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Test Methods for Energy Consumption of Light-duty Hybrid Electric Vehicles

轻型混合动力电动汽车

能量消耗量试验方法

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Test Methods for Energy Consumption of Light-duty Hybrid Electric Vehicles

1 Scope

This Standard stipulates the test methods for energy consumption of light-duty hybrid electric vehicles equipped with ignition engine or compression ignition engine.

This Standard is applicable to Category-N₁ vehicles equipped with ignition engine or compression ignition engine, and Category-M₁ and Category-M₂ vehicles with a maximum design total mass of not more than 3,500 kg. Category-M₁ vehicles with a maximum design total mass of more than 3,500 kg may take this as a reference.

2 Normative References

The contents of the following documents constitute the indispensable clauses of this document through the normative references in this document. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 15089 Classification of Power-driven Vehicles and Trailers

GB 18352.6-2016 Limits and Measurement Methods for Emissions from Light-duty Vehicles (CHINA 6)

GB/T 19233-2020 Measurement Methods of Fuel Consumption for Light-duty Vehicles

GB/T 19596 Terminology of Electric Vehicles

GB/T 38146.1-2019 China Automotive Test Cycle - Part 1: Light-duty Vehicles

3 Terms and Definitions

What is defined in GB/T 15089, GB/T 19596, GB 18352.6-2016 and GB/T 38146.1-2019, and the following terms and definitions are applicable to this document.

3.1 All-electric Range

AER

All-electric range refers to the distance traveled by the vehicle from the start of the charge-depleting mode test to the start of the engine; the upper limit of the distance is

report or other relevant information shall be provided, and determined by the inspection institution.

6.1.1.2 The start-up of the power system shall be carried out in accordance with the stipulations of the vehicle manufacturer.

6.1.1.3 The vehicle shall be tested in accordance with the test cycle specified in 4.5.

6.1.1.4 Vehicles equipped with a manual gear shall be driven in accordance with the requirements of the manual for mass-produced vehicles provided by the vehicle manufacturer, and the driver's assistant shall prompt the gear-shifting time.

6.1.1.5 The vehicle speed shall be properly controlled, so as to accurately track the test cycle curve. The speed tolerance of each test cycle shall satisfy the requirements of C.1.2.6.6 of GB 18352.6-2016.

6.1.1.6 When REESS operating temperature is higher than the normal range, the test personnel shall follow the procedures recommended by the vehicle manufacturer to restore the temperature of REESS to the normal range. The vehicle manufacturer shall submit proof that REESS's thermal management system has not failed or attenuated.

6.1.1.7 Before the start or at the beginning of the test, CO₂, CO and HC emission sampling and electricity consumption test shall be carried out. After the test, the emission sampling shall be stopped. The emission sampling shall be conducted in accordance with the relevant stipulations of C.1.2.9 and C.1.2.12 ~ C.1.2.14 in GB 18352.6-2016.

6.1.1.8 The emission sampling and analysis shall be performed on each speed section. If the internal combustion engine does not start in a certain speed section, then, the analysis of emissions in this speed section may not be performed.

6.1.1.9 Special requirements for test results. If the test cycle is corrected in accordance with CA.5 in GB 18352.6-2016, then, the maximum speed of the vehicle shall be stated in the test report.

6.1.2 Special requirements for charge-sustaining mode test of off-vehicle charging hybrid electric vehicle (OVC-HEV) and test of non-off-vehicle charging hybrid electric vehicle (NOVC-HEV)

6.1.2.1 It is applicable to the forced cooling specified in C.1.2.7.2 of GB 18352.6-2016.

6.1.2.2 Test validity determination. If $\Delta E_{\text{REESS,CS}}$ calculated in accordance with A.1.3 of Appendix A is negative (namely, REESS is in discharge), and the cycle correction criterion c is greater than 0.01, then, the test result is invalid.

6.1.3 Test requirements under special environmental conditions

The vehicle manufacturer and its authorized agent may take the environmental settings

6.2.2.2.1 Vehicle immersion and REESS charging shall respectively be performed in accordance with the stipulations of C.2.2 and C.2.3.

6.2.2.2.2 Selection of driving mode.

In terms of vehicles equipped with a driving mode selection function, in accordance with D.2 of Appendix D, select the driving mode of the charge-depleting mode test.

