such as IEC 62308:2006 Equipment reliability - Reliability assessment methods.

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/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 The fuel supply line to each fuel cell space is to be equipped with a manually operated stop valve and an automatically operated “master fuel valve” coupled in series or a combined manually and automatically operated valve. The valves are to be situated in the part of the piping that is outside the fuel cell space. The master fuel valve is to automatically cut off the fuel supply when activated by the safety system. In cases where the master fuel valve is automatically shut down, the complete fuel supply branch downstream of the double block and bleed valve (See [3.1.2]), if any, is to be automatically ventilated assuming reverse flow from the fuel cell power system to the pipe.

3.1.2 The automatic master fuel valve is to be operable from safe locations on escape routes inside a machinery space containing a gas consumer, the engine control room, outside the machinery space, and from the navigation bridge.

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

3.1.4 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.

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

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

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

3.1.8 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.

3.1.9 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
- 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.

3.1.10 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.

3.1.11 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 GVU spaces / enclosures
- for venting pipes
- in fuel cell spaces too small to be entered when the spaces boundaries comply with the requirement given in [3.1.10].

3.1.12 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.

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, [10.4].

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 on the primary fuel (see Sec 1, [1.3.2]).

5 Safety 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 safety or transitory gases inside primary and reformed fuel pipes, as well as inside exhaust gases pipes is to be possible.

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

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

5.1.5 Safety 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. They 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 (lubricating oil, cooling water) are to be equipped with appropriate detection and extraction 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 in the open air.

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.

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. Where this is deemed to be impracticable, alternative boundary designs that provide for an equivalent level of safety may be approved on a case-by-case basis by the Society.

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 required for fuel cell spaces.

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. It 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 it does not induce delay in identifying the source of fire, the maximum extent of the section being the fuel cell space.

4.1.3 Smoke detectors alone are not considered sufficient for rapid detection of a fire. A fuel cell space is also to be fitted with suitable flame detectors or equivalent.

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 General

1.1 Electrical systems and equipment

1.1.1 Electrical systems and equipment are to comply with the relevant requirements of NR467, Part C, Chapter 2.

1.1.2 Electrical equipment and wiring are not in general 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] according to the hazardous area classification.

1.1.3 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.

1.1.4 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 [1.3]. 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.

1.1.5 The temperature class and equipment group specified in Tab 1 are to be used for potential flammable atmosphere for certified safe equipment in accordance with IEC 60079-20-1:2020.

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

Table 1 : Temperature class and equipment groups

	Temperature class	Equipment group
Natural gas	T1	IIA
LPG (propane, butane)	T2	IIA
Hydrogen	T1	IIC
Methyl alcohol	T2	IIA
Ethyl alcohol	T2	IIB
Ammonia	T1	IIA

1.2 Fuel cell connection

1.2.1 The outgoing circuits on a fuel cell arrangement are to be provided with a switch disconnector 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 Area classification

1.3.1 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.

1.3.2 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
- 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 of other sources of release of reformed fuel
- Fuel cell spaces
- Enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes whatever their arrangement.

1.3.3 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.

1.3.4 Ventilation ducts

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

1.3.5 Fuel cell spaces

According to [1.3.2], 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 or equivalent). 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
- 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), and
- 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 GVU spaces and enclosures
- 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 impacts on crew health.

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 on the outcome of the risk assessment 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 Immediately after shutdown, an automatic purge of the fuel reformer with safety 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 provided inside or close to the exit of the fuel cell space, in the engine control room, on the navigation bridge, the fire control station and the safety center. 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 General

10.1.1 Gas or vapour detection

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

- In an inerted fuel cell space, immediate (emergency) shutdown of the fuel supply is not necessary in case of leakage detection. Instead, a changeover to another power supply system and controlled shutdown of the fuel cell and the affected fuel supply system is to be initiated, avoiding damage to the fuel cell power system.
- After gas or vapour detection, safety gas is to be injected in the primary and reformed fuel pipes and sent to the outside atmosphere.

