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Test methods of energy consumption and range for fuel cell electric vehicles

燃料电池电动汽车能量消耗量及续驶里程试验方法

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1 Scope

This document describes the test method for measuring the energy consumption and range for fuel cell electric vehicles on a chassis dynamometer.

This document applies to Category-M and Category-N fuel cell electric vehicles (hereinafter referred to as “vehicles”) that use compressed gaseous hydrogen.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB/T 8170, Rules of rounding off for numerical values & expression and judgment of limiting values

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 18386.2-2022, Test methods for energy consumption and range of electric vehicles - Part 2: Heavy-duty commercial vehicles

GB/T 24548, Fuel cell electric vehicles - Terminology

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

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

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

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

-- Make the viscosity of the lubricating oil for mechanical moving parts and the tire pressure comply with the regulations of the vehicle manufacturer;

-- Run-in the transmission system and tires according to the requirements of the vehicle manufacturer's instructions, and drive at least 300 km using the fuel cell power system installed on the test vehicle;

-- Except for the equipment necessary for testing and the daily operating parts of the vehicle, turn off the lighting devices and auxiliary devices that use electricity on the vehicle;

-- Make the fuel used in the vehicle complies with the provisions of GB/T 37244.

5.2 Ambient temperature conditions and vehicle immersion requirements

The laboratory temperature shall be set to 23 °C with an allowable deviation of ±5 °C.

The temperature in the immersion area shall be set to 23 °C, with an allowable deviation of ±3 °C, and the immersion time shall be no less than 2 hours.

5.3 Driving mode selection

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

5.4 Vehicle load setting

5.4.1 Determination of driving resistance and simulation on chassis dynamometer: Category-M_1, Category-N_1 , as well as Category-M_2 with a maximum design total mass not exceeding 3 500 kg, shall comply with the provisions of Appendix CC of GB 18352.6-2016; the chassis dynamometer settings of other types of vehicles shall comply with the provisions of Appendix C of GB/T 27840-2021, where the additional mass of city buses is 65% of the maximum design loading mass.

5.4.2 If the driving resistance curve is provided by the vehicle manufacturer, a test report, a calculation report or other relevant information shall be provided and inspected by a testing agency to ensure the reliability of the test results.

5.5 Test tolerance requirements

The schematic diagram of the reference curve, speed tolerance and time tolerance of the test process is shown in Figure 1.

Other types of vehicles shall meet the requirements of 5.5.1 of GB/T 27840-2021. If the maximum speed declared by the vehicle is lower 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 Appendix 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 shall not exceed the lower tolerance limit.

6 Classification of test vehicles

The test vehicles are classified by Class A vehicles and Class B vehicles. Vehicles that meet Formula (1) are Class A vehicles, and vehicles that do not meet Formula (1) are Class B vehicles. For vehicles declared as Class A vehicles, carry out the test in accordance with 7.1, and calculate the ratio α of the net energy change of the rechargeable electrical energy storage system (REESS) of the vehicle under the total test cycle to the energy of hydrogen consumed by the fuel cell electric vehicle according to Formula (1).

$$\alpha = \left| \frac{\Delta E}{m_{TH} \times q_l} \right| \times 100\% \leqslant 1.0\% \qquad \cdots\cdots (1)$$

Where:

ΔE – net energy change of REESS under the total test cycle, in kilojoule (kJ);

m_{TH} – mass of hydrogen under the total test cycle, in grams (g);

q_l – lower calorific value of hydrogen, 1.2×10^5 kJ/kg.

After the test, if the vehicle does not meet the requirements of Formula (1), the test is invalid and the test shall not be repeated according to 7.1; instead, the test vehicle shall be tested according to the method specified in 7.2. If the vehicle meets the requirements of Formula (1), the vehicle manufacturer may conduct the test according to the method specified in 7.1 or according to the method specified in 7.2. The vehicle manufacturer can decide at its own discretion.

7 Test methods

7.1 Shortening method

7.1.1 Test procedure

Test the vehicle according to the following steps:

a) Adopt the method of supplying hydrogen outside the vehicle;

b) Before the test, adjust the SOC state of the vehicle REESS according to the requirements of the vehicle manufacturer;

c) Fix the vehicle on the chassis dynamometer and set the resistance according to the provisions of 5.4;

d) Run the vehicle for a complete cycle on the chassis dynamometer; at the end of the cycle, turn off the vehicle and leave to stand for 15 minutes;

e) Carry out the driving range test under working conditions in accordance with 7.1.2.

