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CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR SHIPS USING FUEL CELL POWER INSTALLATIONS

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CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 The Guidelines For Ships Using Fuel Cell Power Installations (hereinafter referred to as the Guidelines) apply to ships of 20 m in length and above, constructed by steel or equivalent metallic material and provided with fuel cell (FC) power installations or ready for hydrogen fuel cell power installations (hereinafter referred to as FC ships). Where a FC power installation is used on ships of less than 20 m in length and constructed by steel or equivalent metallic material, a risk assessment is to be conducted, and the Guidelines may be referred to at the discretion of China Classification Society (CCS). An offshore unit provided with a FC power installation could refer to applicable parts of the Guidelines.

1.1.1.2 In addition the Guidelines, FC ships are to comply with the relevant requirements of CCS Rules for Classification of Sea-going Steel Ships, Rules for the Construction of Inland Waterways Steel Ships or Regulations for Classification of Inland Waterways Ships (hereinafter referred to as CCS Rules). These ships are also to comply with the related provisions (if any) of the Administration of the flag State.

1.1.1.3 Where a special or novel FC system is used onboard due to the developing FC technology, which could not comply with the Guidelines, an assessment based on the corresponding theoretical calculations, experimental results, practical experience or effective accepted standards may be accepted as an alternative or equivalent method to the Guidelines upon agreement by CCS.

1.1.1.4 Where hydrogen is used as primary fuel, the technical requirements for ship's arrangement, materials, pipe design, fuel storage, fuel bunkering, fuel supply and fuel utilization, electrical equipment, ventilation, firefighting and monitoring, plans and documents as well as surveys are to comply with the relevant requirements of the Guidelines. Where natural gas, methanol/ethanol, ammonia or other fuel is used as primary fuel, the technical requirements for ship's arrangement, materials, pipe design, fuel storage, fuel bunkering, fuel supply and fuel utilization, electrical equipment, ventilation, firefighting and monitoring, plans and documents as well as surveys are also to comply with the related requirements of CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel.

1.1.1.5 A ship applying for assignment of the class notation of hydrogen fuel cell power installation ready is to comply with Chapter 11 of the Guidelines.

1.1.2 Definitions

Unless expressly provided in this Section, the relevant definitions in CCS Rules for Ships Using Natural Gas Fuel apply for the Guidelines.

1.1.2.1 **FC** 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.

1.1.2.2 **FC stack** is an assembly of cells, separators, cooling plates, manifolds and a supporting structure that electrochemically converts, typically, hydrogen rich gas and air reactants to DC power, heat and other reaction products.

1.1.2.3 **FC module** is an assembly incorporating one or more FC stacks and other main and, if applicable, additional components.

1.1.2.4 **Primary fuel** is the fuel supplied to the FC power system.

1.1.2.5 **Reformed fuel** is the hydrogen rich gas generated in the fuel reformer.

1.1.2.6 **Fuel reformer** is an arrangement of all related fuel reforming equipment for processing primary fuel to reformed fuel for use in FCs.

1.1.2.7 **FC power system** means FC(s), fuel reformers (if fitted) and associated piping systems.

1.1.2.8 **FC power installation** means the FC power system and other components and systems required to supply electrical power to the ship. It may also include converters and ancillary systems for the FC operation.

1.1.2.9 **FC space** means a space or enclosure containing the FC power system or its parts.

1.1.2.10 **Exhaust gas** is exhaust form the reformer or anode side of the FC.

1.1.2.11 **Exhaust air** is exhaust from the cathode side of the FC.

1.1.2.12 **Process air** is air supply to the reformer and / or the cathode side of the FC.

1.1.2.13 **Ventilation air** is air used to ventilate the FC space.

1.1.2.14 **Fuel tank** means a vessel used for fuel storage on board.

1.1.2.15 **Compressed hydrogen fuel tank** means a vessel used for compressed hydrogen fuel storage on board.

1.1.2.16 **Hydrogen cylinder** is a rechargeable gas bottle with a nominal pressure not greater than 70 MPa for storing compressed hydrogen, which is a type of compressed hydrogen fuel tank.

1.1.2.17 **Fuel tank space** is the space enclosed by the ship's structure in which a fuel tank is situated. If tank connections are located in the fuel tank space, it will also be a tank connection space, e.g. a hydrogen cylinder room.

1.1.2.18 **Tank connection space** means a space enclosing all tank connections and valves.

1.1.2.19 **ESD** means emergency shutdown. It is necessary to shut off the operation of fuel cell and fuel supply and the power supply of non-explosion-proof electrical equipment without delay, to avoid damage to the surrounding environment and personnel.

1.1.2.20 **CSD** means controlled shutdown. It is necessary to shutdown the operation of fuel cells, reformers and supply systems during the normal running or due to minor technical anomaly. Controlled shutdown is executed by the control system, e.g. the main controller of fuel cell, to protect the equipment and the surrounding environment.

1.1.3 Goals and functional requirements

1.1.3.1 The goal of the Guidelines is to provide a standard for arrangement, installation, control and monitoring of the machinery, equipment and systems on board FC ships and to minimize the risk to personnel, the ship and the environment.

1.1.3.2 The design and construction of a FC ship are to comply with the following functional requirements for the above goal:

(1) The safety, reliability and dependability of the systems are to be equivalent to that achieved with new and comparable conventional oil-fueled main and auxiliary machinery, regardless of the specific FC type and fuel;

(2) The probability and consequences of fuel-related hazards are to be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of fuel leakage or failure of the risk reducing measures, necessary safety actions are to be initiated;

(3) The design philosophy is to ensure that risk reducing measures and safety actions for the FC power installations do not lead to an unacceptable loss of power;

(4) Hazardous areas are to be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment;

(5) Equipment installed in hazardous areas are to be minimized to that required for operational purposes, their performance is to be compatible with the working environment and they are to be approved by CCS;

(6) Unintended accumulation of explosive, flammable or toxic gas concentrations is to be prevented;

(7) System components are to be suitably protected to prevent external damage;

(8) Sources of ignition in hazardous areas are to be minimized to reduce the probability of explosions;

(9) Safe and suitable fuel supply, storage and bunkering arrangements are to be provided to receive and contain the fuel in the required state without leakage;

(10) Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application are to be provided;

(11) Machinery, systems and components are to be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation;

(12) Fuel containment systems and FC spaces are to be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable;

(13) Suitable control, alarm, monitoring and shutdown systems are to be provided to ensure safe and reliable operation;

(14) Fixed gas and/or fuel leakage detection systems suitable for all spaces and areas concerned are to be arranged;

(15) Fire detection, protection and extinction appropriate to the potential fire hazards are to be provided;

(16) Suitable personnel protective equipment are to be provided on board in order to protect persons engaged in fuel operation.

(17) Commissioning, trials and maintenance of fuel systems and FC power systems are to satisfy the goal in terms of safety, availability, maintainability and reliability;

(18) The technical documentation is to permit an assessment of the compliance of the system and its components with the followings:

① the applicable rules, guidelines, design standards used;

② the principles related to safety, availability, maintainability and reliability;

(19) A single failure in a technical system or component is not to lead to an unsafe or unreliable situation;

(20) Safe accesses are to be made available for operation, inspection and maintenance.

1.1.4 Class notations

1.1.4.1 Upon the request of the owner or shipyard/designer, class notations of FC-FULL, FC-POWER 1 or FC-POWER 2 may be granted to a FC ship after approval by CCS. The detailed explanations of the notations are as follows:

(1) FC-FULL: A ship is only provided with FC power installations without any other main power, such as any main engine/main generating set/power battery. The FC power installations supply power to the ship's electrical equipment;

(2) FC-POWER 1: A ship is provided both FC power installations and other main power (any main engine/main generating set/power battery etc.), and the former, as part of the main source of electrical power of the ship, supplies power to the ship's electrical equipment;

(3) FC-POWER 2: A ship is provided both FC power installations and other main power (any main engine/main generating set/power battery etc.), and the former, not as part of the ship’s main generator, supplies power to the ship's electrical equipment .

1.1.4.2 Upon the request of the owner or shipyard/designer, class notations of HFC① Ready 1, HFC Ready 2 or HFC Ready 2(X) may be granted to an HFC power installations ready ship after confirmation by CCS through plan approval and survey that relevant requirements of Chapter 11 of the Guidelines are complied with. The detailed explanations of the notations are as follows:

(1) HFC Ready 1: principled HFC power installations ready plan design and approval is carried out to ensure that the ship complies with basic requirements for using HFC power installations in the future, and equipment and system related to HFC power installations are not fitted on board, for which HFC Ready 1 may be requested.

(2) HFC Ready 2: detailed HFC power installations ready plan design and approval is carried out to ensure that the intended HFC power installations can satisfy relevant requirements of the Guidelines, and equipment and system related to HFC power installations are not fitted on board, for which HFC Ready 2 may be requested.

① HFC in these notations is the abbreviation of Hydrogen Fuel Cell.

(3) HFC Ready 2(X): bases on satisfying the requirement of HFC Ready 2, equipment or system related to HFC power installations are partially fitted on board, subject to CCS survey and approval, for which HFC Ready 2(X) may be requested, such as HFC Ready 2(S, P, ...) . The suffix X refers to:

① The letter S in capital means that relevant hull structure has been strengthened and the supporting members of hydrogen fuel tanks/hydrogen cylinders have been fitted;

② The letter P in capital means that the piping system of hydrogen fuel has been fitted;

③ The letter FC in capital means that the cell module of hydrogen fuel has been fitted;

④ The letter D in capital means that the classification of all the hazardous areas related to HFC power installations has been considered and the electrical equipment within the above areas meets the corresponding explosion-proof requirements.

1.1.4.3 After the class notation of HFC power installations ready is assigned, where the ship is subject to modifications, relevant revised plans are to be submitted to CCS for review prior to the onboard installation and modification of HFC power installations.

1.1.4.4 Class notations of FC-FULL, FC-POWER1 or FC-POWER2 may be assigned after satisfactory survey to the installation and modification of HFC power installations by CCS according to the Guidelines and the class notation of HFC power installations ready is withdrawn.

1.1.5 Alternative design

1.1.5.1 Where the Guidelines require that a particular fitting, material, appliance, apparatus, item of equipment or type thereof is to fitted or carried in a ship, or that any particular provision is to be made, or any procedure or arrangement is to be complied with, CCS may allow alternative equipment or measure, if it is confirmed by trial or other methodologies to be at least as effective as that required by the Guidelines.

1.1.5.2 The equivalence of the alternative design is to be demonstrated in accordance with CCS Guidelines for Application of Alternative Designs and arrangements of Ships and approved by CCS.

1.1.5.3 However, CCS does not allow operational methods or procedures to be applied as an alternative to particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by the Guidelines.

Section 2 PLANS AND DOCUMENTS

1.2.1 Plans and documents for approval

1.2.1.1 In addition to those specified in CCS Rules, the following plans and documents are to be submitted to CCS for approval:

(1) Ship arrangements

① fuel containment systems;

② fuel preparation room, if any;

③ fuel bunkering system, including bunkering connections;

④ accesses, vent pipes and other openings of fuel storage tank spaces / tank connection spaces;

⑤ ventilation pipes, doors and openings in the fuel preparation room and other hazardous areas;

⑥ fuel supply system;

⑦ FC space, indicating the location of each component of the FC system;

⑧ geometrical form of the FC space, see 2.3.2.5;

⑨ air lock (if any) and its structures;

⑩ instruction of drip trays (if fitted) or other protection means;

⑪ classification of hazardous areas.

(2) Piping systems

① details or instruction of the gas fuel piping, including pressure relief valves and vent pipes;

② technical documents of the branch pipes, return pipes, bends, expansion joints, bellows or similar devices;

③ plans and instruction of the flanges, valves and other devices;

④ technical documents of the materials, welding, post-weld heat treatment and non-destructive testing of gas piping;

⑤ technical documents of pressure testing (strength and gas tightness test) of gas piping;

⑥ functional test guidelines for all piping, including valves, fittings and equipment relating to gas (liquid or vapour) operation;

⑦ technical documents of electrical bonding of piping;

⑧ technical documents of the arrangements for removing fuel from fuel bunkering pipes before the bunkering joint is cut off;

⑨ arrangement and specifications of cooling water systems or hot water systems (if fitted) relating to gas fuel systems, if any;

⑩ arrangement and instruction of gas freeing and inert gas purging systems;

⑪ arrangement of bilge and drainage systems for the fuel preparation room and tank connection space, if any.

(3) Ventilation systems

① arrangement and instruction (e.g. displacement calculations etc.) of mechanical ventilation systems in fuel tank spaces, fuel preparation rooms, FC spaces and other hazardous areas, including the capacity and arrangement of fans and their motors, drawings and material documents of the moving parts and covers of fans;

② arrangement of double-wall pipes (air ducts);

③ arrangement of air intake and exhaust system of the FC system, including filters.

(4) Gas detection systems

① gas detection and alarm systems and their arrangement, including probes, alarm arrangements and alarm set points;

② specifications of gas detectors, including alarm arrangements.

(5) Control, monitoring and safety systems

① gas tank monitoring and control systems and their arrangement, including sensors, alarm set points;

② electrical schematic diagram and monitoring lists of the gas fuel bunkering and supply system;

③ other control, monitoring and safety systems related to the fuel;

④ arrangement of ESD systems, including:

(a) details of shutdown actions, including fuel supply systems and fuel bunkering systems etc.;

(b) locations of manual ESD buttons.

(6) Fire-fighting appliances and systems

① fire detecting and alarm systems and their arrangement;

② fire-fighting piping systems of the FC space;

③ structural fire protection arrangement of fuel tank spaces and tank connection spaces and their vent pipes, bunkering stations (if applicable);

④ arrangement of portable /wheeled fire extinguishers (see 9.3.1);

⑤ documents showing that the FC space has sufficient strength to be subject to the worst explosion, see 9.2.3.3.

(7) Electrical systems

① FC power systems;

② documents demonstrating that the systems have complied with 7.4.3, 7.4.4 and 7.4.5 of the Guidelines if requesting the class notations FC-FULL, FC-POWER 1 and FC-POWER 2;

③ documents demonstrating that the systems have complied with 7.4.2 where FC power installations are used as the main generator;

④ capacity calculations of the energy storage system (see 7.4.4.4);

⑤ arrangement of electrical installations in the hazardous area, including all electrical equipment thereof and the following information:

(a) type of protection, explosion group and temperature class;

(b) degree of protection;

(c) hazardous classification of the installation area.

⑥ check data[①] of intrinsically safe circuits, including voltage, current, inductance and capacitance;

(8) Test guidelines and procedures

① dock and sea trials procedure relating to FC power installations, primary fuel and reformed fuel, such as functional tests for FC power installations, all gas piping and their valves, fittings and relevant equipment.

Note: The actual drawing names may be different from those mentioned above, but the drawings are to show the requirements above.

1.2.2 Plans and documents for information

1.2.2.1 In addition to those specified in CCS Rules, the following plans and documents are to be submitted for information:

(1) FC power installations

① principles and system charts of the installations;

② nominal parameters and operating conditions of the installations, including input power, output power and demand for fuel (fuel type, pressure, capacity and temperature), water and air;

(2) lifetime performance instruction of FC power systems required in 7.4.3.12 and 7.4.4.10;

(3) risk assessment of FC power installations (see 7.3.2);

(4) a Failure Mode and Effects Analysis (FMEA) report of FC power systems for determining the monitoring and control range, see 10.2.4.2, which may be part of the risk assessment report specified in 1.2.2.1(2);

(5) a risk assessment of enclosed or semi-enclosed bunkering stations, see 6.2.1.1;

(6) stress analysis report required in 4.2.2.7.

