AIS-038

AUTOMOTIVE INDUSTRY STANDARDS

Battery Operated Vehicles - Requirements for Construction and Functional Safety

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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 & HIGHWAYS
GOVERNMENT OF INDIA

September 2003

Status chart of the Standard to be used by the Purchaser for
Up dating the record

Sr. No.	Corrigenda	Amend-ment	Revision	Date	Remark	Misc.

General Remarks:

Introduction

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 of preparation of 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 Ministry of Surface Transport (MoST) has constituted a permanent Automotive Industry Standard 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 website.

This Standard prescribes the requirements for the construction and functional safety of battery operated vehicles.

Considerable assistance has been taken from ECE 100, ISO DIS 6469 and IEC 60529.

The Committee responsible for preparation of this standard is given in Annexure- 4.

Battery Operated Vehicles – Requirements for Construction and Functional Safety

1.0 SCOPE

This standard specifies requirements for the construction and functional safety of battery operated vehicles (BOVs) for the purpose of establishing compliance to statutory requirements.

2.0 TERMINOLOGY

Refer Annexure – E of AIS – 049 for the definitions.

3.0 VEHICLE CONSTRUCTION REQUIREMENTS AND TEST PROCEDURE

3.1 Traction Battery

3.1.1 Installation of the traction battery in the vehicle shall not allow any potential dangerous accumulation of gases. Details of the ventilation provided by manufacturer shall be verified by Test Agency at the time of type approval.

3.1.2 Battery compartments containing battery modules, which may produce hazardous gases shall be safely ventilated. Details of ventilation provided by manufacturer shall be verified by the Test Agency at the time of type approval.

3.1.3 The traction battery and the power train shall be protected by properly rated fuse or circuit breakers. The components on the vehicle shall be as per the specifications declared by the manufacturer as per information provided in AIS 007. The same shall be verified by the Test Agency at the time of type approval.

3.1.4 **Mounting of Batteries**

The mounting of batteries in the battery operated vehicle shall be such that batteries / battery packs are not displaced from their place and there is no spillage of electrolyte when vehicle is driven on gradient or any other type of road. This condition shall be deemed to be satisfied if no spillage of electrolyte is observed while conducting various tests for type approval.

3.1.5 **Creepage Distance Measurement For Traction Batteries**

This clause deals with additional leakage current hazard between the connection terminals of a traction battery module including any conductive fittings attached to them and any conductive parts, due to the risk of electrolyte spillage in normal operating conditions.

It does not apply to traction batteries, for which electrolyte leakage will not occur under normal operating conditions e.g. sealed traction batteries.

The minimum creepage distance shall be as follows:

a) In the case of a creepage distance between two battery connection terminals:

$d \geq 0.25\ U + 5$

Where : d is the creepage distance measured on the tested traction battery in mm

U is the nominal voltage between the two battery connection terminals in V.

b) In the case of creepage distance between live parts and the electrical chassis :

$d \geq 0.125\ U + 5$

Where d is the creepage distance measured between the live part and the electrical chassis in mm.

U is the nominal voltage between the two battery connection terminals in V.

3.2 **Protection against Electric Shock**

3.2.1 **Protection against direct contact with live parts of the power train**

3.2.1.1 If the working voltage of the electric circuit is lower than 60 V DC or 25 V AC, requirements specified in para 3.2.1 are not applicable.

3.2.1.2 Direct contact with live parts of the electrical power train whose maximum voltage is at least 60 V DC or 25 V AC shall be prevented either by insulation or by the use of covers, protection grills, perforated metal sheets, etc. These protections shall be reliably secured and shall be mechanically resistant. They shall not be able to be opened, dissembled or removed without the use of tools.

3.2.1.3 Live parts in passenger and load compartments, shall be protected by enclosures having a protection degree of at least IPXXD.

3.2.1.4 Enclosures in other areas of the vehicle shall have a protection degree of at least IPXXB.

3.2.1.5 In the drive train compartment the access to live parts shall only be possible with voluntary action i.e. with the use of physical tools like screw driver to open the same.

