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Safety Requirements of Conductive Charging and Discharging for Electric Vehicles

电动汽车传导充放电安全要求

(ISO 17409:2020, Electrically Propelled Road Vehicles - Conductive Power Transfer - Safety Requirements, MOD)

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Safety Requirements of Conductive Charging and Discharging for Electric Vehicles

1 Scope

This document specifies the safety requirements for conductive charging and discharging of electric vehicles (hereinafter referred to as "vehicles") when they are conductively connected to an external electric power supply or external load.

This document is applicable to vehicles whose socket-outlets (connection mode B and connection mode C) comply with GB/T 20234.2 and / or GB/T 20234.3, and power supply plugs (connection mode A) comply with GB/T 1002 and / or GB/T 20234.2.

This document is applicable to vehicles with power supply circuit of Class B voltage and can be externally charged and discharged. Vehicles whose power supply circuit is Class A voltage may take this document as a reference in the implementation.

This document is applicable to charging mode 2, charging mode 3 and charging mode 4 defined in GB/T 18487.1-2023. For charging mode 4, this document is applicable to conductive charging with an isolated off-board charger.

NOTE 1: this document does not provide the requirements for charging mode 1.

NOTE 2: the external electric power supply does not belong to the vehicle.

This document is applicable to the on-board part of the vehicle power supply circuit, and also applies to the charging and discharging control function of the vehicles conductively connected to an external electric power supply or external load.

This document does not apply to general safety precautions for manufacturing, maintenance and repair personnel.

NOTE 3: for general safety requirements for the vehicles, see GB 18384.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the 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 1002 Single Phase Plugs and Socket-outlets for Household and Similar Purposes - Types, Basic Parameters and Dimensions

diagram of Scheme 2)

5.3.3 All exposed conductive parts of components on the vehicle power supply circuit shall be connected to the vehicle electric platform through protective conductors.

5.3.4 The cross-sectional area of the protective conductors shall be designed in accordance with GB/T 16895.3.

5.3.5 The protective conductors of the vehicle power supply circuit shall be designed based on relevant parameters (such as: fault current and breaking time), with consideration of the energy sources of the vehicle itself and external electric power supply.

5.3.6 The connection resistance of the protective conductors between the protective conductor contacts of the power supply plug (connection mode A) and the vehicle socket-outlet (connection mode B and connection mode C), and the vehicle electric platform, as well as between all exposed conductive parts on the vehicle power supply circuit, shall be less than 0.1 Ω, and shall be applicable to all conduction paths that function as protective conductor connections.

5.4 Insulation Resistance

5.4.1 AC connection

When the vehicle is not connected to an external electric power supply, the insulation resistance of the vehicle power supply circuit shall be not less than 500 Ω/V, and the measurement reference voltage shall be the maximum working voltage of the vehicle power supply circuit.

5.4.2 DC connection

5.4.2.1 When the vehicle is not connected to an external electric power supply, the insulation resistance of the on-board part of the vehicle power supply circuit shall comply with the requirements of GB 18384.

5.4.2.2 When the vehicle is connected to an off-board charger, the total insulation resistance of the vehicle power supply circuit shall be not less than 100 Ω/V. The safety requirements when the vehicle is connected to an external electric power supply shall comply with 8.1.

5.5 Requirements When Not Connected to External Electric Power Supply

5.5.1 General requirements

5.5.1.1 When the contacts of the power supply plug (connection mode A) and vehicle socket-outlet (connection mode B and connection mode C) are not connected to the external electric power supply and are in one of the following states, they shall satisfy the requirements of 5.5.3:

a) If the contacts cannot be touched by the probe 18 specified in GB/T 16842, then, within 10 s the contacts are disconnected from the conductive charging connection;

b) If the contacts comply with IPXXB specified in GB/T 30038, then, within 5 s the contacts are disconnected from the conductive charging connection;

c) If the contacts do not comply with IPXXB specified in GB/T 30038, then, within 1 s the contacts are disconnected from the conductive charging connection.

5.5.1.2 If the power supply plug (connection mode A) and the vehicle socket-outlet (connection mode B and connection mode C) are equipped with an electronic locking device, the vehicle shall be allowed to be unlocked after reaching the relevant thresholds specified in 5.5.2 and 5.5.3.

