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**Test methods for sub-zero cold start performances of fuel
cell electric vehicles**

燃料电池电动汽车低温冷起动性能试验方法

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Test methods for sub-zero cold start performances of fuel cell electric vehicles

1 Scope

This document describes the test methods for cold start and starting performances of fuel cell electric vehicles in sub-zero (below 0 °C) environments.

This document applies to class M and class N fuel cell electric vehicles using compressed gaseous hydrogen (hereinafter referred to as “vehicles”).

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 18352.6-2016 Limits and measurement methods for emissions from light-duty vehicles (CHINA 6)

GB/T 18386.1-2021 Test methods for energy consumption and range of electric vehicles - Part 1: Light-duty vehicles

GB/T 24548 Fuel cell electric vehicles - Terminology

GB/T 27840-2021 Fuel consumption test methods for heavy-duty commercial vehicles

GB/T 37154-2018 Fuel cell electric vehicles - Test methods of hydrogen emission

GB/T 37244 Fuel specification for proton exchange membrane fuel cell vehicles - Hydrogen

GB/T 38146.1-2019 China automotive test cycle - Part 1: Light-duty vehicles

GB/T 38146.2-2019 China automotive test cycle - Part 2: Heavy-duty commercial vehicles

3 Terms and definitions

For the purpose of this document, the terms and definitions defined in GB/T 24548 and the following apply.

From the start of the vehicle starting operation to the end of the vehicle stopping process (including the purge process), record the fuel cell stack voltage U_{FC} , fuel cell stack current I_{FC} , REESS voltage U_{REESS} , REESS current I_{REESS} , and hydrogen volume concentration C_{H_2} at the vehicle tailpipe. C_{H_2} is measured in accordance with 6.1.3 of GB/T 37154-2018. The average hydrogen volume concentration within any continuous 3 s does not exceed 4 %, and the instantaneous hydrogen volume concentration does not exceed 8 %.

7.2.2 Test steps

The vehicle shall be tested for sub-zero cold start performance in the following steps.

- a) Perform vehicle immersion in accordance with the requirements of 7.1.
- b) After the vehicle immersion is completed, start the vehicle in accordance with the starting operation steps recommended by the manufacturer.
- c) After starting the vehicle, it can turn on the heater, air conditioner, etc. in accordance with the manufacturer's regulations to consume power.
- d) Record the duration, t_1 , from when the vehicle is started to when the vehicle drive system is ready (the vehicle instrument displays "READY" or "OK").
- e) When the fuel cell stack can run continuously for at least 10 min at a power of not less than 1 kW, or within 20 min, it can run for at least 10 min at a power of not less than 1 kW, record the sub-zero cold start time t_2 .
- f) Stop the vehicle according to the stopping steps recommended by the manufacturer.
- g) If all the above steps are completed and the vehicle's hydrogen emissions meet the requirements for hydrogen volume concentration in 7.2.1, the vehicle is considered to have successfully cold started at the set temperature. If the vehicle has an alarm or fault during the starting process, or the hydrogen volume concentration at the vehicle tailpipe does not meet the requirements, the cold start is considered to have failed.

7.3 Sub-zero starting performance test

7.3.1 Setting of vehicle road load

7.3.1.1 The chassis dynamometer setting of class M₁ and class N₁ vehicles and class M₂ vehicles with a total mass not exceeding 3500 kg shall be carried out in accordance with the provisions of Annex CC in GB 18352.6-2016. The chassis dynamometer setting of other types of vehicles shall be carried out in accordance with the provisions of Annex C in GB/T 27840-2021, where the additional mass of city buses is 65 % of the maximum design load mass. When conducting the coasting test on the road and chassis dynamometer, the brake energy recovery system function shall be turned off. If the driving resistance curve is provided by the automobile manufacturer, it shall provide a

test report, calculation report or other relevant information and be inspected by the testing organization.

