Attachment 111

TECHNICAL STANDARD FOR PROTECTION OF OCCUPANTS AGAINST HIGH VOLTAGE AFTER COLLISION IN ELECTRIC VEHICLES, HYBRID ELECTRIC VEHICLES AND FUEL CELL VEHICLES

1. Scope

This Technical Standard shall apply to the power train, battery module for motor and battery pack for motor of motor vehicles equipped with an engine operated by the electrical power (except motor cycles with or without sidecar, three-wheeled motor vehicles, mini-sized motor vehicles with caterpillar tracks and sleds, large-sized special motor vehicles, small-sized special motor vehicles and trailers).

2. Definitions

In addition to the definitions described in Article 1 of the Safety Regulations and Article 2 of the Announcement That Prescribes Details of Safety Regulations for Road Vehicles, the definition of terms prescribed in this Technical Standard shall be defined in Paragraphs 2–1 through 2–19 given below:

2–1 "Power train" is an electric circuit containing the following items in paragraphs 2–1–1 through 2–1–4 and 2–18. The coupling system for charging shall not be included in the power train.

2–1–1 the battery for motor

2–1–2 Electronic converter (It means a device capable of controlling or converting electric power, such as electronic controller for drive motor and DC/DC converter)

2–1–3 the traction motor and associated wire harness, connector, etc.

2–1–4 auxiliary devices related to running (e.g., heater, defroster, power steering, etc.)

2–2 "Battery for motor" is an electrical power storage unit and its aggregate that are connected electrically for the purpose of supplying electric power related to the driving.

2–3 "Battery module for motor" is the smallest single energy storage consisting of one cell or an assembly of cells, electrically connected in series or

in parallel, placed in one container and mechanically associated.

2–4 "Battery pack for motor" is a single mechanical assembly comprising battery modules for motor and retaining frames or trays and cases.

2–5 "Coupling system for charging" is an electric circuit used primarily to charge the battery for motor by connecting to an external electric power supply, which is insulated galvanically from the power train by the contactor switching the electric circuit, insulating transformer, etc., except when the connection is made to the external power supply, and which contains the following items in Paragraphs 2–5–1 to 2–5–3:

2–5–1 the vehicle inlet (referring to the section on the vehicle's side for connecting to an external power supply);

2–5–2 the wiring harness, connectors, etc. between the vehicle inlet and the power train circuit; and

2–5–3 the electrical circuit that is galvanically connected to the electrical circuits of Paragraphs 2–5–1 and 2–5–2.

2–6 "External power supply" is an AC or DC power supply outside of the vehicle.

2–7 "Passenger compartment" is a space for occupant accommodation, bounded by the roof, floor, side walls, doors, window glass, front bulkhead and rear bulkhead, or rear gate, as well as by the barrier and enclosure provided for protecting the power train from direct contact with live parts.

2–8 "Direct contact" means the contact between the human body and live parts.

2–9 The "energized components" are conductive parts which purpose is to transmit electric current during normal applications.

2–10 "Indirect contact" means the contact between the human body and exposed conductive parts.

2–11 "Protection class IPXXB" means that defined in Attached Sheet 1 "Protection Against Direct Contact with Energized Components."

2–12 "Exposed conductive parts" are conductive parts that do not normally conduct electricity, but may do so at the time of insulation failure, and that can be contacted easily without using tools. In this case, it shall be judged whether parts can be contacted easily or not, by the confirmation method as to whether

the construction of protection class IPXXB is provided or not.

2–13 "Electrical circuit" is an aggregate of what connected to live parts, which designed that the electric current can flow during normal operation.

2–14 "Working voltage" is the maximum potential difference, specified by the manufacturer, that might possibly arise between all conductive elements during normal operation or when the circuit is released.

2–15 "Electrical chassis" is an aggregate of conductive parts that have been electrically connected to each other, which potential is regarded as the standard.

2–16 "Barrier" is parts so as to protect from live parts against contacts by all conceivable directions of approach.

2–17 "Enclosure" is parts established to enclose internal units and protect against contact from all directions.

2–18 "Electrical energy conversion system" is a system, such as fuel cell stack, that generates and provides electrical energy for electrical propulsion.

2–19 "High voltage" means the working voltage exceeding DC 60V, but 1,500V or less, or exceeding AC 30V (effective value), but 1,000V (effective value) or less.

3. Requirements for Rear-End Collision

Ordinary-sized motor vehicles or small-sized motor vehicles, or mini-sized motor vehicles for passenger use wholly (except motor vehicles with a passenger capacity more than 11 persons and motor vehicles with a gross vehicle weight exceeding 2.8 tons) shall be subjected to tests according to the method of Paragraph 3–1 and Attached Sheet 2 "Collision Test Method," and shall comply with requirements of Paragraph 4. However, this provision shall not apply if no power train exists rearward from the centre of farthest axles.