10.1.2 Loss of ventilation

- 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.
- 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.

10.1.3 Loss of inert gas

- 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.
- 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.

10.1.4 Loss of fuel cell coolant

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.

10.1.5 Liquid detection

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

10.1.6 Fire detection

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

10.1.7 Fuel cell power system

- 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.
- 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 restart is to be prevented by an independent protective device.
- 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.
- 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.
- After a safety shutdown, an automatic purge of the fuel cell power system with safety 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.

10.1.8 Emergency shutdown push buttons

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

11.1 General

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.

12 Safety actions

12.1 General

12.1.1 Automatic safety actions are to be implemented as detailed in Tab 1. Safety actions additional to the ones required by Tab 1 may be required for unconventional or complex fuel cell power installations (e.g. use of safety gas in fuel and exhaust pipes).

Table 1 : Alarms and safety actions

Symbol convention H = high; HH = high high; L = low; X = Function is required	Monitoring		Automatic control	
Identification of system parameter	Alarm	Criteria	Shutdown of fuel supply to fuel cell 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	
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 **(2)**	
Secondary enclosure of fuel pipes	X	Loss of ventilation	X	
INERTING				
Fuel cell space	L	Loss of overpressure	X **(2)**	
Secondary enclosure of fuel pipes	L	Loss of overpressure	X	
OTHER				
Fire detection in fuel cell space	X		X **(3)**	X
System failure	X	Deviation of the process out of the limit values	**(2)**	
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 **(4)** **(5)**	
Control of atmosphere	X **(6)**	Detection of toxic gas or low level of oxygen		
Differential pressure across filters	H **(7)**			
Loss of fuel cell coolant	X		**(2)**	
Fuel cell stack surface temperature T > 300°C **(8)**	H	X	X	X

(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.

(2) In addition, the fuel cell is to be automatically shutdown by process control

(3) In addition, fire dampers are to close, ventilation is to shutdown and the fire extinguishing system is to be activated.

(4) Time delayed as found necessary

(5) Only double block and bleed valves to close.

(6) Action to be completed depending on the gas detected

(7) Local alarm

(8) If fuel cell stack is not certified for zone 1

Note 1: For primary fuel, reference is made to the relevant requirements, especially for gas detection (flammability, toxicity…). See Sec 1, [1.3.2].

SECTION 9 ONBOARD TESTING

1 General

1.1 Operational tests

1.1.1 If the fuel cell power installation constitutes the main propulsion system of the ship, it is to be verified that the ship has adequate propulsion power in all manoeuvring situations.

1.1.2 Fuel cell spaces and ventilated ducts are to be tested to verify that, depending on the configuration:

- adequate ventilation and underpressure can be achieved. Ventilation rate at minimum flow is to be documented; or
- adequate inert atmosphere and overpressure can be achieved.

1.1.3 Alarms and/or automatic shutdowns required upon reduction and/or loss of ventilation are to be tested. Ventilation rate at minimum flow is to be documented.

1.1.4 The following components are to be checked:

- protective devices (safety and automatic shut-off valves…)
- measurements systems (level indicators, temperature measurement devices, pressure gauges…)
- gas detection systems and alarm devices.

1.1.5 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 load shedding
- interactions with other sources of power, including change-over with the emergency power source.

1.1.6 Hot spot verification

Compliance with the requirements of Sec 4, [2.1.8] 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.

1.1.7 Non-destructive testing

Welded joints, including the inside wherever possible, are to be visually examined.

Radiographic or ultrasonic examination of all butt-welded joints over their full length is to be carried out for piping systems with:

- design temperatures colder than –10°C, or
- design pressure greater than 1,0 MPa, or
- gas supply pipes in ventilated fuel cell spaces, or
- inside diameters of more than 75 mm, or
- wall thicknesses greater than 10 mm.

