AUTOMOTIVE INDUSTRY STANDARD

Requirements for the protection of fuel system and safety of electric power train in the event of rear impact of the motor vehicle

(Incorporating Amendment 1)

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ON BEHALF OF
AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE

UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE

SET-UP BY
MINISTRY OF ROAD TRANSPORT and HIGHWAYS
GOVERNMENT OF INDIA

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INTRODUCTION

0.0 The Government of India felt the need for a permanent agency to expedite the publication of standards and development of test facilities in parallel when the work on the preparation of the standards is going on, as the development of improved safety critical parts can be undertaken only after the publication of the standard and commissioning of test facilities. To this end, the erstwhile Ministry of Surface Transport (MoST) has constituted a permanent Automotive Industry Standards Committee (AISC) vide order No. RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the permanent CMVR Technical Standing Committee (CTSC). After approval, the Automotive Research Association of India (ARAI), Pune, being the secretariat of the AIS Committee, has published this standard. For better dissemination of this information ARAI may publish this document on their Web site.

1.0 The purpose of this standard is to bring about an improvement in the construction of the rear of vehicles and, in particular, those areas which influence the protection of the fuel systems (fuel tanks etc.) and safety of electric power train in the event of rear impact of a vehicle.

2.0 For improving the crashworthiness of a vehicle in the event of rear impact, the seating system should comply to the provisions of seats and seat anchorages standard IS 15546. AIS-101 and IS 15546 together would improve crashworthiness in rear impacts.

3.0 While preparing this AIS considerable assistance is derived from following international standards:

UN R34 (Suppl. 2 to 02 series of amendments (11.06.2007))	Uniform provisions concerning the approval of vehicles with regard to the prevention of fire risks
UN R 153 (22.01.2021)	Approval of vehicles with regard to fuel system integrity and safety of electric power train in the event of a rear-end collision

4.0 The AISC panel and Automotive Industry Standards Committee (AISC) responsible for preparation of this standard are given in Annexure B and Annexure C respectively.

Requirements for the Protection of Fuel System in the Event ofRear Impact of a Motor Vehicle

CONTENTS

Requirements for the protection of fuel system and safety of electric power train in the event of rear impact of the motor vehicle.

1.0 SCOPE

1.1 This standard applies to the vehicles of categories M1 as defined in AIS-053 / IS:14272, with regards to the protection of fuel system and electric power train operating on high voltage in the event of rear impact.

1.2 At the request of the manufacturer, vehicles other than those mentioned in paragraph 1.1 may be approved under this standard.

2.0 REFERENCES

2.1 IS 14272 / AIS-053 Automotive Vehicles - Types – Terminology

3.0 DEFINITIONS

3.1 "Approval of a vehicle" means the approval of a vehicle type with regard to:

3.1.1 the protection of the fuel system and safety of electric power train in the event of rear impact.

3.2 **"Vehicle type"** means a category of power-driven vehicles which do not differ in such essential respects as:

3.2.1 The length and width of the vehicle in so far as they have an effect on the results of the impact test prescribed in this standard.

3.2.2 The structure, dimensions, lines and materials of the part of the vehicle rearward of the transverse plane through the "R" point of the rearmost seat in so far as they have an effect on the results of the impact test prescribed in this standard.

3.2.3 The position of the fuel tank(s) in the vehicle in so far as it has an effect on the requirements of this standard.

3.2.4 The structure, shape, dimensions and materials (plastic / metal) of the fuel tank(s) in so far as they have an effect on the results of the impact test prescribed in this standard.

3.2.5 The siting (front, rear or centre) and the orientation (transversal or longitudinal) of the engine, in so far as they have an effect on the result of the impact test procedure as prescribed in this standard.

3.2.6 Characteristics and siting of fuel feed system (pump, filters, etc.) in so far as they have an effect on the results of the impact test prescribed in this standard.

3.2.7 The characteristics and siting of the electrical installation in so far as they have an effect on the results of the collision tests prescribed in this standard.

3.2.8 The lines and inside dimensions of the passenger compartment in so far as they have an effect on the results of the impact test prescribed in this standard.

3.2.9 The kerb weight, in so far as there is an effect on the result of the impact test prescribed in this standard.

3.2.10 The locations of the REESS, in so far as they have an effect on the result of the impact test prescribed in this standard.

3.3 **“Kerb weight”** means the weight of the vehicle in running order, unoccupied and unladen but complete with fuel, coolant, lubricant, tools and a spare wheel (if provided as standard equipment by the vehicle manufacturer).

3.4 **"Transverse plane"** means the vertical transverse plane perpendicular to the median longitudinal plane of the vehicle;

3.5 **"Passenger compartment"** means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead and rear bulkhead, or rear gate, as well as by the electrical protection barriers and enclosures provided for protecting the occupants from direct contact with high voltage live parts.

3.6 **"Tank"** means the tank(s) designed to contain the liquid fuel, as defined in paragraph 3.7. used primarily for the propulsion of the vehicle excluding its accessories (filler pipe, if it is a separate element, filler hole, cap, gauge, connections to the engine or to compensate interior excess pressure, etc.);

3.7 **"Capacity of the fuel tank"** means the fuel-tank capacity as specified by the manufacturer.

3.8 **"Liquid fuel"** means a fuel which is liquid in normal conditions of temperature and pressure.

3.9 **"High voltage"** means the classification of an electric component or circuit, if its working voltage is > 60 V and ≤ 1,500 V direct current (DC) or > 30 V and ≤ 1,000 V alternating current (AC) root – mean – square (rms).

3.10 **"Rechargeable electrical energy storage system (REESS)"** means the rechargeable energy storage system that provides electric energy for propulsion. A battery whose primary use is to supply power for starting the engine and/or lighting and/or other vehicle auxiliary systems is not considered as a REESS.

3.11 **"Electrical protection barrier"** means the part providing protection against any direct contact to the high voltage live parts.

3.12 **"Electric power train"** means the electrical circuit which includes the traction motor(s), and may also include the REESS, the electric energy conversion system, the electronic converters, the associated wiring harness and connectors, and the coupling system for charging the REESS.

