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

重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 Heavy-duty Hybrid Electric Vehicles

1 Scope

This document specifies the test methods for the energy consumption test of heavy-duty hybrid electric vehicles on a chassis dynamometer.

This document is applicable to hybrid electric vehicles with a maximum total mass of more than 3,500 kg, including trucks, semi-trailer tractors, passenger vehicles, dump trucks and city buses. Concrete mixer trucks may refer to the relevant measurement methods of dump trucks; other special-purpose transport vehicles may refer to the relevant measurement methods of trucks.

This document is applicable to vehicles that run on gasoline or diesel. Other fuel types of vehicles may take this document as a reference.

This document does not apply to special-purpose operating vehicles, including van-type special-purpose operating vehicles, tank-type special-purpose operating vehicles, special-purpose dump trucks, silo-type special-purpose operating vehicles, special-purpose vehicles for hoisting and lifting, as well as special-purpose operating vehicles with special structures, etc.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references. 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 1884 Crude Petroleum and Liquid Petroleum Products - Laboratory Determination of Density - Hydrometer Method

GB/T 3730.1 Motor Vehicles and Trailers - Types - Terms and Definitions

GB/T 12534 Motor Vehicles - General Rules of Road Test Method

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

GB 17691-2018 Limits and Measurement Methods for Emissions from Diesel Fueled Heavy-duty Vehicles (China VI)

through the unit conversion factor k_2 of Formula (4) in accordance with the relevant stipulations of Appendix CE.5 of GB 18352.6-2016.

In accordance with the recommendation of the automobile manufacturer and confirmation by the inspection institution, η_{tr} may be replaced by the value recommended by the automobile manufacturer. Under this circumstance, η_{tr} shall be indicated in the test report.

5 Test Cycle

5.1 In accordance with China heavy-duty commercial vehicle test cycle (CHTC) specified in Appendix A of GB/T 38146.2-2019, measure the fuel consumption of the vehicle. Specifically speaking, city buses shall adopt CHTC-B driving conditions; passenger vehicles (excluding city buses) shall adopt CHTC-C driving conditions; trucks (excluding dump trucks) shall adopt CHTC-LT (GVW ≤ 5,500 kg) or CHTC-HT (GVW > 5,500 kg) driving conditions; dump trucks shall adopt CHTC-D driving conditions; semi-trailer tractors shall adopt CHTC-TT driving conditions.

5.2 If the maximum speed of the vehicle is less than the maximum vehicle speed of CHTC, when the target speed is greater than the maximum vehicle speed, in accordance with the stipulations of Appendix CA.5 in GB 18352.6-2016, correct the test cycle.

6 Test Preparation

6.1 Test conditions

6.1.1 The recommended ambient temperature is (23 ± 5) °C. In accordance with the recommendation of the automobile manufacturer and confirmation by the inspection institution, the range of the ambient temperature may be loosened to 5 °C ~ 35 °C. During the test, and at the beginning and the end of the test, the temperature must not exceed this range, and the actual ambient temperature shall be indicated in the test report.

6.1.2 The test site shall be equipped with ventilation and cooling devices for power storage batteries, flywheel shields, safety devices against high voltage and other necessary safety protection facilities. During the test, a fixed-speed fan may be used to guide the cooling air to the vehicle, so as to ensure that the operating temperature of the engine satisfies the manufacturer's requirements. The fan can only work when the vehicle is running, and shall be turned off when the vehicle is stopped.

6.2 Pre-collection of Vehicle Data

6.2.1 Before the test, in accordance with the content of Appendix B, vehicle parameters shall be recorded in detail.

6.2.2 Any content that is different from the basic procedure, for example, the test vehicle is running in a different working mode than the hybrid electric vehicles, shall be completely recorded for the subsequent tests to reproduce the test process.

6.3 Vehicle Conditions

6.3.1 Run-in

Before the test, in accordance with the automobile manufacturer's stipulations, the vehicle shall be subject to run-in, or the run-in shall not exceed 10,000 km.

6.3.2 Vehicle state

Before the test, the vehicle state shall be checked:

---The performance of the test vehicle shall comply with the automobile manufacturer's stipulations and be able to normally drive.

---In accordance with the automobile manufacturer's stipulations, the engine, motor and vehicle controls shall be adjusted.

---If the cooling fan of the vehicle is temperature-controllable, it shall be kept in normal working condition; the air conditioning system of the passenger compartment shall be turned off.

