Guideline No.E-28 (202501)

E-28

Solid Oxide Fuel Cell

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Foreword

The CCS Product Inspection Guidelines specify the applicable technical requirements and inspection and testing requirements for ship classification products and authorized statutory products that are to apply for CCS approval/inspection.

The Guidelines do not restrict the user from adopting other test methods and requirements, but the relevant test methods and requirements shall not be lower than the requirements of the Guidelines.

The Guidelines are prepared and updated by CCS and published through the website http://www.ccs.org.cn. If the user has any comments on the Society's guidelines, please send feedback to mp@ccs.org.cn

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Main modifications in this version and issue date of this version:

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1 Scope of application

1.1 The Guidelines apply to the approval and inspection of solid oxide fuel cell power generation systems and fuel cell modules installed on ships and offshore facilities.

1.2 As solid oxide fuel cell technology is still under development, special consideration shall be given by CCS for special and new fuel cell power generation systems that do not meet the requirements of the Guidelines.

1.3 The Guidelines are prepared for solid oxide fuel cells (SOFC). For other types of fuel cells that need our approval, please refer to the relevant applicable requirements for implementing the Guidelines.

1.4 When solid oxide fuel cells (SOFC) use natural gas, methanol, ethanol, ammonia or other fuels as primary fuels, the technical requirements, drawings and inspection requirements for materials, pipeline design, fuel storage, filling, supply and use, as well as electrical, ventilation, fire protection and monitoring, shall comply with the relevant requirements of the Guidelines, and shall comply with the relevant requirements of CCS Specification of Liquefied Natural Gas as a Fuel for Marine Applications, Guidelines For Ships Using Methanol/Ethanol Fuel, or Guidelines For Ships Using Ammonia Fuel and other corresponding specifications.

2 Normative references

2.1 CCS Rules for Classification of Sea-going Steel Ships

2.2 CCS Specification of Liquefied Natural Gas as a Fuel for Marine Applications

2.3 CCS Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

2.4 CCS Guidelines For Ships Using Ammonia Fuel

2.5 CCS Guidelines For Ships Using Methanol/Ethanol Fuel

2.6 CCS Guidelines for Use of Low Sulfur Distillates Fuels in Ships

2.7 CCS Guidelines For Ships Using Fuel Cell Power Installations

2.8 CCS Guidelines for Type Approval Test of Electric and Electronic Products

2.9 IEC62282-2-100:2020, Fuel Cell Technologies Part 2-100: Fuel Cell Modules - Safety

2.10 IEC62282-3-100 : 2019, Fuel Cell Technologies Part 3-100: Stationary Fuel Cell Power Generation Systems - Safety

2.11 IEC62282-3-200 : 2015, Fuel Cell Technologies Part 3-200: Stationary Fuel Cell Power Generation Systems - Performance test methods

2.12 GB/T 10193-2019: Solid Oxide Fuel Cell - Terms

2.13 NB/T 10821-2021: Solid Oxide Fuel Cell -Test Methods for Cell Stacks

2.14 NB/T 10671-2021: General Safety Technical Guidelines for Solid Oxide Fuel Cell Modules

2.15 NB/T 10822-2021: General Safety Technical Guidelines for Solid Oxide Fuel Cell Small Stationary Power Generation Systems

Note: The clauses in the above-mentioned basis documents for approval and inspection shall become the clauses of the Guidelines through reference in the Guidelines. For dated references, all subsequent amendments (excluding corrigendum) or revisions shall not apply to this Chapter. Therefore, attention shall be paid to meeting the requirements of the latest versions of these documents during product design, manufacturing and inspection. For undated references, the latest edition shall apply to the Guidelines.

3 Terms and definitions

For the purposes of the Guidelines, the terms and definitions identified in the above-mentioned basis for inspection shall apply. For the convenience of preparation

and use, the Guidelines directly quote and supplement the following definitions:

3.1 Steel Regulations: refers to the Rules for Classification of Sea-going Steel Ships of China Classification Society and its change notices.