6.2.2.3 Test procedures of charge-depleting mode test

6.2.2.3.1 The vehicle shall be tested in accordance with the stipulations of C.1.2.8.1 ~ C.1.2.8.3.1 and C.1.2.8.5 of GB 18352.6-2016.

6.2.2.3.2 The test procedures of charge-depleting mode test shall include multiple continuous test cycles; the vehicle immersion time between the cycles shall be less than 30 min. Repeat the test cycles, until the determination conditions of termination specified in 6.2.2.5 are reached.

6.2.2.3.3 During vehicle immersion, the power transmission system shall be turned off, and REESS shall not be charged. In accordance with Appendix E, determine the electric current and voltage of all REESS. During the vehicle immersion period, it is not allowed to turn off any REESS current and voltage test equipment. If time-based integration equipment is used, then, it shall maintain in the working condition during the vehicle immersion period. After vehicle immersion, the vehicle shall continue to run in the driving mode specified in 6.2.2.2.2.

6.2.2.3.4 On the premise of complying with CD.5.3.1.2 of GB 18352.6-2016, the analyzer may be calibrated and zero-point checked before and after the whole charge-depleting mode test.

6.2.2.4 The end of charge-depleting mode test

When the determination conditions of termination specified in 6.2.2.5 are satisfied for the first time, the charge-depleting mode test ends. The serial No. of cycle at this time is recorded as $n + 1$.

The n^{th} cycle is defined as a transition cycle. After the end of n cycles, the number of speed sections that the vehicle has traveled is n_p . The charge-depleting mode test includes n test cycles.

The $(n + 1)^{\text{th}}$ cycle is defined as a confirmation cycle.

For vehicles that are insufficient to complete the cycle test in the charge-depleting mode, when the standard on-board instrument panel indicates to stop, or the vehicle has deviated from the specified driving tolerance for at least 4 s, the charge-depleting mode test ends. At this time, the pedal shall be released and the brake shall be stepped on, so as to stop the vehicle within 60 s.

6.2.3.3.2 If the test result satisfies the stipulations of 6.1.2.2, then, the test is invalid. The test shall be continuously carried out after the test specified in 6.2.3.3.1, until a valid test result appears. In addition, in accordance with Appendix A, the fuel consumption result shall be corrected.

6.2.3.3.3 The correction and limit of emission results shall satisfy the requirements of 6.2.2.7.

6.2.4 Continuously conducted charge-depleting mode test and charge-sustaining mode test (Option 3, test process and corresponding REESS charging state curve are shown in B.2.3)

6.2.4.1 The charge-depleting mode test shall be conducted in accordance with the stipulations of 6.2.2.1 ~ 6.2.2.5 and 6.2.2.7.

6.2.4.2 The charge-sustaining mode test shall be conducted in accordance with the stipulations of 6.2.3.2 ~ 6.2.3.3.

6.2.4.3 REESS charging and electricity measurement shall be conducted in accordance with the stipulations of 6.2.2.6.

6.2.5 Continuously conducted charge-sustaining mode test and charge-depleting mode test (Option 4, test process and corresponding REESS charging state curve are shown in B.2.4)

6.2.5.1 The charge-sustaining mode test shall be conducted in accordance with the stipulations of 6.2.3.1 ~ 6.2.3.3.

6.2.5.2 The charge-depleting mode test shall be conducted in accordance with the stipulations of 6.2.2.2 ~ 6.2.2.7.

6.3 OVC-HEV Test Procedures

The vehicle may be tested in accordance with one of the four options below:

- a) In accordance with the stipulations of 6.2.2 and 6.2.3, successively carry out the charge-depleting mode test and the charge-sustaining mode test;
- b) In accordance with the stipulations of 6.2.3 and 6.2.2, successively carry out the charge-sustaining mode test and the charge-depleting mode test;
- c) In accordance with the stipulations of 6.2.4, continuously carry out the charge-depleting mode test and the charge-sustaining mode test;
- d) In accordance with the stipulations of 6.2.5, continuously carry out the charge-sustaining mode test and the charge-depleting mode test.