3–1 Test method

The test method shall be the one prescribed in Agreement Regulation No. 34 (limited only to Annex 4 of Supplement 1 to the 03 series of amendments of the said Regulation) or the one prescribed in Paragraph 3–2 (except the provisions of Paragraphs 3–1–2–4 and 3–1–2–6 through 3–1–2–8 as well as the provision after the phrase "Also," in 3–2–4 that apply mutatis mutandis in Paragraph 3–2–3) of Attachment 17 "Technical Standard for Prevention of Fuel Leakage in Collisions, etc." In this case, the phrase "As for those parts mounted on the test vehicle, it is permissible to use those other than genuine parts or to

remove them, except for those parts with the possibility of interfering with the fuel tank and fuel line" appearing in Paragraph 3–1–2–2 of the same Attachment that applies mutatis mutandis in Paragraph 3–2–3 of the same Attachment shall read as "As for those parts that are unlikely to affect the test results among the parts mounted on the test vehicle, it is permissible to use those other than genuine parts or to remove them"; the phrase "shall be used as substitute gas." in Paragraph 3–1–2–3 of the same Attachment that applies mutatis mutandis in Paragraph 3–2–3 of the same Attachment as "shall be used as substitute gas. In this case, it shall be allowed to modify the fuel system so that an appropriate amount of fuel can be used to run the engine or the electrical energy conversion system."; and the phrase "It is permissible for systems other than the fuel tank and fuel lines to be empty." in Paragraph 3–1–2–5 of the same Attachment that applies mutatis mutandis in Paragraph 3–2–3 of the same Attachment as "Liquids, such as oil, may be drained."

Main text: Provision after "Also" in Paragraph 3–2–4

4. Criteria

Following the tests conducted in accordance with Paragraphs 3 have been conducted, the requirements prescribed in Paragraphs 4–1 to 4–3 shall be met in any case.

4–1 Requirements for electrolyte spillage of battery module for motor

In the period of 30 minutes after the impact test, no electrolyte from the battery module for motor shall spill into the passenger compartment. Moreover, no more than 7% of the total electrolyte volume shall spill from the battery module for motor to the vehicle exterior, except open type batteries for motor outside the passenger compartment (referring to a liquid type of battery requiring liquid and generating hydrogen gas released to the atmosphere. Hereinafter the same.). For open type batteries for motor, no more than 7% of the total electrolyte volume with a maximum of 5.0 liters shall spill outside the passenger compartment.

Appropriate coating may be applied, if necessary, to the cover protecting the battery module for motor in order to confirm any electrolyte leakage from the battery module for motor after the impact test.

Unless the motor vehicle manufacturer, etc. provides means to differentiate between the leakage of different liquids other than the electrolyte, all liquid leakage shall be considered as the electrolyte.

4–2 Requirements for retention of battery module for motor

The battery module for motor located inside the passenger compartment shall remain in the designated position. In this case, for the construction in which the battery module for motor is installed in the battery pack for motor the battery pack for motor shall be retained.

No part of any battery module for motor that is located outside the passenger compartment shall enter the passenger compartment after the impact test.

4–3 Requirements for protection against electric shock

After the impact test, at least one of the requirements specified in Paragraphs 4–3–1 through 4–3–4 shall be met.

If the test vehicle has an automatic disconnect function or device(s) that galvanically divide the power train during the driving condition, at least one of the following criteria shall apply to the disconnected circuit or to each divided circuit individually after the disconnect function is activated.

However, the criteria defined in Paragraph 4–3–4 shall not apply if more than a part of the high voltage bus having different potentials is not protected under the protection class IPXXB.

In cases where the impact test is performed under the condition that the high voltage circuit is not energized, the protection against electric shock shall satisfy either Paragraph 4–3–3 or Paragraph 4–3–4 for the relevant parts.

4–3–1 Absence of high voltage

When the voltage (V_b, V_1 and V_2) of the high voltage buses is measured at a point in time between 5 seconds and 60 seconds after the impact test, the voltage shall be equal to or less than DC 60V or AC 30V (effective value). (See the figure below.)

However, this provision shall not be applicable if the impact test is performed under the condition where the high voltage bus is not energized.