3.2 Solid oxide fuel cells (SOFC): fuel cells that use an ion-conducting oxide as an electrolyte.

3.3 Solid oxide fuel cells (hereinafter referred to as fuel cells) power generation system: a complete and stable power generation system composed of fuel cell modules, external auxiliary equipment that provides fuel and air (oxygen), and their associated pipe accessories. Depending on the design, the system may also include a system control unit, a power supply conversion unit, and associated auxiliary equipment for cooling, ventilation, and other related functions.

3.4 Fuel cell modules: an assembly of one or more fuel cell stacks and exhaust ducting components, electrical connections and output systems, and other auxiliary units.

3.5 Fuel processing system: a combination of chemical processing devices that convert input fuel into chemical composition fuel required by fuel cell stack, and their associated heat exchangers and control devices.

3.6 Oxidizing agent processing system: a processing system that can purify, measure, preheat, adjust, compress, etc. the oxidizing agent used for fuel cell power generation system.

3.7 Water treatment system: a system used to treat the recycled or make-up water used in the fuel cell power generation system.

3.8 Thermal management system: a system that provides cooling or heating to keep the temperature of each module inside the fuel cell system within the normal range when the fuel cell system is working, and can also provide the function of reusing excess heat.

3.9 Power supply regulation system: a device that changes or regulates the output of

the power supply by changing the voltage level or waveform, or by other means.

3.10 Automatic control system: a system composed of detection devices, execution devices and control units, which can make the fuel cell power generation system start, run and shut down automatically without manual intervention.

3.11 Ventilation system: a system that realizes the air exchange inside and outside the casing of the fuel cell system by mechanical or natural means.

3.12 Fuel cell stack: a combination of two or more single cells, interconnects, seals, manifolds, and necessary structural components that have a unified electrical output.

4 Drawings and data

4.1 The following drawings and data shall be submitted to CCS for approval:

(1) General drawing (outline and structure drawings);

(2) Electrical schematic diagram;

(3) Schematic diagrams of fuel processing system, thermal management system, water treatment system, waste heat recovery system and combined cycle system (if applicable);

(4) Drawings of main parts (stack, reformer, burner, heat exchanger, evaporator and other main parts);

(5) Technical conditions for products;

(6) Type approval program (at the time of approval);

(7) Factory test program;

(8) Dilution zone analysis report required by IEC62282-3-100:2019 Clause 4.6.1.

4.2 The following drawings and data shall be submitted to CCS for future reference:

(1) External wiring diagram;

(2) External pipeline connection diagram;

(3) List of main parts;

(4) Principle description and system block diagram of fuel cell power generation system (module);

(5) User manual of fuel cell power generation system (module);

(6) Risk assessment of fuel cell power generation system (module);

(7) Overview of key production processes (stacks, modules);

(8) Nameplate diagram.

Note: The name of the actual drawings/documents can be different from the above drawings/documents, but shall reflect their content requirements; The above requirements are mainly applicable to fuel cell power generation systems, and for fuel cell modules, please refer to applicable parts.

5 Technical requirements

5.1 The equipment shall work normally under the working conditions specified in Section 2, Chapter 1, Part 4 of the Steel Regulations, and can meet the nominal technical parameters of the product.

5.2 The commissioning, testing and maintenance of the fuel cell power generation system shall meet the requirements of safety, availability and reliability.

5.3 The system and components shall be designed, manufactured, installed, operated, maintained and protected so that they can ensure safe and reliable operation.

5.4 The structural design of the fuel cell power generation system (module) shall prevent the accidental accumulation of explosive, flammable or toxic gas concentrations. When the structural design cannot guarantee the rapid dispersion of flammable, explosive or toxic gases, forced (ventilation) dilution or dispersion must be considered. Flammable materials shall not be used inside the system as far as possible. The housing materials shall be capable of protecting the components of the system from external damage.

