Electrolyte Spillage and Electrical Shock Protection


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(Ce document est aussi disponible en français)
Introduction

As defined by section 12 of the *Motor Vehicle Safety Act*, a Technical Standards Document (TSD) is a document that reproduces an enactment of a foreign government (e.g. a Federal Motor Vehicle Safety Standard issued by the U.S. National Highway Traffic Safety Administration). According to the Act, the *Motor Vehicle Tire Safety Regulations* may alter or override some provisions contained in a TSD or specify additional requirements; consequently, it is advisable to read a TSD in conjunction with the Act and the *Motor Vehicle Tire Safety Regulations*. As a guide, where the corresponding Regulation contains additional requirements, footnotes indicate the amending subsection number.

TSDs are revised from time to time in order to incorporate amendments made to the reference document, at which time a Notice of Revision is published in the *Canada Gazette*, Part I. All TSDs are assigned a revision number, with “Revision 0” designating the original version.

Identification of Changes

In order to facilitate the incorporation of a TSD, certain non-technical changes may be made to the foreign enactment. These may include the deletion of words, phrases, figures, or sections that do not apply under the Act or Regulations, the conversion of imperial to metric units, the deletion of superseded dates, and minor changes of an editorial nature. Additions are underlined, and provisions that do not apply are stroked through. Where an entire section has been deleted, it is replaced by: “[CONTENT DELETED]”. Changes are also made where there is a reporting requirement or reference in the foreign enactment that does not apply in Canada. For example, the name and address of the United States Department of Transportation are replaced by those of the Department of Transport.

Effective Date and Mandatory Compliance Date

The effective date of a TSD is the date of publication of its incorporating regulation or of the notice of revision in the *Canada Gazette*, and the date as of which voluntary compliance is permitted. The mandatory compliance date is the date upon which compliance with the requirements of the TSD is obligatory. If the effective date and mandatory compliance date are different, manufacturers may follow the requirements that were in force before the effective date, or those of this TSD, until the mandatory compliance date.

In the case of an initial TSD, or when a TSD is revised and incorporated by reference by an amendment to the Regulations, the mandatory compliance date is as specified in the Regulations, and it may be the same as the effective date. When a TSD is revised with no corresponding changes to the incorporating Regulations, the mandatory compliance date is six months after the effective date.
Official Version of Technical Standards Documents

The PDF version is a replica of the TSD as published by the Department and is to be used for the purposes of legal interpretation and application.
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S1. Scope

This Technical Standards Document (TSD) standard specifies requirements for limitation of electrolyte spillage and retention of electric energy storage/conversion devices during and after a crash, and protection from harmful electric shock during and after a crash and during normal vehicle operation.

S2. Purpose

The purpose of this TSD standard is to reduce deaths and injuries during and after a crash that occur because of electrolyte spillage from electric energy storage devices, intrusion of electric energy storage/conversion devices into the occupant compartment, and electrical shock, and to reduce deaths and injuries during normal vehicle operation that occur because of electric shock or driver error.

S3. Application

Motor Vehicle Safety Regulations. [CONTENT DELETED] For applicability, please see Schedule III and subsection 305(1) of Schedule IV to the Motor Vehicle Safety Regulations.

S4. Definitions

Automatic disconnect means a device that when triggered, conductively separates a high voltage source from the electric power train or the rest of the electric power train. *(Dispositif de débranchement automatique)*

Charge connector is a conductive device that, by insertion into a vehicle charge inlet, establishes an electrical connection of the vehicle to the external electric power supply for the purpose of transferring energy and exchanging information. *(Connecteur de charge)*

Connector means a device providing mechanical connection and disconnection of high voltage electrical conductors to a suitable mating component, including its housing. *(Connecteur)*

Direct contact is the contact of persons with high voltage live parts. *(Contact direct)*

Electric energy storage device means a high voltage source that stores energy for vehicle propulsion. This includes, but is not limited to, a high voltage battery or battery pack, rechargeable energy storage device, and capacitor module. *(Dispositif d’accumulation d’énergie électrique)*

Electric energy storage/conversion device means a high voltage source that stores or converts energy for vehicle propulsion. This includes, but is not limited to, a high voltage battery or battery pack, fuel cell stack, rechargeable energy storage device, and capacitor module. *(Dispositif d’accumulation/de conversion d’énergie électrique)*