6.3.3 Load of test vehicle

6.3.3.1 For city buses, the test shall be carried out under the condition of 65% of the maximum design loading mass. The setting of the road load shall take the taxiing test specified in GB/T 27840 as a reference. In accordance with the recommendation of automobile manufacturer and confirmation by the inspection institution, the setting of the road load may also be based on the interpolation calculation of the recommended scheme of driving resistance coefficient specified in GB/T 27840, or the test shall be carried out under the condition of the maximum design total mass. The setting of the road load shall take the taxiing test or the recommended scheme of driving resistance coefficient specified in GB/T 27840 as a reference. For other heavy-duty commercial vehicles, the test shall be carried out under the condition of the maximum design total mass; the setting of the road load shall take the taxiing test or the recommended scheme of driving resistance coefficient specified in GB/T 27840 as a reference.

6.3.3.2 The occupant mass and its loading requirements shall comply with the relevant stipulations of GB/T 12534.

NOTE: for semi-trailer tractors, the maximum design total mass in this document refers to the maximum mass of the combination vehicle.

6.3.4 Tire pressure

Figure 1 -- Reference Curve and Tolerances

6.3.6.2 If the maximum speed of the vehicle is less than the maximum vehicle speed of CHTC, in accordance with the test cycle specified in 5.2, the test shall be performed. The speed tolerance and time tolerance of the test cycle, and the cumulative time of exceeding the tolerance range shall comply with the stipulations of 6.3.6.1. For the part exceed the maximum speed of the vehicle, the accelerator pedal shall be stepped down to the end; the actual speed of the vehicle is allowed to exceed the upper limit of the speed tolerance, but it shall satisfy the requirement of the lower limit of the speed tolerance.

6.3.6.3 If the vehicle cannot satisfy the tolerance requirements of the test cycle, the automobile manufacturer may apply to the competent authority for the vehicle to be a special vehicle model, and provide relevant information.

6.3.7 Other vehicle settings

If the vehicle has the function of braking energy regeneration, the same control strategy as the actual vehicle shall be used during the test. If the vehicle is equipped with an anti-lock braking system (ABS), traction control system (TCS) or electronic braking system (EBS), and is tested on a single-axle driven chassis dynamometer, these systems may regard a non-rotating wheel not mounted on the wheel hub as a faulty system by mistake, and under this circumstance, they shall be shielded to achieve normal system operation.

6.3.8 Test fuel

6.3.8.1 The test fuel shall comply with the stipulations of the automobile manufacturer, and adopt the benchmark fuel that complies with the requirements of Appendix K in GB 18352.6-2016, or the commercially available vehicle fuel that complies with the stipulations of the relevant national standards.

6.3.8.2 In accordance with GB/T 1884, determine the fuel density.

6.3.8.3 When the carbon balance method is adopted to calculate the fuel consumption, it is assumed that the hydrogen-to-carbon ratios of gasoline and diesel are respectively 1.85 and 1.86.

6.4 Failure of REESS

When REESS is damaged, or the energy storage capacity of REESS is lower than the value specified by the automobile manufacturer, the REESS shall be considered as failure. The failed REESS shall be repaired, replaced and balanced, then, the test shall be re-conducted.

6.5 Measurement of Sliding Resistance and Technical Conditions of Chassis Dynamometer

The measurement of sliding resistance and the technical conditions of chassis dynamometer shall comply with the relevant requirements of GB/T 27840.

6.6 Test Equipment

The test equipment and accuracy requirements are as follows.

---For the test instruments (for example, non-contact speedometer) used to measure vehicle speed and distance, the measurement accuracy of vehicle speed shall be not lower than ± 0.2 km/h; the measurement accuracy of time shall be not lower than ± 0.1 s. The measurement devices for fuel consumption, energy consumption, vehicle speed and time shall be simultaneously activated.

---For the auxiliary driver-assist display screen used to display the theoretical speed and actual speed of the test cycle in real time, and guide the driver to adjust the speed of the vehicle, the actual driving speed and theoretical speed shall be recorded, and the recording frequency must not be lower than 1 Hz.

---For the equipment used to measure fuel consumption, the carbon balance method shall be used, and the equipment and accuracy shall comply with the relevant requirements of GB 17691-2018; or the fuel consumption meter method shall be used, and the accuracy of the fuel consumption meter must be not lower than ± 0.5% of the measured value; or the weighing method shall be used, and the accuracy of the balance must be not lower than ± 0.5% of the measured value.

---For the equipment used to measure current, the accuracy must be not lower than ± 0.5% of the maximum measured value, or ± 0.2% FS; the operating frequency must be not lower than 20 Hz.

---For the equipment used to measure voltage, the accuracy must be not lower than ± 0.5% of the maximum measured value, or ± 0.2% FS; the operating frequency must be not lower than 20 Hz.