5.5 The fuel piping of fuel cell power generation system shall be installed with sufficient flexibility. The connection of the fuel pipelines shall be of the full penetration welding type, and the butt weld shall be subject to radiographic inspection. If other connection methods (e.g. flange connection) cannot be avoided, appropriate protective measures shall be taken, and the connection shall meet the national standard requirements for the type of fuel supplied. The pipeline joints shall be as few as possible and easy to maintain.

5.6 For fuel cell auxiliary systems where gas may leak into the system medium (e.g., emissions), a suitable gas monitoring device shall be provided at the medium outlet to monitor gas leakage.

5.7 The pipelines, accessories, joints and valves of fuel, air (oxygen) and similar fuel supply systems shall generally meet the requirements of Class I piping.

5.8 Metal parts supporting and fixing fuel pipelines shall not be in direct contact with the pipeline, except where the pipeline is directly welded to the support and fixing parts and/or connected by solder.

5.9 The fuel cell power generation system shall be equipped with start and stop buttons, and shall be able to enter start or emergency shutdown operation by manually starting the emergency button or by automatic control program.

5.10 The electrical equipment in the fuel cell power generation system shall be provided with appropriate fire and anti-explosion measures according to the IEC62282-3-100 standard. If it is in a position where it is easy to contact the fuel, it shall meet the corresponding explosion-proof grade.

5.11Necessary purging systems shall be provided to make the fuel cell power generation system in a passive state in case of emergency. The purging system may use the media specified by the manufacturer, including but not limited to nitrogen and air, to purge the fuel cell power generation system. In addition, the fuel pipelines shall be purged with hydrogen and nitrogen shielding gas.

5.12 Outlets from which gas may escape or leak shall be well ventilated and clear of obstructions and away from appliances that may produce sparks or high heat.

5.13 The fuel cell power generation system output circuit shall be equipped with corresponding disconnecting devices such as disconnectors to facilitate system maintenance, and contactors shall not be used as disconnecting devices.

5.14 The fuel cell power generation system shall prevent over power and ensure that the connection between fuel cells and the load can be cut off under any possible load conditions.

5.15 The fuel cell modules shall be provided with reverse power protection to prevent energy from flowing back into the fuel cell modules from the load side. If fuel cell modules are connected to a power conversion unit, the reverse power protection can be provided by this power conversion unit, and the power conversion unit can be equipped with a braking resistor or a similar functional component to achieve this function.

5.16 When the fuel cell power generation system has completed the additional test of equivalent generator unit characteristics as specified in Clause 7.3.10, it can be used as the main power supply or part of the main power supply of the ship, and shall be indicated in the certificate.

5.17 The fuel cell power generation system, together with the converter, shall be capable of withstanding the mechanical stress and thermal effects of the short-circuit current during any time delayed tripping/fusing time of the selective protective device.

5.18 Fuel cell power generation system (module) shall be monitored as necessary to avoid loss or reduction of its safety, such as leakage monitoring of fuel, etc.

5.19 Failure mode and effect analysis (FMEA) shall be carried out for all possible faults that may affect operation and safety of the fuel cell power generation system, and the scope of monitoring and control shall be determined based on the analysis results, which shall at least include the following:

Control items:

(1) Output current;

Monitored items:

(2) Fuel cell voltage;

(3) Fuel cell voltage fluctuation;

(4) Exhaust temperature;

(5) The operating temperature of the fuel cell stack. The load can be disconnected/reduced or cooling measures such as cutting off the fuel can be taken when the operating temperature exceeds the maximum operating temperature allowed by the manufacturer;

(6) The main reaction zone temperature of main components of the fuel processing system and thermal management system. If the temperature is abnormal, the parts shall be replaced due to failure and damage;

(7) Surface temperature of the fuel cell power generation system;

(8) Fuel gas purity (if required);

(9) Control system failure;

If hydrogen fuel is used, the items shall also include:

(10) Air enters the fuel pipeline (indirect monitoring can be used);

(11) Fuel enters the air pipeline (indirect monitoring can be used).

