SAE International™ SURFACE VEHICLE STANDARD

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Electric and Hybrid Vehicle Propulsion Battery System Safety Standard - Lithium-based Rechargeable Cells

RATIONALE

Existing propulsion battery system safety documents define evaluation methods and make recommendations for battery system performance. They do not define specific pass/fail safety performance criteria. In order to provide consistency within the industry which supports innovation and public confidence, such criteria are necessary.

1. SCOPE

This SAE Standard defines a minimum set of acceptable safety criteria for a lithium-based rechargeable battery system to be considered for use in a vehicle propulsion application as an energy storage system connected to a high voltage power train. While the objective is a safe battery system when installed into a vehicle application, this Standard is primarily focused, wherever possible, on conditions which can be evaluated utilizing the battery system alone. As this is a minimum set of criteria, it is recognized that battery system and vehicle manufacturers may have additional requirements for cells, modules, packs and systems in order to assure a safe battery system for a given application.

A battery system is a completely functional energy storage system consisting of the pack(s) and necessary ancillary subsystems for physical support and enclosure, thermal management, and electronic control.

1.1 Purpose

This SAE Standard should assure that a battery pack can safely be integrated into an electric or hybrid vehicle. Specifically, it is designed to assure that a single point fault will not result in fire, explosion, battery enclosure rupture or high voltage hazard. This Standard includes tests that simulate "normal" conditions and "off-normal" conditions that, although infrequent, may occur during service life. Pass/fail criteria are assigned to each test.

1.2 Future Considerations

In order to expedite the release of the first version of this Standard, several topic areas were deferred for consideration in future revisions. These items include, but may not be limited to, the following:

- Expanded flammability/thermal propagation considerations
- Enhanced definition of flammability test condition
- Expanded enclosure integrity test conditions

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- Potential toxicity of vented materials under certain failure conditions
- Expanded compatibility with other related global standards
- Electromagnetic compatibility

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1715 FEB2008 Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology

SAE J1766 APR2005 Recommended Practice for Electric and Hybrid Electric Vehicle Battery Systems Crash Integrity Testing

SAE J2380 MAR2009 Vibration Testing of Electric Vehicle Batteries

SAE J2464 NOV2009 Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing

2.1.2 IEC Publications

Available from International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41-22-919-02-11, www.iec.ch.

IEC60068-2-30 Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle). Third Edition, 2005-08-01

2.1.3 ISO Publications

Available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

ISO 20653 Road vehicles - Degrees of protection (IP-Code) - Protection of electrical equipment against foreign objects, water and access. First Edition, 2005-08-15

ISO 6469-1 Electrically propelled road vehicles - safety specifications - Part 1: On-board rechargeable energy storage systems (RESS). Second Edition, 2009-09-15

ISO/DIS 6469-3.2 Electrically propelled road vehicles - safety specifications - Part 3: Protection of persons against electric shock. Revision of First Edition, 2010-07-23

2.1.4 UNECE Publications

Available from UN Economic Commission for Europe, Information Service, Palais des Nations, CH-1211 Geneva 10, Switzerland, Tel: +41-0-22-917-44-44, www.unece.org.

Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, 5th Revised Edition, 2009. ST/SG/AC.10/11/Rev. 5

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2.1.5 United States Publications

Available from National Highway Traffic Safety Administration-Department of Transportation, 1200 New Jersey Avenue, SE, West Building, Washington, DC 20590, Tel. 1-888-327-4236, www.nhtsa.gov.

FMVSS 305 Federal Motor Vehicle Safety Standard No. 305 Electric-Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection, June 14, 2010

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1739 JAN2009 Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)

SAE J2579 JAN2009 Technical Information Report for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles

2.2.2 UL Publications

Available from Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-664-3480, www.ul.com.

UL 1642 Standard for Lithium Batteries, 4th Edition, September 19, 2005

2.2.3 UNECE Publications

Available from UN Economic Commission for Europe, Information Service, Palais des Nations, CH-1211 Geneva 10, Switzerland, Tel: +41-0-22-917-44-44, www.unece.org.

Regulation No. 34 Uniform Provisions Concerning the Approval of Vehicles with Regard to the Prevention of Fire Risks, February 19, 2010

2.2.4 United States Publications

Available from National Highway Traffic Safety Administration-Department of Transportation, 1200 New Jersey Avenue, SE, West Building, Washington, DC 20590, Tel. 1-888-327-4236, www.nhtsa.gov.

