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**Technical requirements of hydrogen supply system for
proton exchange membrane fuel cells**
质子交换膜燃料电池供氢系统技术要求

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TECHNICAL requirements of hydrogen supply system for proton exchange membrane fuel cells

1 Scope

This Standard specifies system classification, technical requirements, test methods, identification, packaging and transportation for hydrogen supply system for proton exchange membrane fuel cells (hereinafter referred to as "fuel cell hydrogen supply system" or "hydrogen supply system").

This Standard is applicable to the system in which proton exchange membrane fuel cells provide hydrogen.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 3634.1, *Hydrogen - Part 1: Industrial hydrogen*

GB/T 4208-2017, *Degrees of protection provided by enclosure (IP code)*

GB/T 6681, *General rules for sampling gaseous chemical products*

GB 12358, *Gas monitors and alarms for workplace - General technical requirements*

GB 16808, *Combustible gas alarm control units*

GB/T 17626.2-2006, *Electromagnetic compatibility (EMC) - Testing and measurement techniques - Electrostatic discharge immunity test*

GB/T 17626.3-2016, *Electromagnetic compatibility - Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test*

GB/T 18384 (all parts), *Electrically propelled road vehicles - Safety specifications - Part 1: On-board rechargeable energy storage system (REESS)*

GB/T 20042.1, *Proton exchange membrane fuel cell - Part 1: Terminology*

GB/T 24499, *Technology glossary for gaseous hydrogen, hydrogen energy and hydrogen energy system*

GB/T 24548, *Fuel cell electric vehicles - Terminology*

IEC 61779-6, *Electrical apparatus for the detection and measurement of flammable Gases - Part 6: Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of flammable gases*

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 20042.1, GB/T 24499, GB/T 24548 as well as the followings apply.

3.1 fuel cell hydrogen supply system

the device sum that supplies hydrogen for fuel cells, is related to hydrogen production, storage and supply

3.2 hydrogen storage vessel

the container for containing hydrogen gas or hydrogen storage materials, excluding any accessories placed or embedded inside or outside the container

3.3 hydrogen production material

the substances that produce hydrogen gas by themselves or with other substances through physical or chemical processes

3.4 hydrogen production equipment

the device that produces hydrogen through a physical or chemical process of a hydrogen-producing substance

NOTE: The device includes a filling port for the hydrogen-producing material.

4 System classification

The hydrogen supply system can be divided into:

- The hydrogen supply system for proton exchange membrane fuel cells, that stores hydrogen as a gaseous element, is a system that stores hydrogen in a hydrogen storage container and supplies hydrogen directly to a fuel cell. It includes the following individual equipment or devices: hydrogen storage container, hydrogen pipeline, stop valve, pressure reducing valve, pressure release device, heat exchange device, monitoring device and other auxiliary devices, and so on. A schematic diagram of the structure is shown in Figure 1. The pipe assembly in the figure includes components, pipelines and joints that are in direct contact with hydrogen or become part of the hydrogen supply system. It can be constructed

5.1.1 General

The fuel cell hydrogen supply system should meet the technical requirements for the scale of hydrogen used in fuel cells and the quality of hydrogen and be reasonably configured. The design, manufacture, inspection and acceptance of the single equipment or devices, pipe fittings, materials used shall comply with the relevant standards.

5.1.2 Vibration and Shock

The fuel cell hydrogen supply system should have a certain ability to resist vibration and shock, so as to ensure that vibration and shock generated during normal use, transportation or storage will not cause damage to various components of the hydrogen supply system. The adverse effects of vibration and shock can be avoided by installing anti-vibration devices, including vibration and shock generated by the unit and auxiliary equipment in the system itself, as well as by the external environment.

After the hydrogen supply system has experienced adverse vibration and impact, it must meet the requirements of 6.2.1 and 6.2.2. Precautions shall be in place to ensure the safety of persons and property.