When such butt welded joints of piping sections are made by automatic welding procedures approved by the Society, a progressive reduction in the extent of radiographic or ultrasonic examination may be agreed, but in no case to less than 10% of the length of each butt joint. If defects are revealed the extent of examination is to be increased to the full length of the butt joint and is to include examination of previously accepted welds. This approval can only be granted if well-documented quality assurance procedures and records are available to assess the ability of the manufacturer to produce satisfactory welds consistently.

The radiographic or ultrasonic examination may be reduced up to 10% of butt-welded joints in the outer pipe of double-walled fuel piping.

For other butt-welded joints, spot radiographic or ultrasonic examination or other non-destructive tests is to be carried out depending upon service, position and materials. In general, at least 10% of butt-welded joints of pipes is to be subjected to radiographic or ultrasonic examination.

1.1.8 Electrical equipment in hazardous area

For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and / or operation of an alarm (for example loss of pressurization for an Ex(p) control panel) it is to be verified in the presence of a surveyor that the devices have correct settings and/or correct operation of alarms.

SECTION 10 SURVEY AT WORKS AND CERTIFICATION

1 General

1.1 Principles

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

1.1.2 Fuel cell power systems are to be tested for type approval at works, when required. Tests are to be carried out under the survey of the Society.

1.1.3 Inspection and testing of fuel piping systems are to comply with NR467, Pt C, Ch 1, Sec 10, Tab 41.

2 Type approval testing

2.1 General

2.1.1 Fuel cell modules and power systems are to be designed, type tested and approved by the Society in accordance with IEC 62282-2-100:2020 and IEC 62282-3-100:2019 or recognized standards acceptable to the Society.

2.1.2 In addition, automation systems are to be type tested and approved by the Society in accordance with NR467, Pt C, Ch 3, Sec 6.

2.1.3 Expansion bellows intended for use in fuel cell fuel systems are to be type tested and approved by the Society as given in NR529, 16.7.2.

2.1.4 Valves and pipings are to be type tested and approved by the Society in accordance with NR467, Pt C, Ch 1, Sec 10.

3 Production testing

3.1 General

3.1.1 Valves

Valves are to be tested in the presence of the Surveyor. Valves are to be leakage tested with an appropriate test gas depending on the used fuel according to a recognized standard acceptable to the Society. Testing is to include hydrostatic test of the valve body at a pressure equal to 1,5 times the design pressure for all valves, seat and stem leakage test at a pressure equal to 1,1 times the design pressure for valves other than safety valves. The set pressure of safety valves is to be tested at ambient temperature.

For valves used for isolation of instrumentation in piping not greater than 25mm, unit production testing need not be witnessed by the Surveyor. Records of testing are to be available for review.

3.1.2 Piping

After assembly, piping systems are to be tightness tested with an appropriate test gas to show that there is no leakage.

3.1.3 Expansion bellows

All bellows are to be tested in the presence of the surveyor. Testing is to include hydrostatic test of the bellow at a pressure equal to 1,5 times the design pressure.

3.1.4 Pressure relief valves

Each pressure relief valve is to be tested in the presence of the surveyor to ensure that:

- it opens at the prescribed pressure setting, with an allowance not exceeding:
  - ± 10% for 0 to 0,15 MPa
  - ± 6% for 0,15 to 0,3 MPa
  - ± 3% for 0,3 MPa and above
- seat tightness is acceptable, and
- pressure containing parts will withstand at least 1,5 times the design pressure.

3.1.5 Fuel cell power system

The routine tests as described in IEC 62282-2-100:2020 §6 and IEC 62282-3-100:2019 §6 of all fuel cell power systems are to be witnessed by a Society's surveyor. Tests for fuel cell power systems under 100 kW which are type approved by the Society need not be attended by the Surveyor.

4 Certification

4.1 General

4.1.1 Equipment are to be certified as listed in Tab 1.

Symbols used in the table have the following meaning:

TA : indicates that Type Approval is required

TA (HBV): indicates that Type Approval is required with work's recognition (HBV scheme as per NR320)

DA : indicates that Design assessment / Appraisal of the product is required; this one may be carried out as applicable either for a specific unit or using the Type Approval procedure.