8.6 Road Load Lineage and Road Load Matrix Lineage

If vehicles satisfy the requirements of C.1.2.3.1.2 in GB 18352.6-2016, they may constitute the same road load lineage; if vehicles satisfies the requirements of C.1.2.3.1.3 in GB 18352.6-2016, they may constitute the same road load matrix lineage. In accordance with the vehicle manufacturer's requirements, adopt one of the following two methods to determine the road load of vehicles in the test lineage:

- a) In accordance with the stipulations of 6.1.1.1 and CC.4.2.1.1 in GB 18352.6-2016, obtain the road load of vehicle H through tests, which is applicable to all vehicle models in the road load lineage and the road load matrix lineage;
- b) In accordance with the stipulations of 6.1.1.1, obtain the road load of vehicle H and vehicle L through tests. In addition, in accordance with the relevant stipulations of CC.4.2.1.2 ~ CC.4.2.1.4 in GB 18352.6-2016, calculate the road load of all vehicle models in the road load lineage and the road load matrix lineage.

9 Conformity of Production

9.1 General Rules

9.1.1 The vehicle manufacturer shall establish and implement a production conformity assurance scheme in accordance with 9.2.

9.1.2 In accordance with 9.3 and 9.4, determine whether the conformity of production satisfies the requirements. If a certain vehicle model cannot satisfy any requirement of the production conformity inspection, then, it shall be determined that this vehicle model does not satisfy the requirements of production conformity stipulated in this document.

9.1.3 For vehicles undergoing the production conformity inspection, the test settings shall be consistent with the type approval inspection specified in Chapter 7. The vehicle preparation before the test shall be performed in accordance with the recommendations of the vehicle manufacturer.

9.1.4 If a certain vehicle model has several extended models or interpolation lineage models, the production conformity inspection shall be performed on the basic vehicle model described in the application materials for the first type inspection. If the production of the basic model for the first type inspection has been suspended, the production conformity inspection shall be performed on the extended models or the interpolation lineage models.

9.2 Production Conformity Assurance Scheme

9.2.1 The vehicle manufacturer shall randomly take multiple vehicles from the same

$EC_{AC,CD}$ ---when performing the type approval inspection specified in 7.3, the externally obtained electricity consumption of the charge-depleting mode test calculated in accordance with Formula (10), expressed in (Wh/km). If the type approval inspection has been performed for multiple times, then, this value is the arithmetic mean value of the multiple tests.

9.3 OVC-HEV Production Conformity

9.3.1 In terms of the fuel consumption FC_{CD} determined in accordance with 7.1.1.1 and the fuel consumption FC_{CS} determined in accordance with 7.1.1.2, the production conformity inspection and the requirements shall comply with the relevant stipulations of 8.1.2 ~ 8.3.5 in GB/T 19233-2020.

9.3.2 In terms of the fuel consumption $EC_{AC,CD}$ determined in accordance with 7.1.2.1, the production conformity inspection and the requirements shall comply with the relevant stipulations of 8.1.2 ~ 8.3.5 in GB/T 19233-2020. In terms of the fixed gradient coefficient specified in 8.1.3.4 in this document, when determining the production conformity in electricity consumption, 0.96 shall be adopted.

9.3.3 In terms of the all-electric range (AER) determined in accordance with 7.1.3.1 and the equivalent all-electric range (EAER) determined in accordance with 7.1.3.2, the production conformity inspection and the requirements shall comply with the relevant stipulations of 8.1.2 ~ 8.3.5 in GB/T 19233-2020. In terms of the fixed gradient coefficient specified in 8.1.3.4 in this document, in the determination of the production conformity in actual range, 1.04 shall be adopted. In terms of the calculation of test statistics specified in 8.2.2 in this document, during the test statistics of actual range, Formula (35) shall be used as a replacement. In terms of the calculation formula (9) of test statistics specified in 8.3.3 in this document, during the test statistics of actual range, Formula (36) shall be used as a replacement.

$$\frac{1}{s} \sum_{i=1}^n (x_i - L) \quad \dots\dots\dots (35)$$

$$d_j = L - x_j \quad \dots\dots\dots (36)$$

Where,

s ---the estimated value of the production standard deviation after taking the natural logarithm of the measured value of AER or EAER;

n ---the number of current sample vehicles;

i, j ---the serial No. of sample vehicles;

x_i ---the natural logarithm of the measured value of AER or EAER of the i^{th} and the j^{th} vehicles in the sample vehicles;