5.5.1.3 If the power supply plug (connection mode A) and the vehicle socket-outlet (connection mode B and connection mode C) are not equipped with an electronic locking device, when the contacts are not connected to the external electric power supply and are in one of the following states, they shall satisfy the requirements of 5.5.2:

a) If the contacts cannot be touched by the probe 18 specified in GB/T 16842, then, within 10 s the contacts are disconnected from the conductive charging connection;

b) If the contacts comply with IPXXB specified in GB/T 30038, then, within 5 s the contacts are disconnected from the conductive charging connection;

c) If the contacts do not comply with IPXXB specified in GB/T 30038, then, within 1 s the contacts are disconnected from the conductive charging connection.

NOTE 1: if the contacts comply with IPXXD, then, they shall be deemed to comply with IPXXB.

NOTE 2: the locking device is usually located on the vehicle or external electrical equipment.

5.5.2 Normal operation

5.5.2.1 When the contacts of the power supply plug (connection mode A) and the vehicle socket-outlet (connection mode B and connection mode C) are not connected to the external electric power supply, they shall at least satisfy the following requirements:

a) The contacts shall comply with IPXXD specified in GB/T 30038;

b) When they do not comply with IPXXD specified in GB/T 30038, the voltage between the contacts and any other contact, and between the contacts and the electric platform shall be less than DC 60 V and AC 30 V;

c) When they do not comply with IPXXD specified in GB/T 30038, the steady-state touch current between the contacts and any other contact, and between the contacts and the electric platform shall be less than AC 0.5 mA and DC 2 mA, and the electric energy stored between the contacts and any other contact, as well as between the contacts and the electric platform, shall not trigger a startle reaction. The limits are specified by the manufacturer with reference to GB/T 13870 (all parts).

NOTE 1: GB/T 17045 and GB/T 13870.1 provide the steady-state touch current threshold.

NOTE 2: independent of the electric energy stored in the on-board power supply (for example, a rechargeable energy storage system), the touch current touching this electric energy is limited by a sufficiently high protective impedance.

NOTE 3: GB/T 13870.2 provides the stipulations for perception threshold and pain threshold.

NOTE 4: GB/T 13870.2 provides the specified charge or specified electric energy for the pain threshold. The specified electric energy provided by GB/T 13870.2 may not be relevant to the fault type of the socket-outlet.

5.5.2.2 If it can be proven through design review that there is no conductive path from the on-board power supply (for example, a rechargeable energy storage system) to the accessible conductor part, then, it can be regarded as satisfying the requirements for steady-state touch current.

5.5.3 Operation under single-point failure condition

5.5.3.1 Under the condition of single-point failure, when the contacts of the power supply plug (connection mode A) and the vehicle socket-outlet (connection mode B and connection mode C) are not connected to the external electric power supply, they shall satisfy at least one of the following requirements:

a) The contacts shall comply with IPXXD specified in GB/T 30038;

b) When they do not comply with IPXXD specified in GB/T 30038, the voltage between the contacts and any other contact, and between the contacts and the electric platform shall be less than DC 60 V and AC 30 V;

NOTE 1: a power outage will generate the same voltage levels as under normal operating conditions. Different thresholds are independent of single-point failure situations.

c) When they do not comply with IPXXD specified in GB/T 30038, the steady-state touch current between the contacts and any other contact, and between the contacts and the electric platform shall be less than AC 3.5 mA and DC 10 mA, and the electric energy stored between the contacts and any other contact, and between the contacts and the electric platform shall not trigger strong involuntary muscle reactions. The limits are specified by the manufacturer with reference to GB/T 13870 (all parts).

NOTE 2: GB/T 17045 and GB/T 13870.1 provide the steady-state touch current threshold.

NOTE 3: independent of the electric energy stored in the on-board power supply (for example, a rechargeable energy storage system), the touch current touching this electric energy is limited by a sufficiently high protective impedance.

5.5.3.2 If it can be proven through design review that there is no conductive path from the on-board power supply (for example, a rechargeable energy storage system) to the accessible

in 11.3 of GB/T 18487.1-2023.

6 Requirements for Thermal Accident Protection

6.1 Requirements under Normal Operating Conditions

6.1.1 The cross-sectional area of the live part of the vehicle power supply circuit, as well as the rated current of the power supply plug (connection mode A), and the vehicle socket-outlet (connection mode B and connection mode C) shall comply with the maximum current that the vehicle power supply circuit can carry under normal operating conditions.

6.1.2 For DC conductive charging, when considering the maximum ambient temperature of the vehicle, if the temperature limit specified in 8.6 is not exceed, and overheating protection is provided to prevent the vehicle power supply circuit from exceeding the temperature limit, the cross-sectional area of the live parts can be reduced.

