GUIDANCE NOTES
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China Classification Society

GUIDELINES FOR APPLICATION OF FUEL CELL POWER SYSTEMS

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Beijing

Contents

Chapter 1 General

1.1 General provisions

1.1.1 The Guidelines apply to stationary fuel cell power systems using natural gas or hydrogen as fuel on sea-going ships. The fuel above is stored onboard the ship in gaseous or liquid state.

1.1.2 Ships provided with fuel cell power systems are, in addition to the requirements of the Guidelines, to comply with the provisions of other applicable CCS rules.

1.2 Class notations

1.2.1 Ships provided with fuel cell power systems may be assigned the following class notations according to scope of supply:

(1) FC-FULL: The ship is not provided with other power source except the fuel cell power system. The fuel cell power system provides power to all equipment onboard the ship (propulsion, steering gears and other essential equipment, emergency equipment as well as other equipment) and complies with the provisions of the Guidelines;

(2) FC-POWER 1: The ship is provided with the diesel generating set and the fuel cell power system. The fuel cell power system provides power to essential equipment of the ship and complies with the provisions of the Guidelines;

(3) FC-POWER 2: The ship is provided with the diesel generating set and the fuel cell power system. The fuel cell power system provides power to non-essential equipment and non-emergency equipment and complies with the provisions of the Guidelines.

1.3 Definitions

1.3.1 Stationary fuel cell power system

A system that is connected and fixed in place, using one or more fuel cell module(s) to generate electric power and heat. The system may either be assembled, self-contained or integrated by the manufacturer, and is to be composed of part or all of components listed in 1.3.2 to 1.3.11. The typical stationary fuel cell power system is shown in Figure 1.3.1. The energy storage unit may also be external.

1.3.2 Fuel cell stack

Equipment 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.

1.3.3 Fuel cell module

Equipment assembly of one or more fuel cell stacks which electrochemically converts chemical energy to electric energy and thermal energy within the fuel cell power system.

1.3.4 Fuel processing system

System of chemical and/or physical processing equipment plus associated heat exchangers and controls required to prepare, and if necessary, pressurize, the fuel for utilization within the fuel cell power system.

1.3.5 Oxidant processing system

System that meters, conditions, processes and may pressurize the incoming supply of oxidant for use within the fuel cell power system.

1.3.6 Automatic control system

System that is composed of sensors, actuators, valves, switches and logic components that maintain the fuel cell power system parameters within the manufacturer's specified limits without manual intervention.

1.3.7 Power conditioning system

Equipment that is used to adapt the electrical energy produced by the fuel cell stack(s) to application requirements as specified by the manufacturer.

1.3.8 Ventilation system

System that provides air through forced or natural means to the fuel cell power system's enclosure so as to guarantee the air quality within the enclosure.

1.3.9 Water treatment system

System that provides all of the necessary treatment of the recovered or added water for use within the fuel cell power system.

1.3.10 Thermal management system

System that provides cooling and heating to maintain the fuel cell power system in the operating temperature range, and may provide for the recovery of excess heat and assist in heating the power train during startup.

1.3.11 Internal energy storage unit

System of internal electric energy storage devices intended to aid or complement fuel cell module in providing power to internal or external loads.

1.3.12 Fuel cell installation

Installation containing the fuel processing system and/or fuel cell module(s), excluding fuel storage tanks.

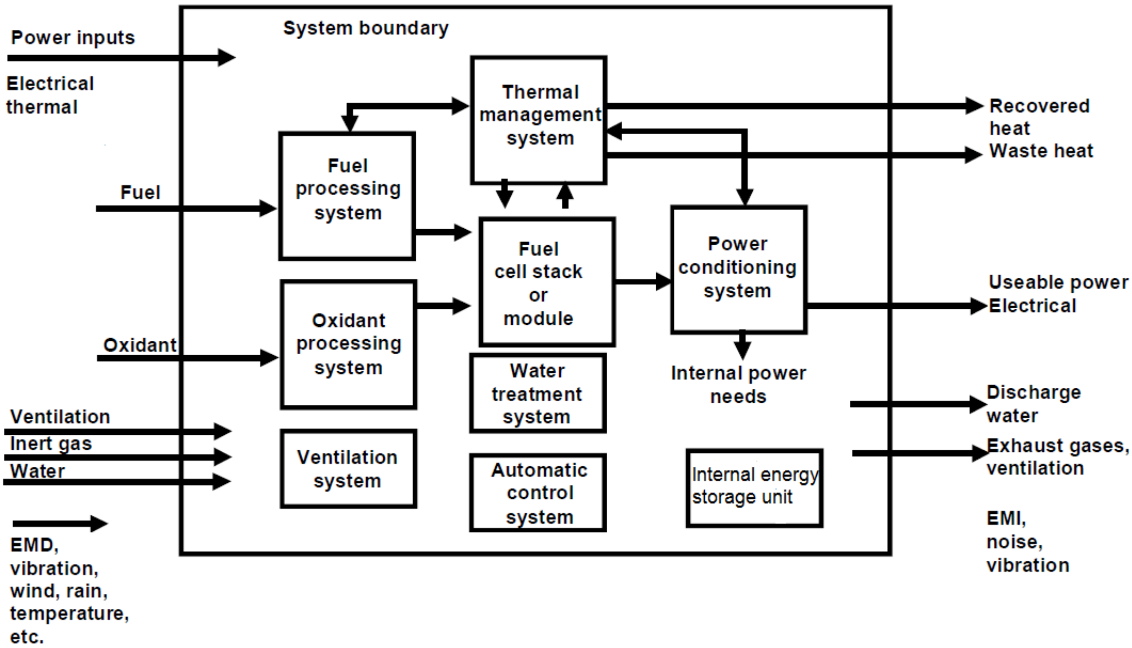

Figure 1.3.1 Stationary fuel cell power systems

1.4 Plans and documents

1.4.1 Ships provided with stationary fuel cell power systems are to comply with the requirements of 1.4.2 and 1.4.3 of this Section, in addition to submitting plans and documents in accordance with the provisions of the Administration and the relevant requirements of CCS rules.