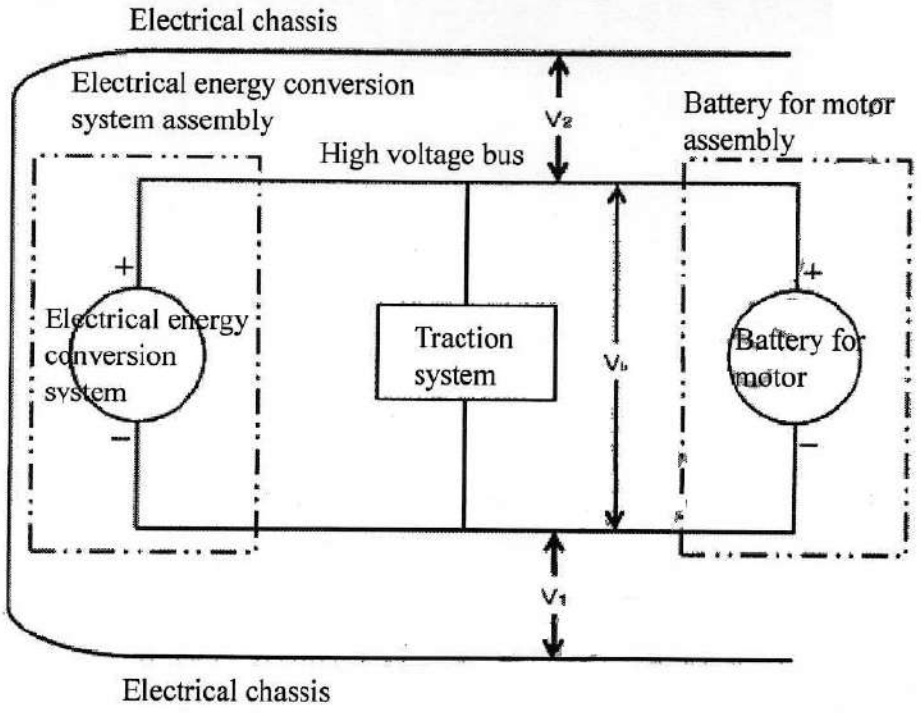


Fig. Measurement of V_b, V_1 and V_2

4–3–2 Low electrical energy

The total energy (TE) on the high voltage buses shall be less than 2.0 joules when measured according to the test procedure as specified in Attached Sheet 4. The total energy may be calculated by the measured voltage V_b of the high voltage bus and the capacitance of the X-capacitors (C_x) specified by the motor vehicle manufacturer, etc.

The energy stored in the Y-capacitors (TE_{y1}, TE_{y2}) shall also be less than 2.0 joules. The energy stored in the Y-capacitors may be calculated by measuring the voltages V_1 and V_2 between the high voltage bus and the electrical chassis, as well as the capacitance of the Y-capacitors (C_{y1}, C_{y2}) specified by the motor vehicle manufacturer, etc.

4–3–3 Protection against contact

The protection against direct contact with live parts of the high voltage buses shall satisfy the protection class IPXXB when verified by the test procedure provided for in Attached Sheet 1.

The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 ohm when there is current flow of at least 0.2A.

However, the said resistance shall be regarded as being less than 0.1 ohm in the case of welding.

4–3–4 Isolation resistance

The isolation resistance shall meet the following requirements when measured in accordance with the test procedure provided for in Attached Sheet 3.

4–3–4–1 Power train consisting of separate DC- and AC-buses

If the DC high voltage buses and the AC high voltage buses are galvanically isolated from each other, the isolation resistance between the high voltage bus and the electrical chassis (R) shall have a minimum value of 100 Ω/V of the working voltage for the DC buses, and a minimum value of 500 Ω/V of the working voltage for the AC buses.

4–3–4–2 Power train consisting of combined DC- and AC-buses

If the DC high voltage buses and the AC high voltage buses are galvanically connected to each other, the isolation resistance (R_i) shall have a minimum value of 500 Ω/V of the working voltage.

However, if the protection class IPXXB is satisfied for all AC high voltage buses or the AC voltage is equal to or less than 30V (effective value) after the vehicle impact, the isolation resistance (R_i) between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage.

5. Requirements for Installation Position of Battery Pack for Motor and Electrical Circuit

5–1 Distance from front edge of vehicle

The battery pack for motor and electrical circuit of the power train having a section whose working voltage is more than DC 60V or AC 30V (effective value) (except the section whose working voltage is equal to or less than DC 60V or AC 30V (effective value) and which is thoroughly insulated from the sections whose working voltage is more than DC 60V or AC 30V (effective value), and whose pole at one side, either positive or negative, is connected to the electrical chassis galvanically) shall be mounted at a position where the horizontal distance parallel to the centre line of the vehicle from the foremost edge to the front edge of the motor vehicle is more than 420 mm. However, this provision shall not apply to battery packs for motor and electrical circuits of the

power train mounted at a height exceeding 800 mm above the ground.

5–2 Distance from rear edge of vehicle

The battery pack for motor and electrical circuit of the power train having a section whose working voltage is more than DC 60V or AC 30V (effective value) (except the section whose working voltage is equal to or less than DC 60V or AC 30V (effective value) and which is thoroughly insulated from the section whose working voltage is more than DC 60V or AC 30V (effective value), and whose pole at one side, either positive or negative, is connected to the electrical chassis galvanically) shall be mounted at a position where the horizontal distance parallel to the centre line of the vehicle from the rearmost edge to the rear edge of the motor vehicle is more than 300 mm. However, this provision shall not apply to battery packs for motor and electrical circuits of the power train mounted at a height exceeding 800 mm above the ground.

6. Requirements for Strength at Battery Pack for Motor Installation Section

6–1 Strength against acceleration in direction parallel to centerline of vehicle.

The battery pack for motor installed section shall not be broken due to the acceleration in a direction parallel to the centerline of the vehicle enumerated in Paragraphs 6–1–1 through 6–1–3 below according to the kind of the motor vehicle under a condition that the battery pack for motor is installed. In this case, the compliance with the requirement for acceleration may be proven by the calculation.