6.1.3 Appropriate measures may be taken to monitor and control the temperature of the vehicle power supply circuit. Under the condition that the DC contact temperature complies with the stipulations of 8.6 and the temperature of other on-board parts of the vehicle power supply circuit complies with the vehicle manufacturer’s regulations, the vehicle charging current can be greater than the continuous maximum charging current value of the vehicle socket-outlet and other on-board parts of the vehicle power supply circuit.

6.2 Overcurrent Protection

6.2.1 General rules

6.2.1.1 The vehicle power supply circuit shall have measures to prevent thermal accidents caused by the following situations:

---overload.

---short circuit.

6.2.1.2 Different overcurrent protection methods can be adopted for different circuit parts.

NOTE 1: overcurrent protection is not regarded as a method of detecting and interrupting series or parallel arcs. Arcing may cause injury. Appropriate measures to address arcing problems include maintenance, pollution levels, insulation, clearances, creepage distances and other modes.

NOTE 2: the rated current of the external electric power supply may be greater than the rated current of the on-board part of the vehicle power supply circuit.

6.2.2 Overload protection

The vehicle shall provide overload protection to prevent the charging current from exceeding

the continuous maximum charging current value of the vehicle power supply circuit or the temperature from exceeding the temperature limit of the vehicle power supply circuit.

NOTE: overload protection methods include, but are not limited to, overload monitoring and contactor disconnection functions.

6.2.3 Short-circuit protection of AC connection

6.2.3.1 For short-circuit currents generated by the external electric power supply, one of the following requirements shall be satisfied.

a) In accordance with the overcurrent protection characteristics of the external electric power supply, the cross-sectional area of the live conductor of the vehicle power supply circuit has a certain short-circuit current tolerance capacity value (I^2t). The short-circuit current tolerance capacity value (I^2t) of the vehicle power supply circuit is not less than 80,000 A^2s. The short-circuit current tolerance capacity value (I^2t) is calculated in accordance with GB/T 16895.5-2012.

NOTE: overcurrent protection has a breaking time of up to 5 seconds (see GB/T 16895.21).

b) Each live conductor of the vehicle power supply circuit is provided with overcurrent protection (such as: fuse and circuit breaker). The live conductor protected by the overcurrent protection device has a sufficient cross-sectional area to carry the overcurrent value corresponding to the overcurrent protection characteristic. The cross-sectional area of the live conductor between the vehicle socket-outlet and the overcurrent protection device satisfies a).

c) The on-board charger provides an overcurrent protection device (for example, fuse or circuit breaker) on each live conductor of the vehicle power supply circuit. The live conductor between the vehicle socket-outlet and the overcurrent protection device has a sufficient cross-sectional area to carry the overcurrent value corresponding to the overcurrent protection characteristic. The on-board part of the vehicle power supply circuit between the vehicle socket-outlet and the overcurrent protection device can prevent mechanical damage, so that no insulation fault occurs between live conductors, and between live conductor and the electric platform due to single-point failure.

6.2.3.2 The vehicle shall provide short-circuit protection against short-circuit currents generated by the vehicle's power supply.

6.2.4 Short-circuit protection of DC connection

6.2.4.1 Short-circuit electric energy generated by external electric power supply

For short-circuit currents generated by the external electric power supply, the following short-circuit protection requirements shall be satisfied.

a) The short-circuit current tolerance capacity value (I^2t) of the vehicle power supply circuit is greater than 1,000,000 A^2s. The minimum cross-sectional area of the live conductor is calculated in accordance with Formula (3) of GB/T 16895.5-2012.

NOTE: the short-circuit current tolerance capacity value (I^2t) corresponds to the characteristics of the overcurrent protection device of the external electric power supply. The provided short-circuit current tolerance capacity value is coordinated with NB/T 33001-2018.

b) The vehicle power supply circuit provides an overcurrent protection device (for example, fuse or circuit breaker). The cross-sectional area of the live conductor protected by the overcurrent protection device complies with the short-circuit current breaking capacity of the overcurrent protection device. The cross-sectional area of the live conductor between the vehicle socket-outlet and the overcurrent protection device complies with the requirements of a). The short-circuit current breaking time is obtained from the table of technical parameters of the overcurrent protection device.

6.2.4.2 Short-circuit current generated by vehicle power supply

6.2.4.2.1 The vehicle shall provide overcurrent protection for the vehicle power supply circuit and the external power circuit. The overcurrent protection shall satisfy the following requirements:

a) The cut-off current generated by the on-board power supply at the vehicle socket-outlet contact is not greater than 30 kA;

b) The vehicle cuts off the short-circuit current from the vehicle to the external electric power supply within 1 second after the short-circuit occurs;

c) The I^2t at the vehicle socket-outlet contact is not greater than 5,000,000 A^2s.

