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**Test methods for power performance of fuel cell electric
vehicles**

燃料电池电动汽车动力性能试验方法

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Test methods for power performance of fuel cell electric vehicles

1 Scope

This document describes the test methods for power performance – such as acceleration performance, maximum speed and gradeability – of fuel cell electric vehicles.

This document applies to the power performance tests of M and N fuel cell electric vehicles using compressed hydrogen (hereinafter referred to as “vehicles”).

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 edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 3730.2, Road vehicle - Masses - Vocabulary and codes

GB/T 12428, Laden mass calculating method for bus

GB/T 12534, Motor vehicles - General rules of road test method

GB/T 12539, Motor vehicles steep hill climbing test method

GB/T 12545.1-2008, Measurement methods of fuel consumption for automobiles - Part 1: Measurement methods of fuel consumption for passenger cars

GB/T 15089, Classification of power-driven vehicles and trailers

GB 18384, Electric vehicles safety requirements

GB/T 18385, Electric vehicles - Power performance - Test method

GB/T 19596, Terminology of electric vehicles

GB/T 19752, Hybrid electric vehicle - Power performance - Test method

GB/T 24548, Fuel cell electric vehicles - Terminology

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

in 4.3.2 and 4.3.3; when conducting the 4% and 12% speed uphill test, maximum gradient and hill starting ability test, the vehicle shall be loaded according to the maximum authorized pay mass (including the mass of the tester and instrument), and the load shall be uniformly distributed and firmly fixed.

4.3.2 M₁ vehicles AND N₁ vehicles of maximum design total mass less than 2 t

The M₁ vehicles AND N₁ vehicles of maximum design total mass less than 2 t are classified as follows according to the maximum authorized pay mass:

- If the maximum authorized pay mass is less than or equal to 180 kg, the mass shall be the maximum authorized pay mass;
- If the maximum authorized pay mass is more than 180 kg and less than or equal to 360 kg, the mass shall be 180 kg;
- If the maximum authorized pay mass is more than 360 kg, the mass shall be 50% of the maximum authorized pay mass (including the mass of the driver and necessary test equipment).

The load distribution shall be in accordance with the requirements of 6.1.2 in GB/T 12545.1-2008.

4.3.3 M₂, M₃ vehicles AND N vehicles of maximum design total mass not less than 2 t

Unless otherwise specified, the load applicable to the M₂ and M₃ city-bus shall be 65% of the maximum authorized pay mass; the load for other vehicles shall be the maximum authorized pay mass (including the mass of the tester and instrument). The load distribution of M₂ and M₃ vehicles shall be according to the regulations in GB/T 12428, while the load distribution of N vehicles shall be according to the regulation in GB/T 12534.

4.4 Vehicle conditions

4.4.1 The shape structure and technical parameters of the vehicle must be maintained as that when it leaves the factory.

4.4.2 The vehicle under test shall be loaded according to the technical requirements in 4.3.

4.4.3 In the ambient temperature, except for the maximum gradient test, the tire pressure of vehicle shall meet the requirements of the manufacturer. During the maximum gradient test, the tire pressure shall be 20 kPa above the factory-set tire charging pressure under the cold state; the tread pattern depth shall be at least 75% above the original pattern depth, and the tread shall be in good condition.

4.4.4 The viscosity of lubricating oil for mechanical parts shall meet the manufacturer's requirements.

4.4.5 The lighting, signal device and auxiliary equipment on the vehicle shall be powered off, unless required by the test and daytime operation.

4.4.6 The vehicle shall be clean; the windows and vents not affecting the normal operation of vehicle and driving system shall be closed through normal operation.

4.4.7 The drive system and tires shall be running-in according to the requirements of the manufacturer's manual.

4.4.8 Before test, the vehicle under test shall at least run for 300 km under the support of fuel cell system on the vehicle.

4.4.9 The hydrogen fuel of vehicle shall meet the regulations of GB/T 37244.

4.5 Road conditions

4.5.1 General conditions

The test shall be conducted on a dry straight or circular track. The pavement shall be hard, flat, clean and good in adhesion coefficient.

4.5.2 Straight conditions

The length of measurement area shall be at least 1 000 m.

The acceleration area shall be long enough so that the vehicle can achieve the maximum speed within 200 m before entering the measurement area. The longitudinal gradient of both the measurement area and the area 200 m after the acceleration area shall not exceed 0.5%. The longitudinal gradient of the acceleration area shall not exceed 4%. The lateral gradient of the measurement area shall not exceed 3%.

To reduce the test errors, the test shall be conducted in two directions of the test track and in the same path as far as possible. If the test cannot be conducted in two directions due to limited conditions, the vehicle can be tested in one direction according to 4.5.4. When testing in one direction, the longitudinal gradient of the straight track shall not exceed 0.1%.

4.5.3 Circular track

The length of the circular track shall be at least 1 000 m. The circular track is not a complete circle, but being connected by a linear part and a part approximate to a ring. The curvature radius of the curve shall be no less than 200 m.