FMVSS 304 Federal Motor Vehicle Safety Standard No. 304 Compressed Natural Gas Fuel Containers, October 30, 2000

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3. DEFINITIONS

Except as noted below, all definitions are in accordance with SAE J1715.

BATTERY CELL RUPTURE: Loss of mechanical integrity of the cell housing, resulting in release of contents. The kinetic energy of released material is not sufficient to cause physical damage external to the battery system

BATTERY CONTROL FUNCTION: The physical and/or functional portion of a battery system which monitors battery state (voltage, temperature, current) and controls the connection/disconnection of the battery system to the rest of the high voltage system.

BATTERY ENCLOSURE: The physical housing surrounding battery system components, particularly battery cells and modules.

BATTERY ENCLOSURE RUPTURE: Openings through the battery enclosure which are rapidly created or enlarged by an event and which are sufficiently large for a 50 mm diameter sphere to contact battery system internal components (see ISO20653, IPXXA).

CHARGE/DISCHARGE CONTROL FUNCTION: The physical and/or functional portion of a battery system which controls the amount of energy and power flow into and out of the battery system.

DISCONNECT: A condition in which the battery system is deliberately disconnected from external circuitry, as for example by an automatic disconnect device. Such disconnect normally requires that both the positive and negative HV source leads be disconnected in order to isolate the battery system from propulsion system and other external circuits.

ELECTRICAL ISOLATION: The electrical resistance between the vehicle high-voltage system and any vehicle conductive structure.

FIRE: The emission of flames from a battery (approximately more than 1 s). Sparks are not flames.

EXPLOSION: Very fast release of energy sufficient to cause pressure waves and/or projectiles that may cause considerable structural and/or bodily damage.

LITHIUM-BASED RECHARGEABLE CELLS: Rechargeable battery cell chemistry in which lithium ion is the charge carrier.

RESPONSIBLE ORGANIZATION: The organization which is responsible for overseeing the required tests and assuring the propriety of the tests and results. Examples are vehicle or battery system manufacturers or independent test authorities.

VENTING: The release of excessive internal pressure from a RESS cell, module or pack in a manner intended by design to preclude rupture or explosion.

4. TECHNICAL REQUIREMENTS

4.1 General Requirements and Considerations

4.1.1 Common Test Conditions

Except where specifically noted to the contrary, battery state of charge (SOC) shall be at the maximum which is possible during normal vehicle operation and battery temperature shall be 25 °C ± 5 °C prior to initiation of the test. If the responsible organization is aware that a different temperature within the normal operating temperature range of the battery system may represent a more severe condition, the responsible organization shall alternatively specify this temperature. If the responsible organization is aware that a different SOC within the normal operating range of the battery system may represent a more severe condition, the responsible organization shall alternatively specify this SOC.

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Unless otherwise stated, re-use of the battery system and/or components in multiple evaluations is acceptable at the discretion of the responsible organization.

Unless otherwise stated, all battery system electronic control modules are to be connected and in either the “operational” or “off” state during testing, as determined by the responsible organization.

4.1.2 Data Collection

All data necessary for assessing conformance to the requirements included in this Standard shall be collected. Additional data, as suggested by a referenced test procedure or as determined by the responsible organization, may be collected at the discretion of the responsible organization.

4.1.3 Subsystem Testing

All tests specified within this Standard are intended to apply to a complete battery system and the responsible organization is strongly encouraged to conduct these tests using a complete battery system. However, if, in the judgment of the responsible organization, a complete battery system test is not appropriate, subsystem testing may be conducted instead. Unless otherwise indicated, the responsible organization shall define and document the specific subsystems to be tested in order to achieve the system requirement and meet the intent of the test. A subsystem should consist of the set of components that in a complete battery assembly are thermally, mechanically and/or electrically connected such that the subsystem behavior accurately replicates the complete battery system behavior for the specific test.

4.1.4 Design Changes

In the case of a revised battery system design, conformance to this Standard must be re-tested for all conditions where the changes in the design potentially change safety performance. The responsible organization shall make this determination. Use of subsystem testing, as described above, would also apply to this situation.

4.1.5 Additional Observation Period

For all test conditions in this Standard in which battery system temperatures increase above ambient as a result of the test condition, temperature shall be monitored during the test and any post-test observation period. If, at the end of the prescribed observation period, the temperature is not decreasing and approaching ambient temperature, the observation period shall be extended until such time as temperature is decreasing toward ambient. In this case, the extended observation period shall be considered to be part of the test and all requirements shall be met during this time.