5.1.3 Material selection

The fuel cell hydrogen supply system should be compatible with hydrogen due to its direct or indirect contact with hydrogen. The selected material should meet the following requirements:

- It shall have necessary chemical stability under all conditions of use. Various forms of chemical reactions will not occur in use to avoid the formation of hydrogen pollution by these reactions. Hydrogen embrittlement, hydrogen corrosion, stress corrosion and other forms of corrosion shall be greatly avoided. The hydrogen embrittlement resistance of the selected materials can be tested with reference to ISO 11114-4.
- It can adapt to the changes of the physical environment of the hydrogen supply system, meet the requirements of various mechanical properties, and maintain stable mechanical properties under the conditions of use.
- Non-metallic piping and related fitting materials meet the specified requirements of the corresponding standards.
- The selected materials meet the requirements of the overall life expectancy of the hydrogen supply system.
- When the materials used are known to be dangerous under certain conditions, manufacturers should take various precautions and provide users with the necessary information to minimize risks to personal safety and health.

5.1.4 Electrical system

5.1.4.1 All electrical components and wiring of the hydrogen supply system should meet the requirements for safe use of hydrogen in terms of mechanical strength, insulation and current carrying capacity. The wiring harness direction should be arranged reasonably. The clamping should be good. Try to avoid friction with adjacent parts. An overcurrent protection device should be installed in the line.

5.1.4.2 The materials of electrical components should be able to meet the usage environment of the hydrogen supply system. When selecting an electrical insulating material, the mechanical strength, electrical insulating strength and thermal insulating properties of the material should be considered. Provide protection even in the event of fires and accidents.

5.1.4.3 Necessary measures should be taken for the components and parts of the electromagnetic opening and closing used in the hydrogen supply system. Avoid adverse effects with other electromagnetic equipment due to electromagnetic interference.

5.1.4.4 The openings or joints of all electrical components of the hydrogen supply system shall be protected from damage. Electrical components that have the risk of sparking should be properly covered.

5.1.4.5 Electromagnetic waves emitted by electrical components should not cause continuous and significant interference to the function of other electrical equipment.

5.1.4.6 To prevent damage and short circuit during the use of the electrical system, and to avoid electrical sparks and other hazards to users or operators, lines should be properly protected or guarded in an unobstructed location. The power interface should be avoided to be located near the hydrogen inlet.

5.1.4.7 Conduct grounding inspections on electrical systems and wiring according to the structural characteristics of the hydrogen supply system.

5.1.5 Installation

5.1.5.1 Before the installation of the fuel cell hydrogen supply system, various certificates and technical documents of the individual equipment, pipelines and accessories of the hydrogen supply system should be checked, and the installation plan and relevant safety measures should be formulated.

5.1.5.2 It is necessary to fully consider the possible damage to the hydrogen supply system caused by the use environment. Take necessary measures to avoid the safety impact of heat sources, electrical appliances, batteries and other components that may generate arcs on the hydrogen supply system.

5.1.5.3 The place where the hydrogen supply system may generate static electricity

- b) Working temperature;
- c) Relative humidity;
- d) Storage temperature;
- e) Service life.

5.1.6.2 It is recommended that the fuel cell hydrogen supply system should be able to operate normally under the following environmental conditions:

- a) Altitude: $\leq 3000\text{m}$;
- b) Ambient temperature: $-10^{\circ}\text{C}\sim 50^{\circ}\text{C}$;
- c) Relative humidity: $\leq 95\%$;
- d) Storage temperature: $-40^{\circ}\text{C}\sim 60^{\circ}\text{C}$.

5.1.7 Dynamic response

The hydrogen supply flow of the hydrogen supply system should meet the demand of the fuel cell. That is, when the hydrogen supply pressure of the hydrogen supply system reaches the required range, the hydrogen flow provided by the hydrogen supply system can dynamically follow the demand of the fuel cell system to meet the hydrogen consumption demand of the fuel cell system.

5.2 Functional requirements

5.2.1 Hydrogen supply capacity

The hydrogen supply system should be able to meet the hydrogen demand of the fuel cell system within the available pressure range.

The hydrogen supply system should have overcurrent protection device or other measures. When it is detected that the pressure in the hydrogen storage container or pipeline is abnormally reduced or the flow rate is abnormally increased, the hydrogen supply in the hydrogen storage cylinder can be automatically shut off. If an overcurrent protection valve is used, the valve should be installed on or close to the main shut-off valve.