3.13 **"Live parts"** means conductive part(s) intended to be electrically energized under normal operating conditions.

3.14 **"Exposed conductive part"** means the conductive part which can be touched under the provisions of the protection degree IPXXB which is not normally energized, but which can become electrically energized under isolation failure conditions. This includes parts under a cover that can be removed without using tools.

3.15 **"Direct contact"** means the contact of persons with high voltage live parts.

3.16 **"Indirect contact"** means the contact of persons with exposed conductive parts.

3.17 **"Protection degree IPXXB"** means protection from contact with high voltage live parts provided by either an electrical protection barrier or an enclosure and tested using a Jointed Test Finger (protection degree IPXXB) as described in paragraph A.6.4 of Annexure A.

3.18 **"Working voltage"** means the highest value of an electrical circuit voltage root-mean-square (rms), specified by the manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operating conditions. If the electrical circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively.

3.19 **"Coupling system for charging the Rechargeable Electrical Energy Storage System (REESS)"** means the electrical circuit used for charging the REESS from an external electrical power supply including the vehicle inlet.

3.20 **"Electrical chassis"** means a set made of conductive parts electrically linked together, whose electrical potential is taken as reference.

3.21 **"Electrical circuit"** means an assembly of connected high voltage live parts which is designed to be electrically energized in normal operation.

3.22 **"Electronic converter"** means a device capable of controlling and/or converting electric power for electric propulsion.

3.23 **"Enclosure"** means the part enclosing the internal units and providing protection against any direct contact.

3.24 **"High Voltage Bus"** means the electrical circuit, including the coupling system for charging the REESS that operates on a high voltage. Where electrical circuits are galvanically connected to each other and fulfil the specific voltage condition, only the components or parts of the electric circuit that operate on high voltage are classified as a high voltage bus.

3.25 **"Solid insulator"** means the insulating coating of wiring harnesses, provided in order to cover and prevent the high voltage live parts from any direct contact.

3.26 **"Automatic disconnect"** means a device that when triggered, conductively separates the electrical energy sources from the rest of the high voltage circuit of the electric power train.

3.27 **"Aqueous electrolyte"** means an electrolyte based on water solvent for the compounds (e.g. acids, bases) which provides conducting ions after its dissociation.

3.28 **"Electrolyte leakage"** means the escape of electrolyte from REESS in the form of liquid.

3.29 **"Non-aqueous electrolyte"** means an electrolyte not based on water as the solvent.

3.30 **"Normal operating conditions"** includes operating modes and conditions that can reasonably be encountered during normal operation of the vehicle including driving at legal speeds, parking or idling in traffic, as well as, charging using chargers that are compatible with the specific charging ports installed on the vehicle. It does not include, conditions where the vehicle is damaged, either by a crash, road debris or vandalization, subjected to fire or water submersion, or in a state where service and or maintenance is needed or being performed.

3.31 **"Specific voltage condition"** means the condition that the maximum voltage of a galvanically connected electrical circuit between a DC live part and any other live part (DC or AC) is ≤ 30 V AC (rms) and ≤ 60 V DC.

Note: When a DC live part of such an electrical circuit is connected to chassis and the specific voltage condition applies, the maximum voltage between any live part and the electrical chassis is ≤ 30 V AC (rms) and ≤ 60 V DC.

4.0 APPLICATION FOR APPROVAL

4.1 The application for approval of a vehicle type with regard to the protection of the fuel system and safety of electric power train in the event of rear impact shall be submitted by the vehicle manufacturer or by his duly accredited representative.

4.2 It shall be accompanied by the under mentioned documents in triplicate, and by the following particulars:

4.2.1 A detailed description of the vehicle type with respect to its structure, dimensions, lines and constituent materials;

4.2.2 Drawings of the vehicle showing the vehicle type in front, side and rear elevation and design details of the rear part of the structure; and

4.2.3 Particulars of the vehicle's kerb weight.

4.3 A vehicle representative of the type to be approved shall be submitted to the testing agency responsible for conducting the approval tests

4.3.1 A vehicle not comprising all the components proper to the type may be accepted for test provided that it can be shown that the absence of the components omitted has no detrimental effect on the results of the test, so far as the requirements of this standard are concerned.

4.3.2 The testing agency responsible for conducting the tests may allow the same vehicle as is used for tests prescribed by other standards (including tests capable of affecting its structure) to be used also for the tests prescribed by this standard; and the vehicle may be weighted to an extent not exceeding 10 per cent of its kerb weight with additional weights rigidly secured to the structure in such a way as not to affect the behaviour of the structure of the passenger compartment during the test.

4.4 It shall be the responsibility of the vehicle manufacturer for approval to show that acceptance of the variants referred to in paragraph 4.3.1. is compatible with compliance with the requirements of this standard.

5.0 REQUIREMENTS

5.1 When the vehicle has undergone the test referred to in paragraph 6 below, the provisions in paragraph 5.2 shall be fulfilled.

A vehicle with all parts of the fuel system installed in front of the midpoint of the wheelbase is deemed to fulfill the provisions in paragraph 5.2.1.

A vehicle with all parts of the electric power train operating on high voltage installed in front of the midpoint of the wheelbase is deemed to fulfill the provisions in paragraph 5.2.2.

5.2 Following the test conducted in accordance with the procedure laid down in Annexure A to this standard, following provisions with regard to fuel system integrity and safety of electric power train shall be fulfilled.