L ---the natural logarithm of the type approval value of AER or EAER;

Appendix A

(normative)

Correction Program Based on REESS Electrical Energy Changes

A.1 Overall Requirements

A.1.1 General requirements

This Appendix describes a program of correcting the fuel consumption of the charge-sustaining mode test based on REESS electrical energy changes. If the correction factor is provided by the vehicle manufacturer, then, relevant instructions shall be submitted to the inspection institution to prove the scientific character of the correction factory; otherwise, the correction factor shall be tested and determined at the inspection institution.

A.1.2 Application of correction program

A.1.2.1 For the charge-sustaining mode test that satisfies certain requirements, the fuel consumption needs to be corrected.

A.1.2.2 On the premise of failing to satisfy the requirements of A.1.2.3 c), if $\Delta E_{\text{REESS,CS}}$ calculated in accordance with Formula (2) is negative, and the cycle correction criterion calculated in accordance with A.1.3 is greater than 0.005, then, correction is required.

A.1.2.3 If one of the following conditions is satisfied, then, no correction is required:

- a) $\Delta E_{\text{REESS,CS}}$ is positive, and the cycle correction criterion calculated in accordance with A.1.3 is greater than 0.005;
- b) The cycle correction criterion calculated in accordance with A.1.3 is not greater than 0.005;
- c) The vehicle manufacturer can prove to the inspection institution that $\Delta E_{\text{REESS,CS}}$ is irrelevant with the fuel consumption of the charge-sustaining mode test through tests.

A.1.3 Calculation of correction criterion

The correction criterion c shall be calculated in accordance with Formula (A.1):

$$c = \frac{|\Delta E_{\text{REESS,CS}}|}{E_{\text{fuel,CS}}} \dots\dots\dots (A.1)$$

Where,

The correction factor shall be determined through the charge-sustaining mode test specified in 6.2.3. The number of tests conducted by the vehicle manufacturer shall be not less than 5 times.

Before the test, in accordance with the vehicle manufacturer's recommendations and the stipulations of A.3, the REESS charging state may be set up. This setting can only be used for the purpose of completing the correction program of the charge-sustaining mode test, and the permission of the inspection institution shall be obtained before the setting.

This set of measured values shall satisfy the following conditions:

- a) At least one test of $\Delta E_{\text{REESS,CS}} \leq 0$ and one test of $\Delta E_{\text{REESS,CS}} > 0$ shall be included.
- b) For the two tests with the highest negative electrical energy change and the highest positive electrical energy change, the difference in the fuel consumption shall be not less than 0.2 L/100 km;

When determining the correction factor, if the following conditions are also satisfied in addition to a) and b), then, the number of tests may be reduced to 3 times.

- c) In any two consecutive tests, the difference in fuel consumption converted from electrical energy change shall not exceed 0.4 L/100 km.
- d) For the two tests with the highest negative electrical energy change and the highest positive electrical energy change, the correction criterion c calculated in accordance with A.1.3 is greater than 0.01.
- e) The difference of fuel consumption between the test with the highest negative electrical energy change and the intermediate value, and the difference of fuel consumption between the intermediate value and the test with the highest positive electrical energy change shall be approximately the same. For the intermediate value, the correction criterion c calculated in accordance with A.1.3 shall be not greater than 0.01.

Before using the correction factor, the vehicle manufacturer shall submit it to the inspection institution for review and approval.

If a) or b) is not satisfied in at least 5 tests, the vehicle manufacturer shall explain to the inspection institution. If the inspection institution believes that the explanation is insufficient, it may request additional tests. If after the additional tests, the criterion is still not satisfied, the inspection institution will determine a conservative alternative correction factor based on the test result.

All test results shall comply with the requirements of 5.3.1.4 in GB 18352.6-2016.

A.3.2.1.1 Pre-treatment and vehicle immersion

The pre-treatment and vehicle immersion shall be conducted in accordance with the stipulations of C.3.

A.3.2.1.2 REESS adjustment

Before conducting the test, the vehicle manufacturer may adjust REESS, but shall provide proof suggesting that the adjusted REESS complies with the requirements for the commencement of the test.