1.4.2 The following plans and documents are to be submitted for approval:

(1) FMEA of the fuel cell power system[①], which is to take into account all foreseeable failures and hazards related to the system, including explosion and fire hazards. If a fuel cell power system is connected to the grid any potential hazards affecting the ship's total power system are to be included;

(2) ships applying for notation FC-FULL or FC-POWER 1 are to submit documents demonstrating that the system complies with the requirements of Chapter 7;

(3) arrangement of the fuel cell power system is to indicate the location of each component of the system, such as fuel cell module, fuel processing equipment, fuel storage unit, cooling unit, etc.;

(4) drawing(s) of the fuel piping system;

(5) drawings of other piping systems related to the fuel cell power system;

(6) hazardous area classification drawing(s);

(7) drawing(s) showing locations of all electrical equipment in hazardous areas and list of installations are to indicate clearly the explosion protection type, explosion protection category, temperature class and protection grade of the installations;

(8) plans of control, monitoring and safety systems related to fuel;

(9) set values of safety systems related to the fuel cell power system.

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

(1) principle explanations and system diagrams of the fuel cell power system;

(2) operation procedures and functional descriptions of the fuel cell power system in all conditions;

(3) descriptions of the life cycle of the fuel cell power system, such as the power attenuation curve or similar documents;

(4) operation and maintenance manuals of the fuel cell power system.

1.5 Equivalents and exemptions

1.5.1 Considering the fuel cell technology being under development, where the application of the provisions of the Guidelines is unreasonable or impracticable, it may be waived subject to agreement of CCS.

1.5.2 Equivalence or substitution to those survey and test methods specified by the Guidelines may be accepted subject to agreement of CCS, when relevant tests, theoretical basis or experience in application is provided, or recognized effective standards are available.

① FMEA is to be based on IEC Publication 62282-3-100 Stationary fuel cell power systems—Safety, and also to consider the arrangement of the system onboard the ship as well as interfaces with relevant systems.

Chapter 2 Ship Arrangements

2.1 General provisions

2.1.1 The arrangement and location of spaces for gas fuel storage, distribution and use are to be such that the number and extent of hazardous areas is kept to a minimum.

2.2 Fuel cell spaces

2.2.1 Fuel cell spaces are to have as simple geometrical shape as possible to facilitate effective ventilation and avoid concentration of fuel gas. Fuel cell spaces where hydrogen may be present are to have no obstructing structures in the upper part and are to be arranged with a smooth ceiling sloping up towards the ventilation outlet. Support structure like girders and stiffeners is to be facing outwards.

2.2.2 Fuel cell installations are to be located in separate spaces. Spaces containing fuel cell installations are to be located outside of and separate from the accommodation spaces, service spaces, machinery spaces and control stations.

Where fuel cell installations are located in the machinery spaces, the installations and the fuel supply system thereof are to be installed in a gastight enclosure which is to be fitted with a ventilation system as required in 4.2.4, Chapter 4 of the Guidelines as well as a gas detection and automatic shutdown system as required in Chapter 6 of the Guidelines.

2.2.3 Fuel cell spaces may be categorized as follows according to the design of the gas supply piping within the spaces:

(1) gas safe fuel cell spaces: arrangements in spaces are such that the spaces are considered gas safe under all conditions, normal as well as abnormal conditions, i.e. inherently gas safe;

(2) ESD-protected fuel cell spaces: arrangements in spaces are such that the spaces are considered non-hazardous under normal conditions, but under certain abnormal conditions may have the potential to become hazardous. In the event of abnormal conditions involving gas hazards, emergency shutdown (ESD) of non-safe equipment (ignition sources) is to be automatically executed while equipment in use or active during these conditions is to be of a certified safe type.

2.3 Fuel compressor/pump rooms

2.3.1 Fuel compressor/pump rooms, in general, are to be located on open deck. If the compressor/pump rooms are located below the freeboard deck, the following requirements are to be complied with:

(1) the room is not to be located adjacent to machinery spaces of category A. If the separation is by means of a cofferdam the separation is at least to be 900 mm and insulation to class A-60 is to be fitted on the engine-room side;

(2) room boundaries including access doors are to be gastight;

(3) the room is to be provided with an independent access from open deck, not shared with any other spaces.

2.3.2 If the compressor/pump is driven by shafting passing through a bulkhead or deck, the bulkhead penetration is to be of gastight type, so as to prevent gas fuel leaking into the room where shafting is located.

2.4 Fuel storage tanks

2.4.1 Unless provided otherwise by this Chapter, liquefied gas fuel storage tanks may be in accordance with the relevant requirements of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk or of recognized standards. Compressed gas fuel tanks may be in accordance with the relevant requirements for pressure vessels in Chapter 6, PART THREE of CCS Rules for Classification of Sea-going Steel Ships or of recognized standards.

2.4.2 Fuel storage tanks are to be provided with pressure relief valves as required in Chapter 8 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

The outlet from the pressure relief valves is normally to be located at least *B*/3 or 6 m, whichever is greater, above the weather deck and 6 m above the working area and gangways, where *B* is the greatest moulded breadth of the ship, in m. The outlets are normally to be located at least 10 m from the nearest:

(1) air intake, air outlet or opening to accommodation, service and control spaces, or other gas safe spaces; and

(2) exhaust outlet from machinery or from furnace installation.

2.4.3 Compressed or liquefied fuel is generally to be stored above the main deck level and compressed gas is generally not to be stored below the main deck. Fuel storage tanks below the main deck are generally to have a maximum design pressure not more than 10 bar.

2.4.4 The fuel storage tank is to be placed as close as possible to the centerline and comply at least with the following requirements:

(1) minimum, the lesser of *B*/5 and 11.5 m from the ship side;

(2) minimum, the lesser of *B*/15 and 2 m from the bottom plating; and

(3) not less than 800 mm from any position of the shell plating.

2.4.5 Fuel storage tank rooms below the main deck are also to comply with the requirements of 2.3.1(2) and (3).

2.4.6 Fittings, such as connections, flanges and valves, of the fuel storage tank, when not arranged on open deck, are to be enclosed in the tank connection space. The space is to be capable of containing leakage from the tank in case of the tank connections leakage. The material of the bulkheads of this space is to have the same design temperature as the fuel storage tank, and the space is to be designed to withstand the maximum pressure build-up. Alternatively, pressure relief venting to a safe location (mast) can be provided. The space is to be isolated thermally so that the surrounding hull is not exposed to unacceptable cooling, in case of leakage of the gas fuel.

2.4.7 The boundaries, including access doors (if fitted), accesses, fireproof structure as well as the gas detection system of the tank connection space, are to be same as those of the fuel storage tank room.

2.4.8 Where the liquefied gas fuel storage tank is located on open deck, the steel structure of the hull is to be protected by drip trays from potential leakage from tank connections or other sources of leakage. The design temperature of the material is to be corresponding to the temperature of the fuel carried at atmospheric pressure.