Moreover, the requirement of this Paragraph shall not apply to motor vehicles subjected to the application of Paragraph 3 and those which comply with Paragraph 7–2 after completion of the test of Attachment 17 "Technical Standard for Fuel Leakage in Collisions, etc."

6–1–1 Motor vehicles for passenger use wholly with a passenger capacity of 10 persons or less or motor vehicles for transport of the freight with a gross vehicle weight of less than 3.5 tons: ±196 m/s2

6–1–2 Motor vehicles for passengers use wholly with a passenger capacity more than 11 persons and with a gross vehicle weight of less than 5 tons or motor vehicles for transport of the freight with a gross vehicle weight more than 3.5 tons and less than 12 tons: ±98 m/s2

6–1–3 Motor vehicles for passengers use wholly with a passenger capacity of more than 11 persons and with a gross vehicle weight of more than 5 tons, or motor vehicles for transport of the freight with a gross vehicle weight of more than 12 tons: ±64.7 m/s2

6–2 Strength against acceleration in direction perpendicular to vehicle centerline

The battery pack for motor installed section shall not be broken due to the acceleration in a horizontal direction perpendicular vehicle centerline enumerated in Paragraphs 6–2–1 and 6–2–2 below according to the kind of the motor vehicle. In this case, the compliance with the requirement for acceleration may be proven by the calculation.

Moreover, the requirement of this Paragraph shall not apply to motor vehicles subjected to the application of Paragraph 6 and those which comply with Paragraph 7–2 after completion of the test of Attachment 24 "Technical Standard for the Protection of the Occupants in the Event of A Lateral Collision."

6–2–1 Motor vehicles for passengers use wholly with a passenger capacity of 9 persons or less or motor vehicles for transport of the freight with a gross vehicle weight of less than 3.5 tons: ±78.4 m/s2

6–2–2 Motor vehicles for passengers use wholly with a passenger capacity of more than 10 persons, or motor vehicles for transport of the fright with a gross vehicle weight of more than 3.5 tons: ±49 m/s2

Attached Sheet 1

PROTECTION AGAINST DIRECT CONTACT WITH LIVE PARTS

1. General Provisions

"Protection class IPXXB" against direct contact with live parts shall be prescribed in this Attached Sheet. Furthermore, this Attached Sheet shall apply to the power train which working voltage does not exceed AC 1000V and DC 1500V.

Moreover, in this Attached Sheet, the sections described in Paragraphs 1–1 and 1–2 below shall be regarded as the "live parts" as well as live parts provided for in Paragraph 2–9 of the main text.

1–1 Live parts that are protected only by varnish or paint;

However, it's not necessarily this requirement to those where varnish or paint has been used for the purpose of insulation.

1–2 Live parts that are protected through oxidation treatment or similar treatment.

2. Test Conditions

The test vehicle shall be, in principle, in a state immediately after the collision test.

2–1 Proximity probe, etc.

2–1–1 As regards the proximity probe to be used for the confirmation of protection class, those prescribed in Table 1 shall be used.

2–1–2 In checking for the presence/absence of contact between the proximity probe and live parts inside the barrier, enclosure, etc., using the signal display circuit method, the lamp which suit to a low-voltage power supply (more than 40V, but not exceeding 50V) is connected in series between the proximity probe and live parts.

2–1–3 In the case of the signal display circuit method, prior to the collision test, sections provided for in Paragraphs 1–1 and 1–2 above shall be covered with electroconductive metal foil and the said metal foil shall be connected electrically to regular live parts.

3. Test Methods

3–1 Using the force prescribed in the "Test force" column of Table 1. the proximity probe is pressed against the opening (It means a gap or opening of the barrier, enclosure, etc. that already exists or can appear whenever the proximity probe is pressed at the prescribed force) of the barrier, enclosure, etc.

3–2 If it is possible, the moveable parts in the enclosure are operated slowly.

3–3 When the proximity probe is invaded in whole or in part, it shall be pressed to all sections where there is the possibility of contact and checked whether it contact or not. (In the case of the signal display circuit method, the illumination condition of the lamp shall be confirmed (hereinafter the same in this Attached Sheet).). In this case, the indirect test indicator is in straight state and the test begins. Both joints must be bent sequentially until they are 90° against the axis of the joint where the indirect test indicator adjoin each other. Then, those which shall be confirmed whether they contact or not to all sections have possibility of contact.