5 Test vehicle preparation

5.1 Hydrogenation

Hydrogen shall be added according to the manufacturer's hydrogenation procedures.

5.2 Power regulation of conventional REESS

To ensure the normal operation of fuel cell system in the vehicle and avoid the single operation of REESS during test, perform the power regulation of REESS in the following procedures before test.

- a) Before test, confirm and record the rated capacity C_0 of REESS of the vehicle, perform power regulation according to the manufacturer's requirements and keep the state-of-charge (SOC) of REESS within the range of 30% ~ 70%.
- b) Conduct the maximum thirty-minutes speed test according to 7.2 and sampling from the starting of the whole vehicle till the test is over. The collected parameters shall include the REESS current I_{REESS} (A). Record the maximum value C_{max} of the changed REESS capacity during test.
- c) Take $C_{max} \pm 0.1C_0$ as the capacity loss interval of REESS, i.e., the REESS target setting status interval before the subsequent power performance tests, and the data acquisition shall not be interrupted during test.
- d) If the test requires interruption or data acquisition is interrupted, test and collect the data again according to b) and c) and determine the REESS target setting status interval before conducting subsequent power performance tests, then start the power performance test.
- e) When performing the maximum speed and acceleration capacity test according to the manufacturer's recommended driving mode, regulate the power of vehicle REESS according to the requirements.

5.3 Warm-up

Before carrying out the test, warm up the vehicle system and components that may affect the test result, so as to meet the manufacturer's requirement for stable temperature.

6 Test items

6.1 Arrangement of test items

For the externally rechargeable and non-externally rechargeable vehicles, arrange the test items as follows:

test under the REESS mode; otherwise, the power performance test under the REESS mode can be omitted, or the unnecessary items can be reduced.

7 Test method

7.1 Maximum speed test

7.1.1 Standard test procedures (two-direction test)

The standard test procedures are as follows.

- a) Apply the test mass to the vehicle under test (see 4.3) and ensure the increased load distribution is reasonable.
- b) Prepare the vehicle according to the requirements in Chapter 5.
- c) To reduce the effect of factors such as road gradient and wind direction (speed), test the vehicle in the two directions of test road, try to use the same path and conduct the two tests continuously.
- d) Accelerate the vehicle under test on the test road according to the requirements in 4.5.2, ensure that the vehicle achieves the maximum stable speed and runs stably for 1 000 m before entering the measurement area, and drive the vehicle through the set measurement length at this speed. During test, the change rate of running speed of the vehicle shall not exceed 2%. Record the passing time t_i .
- e) Test the vehicle in the reverse direction immediately, ensure the testing times in the round trip is equal to and no less than 1, and record the passing time t_i of each time. The change rate of t_i shall not exceed 3%.
- f) Calculate the test result according to Formula (2):

$$v = \frac{l \times 3.6}{t} \dots\dots\dots (2)$$

Where:

v – maximum speed, in kilometer per hour (km/h);

l – length of measurement road, in meters (m);

t – arithmetic mean of the passing time t_i tested in round trip, in seconds (s).

7.1.2 Test procedures in single direction

The test procedures in single direction are as follows.

Where:

k – correction factor ($1.00 \leq k \leq 1.05$) determined based on Appendix A.

7.2 Maximum thirty-minutes speed test

The maximum thirty-minutes speed test can be conducted on the circular track. The test procedures are as follows.

- a) Apply the test mass to the vehicle under test (see 4.3) and ensure that the increased load distribution is reasonable.
- b) Keep the vehicle under test running for 30 min at the speed of $\pm 5\%$ of the estimated maximum thirty-minutes speed. If the speed changes during test, step on the accelerator pedal to adjust the speed to be equal to $\pm 5\%$ of the estimated maximum thirty-minutes speed.
- c) If the speed cannot reach 95% of the estimated maximum thirty-minutes speed during test, test again at the above estimated maximum thirty-minutes speed or the maximum thirty-minutes speed re-estimated by the manufacturer.
- d) Measure the mileage S_1 of the vehicle and calculate its average maximum thirty-minutes speed according to Formula (10).

$$v_{30} = S_1 / 500 \quad \dots\dots\dots (10)$$

Where:

v_{30} – maximum thirty-minutes speed of vehicle, in kilometers per hour (km/h);

S_1 – mileage of the vehicle, in meters (m).

7.3 Acceleration capacity test

7.3.1 Acceleration capacity test procedures

7.3.1.1 Acceleration performance test in start place

The acceleration performance test procedures in start place are as follows.

- a) Apply the test mass to the vehicle under test (see 4.3) and ensure that the increased load distribution is reasonable.
- b) Prepare the vehicle according to the requirements in Chapter 5.
- c) When the drive motor is powered on, step on the brake, place the transmission at the forward gear, step on the accelerator pedal completely from the idle state,

ensure the vehicle achieves the maximum acceleration performance when the wheel slip is minimum, and trigger the recording device when the vehicle moves.