5.2.1 In the case of a vehicle propelled by liquid fuel, compliance with paragraphs 5.2.1.1 and 5.2.1.2 shall be shown.

5.2.1.1. No more than slight leakage of liquid from the fuel-feed installation shall occur on collision.

5.2.1.2. If there is continuous leakage in the fuel installation after the collision, the rate-of leakage shall not exceed 30 g/min; if the liquid from the fuel installation mixes with liquids from the other systems, and if the several liquids cannot be easily separated and identified, the continuous leakage shall be evaluated from all the fluids collected

5.2.2 In case of a vehicle equipped with an electric power train operating on high voltage, the electric power train and the high voltage systems which are galvanically connected to the high voltage bus of the electric power train shall meet the requirements in paragraphs 5.2.2.1 to 5.2.2.3

5.2.2.1 **Protection against electrical shock**

After the impact, the high voltage buses shall meet at least one of the four criteria specified in paragraph 5.2.2.1.1. through paragraph 5.2.2.1.4.2. below. If the vehicle has an automatic disconnect function, or device(s) that conductively divide the electric power train circuit during 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, criteria defined in 5.2.2.1.4. below shall not apply if more than a single potential of a part of the high voltage bus is not protected under the conditions of protection degree IPXXB. In the case that the crash test is performed under the condition that part(s) of the high voltage system are not energized and with the exception of any coupling system for charging the REESS which is not energized during driving, the protection against electrical shock shall be proved by either paragraph 5.2.2.1.3. or paragraph 5.2.2.1.4. for the relevant part(s).

5.2.2.1.1 **Absence of high voltage**

The voltages Ub, U1 and U2 of the high voltage buses shall be equal or less than 30 VAC or 60 VDC within 60 s after the impact when measured in accordance with paragraph A.6.2 of Annexure A.

5.2.2.1.2 **Low electrical energy**

The Total Energy (TE) on the high voltage buses shall be less than 0.2 J when measured according to the test procedure as specified in paragraph A.6.3 of Annexure A with the formula (a). Alternatively, the Total Energy (TE) may be calculated by the measured voltage Ub of the high voltage bus and the capacitance of the X-capacitors (Cx) specified by the manufacturer according to formula (b) of paragraph A.6.3 of Annexure A.

The energy stored in the Y-capacitors (TEy1, TEy2) shall also be less than 0.2 J. This shall be calculated by measuring the voltages U1 and U2 of the high voltage buses and the electrical chassis, and the capacitance of the Y-capacitors specified by the manufacturer according to formula (c) of paragraph A.6.3 of Annexure A.

5.2.2.1.3 **Physical protection**

For protection against direct contact with high voltage live parts, the protection degree IPXXB shall be provided.

The assessment shall be conducted in accordance with paragraph A.6.4 of Annexure A.

In addition, for protection against electrical shock which could arise from indirect contact, the resistance between all exposed conductive parts of electrical protection barriers/enclosures and the electrical chassis shall be lower than 0.1 Ω and the resistance between any two simultaneously reachable exposed conductive parts of electrical protection barriers/enclosures that are less than 2.5 m from each other shall be less than 0.2 Ω when there is current flow of at least 0.2 A. This resistance may be calculated using the separately measured resistances of the relevant parts of electric path.

This requirement is satisfied if the galvanic connection has been made by welding. In case of doubt or the connection is established by means other than welding, measurement shall be made by using one of the test procedures described in paragraph A.6.4 of Annexure A.

5.2.2.1.4 **Isolation resistance**

The criteria specified in the paragraphs 5.2.2.1.4.1. and 5.2.2.1.4.2. below shall be met. The measurement shall be conducted in accordance with paragraph A.6.5 of Annexure A.

5.2.2.1.4.1 **Electric power train consisting of separate DC- or AC-buses**

If the AC high voltage buses and the DC high voltage buses are galvanically isolated from each other, isolation resistance between the high voltage bus and the electrical chassis (Ri, as defined in paragraph A.6.5 of Annexure A) shall have a minimum value of 100 Ω/V of the working voltage for DC buses, and a minimum value of 500 Ω/V of the working voltage for AC buses.

5.2.2.1.4.2 **Electric power train consisting of combined DC- and AC-buses**

If the AC high voltage buses and the DC high voltage buses are conductively connected, they shall meet one of the following requirements:

(a) Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 500 Ω/V of the working voltage;

(b) Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage and the AC bus meets the physical protection as described in paragraph 5.2.2.1.3;

(c) Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage and the AC bus meets the absence of high voltage as described in paragraph 5.2.2.1.1.

5.2.2.2 **Electrolyte leakage**

5.2.2.2.1 **In case of aqueous electrolyte REESS**

For a period from the impact until 60 minutes after the impact, there shall be no electrolyte leakage from the REESS into the passenger compartment and no more than 7 per cent by volume of the REESS electrolyte with a maximum of 5.0 l leaked from the REESS to the outside of the passenger compartment. The leaked amount of electrolyte can be measured by the usual techniques of determining liquid volumes after its collection. For containers containing Stoddard, colored coolant and electrolyte, the fluids shall be allowed to separate by specific gravity then measured.

5.2.2.2.2 **In case of non-aqueous electrolyte REESS**

For a period from the impact until 60 minutes after the impact, there shall be no liquid electrolyte leakage from the REESS into the passenger compartment or luggage compartment and no liquid electrolyte leakage to outside the vehicle. This requirement shall be verified by visual inspection without disassembling any part of the vehicle. The manufacturer shall demonstrate compliance in accordance with paragraph A.6.6 of Annexure A.

5.2.2.3 **REESS retention**

REESS shall remain attached to the vehicle by at least one component anchorage, bracket, or any structure that transfers loads from REESS to the vehicle structure, and REESS located outside the passenger compartment shall not enter the passenger compartment.

The manufacturer shall demonstrate compliance in accordance with paragraph A.6.7 of Annexure A.

6.0 TESTS

6.1 The vehicle's compliance with the requirements of paragraph 5 above shall be checked by the method set out in Annexure A to this standard.

6.2 At the choice of manufacturer testing may be carried with impact speed specified in UN Regulation 153, Annex 3, paragraph 3.0.

7.0 MODIFICATIONS OF THE VEHICLE TYPE

7.1 Every modification of the vehicle type shall be notified to the testing agency which approved the vehicle type. The testing agency may then either:

7.1.1 Consider that the modifications made are unlikely to have appreciable adverse effects, and that in any case the vehicle still meets the requirements; or

7.1.2 Require a further test report.

7.2 Without prejudice to the provisions of paragraph 7.1. above, a variant of the vehicle whose unladen mass is lower or does not exceed by more than 25% from that of the approval-tested vehicle shall not be regarded as a modification of the vehicle type.