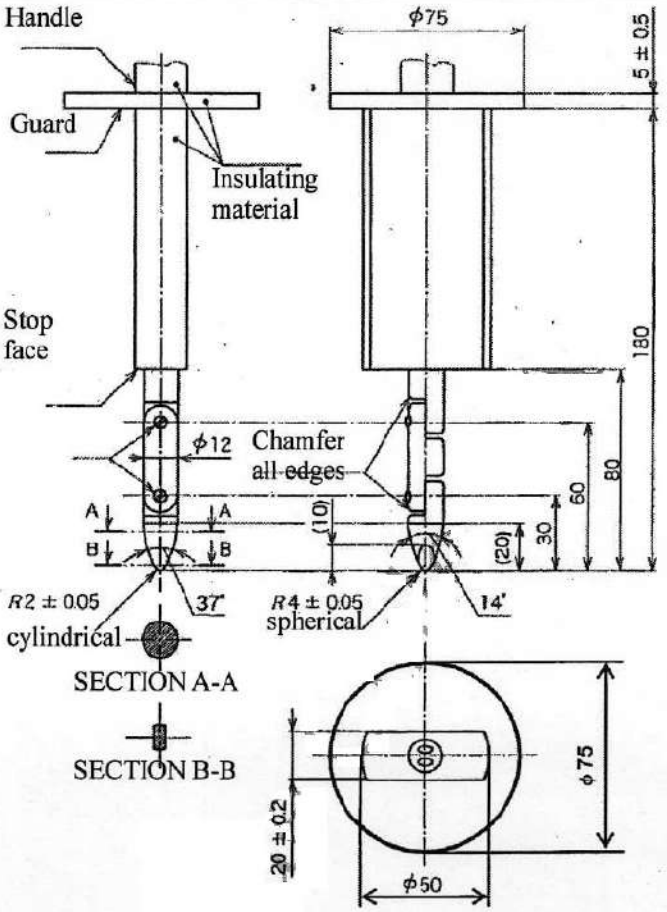
4. Assessment Criteria

4–1 The proximity probe must not contact live parts.

4–2 The end surface of the proximity probe must not be fully invaded through the opening of the barrier, enclosure, etc.

4–3 In conducting the confirmation using the signal display circuit method, the lamp must not turn on.

Table 1 – Access Probe

	Access probe	Test force
When test is conducted for protection degree IPXXB	 Material: metal except where otherwise specified Linear dimensions in millimeters Tolerances on dimensions without specific tolerance: on angles, 0/-10' on linear dimensions: up to 25 mm: 0/-0.05 over 25 mm:+/- 0.2 Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to +10° tolerance.	10N±10%

Attached Sheet 2

COLLISION TEST METHOD

The collision test shall be conducted in the following method.

1. Definitions of Terms

In addition to the definitions described in Article 1 of the Safety Regulations and Article 2 of the Announcement That Prescribes Details of Safety Regulations for Road Vehicles, the terms appearing in this Attached Sheet shall be defined in Paragraphs 1–1 through 1–4 given below:

1–1 "Electrical circuit at the battery for motor side" means a section including the battery for motor of the electrical circuit of the power train that is shut off by the automatic shut-off device.

1–2 "Electrical circuit at traction motor side" means a section including the traction motor of the electrical circuit of the power train that is shut off by the automatic shut-off device.

1–3 "Electrical circuit at the electrical energy conversion system" means a section including the electrical energy conversion system of the power train separated by the automatic disconnect device.

1–4 "Automatic disconnect device" means a mechanism that separates the electrical circuit at the battery for motor side or the electrical circuit at the electrical energy conversion system from the electrical circuit at the traction motor side when an impact at the time of the collision is detected.

2. Test Conditions for Collision Test

2–1 Test vehicle

The test vehicle shall be in the following conditions.

2–1–1 The engine shall be in a stopped state.

2–1–2 The shift position of the transmission shall be the neutral position.

2–1–3 The air inflation pressure of the tyres shall be set to the air inflation pressure described in the Specification Table.

2–1–4 The battery for motor shall be charged to a condition that it functions normally. Moreover, in the case of an open type battery for motor, electrolyte

shall be replenished to the specified maximum level.

2–1–5 After clarifying the operating principle of an electronic converter, it is possible to perform the collision test under a condition that the operation of the said converter is stopped. In this case, as measures, make the electronic converter shall be in stopped state and modification necessary for the measurement may be carried out, such as change in software.

2–1–6 In cases where an automatic shut-off device is provided, the collision test shall be conducted in the procedure given in Paragraph 2–1–6–1 or 2–1–6–2.

2–1–6–1 The automatic shut-off device shall operate normally at the time of the collision, and the collision test shall be conducted with the said device connected.

2–1–6–2 The collision test shall be conducted under a condition that the automatic disconnect device shuts off the battery for motor or the electrical energy conversion system. In this case, when the collision test is conducted, the operating principle of the said device shall be clarified in advance, and it shall be proved that the alternative characteristics (such as airbag deployment signals) indicating that the said device operates normally.

2–1–7 If it is necessary, the test vehicle shall be equipped with a brake system, etc. for measuring the amount of the electrolyte leakage from the battery module for motor immediately after the collision.

2–1–8 If necessary, measures shown in Paragraphs 2–1–8–1 and 2–1–8–2 shall be taken.

2–1–8–1 Appropriate paint, etc. shall be applied to the barrier and enclosure in order to confirm whether or not the electrolyte is leaking from the battery module for motor after the collision.

2–1–8–2 Add color to other aggregates (such as substitute liquid of oil and fuel) so that the electrolyte and other aggregates can be classified or separated.

2–1–9 In cases where the measured values are not stable due to the operation of the insulation resistance drop monitor, etc., necessary modification for conducting the measurement may be carried out, such as stopping of the device operation or removing of the said device. Furthermore, when the said device is removed, it must be proven, using drawings, etc., that it will not change the insulation resistance between live parts and the electrical chassis.