1.2.3 Plans and documents kept on board

1.2.3.1 In addition to those specified in CCS Rules, the following documents are to be kept on board:

(1) an operation manual of FC power installations, see 7.3.3.1;

(2) a maintenance manual (see 7.3.3.2) and maintenance / check records of FC power installations;

(3) potential hazards instruction (see 7.3.3.3) and safety precautions to mitigate risks;

(4) a safe operation procedure of fuel tanks.

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① The intrinsically safe circuits are to be so installed that the inductance and capacitance of their equipment, including cables, do not exceed the listed values of the associated apparatus, and the values of permissible input voltage, input current of each intrinsically safe apparatus is to be greater than or equal to the listed values respectively of the associated apparatus. Refer to IEC 60079-14: "Explosive atmosphere-Part 14: Electrical installations design, selection and erection" or equivalent standards.

Section 3 PRODUCTS SURVEYS

1.3.1 General requirements

1.3.1.1 In addition to the Guidelines, products surveys are to comply with the relevant requirements of CCS Rules and the products surveys guidelines of CCS.

1.3.1.2 Equipment, piping and valves related to the fuel, such as hydrogen cylinders, fuel reformers, fuel cell modules and fuel cell power systems, may be used on board after approved and certified by CCS.

Section 4 SHIP SURVEYS

1.4.1 General requirements

1.4.1.1 All survey programmes, survey methods, types of survey, intervals between the surveys, survey conditions, preparations before survey, survey and testing requirements and preservation of the drawings and documentation, certificates, records and reports etc., are to be in compliance with CCS Rules for Classification of Sea-going Steel Ships, or in compliance with CCS Regulations for Classification of Inland Waterways Ships for inland waterways ships.

1.4.2 Surveys during construction

1.4.2.1 In addition to following the applicable requirements of CCS rules, the following survey items are to be carried out in surveys during construction:

(1) Installation and testing of the FC power installations. Testing of the whole system is to be performed in different relevant load conditions (typically: ‘start up’, ‘normal running’, ‘full load’, ‘controlled shut-down’ and ‘emergency shut-down’). It is to be verified for the following events that the FC power installation is automatically transferred into a safe condition:

① fire detection;

② gas detection;

③ failure of the power supply;

④ failure of the programmable logic controllers ;

⑤ triggering of the protective devices;

⑥ failure of the protective devices;

⑦ failure in the protective system;

⑧ other failures with a high risk level based on the risk assessment report.

(2) Installation and testing of the fuel containment systems;

(3) Installation and testing of the fuel bunkering systems;

(4) Installation and testing of the fuel supply systems;

(5) Installation and testing of the piping systems. The piping, valves and connections are to be tested with an appropriate test gas to show that there is no leakage;

(6) Installation and testing of the ventilation systems of the FC spaces, fuel tank spaces, double-wall pipes (if any) and tank connection spaces (if any) ;

(7) Installation and testing of the gas detection systems;

(8) Installation and test of means of the fire protection, detection and extinction;

(9) functional tests of the monitoring, control and safety systems;

(10) verification and safety inspection of the explosion-proof or ignition-proof equipment;

(11) examination of the availability of the interlock (if fitted) of the circuit-breakers connecting the FC power installation and the ship’s main grid;

(12) The followings are to be tested to verify the interaction of the FC power installation with other systems of the ship for ships requesting FC-FULL and FC-POWER 1 notations:

① power supply independently by the FC power installation (appropriate for a ship with the FC-FULL notation);

② power supply by the FC power installation and the generating set (if any);

③ power supply by the FC power installation and the battery (if any);

④ changeover to the stand-by power supply system;

⑤ cut-in and cut-off of the FC power installation;

⑥ sudden load change and load cut-off.

If the FC power installation constitutes the main propulsion system of the ship, it is to be verified that the ship has adequate propulsion power in all maneuvering situations.

If the FC is needed for starting from a dead ship condition, it is to be demonstrated that it complies with the relevant requirements of 7.4.3.8 and 7.4.4.7.

(13) Verifying that the technical documents required in 1.2.3 are kept on board the ship.

1.4.3 Surveys after construction

1.4.3.1 Annual surveys: in addition to following the applicable requirements of CCS Rules, the following survey items are to be carried out:

(1) Fuel containment systems

① checking of the outer walls and key portions of the fuel tank for any defect or abnormality;

② checking of the satisfactory operation of the tank’s indicators and monitoring and alarm devices;

③ checking of the correct calibration and satisfactory operation of the pressure relief system;

④ confirmation of the safe operation procedure for the tank being on board;

⑤ the following items[①] are to be subject to examination and testing for hydrogen cylinders:

(a) external examination;

(b) screw examination;

(c) cylinder accessories examination;

(d) internal examination;

(e) pressure test;

(f) gas tightness test;

(g) non-destructive testing (applicable for welded steel hydrogen cylinders and seamless steel hydrogen cylinders);

(h) welding inspection (applicable for welded steel hydrogen cylinders);

(i) wall thickness measurement (applicable for welded steel hydrogen cylinders);

(j) weight (volume) determination (applicable for seamless steel hydrogen cylinders).

(2) Examining the satisfactory situation of the sealing devices for the tank connection space (if any) and gas valve unit space;

(3) Examining whether the doors, side scuttles and windows of the end bulkheads of the superstructure and deckhouse facing the hazardous area are in good conditions;

(4) Examining whether the shutdown devices and other means (if any) used to close any special enclosed space to protect the crew in case of fuel leakage are in normal working condition;

(5) Examining whether the ventilation system and air lock (if any) of working spaces and the ventilation shutdown device of accommodation spaces are in order;

(6) Examining whether the manual ESD buttons are in order;

(7) Examining the vent pipe system, including vent masts and protective screening; Special attention is to be given to the expansion joints and brackets on gas pipes;

(8) Examining whether the electrical installations in hazardous areas are in order, and checking the maintenance repair records;

(9) Examining and testing the gas detection systems to confirm their satisfactory operation;

(10) Examining and confirming that no significant changes have been made to the fire structures and arrangement of fuel tank spaces, bunkering stations and FC spaces etc.;

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① The items (d) to (j) are to be checked every three years. The items (d) to (j) are to be checked every two years for seamless steel hydrogen cylinders or welded steel hydrogen cylinders exposed to a corrosive atmosphere, such as corrosive gas and salt water. The shipowner or operator is to immediately apply for regular inspection of hydrogen cylinders in any of the following circumstances during use: (1)an open fire to the cylinder; (2)the cylinder under an attack; (3)the ship suffering from a collision; (4)the cylinder exposing to chemical substances; (5)the cylinder making an abnormal sound; (6)confirmation of any damage, in some way, to the cylinder; (7)any doubt as to the cylinder's safety.

(11) Examining the fire detection and extinction systems, and testing one main fire-fighting pump;

(12) Examining the satisfactory operation of the fire-extinguishing systems and water spray systems;

(13) Confirming the satisfactory operation of the FC power system and checking its running to ensure adequate generated power for the whole ship's load. Otherwise it is to be replaced.

(14) Confirming the safety earthing of pipes and tanks to the hull;

(15) Checking the maintenance repair records of the fuel system, e.g. the engine logbook;

(16) The fuel cell power system is to be maintained and inspected by professionals (generally the manufacturer or its authorized personnel), which is to be recorded and kept up to date. The Surveyor is to check the maintenance/inspection records and confirm that the system has been maintained and inspected in accordance with the time limit specified in the Maintenance Manual of 7.3.3.2 and is in good condition.

1.4.3.2 Intermediate surveys: in addition to following the applicable requirements of CCS Rules and the requirements of 1.4.3.1, the following survey items are to be carried out:

(1) Confirming the provision of spares for the fans used for the mechanical ventilation of hazardous spaces;

(2) Examining visually the pressure, temperature and liquid level instruments of fuel systems and carrying out comparative test by changing the pressure, temperature and liquid level; A simulation test may be accepted to the inaccessible sensors. including alarm test and safety functional test;

(3) Electrical equipment: ground protection (checking of earthing contact), integrity of flame-proof enclosures, damage of cable jackets, functional tests of pressurized apparatuses and the related alarm devices for the electrical equipment within hazardous areas as far as possible, testing of shutoff the power supply for non-certificated explosion-proof electrical equipment in the spaces protected by air locks (if any), and measurement of insulation resistance.

1.4.3.3 Special surveys: in addition to following the applicable requirements of CCS Rules and the requirements of 1.4.3.2, the following survey items are to be carried out:

(1) Fuel containment systems

① gastight testing for the tank together with its connecting pipes with an appropriate test medium. Air is not permitted to be used as test medium unless gas composition in the tank is qualified before the gas-tightness test;

② a hydraulic / pressure test for the tank and its connecting pipes. The hydraulic test may be dispensed with, provided that the plate and tower structures of the tank supporting, bearing and pipe connecting pieces and sealing devices of penetrations in the deck are in order, the working of gas monitoring systems is satisfied and the navigation records declare no abnormal operation;

③ all valves and cocks directly connecting to the tank are to be opened up for examination, and where practicable the internal examination is to be carried out for connecting pipes;

④ the tank's pressure relief valves and vacuum relief valves are to be opened out for examination, and the valve settings are to be calibrated, if applicable;

⑤ in the case of tanks covered by insulation, enough insulation is to be removed, in particular, in way of connections and supporting, to ensure that the tank is in order.

(2) Checking of the set value of pressure relief valves on gas and liquid fuel pipes;

(3) Valves on gas pipes are to be calibrated, and the valves may be dismantled for setting with air or other applicable gas;

(4) Examining the inert gas generator to confirm that the generated inert gas is compliance with the technical specifications and the generator is in order;

(5) A general examination of inert gas distributing valves and pipes, an internal and external examination of pressure vessels for storage of inert gas and a special survey are to be carried out, and the satisfactory condition of pressure relief valves confirmed;

(6) Removing the shaft seal on the gastight bulkhead and examining the sealing device;

(7) Each compressor being opened up to examine the moving parts, fixed parts, valves, valve seat rings, gland covers, relief devices, filters and lubricating equipment, etc. Where the Surveyor is satisfied to the alignment and abrasion, the lower bearing and crankcase seal glands may not be opened up for examination;

(8) Examination of the pipes covered with insulation material by removing sufficient insulation material to confirm the situation of the pipe. A special inspection is to be carried out to the sealing condition;

(9) Checking of the maintenance records of the FC power installation to confirm the completion of all periodical and routine maintenance according to the requirements of the manufacturer specified in 7.3.3.2.

CHAPTER 2 SHIP DESIGN AND ARRANGEMENT

Section 1 GENERAL PROVISIONS

2.1.1 General requirements

2.1.1.1 Unless otherwise specified, the arrangement and system design of a fuel cell powered ship are to comply with the provisions of this Chapter. In addition, they are to comply with the relevant requirements of CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel, or Guidelines for Ships Using Ammonia Fuel where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

Section 2 ARRANGEMENT OF HYDROGEN TANKS

2.2.1 General requirements

2.2.1.1 Hydrogen tanks are to be located in such a way that the probability of damage following a collision or grounding is minimized.

2.2.1.2 Hydrogen fuel is to be stored above the main deck as far as practicable and as far as practicable away from the bridge, accommodation space and service space.

2.2.1.3 Hydrogen tanks are to be protected against mechanical damage.

2.2.1.4 The shell of each hydrogen tank is to be equipped with earthing arrangements according to CCS Rules, and the number of ground points is not to be less than two.

2.2.2 Hydrogen tanks

2.2.2.1 Hydrogen tanks are to be located in such a way that their external structure and necessary accessories thereof, including the tank head valves and safety relief devices, comply with the following requirements to avoid from external damage following a collision or grounding:

(1) For sea-going ships:

① The tank(s) is(are) to be located at a minimum distance of $B/5$ or 11.5 m, whichever is less, measured inboard from the ship side at right angles to the centreline at the level of the summer load line draught;

② The tank(s) is(are) to be located above the minimum distance of $B/15$ or 2.0 m, whichever is less, measured from the moulded line of the bottom shell plating at the centreline;

③ In no case, the boundary of the fuel tank is to be located closer to the shell plating or aft terminal of the ship than as follows:

(a) For passenger ships: $B/10$ but in no case less than 0.8 m.

(b) For cargo ships: not less than 0.8 m.

(2) For inland waterways ships:

① The tank(s) is(are) to be located at a minimum distance of B/10 or 1.0 m, whichever is less, measured inboard from the ship side at right angles to the centreline at the level of the full load line draught;

② The tank(s) is(are) to be located above the minimum distance of B/15 or 2.0 m, whichever is less, measured from the moulded line of the bottom shell plating at the centreline;

③ In no case, the boundary of the fuel tank is to be located to the shell plating or aft terminal of the ship not less than 0.8 m.

(3) The tank(s) is (are) to be abaft a transverse plane at 0.08L measured from the forward perpendicular for passenger ships, and abaft the collision bulkhead for cargo ships.

Where:

B, in m, taken as the greatest breadth between the transverses at both sides amidships (for sea-going ships); and B is taken as the horizontal distance between the inner surfaces of side plating at the widest part of the ship, excluding sponson decks, fenders and other projections (for inland waterways ships). B is the demihull breadth for mutihull vessels.

L is the ship's length defined by the load line, in m.

2.2.2.2 Hydrogen tanks, hydrogen buffer tanks or similar devices located on open deck are to be located to ensure sufficient natural ventilation against accumulation of escaped gas.

2.2.2.3 The hydrogen tank located on the aft open deck is to provide suitable protection against damage to the tank due to rear-front collision.

2.2.2.4 A hydrogen tank space is not to be located in FC spaces, machinery spaces of category A (for sea-going ships) / essential machinery spaces (for inland waterways ships) and other rooms with high fire risk or adjacent to such spaces. Cofferdams and fire divisions between a hydrogen tank space and the adjacent space are to be provided according to 9.2.1 of Chapter 9.

2.2.2.5 "NO SMOKING", "NO OPEN FLAME" and similar warning signs are to be prominently and permanently displayed for a hydrogen tank space and are to be painted in a contrasting colour.

2.2.2.6 Any installation or material which may be taken as a source of ignition is not to be provided in a hydrogen tank space. If this is inevitable, the fitted electrical installations are to be of a certified safe type. As an exception, head valves with automatic shut-off function on a hydrogen cylinder are to comply with the requirements of 7.2.1.3 of Chapter 7.

2.2.2.7 In addition to all requirements in this Section, hydrogen cylinders are to be arranged according to the followings:

(1) Only hydrogen cylinders and fire extinguishers are permitted to be stored in a hydrogen cylinder store room.

(2) The store room is to be constructed of steel and have direct access from an open deck.

(3) The store room is to be fitted with a mechanical extraction ventilation system of the extraction type

that meets the requirements of Section 3 of Chapter 8 of the Guidelines, independent of other ventilation systems. The ventilation outlet is to be vertically upwards from the top of the store room and far away from any sources of ignition and heat source.

(4) Where stored on an open deck, hydrogen cylinder is to be:

① protected against any damage to the hydrogen cylinder and pipes;

② provided with anti-collision and protective fences, as well as obvious "No fire" signs;

③ provided with proper drainage;

④ protected from exposing to the sun with sun-shading measures;

⑤ so arranged that its outlet is so far as practicable to be clear of personnel activity area, such as an accommodation space, public space, service space, life-saving appliance area and access.

Section 3 FUEL CELL SPACES

2.3.1 Safety principles

2.3.1.1 In order to minimize the probability of a gas explosion in a FC space, it is to meet the requirements of this Section, or an equivalent safety concept.

