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Drive Motor System for Electric Vehicles

电动汽车用驱动电机系统

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Drive Motor System for Electric Vehicles

1 Scope

This document specifies the model naming, technical requirements, test methods, inspection rules, marking and identification of drive motor system for electric vehicles.

This document is applicable to drive motor systems, drive motors and drive motor controllers for electric vehicles.

Vehicle motors that only have the function of generating electricity, and their controllers may take this document as a reference.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through normative references in the text. 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 1971 Rotating Electrical Machines - Terminal Markings and Direction of Rotation

GB/T 2900.25 Electrotechnical Terminology - Rotating Electrical Machines

GB/T 2900.33 Electrotechnical Terminology - Power Electronics

GB/T 4208-2017 Degrees of Protection Provided by Enclosure (IP code)

GB/T 12673 Motor Vehicle Main Dimensions Measurement Method

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

GB 18384 Electrically Propelled Road Vehicles - Safety Specifications

GB/T 18655-2018 Vehicles, Boats and Internal Combustion Engines - Radio Disturbance Characteristics - Limits and Methods of Measurement for the Protection of On-board Receivers

GB/T 19596-2017 Terminology of Electric Vehicles

GB/T 21437.2 Road Vehicles - Test Method of Electrical Disturbances from Conduction and Coupling - Part 2: Electrical Transient Conduction along Supply Lines Only

GB/T 33014.2 Road Vehicles - Component Test Methods for Electrical / Electronic Disturbances from Narrowband Radiated Electromagnetic Energy - Part 2: Absorber-lined Shielded Enclosure

The drive motor system shall be flexibly idling, without abnormal noise (such as: friction between the stator and rotor, periodic abnormal noise, abnormal noise after bearing damage, and abnormal noise caused by tiny foreign objects stuck in the rotating parts, etc.) or jamming.

5.1.2 Appearance

5.1.2.1 The outer surface of the drive motor system shall have no obvious damage or deformation, and the coating shall not peel off.

5.1.2.2 If a nameplate is installed, the nameplate of the drive motor system shall be squarely and firmly installed, with clear writing.

5.1.2.3 The lead wires or terminals of the drive motor system shall be intact, and the fastener connections shall not be loose.

5.1.2.4 The drive motor and drive motor controller shall satisfy the requirements of 5.1.2.1 ~ 5.1.2.3.

5.1.3 Cooling circuit sealing performance of liquid cooling system

5.1.3.1 The cooling circuit of the drive motor system with liquid cooling system shall be able to withstand a pressure of no less than 200 kPa.

5.1.3.2 For the drive motor system whose cooling circuit is connected to the interior of the cavity, it shall satisfy the product technical specifications and be indicated in the report.

5.1.3.3 If the cooling circuit of the drive motor system has transition joints, they may be respectively measured or satisfy the product technical specifications and be indicated in the report.

5.1.4 Insulation resistance

5.1.4.1 For the split drive motor system whose DC bus voltage is Class B voltage, the insulation resistance shall satisfy the requirements of Appendix B.

5.1.4.2 For the integrated drive motor system whose DC bus voltage is Class B voltage, the insulation resistance between the DC power terminal and the shell, and between the DC power terminal and the signal terminal shall not be less than 1 M Ω .

NOTE: when the signal ground of the drive motor controller is short-circuited to the shell, only the insulation resistance test between the DC power terminal and the shell is required.

5.1.5 Voltage resistance

5.1.5.1 For the split drive motor system whose DC bus voltage is Class B voltage, the voltage resistance shall satisfy the requirements of Appendix B.

5.1.5.2 For the integrated drive motor system whose DC bus voltage is Class B voltage, between

not exceeding 30 minutes, 5.2.2 and 5.2.3 are not required, and shall be indicated in the report.

5.2.4 Peak torque

5.2.4.1 The peak torque of the drive motor system of Category-M₁ and Category-N₁ vehicles in a duration of 10 seconds shall not be lower than what is specified in the product specifications, and there shall be no alarms or abnormalities.

5.2.4.2 The peak torque of the drive motor system of vehicles other than Category-M₁ and Category-N₁ vehicles in a duration of 30 seconds shall not be lower than what is specified in the product specifications, and there shall be no alarms or abnormalities.