5.20 Depending on the working mode and working characteristics of the fuel cell, the following monitoring contents shall be added:

Control items:

(1) Air flow and pressure;

(2) Make-up water flow, pressure and temperature (if applicable);

(3) Fuel flow and pressure;

Monitored items:

(4) Air temperature;

(5) Fuel temperature;

(6) Liquid level of water system;

(7) Purity of the water system;

(8) Detection of flammable gas concentration in emissions (at operating temperature);

(9) Fuel type and proportion(if required).

5.21 In addition to the above, the product safety shall meet the applicable requirements of IEC 62282-2-100:2020 Clause 4 and IEC 62182-3-100: 2019 Clause 4.

6 Raw materials and parts

6.1 The materials of the fuel cell power generation system (module) shall comply with recognized standards and the relevant materials shall meet the relevant standard requirements accepted by CCS.

6.2 When hydrogen fuel is used, all components in contact with hydrogen shall be made of materials that are resistant to hydrogen embrittlement and, where applicable, hydrogen attack.

6.3 Corresponding standards shall be met, depending on different fuels (methanol, natural gas, liquefied gas, ammonia, etc.)

6.4 The fuel pipeline shall generally be made of seamless steel pipe, flexible metal hose or other equivalent materials approved by the Society, and the corrosion effect of different fuels on the materials shall be taken into account.

6.5 Metal, plastic, non-metal and other materials in contact with water vapor and water shall not be affected by corrosion and shall not pollute the water quality.

6.6 The thermal insulation materials used in the fuel cell power generation system and power generation module shall consider the chemical compatibility with the insulated metal parts, the performance aging and the structural strength under high temperature environment.

7 Type test

The fuel cell power generation system (module) shall be approved by the Society. The issuance, maintenance, modification, renewal and cancellation of the type approval certificate shall be carried out in accordance with the relevant requirements of Chapter 3, Part 1 of the Steel Regulations.

7.1 Selection of typical samples

The model and specification of the type test prototype shall cover the range of products applying for approval and shall be technically representative, so as to determine through the type test whether the manufacturer has the ability to produce approved products according to CCS requirements. For each series, a product of one specification shall be taken as the test sample, and at least one specification in the samples from different series shall not be less than 80% of the maximum power applied for. One sample of each specification sampled may be submitted for testing.

7.2 Testing institute

The type approval test shall be carried out by a testing institute approved by the Society or an authoritative and impartial testing institute. For some functional test items, if the product manufacturer has the test conditions, it can be carried out at the manufacturer under the review and approval and on-site supervision of a CCS surveyor.

7.3 Type approval test requirements:

7.3.1 See Table 7.3.1 for the test items and test method of fuel cell power generation systems.

7.3.2 See Table 7.3.2 for the test items and test method of fuel cell modules.

7.3.3 When fuel cell modules are approved, their environmental adaptability test shall meet the relevant requirements in the CCS Guidelines for Type Approval Test of Electrical and Electronic Products.

7.3.4 When a fuel cell power generation system is approved, its environmental adaptability test shall meet the relevant requirements in the CCS Guidelines for Type Approval Test of Electrical and Electronic Products. If the fuel cell module holds the type approval certificate of the Society and has undergone the above environmental adaptability test, it can be exempted from the above test items for fuel cell modules during system approval.

7.3.5 The fuel cell power generation system shall be tested for safety in accordance with the requirements of IEC62282-3-100 Fuel Cell Technologies Part 3-100 Stationary Fuel Cell Power Generation System - Safety, and at least the following test items shall be carried out: pneumatic or hydraulic leakage test (twice), pneumatic or hydraulic strength test, normal rotation type test, electrical overload test (according to the manufacturer's design plan), exhaust temperature test, surface and component temperature test, which are recommended to be carried out in the test arrangement sequence.

7.3.6 The fuel cell power generation system shall be subject to start-up and shutdown functional tests, and the functions of all control systems and protection components that can participate in the test shall be verified as much as possible (requirements of Clause 4.9.2.3 of IEC62282-3-100 publication).