4.1.6 Safety

The responsible organization and all organizations involved in conducting tests outlined in this Standard are cautioned that many of the tests and conditions may result in hazardous conditions both during the test and with the test article following the test. Proper care should be taken to protect personnel and property during the test and afterward. If appropriate, battery system external surface temperatures may be monitored and test personnel advised to avoid direct contact with the test article until the battery system has reached near ambient temperatures. In some instances, hazardous conditions may not be evident until an extended period of time has passed.

If, in the judgment of the responsible organization, a test cannot be conducted while maintaining the safety of test personnel, rationale for not conducting the test shall be provided and documented. Documentation shall include analysis demonstrating the expected results of the battery system, had the test been performed.

4.1.7 Vent System Considerations

For battery systems that are equipped with a vent or a vent system, adequate design considerations should be made to mitigate any external displacement of flammable, corrosive, and/or toxic materials from the battery system. Vented materials fitting this description are normally reported on a Material Safety Data Sheet (MSDS).

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4.2 Normal Operation

4.2.1 General

The following requirements, related to normal operating conditions, are intended to ensure a safe battery system under typical vehicle environmental use conditions. A battery system is assumed to meet quality, reliability and durability (QRD) requirements appropriate for the application, which are beyond the scope of this Standard.

4.2.2 Vibration

Rationale: This condition simulates a vibration environment which a battery system will likely experience during its life.

The battery system shall meet the applicable requirements when tested according to one of the following two alternatives.

4.2.2.1 Alternative 1: Complete Battery System Vibration Test

Condition: The complete battery system is to be tested in accordance with one of the following options: the vibration profile defined in UN Test Manual, Test T.3; or the vibration profile defined in SAE J2380; or a profile from the responsible organization which reflects the actual application. Note that, while battery modules or sections may be individually tested in accordance with UN requirements, a complete battery system is to be tested for this condition, except as allowed per 4.2.2.2.

The following exceptions/clarifications apply to SAE J2380:

- Battery state of charge shall be at the maximum which is possible during normal vehicle operation throughout the entire test sequence.

Requirements: Prior to the test, during the test and for a 1 h post-test observation period, the battery system shall exhibit no evidence of venting outside of battery enclosure or venting system, battery enclosure rupture, fire, or explosion, and shall maintain high voltage to ground isolation no less than 100 Ω/V. Isolation measurement is to be done in accordance with ISO 6469-1, Section 6.1.3; or equivalent. Post-test pack open circuit voltage shall be no less than 90% of the pre-test pack open circuit voltage. Post-test visual inspection of battery system internal components shall identify no evidence, as a result of the test, of cracked, damaged or loosened high voltage conductors which are part of the primary power current path.

4.2.2.2 Alternative 2: Battery Subsystem Vibration Test

The battery system and its subsystems shall meet the requirements of both Part A and Part B below.

4.2.2.2.1 Part A

Condition: Components or subsystems of the battery system, as defined by the responsible organization, are to be tested in accordance with one of the following options: the vibration profile defined in UN Test Manual, Test T.3; or the vibration profile defined in SAE J2380; or a profile from the responsible organization which reflects the actual application. The responsible organization shall define the specific components or subsystems to be tested in order to achieve the system requirement. A subsystem should consist of the set of components that, in a complete battery system, are mechanically and electrically connected such that a vibration would be faithfully transmitted to the device under test

Requirements: During the test and for a 1 h post-test observation period, the components or subsystems shall exhibit no evidence of fire or explosion. The responsible organization shall determine what, if any, additional test requirements are necessary, based on the component or subsystem tested.

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4.2.2.2.2 Part B

Condition: The complete battery system shall be tested as part of a vehicle level vibration test where the battery system is subject to conditions that are appropriate to the vehicle's operation. The responsible organization shall define the appropriate vibration testing profile which reflects actual application.

NOTE: For vehicle testing, the battery SOC and temperature shall be that of normal vehicle operation for the ambient conditions during the vehicle test and shall not be artificially restricted.

Requirements: Prior to the test, during the test and for a 1 h post-test observation period, the battery system shall exhibit no evidence of venting outside of battery enclosure or venting system, battery enclosure rupture, fire, or explosion, and shall maintain high voltage to ground isolation no less than 100 Ω/V. Isolation measurement is to be done in accordance with ISO 6469-1, Section 6.1.3; or equivalent. Post-test pack open circuit voltage shall be no less than 90% of the pre-test pack open circuit voltage. Post-test visual inspection of battery system internal components shall identify no evidence, as a result of the test, of cracked, damaged or loosened high voltage conductors which are part of the primary power current path.