Electric energy storage/conversion system means an assembly of electrical components that stores or converts electrical energy for vehicle propulsion. This includes, but is not limited to, high voltage batteries or battery packs, fuel cell stacks, rechargeable energy
storage systems, capacitor modules, inverters, interconnects, and venting systems. (Système d’accumulation/de conversion d’énergie électrique)

**Electrical protection barrier** is the part providing protection against direct contact with high voltage live parts from any direction of access. (Barrière de protection contre les décharges électriques)

**Exposed conductive part** is the conductive part that can be touched under the provisions of the IPXXB protection degree and that is not normally energized, but that can become electrically energized under isolation fault conditions. This includes parts under a cover, if the cover can be removed without using tools. (Pièce conductrice exposée)

**External electric power supply** is a power supply external to the vehicle that provides electric power to charge the electric energy storage device in the vehicle through the charge connector. (Source d’alimentation électrique externe)

**Fuel cell system** is a system containing the fuel cell stack(s), air processing system, fuel flow control system, exhaust system, thermal management system, and water management system. (Système de pile à combustible)

**High voltage live part** means a live part of a high voltage source. (Pièce sous haute tension)

**High voltage source** means any electric component which is contained in the electric power train or conductively connected to the electric power train and has a working voltage greater than 30 VAC or 60 VDC. (Source de haute tension)

**Indirect contact** is the contact of persons with exposed conductive parts. (Contact indirect)

**Live part** is a conductive part of the vehicle that is electrically energized under normal vehicle operation. (Pièce sous tension)

**Luggage compartment** is the space in the vehicle for luggage accommodation, separated from the passenger compartment by the front or rear bulkhead and bounded by a roof, hood or trunk lid, floor, and side walls, as well as by electrical protection barriers provided for protecting the occupants from direct contact with high voltage live parts. (Compartiment à bagages)

**Passenger compartment** is the space for occupant accommodation that is bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead and rear bulkhead or rear gate, as well as electrical protection barriers provided for protecting the occupants from direct contact with high voltage live parts. (Habitacle)
**Possible active driving mode** is the vehicle mode when application of pressure to the accelerator pedal (or activation of an equivalent control) or release of the brake system causes the electric power train to move the vehicle. (*Mode de conduite active possible*)

**Propulsion system** means an assembly of electric or electro-mechanical components or circuits that propel the vehicle using the energy that is supplied by a high voltage source. This includes, but is not limited to, electric motors, inverters/converters, and electronic controllers. (*Système de propulsion*)

**Protection degree IPXXB** is protection from contact with high voltage live parts. It is tested by probing electrical protection barriers with the jointed test finger probe, IPXXB, in Figure 7b. (*Degré de protection IPXXB*)

**Protection degree IPXXD** is protection from contact with high voltage live parts. It is tested by probing electrical protection barriers or enclosures with the test wire probe, IPXXD, in Figure 7a. (*Degré de protection IPXXD*)

**Service disconnect** is the device for deactivation of an electrical circuit when conducting checks and services of the vehicle electrical propulsion system. (*Commande de mise hors tension aux fins d’entretien*)

**VAC** means volts of alternating current (AC) expressed using the root mean square value. (*VCA*)

**VDC** means volts of direct current (DC). (*VCC*)

**Vehicle charge inlet** is the device on the electric vehicle into which the charge connector is inserted for the purpose of transferring energy and exchanging information from an external electric power supply. (*Prise de charge du véhicule*)

**Working Voltage** means the highest root mean square voltage of the voltage source, which may occur across its terminals or between its terminals and any conductive parts in open circuit conditions or under normal operating conditions. (*Tension de fonctionnement*)

**S5. General requirements**

Each vehicle to which this TSD standard applies, must meet the requirements in S5.1, S5.2, and S5.3 when tested according to S6 under the conditions of S7.

**S5.1 Electrolyte spillage from propulsion batteries**

Not more than 5.0 liters of electrolyte from propulsion batteries shall spill outside the passenger compartment, and no visible trace of electrolyte shall spill into the passenger compartment. Spillage is measured from the time the vehicle ceases motion after a barrier impact test until 30 minutes thereafter, and throughout any static rollover after a barrier impact test.

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1 Please see subsection 305(5) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.
S5.2 Electric energy storage/conversion device retention

During and after each test specified in S6 of this TSD standard:

(a) Electric energy storage/conversion devices shall remain attached to the vehicle by at least one component anchorage, bracket, or any structure that transfers loads from the device to the vehicle structure, and
(b) Electric energy storage/conversion devices located outside the occupant compartment shall not enter the occupant compartment.