8.0 CRITERIA FOR EXTENSION OF TYPE APPROVALS

8.1 Criteria for extension of approval shall be as mutually agreed between the testing agency and vehicle manufacturer.

ANNEXURE A
(See 6.1)
TEST PROCEDURE

A.1 Purpose and scope

A.1.1 The purpose of the test is to simulate the conditions of rear-end collision by another vehicle in motion.

A.2 Installations, procedures and instruments

A.2.1 **Testing ground**

The test area shall be large enough to accommodate the impactor (striker) propulsion system and to permit after-collision displacement of the impacted vehicle and installation of the test equipment. The part in which vehicle collision and displacement occur shall be horizontal, flat and uncontaminated, and representative of a normal, dry, uncontaminated road surface."

A.2.2 **Impactor (striker)**

A.2.2.1 The impactor shall be of steel and of rigid construction.

A.2.2.2 The impacting surface shall be flat, not less than 2,500 mm wide, and 800 mm high, and its edges shall be rounded to a radius of curvature of between 40 and 50 mm. It shall be covered with layer of plywood 20±2 mm thick.

A.2.2.3 At the moment of collision, the following requirements shall be met:

A.2.2.3.1 the impacting surface shall be vertical and perpendicular to the median longitudinal plane of the impacted vehicle;

A.2.2.3.2 the direction of movement of the impactor shall be substantially horizontal and parallel to the median longitudinal plane of the impacted vehicle;

A.2.2.3.3 the maximum lateral deviation tolerated between the median vertical line of the surface of the impactor and the median longitudinal plane of the impacted vehicle shall be 300 mm. In addition, the impacting surface shall extend over the entire width of the impacted vehicle;

A.2.2.3.4 the ground clearance of the lower edge of the impacting surface shall be 175 ± 25 mm.

A.2.3 **Propulsion of the impactor**

A.2.3.1 The impactor may either be secured to a carriage (moving barrier) or form part of a pendulum

A.2.4 **Special provisions applicable where a moving barrier is used**

A.2.4.1 If the impactor is secured to a carriage (moving barrier) by a restraining element, the latter shall be rigid and be incapable of being deformed by the collision; the carriage shall at the moment of collision be capable of moving freely and no longer be subject to the action of the propelling device.

A.2.4.2 The velocity of collision shall be between 35 and 38 km/h.

A.2.4.3 The aggregate weight (mass) of carriage and impactor shall be 1,100 ± 20 kg.

A.2.5 **Special provisions applicable where a pendulum is used**

A.2.5.1 The distance between the centre of the impacting face and the axis of rotation of the pendulum shall be not less than 5 m.

A.2.5.2 The impactor shall be freely suspended by rigid arms rigidly secured to it. The pendulum so constituted shall be substantially incapable of being deformed by the collision.

A.2.5.3 Arresting gear shall be incorporated in the pendulum to prevent any secondary collision by the impactor on the test vehicle.

A.2.5.4 At the moment of collision, the velocity of the centre of percussion of the pendulum should be between 35 and 38 km/h.

A.2.5.5 The reduced mass "mr" at the centre of percussion of the pendulum is defined as a function of the total mass "m", of the distance "a"* between the centre of percussion and the axis of rotation, and of the distance "l" between the centre of gravity and the axis of rotation, by the following equation:

$$m_r = m\ (l/a)$$

*It is recalled that the distance "a" is equal to the length of the synchronous pendulum under consideration.

A.2.5.6 The reduced mass mr shall be 1,100 ± 20 kg.

A.2.6 **General provisions relating to the mass and velocity of the impactor**

A.2.6.1 If the test has been conducted at a collision velocity higher than those prescribed in paragraphs A.2.4.2 and A2.5.4 and/or with a mass greater than those prescribed in paragraphs A2.4.3 and A2.5.6, and the vehicle has met the requirements prescribed, the test shall be considered satisfactory.

A.3 State of vehicle under test

A.3.1 The vehicle under test shall either be fitted with all the normal components and equipment included in its kerb weight or be in such condition as to fulfill this requirement so far as the components and equipment affecting fire risks are concerned.

A.3.2 The fuel tank shall be filled to at least 90 per cent of its capacity either with fuel or with a non-inflammable liquid having a density and a viscosity close to those of the fuel normally used. All other systems (brake-fluid header tanks, radiator, etc.) may be empty.

A.3.3 At the choice of the vehicle manufacturer, a gear may be engaged and the brakes may be applied.

A.3.4 The doors should be latched but not locked.

A.3.5 Electric power train adjustment

A.3.5.1 The REESS shall be at any state of charge, which allows the normal operation of the power train as recommended by the manufacturer

A.3.5.2 The electric power train shall be energized with or without the operation of the original electrical energy sources (e.g. engine-generator, REESS or electric energy conversion system), however:

A.3.5.3 By the agreement between Testing Agency and manufacturer it shall be permissible to perform the test with all or parts of the electric power train not being energized insofar as there is no negative influence on the test result. For parts of the electric power train not energized, the protection against electrical shock shall be proved by either physical protection or isolation resistance and appropriate additional evidence.

A.3.5.4 In the case where an automatic disconnect is provided, at the request of the manufacturer, it shall be permissible to perform the test with the automatic disconnect being triggered. In this case it shall be demonstrated that the automatic disconnect would have operated during the impact test. This includes the automatic activation signal as well as the galvanic separation considering the conditions as seen during the impact.

A.4 Measuring instruments

A.4.1 The instruments used to record the speed referred to in paragraphs A.2.4.2 and A.2.5.4 above shall be accurate to within one per cent.

A.5 Equivalent test methods

A.5.1 Equivalent test methods are permitted provided that the conditions referred to in this standard can be observed either entirely by means of the substitute test or by calculation from the results of the substitute test.

A.6 Test procedures for the vehicles equipped with electric power train

This section describes test procedures to demonstrate compliance to the electrical safety requirements of paragraph 5.2.2 of this standard.

A.6.1 Test setup and equipment

If a high voltage disconnect function is used, measurements are to be taken from both sides of the device performing the disconnect function. However, if the high voltage disconnect is integral to the REESS or the energy conversion system and the high-voltage bus of the REESS or the energy conversion system is protected according to protection degree IPXXB following the impact test, measurements may only be taken between the device performing the disconnect function and the electrical loads.