7.3.7 The fuel cell power generation system shall be subject to performance test to verify the values indicated on the nameplate and technical specification. At least the following performance test items shall be carried out at the rated power:

(1) Electric power measurement;

(2) Measurement of input fuel consumption;

(3) Exhaust emission measurement (fuel side) (if applicable);

(4) Measurement of oxidizing agent (air) consumption;

(5) Measurement of make-up water consumption (if applicable);

(6) Exhaust emission measurement (oxidizing agent side);

(7) Discharge water measurement;

(8) Noise level measurement;

(9) Measurement of electrical efficiency or total energy efficiency;

(10) Measurement of output power response time;

(11) Cold start time (to reach generation-ready state from cold state).

7.3.8 Fuel cell modules shall be tested in accordance with IEC 62282-2 Fuel Cell Technologies Part 2-100: Fuel Cell Modules - Safety.

7.3.9 For fuel cell modules and fuel cell power generation systems produced by the same manufacturer, the repeated test items in Table 7.3.1 and Table 7.3.2 can be combined.

Table 7.3.1 Type Test Items of Fuel Cell Power Generation System

No.	Inspection items	Test method reference standard
1	Appearance inspection	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.1
2	Pneumatic or hydraulic leak test	Clause 5.4 of IEC62282-3-100-2019 Clause 5.4 of GB/T 27748.1-2017
3	Pneumatic or hydraulic strength test	Clause 5.5 of IEC62282-3-100-2019 Clause 5.5 of GB/T 27748.1-2017
4	Type test of normal operation	Clause 5.6 of IEC62282-3-100-2019 Clause 5.6 of GB/T 27748.1-2017
5	Electrical overload test (if applicable)	Clause 5.7 of IEC62282-3-100-2019 Clause 5.7 of GB/T 27748.1-2017
6	Burner operating	Clause 5.9 of IEC62282-3-100-2019

	characteristic test	Clause 5.9 of GB/T 27748.1-2017
7	Exhaust temperature test	Clause 5.11 of IEC62282-3-100-2019 Clause 5.11 of GB/T 27748.1-2017
8	Temperature test of surfaces and components	Clause 5.12 of IEC62282-3-100-2019 Clause 5.12 of GB/T 27748.1-2017
9	Wind resistance test (for outdoor installation only)	Clause 5.13 of IEC62282-3-100-2019 Clause 5.13 of GB/T 27748.1-2017
10	Condensate discharge/block condenser test (only for power generation systems equipped with condensate treatment system)	Clauses 5.16/17 of IEC62282-3-100-2019 Clauses 5.16/17 of GB/T 27748.1-2017
11	Start-up and shutdown test	Clause 4.9.2.3 of IEC62282-3-100-2019 Clause 4.9.2.3 of GB/T 27748.1-2017
12	Electric power measurement	Clause 7.3.1 of IEC62282-3-200-2015
13	Measurement of input fuel consumption	Clause 7.3.2 of IEC62282-3-200-2015
14	Measurement of oxidizing agent (air) consumption	Clause 7.3.5 of IEC62282-3-200-2015
15	Measurement of make-up water consumption (if applicable)	Clause 7.3.6 of IEC62282-3-200-2015
16	Exhaust emission measurement (fuel side) (if applicable)	Clause 7.3.7 of IEC62282-3-200-2015
17	Exhaust emission measurement (oxidizing agent side)	Clause 7.3.7 of IEC62282-3-200-2015
18	Discharge water measurement (if applicable)	Clause 7.3.8 of IEC62282-3-200-2015
19	Noise level measurement	Clause 7.3.9 of IEC62282-3-200-2015
20	Measurement of electrical efficiency or total energy efficiency	Clause 9.2 of IEC62282-3-200-2015
21	Measurement of output power response time	Clause 9.3 of IEC62282-3-200-2015
22	Cold start time (to reach generation-ready state from cold state)	Refer to the factory technical requirements
23	Dielectric strength test	Clause 6.3 of IEC62282-3-100-2019