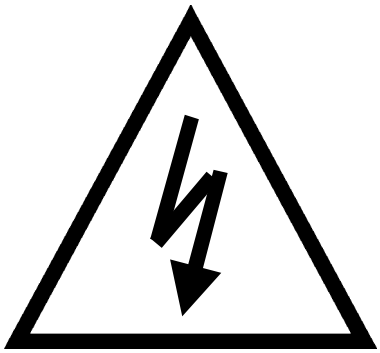
3.2.1.6 After opening the cover, the access to the parts of the coupling system shall be protected with IPXXB protection.

3.2.1.7 Protection degrees IPXXB and IPXXD are related respectively to the contact of a jointed test finger and a test wire with hazardous parts. Refer Annexure-1 for the test procedure.

3.2.1.8 Vehicle markings: Protection covers of live parts described in Paragraph **3.2.1.2** shall be marked by a symbol as shown below.

SYMBOL FOR THE INDICATION OF A VOLTAGE

(Reference to ISO 3864 and IEC 417 k Standards)



Black on a yellow ground

3.2.2 **Protection against indirect contacts with exposed conductive parts of the power train.**

3.2.2.1 If the working voltage of the electric circuit is lower than 60 V DC or 25 V AC, no requirements are necessary under clause 3.2.2.

3.2.2.2 The design, installation and manufacture of electric material shall be such that insulation failures are avoided. This shall be considered as a design guideline.

3.2.2.3 Insulation used shall ensure protection against indirect contacts and additionally, the exposed conductive parts of the on-board equipment shall be electrically connected together. This potential equalization is obtained by connecting the exposed conductive parts together either by a protective conductor e.g. wire, ground truss, or directly by the vehicle metallic chassis. Two exposed conductive parts welded together are considered as having no discontinuity points. If there is some discontinuity, this point shall be by-passed by potential equalization.

3.2.3 **Insulation Resistance of Traction Batteries**

3.2.3.1 The insulation resistance measurement is performed after maintaining the vehicle for a conditioning time of 8 hours with the following conditions :

Temperature:	20 to 35°C
Humidity:	90% + 10/-5%

3.2.3.2 Using a measuring DC voltage equal to the nominal voltage of the traction battery, insulation resistances between any exposed conductive part and each polarity of the traction battery shall have a minimum value of 500 Ω/V of the nominal voltage. (Refer Annexure-2 for details.)

3.2.3.3 Resistance of the Protective Conductor : The potential equalization resistance between any two exposed conductive parts shall be lower than 0.1 Ω. This test shall be performed by a current of at least 0.2 A after conditioning as mentioned in clause 3.2.3.1

3.2.4 **Connection of the vehicle to the mains network**

3.2.4.1 In no case the vehicle shall be capable to move by its own means when it is electrically connected to an energy supply network or to an off-board charger.

3.2.4.2 The components used when charging the battery from an external source shall allow the charging current to be cut without physical damage in case of disconnection.

This shall be checked by reconnection and ensuring that there is no fault in the system.

3.2.4.3 The coupling system parts likely to be live shall be protected against any direct contact in all operating conditions.

3.2.4.4 For on-board charger all exposed conductive parts, shall be electrically linked through a conducting wire plugged to earth when charging.

3.3 **Functional Safety Requirements**

3.3.1 **Power ON Procedure**

3.3.2 The power ON procedure shall be applied via a key switch.

3.3.3 It shall not be possible to remove this key in any position that energises the drive train or that makes active driving possible

3.3.4 Running and Stopping Conditions

3.3.5 At least a momentary, optical or audible indication shall be given to the driver when:

a) the vehicle is in "active driving possible mode"

OR

b) At least one further action is required to place the vehicle in "active driving possible mode".

There shall also be an indication to the driver when state of charge of the battery reaches a level where re-charging is recommended. When this condition is reached, the user shall be warned to perceive this situation quickly enough to be able to drive the vehicle, on its own power, at least out of the traffic zone. The manufacturers shall provide the information regarding the state of charge after the warning indication comes on.