5.2.5 Peak power

5.2.5.1 The peak power of the drive motor system of Category-M₁ and Category-N₁ vehicles in a duration of 10 seconds shall not be lower than what is specified in the product specifications, and there shall be no alarms or abnormalities.

5.2.5.2 The peak power of the drive motor system of vehicles other than Category-M₁ and Category-N₁ vehicles in a duration of 30 seconds shall not be lower than what is specified in the product specifications, and there shall be no alarms or abnormalities.

5.2.6 Maximum working speed

The maximum working speed of the drive motor system shall not be lower than what is specified in the product specifications. When working at the maximum power allowed at this speed, the duration shall satisfy the stipulations of 5.2.5, and there shall be no alarms or abnormalities.

5.2.7 Drive motor system efficiency

5.2.7.1 Under the rated voltage, the maximum efficiency of the drive motor system shall not be less than 85%.

5.2.7.2 Under the rated voltage, the percentage of the high efficiency working area (with an efficiency not lower than 85%) of the drive motor system to the total working area shall satisfy the product technical specifications.

5.2.8 Control accuracy

5.2.8.1 Control accuracy of speed

For the drive motor system with speed control function, when the drive motor shaft extension speed is below 10,000 r/min, the control accuracy shall be within the range of -50 r/min ~ 50 r/min; when the drive motor shaft extension speed is 10,000 r/min and above, the control accuracy shall be within the range of -0.5% ~ 0.5%.

5.2.8.2 Control accuracy of torque

5.2.8.2.1 For the drive motor system with torque control function and a peak torque of not greater than $500 \text{ N} \cdot \text{m}$, when the drive motor shaft extension torque is below $100 \text{ N} \cdot \text{m}$, the control accuracy shall be within the range of $-5 \text{ N} \cdot \text{m} \sim 5 \text{ N} \cdot \text{m}$; when the drive motor shaft extension torque is $100 \text{ N} \cdot \text{m}$ and above, the control accuracy shall be within the range of $-5\% \sim 5\%$.

5.2.8.2.2 For the drive motor system with torque control function and a peak torque of greater than $500 \text{ N} \cdot \text{m}$, when the drive motor shaft extension torque is not greater than one-fifth of the peak torque, the control accuracy shall be within the range of $-1\% \sim 1\%$ of the peak torque; when the drive motor shaft extension torque is greater than one-fifth of the peak torque, the control accuracy shall be within the range of $-5\% \sim 5\%$.

5.2.9 Locked-rotor torque

5.2.9.1 For the drive motor system of Category- M_1 and Category- N_1 vehicles with locked-rotor torque control requirements, the maximum locked-rotor torque for a duration of not less than 5 seconds shall not be lower than the product technical specifications, and there shall be no alarms or abnormalities.

5.2.9.2 For the drive motor system of vehicles other than Category- M_1 and Category- N_1 vehicles with locked-rotor torque control requirements, the maximum locked-rotor torque for a duration of not less than 10 seconds shall not be lower than the product technical specifications, and there shall be no alarms or abnormalities.

5.2.10 Feed characteristics

When the drive motor system operates in the feed state, the input & output characteristics shall satisfy the requirements of 5.2.1 ~ 5.2.8.

5.3 Safety

5.3.1 Potential equalization

5.3.1.1 The resistance between the accessible conductive parts and the shell grounding point in the drive motor system whose DC bus voltage is Class B voltage shall not be greater than 0.1Ω .

5.3.1.2 If there are two or more grounding points, they shall be respectively measured. For the split drive motor system, the drive motor and the drive motor controller shall be respectively measured.

5.3.1.3 When the split drive motor and the drive motor controller are located in the potential equalization path, the resistance between the two conductive parts with a distance of no more than 2.5 m shall not be greater than 0.2Ω .

5.3.1.4 The grounding point shall have a grounding mark. If there is no specific grounding point,

- a) Implementation mode;
- b) Test results.

5.3.3 DC bus capacitor discharge time

5.3.3.1 The drive motor system whose DC bus voltage is Class B voltage shall have a passive discharge function. When the drive motor controller is cut off from the DC bus terminal power supply, the time it takes for the DC bus capacitor of the drive motor controller to discharge to 60 V shall not be greater than 5 minutes.