The main shut-off valve, the one-way valve of the hydrogen storage container and the pressure relief valve shall be integrated and installed at the end of the hydrogen storage container. For multiple hydrogen cylinder systems, a manual shut-off valve or other device should be installed at the end of each hydrogen storage cylinder. Each hydrogen storage bottle can be isolated as required during hydrogenation, hydrogen discharge and maintenance.

5.2.2 Hydrogen quality

flanges, gaskets, valves and joints. No visible air bubbles or foam can be generated at all detection points within 3 minutes.

5.3.2 Leakage

Under 1.05 times to 1.1 times the rated working pressure, the hydrogen leakage per hour of the hydrogen supply system should be less than 0.5% under steady state conditions. Install at least one hydrogen concentration sensor at a suitable position above the closed or semi-closed space where the hydrogen supply system is installed, so as to monitor the leakage of hydrogen in real time and transmit the signal to the hydrogen leakage alarm device.

5.3.3 Safety measures

5.3.3.1 Pressure protection

The system should have components to detect pressure. When the system detects that the hydrogen supply pressure is lower than the minimum pressure specified by the product, an alarm should be issued. When the system detects that the hydrogen supply pressure is higher than the maximum pressure specified by the product, an alarm should be issued. At the same time, shut off the gas cylinder valve to stop the hydrogen supply.

5.3.3.2 Pressure relief device

The system should have a pressure relief device. When the system pressure is greater than the design pressure, the pressure can be released in time. To facilitate the operation and maintenance of the hydrogen supply system, a manual pressure relief valve can be installed as required.

5.3.3.3 Grounding performance

The system should have a grounding point. There should be obvious signs. It shall use copper nuts for the grounding point. The resistance between the casing of the hydrogen supply system, all accessible metal parts and the ground terminal should not exceed 0.1Ω.

5.3.3.4 Protection level

The protection level of the system should conform to IP53. When the degree of protection test is completed, the system components shall show no signs of damage or failure. There should also be no harmful accumulation of water in any part of the power generation system.

5.3.3.5 Hydrogen leak detection, pressure relief device

5.3.3.5.1 Hydrogen concentration sensor alarm

The hydrogen supply system or its installation and use location shall be provided with

a continuous measurement and alarm device for hydrogen leakage concentration. The hydrogen concentration sensor should meet the requirements of GB 16808 and GB 12358. The alarm device should be able to send out different levels of alarm signals according to the hydrogen concentration. The level of concentration and alarm signal can be determined by the user of the hydrogen supply system according to the specific use environment and requirements.

Safety-related gas sensors should be selected, installed, calibrated, used and maintained in accordance with IEC 61779-6.

5.3.3.5.2 Pressure relief device

The hydrogen supply system shall be provided with a pressure release device (PRD). Take necessary protective measures at the outlet of the release pipeline to prevent it from being blocked by foreign objects during use and affecting the gas release. Hydrogen released through pressure relief devices should not:

- a) Be directly discharged into closed or semi-enclosed space;
- b) Be discharged to devices or spaces that are prone to static electricity;
- c) Be discharged to exposed electrical terminals, electrical switching devices and other ignition sources;
- d) Be discharged to other hydrogen storage containers.

5.3.4 Electromagnetic compatibility

The fuel cell hydrogen supply system shall not generate electromagnetic interference exceeding the specified level in its surroundings. In addition, the electrical equipment of the hydrogen supply system should have sufficient resistance to electromagnetic interference to operate normally in its working environment. The specific requirements are as follows:

The electrostatic discharge immunity limit of the hydrogen supply system shall comply with the requirements of test level 3 in GB/T 17626.2-2006. During the test, the sample under test should not be damaged, malfunction or change state, but the indicator light is allowed to flash. After the test, the system should work normally.

The radio frequency electromagnetic field radiation immunity limit shall comply with the requirements of test level 3 in GB/T 17626.3-2016. After the test, the performance of the equipment should not be permanently damaged or reduced, and the system should be able to work normally.

5.3.5 Insulation requirements

The electric shock protection of the hydrogen supply system shall meet the requirements of GB/T 18384.

- When the system hydrogen pressure is higher/lower than the set safety value;
- When the system detects that the temperature exceeds the design safety value;
- When the system detects an abnormal increase in flow or a rapid drop in pressure in the hydrogen storage container or pipeline.