2.3.1.2 The FC space concept is such that the space is designed to mitigate hazards to non-hazardous levels under normal conditions, but under certain abnormal conditions may have the potential to become hazardous, which may be achieved by one of the followings:

(1) Equipment protected FC spaces: such FC spaces are considered as hazardous zone 1 and all electrical equipment is to be certified for zone 1. The fuel cell itself is not considered a source of ignition if the surface temperature of the stack is kept below 300℃[①] 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.

(2) Where the prescriptive area classification is considered to be inappropriate, area classification according to a standard[②] accepted by CCS may be applied according to 7.2.1.1 after CCS approval, taking into account the following guidance: All electrical equipment is to be chosen according to the resulting area classification.

(3) Where the space is inerted according to 8.2.3, the following guidance may be taken into account after CCS approval: An emergency shutdown (ESD) need not be carried out in the case of detecting leakage because inerting mitigates the ignition hazards. In this condition, another power supply system is to supply power automatically , and a controlled shutdown (CSD) of the fuel cell and the affected fuel supply system is to be initiated in order to avoid a failure of the fuel cell power system.

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① The 300℃ threshold is taken from IEC 60079-20-1:2010, where the maximum surface temperature is set to 450℃ for hydrogen and LNG, and 300℃ for methanol/ethanol and LPG. To ensure safe operation of the fuel cell power systems regardless of the fuel cell and fuel type, these Guideline refer to the lowest threshold for the relevant fuels mentioned in IEC60079-20-1:2010, that is 300℃.

② Refer to IEC 60079-10-1: Explosive atmosphere-Part 10-1: Classification of areas-Explosive gas atmospheres.

2.3.1.3 The design of FC power systems is to comply with the standards[①] accepted by CCS, or industry standards having at least equivalent safety level.

2.3.1.4 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.

2.3.1.5 A means is to be provided to safely remove the primary fuel and reformed fuel in the fuel cell power system.

2.3.1.6 A means is to be provided to set a fuel cell power installation in a safe state for maintenance and shutdown.

2.3.1.7 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.

2.3.1.8 The probability of a gas accumulation and explosion in FC spaces is to be minimized by a mitigating strategy which may include one or more of the below:

(1) purging the FC power system before initiating the reaction (see 7.3.1.6 of Chapter 7);

(2) purging the system as necessary after shutdown; (see 7.3.1.6 of Chapter 7);

(3) providing failure monitoring for the buffer tank (if fitted) within the fuel cell;

(4) monitoring potential contamination of air into fuel cells fuel lines, or fuel cells fuel into air pipes (see 10.2.4.2(1) and 10.2.4.2(2) of Chapter 10). A monitoring device is to be provided to maintain the gas concentration below the explosion limit after fuel cells fuel into air pipes by increasing the air.

(5) monitoring pressures and temperatures of the fuel cell;

(6) implementing a pre-programmed sequence to contain or manage the propagation of the reaction to other sections of the fuel cell system or to the surrounding space;

(7) any other protection measures as deemed necessary by CCS.

2.3.2 Arrangement and access

2.3.2.1 It is to be possible to shut down the fuel cell power system from an easily accessible location outside the fuel cell spaces.

2.3.2.2 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(s).

2.3.2.3 Fuel cell space boundaries are to be gastight to other enclosed spaces in the ship.

2.3.2.4 Fuel cell spaces are to be arranged outside of accommodation spaces, service spaces, machinery spaces of category A (for sea-going ships) / essential machinery spaces (for inland waterways ships) and control stations.

2.3.2.5 Fuel cell spaces are to be designed to safely contain fuel leakages and they are to be provided with suitable leakage detection systems and to be arranged to avoid the accumulation of flammable gas by

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① Refer to IEC 62282 Fuel Cell Technologies - Part 2-100: Fuel Cell Modules - Safety and IEC 62282 Fuel Cell Technologies - Part 3-100: Stationary Fuel Cell Power Systems - Safety.

having simple geometrical shape and no obstructing structures in the upper part and with a smooth ceiling sloping up towards the ventilation outlet. Beams, stiffeners and similar support structures are to be arranged externally. Thin plate ceiling to cover support structure under the deck plating is not acceptable.

2.3.2.6 Where containing any reformer, the FC space is to comply with the safety principles and rules related to the primary fuel concerned.

2.3.2.7 Where an independent and direct access to the fuel cell space from the open deck cannot be arranged, access to the fuel cell space is to be through an air lock which complies with Section 6 of this Chapter.

2.3.2.8 An air lock required in 2.3.2.7 of this Section is not required if appropriate technical provisions are made such that access to the space is not required and not made 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. These provisions include but are not limited to:

(1) 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;

(2) All parameters required for safe operation and gas freeing are to be remotely monitored and alarms are to be given;

(3) The space openings are to be equipped with an interlock (with the running signals of the FC power installation) preventing operation with the space open;

(4) The spaces are to be provided with suitable fuel leakage collection and draining arrangements for remote operation from outside the space; and

(5) Provisions are to be made that the fuel equipment inside can be isolated from the fuel system, drained of fuel and purged safely for maintenance.

Section 4 HYDROGEN FUEL PREPARATION ROOMS

2.4.1 General requirements

2.4.1.1 Fuel preparation rooms are to be located on an open deck. If located below the freeboard deck, it is to meet the following requirements:

(1) The boundary of the fuel preparation room adjacent to machinery space of category A (for sea-going ships) /essential machinery space (for inland waterways ships) is to be insulated to ‘A-60’ class standard;

(2) Its boundaries, including exits, are to be gastight;

(3) Fuel preparation rooms are to have independent access direct from the open deck which cannot be serviced for any other space.

2.4.1.2 If compressors or pumps are driven by shafting passing through a bulkhead or deck, the bulkhead penetrations are to be of gastight type to prevent gas leakage into the compartment where the shaft power is located.

2.4.1.3 The compressors/bumps mentioned in 2.4.1.2 of this Section, installed in a compartment, are to be fitted with temperature sensing devices for shaft glands, bearings and pump casings. A continuous audible and visual alarm signal is to be automatically effected in the compressor/pump control station.

Section 5 ENTRANCES AND OTHER OPENINGS IN ENCLOSED SPACES

2.5.1 General requirements

2.5.1.1 Fuel tank spaces are to have an independent access direct from the open deck as far as practicable. Where a separate access from deck is not practicable, an airlock which complies with Section 6 of this Chapter is to be provided.

2.5.1.2 For inerted spaces access arrangements are to be such that unintended entry by personnel is to be prevented. If access to such spaces is not from an open deck, sealing arrangements are to ensure that leakages of inert gas to adjacent spaces are prevented.

2.5.1.3 For fuel storage hold spaces and inerted spaces, safety marks are to be equipped near the entrance and exit to prevent accidental entry.

Section 6 AIRLOCKS

2.6.1 General requirements

2.6.1.1 An airlock is a space enclosed by gastight bulkheads with two substantially gastight doors spaced at least 1.5 m and not more than 2.5 m apart. The doors are to be self-closing without any holding back arrangements. The door sill is not to be less than 300 mm in height. In addition, the door still for sea-going ships is to comply with the International Convention on Load Lines or the relevant requirements for the openings of freeboard decks and superstructure decks in PART 3 of the Technical Regulations for Statutory Surveys of Sea-going Ships Engaged on Domestic Voyages.

2.6.1.2 Airlocks are to be mechanically ventilated at an overpressure relative to the adjacent hazardous area or space.

2.6.1.3 The airlock is to be designed in a way that no gas can be released to safe spaces in case of the most critical event in the gas dangerous space separated by the airlock.

2.6.1.4 Airlocks are to have a simple geometrical form. They are to provide free and easy passage, and are to have a deck area not less than 1.5 m^2. Airlocks are not to be used for other purposes, for instance as store rooms.

2.6.1.5 An audible and visual alarm system to give a warning on both sides of the airlock is to be provided to indicate if more than one door is moved from the closed position.

2.6.1.6 For non-hazardous spaces with access from hazardous spaces below deck where the access is protected by an airlock, upon loss of underpressure in the hazardous space access to the space is to be restricted until the ventilation has been reinstated. Audible and visual alarms are to be given at a manned location to indicate both loss of pressure and opening of the airlock doors when pressure is lost.

2.6.1.7 Essential electrical equipment required for safety is not to be de-energized and is to be of a certified safe type. This may include lighting, fire detection, public address, general alarms systems.

CHAPTER 3 MATERIALS

Section 1 GENERAL PROVISIONS

3.1.1 General requirements

3.1.1.1 Materials used for components and equipment using hydrogen fuel and fuel cells are to be accordance with the requirements of this Chapter. In addition, the materials are to comply with the relevant requirements of CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel, where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

3.1.1.2 Unless expressly provided in this Chapter, materials and welding of a ship are to comply with the requirements of the CCS Rules for Materials and Welding.

3.1.1.3 The use of materials within the FC power installations is to be suitable for the intended application and environment.

3.1.1.4 The use of combustible materials inside the fuel cell power system are to be minimized. However, the use of combustible materials is to be acceptable for sealing and electrical insulating purposes subject to CCS approval.

3.1.2 Materials for components and equipment using hydrogen fuel

3.1.2.1 Materials used in all components in contact with hydrogen are to be resistant to hydrogen embrittlement and hydrogen attack.

3.1.2.2 Materials used for hydrogen cylinders with a working pressure not exceeding 30 MPa are to comply with the standards accepted by CCS[①], and are to comply with the relevant safety technical specifications for gas cylinders[②].

3.1.2.3 Materials used for hydrogen cylinders with a working pressure exceeding 30 MPa may refer to the standards accepted by CCS[③], and are to comply with the relevant safety technical specifications for gas cylinders[④].

3.1.2.4 Fuel pipes are to be seamless steel pipe and made of austenitic stainless steel. Materials used for pipes with a design pressure of 20 MPa or above are to be S31603 or S31608 stainless steel.

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① The international, national and industrial standards for gas cylinders. Such as ISO 1114 Gas Cylinders - Compatibility of Cylinder and Valve Materials with Gas Contents, ISO 09809 Gas Cylinders — Refillable Seamless Steel Gas Cylinders - Design, Construction and Testing, GB/T 5099 Seamless Steel Gas Cylinders and GB 11640 Seamless Aluminum Alloy Gas Cylinders.

② Refer to TSG 23: 2021 Regulations on Safety Technology for Gas Cylinder.

③ Refer to ISO 19881 Gaseous hydrogen - Land vehicle fuel containers, GTR 13 Global technical regulations on hydrogen and fuel cell vehicles and GB/T 35544 Fully-wrapped carbon fiber reinforced cylinders with an aluminum liner for the on-board storage of compressed hydrogen as a fuel for land vehicles.

④ Refer to TSG 23: 2021 Regulations on Safety Technology for Gas Cylinder.

3.1.3 Fuel cells

3.1.3.1 Materials are to comply with the standards accepted by CCS[①].

① The international, national and industrial standards for fuel cells, e.g. IEC 62282 series.

CHAPTER 4 PIPE DESIGN AND FUEL SUPPLY

Section 1 GENERAL PROVISIONS

4.1.1 General requirements

4.1.1.1 Unless otherwise specified, the design of the pipes which may contact with hydrogen fuel and the hydrogen supply are to comply with the requirements of this Chapter. In addition, the design of the pipes contacting with natural gas, methanol/ethanol, ammonia or other fuel and the fuel supply are to comply with the relevant requirements of CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel.

4.1.1.2 The manufacture, process and testing of the fuel pipes are to comply with the appropriate requirements of Chapter 13 of CCS Rules for Ships Using Natural Gas Fuel.

4.1.1.3 Fuel piping are to be capable of absorbing thermal expansion or contraction caused by extreme temperatures of the fuel without developing substantial stresses.

4.1.1.4 Provision is to be made to protect the piping, piping system and components and fuel tanks from excessive stresses due to thermal movement and from movements of the fuel tank and hull structure.

4.1.1.5 If the fuel gas contains heavier constituents that may condense in the system, means for safely removing the liquid are to be fitted.

4.1.1.6 Low / high temperature piping are to be thermally isolated from the adjacent hull structure to prevent the temperature of the hull from falling below the design temperature of the hull material.

4.1.1.7 The fuel supply system is to be so arranged that the consequences of any release of fuel will be minimized, while providing safe access for operation and inspection.

4.1.1.8 The piping system for fuel transfer to the consumers is to be designed in a way that a failure of one barrier cannot lead to a leak from the piping system into the surrounding area causing danger to the persons on board, the environment or the ship;.

4.1.1.9 Fuel lines outside the fuel cell spaces are to be installed and protected so as to minimize the risk of injury to personnel and damage to the ship in case of leakage.

Section 2 DESIGN AND ARRANGEMENT OF HYDROGEN PIPES

4.2.1 General requirements

4.2.1.1 Fuel pipes and all the other piping are to be colour marked in accordance with a standard accepted by CCS①.

4.2.1.2 Where tanks or piping are separated from the ship's structure by thermal isolation, provision is to

① E.g. GB 3033 and EN ISO 14726 Ships and marine technology － Identification colours for the content of piping systems.

be made for electrically bonding to the ship's structure both the piping and the tanks. All gasketed pipe joints and hose connections are to be electrically bonded.

4.2.1.3 Pipes, which may contain low temperature fuel, are to be thermally insulated to an extent which will minimize condensation of moisture or frosting.

4.2.1.4 Piping other than fuel supply piping and cabling may be arranged in the double-wall piping or duct provided that they do not create a source of ignition or compromise the integrity of the double pipe or duct. The double wall piping or duct is to only contain piping or cabling necessary for operational purposes.

4.2.1.5 Unless otherwise specified, the fuel supply piping system for fuel cells is to be independent of other fuel supply systems.

4.2.1.6 Fuel cell fuel pipes are not to be located less than 800 mm from the ship's side, except the inner sides of the hull of a catamaran.

4.2.1.7 Fuel pipes located on the exposed deck or led through ro-ro spaces, special category spaces and on open decks are to be protected against mechanical damage.

4.2.1.8 An arrangement for purging fuel cell fuel bunkering and supply lines with inert gas is to be provided.

4.2.1.9 The arrangement and installation of fuel piping for fuel cells are to provide the necessary flexibility to maintain the integrity of the piping system in the actual service situations, taking potential for fatigue into account.

4.2.1.10 The welded joints of fuel pipes are to be of full penetration as far as practicable. If it is not practicable to avoid using other types of joints, protection is to be provided based on the requirements in 4.3.5.2 or other protective measures that have been tested and verified to reliable to prevent leakage dispersion.

4.2.1.11 All components in fuel piping are to be made of materials suitable for their intended use and with corrosion resistance, and all tubes in fuel piping are to be seamless steel pipe.

4.2.1.12 Pipes, fittings, joints and valves of hydrogen, oxygen, natural gas or similar fuel supply systems are to comply with the requirements for class I pipe.

4.2.1.13 For the auxiliary systems of the fuel cell power system where fuel may leak directly into a system medium (e.g., cooling water), such auxiliary systems are to be equipped with appropriate gas extraction and detection measures fitted as close as possible after the media outlet from the system or in the expansion tank in order to prevent gas dispersion. The gas extracted from the auxiliary system media is to be vented to a safe location on the open deck and be suitably protected against collision or damage due to handling cargo.

4.2.2 Wall thickness and strength

4.2.2.1 The minimum wall thickness is to be calculated as follows:

$$t = (t_0 + b + c) / (1 - a/100) \text{ (mm) mm}$$

where, t_0——theoretical thickness, in mm $t_0 = PD / (2.0Ke + P)$ (mm);

with: P = design pressure, in MPa;

D = outside diameter, in mm;

K = allowable stress, in N/mm^2;

e = efficiency factory equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, that are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases an efficiency factor of less than 1.0, in accordance with recognized standards, may be required depending on the manufacturing process;

b = allowance for bending (mm). The value of b is to be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b is to be: $b=D\cdot t_0/2.5r$ (mm)

with: r = mean radius of the bend (mm);

c = corrosion allowance, in mm. If corrosion or erosion is expected the wall thickness of the piping is to be increased over that required by other design regulations. This allowance is to be consistent with the expected life of the piping; and

a=negative manufacturing tolerance for thickness (%).