5.3.3.2 When the drive motor system has active discharge requirements, after the drive motor controller is cut off from the DC bus terminal power supply, the time it takes for the DC bus capacitor of the drive motor controller to discharge to 60 V shall not be greater than 3 seconds.

5.4 Environmental Adaptability

5.4.1 Low temperature

5.4.1.1 The drive motor system whose DC bus voltage is Class B voltage shall be able to withstand low-temperature storage at $-40\text{ }^{\circ}\text{C}$ for no less than 12 hours. The drive motor system with other voltage levels shall be able to withstand the low-temperature storage specified in the product technical specifications.

5.4.1.2 After storage, maintain the temperature inside the chamber unchanged. The insulation resistance retested in the chamber shall comply with the stipulations of 5.1.4, then, perform a no-load starting at the rated voltage. After starting, in accordance with the torque and speed specified in the product technical specifications, operate for 0.5 hour, there shall be no alarms or abnormalities.

5.4.1.3 After returning to normal, the drive motor system shall be able to normally operate at peak torque and peak power at the rated voltage. The drive motor system of Category- M_1 and Category- N_1 vehicles shall last for 10 seconds. The drive motor system of vehicles other than Category- M_1 and Category- N_1 vehicles shall last for 30 seconds.

5.4.2 High temperature

5.4.2.1 High-temperature storage

5.4.2.1.1 The drive motor system shall be able to withstand high-temperature storage at $85\text{ }^{\circ}\text{C}$ for no less than 12 hours.

5.4.2.1.2 After storage, maintain the temperature inside the chamber unchanged. The insulation resistance retested in the chamber shall comply with the stipulations of 5.1.4.

5.4.2.1.3 After returning to normal, the drive motor system shall be able to normally operate at peak torque and peak power at the rated voltage. The drive motor system of Category- M_1 and Category- N_1 vehicles shall last for 10 seconds. The drive motor system of vehicles other than

test in accordance with the product technical specifications.

5.4.5.3 In accordance with 6.5.5, carry out the test, and there shall be no abnormal phenomena, for example, interruption of signal transmission.

5.4.5.4 After the test, the drive motor system shall not have mechanical damage or deformation that affects high-voltage safety. The retested insulation resistance shall comply with the stipulations of 5.1.4, and the retested sealing of the liquid cooling circuit shall comply with the stipulations of 5.1.3.

5.4.5.5 After the test, the drive motor system shall be able to normally operate at peak torque and peak power at the rated voltage. The drive motor system of Category-M₁ and Category-N₁ vehicles shall last for 10 seconds. The drive motor system of vehicles other than Category-M₁ and Category-N₁ vehicles shall last for 30 seconds.

5.4.5.6 When the sample under test has multiple directions or the direction is unclear, the test shall be respectively conducted in three directions.

5.4.5.7 If there are special requirements, during the test, the motor operation can be controlled, and the operating speed is proposed by the manufacturer and indicated in the report.

5.4.6 Waterproof and dustproof

5.4.6.1 The dustproof and waterproof requirements of the drive motor system shall satisfy at least one of the following two requirements.

- a) Satisfy the protection requirements of IP67 or higher specified in GB/T 4208-2017.
- b) If there are clear stipulations on the installation position in the product technical specifications, the dustproof and waterproof levels of the drive motor system shall be determined based on the layout height of the vehicle under no load. The requirements are as follows:

---If the height of the lower surface of the drive motor system from the ground is less than 300 mm, it shall satisfy the protection requirements of IP67 or higher specified in GB/T 4208-2017;

---If the height of the lower surface of the drive motor system from the ground is not less than 300 mm, and there is no obstruction underneath the components, the high-voltage components shall satisfy the protection requirements of IP55 or higher specified in GB/T 4208-2017;

---If the height of the lower surface of the drive motor system from the ground is not less than 300 mm, and there is an obstruction underneath the components, the high-voltage components shall satisfy the protection requirements of IP54 or higher specified in GB/T 4208-2017.

5.4.6.2 The fan protection level of the air cooling system shall satisfy the product technical

specifications.

5.4.6.3 For the drive motor system that shares a shell with other components, the drive motor system can be tested in the form of complete-vehicle installation.

5.4.6.4 In accordance with 6.5.6, carry out the test, and the retested insulation resistance shall comply with the stipulations of 5.1.4.

