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**Test methods for proton exchange membrane
fuel cell power system at subzero environment**

质子交换膜燃料电池发电系统低温特性测试方法

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Test methods for proton exchange membrane fuel cell power system at subzero environment

1 Scope

This Standard specifies, at low temperature environment (subzero), the general safety requirements, test conditions, test benches, routine tests before low temperature test, and low temperature test methods and test reports of proton exchange membrane fuel cell power system.

This Standard is applicable to the storage test, startup test, working performance test of proton exchange membrane fuel cell power system at low temperature environment (subzero) that use air as oxidant.

This Part is applicable to the complete fuel cell power system.

NOTE: According to the needs, realize the locking function. The system consists of some or all of the following components:

- fuel processing system: a system for metering, adjusting, processing, and pressure-regulating of fuel needed for fuel cell power system;
- air processing system: a system for metering, adjusting, processing, and pressure-applying of air needed for fuel cell power system;
- thermal management system: related parts that provide cooling and heat dissipation to maintain heat balance inside the fuel cell power system, also recover waste heat and assist the heating system during start-up;
- water treatment system: treat recycled or added water for use in fuel cell power system;
- power regulation system: control that the generated power matches user-specified power requirements;
- automatic control system: consist of sensors, actuators, valves, switches, and logic components to maintain fuel cell power system parameters within the manufacturer's set-up without manual intervention;
- ventilation system: provide air to the chamber of fuel cell power system through natural or mechanical methods;
- fuel cell stack: an assembly consisting of a plurality of single cells, plates, cooling plates, common pipes and supporting structures; its typical function is to convert hydrogen-rich

4 General safety requirements

The general safety requirements for proton exchange membrane fuel cell stack shall comply with the provisions of 4.2 in GB/T 20042.2.

The safety requirements of fuel cell power system for automobile use shall comply with the provisions of 4.2 in GB/T 25319-2010.

The fixed proton exchange membrane fuel cell power system shall comply with the provisions of GB/T 27748.1.

The portable proton exchange membrane fuel cell power system shall comply with the provisions of 1.2 in GB/T 30084-2013.

5 Test conditions

When testing, the test conditions shall meet the following requirements:

- Ambient temperature: the ambient chamber temperature is $23^{\circ}\text{C}\pm 2^{\circ}\text{C}$, and the low-temperature ambient temperature is $0^{\circ}\text{C}\sim -40^{\circ}\text{C}$. In the specific test, the parties to the test shall negotiate and determine the ambient temperature adopted for the test according to the purpose of the test;
- Test environment air pressure: 91kPa~104kPa.

6 Test platform

6.1 Test equipment and requirements

The subzero environmental test chamber and the fuel cell power system test platform required for the test of the fuel cell power system shall at least meet the following requirements.

- Subzero environmental test chamber: the subzero environmental test chamber shall be able to meet the subzero environmental conditions required by the test. The difference in the temperature distribution within the chamber shall not exceed $\pm 2^{\circ}\text{C}$. In addition to the hydrogen source, the gas supply, coolant, and circuit interface are all placed in the environmental test chamber. Temperature measurements are set at the inlet and coolant connections to ensure that the air and fuel inlet gas temperature of the fuel cell power generation system is the set ambient temperature. The fuel cell power system, as well as its controller and radiator, is also set in the environmental test chamber. The hydrogen alarm and air outlet shall be installed in the chamber to ensure the safety

- Requirements for operation condition of fuel cell power system:
 - fuel intake and exhaust flow;
 - air intake and exhaust flow;
 - fuel operating pressure (represented value: upstream of the fuel cell stack);
 - air operating pressure (represented value: upstream of the fuel cell stack);
 - fuel composition;
 - air composition;
 - fuel stoichiometric ratio;
 - air stoichiometric ratio;
 - working current;
 - working voltage.

In an environment with an environmental cabin temperature of $(23^{\circ}\text{C}\pm 2^{\circ}\text{C})$, the fuel cell power system shall be tested in the order of 7.2~7.5.

Through 7.2 to 7.5, the fuel cell power system's gas leakage rate, startup time and energy consumption, shutdown time and energy consumption, purge time and energy consumption, external energy consumption and other fuel cell power system performance parameters can be obtained.

7.2 Gas tightness test

Conduct gas leakage test of fuel cell power system in accordance with 5.1.1 of GB/T 25319-2010.