There shall be an additional indication indicating that the state of charge of battery has reached a level at which driving the vehicle further may cause damage to the battery. This indication is not necessary if the emergency power reduction (para 3.3.12 below) takes into account this state of charge of battery. This shall be declared by the manufacturer.

3.3.6 Unintentional acceleration, deceleration and reversal of the drive train shall be prevented. In particular, a failure (e.g. in the power train) shall not cause more than 0.1 m movement of a standing un-braked vehicle on level road.

3.3.7 When leaving the vehicle, the driver shall be informed by an optical or audible signal if the drive train is still in the active driving possible mode.

This condition shall be deemed to be satisfied if the indication specified in 3.3.5 (a) above is not momentary and continues to be displayed.

3.3.8 **Reversing (in line with CMVR rule 99)**

3.3.9 Reversing shall be possible only after a specific action. This action shall require either :

a) The combination of two different actuations for example gear and clutch

Or

b) An electric switch, which allows reverse to be engaged only when the vehicle is moving at a forward speed not exceeding 5 km/h. It shall not be possible for the vehicle to move in reverse direction, if the switch is operated at any vehicle is moving forward at a speed beyond 5 km/h.

The device shall have only one stable position for achieving the reverse motion of the vehicle.

3.3.10 The state of the drive direction control unit shall be easily identifiable.

3.3.11 The maximum speed achieved in reverse direction shall not be more than 20 km/h.

3.3.12 **Emergency Power Reduction**

3.3.13 If the vehicle is equipped with a device to limit the performance in an emergency (e.g. overheating of a component) the user shall be informed by an obvious signal indicating state of limited performance.

3.3.14 **On-board charger**

3.3.14.1 The charger socket of the on-board charger shall have the time rating in addition to the ampere rating. The time rating shall be 5 h or the recommended time for charging fully discharged battery, whichever is higher. The charging socket shall be capable of withstanding the in-rush current and the continuous current rating of the socket shall be commensurate with the charging current.

3.3.14.2 The rated maximum and continuous duty specification of the power socket in terms of current, voltage etc. shall be declared by the manufacturer. These values shall be compatible with the specification of the onboard charger. The manufacturer shall certify compliance to these parameters.

The mains plug shall be compatible for use with sockets as per IS 1293 : 1988 or IS/IEC 309-2 (1989) or any equivalent.

3.3.14.3 On-board charger shall have soft start facility, limiting the initial in-rush current. The manufacturer shall specify the initial rush current and the time duration from the mains to the charger.

3.3.14.4 The charger shall have at least indication of 'charging in process' and 'charging is over. These conditions are deemed to be satisfied if the indicator for State of Charge of battery provided on vehicle takes care of this requirement.

3.4 **On-board Indicators**

3.4.1 All the indicators meant for the driver referred above shall be suitably located so as to be visible to the driver easily (e.g. on the dashboard).

Additionally, the battery-operated vehicle shall have the battery state of charge indicator.

For additional indications of temperatures like motor temperature, the existing water temperature symbol may be suitably modified.

3.5 **Protection against water effects**

The test as per 3.5.1, 3.5.2 and 3.5.3 shall be performed. After each exposure (vehicles still wet), the vehicle shall then comply with the insulation resistance test as in para 3.2.3.2 above, at normal environmental condition, but keeping the power equipment connected to the traction battery (main switch closed), with the requirements of at least 100 Ω/V.

3.5.1 **Washing**

This test is intended to simulate a normal washing of battery-operated vehicles, but not specific cleaning using high water pressure or underbody washing. The vehicle manufacturer shall specify detailed conditions for such specific cleaning or washing in the owner's manual. The critical areas of the vehicle regarding this test are border lines i.e. a seal of two parts as flaps, glass seals, outline of opening parts, outline of front grille, seals of lamps.
In the case of open vehicles such as 3-wheelers without doors and windows, or 2-wheelers etc the manufacturer shall specify the procedure for normal washing also. In such cases, the washing test shall be conducted by taking into account the above recommendation.