5.4.6.5 The drive motor system shall be able to normally operate at peak torque and peak power at the rated voltage. The drive motor system of Category-M₁ and Category-N₁ vehicles shall last for 10 seconds. The drive motor system of vehicles other than Category-M₁ and Category-N₁ vehicles shall last for 30 seconds.

5.4.7 Salt spray

5.4.7.1 The salt spray resistance of the drive motor system shall be able to satisfy the relevant stipulations of 5.4.3.2 in GB/T 42284.4-2022, and the test period shall be no less than 48 hours.

5.4.7.2 In accordance with 6.5.7, carry out the test. The visual inspection of the drive motor system shall comply with the requirements of 5.1.2.

5.4.7.3 The retested insulation resistance shall comply with the stipulations of 5.1.4, and the retested sealing of the liquid cooling circuit shall comply with the stipulations of 5.1.3.

5.4.7.4 After returning to normal, the drive motor system shall be able to normally operate at peak torque and peak power at the rated voltage. The drive motor system of Category-M₁ and Category-N₁ vehicles shall last for 10 seconds. The drive motor system of vehicles other than Category-M₁ and Category-N₁ vehicles shall last for 30 seconds.

5.4.8 Ice water impact

5.4.8.1 When the DC bus terminal is de-energized and no coolant liquid is introduced to the cooling circuit, the drive motor system shall be able to withstand the ice water impact test specified in 5.3.2 and 5.3.3 in GB/T 42284.4-2022. Specifically speaking, carry out the splash test for 10 times and the immersion test once, and T_{\max} is selected to be 85 °C.

5.4.8.2 In accordance with 6.5.8, carry out the test. The retested insulation resistance shall comply with the stipulations of 5.1.4, and the retested sealing of the liquid cooling circuit shall comply with the stipulations of 5.1.3.

5.4.8.3 After returning to normal, the drive motor system shall be able to normally operate at peak torque and peak power at the rated voltage. The drive motor system of Category-M₁ and Category-N₁ vehicles shall last for 10 seconds. The drive motor system of vehicles other than Category-M₁ and Category-N₁ vehicles shall last for 30 seconds.

5.4.8.4 If the height of the lower surface of the drive motor system from the ground is not less than 300 mm, the immersion test in 5.3.3 of GB/T 42284.4-2022 does not need to be performed.

6.1.6 Signal shielding

When necessary, related signals shall be simulated or shielded through other methods.

6.2 Tests of General Items

6.2.1 General inspection

6.2.1.1 During the inspection, the drive motor system under test is not connected to high-voltage and low-voltage power supplies, no external loads are connected, and the power lines are not short-circuited.

6.2.1.2 Rotate the output shaft of the drive motor system and check for abnormal noise by listening.

6.2.2 Appearance inspection

Through visual inspection and touching, perform appearance inspection.

6.2.3 Cooling circuit sealing performance test of liquid cooling system

6.2.3.1 For the split drive motor system, the cooling circuits of the drive motor and the drive motor controller should be separated and respectively measured.

6.2.3.2 Before the test, the surface of the drive motor system shall not be coated with a coating that can prevent leakage, and chemical anti-corrosion treatment without sealing effect can be carried out.

6.2.3.3 During the test, the temperature of the test medium shall be consistent with the temperature of the test environment and maintain stable.

6.2.3.4 The medium used in the test can be gas or liquid. The gas medium should be dry, clean and oil-free compressed air, and other non-harmful gases. The liquid medium should be water containing rust inhibitor, kerosene or non-corrosive liquid with a viscosity no higher than water.

6.2.3.5 When using a gas medium for the test, the liquid in the circuit needs to be blown out and dried; one end of the cooling circuit of the sample under test is blocked, but deformation that may affect the sealing performance cannot be generated. Fill the circuit with the pressure test medium specified in 5.1.3, the pressure rise time shall not be greater than 15 seconds, and the pressure holding (equilibrium) time shall not be less than 1 minute. After disconnecting from the gas source, the pressure drop within 1 minute shall not be greater than 300 Pa.

6.2.3.6 When using a liquid medium for the test, the air in the cooling circuit cavity needs to be purged, and the test method shall comply with the product technical specifications.

6.2.3.7 After the test, reduce the test medium pressure to the pre-test level.

6.2.4 Test of insulation resistance

with B.1.2.