2–2 Test speed

2–2–1 When a motor vehicle after used for the test has been conducted at a speed exceeding the specified speed, complies with the requirements, the motor vehicle shall be regarded as complying with the requirements.

2–3 Equipment for rear-end collision test

The equipment to be used for and rear-end collision test shall be as follows:

2–3–1 Impactor

The thickness of a plywood board to be installed to the front of an impactor shall be 20±2 mm.

2–3–2 Speed measuring equipment

2–3–2–1 The speed measuring equipment shall be capable of measuring the time required for the test vehicle or impactor to pass the speed measuring zone in a unit of 0.1 ms or less. Moreover, when the speed converted from the passing time is measured by the unit of km/h, the indication shall be made down to the first decimal place.

2–3–2–2 The speed measuring equipment shall be mounted at a position immediately before the impactor collides against the test vehicle.

Attached Sheet 3

ISOLATION RESISTANCE MEASUREMENT METHOD

The isolation resistance between the high voltage bus and the electrical chassis shall be determined either by a method in which the isolation resistance is measured using an isolation resistance test instrument capable of applying a DC voltage higher than the working voltage of the electric bus of the power train or by a method in which the isolation resistance is determined by calculation after measuring the voltage using a DC voltmeter having an internal resistance of, in principle, at least 10 MΩ. In this case, the isolation resistance monitoring system may be deactivated.

In the case of motor vehicles equipped with an automatic disconnect device, it shall be confirmed that there is no continuity between the terminals of the automatic disconnect device in order to verify that the said device has operated normally after the impact test. However, if the automatic disconnect device is integral to the battery for motor or the electrical energy conversion system and the battery for motor or the electrical energy conversion system is protected according to the protection class IPXXB following the impact test, measurements may be taken between the automatic disconnect device and the electrical load points.

Measure and record the voltage (V_b) between the negative and positive sides of the high voltage bus. (See Fig. 1.)

Measure and record the voltage (V_1) between the negative side of the high voltage bus and the electrical chassis. (See Fig. 1.)

Measure and record the voltage (V_2) between the positive side of the high voltage bus and the electrical chassis. (See Fig. 1.)

If V_1 is greater than or equal to V_2, insert a resistance (R_0) between the negative side of the high voltage bus and the electrical chassis. With R_0 installed, measure the voltage (V_1') between the negative side of the high voltage bus and the vehicle electrical chassis. (See Fig. 2.) Calculate the isolation resistance (R_i) according to the formula shown below.

$$R_i = R_0 \times (V_b / V_1' - V_b / V_1) \text{ or } R_i = R_0 \times V_b \times (1 / V_1' - 1 / V_1)$$

Divide the result Ri, which is the electrical isolation resistance value (unit: Ω), by the working voltage of the high voltage bus (unit: V).

$$R_i\ (\Omega / V) = R_i\ (\Omega) / \text{Working voltage (V)}$$

If V_2 is greater than V_1, insert a resistance (R_0) between the positive side of the high voltage bus and the electrical chassis. With R_0 installed, measure the voltage (V_2') between the positive side of the high voltage bus and the vehicle electrical chassis. (See Fig. 3.)

Calculate the isolation resistance (R_i) according to the formula shown below.

$$R_i = R_0 \times (V_b / V_2' - V_b / V_2) \text{ or } R_i = R_0 \times V_b \times (1 / V_2' - 1 / V_2)$$

Divide the result Ri, which is the electrical isolation resistance value (unit: Ω), by the working voltage of the high voltage bus (unit: V).