Chapter 3 Fuel Systems

3.1 General provisions

3.1.1 Fuel cell equipment and system are to be effectively designed, manufactured, installed, operated, maintained and protected to ensure their safe and reliable operation.

3.1.2 Fuel piping is to comply with the relevant requirements of Chapter 5 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. The materials of all piping having direct contact with fuel are to comply with the relevant requirements of Chapter 6 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

3.1.3 Fuel pipes are not to be located less than 800 mm from ship's side.

3.1.4 Fuel piping is not to be led through other machinery spaces, accommodation spaces, service spaces or control stations.

3.1.5 Fuel piping is to be separated from other piping and marked with appropriate color. The arrangement of the piping is to be capable of preventing external damages.

3.1.6 Installations for inerting and purging fuel piping are to be fitted.

3.1.7 If the fuel gas contains heavier components that may condense in the system, knock out drums or equivalent means for safely removing the liquid are to be fitted.

3.1.8 The piping arrangement specified by 3.2 does not apply to hydrogen piping.

3.2 Piping in gas safe fuel cell spaces

3.2.1 All gas supply lines within fuel cell space boundaries are to be completely enclosed by a double pipe or duct to ensure that the fuel cell space is gas safe.

The double pipe or duct is to fulfil one of the following:

(1) the gas piping is to be a double wall piping system 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 pipes; or

(2) the air space between the gas fuel piping and the wall of the outer pipe or duct is to be equipped with mechanical under pressure 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 on open deck where no flammable gas-air mixture may be ignited.

3.2.2 All fuel cell gas piping in the space is to be protected by the ducting. The arrangement is to facilitate replacement and overhaul of valves and other parts.

3.2.3 For high-pressure piping (the maximum working pressure is more than 1 MPa) the design pressure of the ducting is to be taken as the higher of the following:

(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: this pressure is 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.

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. Test reports are then to be submitted.

3.2.4 For low pressure piping (the maximum working pressure is not more than 1 MPa) the duct is to be dimensioned for a design pressure not less than the maximum working pressure of the gas pipes. The duct is also to be pressure tested to show that it can withstand the expected maximum pressure at gas pipe rupture.

3.3 Piping in ESD-protected fuel cell spaces

3.3.1 Where ESD-protected design approach is adopted for the fuel system, the fuel cell space is to be provided with a gas detection and automatic shutdown system as required in Chapter 6 of the Guidelines.

3.3.2 Where ESD-protected design approach is adopted for the fuel system, the working pressure inside the fuel lines in the fuel cell space is not to exceed 10 bar. The fuel lines are to have a design pressure not less than 10 bar.

3.3.3 The ventilation of such spaces is to comply with the requirements of 4.4, Chapter 4 of the Guidelines.

3.3.4 Pipe connections are to be kept at a minimum and butt welding with complete penetration is to be adopted. 100% radiographic testing is to be carried out after the completion of welding.

3.3.5 For flanged connections, flanges are to be of the welding neck (i.e. type A flanges). 100% radiographic testing is to be carried out for the welded part.

3.4 Piping outside fuel cell spaces

3.4.1 Gas fuel piping is not to be led through accommodation spaces, service spaces or control stations. Hydrogen piping is not to be led through enclosed spaces outside fuel cell spaces.

3.4.2 Where fuel pipes pass through enclosed spaces in the ship, they are to be enclosed in a duct. This duct is to be mechanically under pressure ventilated with 30 air changes per hour, and gas detection as required in Chapter 6 of the Guidelines is to be provided.

3.4.3 The ventilation inlet and outlet for the duct is to be located in open air, away from ignition sources.

3.4.4 Fuel pipes located in open air are to be protected from accidental mechanical impact.

3.4.5 High-pressure gas lines outside the fuel cell spaces are to be installed and protected so as to minimize the risk of injury to personnel in case of rupture.

3.5 Fuel bunkering systems

3.5.1 The bunkering station is to be located on open deck so that sufficient natural ventilation can be provided. Closed or semi-enclosed bunkering stations are to be subject to special consideration.

3.5.2 Drip trays are to be fitted below liquid gas bunkering connections and where leakage may occur. The drip trays are to be made of materials resistant to low temperature, and are to be drained over the ship's side by a pipe. This pipe could be temporarily fitted for bunkering operations. The surrounding hull or deck structures are not to be exposed to unacceptable cooling, in case of leakage of liquid gas.

3.5.3 Control of the bunkering is to be possible from a safe location in regard to bunkering operations. At this location tank pressure and tank level are to be monitored. Overfill alarm and automatic shutdown are also to be indicated at this location.

3.5.4 The bunkering system is to be so arranged that no gas is discharged to air during filling of storage tanks.

3.5.5 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 shore connecting point. It is to be possible to release the remote-operated valve in the control location for bunkering operations and/or another safe location.

3.5.6 If the ventilation in the ducting around the gas bunkering lines stops, an audible and visual alarm is to be provided at bunkering control location.

3.5.7 If inflammable gas is detected in the ducting around the bunkering lines an audible and visual alarm is to be provided at the bunkering control location.

3.5.8 Means are to be provided for draining the liquid or gas from the bunkering pipes at bunkering completion.

3.5.9 Bunkering lines are to be arranged for inerting and gas freeing. During operation of the vessel the bunkering pipes is to be gas free.

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Chapter 4　Fire Fighting

4.1　Structural fire protection

4.1.1　For any space containing equipment for the fuel processing (e.g. pumps, compressors, heat exchangers, vaporizers and pressure vessels), the structural fire protection is to comply with the requirements for machinery spaces of category A.

4.1.2　Gas fuel storage tanks located on open deck are to be shielded with class A-60 insulation towards accommodation spaces, service spaces, cargo spaces, machinery spaces and control stations. Such insulation is to extend to the bottom of the bridge deck or the actual height of the bulkhead. The boundaries above the bridge deck, including bridge sidescuttles, are to be shielded with class A-0 insulation. In addition, the separation of gas fuel storage tanks and cargo holds is to comply with the relevant requirements for cargo in 2.1 of IMO International Maritime Dangerous Goods (IMDG) Code.

4.1.3　The space containing fuel is to be separated from the machinery spaces of category A or other rooms with high fire risks. The separation is to be done by a cofferdam of at least 900 mm with insulation of A-60 class. When determining the insulation of the space containing fuel from other spaces with lower fire risks, the space containing fuel is to be considered as a machinery space of category A, in accordance with SOLAS regulation II-2/9. The boundary between spaces containing fuel is to be either a cofferdam of at least 900 mm or A-60 class division.