The test uses a hose nozzle according to IPX5 as specified in IEC 60529 (Refer Annexure-3 for details). Using fresh water with a flow rate of 12.5 l/min, all borderlines shall be exposed and followed in all directions with the water stream at a speed rate of 0.1 m/s, keeping a distance of 3 m between the nozzle aperture and the borderline.

3.5.2 **Flooding**

This test is intended to simulate the driving of a battery-operated vehicle on flooded streets or in water puddles.
The vehicle shall be driven in a wade pool, 10 cm in depth, over a distance of 500 m at a speed of 20 km/h resulting in a time of approximately 1.5 min.

If the wade pool used is less than 500 m in length, so that it has to be driven through several times, the total time including the periods outside the wade pool shall be less than 10 min.

3.5.3 **Heavy Rainstorm**

This test is intended to simulate a sudden heavy rainstorm e.g. a thunderstorm, when opening parts especially to access to the passenger, load and motor compartments are open except those requiring one or more tools.

In case of voltage class B equipment shielded from exposure to water, this test of the whole vehicle may be replaced by equivalent tests on the components individually.

The critical areas of the vehicle regarding this test are those accessible with opened opening parts.

This test uses a spray nozzle according to IPX3 as specified in IEC 60529.

Using fresh water with a flow rate of 10 l/min, all surfaces with normally open opening parts shall be exposed for 5 min, possibly through a regular movement of the spray nozzle.

Note : Voltage class B equipment is an equipment with nominal voltage (U)

DC: 60 V < U <= 1500 V

AC: 25 V rms < U < = 1000 V rms – 15 to 150 Hz

4.0 TECHNICAL SPECIFICATIONS

The details of technical specification, approvals of changes in specification shall be as per para 6.0 of AIS-049.

Annexure-1
Protection against direct contacts of parts under voltage
(Extract from the IEC 529 Standard (1989)

1	**Protection provided by an Enclosure Against Access to Hazardous Parts.** The protection of persons shall be given against : a) Contact with hazardous low-voltage live parts b) Contact with hazardous mechanical parts c) Approach to hazardous high-voltage live parts below adequate clearance inside an enclosure. **Note :** This protection may be provided : a) By means of the enclosure itself b) By means of barriers as part of the enclosure or distances inside the enclosure.
2	**Test for protection against access to Hazardous parts**
2.1	**Access Probes :** Access probes to verify the protection of persons against access to hazardous parts are given in Table 1.
2.2	**Test Conditions :** The access probe is pushed against any openings of the enclosure with the force specified in Table 1. If it partly or fully penetrates, it is placed in every possible position, but in no case shall stop face fully penetrate through the opening. Internal barriers are considered part of the enclosure as given in the definition. For tests on low-voltage equipment, a low voltage supply (or not less than 40 V and not more than 50 V) in series with a suitable lamp shall be connected between the probe and the hazardous parts inside the enclosure. Hazardous live parts covered only with varnish or paint, or protected by oxidation or by a similar process, are covered by metal foil electrically connected to those parts, which are normally live in operation. The signal circuit method shall also be applied to the hazardous moving parts of a high voltage equipment. Internal moving parts may be operated slowly, where this is possible.

2.3	**Acceptance Conditions :** The protection is satisfactory adequate clearance is kept between the access probe and hazardous parts. In the case of the test for the additional letter B, the jointed test finger may penetrate to its 80 mm length, but the stop face (ϕ 50 mm x 20 mm) shall not pass through the opening. Starting from the straight position, both joints of the test finger shall be successively bent through and 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. In case of the tests for the additional letter D, the access probe may penetrate to its full length, but the stop face shall not fully penetrate through the opening. Conditions for verification of adequate clearance are identical with those given in Paragraph 2.3.1 below
2.3.1	For low voltage equipment (rated voltages not exceeding 1,000 V AC and 1,500 V DC). The access probe shall not touch hazardous live parts. If adequate clearance is verified by a signal circuit between the probe and hazardous parts, the lamp shall not light.