The voltmeter used in this test shall measure DC values and have an internal resistance of at least 10 MΩ.

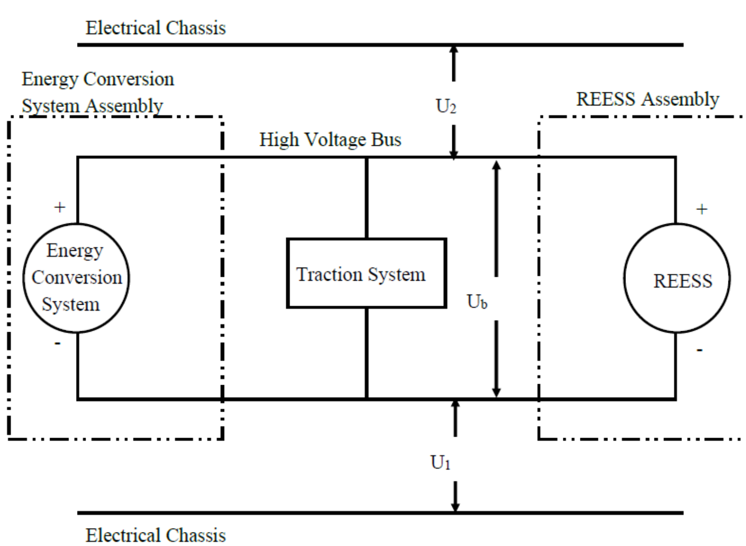
A.6.2 The following instructions may be used if voltage is measured.

After the impact test, determine the high voltage bus voltages (Ub, U1, U2) (see Figure 1 below).

The voltage measurement shall be made not earlier than 10 seconds, but, not later than 60 seconds after the impact.

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

Figure 1
Measurement of U_b, U_1, U_2



A.6.3 Assessment procedure for low electrical energy

Prior to the impact a switch S1 and a known discharge resistor Re is connected in parallel to the relevant capacitance (ref. Figure 2 below).

(a) Not earlier than 10 seconds and not later than 60 seconds after the impact the switch S1 shall be closed while the voltage Ub and the current Ie are measured and recorded. The product of the voltage Ub and the current Ie shall be integrated over the period of time, starting from the moment when the switch S1 is closed (tc) until the voltage Ub falls below the high voltage threshold of 60 V DC (th). The resulting integration equals the Total Energy (TE) in joules.

$$TE = \int_{tc}^{th} U_b \, x \, I_e dt$$

(b) When Ub is measured at a point in time between 10 seconds and 60 seconds after the impact and the capacitance of the X-capacitors (Cx) is specified by the manufacturer, Total Energy (TE) shall be calculated according to the following formula:

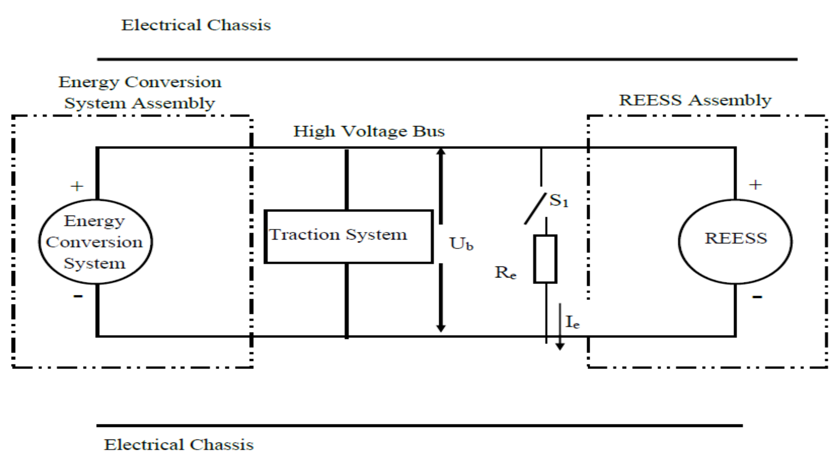
TE = 0.5 x Cx x Ub2

(c) When U1 and U2 (see Figure 1 above) are measured at a point in time between 10 seconds and 60 seconds after the impact and the capacitances of the Y-capacitors (Cy1, Cy2) are specified by the manufacturer, Total Energy (TEy1, TEy2) shall be calculated according to the following formulas:

TEy1 = 0.5 x Cy1 x U12
TEy2 = 0.5 x Cy2 x U22

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

Figure 2
e.g. measurement of high voltage bus energy stored in X-capacitors



A.6.4 Physical protection

Following the vehicle impact test any parts surrounding the high voltage components shall be, without the use of tools, opened, disassembled or removed. All remaining surrounding parts shall be considered part of the physical protection.

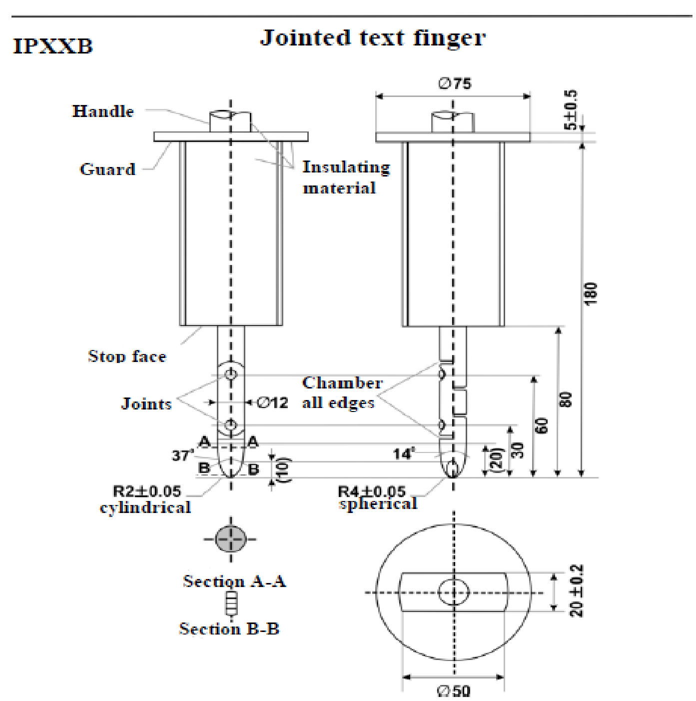
The jointed test finger described in Figure 3 shall be inserted into any gaps or openings of the physical protection with a test force of 10 N ± 10 per cent for electrical safety assessment. If partial or full penetration into the physical protection by the jointed test finger occurs, the jointed test finger shall be placed in every position as specified below.