		Clause 6.3 of GB/T 27748.1-2017
24	Insulation resistance measurement	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.3
25	Withstanding voltage test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.14
26	Energy source fluctuation test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.4
27	Energy source failure test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.5
28	Motions and Inclinations Test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.6
29	Vibration test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.7
30	High temperature test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.8
31	Low temperature test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.9
32	Alternating damp heat test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.10
33	Housing protection test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.15
34	Fire retarding test (if applicable)	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.16
35	Electromagnetic compatibility test (applicable to system)	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Chapter 3

Note 1: For safety, the environmental and electromagnetic compatibility test items (No. 26-33, 35) above shall be considered of no-load operation with protective gas such as nitrogen in the fuel pipeline during the test (in addition, hydrogen nitrogen protective gas shall be used for fuel pipeline purging); The test subjects shall be fuel cell modules and other electrical parts.

Table 7.3.2 Type Test Items of Fuel Cell Modules

No.	Inspection items	Test method reference standard
1.	Appearance inspection	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.1
2.	Shock and vibration test (Note 2)	IEC62282-2, Clause 5.2
3.	Normal operation test	IEC62282-2 -100-2020, Clause 5.4, 5.12, GB/T 29838-2013, Clause 5.4, 5.13, Factory test only required for voltage and current and nominal power output
4.	Allowable working pressure test	IEC62282-2 -100-2020, Clause 5.5, GB/T 29838-2013, Clause 5.5
5.	Pressure withstanding test of reaction water supply system (if applicable) (For module with pure hydrogen selected as fuel, pure water supply is not required)	IEC62282-2 -100-2020, Clause 5.6, GB/T 29838-2013, Clause 5.6
6.	Continuous and short-time electrical power test	IEC62282-2 -100-2020, Clause 5.7, GB/T 29838-2013, Clause 5.7
7.	Over-pressure test (if applicable) (This test is conducted for module equipped with a pressure-limiting device)	IEC62282-2 -100-2020, Clause 5.8, GB/T 29838-2013, Clause 5.8
8.	Dielectric strength test	IEC62282-2 -100-2020, Clause 5.9, GB/T 29838-2013, Clause 5.9, 6.3
9.	Insulation (static) test	GB/T29838-2013, Clause 5.10
10.	Differential pressure test	IEC62282-2 -100-2020, Clause 5.10, GB/T 29838-2013, Clause 5.11
11.	Abnormal operating condition test	IEC62282-2 -100-2020, Clause 5.14, GB/T 29838-2013, Clause 5.15
12.	Gas tightness test	IEC62282-2 -100-2020, Clause 6.2, GB/T 29838-2013, Clause 6.2
13.	Energy source fluctuation test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.4
14.	Energy source failure test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.5
15.	Motions and Inclinations Test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.6
16.	Vibration test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.7
17.	High temperature test	CCS Guidelines for Type Approval Test of

		Electric and Electronic Products, Clause 2.8
18.	Low temperature test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.9
19.	Alternating damp heat test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.10
20.	Housing protection test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.15
21.	Fire retarding test (if applicable)	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.16
22.	Electromagnetic compatibility test	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Chapter 3
23.	Salt spray test (if applicable)	CCS Guidelines for Type Approval Test of Electric and Electronic Products, Clause 2.12

Note 1: For safety, the environmental adaptability test items (No. 13-23) above shall be considered of no-load operation with protective gas such as nitrogen in the fuel pipeline during the test (in addition, hydrogen and nitrogen protective gas shall be used for fuel pipeline purging); Other type test items shall be conducted on the same sampler.

Note 2: If the manufacturer does not specify the shock and vibration limits, this test may be omitted, only the relevant tests shall be carried out according to the marine environment requirements of Guidelines for Type Approval Test of the Society.

7.3.10 According to the requirements of Section 4, Chapter 7 of "Guidelines for Ship Application Fuel Cell Power Generation Devices" of the Society, additional tests of "equivalent generator unit characteristics" shall be carried out when the fuel cell power generation system is used as the main power supply or the only main power source of the ship, and the tests above can be noted in the approval certificate.