4.2.3 Thermal Shock

Rationale: This condition simulates a rapid temperature change environment which a battery system will likely experience during its life.

Condition: The complete battery system is to be tested in accordance with one of the following options: UN Test Manual, Test T.2; or the thermal shock profile defined in SAE J2464, Section 4.4.4. Note that, while battery modules or sections may be individually tested in accordance with UN requirements, a complete battery system is to be tested for this condition, except as allowed per 4.1.3.

Requirements: Prior to the test, during the test and for a 1 h post-test observation period, the battery system shall exhibit no evidence of venting outside of battery enclosure or venting system, battery enclosure rupture, fire, or explosion, and shall maintain high voltage to ground isolation no less than 100 Ω/V. Isolation measurement is to be done in accordance with ISO 6469-1, Section 6.1.3; or equivalent. Post-test pack open circuit voltage shall be no less than 90% of the pre-test pack open circuit voltage. Post-test visual inspection of battery system internal components shall identify no evidence, as a result of the test, of cracked, damaged or loosened high voltage conductors which are part of the primary power current path.

4.2.4 Humidity/Moisture Exposure

Rationale: This condition simulates a temperature/humidity environment which a battery system will likely experience during its life.

Condition: The complete battery system is to be tested in accordance with IEC 60068-2-30 with a severity of 55 °C with 6 cycles, utilizing Variant 1 during the temperature lowering period.

Requirements: Prior to the test and during the test, including the defined recovery period, the battery system shall exhibit no evidence of venting outside of battery enclosure or venting system, battery enclosure rupture, fire, or explosion, and shall maintain high voltage to ground isolation no less than 100 Ω/V. Isolation measurement is to be done in accordance with ISO 6469-1, Section 6.1.3; or equivalent. Post-test pack open circuit voltage shall be no less than 90% of the pre-test pack open circuit voltage. Post-test visual inspection of battery system internal components shall identify no evidence, as a result of the test, of cracked, damaged or loosened high voltage conductors which are part of the primary power current path.

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4.3 Drop Test

Rationale: This condition simulates a service condition where the battery system is removed (or being removed) from the vehicle and is dropped while separate from the vehicle.

Condition: The complete battery system is to be tested in accordance with SAE J2464, Section 4.3.2, with the following exceptions/clarifications:

- Drop surface shall be:
  - integral and massive enough to be immovable;
  - horizontally flat with a surface free from local defects capable of influencing the test results;
  - rigid enough to be non-deformable under test conditions and not liable to become damaged by the test; and
  - sufficiently large to ensure that the battery system falls entirely upon the surface.
- The battery system shall be oriented in such a way to represent the most likely impact orientation based on battery system size, shape, installation location and usage. The responsible organization shall develop and document the rationale for the selected orientation. If the judged most likely orientation is a flat drop impacting the bottom surface, the test shall instead be conducted at the second most likely orientation.
- State of charge shall be the maximum level specified by the user/manufacturer for service situations, if different from the level defined in 4.1.1.
- If battery removal requires the attachment of a tool/fixture, prior to removal from the vehicle, which remains affixed to the battery while separated from the vehicle, the tool/fixture may be included as part of the drop test.
- The drop height shall be the maximum distance to ground or maximum possible drop distance which the battery system experiences when serviced according to documented procedures, but not less than 1 m.

Requirements: During the drop test and for a 1 h post-drop observation period, the battery system shall exhibit no evidence of fire, or explosion.

4.4 Immersion Test

Rationale: This condition simulates a situation in which a vehicle is flooded.

Condition: The complete battery system is to be tested in accordance with SAE J2464, Section 4.3.5, with the following exceptions/clarifications:

- Contactors are to be closed at start of test and all vehicle interface connections, including high voltage, low voltage, electronic signals, and thermal management system, are in place to simulate vehicle in use condition.
- Contactor control and battery monitoring system are connected and operational. All battery system electronic control modules are to be connected and in the “operational” power state.
- The battery system shall be fully submerged within 5 min following initial contact with the water.

Requirements: During the test, the battery system shall exhibit no evidence of battery enclosure rupture, fire, or explosion.

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4.5 Mechanical Shock

Rationale: This condition simulates inertial loads which may occur during a vehicle crash situation.

The battery system shall meet the requirements in 4.5.3 when tested according to one of the following two alternatives.