4.1.4　Fuel cell spaces are to be arranged outside of accommodation, service and machinery spaces and control rooms, and are to be separated from such spaces by a cofferdam or A-60 class bulkhead. Installation in a conventional machinery space is admissible, on condition that a suitable enclosure is provided.

4.1.5　The bunkering station is to be separated by A-60 class divisions towards machinery spaces of category A, accommodation spaces, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard may be reduced to class A-0.

4.1.6　Boundaries of fuel cell spaces, including access doors, if fitted, are to be gastight.

4.1.7　Spaces containing fuel processing systems are to be separated from spaces containing fuel by steel bulkhead and no door is allowed between spaces.

4.1.8　When ESD-protected machinery spaces are separated by a single bulkhead, the bulkhead is to be class A-60.

4.1.9　Machinery or equipment of fire risk is not allowed to be installed in spaces containing fuel.

4.2　Ventilation

4.2.1　Any ducting used for the ventilation of hazardous spaces is to be separate from that used for the ventilation of non-hazardous spaces. The ventilation is to function at all temperature conditions the ship will be operating in.

(1) Ventilation fans and fan ducts, in way of fans only, are to be of non-sparking type in hazardous areas. Electric motors driving fans are to comply with the required explosion protection in the installation area.

(2) Air inlets for hazardous areas are to be taken from areas which, in the absence of the considered inlet, would be non-hazardous. Air outlets from hazardous spaces are to be located in

an open area which, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space. Air inlets and outlets are to be provided with protection screen with square mesh not more than 13 mm.

(3) Air inlets for non-hazardous enclosed spaces are to be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct is to be gastight and have over-pressure relative to this space. Air outlets from non-hazardous spaces are to be located outside hazardous areas.

(4) Non-hazardous spaces with opening to a hazardous area are to be arranged with an air-lock as required in CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and be maintained at overpressure relative to the external hazardous area in accordance with the following requirements:

① During initial start-up or after loss of overpressure ventilation, before energizing any electrical installations not certified safe for the space in the absence of pressurization, it is to be required to:

(a) proceed with purging (at least 5 air changes) or confirm by measurements that the space is non-hazardous; and

(b) pressurize the space.

② Operation of the overpressure ventilation is to be monitored. In the event of failure of the overpressure ventilation:

(a) an audible and visual alarm is to be given at a manned location; and

(b) if overpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations according to a recognized standard.

(5) Non-hazardous spaces with opening to a hazardous area are to be arranged with an air-lock and be maintained at overpressure relative to the external hazardous area. Operation of the overpressure ventilation is to be monitored. In the event of failure of the overpressure ventilation:

① an audible and visual alarm is to be given at a manned location; and

② if overpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations according to a recognized standard.

(6) When the space is dependent on ventilation for its area classification:

① During initial start-up, and after loss of ventilation, the space is to be purged (at least 5 air changes), before connecting electrical installations which are not certified for the area classification in absence of ventilation. Warning notices to this effect are to be placed in an easily visible position near the control stand.

② Operation of the ventilation is to be monitored.

③ In the event of failure of ventilation:

(a) an audible and visual alarm is to be given at a manned location; and

(b) immediate action is to be taken to restore ventilation.

4.2.2 Ventilation of enclosed gas fuel storage spaces is at least to comply with the following requirements:

(1) Enclosed gas fuel storage spaces are to be provided with an effective mechanical forced ventilation system of the under pressure type, providing a ventilation capacity of at least 30 air changes per hour.

(2) Approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for gas fuel

storage spaces

4.2.3 Ventilation of pump and compressor rooms

(1) Pump and compressor rooms are to be fitted with effective mechanical ventilation system of the under pressure type, providing a ventilation capacity of at least 30 air changes per hour.

(2) The number and power of the ventilation fans are to be such that the capacity is not reduced by more than 50%, if a group of fans is out of action.

(3) Ventilation systems for pump and compressor rooms are to be in operation when pumps or compressors are working. The pump and compressor can only start after the ventilation systems have been operated for 10 min.

4.2.4 Ventilation of fuel cell spaces is at least to comply with the following requirements:

(1) Ventilation of fuel cell spaces is to effectively avoid gas from accumulating to the point of flammability limit during any leakage, including pipe rupture.

(2) The number and power of the ventilation fans are to be such that the capacity is not reduced by more than 50%, if a group of fans is out of action.

4.2.5 Where the gas fuel bunkering station is located in enclosed spaces, an effective mechanical ventilation system is to be provided, providing a ventilation capacity of at least 30 air changes per hour. For the calculation of the number of air changes, the volume of the bunkering space without ventilation pipes and equipment is to be used as the reference volume.

4.2.6 Ducts and double pipes containing inflammable gas are at least to comply with the following requirements:

(1) The air space between the gas fuel piping and the wall of the outer pipe or duct is to be equipped with mechanical ventilation system of the extraction type having a capacity of at least 30 air changes per hour. If the space between the concentric pipes is pressurized with inert gas at a pressure greater than the gas fuel pressure, and the inert gas pressure is monitored continuously and suitable alarms are provided to indicate a loss of inert gas pressure between the pipes, the mechanical ventilation system may not be installed.

(2) The ventilation inlet for the duct and double pipe containing inflammable gas is to be away from ignition sources. The inlet opening is to be fitted with a suitable wire mesh guard and protected from ingress of water.

(3) The capacity of the ventilation for a pipe duct or double wall piping may be below 30 air changes per hour if a flow velocity of minimum 3 m/s is ensured. The flow velocity is to be calculated for the duct with fuel pipes and other components installed.

4.2.7 The outlets for exhaust generated during fuel processing are normally to be located at least $B/3$ or 6 m, whichever is greater, above the weather deck and 6 m above the working area and gangways, where B is the greatest moulded breadth of the ship, in m. The outlets are normally to be located at least 10 m from the nearest air intake, air outlet or opening to accommodation spaces, service spaces and control stations, or other gas safe spaces; and exhaust outlet from machinery. If this is impracticable for inland waterway ships, relaxation may be granted as appropriate subject to approval of CCS.

4.2.8 Openings to accommodation spaces, service spaces, machinery spaces and control stations are not to face towards and are at least 3 m away from openings of spaces containing fuel processing equipment.

4.2.9 For exhaust released by fuel cell stacks, the outlets must be located on open deck and there are not to be ignition sources and openings to accommodation spaces, service spaces, machinery spaces and control stations as well as other spaces containing ignition sources within 3 m from the outlets.