---For other equipment that can satisfy the functional requirements of the power consumption test, with the approval of the competent authority, they may be used for the test, but the accuracy must be not lower than ± 0.5% of the measured value.

---For the equipment used to measure the hybrid electric vehicles fueled by natural gas, the carbon balance method shall be used, and the equipment and accuracy shall comply with the relevant requirements of GB 17691-2018; or the gas consumption meter shall be used, and the accuracy shall be not lower than ± 0.5% of the measured value.

7.3 Test Procedure of Non-External Rechargeable Hybrid Electric Vehicle (NOVC-HEV)

7.3.1 REESS pre-setting

For NOVC-HEV, the vehicle REESS shall be in the state of charge (SOC) for normal use as specified by the automobile manufacturer, otherwise, in accordance with the automobile manufacturer's requirements, and through the mode of external charging or the use of vehicle-mounted engine, REESS shall be preset and adjusted to the SOC for normal use.

7.3.2 Test procedure

The vehicle shall be tested in accordance with the test cycle. After each test is completed, as required, the ignition lock may be turned off for vehicle immersion; the immersion time shall not exceed 30 min. The test shall be continuously carried out. Before the test is completed, if non-test driving is carried out, then, the test is invalid and need to be re-conducted.

7.3.3 Number of test cycles and their treatment

It is required to carry out at least 3 test cycles. In accordance with the stipulations of 8.7.2.1 and 8.7.2.2, determine whether the test results are valid and whether the number of tests is sufficient. If the test vehicle still fails to satisfy the requirements of 8.7.2.1 and 8.7.2.2 after continuously running multiple test cycles, in accordance with the automobile manufacturer's recommendation and confirmation by the inspection institution, the test may be terminated after running a specified number of test cycles. For city buses and dump trucks, the number of the test cycles is 12. For other heavy-duty commercial vehicles, the number of the test cycles is 6. Through the automobile manufacturer's recommendation, the number of test cycles may be appropriately increased.

7.4 Test Procedure of External Rechargeable Hybrid Electric Vehicle (OVC-HEV)

7.4.1 REESS pre-setting

7.4.1.1 General rules

For OVC-HEV, before conducting the first test, the vehicle shall be charged. Unless it is otherwise specified by the automobile manufacturer or REESS manufacturer, the charging of REESS may be carried out in accordance with the stipulations of 7.4.1.2 and 7.4.1.3.

7.4.1.2 REESS discharge

In accordance with the automobile manufacturer's recommendation, before charging

REESS, REESS may be discharged first. REESS discharge shall be performed in accordance with the discharge procedure specified by the automobile manufacturer's recommendation. The automobile manufacturer shall ensure that the residual energy of REESS after the discharge is completed shall not exceed 20% of SOC, or the SOC fault alarm value set by the automobile manufacturer.

7.4.1.3 REESS charge

7.4.1.3.1 Regular charge

The mode of conductive charging shall be used to charge REESS. If the charging modes of DC and AC simultaneously exist in the vehicle, it shall be selected in accordance with the automobile manufacturer's recommendation. REESS recommends charging in one of the following modes at the ambient temperature specified in 6.1.1:

a) Vehicle-mounted charger (if equipped);

b) For the external charger recommended by the automobile manufacturer, use the normal mode.

The above-mentioned charging procedure does not include any special charging procedures that are automatically or manually initiated, for example, equalization charging mode or maintenance mode. The automobile manufacturer shall declare that no special charging procedures are performed during the test. A charging strategy that does not require additional operations for vehicles in effective sale is not considered to be a special charging procedure, and the automobile manufacturer shall provide relevant certification documents.

7.4.1.3.2 Criteria of end-of-charge

When the vehicle-mounted or external device shows that REESS is fully charged, it shall be determined that the charging is complete. If the vehicle-mounted or external device sends out an obvious signal indicating that REESS is not fully charged, under this circumstance, the maximum charging time is: 3 × REESS energy (kWh) specified by the automobile manufacturer / supply power (kW).

7.4.2 OVC-HEV test procedure including pure electric working mode

7.4.2.1 General requirements

7.4.2.1.1 OVC-HEV, which includes pure electric working mode, refers to a vehicle that can complete a test cycle in a pure electric working mode on the premise of satisfying 6.3.6. If the hybrid power design of the vehicle decides or the control strategy is set to use the pure electric mode to work below a certain vehicle speed, and to use the hybrid mode to work above a certain vehicle speed, it does not belong to the OVC-HEV including pure electric working mode specified in this document. This type of vehicles

7.4.2.3.2 For vehicles that use the pure electric mode switch or automatically switch the pure electric working mode, when the vehicle speed cannot satisfy the stipulations of 6.3.6, or when the engine automatically starts, or under other conditions specified by the automobile manufacturer that the test shall be terminated, if the condition for the end of Stage I test is reached, the test cycle No. is counted as n_1 + 1. The vehicle shall be promptly stopped, then, the power supply shall be cut off. Turn off the ignition lock to perform vehicle immersion. The immersion time shall not exceed 30 min.