4.5.1 Alternative 1: Battery System-Level Evaluation

Condition: The complete battery system is to be tested, with the following exceptions/clarifications, in accordance with one of the following options: UN Test Manual, Test T.4; or SAE J2464, Section 4.3.1.

Exceptions/Clarifications:

- Evaluations, one repetition each, are to be conducted in the positive and negative directions of the primary vehicle longitudinal and lateral axes, as installed, for a total of 4 separate evaluation conditions. It is not required that all evaluation conditions be conducted on a single test sample.
- Battery system shall be firmly secured to the test fixture.

Note that, while battery modules or sections may be individually tested in accordance with UN requirements, a complete battery system is to be tested for this condition, except as allowed per 4.1.3.

NOTE: For battery systems with mass >100 kg, shock test may need to occur using crash simulation sled, or similar device.

4.5.2 Alternative 2: Vehicle-Level Evaluation

Condition: The complete battery system is to be assessed following vehicle tests simulating front, rear and side impacts, as defined in FMVSS 305, S6.1, 6.2, 6.3 with the following exceptions/clarifications:.

- Battery state of charge (SOC) shall be at the maximum which is possible during normal vehicle operation and battery temperature shall be 25 °C ± 5 °C.

4.5.3 Requirements

The following requirements are to be met following the test for either alternative selected.

During the test and for a 1 h post-test observation period, the battery system shall exhibit no evidence of battery enclosure rupture, fire, or explosion and shall maintain high voltage to ground isolation no less than 100 Ω/V. Isolation measurement is to be done in accordance with ISO 6469-1, 6.1.3; or equivalent. For Alternative 2, the battery system shall be retained at its mounting location (per SAE J1766, Section 4.4.2).

4.6 Battery Enclosure Integrity

Rationale: This condition simulates contact loads which may occur during a vehicle crash situation.

The battery system shall meet the requirements in 4.6.4 when tested according to one of the following three alternatives.

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4.6.1 Alternative 1: Battery System-Level Evaluation - Application-Specific

Condition: The complete battery system is to be tested in accordance with SAE J2464, Section 4.3.6, with the following exceptions/clarifications:

- Crush condition shall simulate the expected battery enclosure intrusion for each of the conditions defined in FMVSS 305, S6.1, 6.2, and 6.3. (Note: If, due to battery packaging location, no battery enclosure deformation is expected during these conditions, this requirement is presumed to be met. The responsible organization shall be responsible to make and document this conclusion.)

- Battery state of charge (SOC) shall be at the maximum which is possible during normal vehicle operation and battery temperature shall be 25 °C ± 5 °C.

- Magnitude, direction, location, and loading surface size and shape of crush shall simulate an in-vehicle crash condition, as determined by the responsible organization.

- If vehicle structure is used as part or all of the battery enclosure, then that vehicle structure shall be included in the test.

4.6.2 Alternative 2: Battery System-Level Evaluation - Generic

Condition: The complete battery system is to be tested in accordance with SAE J2464, Section 4.3.6, with the following exceptions/clarifications:

- The extent of crush specified in SAE J2464, Section 4.3.6.1 is not applicable.

- The crush shall continue until a force of 100 kN is achieved.

4.6.3 Alternative 3: Vehicle-Level Evaluation

Condition: The complete battery system is to be assessed following vehicle tests simulating front, rear and side impacts, as defined in FMVSS 305, S6.1, 6.2, 6.3 with the following exceptions/clarifications:

- Battery state of charge (SOC) shall be at the maximum which is possible during normal vehicle operation and battery temperature shall be 25 °C ± 5 °C.

4.6.4 Requirements

The following requirements are to be met following the test for any alternative selected.

During the test and for a 1 h post-test observation period, the battery system shall exhibit no evidence of battery enclosure rupture, fire, or explosion and shall maintain high voltage to ground isolation no less than 100 Ω/V. Isolation measurement is to be done in accordance with ISO 6469-1, 6.1.3; or equivalent. For Alternative 3, the battery system shall be retained at its mounting locations (per SAE J1766, Section 4.4.2).

4.7 Exposure to Simulated Vehicle Fire

Rationale: This condition simulates exposure to a vehicle fire condition to verify that the battery system does not pose additional risk due to explosion.

Condition: The complete battery system is to be subjected to a high temperature heat and flame environment until the battery system is fully involved in the fire. The external heat and flame source is removed once this condition is achieved and the battery system is allowed to continue burning. The test is completed and the post-test observation period begins when there is no longer visible flame.