TABLE – 1
ACCESS PROBES FOR THE TESTS FOR PROTECTION OF PERSONS

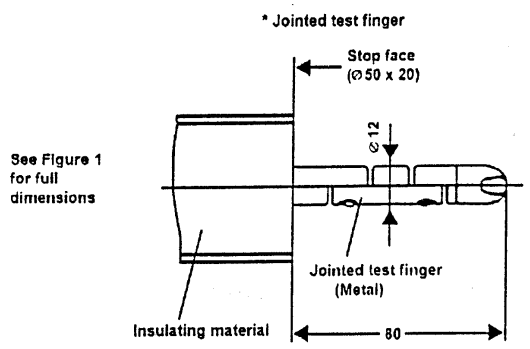
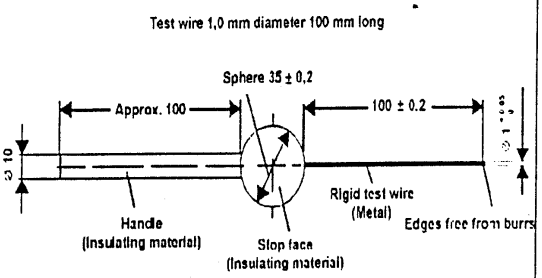
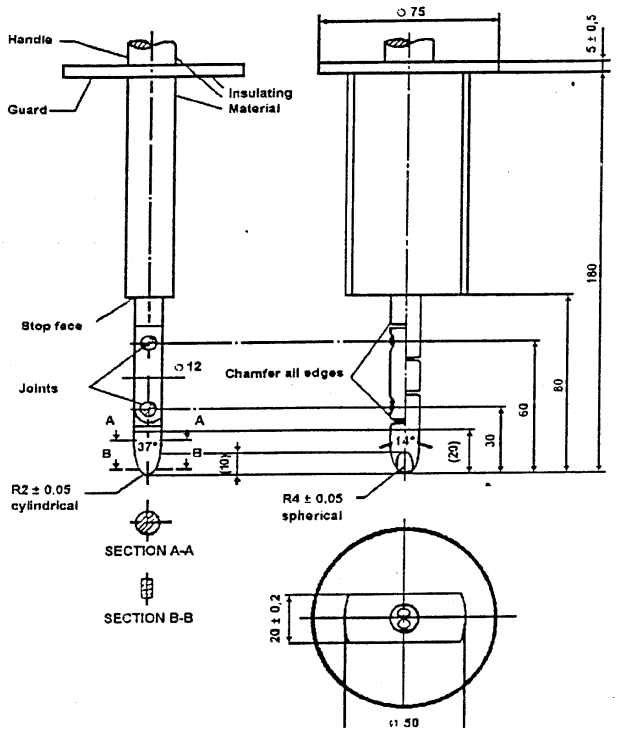
B		10 N ± 10%
D		1 N ± 10%

Figure 1
JOINTED TEST FINGER



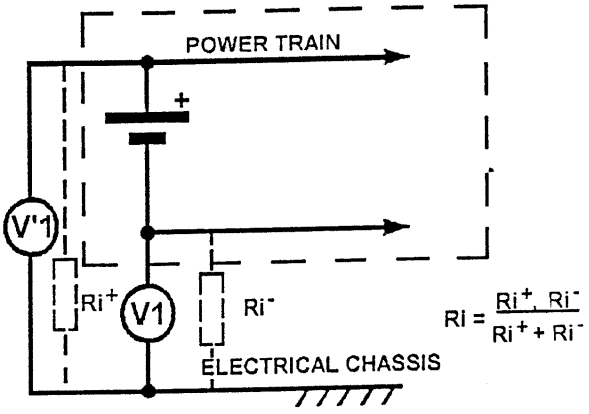
Please see Table-1 enclosed herewith.