7.4.2.3.3 Through the automobile manufacturer's recommendation and confirmation by the inspection institution, Stage I test may be terminated early. During the test, the start of the engine caused by pumping is not regarded as the end of the test, and the automobile manufacturer needs to provide corresponding materials to prove that there is no power output during the pumping process and that the REESS is not charged.

7.4.2.3.4 After Stage I, the fuel consumption, electricity consumption and driving range of each test cycle shall be recorded.

7.4.2.4 REESS energy adjustment stage (Stage II)

Adopt the test cycle specified in Chapter 5 to continuously carry out the test. In addition, in accordance with 4.3, calculate the relative change of *NEC* of each test cycle. When there is a test with an absolute value not greater than 5%, and the condition for the end of Stage II test is reached, the test cycle No. is counted as n_2 + 1; Stage II test includes n_1 + 2 ~ n_2 test cycles. Through the automobile manufacturer's recommendation, the number of test cycles may be appropriately increased. When the absolute value of the relative change of *NEC* is not greater than 5%, Stage II test ends, and the test cycle No. is counted as n_2 + 1. For vehicles that do not have the electric energy balance operation stage, in accordance with the required number of test cycles specified in 7.4.2.1.3, continuously carry out the test, until the test comes to an end. The test cycle No. at the end of the test shall be counted as n_2.

7.4.2.5 Electric energy balance operation stage (Stage III)

Adopt the test cycle specified in Chapter 5 to continuously carry out the test. In addition, in accordance with 4.3, calculate the relative change of *NEC* of each test cycle. After the $(n_2 + 1)^{th}$ test cycle, when the absolute value of the relative change of *NEC* is not greater than 5% for two times, the condition for the end of Stage III test is reached.

7.4.2.6 Charge and electricity measurement

7.4.2.6.1 After the test, the vehicle shall be charged within 120 min in accordance with the stipulations of 7.4.1.3.1. When the requirements of 7.4.1.3.2 are satisfied, REESS charge ends.

7.4.2.6.2 An electricity measurement device shall be installed between the vehicle REESS and the power supply device to measure the power E_{AC} charged from the external power supply and the charging time. If the vehicle is equipped with a vehicle-

mounted charger, then, the electricity measurement device shall be installed between the vehicle-mounted charger and the power supply device. When the requirements of 7.4.1.3.2 are reached, stop the electricity measurement.

7.4.3 OVC-HEV test procedure excluding pure electric working mode

7.4.3.1 General requirements

7.4.3.1.1 The energy consumption test of OVC-HEV excluding pure electric working mode is divided into: REESS energy adjustment stage and electric energy balance operation stage. If the test vehicle starts from the REESS energy adjustment stage, continuously runs multiple test cycles and still fails to reach the condition of ending the electric energy balance operation stage specified in 7.4.2.5, then, in accordance with the automobile manufacturer's recommendation and confirmation by the inspection institution, it can be determined that there is no electric energy balance operation stage. Under this circumstance, the REESS energy adjustment stage needs to run a specific number of test cycles. For city buses and dump trucks, the number of the test cycles is 12. For other heavy-duty commercial vehicles, the number of the test cycles is 6. The test needs to be continuously carried out. If all the tests have not been completed and the vehicle has been on non-test driving, then, the test shall be re-conducted.

7.4.3.1.2 Unless it is otherwise specified, vehicle immersion is allowed in each test cycle; the immersion time shall not exceed 30 min. During the vehicle immersion, the ignition lock shall be turned off; the hood shall be closed; the test bench fan shall be turned off; the brake pedal shall be released; the external power supply shall not be used for charging.

7.4.3.2 Movement of vehicle

7.4.3.2.1 In the case where the parking location where the vehicle completes the charging is not in the same place as the test site, the vehicle is required to move to the test site at a constant speed of not more than 30 km/h; the maximum distance from the vehicle preset location to the test site must not exceed 3 km. Then, cut off the power supply and turn off the ignition lock to perform vehicle immersion. The immersion time shall not exceed 15 min.

7.4.3.2.2 The test may directly start from the cold state.

7.4.3.3 REESS energy adjustment stage

In accordance with the stipulations of 7.4.2.4, perform the test.

7.4.3.4 Electric energy balance operation stage

In accordance with the stipulations of 7.4.2.5, perform the test.

7.4.3.5 Charge and electricity measurement

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