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.

W : indicates that a manufacturer's document is required, stating the results of the tests performed and/or stating compliance with the approved type (as applicable).

X : indicates that examinations and tests are required.

Where fitted, each additional index (h, ndt) indicates a specific type of test:

h : Hydraulic pressure test (or equivalent)

ndt : Non-destructive tests as per Rules.

Table 1 : Certification requirements

No.	Item	Product certification				Remarks
		Design Assessment / Approval	Raw material certificate	Examination and testing	Product certificate	
1	Fuel cell power system	TA (1)			C or W (3)	(1) In compliance with national or international standard (e.g. IEC 62282-3-100:2019 or other recognized standard acceptable to the Society) (2) In compliance with national or international standard (e.g. IEC 62282-2-100:2020 or other standard acceptable to the Society) (3) When < 100 kW and type approved by the Society, work certificate (W) will be accepted
	• Fuel cell module	TA (2)			C or W (3)	
	• Fuel cell monitoring and control system	TA (1)			C or W (3)	
2	Fans for hazardous enclosed spaces, and their prime movers					(1) For anti-sparking fans (2) For electrical motors, refer to NR266, item K (3) As per conditions set in the TA
	• Fans	TA (1)		X	C or W (3)	
	• Prime movers	(2)		X (2)	C	
3	Fire and gas detection system	TA (1)		X	C	Automation systems: see relevant provisions of NR266, item N
4	Gas fuel valve (1)	DA	C or W (2)	X h ndt (3) (4)	C	(1) Class of piping as per provisions of Sec 3 (2) C: ND ≥ 50 mm; W: ND < 50 mm (3) In case of welded construction. When the valves have welded elements, the welding procedures are to be examined (4) Unit production testing: all valves are to be tested as per Sec 9
5	Safety relief valves	TA or DA (3)	C	X h ndt (1) (2)	C	(1) Checking of the setting (2) When the valves have welded elements, the welding procedures are to be examined (3) TA, or case-by-case DA
6	Fuel pipes for gaseous fuel with design pressure equal or lower than 10 bar (Class I or Class II):					(1) As per provisions of this Rule Note and NR467, Pt C, Ch 1, Sec 10 (2) W for Seamless pipes, C for longitudinally welded steel pipes (3) Non-destructive testing to be carried out as required by Sec 9
	• Class I: single wall pipes, and ND ≥ 50 mm • Class II: double wall pipes, and ND ≥ 100 mm		C	X h ndt (1) (3)	C	
	• Class I: single wall pipes, and ND < 50 mm • Class II: double wall pipes, and ND < 100 mm		W	X h ndt (1) (3)	C/W (2)	

No.	Item	Product certification				Remarks
		Design Assessment / Approval	Raw material certificate	Examination and testing	Product certificate	
7	Fuel pipes for gaseous fuel with design pressure higher than 10 bar (Class I) (1)					(1) For both single and double wall configuration (2) As per provisions of this Rule Note and NR467, Pt C, Ch 1, Sec 10 (3) W for Seamless pipes, C for longitudinally welded steel pipes (4) Non-destructive testing to be carried out as required by Sec 9
	• ND ≥ 50 mm		C	X h ndt (2) (4)	C	
	• ND < 50 mm		W	X h ndt (2) (4)	C/W (3)	
8	Outer pipe of double wall fuel pipes (Class II) (1)					(1) As per provisions of this Rule Note and NR467, Pt C, Ch 1, Sec 10 (2) W for Seamless pipes, C for longitudinally welded steel pipes
	• ND ≥ 100 mm		C	X h ndt	C	
	• ND < 100 mm		W	X h ndt	C/W (2)	
9	Expansion bellows	TA (1)	C (2)	X h ndt	C	(1) Prototype tests to be performed on each type of expansion belows intended for use on gas fuel piping (2) Refer to Items 6, 7 and 8 as appropriate

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