7.3.1.2 It shall adjust the resistance setting of the chassis dynamometer to simulate the operation of the vehicle on the road in a sub-zero environment. The adjustment can be based on the change of the road driving resistance determined in the sub-zero environment; or the resistance obtained by reducing the coasting time of the driving resistance determined in accordance with 7.3.1.1 by 10 % can be used as an alternative road driving resistance.

7.3.2 Selection of driving mode

The driving mode shall be set according to the selection of driving mode in C.2 of GB/T 18386.1-2021.

7.3.3 Test method

From the start of the vehicle starting operation to the end of the vehicle stopping process (including the purge process), record the fuel cell stack voltage U_{FC} , fuel cell stack current I_{FC} , REESS voltage U_{REESS} , and REESS current I_{REESS} . The vehicle shall be tested for sub-zero starting performance in accordance with the following steps.

- a) Perform vehicle immersion in accordance with the requirements of 7.1.
- b) After the vehicle immersion is completed, start the vehicle in accordance with the operating steps recommended by the manufacturer
- c) Record the duration, t_3 , from when the vehicle is started to when the vehicle drive system is ready (the vehicle instrument displays “READY” or “OK”).
- d) After the vehicle drive system is ready, switch the vehicle state to the drivable mode and run at full throttle until the output power of the fuel cell stack reaches 50 % of the rated power of the fuel cell system (P_{FCE}) for the first time, and record the time t_4 .
- e) Keep the gear unchanged, release the accelerator pedal, slowly press the brake pedal, and complete the parking within 1 min.
- f) Within 3 min after parking, continue to test according to the test cycle specified in Table 2 and complete 1 test cycle.
- g) Stop the vehicle according to the operating steps recommended by the manufacturer, and the test is over.
- h) After completing all the above steps, it is considered that the vehicle starts successfully at the set temperature. If the test termination conditions in 7.3.5 are met during the test, the start fails.

Figure 1 -- Schematic diagram of reference curve and tolerance

The allowable tolerance between the actual vehicle speed and the speed specified in the test cycle is as follows:

- For class M₁ and class N₁ vehicles and class M₂ vehicles with a maximum design gross mass not exceeding 3500 kg, the speed tolerance is ± 2.0 km/h and the time tolerance is ± 1.0 s;
- For other types of vehicles, the speed tolerance is ± 3.0 km/h and the time tolerance is ± 1.0 s, see Figure 1.

Class M₁ and class N₁ vehicles and class M₂ vehicles with a maximum design gross mass not exceeding 3500 kg shall comply with the provisions of C.1.2.6.6 in GB 18352.6-2016. If the maximum speed declared by the vehicle is less than the maximum speed of the CLTC, the test cycle shall be corrected in accordance with the provisions of CA.5 in Annex CA of GB 18352.6-2016 for the part exceeding the maximum speed declared by the vehicle. At this time, the driver is required to step on the accelerator pedal to the bottom, allowing the actual vehicle speed to exceed the upper tolerance limit specified in C.1.2.6.6 in GB 18352.6-2016, but not the lower tolerance limit.

Other types of vehicles shall comply with the provisions of 5.5.1 of GB/T 27840-2021. If the maximum speed declared by the vehicle is less than the maximum speed of the China heavy-duty commercial vehicle test cycle (CHTC), the test cycle shall be corrected in accordance with the provisions of CA.5 in Annex CA of GB 18352.6-2016 for the part exceeding the maximum speed declared by the vehicle. At this time, the driver is required to step on the accelerator pedal to the bottom, allowing the actual vehicle speed to exceed the upper tolerance limit specified in 5.5.1 of GB/T 27840-2021, but not the lower tolerance limit.

7.3.5 Conditions for termination of the test

The test shall be stopped when the following situations occur:

- a) The on-board instrument displays a stop indication;
- b) The on-board instrument displays an alarm or fault signal;
- c) During the test, the vehicle has more than 10 speed deviations specified in 7.3.4;
- d) The maximum speed declared by the vehicle is less than the maximum speed of the test cycle, and the vehicle cannot reach the declared maximum speed.

7.4 Data collection requirements

Test data collection shall meet the following requirements:

- a) The data sampling frequency in the test shall not be less than 5 Hz;

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