Amendment 3 to AIS-156 (09/2022)

Specific Requirements for L Category Electric Power Train Vehicles

1.0 Clause 6.1

Substitute following text for existing text:

6.1 **General**

6.1.1 **REESS Ingress protection requirement.**

REESS with 100% SoC shall be tested for water ingress protection IP X7 as per IEC 60529. There shall be no fire or explosion during IP X7 testing of REESS.

6.1.2 **Battery Management System (BMS) of REESS**

6.1.2.1 BMS shall be microprocessor/microcontroller-based circuit.

6.1.2.2 BMS shall comply EMC requirements as per AIS 004 Part 3 or AIS 004 Part 3 Rev 1 as applicable at ESA level.

6.1.2.3 BMS of REESS shall be verified for following safety features during REESS testing as per Annex 8 of this standard.

a) Over-charge protection

b) Over-discharge protection

c) Over-temperature protection:

d) Overcurrent protection

e) Short circuit protection

6.1.3 **Onboard/portable charger**

a) Charger shall have Charge voltage cut-off to avoid over charging of REESS

b) Charger shall have soft-start function every time REESS is connected for charging.

c) Charger shall have Pre-charge Function to detect deep discharge condition of REESS.

d) Charger shall have input supply variation (230 VAC +/- 10%) protection,.

e) Charger shall have earth leakage detection as per Class 1 of IS 12640

f) On-board/portable charger shall have communication with battery (BMS).

6.1.4 The procedures prescribed in Annex 8 of this Standard shall be applied.

2.0 Clause 6.11

Substitute following text for existing text:

6.11 **Thermal Propagation Test**

This procedure is added to evaluate the ability of REESS to withstand thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway and subsequent thermal propagation and shall not result in fire and explosion of REESS.

6.11.1 REESS manufacturer shall submit a risk reduction analysis using appropriate industry standard methodology (for example, IEC 61508, MIL-STD 882E, ISO 26262, AIAG DFMEA, fault analysis as in SAE J2929, or similar), which documents the risk to vehicle user and bystanders caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway and documents the reduction of risk resulting from implementation of the identified risk mitigation functions or characteristics.

6.11.2 REESS manufacturer shall submit a system diagram of all relevant physical systems and components. Relevant systems and components are those which contribute to the protection of vehicle user and bystanders from hazardous effects caused by thermal propagation triggered by a single cell thermal runaway.

6.11.3 REESS manufacturer shall submit a diagram showing the functional operation of the relevant systems and components, identifying all risk mitigation functions or characteristics.

6.11.4. REESS shall be tested for thermal propagation tests as per **Annex 8J.**

6.11.4.1 **Acceptance criteria**

a. During the thermal propagation test of REESS, there shall be no evidence of fire and explosion triggered by a single cell thermal runaway.

b. REESS shall have audio visual warning for early detection of thermal event/gases in case of thermal run away of cells. This warning shall be activated at least 5 minutes prior to thermal propagation such as fire and explosion occurs.

3.0 Annex 8J and 8K

Substitute existing Annex 8J and Annex 8K with following text:

ANNEX 8J (See 6.11)

THERMAL PROPAGATION TEST

1.0 THERMAL PROPAGATION

In order to ensure the overall safety of vehicles equipped with a REESS, the vehicle user and bystanders should not be exposed to the hazardous environment resulting from a thermal propagation (which is triggered by a single cell thermal runaway due to an internal short circuit).

Heating initiation methods shall be used to verify that the hazard of the thermal propagation is prevented or eliminated by design and shall not result in fire and explosion of REESS. Single cell over-charging method can be employed if heating method is not technically feasible. (Test procedure as per AIS 038 Rev 2 can be referred)

2.0 THERMAL PROPAGATION TEST

The test shall be conducted in accordance with paragraph 3.

(a) If no thermal runaway occurs, the tested device meets thermal propagation requirement for the heating method of initiating thermal runaway.