4.3 Fire extinction

4.3.1 General requirements

(1) Spaces containing fuel transfer piping and installation as well as other machinery spaces containing fuel are to be provided with a fixed pressure water spray system complying with the requirements of the International Code for Fire Safety Systems.

(2) When the storage tank is located on open deck, isolating valves are to be fitted in the fire main in order to isolate damage sections of the main.

(3) A water spray system is to be fitted for cooling and fire prevention and to cover exposed parts of gas storage tank located above deck.

(4) The water spray system is also to provide coverage for boundaries of the superstructures, compressor rooms, pump rooms, cargo control rooms, bunkering control stations, bunkering stations and any other normally occupied deck houses that face the storage tank unless the tank is located 10 m or more from the boundaries.

(5) The water spray system may be part of the fire main system provided that the required fire pump capacity and working pressure is sufficient to operation of both the required numbers of hydrants and the water spray system simultaneously.

4.3.2 Water spray systems

(1) The system is to be designed to cover all areas as specified in 4.3.1(3) and (4) above with an application rate of 10 L/min/m^2 for horizontal projected surfaces and 4 L/min/m^2 for vertical surfaces.

(2) For the purpose of isolating damage sections, stop valves are to be fitted at least every 40 m or the system may be divided into two or more sections with control valves located in a safe and readily accessible position not likely to be cut-off in case of fire.

(3) The capacity of the water spray pump is to be sufficient to deliver the required amount of water to all the areas protected.

(4) A connection to the ship's fire main through a stop valve is to be provided. Remote start of pumps supplying the water spray system and remote operation of any normally closed valves to the system is to be located in a readily accessible position which is not likely to be cut off in case of fire in the areas protected.

(5) The nozzles are to be of an approved type and they are to be arranged to ensure an effective distribution of water throughout the space being protected.

4.3.3 Dry powder fire-extinguishing systems

(1) Where fuel storage tanks are located on open deck, at least two portable dry powder extinguishers of at least 5 kg capacity are to be located near the storage tanks.

(2) Where fuel storage tanks are located in enclosed or semi-enclosed spaces, at least one portable dry powder extinguisher of at least 5 kg capacity is to be located at the entrance to the spaces containing the tanks.

(3) In the bunkering station area a permanently installed dry powder extinguishing system or large wheeled dry powder extinguishing system is to cover all possible leak points. The capacity is to be

at least 3.5 kg/s for a minimum of 45 s discharges. The system is to be arranged for easy manual release from a safe location.

For ships provided with bunkering stations/connections on both sides, a permanently installed dry powder extinguishing system or large wheeled dry powder extinguishing system is to cover the area of the bunkering stations/connections on both sides.

(4) One portable dry powder extinguisher of at least 5 kg capacity is to be located near the bunkering station.

4.4 Fire detection and alarm

4.4.1 An approved fixed fire detection system is to be provided for all spaces where inflammable gas may exist. Where the fire detection system does not include means of remotely identifying each detector individually, the detectors are to be arranged on separate loops.

4.4.2 An fixed automatic fire detection and alarm system is not to be provided with smoke detectors only.

4.4.3 Required safety actions at fire detection in the fuel cell space and fuel storage tank are given in Table 6.3.1 of the Guidelines. In addition, the ventilation is to stop automatically and fire dampers are to close.

Chapter 5　Explosion Protection

5.1　General provisions

5.1.1　Electrical equipment and wiring are in principle not to be installed in hazardous areas. Where such arrangement is unavoidable, the provisions of this Chapter are to be complied with.

5.1.2　Installation of electrical equipment in hazardous areas is to comply with the requirements of 2.16.4, Section 16, Chapter 2, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships; and explosion group and temperature class of electrical equipment are to be determined based on the type of inflammable and explosive gas that may accumulate in hazardous areas:

(1) for natural gas, based on its components, the explosion protection category and temperature class are not be lower than II A and T2 respectively;

(2) for hydrogen, the explosion protection category and temperature class are not be lower than II C and T1 respectively.

5.1.3　Cables and cable-laying in hazardous areas are to comply with the applicable requirements in 2.16.3, Section 16, Chapter 2, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships.

5.1.4　In ESD-protected machinery spaces, ventilation fans, inflammable gas detectors, fire detectors, alarms and lighting as well as switches are to be certified safe for zone 1. All electrical equipment not certified for zone 1 is to be automatically disconnected, if gas concentration above 40% LEL is detected.

5.1.5　In order to avoid the hazard of an incentive discharge due to the build-up of static electricity resulting from the flow of liquids/gases/vapours, requirements of 1.3.4.12, Chapter 1, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships are to be complied with.

5.1.6　When an inflammable gas/liquid is bunkered to the ship, electrical insulation of the ship/shore connection is to be ensured. The insulation is to be provided by the shore bunkering terminal.

5.2　Hazardous area classification

5.2.1　The main objective of hazardous area classification is to select and install electrical equipment in the hazardous area correctly to ensure safe application. The Chapter divides typical areas or spaces of the ship into zones 0, 1 and 2 in accordance with the provisions of IEC 60079-10-1. For areas or spaces not mentioned in this Chapter, hazardous area classification is to be in accordance with the provisions of IEC 60092-502.

5.2.2　Fuel is generally stored onboard the ship in Type C pressure vessels or fuel storage tanks. Zone 0 includes: the interiors of fuel storage tanks and pipework supplying fuel, as well as the interiors of other equipment using fuel, such as cell stacks, compressors and pumps of fuel systems, fuel refilling installation, etc.

5.2.3　Hazardous area—Zone 1 normally includes:

(1) enclosed or semi-enclosed spaces containing fuel storage tanks, fuel piping, compressors and pumps of fuel systems, fuel refilling installations and fuel cell stacks, tank connection spaces;

(2) areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel storage tank outlet, gas or vapour outlet[①], bunker manifold valve, other gas valve, gas pipe flange, gas pump

① These outlets include ullage openings, sounding pipes for fuel storage tanks and gas vapour outlets.

room ventilation outlets and gas tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation;

(3) areas on open deck or semi-enclosed spaces on deck, within 1.5 m of gas compressor and pump room entrances, gas pump and compressor room ventilation inlets and other openings into zone 1 spaces;

(4) areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck;

(5) the ESD-protected machinery space is considered as non-hazardous area during normal operation, but changes to zone 1 in the event of gas leakage.