6.2.4.2.2 The cross-sectional area of the live conductor between the overcurrent protection device and the vehicle socket-outlet shall comply with the short-circuit current breaking capacity of the overcurrent protection device.

6.2.4.2.3 The minimum cross-sectional area of the live conductor shall be calculated in accordance with Formula (3) of GB/T 16895.5-2012.

6.3 Arc Protection of DC Connection

The locking function of the charging interface can achieve arc protection of DC connection. See 8.5 for interface locking.

6.4 Remaining Power after Disconnection

Within 1 second after the vehicle is disconnected from the external electric power supply, the electric energy stored in Class B voltage live parts of the power supply plug (connection mode A) and vehicle socket-outlet (connection mode B and connection mode C) shall be less than 20 J.

current of the vehicle is not greater than 8 A.

NOTE: in accordance with Appendix A of GB/T 18487.1-2023, if the vehicle charging current exceeds the maximum power supply current corresponding to the PWM signal, the electric vehicle power transmission equipment may cut off the output power supply.

7.2.1.2 The maximum allowable charging current of the cable assembly in charging mode 2 using a standard power supply plug should be 8 A.

7.2.2 Surge current

7.2.2.1 The vehicle shall limit the following surge currents from entering the vehicle power supply circuit.

a) Event 1: the peak supply voltage that occurs after the electric vehicle power transmission equipment closes the contactor. The peak current of each live conductor within 100 μs does not exceed 230 A. After 100 μs, till the occurrence of Event 2, the current decreases and does not exceed the limit of Event 2.

NOTE 1: the maximum surge current value of Event 1 is coordinated with the switching device of the electric vehicle power transmission equipment to avoid sticking.

NOTE 2: The requirements of 100 μs and 230 A are the limits adopted by IEC 61851-1 and IEC 62752.

b) Event 2: during the pre-charge period of the capacitor in the charger, the current of each live conductor does not exceed 30 A (rms). The absolute value of the current peak value does not exceed 42.4 A. When complying with the requirements of GB/T 17625.2 or GB/T 17625.7, the peak current value may exceed 42.4 A. Event 2 does not exceed 1 s.

NOTE 3: Event 2 surge current is limited to avoid tripping of the miniature circuit breaker (MCB). The current value of 30 A (rms) corresponds to Type B MCB with a rated current of 10 A specified in GB/T 10963.1.

NOTE 4: surge current is generated by the following two phenomena: during Event 1, the surge current is generated by the EMC filter upstream of the charger power module; during Event 2, the surge current is generated by the capacitor of the DC circuit on the charger power module.

7.2.2.2 Event 2 does not need to follow Event 1.

7.3 Power Factor

7.3.1 The power factor of the vehicle at rated power shall not be lower than 0.95.

7.3.2 The power factor of the vehicle in the entire power range shall not be lower than 0.9, unless the actual power is less than 5% of the rated power, or less than 300 W, whichever is

greater.

7.3.3 Compliance test can be performed at the complete-vehicle level or component level. When testing at the component level, a resistive load shall be connected within the operating power range of the test object for testing.

NOTE: generally speaking, the component-level test only considers the defined operating power point of the complete-vehicle.

7.4 Interlock Function of Vehicle Interface

7.4.1 The connection confirmation circuit shall provide an interlock function. Within 100 ms after the S3 switch in the connection confirmation circuit is disconnected, the vehicle shall stop charging and the current passing through the vehicle interface shall be reduced to not greater than 1 A.

7.4.2 When the vehicle charging current is greater than 16 A, the electronic locking device of the vehicle socket-outlet shall provide a locking function.

7.5 Phase Sequence of Three-phase Charging

When a vehicle can be charged with three phases, the vehicle shall be able to normally operate under the following conditions:

---When the vehicle is connected to an external electric power supply with clockwise phase sequence (L1–L2–L3);

---When the vehicle is connected to an external electric power supply with counterclockwise phase sequence (L1–L3–L2).

8 Additional Requirements for DC Charging

8.1 General Requirements

8.1.1 The on-board part of the vehicle power supply circuit shall satisfy the following optional protective measures, and the following measures shall provide basic protection and fault protection:

---Double insulation or reinforced insulation;

---Basic protection and shielding or enclosure;

---Basic protection and conductive shielding or enclosure with equipotential bonding;

---Rigid shielding or enclosure with sufficient mechanical strength and durability within the lifetime of the vehicle;

---Other measures or mechanisms that can provide adequate protection against electric

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