(b) If thermal runaway occurs: If no external fire or explosion occurs, the tested device meets thermal propagation requirement. The observation shall be made by visual inspection without disassembling the Tested-Device;

3.0 TEST PROCEDURES

3.1 Purpose

The purpose of the thermal propagation test is to ensure the user and bystander safety from a vehicle if thermal runaway occurs in the battery system.

3.2 Installations

This test shall be conducted with the complete REESS or with related REESS subsystem(s) including the cells and their electrical connections. If the manufacturer chooses to test with related subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. In case the electronic management unit (Battery Management Systems (BMS) or other devices) for the REESS is not integrated in the casing enclosing the cells, it must be operational.

3.3 Procedures

3.3.1 General test conditions

The following condition shall apply to the test:

(a) The test shall be conducted at temperature: 25 ± 2 °C;

(b) A standard cycle as per ANNEX 8 – APPENDIX 1 shall be done on REESS. At the beginning of the test, the state of charge (SOC) shall be adjusted not less than 95% SOC.

(c) At the beginning of the test, all test devices shall be operational;

(d) The test may be performed with a modified Tested-Device which is intended to minimize the influence of modification. The manufacturer should provide a modification list;

(e) The test shall be conducted at an indoor test facility or in a shelter to prevent the influence of wind.

3.3.2 **Initiation method**

Cell Heating methods used to initiate the thermal runaway of a single cell.

Use a block heater, film heater or other heating device to initiate thermal runaway. In the case of a block heater of the same size of the component cell, one of the component cells is replaced with the heater. In the case of a block heater that is smaller than a component cell, it can be installed in the module contacting the surface of the initiation cell. In the case of a film heater, it shall be attached on the initiation cell surface.

Heating: Heating shall be conducted with the following conditions:

(i) Shape: Plate or rod heater covered with ceramics, metal or insulator shall be used. Heating area of heater contacting the cell shall not be larger than area of cell surface wherever possible;

(ii) Heating procedure: After installation, the heater should be heated up to its maximum power. Stop the initiation when the thermal runaway occurs or the measured temperature following 3.3.2 is over [300 °C]. The stop of initiation by heating should be reached within [30min];

(iii) Set position: Heating area of the heater is directly contacting the cell surface. Set the heater to conduct its heat to initiation cell. The heater position is correlated with the temperature sensor position, which is described in 3.3.6.

If no thermal runaway occurs and the heating test is stopped, refer to paragraph 1 and 2 of this Annexure.

3.3.3 **Detection of thermal runaway**.

Thermal runaway can be detected by the following conditions:

(i) The measured voltage of the initiation cell drops;

(ii) The measured temperature exceeds [the maximum operating temperature defined by the manufacturer];

(iii) dT/dt ≥ [1 °C/s] of the measured temperature.

Thermal runaway can be judged when:

(a) Both (i) and (iii) are detected; or

(b) Both (ii) and (iii) are detected.

If no thermal runaway occurs and the test stops, refer to paragraph 1 and 2 of this Annexure.

The definition of the measured temperature is in paragraph 3.3.6.

3.3.4 **Initiation method**

Heating initiation method is selected here for this test.

3.3.5 **Selection of initiation cell**

Select an initiation cell, which is accessible by the selected trigger method described in paragraph 3.3.2. and also whose heat generated by thermal runaway is most easily conducted to adjacent cells. For example, select the cell that is the nearest to the centre of battery casing or the cell that is surrounded by other cells which makes it difficult for the triggered cell to dissipate heat.

3.3.6 **Measurement of voltage and temperature**

Measure the voltage and temperature in order to detect thermal runaway of the initiation cell.

In measuring voltage, the original electric circuit shall not be modified.

The measured temperature means the maximum temperature of Temperature A, as defined below. The accuracy of the temperature sensor shall be within ± 2 °C, and the sampling interval should be less than 1 s. The diameter of the tip of the sensor shall be less than 1 mm.

Temperature A: The maximum surface temperature of the initiation cell measured during the test.