4.2.2.2 The greater①② of the following design conditions is to be used for piping, piping system and components:

(1) for systems or components which may be separated from their relief valves and which contain only vapour at all times, vapour pressure at 45° C assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature;

(2) the MARVS of the fuel tanks and fuel processing systems;

(3) the pressure setting of the associated pump or compressor discharge relief valve;

(4) the maximum total discharge or loading head of the fuel piping system;

(5) the relief valve setting on a pipeline system.

4.2.2.3 Piping systems are to have a minimum design pressure of 1.0 MPa (gauge pressure) except for open ended lines where it is not to be less than 0.5 MPa (gauge pressure).

4.2.2.4 For pipes made of steel including stainless steel, the allowable stress to be considered in the formula of the strength thickness in 4.2.2.1 is to be the lower of the following values:

$$Rm/2.7 \text{ or } Re/1.8$$

where: R_m= specified minimum tensile strength at room temperature (N/mm^2); and

① Lower values of ambient temperature regarding design condition in 4.2.2.2(1) may be accepted by CCS for ships operating in restricted areas.

② For ships on voyages of restricted duration, P0 may be calculated based on the actual pressure rise during the voyage and account may be taken of any thermal insulation of the tank. Reference is made to the Application of amendments to gas carrier codes concerning type C tank loading limits (SIGTTO/IACS).

R_e= specified minimum yield stress at room temperature (N/mm^2). If the stress strain curve does not show a defined yield stress, the 0.2% proof stress applies.

4.2.2.5 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness is to be increased over that required by 4.2.2.1 of this Section or, if this is impracticable or would cause excessive local stresses, these loads are to be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to supports, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections, or otherwise.

4.2.2.6 High pressure fuel piping systems are to have sufficient constructive strength. This is to be confirmed by carrying out stress analysis and taking into account:

(1) stresses due to the weight of the piping system;

(2) acceleration loads when significant; and

(3) internal pressure and loads induced by hog and sag of the ship.

4.2.2.7 When the design temperature is minus 110° C or colder, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship are to be carried out for each branch of the piping system.

4.2.2.8 Fuel piping systems are to have sufficient constructive strength to withstand maximum operating temperature and pressure.

4.2.2.9 In addition to the provisions mentioned above, the minimum thickness of gas piping is to comply with the requirements of CCS Rules.

Section 3 HYDROGEN FUEL SUPPLY PIPING SYSTEMS

4.3.1 General requirements

4.3.1.1 This Section applies to primary fuel and reformed fuel (if any) supply piping systems other than fuel cell modules, including hydrogen circulating pipes.

4.3.1.2 A manually operated stop valve and a tank master valve in series, or a combined manually operated and master valve are to be fitted in every gas supply outlet of the tank, and to be located close to the tank as far as possible. The master fuel valve is to be capable of automatically shutting off the fuel supply in accordance with Table 10.4.1.

4.3.1.3 The fuel inlet to each fuel cell power system is to be equipped with a manually operated stop valve and an automatically operated stop valve coupled in series or a combined manually and automatically operated valve.

4.3.1.4 The fuel supply manifold to each fuel cell power system is to be equipped with a manually operated stop valve and a master fuel valve coupled in series or a combined manually and automatically operated valve. The master fuel valve is to be capable of automatically shutting off the fuel supply in accordance with Table 10.4.1.

4.3.1.5 The master fuel valve is to be fitted on the pipes outside of the fuel cell space, and is to be capable of being manually shutoff from all escape routes in the fuel cell space, at a location outside spaces containing fuel cells, outside the fuel preparation room and at the bridge etc. The activation device of manual emergency shutdown is to be arranged as a physical button, duly marked and protected against inadvertent operation, as well as be capable of operating under emergency lighting.

4.3.2 Fuel piping systems inside the fuel cell space

4.3.2.1 The surface temperature of fuel piping in the fuel cell space is to be less than 300℃.

4.3.2.2 The heating media from liquid gas vaporizers or gas preheaters is to pass through the deaerator within the hazardous area before its return to a space outside of the fuel preparation room.

4.3.2.3 Gas supply piping in FC spaces is to be double wall piping, which could be designed to be one of the following two forms:

(1) The gas piping is to be a concentric pipe made up by an inner pipe and an outer pipe with the gas fuel contained in the inner pipe. The space between the concentric pipes is to be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms are to be provided to indicate a loss of inert gas pressure between the concentric pipes. When the inner pipe contains high pressure gas, the system is to be so arranged that the pipe between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed.

(2) The gas fuel piping is to be installed within a ventilated duct. The air space between the gas fuel piping and the ventilated duct is to be equipped with mechanical underpressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity may be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors are to comply with the required explosion protection in the installation area. The ventilation outlet is to be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited.

4.3.2.4 The design pressure of the outer pipe or duct of fuel supply pipes is not to be less than the maximum working pressure of the inner pipe. Alternatively, the design pressure of the duct is to be the greater of the followings for high pressure gas piping systems:

(1) the maximum built-up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space;

(2) local instantaneous peak pressure in way of the rupture (p*), given by the following expression:

$$p^* = p_0\left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

where, p_0——maximum working pressure of the inner pipe;

k——constant pressure specific heat divided by the constant volume specific heat, $k = 1.31$ for CH_4 and $k = 1.41$ for H_2.

The tangential membrane stress of a straight pipe is not to exceed the tensile strength divided by 1.5 ($R_m/1.5$) when subjected to the above pressures. The pressure ratings of all other piping components are to reflect the same level of strength as straight pipes. As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests can be used, but the test report is to be submitted.

4.3.2.5 Verification of the strength is to be based on calculations demonstrating the duct or pipe integrity. As an alternative to calculations, the strength can be verified by representative tests.

4.3.3 Fuel supply outside of the fuel cell space

4.3.3.1 Fuel piping are not to be led directly through machinery spaces other than FC spaces, accommodation spaces, service spaces, electrical equipment rooms or control stations and their air inlets. Fuel piping passing through enclosed spaces other than these spaces are to be double walled. The double wall piping is to comply with the applicable requirements of Section 6 of Chapter 8, and a gas detector is to be provided according to Section 3, Chapter 10 of the Guidelines.

4.3.3.2 The design pressure of the double wall pipe in an enclosed space is to comply with 4.3.2.4 and 4.3.2.5 of this Section.

4.3.4 Additional requirements for hydrogen piping

4.3.4.1 Unless provided in 4.3.5 otherwise, hydrogen piping is to be designed and arranged according to all applicable requirements in this Chapter.

4.3.4.2 As far as practicable, hydrogen lines are to be arranged far apart from hot surfaces, electrical installations or other positions where an arc or sources of ignition may occur.

4.3.4.3 Metal parts supporting and securing pipes are not to be in direct contact with the pipes.

4.3.4.4 Rigid piping is to be arranged properly and in order, without any collision and friction with adjacent parts; Pipe supports and protective pads are to be vibration-resistant and eliminate the impact of expansion and contraction. The pipe's radius of curvature of the center line is to be no less than three times the outer diameter of the pipe when bending. The middle part of a pipe fixed at both ends is to be properly bent with supports having a spacing of not more than 1 m.

4.3.4.5 The pipes between hydrogen cylinders and FCs are to be provided with valves and equipment based on the FC's characteristics and the system design, where necessary, such as flow-limiting valves, high pressure-reducing valves, fire valves and regulator valves. The fuel supply pipes are to be monitored and controlled according to 10.2.2 to 10.2.5.

4.3.5 Hydrogen pipes within hydrogen cylinder rooms and FC spaces

4.3.5.1 If the hydrogen supply pipes used in the fuel cell system cannot be double-walled, it is:

(1) not be led through any enclosed spaces outside of FC spaces and hydrogen cylinder rooms;

(2) be fully welded;

(3) be arranged to minimize the number of connections;

(4) use fixed hydrogen detectors being capable of detecting a hydrogen leak in places where leakage of

hydrogen may occur, such as valves, flanges, seals, etc.

4.3.5.2 If a hydrogen supply pipe with a diameter of 25 mm or less cannot be fully welded, the welded joints of full penetration type are to be minimized as far as practicable and located in the gas valve unit space. The gas valve unit space is to comply with the requirements for double piping in Section 6 of Chapter 8 of the Guidelines and the requirements for monitoring, control and safety systems related to double piping in Section 4 of Chapter 10 of the Guidelines.

4.3.5.3 If the connection mentioned in 4.3.5.2 of this Section cannot avoid the use of mechanical joints, it is to comply with the relevant requirements in the CCS Rules for Classification of Sea-going Steel Ships, taking into account of the hydrogen leakage risk.

CHAPTER 5 FUEL STORAGE

Section 1 GENERAL PROVISIONS

5.1.1 General requirements

5.1.1.1 The fuel storage and venting system of the fuel cell powered ship using hydrogen as a primary fuel are to comply with the requirements of this Chapter. In addition, the system is to comply with CCS Rules for Ships Using Natural Gas Fuel, Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel, as appropriate, where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

5.1.1.2 Materials for tanks in contact with fuel are to be compatible with the fuel stored. In addition, hydrogen embrittlement is to be considered in the service life of hydrogen storage systems.

5.1.1.3 Fuel tanks are to be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks is to be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks. The tank support is to prevent against tank movement.

5.1.1.4 Connections of the fuel tank to the ship's fuel piping are to have sufficient flexible compensation.

5.1.1.5 Arrangements are to be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.

5.1.1.6 The fuel tank and fuel supply system are to be so designed that safety actions after any gas leakage do not lead to an unacceptable loss of power.

5.1.1.7 A means is for storing hydrogen other than hydrogen cylinders is to be subject to a risk assessment and approval by CCS.

Section 2 HYDROGEN CYLINDERS

5.2.1 General requirements

5.2.1.1 In addition to 5.1.1.of this Chapter, hydrogen cylinders are to comply with the requirements of this Section.

5.2.1.2 If there is any hydrogen cylinder group, each cylinder, except for pressure relief systems, is to be capable of being isolated by valves at any time. Isolation of pipes of any cylinder is to not impair the availability of the remaining cylinders.

5.2.1.3 The structure and material of the hydrogen cylinder body and valves are to comply with the relevant provisions of TSG 23:2021 Regulation on Safety Technology for Gas Cylinder. The materials for any cylinder valve in contact with gas are to be compatible with the gas filled.

5.2.1.4 The allowable pressure of marine hydrogen cylinders is not to be less than the maximum operating pressure, and is 1.25 times the limited filling pressure at reference temperature (15℃).

5.2.1.5 Hydrogen cylinders are to be provided with a temperature actuated safety relief device and a shutoff valve at the mouth. The safety relief device is to comply with the provisions of TSG 23:2021 Regulation on Safety Technology for Gas Cylinder.

5.2.1.6 The relieving capacity and area of the safety relief devices is to be designed and calculated according to the relevant standards, and both the rated capacity and actual capacity are not to be less than the safety relieving capacity of hydrogen cylinders.

Section 3 HYDROGEN TANK VENTING SYSTEMS

5.3.1.1 The outlet of a hydrogen fuel tank safety relief device is to be connected to the ship's gas fuel venting system, and the outlet from the venting system is to be:

(1) so constructed that the discharge will be unimpeded and be directed vertically upwards at the exit;

(2) arranged to minimize the possibility of water or snow entering the vent system; and

(3) arranged such that the height of vent exits is normally not to be less than $B/3$ or 6 m, whichever is the greater, above the weather deck and 6 m above working areas and walkways. If this is impracticable for inland waterways ships, the height of vent exits is to be 3 m above the weather deck and working areas and walkways after assessment.

(4) located at least 10 m from the nearest air intake, air outlet or opening to accommodation, service and control spaces, or exhaust outlet from machinery installations. If this is impracticable for inland waterways ships, the distance mentioned above may be reduced from 10 m to 5 m after assessment.

5.3.1.2 The venting system is to be provided with a device preventing entry of flame into the tank.

5.3.1.3 The gas fuel venting system is to be independent of those of accommodation, service and control spaces, or other non-hazardous areas.

5.3.1.4 All vent piping is to be designed and arranged not to be damaged by the temperature variations to which it may be exposed, forces due to flow or the ship's motions.

CHAPTER 6 FUEL BUNKERING

Section 1 GENERAL PROVISION

6.1.1 General requirements

6.1.1.1 The compressed hydrogen bunkering of a fuel cell powered ship is to comply with the requirements of this Chapter. In addition, the fuel bunkering is to comply with the relevant requirements of CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanhol Fuel or Guidelines for Ships Using Ammonia Fuel, where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

Section 2 HYDROGEN BUNKERING STATIONS

6.2.1 General requirements

6.2.1.1 The bunkering station is to be located on open deck so that sufficient natural ventilation is provided. A risk assessment of enclosed or semi-enclosed bunkering stations is to be carried out. The special consideration is as a minimum to include, but not be restricted to, the following design features:

(1) segregation towards other areas on the ship;

(2) hazardous area plans for the ship;

(3) requirements for forced ventilation;

(4) requirements for leakage monitoring;

(5) safety actions related to leakage detection;

(6) access to bunkering station from non-hazardous areas through airlocks;

(7) monitoring of bunkering station by direct line of sight or by a closed circuit television (CCTV).

6.2.1.2 The bulkheads of enclosed or semi-enclosed bunkering stations are to be gas tight.

6.2.1.3 Control of the bunkering is to be possible from a safe location. At this location the tank pressure and tank temperature are to be monitored. High temperature and high pressure alarm, automatic and manual shutdown are also to be indicated at this location.

6.2.1.4 Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations are not to face the bunkering connection.

6.2.1.5 Bunkering lines are not to pass directly through accommodation spaces, control stations or service spaces. Bunkering lines passing through an enclosed space are to be enclosed in the venting duct which is arranged in accordance with the requirements of Section 6 of Chapter 8. Ventilation and gas detection are to be continually carried out during the bunkering operation. In case of loss of ventilation or on detection of gas, an audible and visual alarm is to be given at the bunkering control location.

Section 3 HYDROGEN BUNKERING MANIFOLD

6.3.1 General requirements

6.3.1.1 The bunkering manifold is to be designed to withstand the external loads during bunkering.

6.3.1.2 The bunkering coupling is to be appropriate for fuel bunkering operations and capable of withstanding the design temperature and design pressure.

6.3.1.3 The connections at the bunkering station are to be equipped with additional break-away coupling/ self-sealing quick release. The couplings are to be of a standard type. Where the break-away coupling/ self-sealing quick release is provided by the bunkering source, a sign is to be posted in conspicuous places near the bunkering manifold.

Section 4 HYDROGEN BUNKERING SYSTEM

6.4.1 General requirements

6.4.1.1 The temperature in the hydrogen cylinder is not to exceed 85℃ during the bunkering operation.

6.4.1.2 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve are to be fitted in every bunkering line close to the connecting point. It is to be possible to operate the remote valve in the control location for bunkering operations and/or from another safe location.

6.4.1.3 Fuel bunker piping arrangement between the bunkering manifold and the fuel tank are to be in accordance with the requirements for fuel piping in Chapter 4.

6.4.1.4 Bunkering lines are to be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering pipes are to be free of gas.

6.4.1.5 Where bunkering pipes are arranged with a crossover, suitable isolation arrangements are to be provided that fuel cannot be transferred inadvertently to the ship side not in use for bunkering.