6.2.5.2 Voltage resistance test of integrated drive motor system

6.2.5.2.1 Before the test, each DC power terminal of the drive motor system shall be short-circuited, and each signal terminal shall be short-circuited.

6.2.5.2.2 During the voltage resistance test of the DC power terminal and the shell, and the DC power terminal and the controller signal terminal of the drive motor system, other terminals or components not participating in the test shall be connected to the shell, and the shell shall be grounded.

6.2.5.2.3 In accordance with the test voltage requirements in Table 1, set the test voltage. Carry out the test between the DC power terminal and the shell, and between the DC power terminal and the signal terminal of the drive motor system.

6.2.5.2.4 The full value test voltage specified in Table 1 is loaded between the DC bus terminal and the shell of the drive motor. During the loading process, the applied voltage shall start from not exceeding half of the full value of the test voltage, then, at a speed of not exceeding 5% of the full value, uniformly increase to the full value or in sections. The time for the voltage to increase from half value to full value shall not be less than 10 seconds, and the full value test voltage shall last for 1 minute.

6.2.5.2.5 After the test is completed, when the voltage drops to less than one-third of the full value, the power supply can be disconnected, and the capacitance among the tested winding, the power terminal and the shell can be discharged.

6.2.6 Overspeed test

6.2.6.1 The sample under test shall be run-in in accordance with the working conditions specified in the product technical specifications.

6.2.6.2 Before the test, the assembly quality of the drive motor, especially the rotating part, shall be carefully checked, and corresponding protective measures shall be taken to prevent debris or parts from flying out when the speed increases. For the integrated drive motor system with more than one gear, an appropriate gear shall be selected for the test.

6.2.6.3 The no-load rotation or prime mover (dynamometer) drag method can be selected for the drive motor under test in accordance with the specific circumstances:

- a) When adopting the method of no-load rotation for the drive motor under test, the drive motor under test, under the control of the drive motor controller, smoothly rotates to and maintains the test speed specified in 5.1.6. At this speed point, the no-load running time satisfies the stipulations of 5.1.6;
- b) When adopting the prime mover (dynamometer) drag method for the test, the drive motor under test is de-energized. Under the drag of the prime mover (dynamometer),

the drive motor rises to the test speed specified in 5.1.6 at a speed not exceeding 1,000 r/min per second and maintains. At this speed point, the no-load running time satisfies the stipulations of 5.1.6.

6.2.6.4 As the speed increases, when the drive motor reaches the peak speed, observe the motor operation and confirm that there are no abnormal phenomena, then, increase the speed at an appropriate speed, until reaching the specified speed.

6.2.6.5 After the test, reduce the speed of the drive motor under test at an appropriate speed, until it stops.

6.3 Test of Input & Output Characteristics

6.3.1 Preparation of bench test

6.3.1.1 The sample under test shall be run-in in accordance with the working conditions specified in the product technical specifications.

6.3.1.2 Confirm that all connections are correct and secure, and that the control functions of the dynamometer and the drive motor system under test are normal.

6.3.1.3 For the liquid cooling system, the liquid cooling inlet temperature of the drive motor system is 50 °C, the flow rate is set in accordance with the product technical specifications, and the working temperature of the drive motor system and transmission device lubricant is 50 °C; for other cooling modes, set the cooling conditions in accordance with the product technical specifications.

6.3.1.4 During measurement, the readings of each instrument shall be simultaneously read and recorded.

6.3.1.5 During measurement, the measurement point of voltage and current shall be at the drive motor controller close to the terminal. The working torque and speed of the drive motor should be directly measured at the shaft extension end of the drive motor. At this time, there shall be a rigid connection between the shaft extension end of the drive motor and the torque and speed measurement equipment.

6.3.1.6 For the drive motor system with more than one gear transmission device, each gear shall be respectively measured and recorded.

6.3.1.7 For the drive motor system with a transmission device, the test results of 5.2.2 ~ 5.2.9 are included in the efficiency and speed ratio of the transmission device and indicated in the report. The efficiency and speed ratio of the transmission device are provided by the manufacturer and serve as an attachment to the report.

6.3.2 Test of working voltage range

6.3.2.1 During the test, respectively set the DC bus voltage of the drive motor system at the highest working voltage and the lowest working voltage that satisfy the requirements of 5.2.1,

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