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The responsible organization shall define the specific details of the test protocol, considering the intended purpose of this evaluation, battery system design and location, facility availability, and the safety of test personnel and equipment. The test apparatus described in SAE J2464 (Section 4.4.1), ECE R34 (Annex 5, Sections 5.3-5.8), SAE J2579 (Appendix C.8), or FMVSS 304 (S8.3) may be useful references while defining the test protocol.

Requirements: During the test and for a 1 h post-test observation period, the battery system shall not cause a battery system component or any portion of a component to penetrate a wire mesh screen (annealed aluminum wire with a diameter of 0.25 mm and grid density of 6 to 7 wires per cm) which surrounds the battery system, is placed no farther than 200 cm away from the battery system and extends 350 cm above the top surface of the battery system. See Figure 1. The wire mesh screen shall be mounted such that the mesh does not move upon impact in a way which would influence the results.

NOTE: The wire mesh screen description is similar to the description used in other standards for assessing the behavior of batteries (Reference UL 1642 or UN Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, for example).

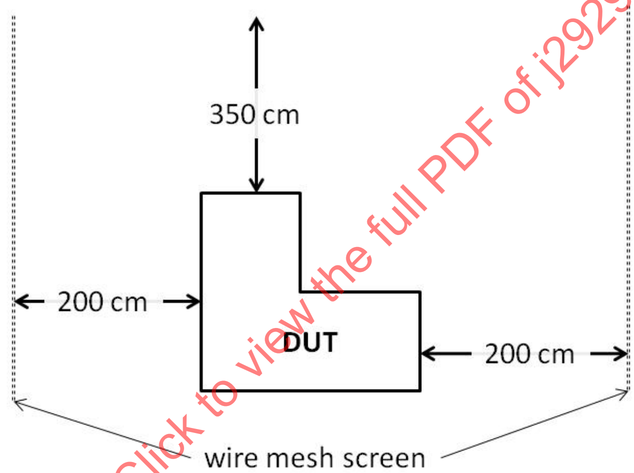

FIGURE 1 - WIRE MESH SCREEN POSITION (SIDE VIEW)

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4.8 Electrical Short Circuit

Rationale: This condition simulates a short circuit condition across the battery terminals.

Condition: The complete battery system is to be tested, with the listed exceptions/clarifications, in accordance with one of the following options: UN Test Manual, Test T.5; or the pack hard short circuit condition defined in SAE J2464, Section 4.5.1.

Exceptions/Clarifications:

- The evaluation called out in SAE J2464, Section 4.5.1, which disables or bypasses protection devices is not to be included.
- All battery system electronic control modules are to be connected and in the “operational” state during testing.
- To assess the presence of flammable gas in sufficient quantity to ignite, a spark source or gas concentration measuring device is required at a minimum of one location. Location is to be selected to represent the location of highest potential for gas leaks, as determined by the responsible organization.

Note that, while battery modules or sections may be individually tested in accordance with UN requirements, a complete battery system is to be tested for this condition.

Requirements: The battery system shall exhibit no evidence of fire, battery enclosure rupture, or explosion. In the event that a gas concentration measuring device is used, flammable gas concentration shall not exceed the lower flammability limit in air.

4.9 Single Point Overcharge Protection System Failure

Rationale: This condition simulates the condition where the battery system charge device is no longer being controlled and the failure may allow the battery system to be overcharged.

Condition: Charge the battery system at the maximum possible charge rate for the application. (If passive over-current circuit protection is below this current, conduct test at maximum current compatible with passive protection device.) Maximum voltage shall be limited to charging device output limit. Continue charging until the charge device voltage is reached or the connection interface disconnects battery from charge device.

The battery system is to be operated under normal operating conditions with the cooling system operating, if it normally would be operating for all charging conditions. The connection interface (e.g., main contactors) which connects the battery system to the charge device is to be controlled by the Battery Control Function. Integrated, passive circuit protection devices are operational. Active charge control (i.e., Charge/Discharge Control Function) shall be disabled/disconnected from the charge device. See Figure 2 for illustrative example.

To assess the presence of flammable gas in sufficient quantity to ignite, a spark source or gas concentration measuring device is required at a minimum of one location. Location is to be selected to represent the location of highest potential for gas leaks, as determined by the responsible organization.

Requirements: During the test and for a 1 h post-test observation period, the battery system shall exhibit no evidence of fire, battery enclosure rupture, or explosion. In the event that a gas concentration measuring device is used, flammable gas concentration shall not exceed the lower flammability limit in air.

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