5.2.4 Hazardous area—Zone 2 normally includes:

(1) spaces forming an air-lock;

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

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

Chapter 6 Control, Monitoring and Safety Systems

6.1 Control and monitoring

6.1.1 Where fuel is stored in liquid state, the requirements of 13.2, 13.3 and 13.5, Chapter 13 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk are to be complied with.

6.1.2 Each fuel storage tank is to be provided with a local reading pressure gauge. The pressure gauge is to clearly indicate the highest and lowest pressure permitted in the tank. Pressure indicators are to be provided in remote control stations, such as navigation bridges, engine control rooms. In addition, high and low pressure alarms are to be provided in manned spaces. The alarms are to be activated before the set pressures are reached.

6.1.3 Equipment related to the fuel processing system is to be fitted with audible and visual alarms on the navigation bridge and/or in the control room of the fuel cell power system, including at least the following items:

(1) high temperature of the fuel heater outlet;

(2) high temperature of the fuel compressor outlet;

(3) low pressure of the fuel compressor inlet;

(4) high and low pressure of the fuel compressor outlet;

(5) low pressure and high temperature of compressor lubricating oil;

(6) control system failure of the power system;

(7) shutdown of the master gas-fuel valve.

6.1.4 Fuel cell modules and power regulating systems are to be provided with indicators and alarms (audio and visual signals) in manned spaces, including at least the following items:

(1) fuel cell output voltage indication and deviation alarm;

(2) fuel cell output current indication and deviation alarm;

(3) fuel cell module temperature indication and high temperature alarm;

(4) low fuel pressure in sealed fuel cell module;

(5) purge gas temperature indication and high temperature alarm.

6.1.5 Single failure of the components of the stationary fuel cell power system is not to result in dangers to the system, the ship and the crew. Systems executing safe shutdown function are to be independent of the control and alarm systems.

6.2 Gas detection

6.2.1 The fixed inflammable gas detection system is to be arranged in accordance with the actual conditions of the fuel cell power system and comply with the following requirements:

(1) The detectors are at least to be installed in air-locks, fuel storage tanks, ventilation ducts or pipes containing gas fuel piping, fuel cell spaces and other spaces containing fuel piping or gas-fuelled equipment. The detectors are to be located where gas may accumulate or at the ventilation outlets. Gas dispersal analysis or a physical smoke test is to be used to find the best arrangement. All detectors are to be arranged with redundancy except for those with self-checking function.

(2) Audible and visible alarms for gas detection are to be located on the navigation bridge and/or in the control room of the fuel cell power system. An alarm is to be activated before the vapour

concentration reaches 20% of the lower explosion limit (LEL). For ventilation ducts or pipes containing gas fuel piping, the alarm limit can be set to 30% LEL. Each type of inflammable gas has its own LEL, e.g. 4% for hydrogen and 5.3% for methane.

(3) Detection of inflammable gas is to be carried out continuously.

6.2.2 In addition to the fixed inflammable gas detection system, two portable gas detection devices are to be provided onboard the ship.

6.3 Safe protection of fuel supply systems

6.3.1 Main gas fuel supply lines

(1) The main gas fuel supply line is to be equipped with a manually operated stop valve and an automatically operated master gas fuel valve coupled in series or a combined manually and automatically operated valve. The valves are to be situated in the part of the piping that is outside space containing fuel cell stacks, and placed as near as possible to the gas supplying end. The master gas-fuel valve is to automatically cut off the gas supply as given in Table 6.3.1.

6.3.2 Gas fuel supply branch lines

(1) The gas fuel supply line to the fuel cell stack is to be provided with a manually operated stop valve to ensure that gas fuel can be safely cut off during repair of the fuel cell stack.

(2) The gas fuel supply line to each fuel cell stack is to be provided with detection installation and an automatically operated stop valve if double wall piping is not used. The stop valve is to be able to automatically cut off the gas supply in case that breakage of the supply line is detected.

6.3.3 Double block and bleed valves

(1) Each gas consuming equipment is to be provided with a set of double block and bleed valves. The set is composed of three automatic valves, two of which are in series in the gas fuel supply line and the third of which is in a pipe that vents to a safe location in the open air that portion of the gas fuel piping that is between the two valves in series.

(2) The set of valves is to automatically cut off the gas supply when failure occurs as given in Table 6.3.1. This will cause the two gas fuel valves that are in series to close automatically and the ventilation valve to open automatically. The two block valves are to be of the fail-to-close type, while the ventilation valve is to be fail-to-open.

(3) The double block and bleed valves are also to be used for normal stop of fuel cells. In cases where the master gas fuel valve is automatically shutdown, the ventilation valve will open and purge the line between the master fuel valve and the double block and bleed valve of gas fuel.

6.3.4 Safety instructions for gas fuel supply

(1) If the gas supply is shut off due to activation of an automatic valve, the gas supply is not to be opened until the reason for the disconnection is ascertained and the necessary precautions are taken. A readily visible notice giving instruction to this effect is to be placed at the operating station for the shut-off valves in the gas supply lines.

(2) A signboard is to be permanently fitted in the fuel cell spaces stating that heavy lifting, repair and maintenance, and other actions that may imply danger of damage to the fuel cell gas pipes, are not to be done when the fuel cell is operating.

6.3.5 The gas compressor/pump and fuel gas supply are be arranged for manual remote emergency stop from the following locations:

(1) safety center, if provided;

(2) cargo control room, if provided;

(3) navigation bridge;

(4) engine control room; and

(5) fire control station or operation locations for releasing the fire extinguishing system.