A.3.2.1.3 Test procedures

A.3.2.1.3.1 Selection of driving mode. In terms of vehicles equipped with a driving mode selection function, in accordance with D.3, select the driving mode of the charge-sustaining mode test.

A.3.2.1.3.2 The vehicle shall be tested in accordance with the test cycle specified in 4.5.

A.3.2.1.3.3 The vehicle shall be tested in accordance with the stipulations of C.1.2.8.1 ~ C.1.2.8.3.1 and C.1.2.8.5 in GB 18352.6-2016.

A.3.2.1.3.4 The determination of the correction factor requires multiple tests; each test needs to satisfy the relevant requirements of A.2.2. The multiple tests may be consecutively conducted; the test procedures are composed of A.3.2.1.3.1 ~ A.3.2.1.3.3.

A.3.2.2 Method 2 - test process

A.3.2.2.1 Pre-treatment

The pre-treatment shall be conducted in accordance with the stipulations of C.3.1 or C.3.2.

A.3.2.2.2 REESS adjustment

After the pre-treatment, the link of vehicle immersion shall be omitted, and REESS adjustment within 60 min shall be allowed. The vehicle immersion time between each test shall be the same. After the vehicle immersion is completed, immediately continue the test in accordance with the test requirements.

In order to ensure that the start-up conditions are the same, through the vehicle manufacturer's requirements, before REESS adjustment, an additional warm-up procedure may be performed. If the warm-up procedure is performed, then, this procedure shall be added before each test cycle.

A.3.2.2.3 Test procedures

Appendix C

(normative)

Pre-treatment, Vehicle Immersion and REESS Charging

C.1 General Rules

This Appendix specifies the pre-treatment procedures of REESS and internal combustion engine.

C.2 Pre-treatment, Vehicle Immersion and REESS Charging Procedures Started from Charge-depleting Mode

C.2.1 Pre-treatment

Drive or push the vehicle onto the chassis dynamometer. The vehicle shall run at least one test cycle to complete the pre-treatment. During pre-treatment, the electrical balance state of REESS shall be simultaneously measured. When the determination conditions of termination specified in 6.2.2.5 are satisfied, at the end of the test cycle, the pre-treatment shall be terminated.

C.2.2 Vehicle immersion

Vehicle immersion shall be performed in accordance with the stipulations of C.1.2.7 in GB 18352.6-2016. Vehicles undergoing the pre-treatment shall not use forced cooling. During vehicle immersion, REESS shall receive regular charging in accordance with C.2.3.

C.2.3 Regular charging

C.2.3.1 AC charging mode is recommended for regular charge; the charging power shall be not higher than 42 kW; the electricity measurement equipment shall be installed between the vehicle plug and the power supply equipment. When there are multiple AC charging modes (such as: conductive charging and inductive charging, etc.), the conductive charging mode shall be used. If there are multiple available levels of conductive charging powers, then, the highest charging power shall be used. If it is recommended by the vehicle manufacturer, then, a relatively low charging power may be selected. If the vehicle only allows the DC charging mode, or in accordance with the vehicle manufacturer's recommendations and the determination by the inspection institution, the DC charging mode may be selected. Under this circumstance, the electricity measurement equipment shall be installed between the power supply equipment and the power grid. Charging shall be continuously conducted, and if a power failure occurs during the charging process, then, it shall be recorded and the reasons shall be explained in the test report. The charging mode shall be selected in

Appendix D

(normative)

Selection of Driving Mode

D.1 General Requirements

D.1.1 The vehicle manufacturer shall select a driving mode for the tests in accordance with this Appendix. This mode shall enable the vehicle to follow the test cycle within the speed tolerance range specified in 6.1.1.5.

D.1.2 The vehicle manufacturer shall provide the competent authority with proof of the following conditions:

- a) Applicable conditions of the main mode;
- b) The maximum speed;
- c) The optimal and the worst scenarios of fuel consumption and CO₂ emissions (if applicable) under all modes, and their explanatory materials;
- d) The highest electricity consumption mode;
- e) Cyclic energy demand (in accordance with CE.5 in GB 18352.6-2016, in which, the target vehicle speed is replaced by the actual vehicle speed).