$$R_i\,(\Omega / V) = R_i\,(\Omega) / \text{Working voltage (V)}$$

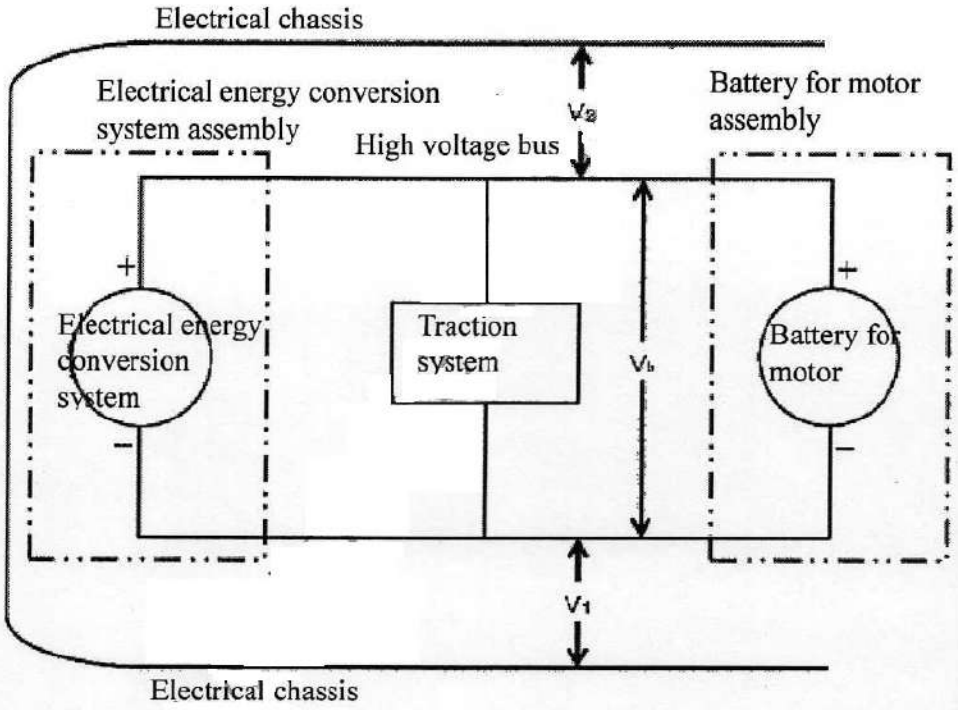


Fig. 1 Measurement of V_b, V_1 and V_2

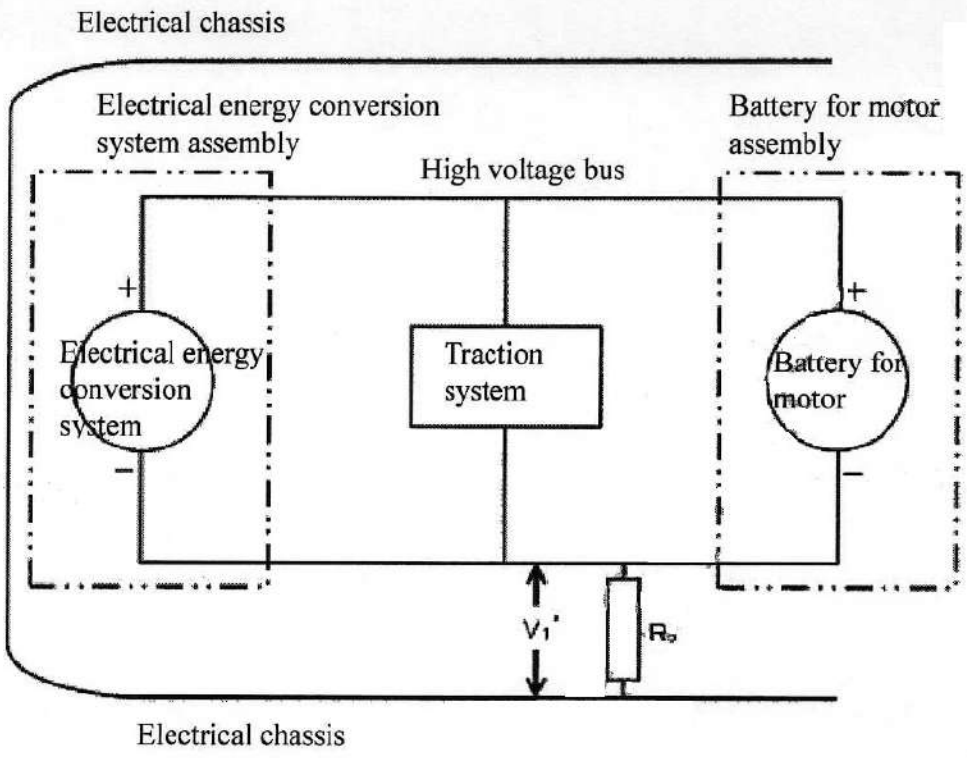


Fig. 2 Measurement of V_1'