6.4.1.6 A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source is to be fitted.

CHAPTER 7 ELECTRICAL EQUIPMENT

Section 1 GENERAL PROVISIONS

7.1.1 General requirements

7.1.1.1 The hazardous area classification, fuel cell power installations and their distribution systems are to comply with the provisions of this Chapter. In addition, the hazardous area classification and electrical equipment are to comply with CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel as appropriate, where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

7.1.1.2 Hazardous areas on open deck and in other spaces not addressed in this Chapter are to be determined according to the standards accepted by CCS①. The electrical equipment fitted within such hazardous areas is to be based on the same standard.

7.1.1.3 Electrical equipment and wiring are in general not to be installed in hazardous areas. If this is impracticable, they are to comply with the standards accepted by CCS②.

7.1.1.4 For sea-going ships engaged in domestic voyages and inland waterways ships, FC power installations complying with 7.4.2 may be used as the main generator or part of the main generator of the ship.

7.1.1.5 Explosion groups and temperature classes are to be determined as follows according to the categories of the flammable gas which may occur and accumulate in a hazardous area. For hydrogen, not less than IIC, T1.

7.1.1.6 Equipment for hazardous areas are to be evaluated, certified and listed by a body authorized by CCS. Automatic isolation of not-certified equipment on detection of a flammable gas is not to be accepted as an alternative to the use of certified equipment.

7.1.1.7 A space having an opening towards the adjacent hazardous area may be provided with a means which is required in the standards③ accepted by CCS, such as positive pressure protection with gastight doors without any holding back arrangements, or mechanical ventilation with airlocks, to make it a safe area or a hazardous area with a lower hazard lever.

7.1.1.8 If a positive pressure protection means is used to reduce the hazard level of a space, the function of prior purging is to be checked and tested. The time for purging at minimum air volume is to be recorded in the relevant documents. The protective measures taken a failure of positive pressure protection, such as power supply shutoff and audible and visual alarms, are to be tested and verified.

7.1.1.9 If the hazard level of a space is reduce by mechanical ventilation, a detection system of the

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① Refer to IEC 60092-502: Electrical Installations in Ships – Tankers – Special Features.
② Refer to IEC 60092-502: Electrical Installations in Ships – Tankers – Special Features and IEC 60079-10-1: Explosive atmosphere-Part 10-1: Classification of areas-Explosive gas atmospheres.
③ Refer to IEC 60092-502: Electrical Installations in Ships – Tankers – Special Features and IEC 60079-10-1: Explosive atmosphere-Part 10-1: Classification of areas-Explosive gas atmospheres.

ventilation flow is to be installed, which will give an audible and visual alarm at manned spaces in the event of failure of the mechanical ventilation.

7.1.1.10 Where cables pass through the deck or bulkhead within a hazardous area, the tightness of the deck or bulkhead is to be maintained and the fire tight integrity of the deck or bulkhead is not to be affected.

7.1.1.11 Where a flammable gas/liquid fuel is filled, it is to be ensured that the ship-to-shore connection is electrically insulated. The insulation is to be provided by the shore bunkering terminal.

7.1.1.12 The control, monitoring and safety systems related to fuel supply are to be supplied by a duplicated power supply, of which one is main sources of electrical power, and the other is storage batteries or uninterruptible power systems (UPS), off-line UPS excluded. They are to be capable of automatically converting to the battery or UPS in the event of failure of the main source of electrical power, and showing an alarm both locally and on the bridge. The period of power supply of the batteries is to be a minimum of 30 min.

Section 2 HAZARDOUS AREA CLASSIFICATION

7.2.1 General requirements

7.2.1.1 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[①] according to 7.2.2. If the provisions in 7.2.2 of this Section are considered not applying to certain circumstances, CCS may allow the use of the standards[②] accepted by CCS for hazardous area classification.

7.2.1.2 The classification of ventilation duct areas is to be the same as that of ventilated spaces.

7.2.1.3 The types of protection of hydrogen cylinder head valves are to be subject to a risk assessment according to the classification standards in 7.2.1.1 of this Section. The head valve may be not considered as a source of ignition provided that its Electrical components do not directly contact with the fuel gas and with additional safety measures, e.g. spark prevention, are provided according to the risk assessment results.

7.2.2 Hazardous areas

7.2.2.1 Hazardous area zone 0

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

7.2.2.2 Hazardous area zone 1[③]

These include, but are not limited to:

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① Refer to IEC 60079-10-1: Explosive atmosphere-Part 10-1: Classification of areas-Explosive gas atmospheres and IEC 60092-502: Electrical Installations in Ships – Tankers – Special Features.
② Refer to IEC 60079-10-1: Explosive atmosphere-Part 10-1: Classification of areas-Explosive gas atmospheres.
③ Instrumentation and electrical apparatus installed within these areas are to be of a type suitable for zone 1.

(1) tank connection spaces, fuel storage hold spaces[①] and interbarrier spaces;

(2) FC spaces designed according to 2.3.1.2 (1) of Chapter 2;

(3) fuel preparation rooms;

(4) areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas[②] or vapour outlet, bunker manifold valve, other fuel valve, fuel pipe flange and other reformed fuel source of release, fuel preparation room ventilation outlets, ventilation outlets of fuel cell spaces designed according to 2.3.1.2(1) of Chapter 2 and zone 1 ventilation outlets and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation;

(5) areas on open deck or semi-enclosed spaces on deck, within 1.5 m of entrances and ventilation inlets of fuel cell spaces designed according to 2.3.1.2(1) of Chapter 2, fuel preparation room entrances and ventilation inlets and other openings into zone 1 spaces;

(6) spaces on the open deck within drip trays for bunker manifold valve and 3 m beyond these, up to a height of 2.4 m above the drip tray;

(7) enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. double walled pipe around fuel pipes, semi-enclosed bunkering stations;

(8) a FC space is considered a non-hazardous area according to 2.3.1.3(2) of Chapter 2, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1;

(9) a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1; and

(10) except for compressed hydrogen tanks, an area within 2.4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.

7.2.2.3 Hazardous area zone 2[③]

These include, but are not limited to:

(1) areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1.

(2) space containing bolted hatch to tank connection space;

(3) FC spaces considered as zone 2 according to 2.3.1.2(2) of Chapter 2.

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① Compressed hydrogen tanks (hereinafter referred to as these Spaces) are normally not considered as zone 1. For the purposes of hazardous area classification, these Spaces with all potential leakage sources in a tank connection space and having no access to any hazardous area, are to be considered non-hazardous. Where these Spaces include potential leakage sources, e.g. tank connections, they are to be considered hazardous area zone 1. Where these Spaces include bolted access to the tank connection space, they are to be considered hazardous area zone 2.

② Including low-flashpoint fuel gas, reformed fuel gas, gas discharged during gas freeing, FC exhaust gas and exhaust air.

③ Instrumentation and electrical apparatus installed within these areas are to be of a type suitable for zone 2.

Section 3 FUEL CELL POWER INSTALLSTIONS

7.3.1 General requirements

7.3.1.1 FC power installations are to operate in the environmental conditions compliance with CCS Rules.

7.3.1.2 Electrical equipment of the FC power system is to be identified for hazardous areas according to the standards① accepted by CCS and provided with suitable explosion prevention, and electrical equipment and components in hazardous areas are to be of a corresponding explosion-proof grade.

7.3.1.3 Monitoring of fuel cell power system is to comply with the requirements of 10.2.4 of Chapter 10.

7.3.1.4 Arrangement is to be provided to discharge safely primary fuel and reformed fuel from the FC power system.

7.3.1.5 A means is to be provided to set a FC power installation into a safe state for maintenance and shutdown.

7.3.1.6 An essential purging system is to be provided to keep the FC power system in the passive state before start-up or after shutdown. The passive state is a state of the fuel cell power system in which the fuel or oxidizer system has been purged by the purging system. The purging system may use the media specified by the manufacturer for purging, including but not limited to nitrogen, air or vapors in non-hazardous conditions.

7.3.1.7 The internal components and the whole of the FC power system are to be capable of preventing unexpected overcurrent and to ensure to be capable of disconnecting the fuel cell to the load under any possible load conditions.

7.3.2 Risk assessment

7.3.2.1 A risk assessment is to be conducted for ships using fuel cell power installations.

7.3.2.2 The risk assessment is to consider all expected failures and risks during the whole life cycle of the FC power installation to ensure that the safety measures can cover all risks to the ship caused by using fuel cells. Consideration is to be given to the hazards associated with physical layout, operation and maintenance following any reasonably foreseeable failure. Consideration is also to be given to the potential dangers which may affect the ship's power system when it is connected to the FC power system. The safety measures and the settings of the related safety systems are to be determined according to the risk assessment result.

7.3.2.3 Several risk assessment techniques may be applied. A Hazard Identification (HAZID) technique and /or a Hazard and Operability (HAZOP) technique may be conducted to identify potential hazards that could result in consequences to personnel, the environment, and assets. Single failure in the components of FC power installations will not result in hazards to the system, ship and personnel. A Failure Mode and Effects Analysis (FMEA) may also be used to demonstrate that any single failure will not lead to an undesirable event.

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① Refer to IEC 62282-3-100: Stationary Fuel Cell Power Systems - Safety.

7.3.2.4 The risks are to be analysed using the standard[①] accepted by CCS and risk analysis techniques, and mechanical damage to components, operational and weather-related influences, electrical faults, unwanted chemical reactions, toxicity, auto-ignition of fuels, fire, explosion, short-term power failure (blackout) are as a minimum to be considered. The analysis is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary.

7.3.3 Operations and maintenance manual and safety instruction

7.3.3.1 Operations Manual for FC power installations is to be kept on board, including, but not be restricted to:

(1) Instruction for the different sub-systems and components of the FC power system and the methods to confirm safe running;

(2) Instructions for operational procedures and functions, including self-checking, start-up, shutdown, emergency shutdown and gas freeing;

(3) Where the operation of equipment can be programmed, detailed information on methods of programming, equipment required, program verification and additional safety procedures (where required) is to be provided;

(4) Methods for querying the running, alarms and failures of FCs and the operating parameter limitation and measures when over the limitation;

7.3.3.2 Maintenance Manual for FC power installations is to be kept on board, including, but not be restricted to:

(1) Proper procedures for the adjustment, servicing and preventive inspection;

(2) A list of all regular and routine maintenance activities to be performed on the FC power system components and instruction for the necessity and minimum frequency for these examinations;

(3) Detailed instruction for the use of self-checking, if any, e.g. software testing procedures;

(4) The manual is to contain clearly defined, legible and complete instructions for the following, at a minimum:

① Illustrations and locations of all relevant components;

② Instruction for the information of all relevant instruments, automation and monitoring;

③ Instructions for lubrication of moving parts, including type, grade and amount of lubricant;

④ Recommended methods for periodic cleaning of necessary parts;

⑤ Specifications for the frequency of filter change or cleaning and the dimensional size and type of filter for replacements;

⑥ Caution to users regarding electrical components that may retain residual voltage/energy after shutdown, and method(s) to properly dissipate the voltage/energy to a safe level;

⑦ Instructions for examining the FC power system installation to confirm any intake or exhaust

① Refer to IEC 60812 Failure Modes and Effects Analysis (FMEA and FMECA).

openings are clear and free of obstructions and there are no obvious signs of physical deterioration of the FC power system or its support;

⑧ Plan for alarm system function checking;

⑨ Periodic examination of the venting system, gas detection system, and related functional parts;

⑩ A replacement parts list, including information necessary for ordering spare or replacement parts;

⑪ Instructions that the area surrounding the fuel cell power system must be kept clean and free of combustible materials, combustibles and fuel leakages.

7.3.3.3 Instructions for potential hazards of FC power installations is to be kept on board, including, but not be restricted to:

(1) Substances that may be produced from leakage, such as toxic substances, flammable substances and corrosive substances;

(2) Gases that might be produced, such as toxic gas, flammable gas and corrosive gas;

(3) Fire / explosion;

(4) Flooding of water;

(5) Methods to shutdown all reaction processes and other safety precautions for mitigating risks;

(6) Recommended methods for fire fighting.

Section 4 SUPPLY AND DISTRIBUTION SYSTEMS OF FUEL CELLS

7.4.1 General requirements

7.4.1.1 In addition to the relevant requirements of this Section, the electric energy provided by the power supply and distribution system to the loads is to meet the requirements for voltage, frequency deviation, harmonics and ripples in CCS Rules.

7.4.1.2 The supply and distribution system is to be designed such that a single failure is not to lead to an unsafe condition.

7.4.1.3 The components of the FC power system are to be designed to operate automatically with the intervention of the control system, and provided with indicating and control equipment required for safety and control specified in 10.2.4 of Chapter 10.

7.4.1.4 The output circuits on a fuel cell module are to be provided with a switch disconnector for isolating purposes so that isolating for maintenance is possible. Contactors are not accepted for isolating purpose.

7.4.1.5 Reverse power protection is to be provided for fuel cell module to prevent power flowing in the reverse direction from the load side. Where the fuel cell module is connected to a converter, reverse power protection may be provided by a brake resistor or similar component to this converter.

7.4.2 Special requirements for FC power installations as all or part of the main source of electrical power of the ship

7.4.2.1 The performance and safety of fuel cell power system are to comply with the standards[①] accepted by CCS and have a Marine Products Certificate issued by CCS, endorsed with ‘Completion of additional cell performance test’.

7.4.2.2 Where fuel cell power installations need to be equipped with batteries to improve the dynamic response capacity according to 7.4.2.4(6) of this Section, the capacity of the batteries is not to be less than that of the same types of the battery specified in the product certificate. Where several fuel cell power systems are provided, it is to be ensured that the storage batteries in each bus-bar section have sufficient capacity at sectional running of the bus-bar.

7.4.2.3 The short circuit current of the fuel cell power installation is to be sufficient to activate the protective device against short-circuit for this branch, taking into account the selectivity of the protective devices for the distribution system. Protection is to be arranged in order to safeguard the fuel cell in case of a short circuit in the main bus-bar. The fuel cell is to be suitable for further use after fault clearance.

7.4.2.4 Additional tests for equivalent generator set characteristics

(1) Fuel cell power systems together with converters, if complying with the requirements of 7.4.2.4(2) to (6) of this Section, may be used as part of the ship’s main power source, and the certificates are to be endorsed with ‘Completion of additional performance test of marine system power generation’.

(2) Fuel cell power systems together with converters are to be capable of withstanding the mechanical and thermal effects of a short-circuit current for the duration of any time delay for discrimination purposes when tripping/fusing a protective device.

(3) For fuel cell power systems together with converters, the voltage regulation characteristics are to be such that voltage variations are within 1% of the rated voltage for 20% of the rated load, that voltage variations are within 2.5% of the rated voltage for the full rated load and that the average of the ascending and descending curves of voltage regulation characteristics between 20% load and full load does not vary more than 3% from the rated voltage.

(4) When the fuel cell power system together with the converter is subjected to a sudden change of 50% of the rated load , and then to the remained 50% after the current is stable:

① The transient voltage is not to fall below 85% of the rated voltage and not below the converter’s threshold voltage;

② The transient voltage is not exceed 120% of the rated voltage and not exceed the converter’s threshold voltage;

③ For AC systems, the transient frequency variations are not to exceed 10% of the rated voltage;

④ The voltage of the system is then to be restored to within plus or minus 3% of the rated voltage in not more than 1.5 s.

(5) For AC fuel cell power systems together with converters, the sinusoidal distortion of the voltage

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① Refer to IEC 62282-2-100: Fuel Cell Modules - Safety and IEC 62282-3-100: Stationary Fuel Cell Power Systems - Safety.

waveform under no-load conditions is not to exceed 5%.