Starting from the straight position, both joints of the test finger shall be rotated progressively through an angle of up to 90° with respect to the axis of the adjoining section of the finger and shall be placed in every possible position. Internal electrical protection barriers are considered part of the enclosure.

If appropriate a low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp should be connected, between the jointed test finger and high voltage live parts inside the electrical protection barrier or enclosure.

Figure 3

Joint Test Finger



Material: metal, except where otherwise specified

Linear dimensions in mm.

Tolerances on dimensions without specific tolerance:

(a) On angles: +0°0′0″/-0°0′10″;

(b) On linear dimensions:

(i) ≤25 mm: +0/-0.05 mm;

(ii) >25 mm: ±0.2 mm

Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to +10° tolerance.

The requirements of paragraph 5.2.2.1.3. of this standard are met if the jointed test finger described in Figure 3, is unable to contact high voltage live parts.

If necessary, a mirror or a fiberscope may be used to inspect whether the jointed test finger touches the high voltage buses.

If this requirement is verified by a signal circuit between the jointed test finger and high voltage live parts, the lamp shall not light.

A.6.4.1 Test method for measuring electric resistance:

(a) Test method using a resistance tester.

The resistance tester is connected to the measuring points (typically, the electrical chassis and electro conductive enclosure/electrical protection barrier) and the resistance is measured using a resistance tester that meets the specification that follows:

(i) Resistance tester: Measurement current at least 0.2 A;

(ii) Resolution: 0.01 Ω or less;

(iii) The resistance R shall be less than 0.1 Ω.

(b) Test method using DC power supply, voltmeter and ammeter.
The DC power supply, voltmeter and ammeter are connected to the measuring points (Typically, electrical chassis and electro conductive enclosure/electrical protection barrier).

The voltage of the DC power supply is adjusted so that the current flow becomes at least 0.2 A.

The current "I" and the voltage "U" are measured.

The resistance "R" is calculated according to the following formula:

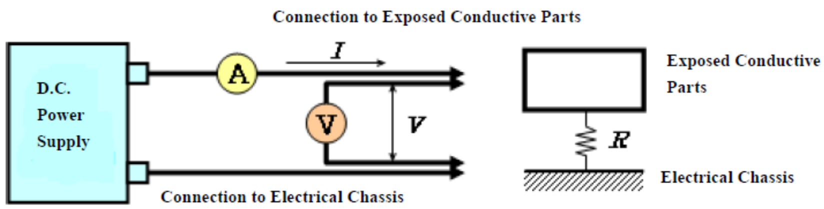
$$R = U / I$$

The resistance R shall be less than 0.1 Ω.

Note: If lead wires are used for voltage and current measurement, each lead wire shall be independently connected to the electrical protection barrier/enclosure/electrical chassis. Terminal can be common for voltage measurement and current measurement.

Example of the test method using DC power supply, voltmeter and ammeter is shown below.

Figure 4
Example of test method using DC power supply



A.6.5 Isolation resistance

A.6.5.1. General

The isolation resistance for each high voltage bus of the vehicle is measured or shall be determined by calculating the measurement values of each part or component unit of a high voltage bus.

All measurements for calculating voltage(s) and electrical isolation are made after a minimum of 10 s after the impact.

A.6.5.2 Measurement method.

The isolation resistance measurement is conducted by selecting an appropriate measurement method from among those listed in paragraphs A.6.5.2.1. to A.6.5.2.2. of this annexure, depending on the electrical charge of the live parts or the isolation resistance.
The range of the electrical circuit to be measured is clarified in advance, using electrical circuit diagrams. If the high voltage buses are conductively isolated from each other, isolation resistance shall be measured for each electrical circuit.

Moreover, modifications necessary for measuring the isolation resistance may be carried out, such as removal of the cover in order to reach the live parts, drawing of measurement lines and change in software.

In cases where the measured values are not stable due to the operation of the on-board isolation resistance monitoring system, necessary modifications for conducting the measurement may be carried out by stopping the operation of the device concerned or by removing it. Furthermore, when the device is removed, a set of drawings will be used to prove that the isolation resistance between the live parts and the electrical chassis remains unchanged.

These modifications shall not influence the test results.

Utmost care shall be exercised to avoid short circuit and electric shock since this confirmation might require direct operations of the high-voltage circuit.

A.6.5.2.1. Measurement method using DC voltage from external sources.

A.6.5.2.1.1. Measurement instrument.
An isolation resistance test instrument capable of applying a DC voltage higher than the working voltage of the high voltage bus shall be used.

A.6.5.2.1.2 Measurement method.

An isolation resistance test instrument is connected between the live parts and the electrical chassis. The isolation resistance is subsequently measured by applying a DC voltage at least half of the working voltage of the high voltage bus.
If the system has several voltage ranges (e.g. because of boost converter) in conductively connected circuit and some of the components cannot withstand the working voltage of the entire circuit, the isolation resistance between those components and the electrical chassis can be measured separately by applying at least half of their own working voltage with those components disconnected.

A.6.5.2.2. Measurement method using the vehicle's own REESS as DC voltage source.

A.6.5.2.2.1 Test vehicle conditions.

The high voltage-bus is energized by the vehicle's own REESS and/or energy conversion system and the voltage level of the REESS and/or energy conversion system throughout the test shall be at least the nominal operating voltage as specified by the vehicle manufacturer.

A.6.5.2.2.2. Measurement method.