7.3.10.1 The fuel cell power generation system, together with the converter, shall be capable to withstand the mechanical stress and thermal effects of the short-circuit current within any delayed trip time/fuse time of the selective protective device.

7.3.10.2 For the fuel cell power generation system together with the converter, the deviation in voltage shall be within 1% of the rated voltage when the load is 20% of the rated power; The deviation in voltage shall be within 2.5% of the rated voltage

with full load applied; Between 20% and full load, the deviation of the average of the rising and the falling curve of the voltage load characteristic from the rated voltage shall be no greater than 3%.

7.3.10.3 For the fuel cell power generation system together with the converter, when suddenly loaded with 50% of the rated load under no load condition, then loaded with the remaining 50%, and then suddenly unloaded by 100% after stabilization, following requirements shall be met:

(1) When the voltage drops, its transient value shall not be less than 85% of the rated voltage, and shall not be less than the threshold voltage for converter operation;

(2) When the voltage rises, its transient value shall not exceed 120% of the rated voltage, and shall not be higher than the threshold voltage for converter operation;

(3) The time required for the voltage to recover to the stable value (with a difference no more than 3% of the rated voltage) should not more than 1.5s;

(4) If it is an AC output system, its transient frequency variation shall not be higher than 10% of the rated frequency.

7.3.10.4 For the fuel cell power generation system with AC output, together with the converter, the sinusoidal distortion rate of the no-load line voltage waveform shall be no more than 5%.

7.3.10.5 For the fuel cell power generation system together with the converter, if it does difficult to meet the requirements of 7.3.10.3, a combination of battery bank and converter can be connected in parallel for test. The parameters of the battery bank added including capacity, type and discharge rate shall be indicated in the product manual and other technical documents for reference when installed on the ship. The ship should be configured with reference to the parameters of the battery bank above. If there are multiple fuel cell power generation modules, the operation of the busbar in sections should be taken into account to ensure that the battery banks on each section of the busbar have sufficient capacity.

8 Single piece/single batch inspection (factory inspection)

8.1 General provisions

8.1.1 After granted with the type approval B certificate of the Society, the manufacturer shall still apply for single piece/single batch inspection from the Society after the factory test specified below for each fuel cell power generation system (module). On the basis of 100% factory test, surveyor shall conduct piece-by-piece inspection for fuel cell power generation system. The surveyor may conduct sampling inspection for fuel cell modules, of which the sampling rate shall be 10% of each model specification but not less than 2 units (except for application for inspection of only one unit).

8.1.2 The system control unit, power supply transferring unit and external auxiliary equipment in the fuel cell power generation system and their associated pipe accessories shall hold type approval certificate or product certificate in accordance with the relevant licensing requirements in Steel Regulations, Part 1, Chapter 3 of the Society.

8.2 The approved single piece/single batch inspection items shall include:

8.2.1 For fuel cell power generation system:

(1) Appearance inspection;

(2) Performance test under rated conditions;

(3) Start-up and shutdown tests;

(4) Pneumatic or hydraulic leak test;

(5) Exhaust temperature test;

(6) Temperature tests of surfaces and components;

(7) Insulation resistance test;

(8) Withstanding voltage test;

(9) Noise level measurement.

8.2.2 For fuel cell modules:

(1) Appearance inspection;

(2) Normal operation test

(3) Insulating strength test;

(4) Air tightness test.

8.2.3 Additional test of "equivalent generator unit characteristics" for fuel cell power generation system as part of the main power supply of the ship.

8.2.3.1 The fuel cell power generation system, together with the converter, meet the test requirements of 7.3.10.1-7.3.10.5 before leaving the factory, can be used as an integral part of the main power supply of the ship, the certificate shall indicate that "the additional test of the equivalent generator unit has been completed", and the converter shall be an integral part of the fuel cell power generation system.

8.2.3.2 For the fuel cell power generation system together with the converter, if it does difficult to meet the requirements of 7.3.10.3, a combination of battery bank and converter can be connected in parallel for test. The parameters of the fuel cell power generation system and the battery bank added including capacity, type and discharge rate shall be indicated in the product certificate.