6.3.6 The gas compressor/pump is to be provided with local emergency stop installation.

List of alarm and control items of fuel cell systems Table 6.3.1

Item	Alarm	Automatic shutdown of master gas-fuel valve	Automatic shutdown of gas supply	Remark
Gas detection in tank or tank connection space above 20% LEL	X			
Gas detection in tank or tank connection space above 40% LEL	X	X①		
Fire detection in tank or tank connection space	X	X①		
Bilge well high level in tank or tank connection space	X			
Bilge well low temperature in tank or tank connection space	X	X①		Applicable to LNG
Gas detection in ventilation pipe or duct between tank or tank connection space and fuel cell space above 20% LEL	X			
Gas detection in ventilation pipe or duct between tank or tank connection space and fuel cell space above 40% LEL	X	X②		
Gas detection in compressor room (if provided) above 20% LEL	X			
Gas detection in compressor room (if provided) above 40% LEL	X	X②		
Gas detection in ventilation pipe or duct inside fuel cell space above 30% LEL	X			If double wall pipe fitted in space
Gas detection in ventilation pipe or duct inside fuel cell space above 60% LEL	X		X	If double wall pipe fitted in space
Gas detection in fuel cell space above 20% LEL	X			Not required if all fuel pipes are in complete double ducts
Gas detection in fuel cell space above 40% LEL	X		X	Not required if all fuel pipes are in complete double ducts. Non-certified safe electrical equipment is to be disconnected in fuel cell space
Loss of ventilation in duct between tank and fuel cell space④	X		X⑤	
Loss of ventilation in duct inside fuel cell space④	X		X⑤	If double wall pipe fitted in space
Loss of ventilation in fuel cell space	X		X	Not required if complete double wall pipes are fitted in fuel cell space
Loss of ventilation in ESD-protected machinery space	X		X	
Fire detection in fuel cell space	X		X	Ventilation is to be cut off in fuel cell space
Failure of valve control actuating medium	X		X③	Time delayed as found necessary
Automatic shutdown of fuel cell	X		X③	

Item	Alarm	Automatic shutdown of master gas-fuel valve	Automatic shutdown of gas supply	Remark
stack				
Emergency shutdown of fuel cell stack manually released	X		X	

① Where type C pressure vessel is used and connection space for two completely independent fuel storage tanks is provided, only master gas-fuel valve in space where gas is leaked is cut off.

② If the following conditions are met, only the master gas-fuel valve on the fuel pipe leading into the duct where inflammable gas is detected is to close:

a. the gas is supplied to more than one fuel cell stack;
b. the different supply pipes are completely separated and fitted in separate ducts;
c. the master gas-fuel valves are fitted outside of the duct.

③ Only double block and bleed valves are to close.

④ If the duct is protected by inert gas then loss of inert gas is to lead to the same actions.

⑤ For this item, fuel supply may be cut off manually. Only fuel ducts with loss of ventilation need to be cut off.

Chapter 7 Additional Requirements for Fuel Cell Power System Notation

7.1 FC-FULL notation

7.1.1 For ships assigned with FC-FULL notation, the fuel cell power system is to have an equivalent level of safety, reliability and independence as that of electricity-powered propulsion installations.

7.1.2 Measures taken to reduce risks are not to lower the power generating capacity and propulsion capability required for ship's operation.

7.1.3 Any single failure in active components① of the fuel cell power system is not to lead to loss of propulsion or power for essential equipment.

7.1.4 Two or more stationary fuel power systems are to be provided. Failure of one system is not to lead to loss of minimum propulsion capability of the ship, i.e. minimum navigation speed not less than 7 kn or half of the design navigation speed, whichever is greater. Safe navigation of the ship and minimum comfortable living conditions are also to be guaranteed.

7.1.5 For fuel cell modules, in addition to complying with the requirements of 6.1.4, their availability or life is to be monitored at the navigation bridge or the control room of the fuel cell power system.

7.1.6 Sea-going ships are to be provided with two or more fuel storage tanks arranged in different spaces at a minimum distance of *B*/5 or 11.5 m, whichever is less. Where type C pressure vessels are used and connection space for two completely independent fuel storage tanks is provided, only one pressure vessel may be accepted.

7.2 FC-POWER 1 notation

7.2.1 For ships assigned with FC-POWER 1 notation, the fuel cell power system is to have an equivalent level of safety, reliability and independence as that of diesel generating set.

7.2.2 Measures taken to reduce risks are not to lower the required power generating capacity.

7.2.3 Any single failure in active components of the fuel cell power system is not to lead to loss of power for essential equipment.

7.2.4 Where the fuel cell power system stops power supply due to failures, the stand-by diesel generating set is to start automatically in 45 s and connected to the main switchboard. All essential equipment with power supplied by the fuel cells is to be capable of being automatically switched to ship's main power supply.

7.2.5 For fuel cell modules, in addition to complying with the requirements of 6.1.4, their availability or life is to be monitored at the navigation bridge or the control room of the fuel cell power system.

7.3 FC-POWER 2 notation

7.3.1 Where the fuel cell power system fails, equipment with power supplied by the system is to be capable of being automatically or manually switched to ship's main power supply.

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① Active components are components for mechanical transfer of energy, e.g. pumps, fans, electric motors, generators, combustion engines and turbines. Fuel cells, heat exchangers, boilers, transformers, switchgear or cables are not considered to be active components.

Chapter 8 Survey and Testing

8.1 General provisions

8.1.1 Stationary fuel cell power systems installed onboard the ship are to have the manufacturer's document and product certificate issued by CCS. The testing and manufacturing processes of stationary fuel cell power systems are, where necessary, to be witnessed by CCS Surveyor.

8.1.2 For power systems of the same manufacturer with same design and similar power, items of environment adaptability test may be exempted subject to agreement of CCS.

8.1.3 Tuning, testing and maintenance of the fuel cell power system are to ensure safety, availability and reliability.

8.1.4 Given the features of the fuel cell power system, CCS reserves the right to add test items.

8.1.5 Test and sea trial programmes are to be submitted to CCS for approval. CCS may raise test requirements not included in this Chapter based on the features of the fuel cell power system.

8.2 Product survey of stationary fuel cell power systems

8.2.1 Prior to installation onboard the ship, the manufacturer is to submit the following plans and documents for approval:

(1) outline drawing and installation plan;

(2) technical specifications of the products (including system flowchart);

(3) electrical schematic diagram;

(4) for computer systems with control, monitoring and safety functions, plans and documents are to be submitted in accordance with the requirements of 1.1.3.2(1), PART SEVEN of CCS Rules for Classification of Sea-going Steel Ships.

8.2.2 The manufacturer is to submit the following plans and documents for information:

(1) drawings of external wiring;

(2) drawings of external piping;

(3) operation instructions for the products.

8.2.3 Environment adaptability test is to be carried out in accordance with CCS Guidelines for Type Approval Test of Electric and Electronic Products (GD01-2006) to ensure safe and reliable operation of the stationary fuel cell power system in ship and marine environment. The stationary fuel cell power system is at least to be subject to the test items as required in Table 8.2.3.