5.4.3 Startup time

For the hydrogen supply system that stores hydrogen in the form of elemental substances, the startup time of high-pressure hydrogen storage is controlled by a solenoid valve.

For the hydrogen supply system that stores hydrogen in the form of compounds, the startup time can be determined according to the user's requirements, generally:

- a) Under hot standby conditions, the startup time of rated flow from 0 to 80% of rated flow should not exceed 10min. The startup time from 0 to 100% rated flow is not more than 15min;
- b) Under shutdown conditions and using fuel combustion to achieve heating of hydrogen generation equipment, the startup time of rated flow from 0 to 80% of rated flow should not exceed 45min. The startup time from 0 to 100% rated flow is not more than 50min;
- c) Under the shutdown condition and using the electric heating device to realize the heating of the hydrogen generation equipment, the startup time of rated flow from 0 to 80% of rated flow should not be greater than 120min. The startup time from 0 to 100% rated flow is not more than 125min.

6 Test methods

6.1 Hydrogen quality

The detection of impurities in the hydrogen supplied by the hydrogen supply system can refer to the method specified in GB/T 3634.2-2011. The sampling principles and general provisions of gas samples shall comply with the provisions of GB/T 6681. The sampling point for hydrogen quality testing should be after the hydrogen cooling device in the hydrogen supply system and before the storage container.

6.2 Safety requirements

6.2.1 Air tightness

The test medium is hydrogen, helium or other inert mixtures. It shall contain 5% hydrogen or 10% helium, or other proven detectable content. If a medium is approved by the relevant technical department, notified body or supervision department, it can

The electrostatic discharge immunity test is carried out according to GB/T 17626.2-2006.

The radio frequency electromagnetic field radiation immunity test is carried out according to GB/T 17626.3-2016.

6.4 Startup and shutdown

6.4.1 Startup and shutdown

Test the manual startup mode. Manually start or close the fuel system. Check if the system starts or shuts down normally.

Test the remote startup mode. Remotely start up or shut down the fuel system. Check if the system starts up or shuts down normally.

When testing the automatic mode, start up or shut down the fuel system regularly. Check if the system starts up or shuts down normally.

6.4.2 Startup time

Take measurements as follows:

- a) Connect the hydrogen supply system as required;
- b) Record the time from starting the tested hydrogen supply system to meeting the rated gas supply flow of the stack.

7 Identification

7.1 The production and installation position of the signs of the hydrogen supply system and its individual equipment can be implemented with reference to the provisions of GB/T 13306.

7.2 The content of the sign should be concise and clear, showing the main performance parameters, indicators and requirements. Signs should be fixed in a conspicuous position for easy viewing.

7.3 The main single equipment of the hydrogen supply system should be marked with signs according to the needs.

7.4 The signs of hydrogen supply system and individual equipment shall include the following contents:

- a) Manufacturer's name and address;
- b) Product models and trademarks;

Annex A

(Normative)

Sealing/venting tests of the sealed box

A.1 Test items

A.1.1 Sealing test of the sealed box

Completely seal the vent. Check whether there is gas leakage from the sealed box when the related equipment of the fuel cell hydrogen supply system is running/stopping.

A.1.2 Air exchange test of the sealed box

Fully open the vent. Measure the change of gas concentration in the sealed box when the fuel cell application equipment is running/stopping.

A.2 Test methods

A.2.1 Gas for test

The gas for test is helium or nitrogen.

A.2.2 Sealing test of the sealed box

The steps of the sealing test are as follows:

- a) Insert the test gas pipe, detector pipe, and pressure gauge pipe into the exhaust hole of the sealed box. Then seal the vent hole completely;
- b) Fill the sealed box with the test gas. After the gas gauge pressure in the box reaches 10kPa, keep this state for 5min;
- c) After that, use a gas detector to detect whether there is a gas leak.

A.2.3 Air exchange test of the sealed box

After the test of A.2.2, open the vent and open the seal of the charge port. After that, measure and record the concentration changes of the test gas in the sealed box every 30s. The measurement and recording shall be continued for 20 minutes or the gas detector shall be used to detect no gas leakage.

A.3 Judgement standard

A.3.1 During the test of A.2.2, there should be no gas leakage.

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