Annexure-2

MEASUREMENT OF THE INSULATION RESISTANCE USING THE TRACTION BATTERY

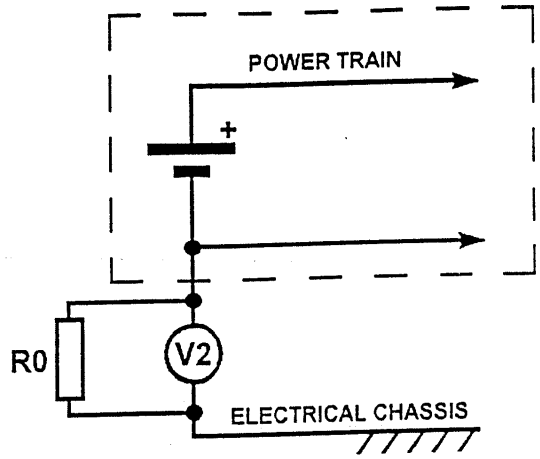
1	**Description of the test method :**
1.1	The traction battery shall be fully charged.
1.2	The voltmeter used in this test shall measure DC values and have an internal resistance greater than 10 Mohm.
1.3	Measurement shall be made in two steps :

Step One

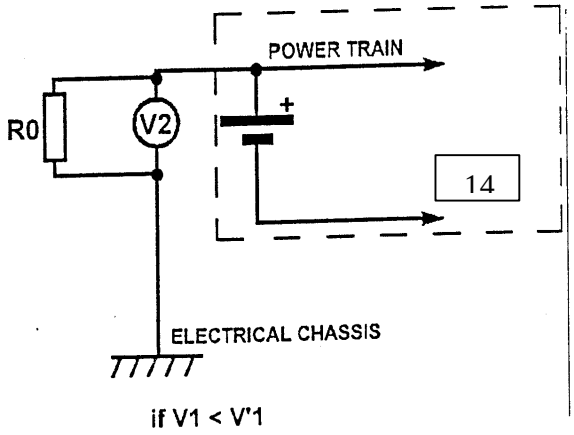


Measure V_1 and V'_1.

Step Two



if V1 > V'1



if V1 < V'1

Where RO is a resistance of 500 Ω/V

The value of the insulation resistance Ri is given by one of the formula:

$$Ri = \frac{V1-V2}{V2} \times Ro \quad \textbf{or} \quad Ri = \frac{V'1-V2}{V2} \times Ro$$

Annexure - 3

HOSE NOZZLE FOR THE TEST FOR PROTECTION AGAINST WASHING

This Annexure specifies dimensionally the hose nozzle to be used for IPX5 test procedure as specified in IEC 60529. (All dimensions are in mm.).

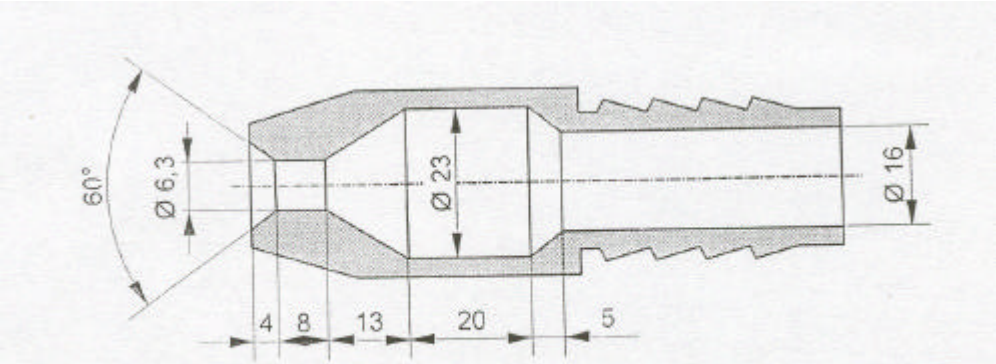


Figure A.1 - Hose nozzle dimensions

Annexure – 4
(See Introduction)
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