(6) Where it is unable to meet the requirements as specified in 7.4.2.4(4) of this Section, the test may be carried out with a fuel cell unit and a converter in parallel, and the volume, type and other parameters of the fuel cell power installation and the additional fuel cell unit are to be noted in the product certificates.

7.4.3 Special requirements for fuel cells as the ship's sole main power source

7.4.3.1 A fuel cell power installation is to have the same safety, reliability and independence as to those of a diesel generating set and to comply with the requirements of 7.4.2 of this Section. The number and ratings of fuel cell power installations are to be such that in the event of any one fuel cell power installation being stopped it will still be possible to supply those services necessary to provide normal operational conditions of propulsion and safety of the ship and essential for carrying refrigerated cargoes. Furthermore, minimum comfortable conditions of habitability are also to be ensured, which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

7.4.3.2 Measures taken for minimizing risks are not to reduce the power generation and propulsion capacity necessary for navigation.

7.4.3.3 A single failure in moving parts[①] of fuel cell power installations is not to lead to a failure of propulsion or loss of vital equipment.

7.4.3.4 Two or more fuel cell power installations are to be provided, of which a failure of one is to not cause unacceptable loss of power and furthermore, minimum comfortable conditions of habitability are also to be ensured.

7.4.3.5 The availability or lifetime is to be monitored in the bridge or fuel cell power system control room.

7.4.3.6 Two or more fuel tanks are to be installed in different compartments. Where LNG tanks of type C with two completely independent fuel tank connection spaces or similar arrangements are provided, only one fuel tank may be required.

7.4.3.7 For sea-going ships, the remained fuel cell power installations are to start automatically upon failure of the electrical supply from any fuel cell power installation, and to connect to the main switchboard, preferably within 30 s, but in any case not more than 45 s, after loss of power. For inland waterways ships, these requirements are to be fulfilled as far as possible.

7.4.3.8 The documents with which restoration of power after interruption or restoring propulsion from a dead ship condition are to comply are to be approved and verified by CCS.

7.4.3.9 Where the fuel is treated using a reformer or other treatment unit, an additional heating unit or power supply is to be provided to provide the heat source required for initial start-up.

7.4.3.10 The starting time of fuel cell power system together with essential reformer are to be in a reasonable span of time.

7.4.3.11 Energy storage system is preferably to be provided to improve the output characteristics of fuel

① The moving parts means mechanical parts used for energy transmission, such as pumps, fan motors, motors, generators, internal combustion engines and turbines. Fuel cells, heat exchangers, boilers, transformers, switching devices and cables are considered as a moving part.

cells. Where a battery is used as an energy storage system, it is to be capable of monitoring the state of charge to avoid over-charging or over-discharging of the battery.

7.4.3.12 The possible power attenuation within the ship’s service life is to be calculated on the basis of the power attenuation rate curve or similar data provided by the supplier, and the fuel cells are to be replaced if their generating power cannot meet the requirements of the whole ship's load.

7.4.4 Special requirements for fuel cells as the ship’s non-unique main power source

7.4.4.1 A fuel cell power installation is to have the same safety, reliability and independence as to those of a diesel generating set and to comply with the requirements of 7.4.2 of this Section. The main power source is to be such that in the event of any one fuel cell power installation being stopped it will still be possible to supply those services necessary to provide normal operational conditions of propulsion and safety of the ship and essential for carrying refrigerated cargoes. Furthermore, minimum comfortable conditions of habitability are also to be ensured, which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

7.4.4.2 Measures taken for minimizing risks are not to reduce the required power generation capacity.

7.4.4.3 A single failure in moving parts of fuel cell power installations is not to lead to loss of vital equipment.

7.4.4.4 Fuel shutoff is not to cause propulsion failure or power loss of essential equipment. This can be achieved by the arrangement of fuel cell spaces or timely using other main power sources. An energy storage system, if used as a stand-by main power source, is to have a capacity appropriate to the voyage.

7.4.4.5 A failure of any fuel cell power system is not to cause unacceptable loss of power and furthermore, minimum comfortable conditions of habitability are also to be ensured.

7.4.4.6 For sea-going ships, the stand-by power sources are to start automatically upon failure of the electrical supply from fuel cell power installations, and to connect to the main switchboard, preferably within 30 s, but in any case not more than 45 s, after loss of power. For inland waterways ships, these requirements are to be fulfilled as far as possible.

7.4.4.7 Where the power necessary for restoration of power after interruption or restoring propulsion from a dead ship condition is supplied by fuel cell power installations, the relevant documents required are to comply are to be approved and verified by CCS.

7.4.4.8 Grid-connected fuel cell power installations are to be put into use with at least one generator running on the grid. The fuel cell power installation is to be cut off from the grid and shut down before the last generator is cut off from the grid.

7.4.4.9 Grid-connected inverters used in grid-connected fuel cell power installations are to be capable of anti-island monitoring. It does not need to stop the power supply when the switch between independent power generation and grid-connected power generation could be done. The continuity of power supply of distribution system is to be ensured during the switch, and a sudden change in service voltage phase and magnitude is not to exceed the power transient wave specified in CCS Rules.

7.4.4.10 In addition, fuel cell power installations are to comply with 7.4.3.5, 7.4.3.11 and 7.4.3.12 of this Section.

7.4.5 Special requirements for fuel cells not used as the ship's main power source

7.4.5.1 Fuel cell power installations may be used, whilst the ship is at sea, to supply the electrical equipment necessary for normal operational and habitable conditions provided that:

(1) sufficient and adequately rated additional generators are fitted, which constitute part of the main source of electrical power;

(2) Frequency (if any) and voltage variations are to comply with the provisions for power quality specified in CCS Rules;

(3) the equipment supplied power by fuel cell power installations is to be capable of automatically switching to the ship' s main power supply when the fuel cell power installations shut down, frequency (if any) or voltage variation over limit;

(4) the short circuit current of the fuel cell power installation is to be sufficient to activate the protective device against short-circuit for this branch, taking into account the selectivity of the protective devices for the distribution system.

(5) automatic load shedding arrangements are provided;

(6) on ships having remote control of the propulsion machinery from the navigation bridge, means are provided or procedures are in place to ensure that the power supply to essential services is maintained during maneuvering conditions in order to avoid a blackout situation.

CHAPTER 8 VENTILATION AND INERTING

Section 1 GENERAL PROVISIONS

8.1.1 General requirements

8.1.1.1 Unless otherwise specified, the ventilation and inerting of a fuel cell powered ship are to comply with the provisions of this Chapter. In addition, the ventilation and inerting are to comply with CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel as appropriate, where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

8.1.1.2 Air inlets for hazardous enclosed spaces are to be taken from areas that, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous spaces are to be fitted in the safe area at least 1.5 m far away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct is to have over-pressure relative to this space, except that its mechanical integrity and air tightness ensure that gases do not penetrate into the space.

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

8.1.1.4 Ventilation systems are to be capable of being controlled at a position outside of the ventilated space. The space is to be so arranged that it can be ventilated prior to personnel entry and operation of equipment. Warning signs are to be placed outside of the space for alerting personnel to start the ventilation system prior to entry. The space is to be monitored for flammable gas.

8.1.1.5 Suitable protective screens of not more than 13 mm square mesh are to be fitted on vent outlets of hazardous spaces.

8.1.1.6 Design of ventilation fans serving spaces containing fuel gas is to fulfill the following:

(1) Ventilation fans are not to produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, are to be of non-sparking construction defined as:

① impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity;

② impellers and housings of non-ferrous metals;

③ impellers and housings of austenitic stainless steel;

④ impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing;

⑤ any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance.

(2) The radial air gap between the impeller and the casing is to be less than 0.1 of the diameter of the impeller shaft in way of the bearing but not less than 2 mm.

(3) Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and is not to be used in hazardous spaces.

8.1.1.7 Air outlets from non-hazardous spaces are to be located outside hazardous areas.

8.1.1.8 Air outlets from hazardous spaces are to be located in an open area that, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

8.1.1.9 The required capacity of the ventilation plant is normally determined based on the total volume of the room. For compartments with complex shapes, due consideration is to be given to increasing the ventilation capacity.

8.1.1.10 For a space having a hazard level depending on ventilation system:

(1) During initial start-up or after loss of overpressure ventilation, and before energizing any electrical installations not certified safe for the space in the absence of pressurization, it is to proceed with purging (at least 5 air changes) or confirm by measurements that the space is non-hazardous. A warning sign is to be posted near the console.

(2) Operation of the overpressure ventilation is to be monitored.

(3) At a failure of ventilation system:

① an audible and visual alarm being given at a location specified in 10.2.6.1 of Chapter 10;

② ventilation is to be immediately restored.

Section 2 FUEL CELL SPACES

8.2.1 General requirements

8.2.1.1 Fuel cell spaces may be protected by inerting or ventilation.

8.2.2 Ventilation

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

8.2.2.2 For fuel cell spaces on open decks, overpressure ventilation may be considered.

8.2.2.3 The ventilation rate in fuel cell spaces is to be sufficient to dilute the average gas/vapour concentration below 25% of the flammable range in all maximum probable leakage scenarios owing to technical failures, and the number of air changes is to be at least 30 per hour.

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

8.2.2.5 Ventilation ducts from spaces containing reformed fuel piping or release sources are to be designed and arranged to avoid any opportunity for gas to accumulate.

8.2.2.6 Two or more ventilation fans are to be provided for the fuel cell space and in addition be arranged with full redundancy (2 × 100% capacity fans from different electrical circuits, of which 100% capacity fans from emergency power). For inland waterways ships without emergency power, the ventilation fans are to be such that the capacity is to be of 100%, if a group of fans with common circuit from the main switchboard is inoperable.

8.2.2.7 In case of loss of one of these fans, the system is to have an automatic change-over to the remained one and give an alarm.

8.2.2.8 In case of loss of ventilation or loss of negative pressure in the fuel cell space, the fuel cell power system is to carry out an automatic, controlled shutdown of the fuel cell and isolation of the fuel supply.

8.2.3 Inerting

8.2.3.1 Fuel cell spaces are to be inaccessible during inerting, and sealing arrangements are to ensure that inert gas could not leak to the adjacent spaces.

8.2.3.2 Inerting systems are to comply with the provisions in Chapter 15 of the International Code for Fire Safety Systems (FSS Code) and of 6.13 and 6.14 of the International Code of Safety for Ships Using Gases or other Low-flashpoint Fuels (IGF Code).

8.2.3.3 The pressure of the inert medium is to always be in a positive state and monitored.

8.2.3.4 Any change in the pressure showing a damage to the boundaries of fuel cell spaces or arrangements containing fuel (such as fuel cell stacks and reformers) is to activate the controlled shutdown of the fuel supply.

8.2.3.5 Fuel cell spaces are to be mechanically ventilated to discharge the inert medium upon starting the inerting.

8.2.3.6 Inerted fuel cell spaces are accessible only upon complete ventilation and shutdown of the fuel supply, pressure reducing or purging.

8.2.3.7 The inerting system is not to operate during maintenance or inspection.

Section 3 HYDROGEN TANK CONNECTION SPACES

8.3.1 General requirements

8.3.1.1 Fuel tank connection spaces are to be provided with a mechanical ventilation system of the underpressure type, with a ventilating capacity of 30 air changes per hour.

8.3.1.2 The number and power of the ventilation fans are to be such that the capacity is to be of 100%, if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

8.3.1.3 If tank connections are located in the fuel tank space, it is also to comply with the requirements of 8.3.1.1 and 8.3.1.2 of this Section.

Section 4 HYDROGEN FUEL PREPARATION ROOMS

8.4.1 General requirements

8.4.1.1 Fuel preparation rooms are to be fitted with an effective mechanical ventilation system of underpressure type, with a ventilating capacity of 30 air changes per hour.

8.4.1.2 The number and power of the ventilation fans are to be such that the capacity is not reduced by more than 50% of the total ventilation capacity if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

8.4.1.3 Ventilation systems for fuel preparation rooms and other fuel handling spaces are to be in operation when pumps or other fuel treatment equipment are working.

Section 5 HYDROGEN BUNKERING STATIONS

8.5.1 General requirements

8.5.1.1 Bunkering stations that are located in enclosed and semi-enclosed spaces are to be suitably ventilated to ensure that any vapour being released during bunkering operations will be removed outside. If the natural ventilation is not sufficient, mechanical ventilation is to be provided in accordance with the risk assessment required by 6.2.1.1 of Chapter 6.

Section 6 ANNULAR SPACES OF DOUBLE PIPES CONTAINING HYDROGEN FUEL PIPES

8.6.1 General requirements

8.6.1.1 Double pipes are to be fitted with effective mechanical ventilation system of the underpressure type, providing a ventilation capacity of at least 30 air changes per hour.

8.6.1.2 The ventilation system for double pipes is to be independent of all other ventilation systems.

8.6.1.3 The ventilation inlet for the double wall piping is always to be located in an open non-hazardous area away from ignition sources. The inlet opening is to be fitted with a suitable metal protective nets and protected from ingress of water.

8.6.1.4 The number and power of the ventilation fans are to be such that the capacity is to be of 100%, if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

Section 7 FUEL CELL EXHAUST SYSTEMS

8.7.1 General requirements

8.7.1.1 Exhaust gases and exhaust air from the fuel cell power systems are not to be combined with any ventilation pipes other than those for the fuel cell space and are to be led to a safe location in the open air.

8.7.1.2 The purging piping of fuel cell power system is to be independently lead to an open area, and to be arranged as air outlets of hazardous areas.

8.7.1.3 The exhaust gas outlets of fuel cell stacks are to be located on open deck, within 3 m there are no sources of ignition.

8.7.1.4 The outlets which may exhaust or leak hydrogen are to be far away from equipment which may produce sparks or heat.

8.7.1.5 Exhaust ducting is to be provided with suitable supporting and a rain cover or a component not limiting or hindering gas flow vertical ascending.

8.7.1.6 Arrangements, e.g. a drainage device, are to be provided to prevent water, ice and other debris from accumulating in or blocking exhaust ducting.

8.7.1.7 Any opening is not to be provided in the pipes and components of exhaust system of fuel cell power system.

CHAPTER 9 FIRE SAFETY

Section 1 GENERAL PROVISIONS

9.1.1 General requirements

9.1.1.1 Unless otherwise specified, the fire safety of a fuel cell powered ship is to comply with the provisions of this Chapter. In addition, the fire safety is to comply with the relevant requirements of CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel, where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

9.1.1.2 For the purposes of fire protection, fuel cell spaces and any space containing equipment for the fuel preparation such as pumps, compressors, heat exchangers, vaporizer s and pressure vessels are to be regarded as a machinery space of category A (sea-going ships) / an essential machinery space (inland waterways ships).

9.1.1.3 The fire safety system in the fuel cell space is to be approved by CCS.

9.1.1.4 Combustibles within the fuel cell space is to be minimized as far as practicable.

9.1.1.5 The fire safety system is to be suitable for use with the fuel cell technology proposed. CCS may allow any alternative fire safety measures if equivalence is demonstrated by a risk assessment considering the fuels used.

Section 2 FIRE PROTECTION

9.2.1 Hydrogen tanks

9.2.1.1 Any boundary of accommodation spaces, service spaces, control stations, machinery spaces, and escape routes facing fuel tanks on open deck are to have a fire integrity class of A-60. These class divisions are to extend up to the underside of the deck of the navigation bridge or up to the true height of the bulkhead.