- d) Step on the accelerator pedal completely from the idle state, increase the speed to 100 km/h (if it cannot reach 100 km/h when the speed is 90% of the maximum speed, round 90% of the maximum speed down to the integral multiples of 5 as the final test speed). Record the speed, acceleration time and acceleration distance during each test.
- e) Step on the accelerator pedal completely from the idle state, to accelerate for 400 m, and record the speed and acceleration time during each test.

7.3.1.2 Surpass acceleration performance test

The surpass acceleration performance test procedures are as follows.

- a) Apply the test mass to the vehicle under test (see 4.3) and ensure that the increased load distribution is reasonable.
- b) Prepare the vehicle according to the requirements in Chapter 5.
- c) Before test, accelerate the vehicle to a range of 2 km/h lower than the specified starting speed, keep the speed uniformly for at least 2 s, and trigger the recording device when the vehicle reaches the specified starting speed.
- d) Step on the accelerator pedal completely from the starting speed, to accelerate the vehicle till it reaches 100 km/h (if it cannot reach 100 km/h when the speed is 90% of the maximum speed, round 90% of the maximum speed down to the integral multiples of 5 as the final test speed). Record the speed, acceleration time and acceleration distance during each test.
 - Starting speed of M_1 and N_1 vehicles: 50 km/h, 60 km/h.
 - Starting speed of fuel cell electric vehicles – other than M_1 and N_1 vehicles – whose maximum speed is not higher than 70 km/h: 30 km/h.
 - Starting speed of fuel cell electric vehicles – other than M_1 and N_1 vehicles – whose maximum speed is higher than 70 km/h: 60 km/h.

7.3.2 General requirements

7.3.2.1 The vehicle shall be tested in round trip for 3 times in each direction. If there is problem during test, a round trip test shall be performed again.

7.3.2.2 The arithmetic mean of all effective data during each test shall be taken as the final test result.

7.3.3 Data processing

- c) Adjust the dynamometer, so that it increases the additional load equivalent to the gradient of 4%.
- d) Accelerate the vehicle by stepping on the accelerator pedal completely or by using a proper gear shift.
- e) Determine the maximum stable speed at which the vehicle under test can achieve and run stably for 1 km, control the vehicle running speed to be less than 2% during test, and record the time for continuous running of 1 km.
- f) Adjust the dynamometer, so that it increases the additional load equivalent to the gradient of 12%.
- g) Repeat the tests in d) and e) as above.
- h) After test, stop the vehicle, check whether there are abnormalities and record the details.
- i) Calculate the test result according to Formula (14):

$$v_{\text{uphill}} = 3\,600/t \quad \dots\dots\dots (14)$$

Where:

v_{uphill} – actual maximum speed uphill, in kilometers per hour (km/h);

t – time measured for continuous running of 1 km, in seconds (s).

7.5 Maximum gradient test

The maximum gradient test procedures are as follows.

- a) Apply the maximum design total mass to the vehicle under test and ensure that the load is distributed reasonably.
- b) When testing on a gradient of larger than 40%, a safety protection device shall be provided.
- c) Park the vehicle on a flat and straight section near to the ramp area.
- d) If the manufacturer designates a special climbing gear, the vehicle gear shall be placed at the position according to the manufacturer's requirement; if no special gear is designated, place the vehicle gear at D and apply the all-wheel drive.
- e) Step on the accelerator pedal completely after starting; collect the vehicle data in the tested section; if the vehicle accelerates during climbing or gets close to the tested section stably, the climbing is successful, then record the average

7.6 Hill starting ability test

The hill starting ability test procedures are as follows.

- a) Apply the maximum design total mass to the vehicle under test and ensure that the load is distributed reasonably.
- b) The hill starting ability shall be tested on the road in the angle of gradient of α_2 . The angle of gradient α_2 is the angle of gradient specified by the manufacturer.
- c) If there is no suitable ramp specified as the manufacturer, increase the mass Δm during test according to Formula (17), and keep Δm uniformly distributed in the passenger compartment and container.

$$\Delta m = m \frac{(\sin \alpha_2 - \sin \alpha_1)}{(\sin \alpha_1 + R)} \dots\dots\dots (17)$$

Where:

m – maximum design total mass of vehicle during test (as defined in GB/T 3730.2), in kilograms (kg);

α_2 – angle of gradient for the hill starting ability under the manufacturer's technical conditions, in degrees (°)

α_1 – angle of gradient corresponding to actual test ramp, in degrees (°);

R – rolling damping coefficient, which is generally 0.01.

- d) At least a 10 m measurement area shall be arranged in the middle section of ramp selected. There shall be a starting area in front of the measurement area, and the starting area and measurement area shall have the same gradient.
- e) The vehicle under test shall climb to the starting area, stop on the ramp stably by means of the braking system and keep still for 2 min after placing the gear at P or N.
- f) Place the vehicle gear at D, the lowest gear or the climbing gear specified by the manufacturer; apply the all-wheel drive for all-wheel drive vehicles; step on the accelerator pedal completely, to accelerate the vehicle or make it climb to pass by the measurement area stably. The vehicle shall not slip obviously when starting.

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