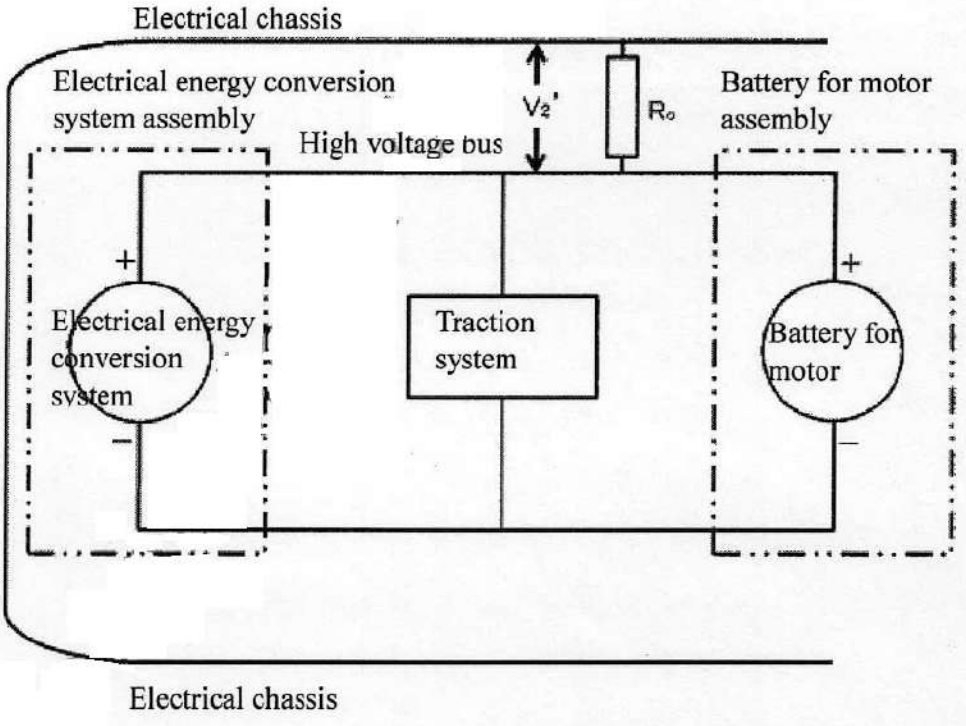


Fig. 3 Measurement of V_2'

Note:

The resistance value of the resistance R_0 (unit: Ω) should preferably be within a range of ±20% of the value of the isolation resistance standard value (unit: Ω/V) multiplied by the working voltage of the test vehicle.

Attached Sheet 4

TEST PROCEDURE FOR LOW ELECTRICAL ENERGY

Prior to the impact test, a switch S_1 and a discharge resistor R_e shall be connected in parallel to the high voltage bus. (See Fig.)

Not earlier than 5 seconds and not later than 60 seconds after the impact test, the switch S_1 shall be closed while the voltage V_b and the current I_e shall be measured and recorded. The product of the voltage V_b and the current I_e shall be integrated over the period of time, starting from the moment when the switch S_1 is closed (t_c) until the voltage V_b falls below the high voltage threshold of DC 60V (t_h).

The resulting integration equals the total energy (TE) in joules.

$$TE = \int_{tc}^{th} V_b \times I_e dt$$

When V_b is measured at a point in time between 5 seconds and 60 seconds after the impact test and the capacitance of the X-capacitors (C_x) is specified by the motor vehicle manufacturer, etc., the total energy (TE) shall be calculated according to the following formula:

$$TE = 0.5 \times C_x \times (V_b^2 - 3{,}600)$$

When V_1 and V_2 are measured at a point in time between 5 seconds and 60 seconds after the impact test and the capacitances of the Y-capacitors (C_{y1}, C_{y2}) are specified by the motor vehicle manufacturer, etc., the total energy (TE_{y1}, TE_{y2}) shall be calculated according to the following formulas:

$$TE_{y1} = 0.5 \times C_{y1} \times (V_1^2 - 3{,}600)$$

$$TE_{y2} = 0.5 \times C_{y2} \times (V_2^2 - 3{,}600)$$

This procedure is not applicable if the test is performed under the condition where the electric power train is not energized.

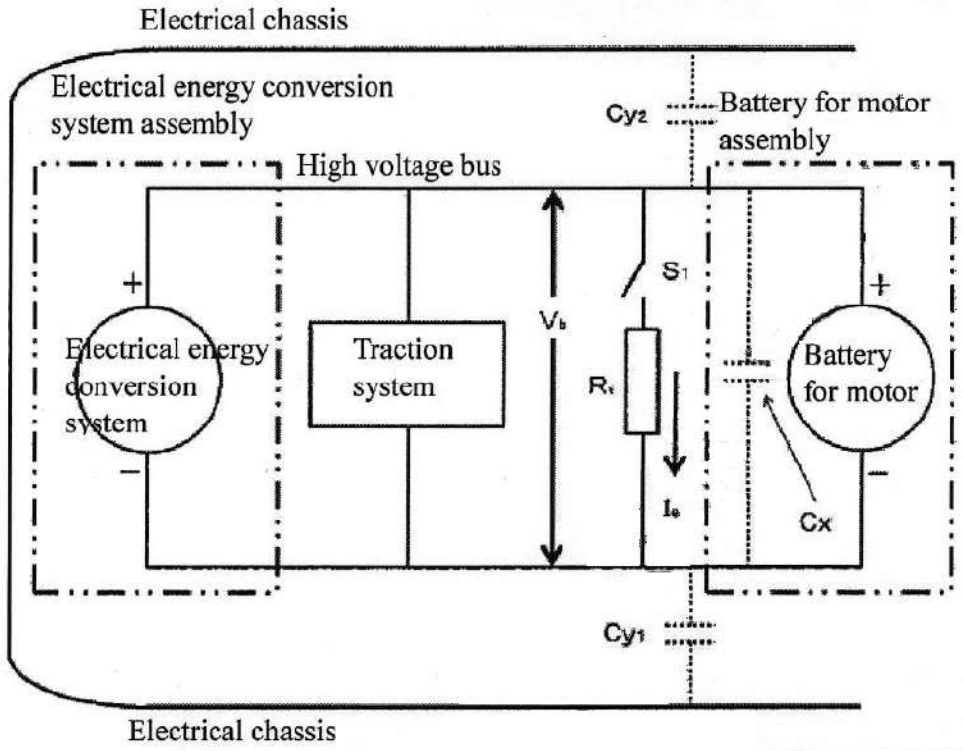


Fig. Measurement of high voltage bus energy stored in X-capacitors