A.6.5.2.2.2.1. First step.
The voltage is measured as shown in Figure 1 and the high voltage bus voltage (Ub) is recorded.

A.6.5.2.2.2.2. Second step.

The voltage (U1) between the negative side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 1).

A.6.5.2.2.2.3. Third step.

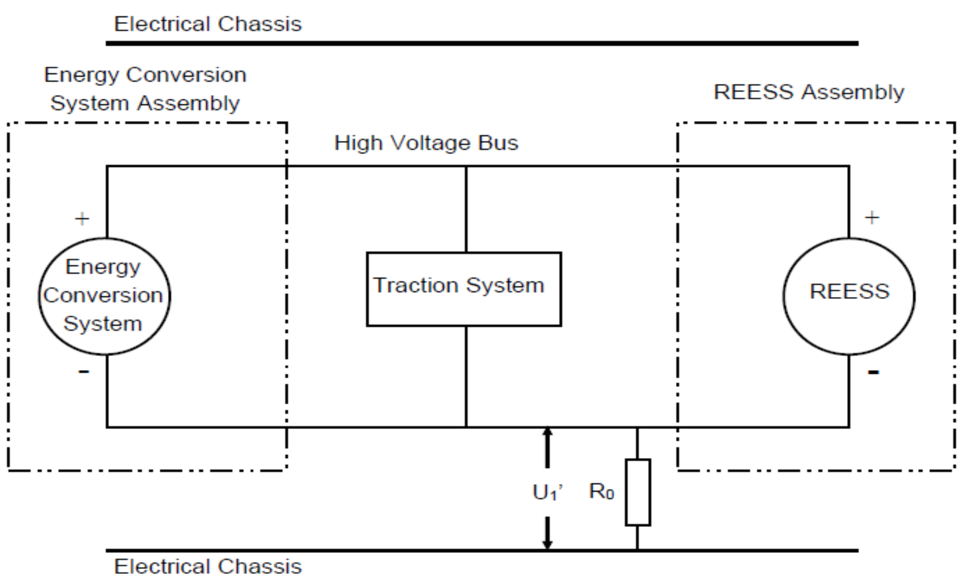
The voltage (U2) between the positive side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 1).

A.6.5.2.2.2.4. Fourth step.

If U1 is greater than or equal to U2, a standard known resistance (Ro) is inserted between the negative side of the high voltage bus and the electrical chassis. With Ro installed, the voltage (U1') between the negative side of the high voltage bus and the electrical chassis is measured (see Figure 5).

The electrical isolation (Ri) is calculated according to the following formula:
Ri = Ro*Ub*(1/U1' – 1/U1)

Figure 5
Measurement of U_1'

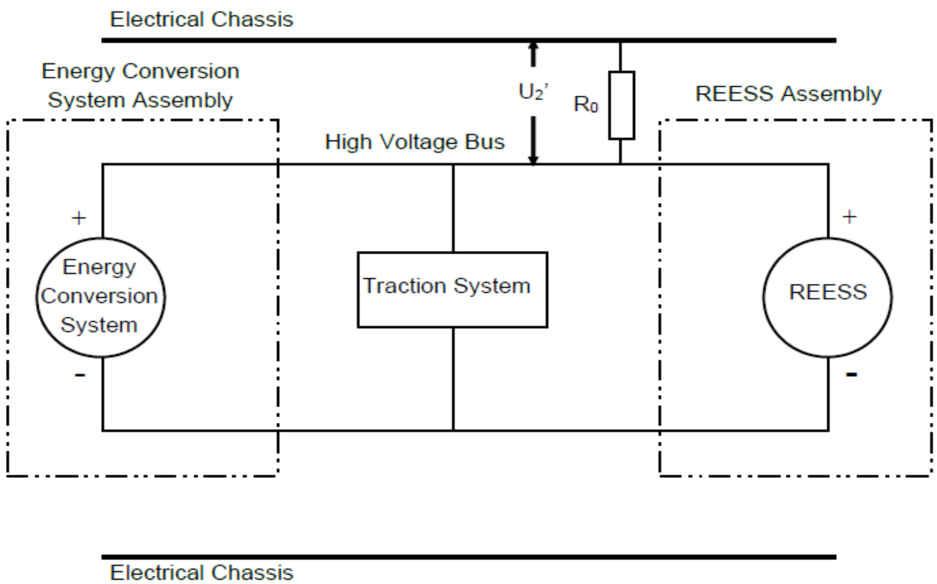


If U2 is greater than U1, insert a standard known resistance (Ro) between the positive side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (U2') between the positive side of the high voltage bus and the electrical chassis (see Figure 6).

The electrical isolation (Ri) is calculated according to the following formula:

Ri = Ro*Ub*(1/U2' – 1/U2)

Figure 6
Measurement of U_2'



A.6.5.2.2.2.5. Fifth step.

The electrical isolation value Ri (in Ω) divided by the working voltage of the high voltage bus (in V) results in the isolation resistance (in Ω/V).

Note: The standard known resistance Ro (in Ω) should be the value of the minimum required isolation resistance (Ω/V) multiplied by the working voltage (V) of the vehicle plus/minus 20 per cent. Ro is not required to be precisely this value since the equations are valid for any Ro; however, a Ro value in this range should provide a good resolution for the voltage measurements.

A.6.6 Electrolyte leakage

An appropriate coating, if necessary, may be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS after the impact test.

A.6.7 REESS retention

Compliance shall be determined by visual inspection.