7.3 Startup test

According to the startup procedures specified by the manufacturer of fuel cell power system, conduct the startup test of fuel cell power system. Record the state from cold startup to idle, rated power output, peak power, fuel input and output flow, air input and output flow, auxiliary power input, auxiliary heat input, purge time and energy consumption of fuel cell power system.

7.4 Power generation performance test

According to the manufacturer's regulations for fuel cell power system, the fuel cell power system operates stably at idle and at rated power output. Record the

current of external auxiliary system, control system voltage (12V, 24V), control system current (12V, 24V).

Test data collection frequency is not less than 1Hz.

The data collected for the tests of gas leakage, shutdown characteristics and power generation performance of fuel cell power system are as follows:

- leakage test items for fuel cell power system: measure the gas leakage and the leakage rate of fuel cell power system by the airtightness test of fuel cell power system;
- startup characteristic test items: startup time, fuel input flow and temperature, external auxiliary power input, auxiliary heat input, purge gas input;
- shutdown characteristics test items: shutdown time, fuel input, external auxiliary power input, auxiliary heat input, purge gas input;
- power generation performance test items: fuel input, external auxiliary power input, auxiliary heat input, electrical output and heat output shall be measured at the same time.

The appropriate test duration shall be determined by reference to the type of fuel cell power system to which the normative references apply. The frequency of data acquisition shall be greater than or equal to 1 Hz.

8.4 Subzero environment test process

8.4.1 General

According to the test requirements, perform the storage and startup tests of fuel cell power system in subzero temperature environment (such as 0°C ~ -40°C). The specific ambient temperature is determined according to test requirements. The fuel cell power system runs automatically according to the manufacturer's requirements during the test .

8.4.2 Subzero storage test

8.4.2.1 Test steps

According to the following steps, perform the subzero storage test of fuel cell power system:

- a) place the fuel cell power system in a cryogenic storage test chamber; under the normal and stable operation conditions of the fuel cell power system, the shutdown of the fuel cell power system shall be carried out in accordance with the shutdown procedures specified by the manufacturer

- b) set the temperature of the environmental chamber to the specified temperature, and start timing after the temperature of the environmental chamber reaches the specified temperature, and let it stand for 12h;
- c) send the startup command to fuel cell power system and start recording relevant test data;
- d) after the power of the fuel cell power system reaches the rated power, it shall continue to operate for 10min;
- e) then send a shutdown command to the fuel cell power system to perform a normal shutdown operation;
- f) after shutdown, the fuel cell power system is allowed to stand for 12h in this environment;
- g) send the startup command to fuel cell power system;
- h) after the power of the fuel cell power system reaches the rated power, it shall continue to operate for 10min;
- i) then send a shutdown command to the fuel cell power system to perform a normal shutdown operation;
- j) after the shutdown is completed, the test ends.

8.4.3.2 Test data processing

Process the test data according to the following requirements:

- a) when the fuel cell power system conducts the test of 8.4.3.1f), test data shall be collected according to the requirements of 7.2~7.5 and calculated;
- b) test data is summarized according to the provisions of 7.6;
- c) compare the performance parameters of the fuel cell power system after the subzero startup test WITH the performance parameters of the standard temperature environment fuel cell power system before the subzero startup test;
- d) from the above comparison, obtain the change in performance parameters of fuel cell power system such as the fluid leakage, startup time, energy consumption and fuel and air consumption, shutdown time and energy consumption, purge time and energy consumption, and external energy and material consumption of the fuel cell power system before and after the subzero startup.

Table 4 shows the subzero startup energy consumption, gas consumption, and

analysis and reference. The report includes three forms: summarized, detailed and complete. Each form of report shall include the appropriate title page and directory. According to the test conducted in this Standard, the summary report shall be provided to the parties concerned.

9.2 Title page

The title page shall describe the following information:

- a) report number (optional);
- b) report form (summarized, detailed and complete);
- c) report author;
- d) test execution organization;
- e) date of the report;
- f) test address;
- g) test name;
- h) test date and time;
- i) power system identification and manufacturer's name.

9.3 Directory

Each form of report shall provide the appropriate directory.

9.4 Summarized report

The summarized report shall include the following information:

- a) test purpose;
- b) descriptions of tests, instruments and equipment;
- c) test item sequence and date, and all test results;
- d) corresponding conclusion.

9.5 Detailed report

The detailed report shall add the following information in addition to the summarized report content:

- a) types, specifications, operational configurations of fuel cell power system and flowcharts illustrating test boundaries;

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