D.1.3 Special driving modes, such as: “mountain mode” and “maintenance mode”, and other non-daily driving modes, if they are only used for some special purposes, they shall not be considered.

D.2 Charge-depleting Mode Test Equipped with a Driving Mode Selection Function

D.2.1 If there is a main mode, and this mode enables the vehicle to follow the test cycle in the charge-depleting mode test, then, this mode shall be selected.

D.2.2 If there is no main mode, or there is a main mode, but this mode cannot enable the vehicle to follow the test cycle in the charge-depleting mode test, then, the driving mode shall be selected in accordance with the following stipulations:

- a) If there is only one optional mode that enables the vehicle to follow the test cycle in the charge-depleting mode test, then, this mode shall be selected;
- b) If there are multiple modes that enable the vehicle to follow the test cycle in the charge-depleting mode test, then, the mode with the highest electricity

Figure D.1 -- Schematic Diagram of Selection of Driving Mode in Charge-depleting Mode Test

D.3 Charge-sustaining Mode Test Equipped with a Driving Mode Selection Function

D.3.1 If there is a main mode, and this mode enables the vehicle to follow the test cycle in the charge-sustaining mode test, then, this mode shall be selected.

D.3.2 If there is no main mode, or there is a main mode, but this mode cannot enable the vehicle to follow the test cycle in the charge-sustaining mode test, then, the driving mode shall be selected in accordance with the following stipulations:

- a) If there is only one optional mode that enables the vehicle to follow the test cycle in the charge-sustaining mode test, then, this mode shall be selected;
- b) If there are multiple modes that enable the vehicle to follow the test cycle in the charge-sustaining mode test, then, the vehicle manufacturer may select the mode with the highest fuel consumption, or simultaneously select the modes with the lowest and the highest fuel consumption, and take the arithmetic mean value of the test result.

D.3.3 If there is no mode that enables the vehicle to follow the test cycle in the charge-sustaining mode test, then, the test cycle shall be corrected in accordance with CA.5 in GB 18352.6-2016; the driving mode shall be selected in accordance with the following stipulations:

- a) If there is a main mode, and this mode enables the vehicle to follow the corrected test cycle in the charge-sustaining mode test, then, this mode shall be selected;
- b) If there is no main mode, or there is a main mode, but this mode cannot enable the vehicle to follow the test cycle in the charge-sustaining mode test, then, from the other modes that enable the vehicle to follow the corrected test cycle in the charge-sustaining mode test, select the mode with the highest fuel consumption.

D.3.4 During the test process and the multiple tests of determining the fuel consumption correction factor in Appendix A, the driving mode shall be consistent. The selection of the driving mode in the charge-sustaining mode test is shown in Figure D.2.

Appendix E

(normative)

Determination of REESS Current and Voltage

E.1 Overview

E.1.1 This Appendix specifies the test methods and equipment for REESS current and voltage.

E.1.2 The measurement of REESS current and voltage shall be conducted before or at the beginning of the test, and immediately end after the vehicle completes the test.

E.1.3 REESS current and voltage of each stage shall be measured. The current during REESS consumption is defined as a negative value.

E.2 REESS Current

E.2.1 External REESS current measurement

E.2.1.1 REESS current shall be measured with a clip-mounted or enclosed current sensor in the test. The precision of the current measurement system shall satisfy the requirements specified in Table 1. The current sensor shall be able to read the peak current when the engine is started, and work under the temperature conditions of the measuring point.

E.2.1.2 The current sensor shall measure REESS current by connecting to REESS cable. The measured current shall be the total current of REESS.

In the case of shielded wires, in accordance with the vehicle manufacturer's requirements and the determination by the inspection institution, appropriate treatment shall be carried out.

In order to make it more convenient for the external measurement equipment to measure REESS current, the vehicle manufacturer shall provide a suitable, safe and convenient connection point on the vehicle. If there is no such connection point, then, the vehicle manufacturer is obliged to support the inspection institution to connect the current sensor to a cable directly connected to REESS that complies with the above-mentioned requirements.

E.2.1.3 In accordance with the vehicle manufacturer's recommendations, the sampling frequency of the current sensor shall be selected. The minimum frequency is 20 Hz.

E.2.2 On-board REESS current data

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