ANNEXURE B
(See introduction)
COMPOSITION OF AISC PANEL ON
REAR IMPACT*

Panel convener	**Representing**
Mr. C Anilkumar	SIAM (Tata Motors Ltd.)
Members	
Mr. A. V. Mannikar	The Automotive Research Association of India
Mr. Dileep D. Kulkarni	The Automotive Research Association of India
Mr. Vishal P. Rawal	The Automotive Research Association of India
Ms. Shubhangi Dalvi	Central Institute of Road Transport
Mr. Praveen Kumar	Global Automotive Research Centre
Mr. Hariharan R	Global Automotive Research Centre
Mr. Murali	Global Automotive Research Centre
Mr. Krushna Magar	Global Automotive Research Centre
Mr. Amit Kumar	International Centre for Automotive Technology
Ms. Vijayanta Ahuja	International Centre for Automotive Technology
Mr. Ashish Kumar	International Centre for Automotive Technology
Mr. Rohit Yadav	International Centre for Automotive Technology
Mr. Ved Prakash Gautam	SIAM (Ashok Leyland Ltd.)
Mr. Satyanarayana Gupta Bolisetty	SIAM (Bajaj Auto Ltd.)
Mr. Girish S. Kodolikar	SIAM (Force Motors Ltd.)
Mr. S. Muthu Kumar	SIAM (Honda Cars R&D India Ltd.)
Mr. Satyanarayana	SIAM (Hyundai Motor India Ltd.)
Mr. P S Vatsalya	SIAM (Hyundai Motor India Ltd.)
Mr. Rahul Rijhwani	SIAM (Isuzu Motors India)
Mr. Praveen Kumar	SIAM (Isuzu Motors India)
Mr. Alauddin Ali	SIAM (Jaguar Land Rover India Ltd.)
Mr. S. Muthukumar	SIAM (Mahindra Truck & Bus Div.)
Mr. Sudhir Sathe	SIAM (Mahindra & Mahindra Ltd.)
Mr. Shailesh Kulkarni	SIAM (Mahindra & Mahindra Ltd.)
Mr. Thangaraj Karuppasamy	SIAM (Mahindra & Mahindra Ltd.)
Mr. Devinder Tangri	SIAM (Mahindra & Mahindra Ltd.)
Ms. Pushpanjali Pathak	SIAM (Mahindra & Mahindra Ltd.)
Mr. Dhotre Abhijit	SIAM (Mahindra & Mahindra Ltd)
Mr. Venkatesh G	SIAM (Mahindra & Mahindra Ltd)
Mr. Alok Jaitley	SIAM (Maruti Suzuki India Ltd.)

Mr. Gururaj Ravi	SIAM (Maruti Suzuki India Ltd.)
Mr. Amit Singh	SIAM (Maruti Suzuki India Ltd.)
Mr. Arun Kumar	SIAM (Maruti Suzuki India Ltd.)
Mr. Sumit Kumar	SIAM (Maruti Suzuki India Ltd.)
Mr. Amit Singh	SIAM (Maruti Suzuki India Ltd.)
Mr. Tarun Nagar	SIAM (Mercedes Benz India Pvt. Ltd.)
Mr. Nikhil Desai	SIAM (Mercedes Benz India Pvt. Ltd.)
Mr. Rajendra Khile	SIAM (Renault Nissan India Pvt. Ltd.)
Mr. S. Vivekraj	SIAM (Renault Nissan India Pvt. Ltd.)
Mr. Makarand Brahme	SIAM (Skoda Auto VW Ind. Pvt. Ltd.)
Mr. Aditi Deshpande	SIAM (Skoda Auto VW Ind. Pvt. Ltd.)
Mr. Milind K. Jagtap	SIAM (Skoda Auto VW Ind. Pvt. Ltd.)
Mr. Pratyush Khare	SIAM (Tata Motors Ltd.)
Mr. P. S. Gowrishankar	SIAM (Tata Motors Ltd.)
Mr. Atul A. Date	SIAM (Tata Motors Ltd.)
Mr. Vinay Maurya	SIAM (Tata Motors Ltd.)
Ms. Namrata Deb	SIAM (Tata Motors Ltd.)
Mr. Rahul Pathak	SIAM (Tata Motors Ltd.)
Mr. B. Sudarshan	SIAM (Tata Motors Ltd.)
Mr. Ganesh Gadekar	SIAM (Tata Motors Ltd.)
Mr. Raju M	SIAM (Toyota Kirloskar Motor Pvt. Ltd.)
Mr. Vijeth Gatty	SIAM (Toyota Kirloskar Motor Pvt. Ltd.)
Mr. Dinesh G. M	SIAM (Toyota Kirloskar Motor Pvt. Ltd.)
Mr. Pavan V	SIAM (Toyota Kirloskar Motor Pvt. Ltd.)
Mr. Pradeep E P	SIAM (Toyota Kirloskar Motor Pvt. Ltd.)
Mr. Tarun Bhat	SIAM (Honda Cars India Ltd.)
Mr. Mandeep	Kia India
Mr. Hitesh Sharma	MG Motors
Mr. Uday Harite	ACMA
Mr. Sivakumar Sudhachandran	ACMA (Autoliv India Pvt. Ltd.)
Mr. Boobalan Natarajan	ACMA (Autoliv India Pvt. Ltd.)
Mr. Kishor Golesar	ACMA (Nippon Audiotronix Ltd.)
Mr. Deepak M. K.	ACMA (Toyota Boshoku Auto. India (P) Ltd.)
Mr. Niladri Sekhar Samanta	Stellantis Group
Mr. Santosh Bhise	Stellantis Group
Mr. Umesh Nagraj	Valeo India

* At the time of approval of this Automotive Industry Standard (AIS)

ANNEXURE C
(See Introduction)

COMMITTEE COMPOSITION *
Automotive Industry Standards Committee

Chairperson	
Dr. Reji Mathai	Director, The Automotive Research Association of India
Members	**Representing**
Representative from	Ministry of Road Transport and Highways
Representative from	Ministry of Heavy Industries
Representative from	Office of the Development Commissioner, MSME, Ministry of Micro, Small and Medium Enterprises
Shri Shrikant R. Marathe	Former Chairman, AISC
Head TED	Bureau of Indian Standards
Director	Central Institute of Road Transport
Director	Global Automotive Research Centre
Director	International Centre for Automotive Technology
Director	Indian Institute of Petroleum
Director	Vehicles Research and Development Establishment
Director	Indian Rubber Manufacturers Research Association
Representatives from	Society of Indian Automobile Manufacturers
Representative from	Tractor and Mechanization Association
Representative from	Automotive Components Manufacturers Association of India
Representative from	Indian Construction Equipment Manufactures' Association
Member Secretary	
Shri Vikram Tandon	The Automotive Research Association of India

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