Environment adaptability test items of stationary fuel cell power systems Table 8.2.3

<table>
<tr><th>No.</th><th>Test item</th><th>Test method</th><th>Remark</th></tr>
<tr><td>1</td><td>Visual inspection</td><td>——</td><td></td></tr>
<tr><td>2</td><td>Insulation resistance test</td><td>2.3 of GD01-2006</td><td></td></tr>
<tr><td>3</td><td>Power supply variation test</td><td>2.4 of GD01-2006</td><td rowspan="2">When the system is connected to the ship's power source, tests are carried out to components using ship's power</td></tr>
<tr><td>4</td><td>Power supply failure test</td><td>2.5 of GD01-2006</td></tr>
<tr><td>5</td><td>Inclination and rolling test</td><td>2.6 of GD01-2006</td><td></td></tr>
<tr><td>6</td><td>Vibration test</td><td>2.7 of GD01-2006</td><td></td></tr>
<tr><td>7</td><td>Dry heat test</td><td>2.8 of GD01-2006</td><td rowspan="3">Where the equipment is installed in controlled environment, the test may be carried out in controlled ambient temperature, or be exempted subject to CCS agreement</td></tr>
<tr><td>8</td><td>Low temperature Test</td><td>2.9 of GD01-2006</td></tr>
<tr><td>9</td><td>Damp heat test(cyclic)</td><td>2.10 of GD01-2006</td></tr>
<tr><td>10</td><td>Damp heat test(steady state)</td><td>2.14 of GD01-2006</td><td></td></tr>
</table>

11	Enclosure test	2.15 of GD01-2006	
12	Flame retardant test	2.16 of GD01-2006	
13	Electromagnetic compatibility test	Chapter 3 of GD01-2006	Electronic control devices, DC/DC converters, DC/AC converters as well as other electrical and electronic equipment of the system need to be tested. If the equipment above is designed and manufactured as integral frame type, such equipment can be tested integrally

8.2.4 Manufacturing and testing are to be carried out in accordance with recognized standards① or other equivalent standards to ensure the safety of the stationary fuel cell power system, and a safety test is to be carried out as per the requirements of Table 8.2.4 as a minimum.

Safety test items of stationary fuel cell power systems Table 8.2.4

No.	Test item	Test method	Remark
1	Start-up test	1. Start the system, simulating start-up condition failure, to verify the effectiveness of the start-up interlock device. 2. Start the system after all start-up conditions have been prepared	The fuel cell power system can only be started when all protection devices have been installed in place and in action
2	Shutdown test	Function test of safe shutdown is carried out using simulated signals and controlled shutdown operation is carried out	1. Safe shutdown includes: (1) high temperature of inner cooling water; (2) hydrogen leakage; (3) low pressure at hydrogen inlet; (4) low voltage or big deviation of voltage of cells. 2. Hydrogen leakage in the compartment is to lead to safe shutdown. 3. The requirements of 4.9.2.3 of IEC 62282-3-100 are to be complied with
3	Pneumatic leakage test	5.4.2 of IEC 62282-3-100	
4	Pneumatic strength test	5.5.2 of IEC 62282-3-100	
5	Electrical overload test	5.7 of IEC 62282-3-100	Specific overload checking indicators are to be specified in accordance with actual system configuration and approved by CCS
6	Exhaust gas temperature test	5.11 of IEC 62282-3-100	
7	Surface and component temperatures test	5.12 of IEC 62282-3-100	

8.2.5 For the stationary fuel cell power system, performance tests are to be carried out to verify the numbers on the nameplate and in the technical instructions. Test items required in Table 8.2.5 are to be carried out at rated power as a minimum. For test methods, refer to IEC Publication 62282-3-200 Fuel cell technologies-Part 3-200: Stationary fuel cell power systems-Performance test methods.

Performance test items of stationary fuel cell power systems Table 8.2.5

No.	Test item	Test method	Remark
1	Electric power measurements	7.3.1 of IEC 62282-3-200	
2	Fuel input measurement	7.3.2.2.3 of IEC 62282-3-200	
3	Purge gas flow measurement (hydrogen side)	7.3.4 of IEC 62282-3-200	Purge gas flow volume downstream of electromagnetic valve is measured
4	Oxidant (air) input measurement	7.3.5 of IEC 62282-3-200	
5	Exhaust gas flow measurement (air side)	7.3.7 of IEC 62282-3-200	Measure the content of SO_x, NO_x, CO_2, CO if possible according to

① IEC Publication 62282-3-100 Fuel cell technologies-Part 3-100: Stationary fuel cell power systems-Safety.

			temperature and water content of the purge gas in each power level
6	Discharge water measurement	7.3.8 of IEC 62282-3-200	Total water content of purge gas and exhaust gas
7	Audible noise level measurement	7.3.9 of IEC 62282-3-200	
8	Total energy efficiency measurement	9.2 of IEC 62282-3-200	
9	Electric power output response time	9.3.2 of IEC 62282-3-200	
10	Fuel fluctuation test	Tested based on data submitted by the manufacturer	

8.3 Surveys during construction

8.3.1 Normal system operation tests are to be carried out, including start-up, rated loading and controlled shutdown.

8.3.2 Simulated tests are to be carried out to the control, monitoring and safety systems specified by Chapter 6, including but not limited to the following items:

(1) checking the effectiveness of all monitoring sensors for hydrogen leakage;

(2) simulating functions of safe shutdown in dangerous situations.

8.3.3 The Surveyor is to check the mechanical ventilation installations in gas hazardous areas, enclosed gas storage spaces, pump and compressor rooms, fuel cell spaces, gas bunkering stations, inflammable gas ducts and double pipes and confirm the operation is in compliance.

8.3.4 The Surveyor is to check the water spray system in the fuel storage areas and confirm that the operation methods have been clearly indicated.

8.3.5 The Surveyor is to check the chemical dry powder system for gas bunkering stations and confirm that the operation methods have been clearly indicated.

8.3.6 The Surveyor is to check whether the marking of cooling water piping, air piping, fuel transfer piping is correct and whether the marking on cables of voltage class is correct.

8.3.7 The Surveyor is to check the effectiveness of interlocking devices, if fitted, of circuit breakers connecting the fuel cell power system and the grid.

8.4 Surveys after construction

8.4.1 During the annual survey, the following items are to be checked:

(1) checking the effectiveness of all monitoring sensors for hydrogen leakage;

(2) simulating functions of safe shutdown in dangerous situations;

(3) confirming that the fuel cell power system is in good condition and carrying out operation tests.

8.4.2 The requirements of the intermediate survey is same as those of the annual survey.

8.4.3 During the renewal survey, in addition to checking the items listed in 8.4.1, the Surveyor is to check the maintenance record of the fuel cell power system and confirm all periodical and regular maintenance has been carried out in accordance with the requirements of the manufacturer①.

① Refer to 7.4.4 of IEC 62282-3-100.