7.1.2 Driving range test under working conditions

The steps for the driving range test under working conditions are as follows.

a) Carry out the driving range test under working conditions according to the provisions in Table 2. The vehicle shall not be stopped during the test until the end of the test.

b) Begin sampling from the start of the vehicle, with a sampling frequency of not less than 5 Hz, until the end of the test. The collected parameters include REESS voltage U_{REESS}, REESS current I_{REESS}, vehicle traveled distance D_T, and hydrogen mass m_{TH}.

c) The measurement method of hydrogen consumption can refer to the method specified in GB/T 35178-2017.

d) Hydrogen bottle cut-off pressure test: Before the test, the hydrogen in the hydrogen bottle on the vehicle shall be guaranteed to be able to travel for at least one complete cycle. Fix the vehicle on the chassis dynamometer and set the resistance according to the provisions of 5.4. Carry out the cyclic working condition test in accordance with the provisions of GB/T 38146.1 and GB/T 38146.2 (see Table 2 for the selection of cyclic working condition types). The vehicle shall not be stopped during the test (except for stopping within the working condition cycle), and at least one complete cycle shall be driven. When the vehicle meets the requirements of 7.2.3, stop the test and measure the internal pressure of the hydrogen bottle. Measure the internal pressure of the hydrogen bottle according to the method specified in A.3 of Appendix A, and record the pressure P_4. This pressure value is the cut-off pressure of the hydrogen bottle. The cut-off pressure measurement of the hydrogen bottle shall be completed within 30 minutes.

18386.2-2022, and measure and record the energy E from the power grid; for non-externally rechargeable fuel cell electric vehicles, proceed to step f).

f) Move the vehicle to the hydrogenation unit, add hydrogen according to the provisions of A.2 and calculate the mass of hydrogen m_{TH}. Keep four significant figures after the decimal point of the calculation result (round off).

Except for step b) and step c), between any two steps, if the vehicle needs to move:

-- For Category-M_1, Category-N_1, as well as Category-M_2 with a maximum design total mass not exceeding 3 500 kg, it is not allowed to use the power on the vehicle to move the vehicle to the next test location, and the regeneration braking system shall be turned off;

-- For other types of vehicles, the use of on-board power is allowed. The vehicle is required to travel at a speed not exceeding 30 km/h or the speed limit of the factory area, and move between the two test locations as evenly as possible. The shift distance of the vehicle between the two test locations each time shall not exceed 3 km.

7.2.2 Driving range test under working conditions

The steps for the driving range test under working conditions are as follows.

a) Carry out the driving range test under working conditions according to the provisions of Table 3; do not step the test until the range specified in 7.2.3 is reached.

b) Unless otherwise specified, the number of stops during the working condition test cycle shall not exceed 3 times (stops outside the operating cycle), and the total cumulative stop time shall not exceed 15 minutes. During the stop period, turn off the test bench fan, and do not use an external power supply to charge the vehicle.

c) Begin sampling from the start of the vehicle, with a sampling frequency of not less than 5 Hz, until the end of the test. The collected parameters include the fuel cell stack voltage U_{FC}, the fuel cell stack current I_{FC}, the REESS voltage U_{REESS}, the REESS current I_{REESS}, and the distance D traveled by the vehicle (the measured value is rounded to an integer, and this distance is the driving range measured by the working condition method); at the same time, record the time used in hours (h) and minutes (min).

Note: For vehicles of which the fuel cell stack voltage U_{FC} and fuel cell stack current I_{FC} cannot be measured directly, measure the voltage and current at the output of the DC/DC converter, and then convert the power of the fuel cell stack. The DC/DC converter conversion efficiency is 97.0%.

e) Based on T_2 and P_2, refer to the temperature-pressure method in Appendix A of GB/T 35178-2017 to calculate the mass m_1 of hydrogen carried by the vehicle before the test.

A.2 Hydrogenation after vehicle testing

After the test, hydrogenation and calculation of the mass of hydrogen consumed shall be carried out according to the following steps:

a) Connect the vehicle to the same hydrogenation unit used before the test; record the ambient temperature T_3 of the vehicle; open the stop valve V1; add a small amount (no more than 0.05 kg) of hydrogen to the vehicle through the buffer tank; record the mass of hydrogen added m_2 (m_2 may be 0 here) through the mass flow meter; close the stop valve V1; record the internal pressure P_3 of the hydrogen bottle after the pressure is balanced;

b) Based on T_3 and P_3, refer to the temperature-pressure method in Appendix A of GB/T 35178-2017 to calculate the mass m_3 of hydrogen carried by the vehicle at this time;

c) Calculate the mass of hydrogen m_{TH} consumed in the test according to Formula (A.1).

$$m_{TH} = m_1 + m_2 - m_3 \quad \cdots\cdots (A.1)$$

For externally rechargeable fuel cell electric vehicles, post-test hydrogenation shall be completed within 30 minutes after the energy storage device is charged; for non-externally rechargeable fuel cell electric vehicles, the above post-test hydrogenation process needs to be completed within 30 minutes after the end of the test.

A.3 Measurement of internal pressure of hydrogen tank after vehicle test

After the test, the pressure in the hydrogen cylinder shall be measured in the following way:

a) Adjust the pressure of the hydrogen source to be higher than the internal pressure of the hydrogen cylinder, and connect the vehicle to the pressure measuring device, as shown in Figure A.2;

b) Make sure the mass of hydrogen entering the hydrogen bottle is no more than 0.05 kg, close the stop valve in time, and record the pressure P_4 after the pressure is balanced;

c) Record the pressure value P_4 as the internal pressure of the hydrogen cylinder after the test.

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