9.2.1.2 Isolation is to be provided between the fuel storage hold space and machinery spaces of category A (sea-going ships) /essential machinery spaces (inland waterways ships) or other high fire risk spaces is to be done by a cofferdam of at least 900 mm with insulation of A-60 class. In determining the insulation of the fuel storage hold space from other spaces with lower fire risks, the fuel storage hold space is to be regarded as a machinery spaces of category A (sea-going ships) /essential machinery spaces (inland waterways ships) . The boundary between fuel storage hold spaces is to be either a cofferdam of at least 900 mm or A-60 class division.

9.2.1.3 The outer wall of compressed hydrogen fuel tank (if any) is to be not less than 900 mm away from the bulkhead of hydrogen cylinder room, and the compressed hydrogen fuel tank space may be regarded as a cofferdam. When a compressed hydrogen fuel tank is directly located above the machinery spaces of category A (for sea-going ships) /essential machinery space (for inland waterways ships) or other spaces of greater fire risk, the separation between the tank space or tank and the above spaces is to be done by a cofferdam of at least 900 mm with insulation of A-60 class. For inland waterways ships, if this is impracticable, the distance of 900 mm may be reduced but not less than 500 mm after assessment.

9.2.2 Hydrogen fuel bunkering stations

9.2.2.1 The boundaries of a machinery spaces of category A (sea-going ships) /essential machinery space (inland waterways ships), accommodation space, control station and space of greater fire risk facing the bunkering station are to be insulation of A-60 class, but the boundaries of a liquid tank, void, auxiliary machinery space and sanitary and other similar space may be reduced to A-0 class.

9.2.3 Fuel cell spaces

9.2.3.1 The boundaries, including access doors (if fitted), of fuel cell space is to be of steel and gastight or other equivalent metal materials.

9.2.3.2 The fuel cell space is to be bounded by “A-60” class divisions on all sides adjoining spaces, including other fuel cell spaces. If it is impractical, CCS may allow an alternative fire boundary design with an equivalent safety level.

9.2.3.3 Where single bulkhead/deck is used to divide fuel cell spaces, it is to have sufficient strength to withstand an explosion in any one of them and not to affect the integrity and equipment of the adjacent space.

Section 3 FIRE EXTINGUISHING

9.3.1 General requirements

9.3.1.1 Spaces such as fuel cell, fuel tank and fuel preparation rooms are to be fitted with a suitable fixed fire extinguishing system (FFES) required in the International Code for Fire Safety Systems (FSS Code).

9.3.1.2 The FFES is to be selected having due regard to the fire growth potential of the protected spaces and are to be readily available.

9.3.1.3 The extinguishing media used in the spaces mentioned in 9.3.1.1 of this Section is to be dry powder or carbon dioxide.

9.3.1.4 The hydrogen bunkering station is to be fitted with a fixed dry powder fire-extinguishing system which is to cover all possible leakage points. The capacity is to be at least 3.5 kg/s for a minimum of 45 s. The system is to be arranged for easy manual release from a safe location outside the protected area.

Sea-going ships engaged on domestic voyages, if it is impracticable to install the above fire extinguishing system, may be provided with a large dry chemical wheeled fire extinguisher having the same capacity.

9.3.1.5 In addition to the portable extinguishers which may be required by the Administration, at least one portable dry powder extinguisher of at least 5 kg capacity is to be located near the bunkering station and the fuel preparation room respectively.

9.3.1.6 At least one portable dry powder extinguisher of a capacity not less than 5 kg respectively provided near the fuel cell power installations and in way of the entrance of the fuel cell space where it is located.

9.3.1.7 A water spray system is to be installed for cooling, fire prevention and crew protection, and the water spray system is to cover exposed parts of fuel storage tank(s) located on open deck.

Section 4 FIRE DETECTION AND FIRE ALARM SYSTEMS

9.4.1 Fire detection

9.4.1.1 Fuel storage hold spaces (including ventilated ducts if located under the deck), fuel cell spaces and other spaces where flammable gases may occur are to be provided with a fixed firefighting system required in FSS Code.

9.4.1.2 The types and arrangement of fire detectors are to be determined based on the fuel and flammable gas which may occur in the fuel cell power installations.

9.4.1.3 Smoke detectors alone are not considered sufficient for rapid detection of a fire when gaseous fuels are used. Suitable fire detectors are to be selected according to the standards accepted by CCS [①].

9.4.2 Alarm and measures for safety

9.4.2.1 On detection of the fire in the spaces mentioned in 9.4.1.1, safety measures specified in Table 10.4.1 of Chapter10 are to be adopted and ventilation is to be automatically shutoff.

Section 5 FIRE DAMPERS

9.5.1 General requirements

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

9.5.1.2 Approved fail-safe automatic closing fire dampers are to be fitted in the ventilation trunk for the tank connection space.

9.5.1.3 Before actuation of the fire extinguishing system the fire dampers are to be automatically closed.

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① For the selection of suitable fire detectors, ISO/TR 15916:2015 Basic Considerations for the Safety of Hydrogen Systems can be taken into account.

CHAPTER 10 CONTROL, MONITORING AND SAFETY SYSTEMS

Section 1 GENERAL PROVISIONS

10.1.1 General requirements

10.1.1.1 The control, monitoring and safety systems and gas detection of a fuel cell powered ship are to comply with the requirements of this Chapter. In addition, the fuel bunkering is to comply with CCS Rules for Ships Using Natural Gas Fuel or Guidelines for Ships Using Methanol/Ethanol Fuel or Guidelines for Ships Using Ammonia Fuel as appropriate, where natural gas, methanol/ethanol, ammonia or other fuel is used as a primary fuel.

10.1.1.2 Suitable instrumentation devices are to be fitted to allow a local and a remote reading of essential parameters to ensure a safe management of the whole fuel-gas equipment including bunkering.

10.1.1.3 The safety system is to be independent of the control and monitoring system, or to comply with the performance requirements specified in the standards accepted by CCS[①], or to have an equivalent safety level.

10.1.1.4 Local-reading manifold pressure indicator are to be provided to indicate the pressure between ship's manifold valves and hose connections to the shore.

10.1.1.5 Each fuel pump or compressor discharge line and each liquid and vapour fuel manifold are to be provided with at least one local pressure indicator.

Section 2 MONITORINGAND CONTROL

10.2.1 Hydrogen fuel tank monitoring

10.2.1.1 A pressure gauge is to be provided for each tank in place, showing clearly for each tank the allowable maximum and minimum pressure, and the pressure is to be displayed in the remote locations, such as the navigation bridge, engine control room, or onboard safety centre. In addition, a high pressure and low pressure alarm is to be provided in a manned room, giving a warning at the maximum / minimum design pressure.

10.2.1.2 A sensor is to be provided for a compressed hydrogen tank to show the temperature inside it.

10.2.1.3 A pressure sensor is to be provided for a hydrogen pressure vessel, shutting off the fuel output in the case of the pressure inside the vessel less than the minimum pressure required for safety. A pressure sensor, capable of locally displaying the data and marked clearly with the allowable maximum and minimum pressure for the tank, may be used for substitution of the pressure gauges required in 10.2.1.1 of

① Refer to ISO 13849-1: Safety of Machinery - Safety-related Parts of Control Systems - Part 1: General Principles for Design.

this Section.

10.2.2 Fuel supply system monitoring

10.2.2.1 An overpressure protection device is to be provided for a fuel supply system, giving an audible and visual alarm at an overpressure.

10.2.2.2 The purity of reforming fuel gas is to be monitored for fuel cells sensitive to gas concentration, giving an audible and visual alarm in exceeding the limits.

10.2.2.3 The following items are to be monitored for the equipment associated to the fuel supply system, and an audible and visual alarm is to be given in exceeding the limits:

(1) High pressure at the outlet from the fuel heat exchanger;

(2) High pressure at the outlet from the fuel compressor;

(3) Low pressure at the inlet to the fuel compressor;

(4) High pressure and low pressure at the outlet to the fuel compressor;

(5) Low pressure and high temperature of the compressor oil;

(6) Abnormal shutdown of the master fuel valve.

10.2.3 Reformer monitoring

10.2.3.1 The operating conditions inside the reformer, such as the temperature and pressure are to be monitored, and an audible and visual alarm is to be given when exceeding the limits and the fuel output is to be shutoff.

10.2.4 Monitoring of fuel cell power system

10.2.4.1 Fuel cell is to be monitored appropriately to avoid any loss or degradation of its safety. For ships requesting FC-FULL and FC-POWER1 notations, the fuel cell installations are to be monitored for the items affecting the availability and lifetime, together with the redundancy of the installations.

10.2.4.2 A failure mode and effects analysis (FMEA) is to be used to analyze and determine the extent of monitoring and control of the fuel cell power systems. The following is to be included as a minimum:

(1) air into the fuel piping (by indirect monitoring);

(2) fuel into the air pipe (by indirect monitoring);

(3) cell voltage;

(4) cell voltage deviations;

(5) exhaust gas temperature, if applicable;

(6) temperature in the fuel cell (if applicable). Where the surface temperature of the fuel cell stack may raise above 300℃, the requirements in 10.4.1.12 of this Chapter are to be met;

(7) purity of fuel gas, if applicable;

(8) output current; and

(9) Failures of the control system.

10.2.4.3 the following monitoring contents are to be considered according to the type, working condition and working characteristics of fuel cell:

(1) air flow;

(2) air pressure;

(3) flow rate, pressure and temperature of cooling medium, if applicable;

(4) fuel flow;

(5) fuel temperature;

(6) fuel pressure;

(7) air-to-fuel ratio, if applicable;

(8) gas detection of exhaust fuel and exhaust air;

(9) liquid level of water system;

(10) pressure of water system;

(11) purity of water system; and

(12) parameters necessary to monitor life time/deterioration of fuel cell.

10.2.4.4 Chemical reactions, such as those that occur during fuel reforming or within the fuel cell, are to be monitored (e.g., by means of temperature, pressure or voltage monitoring).

10.2.4.5 The limit values of the internal parameters of fuel cell, such as temperature, pressure and voltage, are to be determined based on the working process of the fuel cell. Where any actual value exceeds the limit, the safety system is to be activated to achieve the protection for the fuel cell power system.

10.2.5 Liquid fuel monitoring

10.2.5.1 The space where liquid fuel leakage may occur is to be provided with a rapid detector for liquid fuel.

10.2.6 Ventilation monitoring

10.2.6.1 Any loss of the required ventilating capacity is to give an audible and visual alarm on the navigation bridge or in a continuously manned central control station or safety centre.

10.2.6.2 An acceptable means to confirm that the ventilation system has the 'required ventilating capacity' in operation required in 10.2.6.1 of the Guidelines are to be, but not be limited to:

(1) monitoring of the ventilation electric motor or fan operation combined with underpressure indication; or

(2) monitoring of the ventilation electric motor or fan operation combined with ventilation flow indication; or

(3) monitoring of ventilation flow rate to indicate that the required air flow rate is established.

10.2.7 Bilge wells

10.2.7.1 The bilge wells (if fitted) for fuel tanks (tank connection spaces) and fuel cell spaces are to be provided with liquid level sensor, and alarms are to be given at a high level in the bilge well.

10.2.7.2 The bilge wells for low temperature liquid fuel tanks (tank connection spaces,) are to be provided with a temperature and liquid level sensor. Alarms are to be given at a high level and the tank master valve is to be automatically shutdown at a low temperature.

Section 3 GAS DETECTION

10.3.1 General requirements

10.3.1.1 A means is to be provided to directly and rapidly monitor the potential leakage of primary fuel.

10.3.2 Requirements for gas detection

10.3.2.1 A means is to be provided to directly and rapidly monitor the potential leakage of primary fuel.

10.3.2.2 Permanently installed gas detectors are to be fitted in:

(1) Fuel tank connection spaces;

(2) all ventilated annular spaces of the double walled fuel pipes;

(3) machinery spaces (i.e., fuel cell space, etc.) containing fuel piping, fuel equipment or consumers;

(4) compressor rooms and fuel preparation rooms;

(5) other enclosed spaces containing fuel piping or other fuel equipment without ducting;

(6) other enclosed or semi-enclosed spaces where fuel vapours may accumulate including interbarrier spaces and fuel storage hold spaces of independent tanks other than type C;

(7) airlocks;

(8) in way of the medium outlet from the ancillary system of the fuel cell power system or in the expansion tank mentioned in 4.2.1.13 of Chapter 4;

(9) fuel cell coolant supply unit;

(10) motor rooms associated with the fuel systems;

(11) enclosed/semi-enclosed bunkering stations;

(12) gas valve unit spaces, which may be considered as part of the ventilated duct provided that they connect to the ventilated duct and have an inner space of not more than 2 m3; and

(13) inlet openings of accommodation spaces and machinery spaces which may contain flammable gas after the risk analysis.

10.3.2.3 The number of detectors in each space are to be considered taking into account the size, layout and ventilation of the space. Gas detectors are to be located where gas/vapor may accumulate and/or in the ventilation outlets. Gas dispersal analysis or a physical smoke test is to be used to find the best arrangement.

10.3.2.4 Flammable gas detection is to be continuous without delay.

10.3.2.5 Two independent gas detectors located close to each other are required for redundancy reasons. For gas detector used with the self-examination function, the minimum quantity required for a separate space may be reduced to one and spares are to be provided for timely replacing.

10.3.2.6 Gas detectors are to be designed and tested in accordance with the standards accepted by CCS[①].

10.3.2.7 In addition to permanently installed gas detectors, two portable gas detection equipment are to be provided on board the ship.

Section 4 FUNCTIONS OF CONTROL, MONITORING AND SAFETY SYSTEMS

10.4.1 General requirements

10.4.1.1 The fuel supply system is to be arranged for manual remote emergency stop which is to be conducted if containing a compressor and a pump, with the purposed marked and a manual button against touch by mistake, from the following locations (if applicable):

(1) navigating bridge;

(2) cargo control room;

(3) onboard safety centre;

(4) engine control room;

(5) fire control station; and

(6) adjacent to the exit of the fuel cell space.

10.4.1.2 Actuation of the manual emergency shutdown push button is to interrupt the fuel supply and to shut-down all non-certificated explosion prevention electrical equipment within the fuel cell space.

10.4.1.3 Alarms required in this Chapter are to be given at the bridge or in a continuously manned central control room. If alarming involves fuel bunkering, the indication, alarm and safety actions are to be located at the fuel bunkering operation position and / or other safe positions.

10.4.1.4 Gas/vapour detection above a gas or vapour concentration of 20% LEL is to cause an alarm. LEL is different for each fuel gas, such as in the air, 4% for hydrogen, 5.3% for methane and 1.7% for propane.

10.4.1.5 Gas/vapour detection at two detectors above a gas or vapour concentration of 40% LEL is to shut-down the affected fuel cell power system and disconnect all non-certificated explosion prevention electrical equipment within the fuel cell space where a leakage source is located, and to result in automatic

① Refer to IEC 60079-29-1:Explosive atmospheres – Gas detectors – Performance requirements of detectors for flammable detectors.

closing of all valves required to isolate the leakage. Where the fuel cell stack is not permitted to use in hazardous area zone 1, the fuel cell is to be immediately closed. Valves in the primary fuel system supplying liquid or gaseous fuel to the fuel cell space are to close automatically.

10.4.1.6 The fuel cell coolant supply unit is to be provided with gas detectors with an alarm.

10.4.1.7 If primary fuel or liquid fuel leakage is detected in the fuel cell space, the safety system is to shutoff immediately the fuel supply and all non-certificated explosion prevention electrical equipment within the space is to be shutdown. It can be achieved by a bilge high level monitoring device.

10.4.1.8 The safety system is not to restart the fuel supply at the leak point until the fault causing gas or fuel leakage mentioned in 10.4.1.4 to 10.4.1.7 of this Section has been eliminated.