Note: As for the set-up using a heater, place a temperature sensor on the far side of heat conduction, for example, an opposite side of the position where heater is placed (see Figure 1). If it is difficult to apply the temperature sensor directly, place it at the location where the continuous temperature rise of initiation cell can be detected.

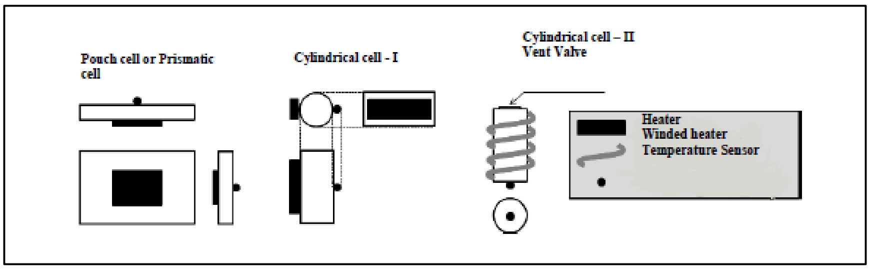

Figure 1

Example of set positions of heater and temperature sensor in Heating method

Annexure 8 K

Technical Requirements for Traction Battery (REESS) of L Category Electric Power Train Vehicles

0. The Traction Battery Pack (REESS) design and manufacture guidelines as specified in this Annexure, to be followed by REESS manufacturer. Same shall be verified by test agency at the time of type approval and CoP of REESS

1. The manufacturing date of battery cells shall be clearly visible on the cells used to build REESS, with clear month and year of manufacture (format mmyyyy). REESS manufacturer shall print clearly visible manufacturing date on the battery pack. If manufacturing date is in the form of code on the cells, then REESS manufacturer shall print manufacturing date on the REESS pack and shall maintain record of manufacturing date(s) of cells used in the assembly of pack.

2. Cells used to make REESS, shall be certified as per as per IS 16893-Part 2 and Part 3 by NABL accredited lab or by test agency notified under CMV Rule 126.

3. Cells used to make REESS, shall undergo minimum 1 cycle of charge-discharge at C/3 current rate. Data of this cycling shall be maintained by REESS pack manufacturer.

4. REESS shall have pressure release vent provided, to avoid building up of internal pressure and release of gases in case internal single cell short circuit.

5. REESS shall have at least 4 temperature sensors in the battery pack to measure the cells temperature and decision thereon by battery management system (BMS). The position of the temperature sensors shall be appropriately placed to obtain the true temperature values. In case the temperature crosses 60 °C an audio-visual alarm shall come as an alert, and if the vehicle is in use, BMS shall gradually cut off the traction battery power supply to the motor.

6. REESS shall have Active paralleling circuits for the parallel connection of strings to eliminate circulating currents. These power semiconductor devices used for interconnecting strings will also act as protection/safety switches which will detect any faulty strings and isolate them. They will allow bidirectional flow of currents to charge and discharge the pack. The parallel strings will get isolated if it is detected to be faulty. Therefore, active paralleling circuits shall be mandatory in

the battery packs or circulating current mitigation techniques shall be adopted.

Alternatively, fuses / bond wires can also be used to prevent circulating currents flowing through the cells connected in parallel. Such precautionary devices will help in isolation of faulty cells connected in parallel.

7. Sufficient cell-to-cell spacing distance shall be maintained for effective heat transfer from the cell and also to isolate the cells in case of thermal run away in REESS. The inter cell gap in REESS shall be decided based on the type of cell geometry used viz., cylindrical, prismatic or pouch and capacity of cells.

8. REESS shall have additional safety fuse or circuit breaker in addition to the features available in Battery Management System (BMS).

9. Each REESS manufactured shall have a traceability document in which the details of cells, BMS, charger used along with serial/batch number, charge discharge data values etc shall be maintained with the REESS manufacturer.

10. Adequate protection of cells in case of regenerative braking shall be considered in REESS design.

11. Data of critical parameters of battery pack shall be logged by BMS and latest data for at least one month shall be maintained. Alternatively, latest data also can be stored on cloud (remote server) at least for one month.