10.4.1.9 In case of loss of ventilation in the fuel cell space, the safety system is to carry out an automatic shutdown of the fuel cell by the process control within a limited period of time. The period for the shut down by process control is to be considered on a case by case basis based on the risk analysis, together with the technical conditions of fuel cell.

10.4.1.10 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. To prevent a potential coolant release in the fuel cell space, pipes or equipment containing the coolant are to be provided. Consideration is to be given to the safety removal of the coolant.

10.4.1.11 If a fire is detected in the fuel cell space, the safe system is to shutoff immediately the fuel supply and all non-certificated explosion prevention electrical equipment within the space is to be shutdown.

10.4.1.12 For fuel cell spaces classified as hazardous area zone 1, the fuel cell power system is to be immediately closed and the fuel supply to the fuel cell space is to be shutoff when the fuel cell stack’s surface temperature raises above 300℃, providing that the fuel cell stack is not been approved for operating in hazardous area zone 1.

10.4.1.13 Safety actions to alarm and to limit the consequences of system failures are to be set according to the requirements mentioned above in this Chapter and Table 10.4.1. Additional alarms and safety actions are to be required for unconventional or complex fuel cell power installations.

Table 10.4.1 Safety Functions of Gas Supply System

Parameters	Alarm	Automatic shutdown tank master valve	Automatic shutdown fuel supply to the fuel cell space	Comments
High pressure in the fuel tank	X			See 10.2.1.1
High pressure in the fuel tank	X	X		See 6.2.1.3
Low pressure in the fuel tank	X	X		See 10.2.1.3
High temperature in the hydrogen fuel tank	X	X		See 10.2.1.2
Vapor detection in the heat exchanger expansion tank, 20%LEL	X			See 10.3.2.2(8)
Vapor detection in the airlock, 20%LEL	X			See 10.3.2.2(7)
Opening of the airlock door	X			
Loss of ventilation in case of opening of the airlock doors	X			
Vapor detection in the hydrogen storage hold	X			See 10.4.1.4

space, 20%LEL				
Vapor detection in the hydrogen storage hold space. Two detectors giving 40% LEL	X	X		See 10.4.1.5
A fire in the hydrogen storage hold space	X	X		Stop of the ventilation in the fuel storage hold space at the same time
High level in the bilge well in the hydrogen storage hold space	X			See 10.2.7.1
Low temperature in the bilge well in the hydrogen storage hold space	X	X		Appropriate for low temperature liquid fuel
Liquid fuel leakage in the hydrogen storage hold space	X	X		
Vapor detection in double wall pipes between the fuel storage hold space and the fuel cell space, 20%LEL	X			See 10.4.1.4
Vapor detection in double wall pipes between the fuel storage hold space and the fuel cell space. Two detectors giving 40% LEL	X	X 1)		See 10.4.1.5
Vapor detection in the fuel preparation room, 20%LEL	X			See 10.4.1.4
Vapor detection in the fuel preparation room. Two detectors giving 40% LEL	X	X 1)		See 10.4.1.5
Liquid fuel leakage in the fuel preparation room	X	X 1)		
Vapor detection in the fuel cell space, 20%LEL	X			See 10.4.1.4
Vapor detection in the fuel cell space. Two detectors giving 40% LEL	X		X	See 10.4.1.5
Liquid fuel leakage in the fuel cell space	X		X	See 10.4.1.7
Loss of ventilation in the double wall pipes between the fuel storage hold space and the fuel cell space 2)	X		X 3)	See 10.2.6
Loss of ventilation in the double wall pipes in the fuel cell space 2)	X		X 3)	See 10.2.6
Partial loss of ventilation in the fuel cell space 2)	X			See 10.2.6
All loss of ventilation in the fuel cell space 2)	X		X	See 10.2.6 and 10.4.1.9
Fire detection in the fuel cell space	X		X	See 10.4.1.11, and stop of the ventilation in the fuel cell space at the same time
Manual emergency shutdown	X		X	See 10.4.1.2
A failure of valve control working medium	X		X	Time delayed as found necessary
Surface temperature of the fuel cell above 300℃	X		X	See 10.4.1.12
Failure of the fuel cell cooling	X		X	
Automatic stop of fuel cell	X		X	See 10.2.4.5
Emergency stop of fuel cell	X		X	

Note: 'X' is applicable.
1) In cases when the fuel tank supplies fuel to more than one engine, different supply pipes are completely separated and located in an independent duct and the master valve is located outside of the duct, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected is to close.
2) If the duct is protected by inert gas then pressure loss of inert gas is to lead to the same actions as given in this table.
3) The parameter is not to lead to automatic stop of fuel supply, but manual operation may be available. Stop of fuel supply is to be required only in the case of fuel leakage into the duct and a ventilation failure in the duct.

CHAPTER 11 REQUIREMENTS FOR HFC POWER INSTALLATIONS READY

Section 1 GENERAL PROVISIONS

11.1.1 Application

11.1.1.1 This Chapter is applicable to newly constructed ships for which an HFC power installations ready plan is adopted and modification and installation of HFC power installations is intended in the future.

11.1.1.2 This Chapter specifies requirements for the arrangement, structural strengthening, materials, fuel bunkering and supply, ventilation and inerting, fire safety, electrical equipment and hazardous areas, control, monitoring and safety systems etc., when an HFC power installations ready plan is adopted.

11.1.1.3 Where the requirements given in this Chapter cannot be satisfied due to special or novel HFC power installations, the design, evaluation standards and survey and test methods are to be evaluated based on corresponding tests, theoretical basis, application experience or effective recognized standards, which may be accepted as an alternative or equivalent method subject to agreement by CCS.

11.1.1.4 The conventional ship systems and/or equipment shared with HFC power installations are to meet the requirements of relevant conventions and regulations as well as CCS Rules.

11.1.2 Goal and functional requirements

11.1.2.1 The goal of this Chapter is to define requirements for HFC power installations ready and provide technical guidance for the subsequent installation of HFC power installations on ships.

11.1.2.2 For HFC power installations ready, the following functional requirements are to be complied with:

(1) HFC power installations ready arrangement and design are to consider that the probability and consequences of hydrogen fuel-related hazards can be limited to a minimum;

(2) In the event of hydrogen fuel gas leakage or failure of the risk reducing measures, initiation of necessary safety actions is to be considered, taking into account that risk reducing measures and safety actions do not lead to an unacceptable loss of power;

(3) HFC power installations ready arrangement is to consider that hazardous areas are to be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment;

(4) Fuel containment systems and HFC spaces are to be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable

Section 2 TECHNICAL REQUIREMENTS

11.2.1 General requirements

11.2.1.1 For HFC power installations ready, due consideration is to be given to the impact of fitting of hydrogen fuel tank/hydrogen cylinders, hydrogen fuel cell stack and fuel supply system on the ship at the design and construction stage.

11.2.1.2 For ships applying for class notations of HFC Ready 2 and HFC Ready 2(X), in order to ensure that the reserved space, positions and interfaces at the construction stage are suitable for future installation of HFC power installations on board, the ready plan is to be developed based on a certain approved product instead of prototype product or novel design insofar as practicable, unless the design has been assessed or approved. For future on-board installation of HFC power installations, equipment or system with design principles similar to the ready plan may be chosen as an alternative and relevant plans and documents are to be submitted.

11.2.1.3 The ready plan is to consider that the intended HFC power installations match the on-board power supply and distribution system.

11.2.1.4 For HFC power installations ready, in addition to satisfying the requirements for system and equipment installation and arrangement, the needs of system operation and maintenance are to be considered.

11.2.2 Ship arrangement

11.2.2.1 Ships applying for class notation of HFC Ready 1 are to meet the requirements of 11.2.2.2 to 11.2.2.5.

11.2.2.2 Sufficient space is to be reserved for fitting and arrangement of hydrogen fuel tank/hydrogen cylinders and hydrogen fuel cell stack/module at the design and construction stage.

11.2.2.3 The reserved space for hydrogen fuel tank/hydrogen cylinders is to meet the requirements of 2.2.1.1, 2.2.1.2 and 2.2.2.

11.2.2.4 The reserved space for hydrogen fuel cell stack/module is to meet the requirements of 2.3.2.4 and 2.3.2.5.

11.2.2.5 The access to reserved space for hydrogen fuel tank/hydrogen cylinders and hydrogen fuel cell stack/module is to meet the requirements of 2.3.2.7 and 2.5.1.1.

11.2.2.6 Ships applying for class notation of HFC Ready 2 or HFC Ready 2(X) are to meet the requirements of Chapter 2 of the Guidelines.

11.2.3 Structural strength

11.2.3.1 Ships applying for class notation of HFC Ready 1 are to consider that the hull structure after the modification of HFC power installations is to meet the requirements for longitudinal strength in CCS Rules.

11.2.3.2 In addition to the requirement in 11.2.3.1, ships applying for class notation of HFC Ready 2 or HFC Ready 2(X) are to comply with relevant requirements of Chapters 1 and 5 of the Guidelines and other applicable requirements in CCS Rules.

11.2.4 Materials

11.2.4.1 Ships applying for class notation of HFC Ready 2 or HFC Ready 2(X) are to comply with requirements of Chapter 3 of the Guidelines.

11.2.5 Fuel bunkering and supply

11.2.5.1 Ships applying for class notation of HFC Ready 1 may consider reserving certain space for fuel supply system. Fuel pipes are to be not less than 800mm away from the shell plating. Fuel pipes which pass through ro-ro spaces and special category spaces and which are arranged on the open deck are to be provided with mechanical protection against damage. The arrangement of fuel supply pipes outside the fuel cell spaces may refer to the requirements of 4.3.3.1. Where consideration is given to passing through enclosed spaces other than the above spaces, sufficient space for double-walled pipes is to be reserved while consideration may be given to reserving sufficient space for ventilation or inerting of double-walled pipes and design and arrangement of gas valves.

11.2.5.2 For ships applying for class notation of HFC Ready 1, where fuel bunkering is considered, space for arrangement of fuel bunkering station is generally to be reserved on the weather deck. Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations are not to face the reserved positions of bunkering connections.

11.2.5.3 For ships applying for class notation of HFC Ready 2 or HFC Ready 2(X), fuel pipe design and installation are to comply with the requirements of Chapter 4 of the Guidelines. Fuel bunkering is to comply the requirements of Chapter 6 of the Guidelines. The manufacture, process and testing of the fuel pipes are to comply with the requirements of 4.1.1.2.

11.2.6 Ventilation and inerting

11.2.6.1 For ships applying for class notation of HFC Ready 1, due consideration is to be given to the impact of the position of vent outlet of fuel tanks/hydrogen cylinders on the general arrangement at the design and construction stage according to the requirements of 5.3.1.1.

11.2.6.2 Ships applying for class notation of HFC Ready 1 may consider to reserve ventilation pipe space for the fuel tank/hydrogen cylinder spaces and hydrogen fuel cell spaces. The design and arrangement of ventilation duct for reserved space containing hydrogen fuel pipes or release source are to avoid any possibility of gas accumulation. The reserved position for ventilation inlets of double-walled piping or air duct not containing hydrogen fuel is always to be located at the open non-hazardous area far away from the ignition source.

11.2.6.3 Ships applying for class notation of HFC Ready 1 may consider to reserve space for exhaust air duct of HFC power system in accordance with the requirement of 8.7.1.1 to 8.7.1.3.

11.2.6.4 For ships applying for class notation of HFC Ready 2 or HFC Ready 2(X), relevant ventilation and inerting systems of HFC power installations are to comply with the requirements of Chapter 8 of the Guidelines.

11.2.7 Fire safety

11.2.7.1 For ships applying for class notation of HFC Ready 1, the fire division of boundary between the on-board spaces reserved for installation and arrangement of hydrogen fuel tank/hydrogen cylinder, hydrogen fuel cell stack/module and bunkering stations at the design and construction stage, and other on-board spaces is to comply with the requirements of Chapter 9 of the Guidelines.

11.2.7.2 In addition to requirements of 11.2.7.1, ships applying for class notation of HFC Ready 2 or HFC Ready 2(X) are to comply with other requirements of Chapter 9 of the Guidelines.

11.2.8 Electrical equipment and hazardous areas

11.2.8.1 For ships applying for class notation of HFC Ready 1, consideration may be given to reserving space for connecting HFC power installations to on-board power grid, such as reserving the position for breakers on the switchboard, reserving space for arrangement of DC/DC or DC/AC devices, etc.

11.2.8.2 For ships applying for class notation of HFC Ready 1, at the design and construction stage, due consideration may be given to the hazardous areas related to HFC power installations, and the accesses and vents of safety areas such as superstructure and engine rooms are to avoid hazardous areas insofar as practicable or space is reserved for air lock.

11.2.8.3 For ships applying for class notation of HFC Ready 2 or HFC Ready 2(X), the electrical equipment is to comply with the requirements of Chapter 7 of the Guidelines.

11.2.9 Control, monitoring and safety system

11.2.9.1 For ships applying for class notation of HFC Ready 1, signal transmission interface may be considered to be reserved for on-board equipment/system such as automation system to meet signal transmission requirement of HFC power installations. Space may also be reserved for installation of alarm devices related to HFC power installations, e.g., alarm and control board or computer at the bridge or engine central control room.

11.2.9.2 For ships applying for class notation of HFC Ready 2 or HFC Ready 2(X), the control, monitoring and safety system is to comply with the requirements of Chapter 10 of the Guidelines.

Section 3 PLANS AND DOCUMENTS

11.3.1 Plans and documents to be submitted for application of class notation of HFC Ready 1

11.3.1.1 In addition to the plans and documents required by CCS Rules, ships applying for class notation of HFC Ready 1 are to submit the following plans and documents for approval:

(1) General arrangement plan, including:

① Reserved arrangement of HFC spaces;

② Reserved arrangement of hydrogen tank/hydrogen cylinder spaces and hydrogen tank/ hydrogen cylinder connection spaces;

③ Reserved arrangement of fuel bunkering system (if applicable);

(2) Structural fire protection arrangement plan of space reserved for hydrogen tank/hydrogen cylinder spaces and hydrogen tank connection spaces, bunkering stations (if applicable) and hydrogen fuel cells.

11.3.1.2 The following plans and documents are to be submitted for information:

(1) Instructions for HFC ready;

(2) Calculation of longitudinal strength (considering HFC stack/module and hydrogen fuel tank/bottle).

11.3.2 Plans and documents to be submitted for application of class notation of HFC Ready 2

11.3.2.1 In addition to the plans and documents required by CCS Rules, ships applying for class notation of HFC Ready 2 are to submit the plans and documents listed in 1.2.1.1(1)-(7) for approval.

11.3.2.2 The plans and documents required in 1.2.2.1 are to be submitted for information.

11.3.3 Plans and documents to be submitted for application of class notation of HFC Ready 2 (X)

11.3.3.1 In addition to all the plans and documents required in 11.3.1 and 11.3.2, the mooring test and sea trial program of equipment/system related to on-board HFC power installations are to be submitted to site surveyors for approval.

Section 4 SURVEYS

11.4.1 General requirements

11.4.1.1 All the survey procedures, methods, types, intervals, conditions and preparations for survey, survey and test requirements, as well as preservation of plans, information, certificates, records and reports of the ship are to be in accordance with applicable requirements of CCS Rules.

11.4.2 Special requirements

11.4.2.1 For ships applying for class notation of HFC Ready 2(X), surveys during and after construction are to be carried out in accordance with applicable requirements of Section 4, Chapter 1 of the Guidelines.

11.4.2.2 The pre-installed equipment related to HFC power installations are to have product certificates and the survey basis for the certificates is to include relevant CCS survey requirements for fuel cell power installations.