S5.3 Electrical safety

After each test specified in S6 of this TSD standard, each high voltage source in a vehicle must meet one of the following requirements: electrical isolation requirements of subparagraph (a) of this section, the voltage level requirements of subparagraph (b) of this section, or the physical barrier protection requirements of subparagraph (c) of this section.

(a) The electrical isolation of the high voltage source, determined in accordance with the procedure specified in S7.6 of this section, must be greater than or equal to one of the following:

(1) 500 ohms/volt for an AC high voltage source; or
(2) 100 ohms/volt for an AC high voltage source if it is conductively connected to a DC high voltage source, but only if the AC high voltage source meets the physical barrier protection requirements specified in S5.3(c)(1) and S5.3(c)(2) of this section; or
(3) 100 ohms/volt for a DC high voltage source.

(b) The voltages V1, V2, and Vb of the high voltage source, measured according to the procedure specified in S7.7 of this section, must be less than or equal to 30 VAC for AC components or 60 VDC for DC components.

(c) Protection against electric shock by direct and indirect contact (physical barrier protection) shall be demonstrated by meeting the following three conditions:

(1) The high voltage source (AC or DC) meets the protection degree IPXXB when tested according to the procedure specified in S9.1 of this section using the IPXXB test probe shown in Figures 7a and 7b to this section;
(2) The resistance between exposed conductive parts of the electrical protection barrier of the high voltage source and the electrical chassis is less than 0.1 ohms.

Please see subsection 305(5) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.

Please see subsection 305(5) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.
The voltage between exposed conductive parts of the electrical protection barrier of the high voltage source and the electrical chassis is less than or equal to 30 VAC or 60 VDC as measured in accordance with S9.3. In addition, the resistance between an exposed conductive part of the electrical protection barrier of the high voltage source and any other simultaneously reachable exposed conductive parts of electrical protection barriers within 2.5 meters of it must be less than 0.2 ohms when tested using the test procedures specified in S9.2 of this section; and

(3) The voltage between exposed conductive parts of the electrical protection barrier of the high voltage source and the electrical chassis is less than or equal to 30 VAC or 60 VDC as measured in accordance with S9.3 of this section. In addition, the voltage between an exposed conductive part of the electrical protection barrier of the high voltage source and any other simultaneously reachable exposed conductive parts of electrical protection barriers within 2.5 meters of it must be less than or equal to 30 VAC or 60 VDC as measured in accordance with S9.3.

S5.4 Electrical safety during normal vehicle operation

S5.4.1 Protection against direct contact.

S5.4.1.1 Marking. The symbol shown in Figure 6 to this section shall be present on or near electric energy storage devices. The symbol in Figure 6 to this section shall also be visible on electrical protection barriers which, when removed, expose live parts of high voltage sources. The symbol shall be yellow and the bordering and the arrow shall be black.

S5.4.1.1.1 The marking is not required for electrical protection barriers that cannot be physically accessed, opened, or removed without the use of tools. Markings are not required for electrical connectors or the vehicle charge inlet.

S5.4.1.2 High voltage cables. Cables for high voltage sources which are not located within electrical protection barriers shall be identified by having an outer covering with the color orange.

S5.4.1.3 Service disconnect. For a service disconnect which can be opened, disassembled, or removed without tools, protection degree IPXXB shall be provided when tested under procedures specified in S9.1 of this section using the IPXXB test probe shown in Figures 7a and 7b to this section.

S5.4.1.4 Protection degree of high voltage live parts.

(a) Protection degree IPXXD shall be provided for high voltage live parts inside the passenger or luggage compartment when tested according to the procedures specified in S9.1 of this section using the IPXXD test probe shown in Figure 7a to this section.

(b) Protection degree IPXXB shall be provided for high voltage live parts in areas other than the passenger or luggage compartment when tested according to the procedures specified in S9.1 of this section using the IPXXB test probe shown in Figures 7a and 7b to this section.

S5.4.1.5 Connectors. Direct contact protection for a connector shall be provided by meeting the requirements specified in S5.4.1.4 when the connector is connected to its corresponding
mating component, and by meeting at least one of the requirements of subparagraphs (a), (b), (c) or (d).

(a) The connector meets the requirements of S5.4.1.4 when separated from its mating component, if the connector can be separated without the use of tools;

(b) The voltage of the live parts becomes less than or equal to 60 VDC or 30 VAC within one second after the connector is separated from its mating component;

(c) The connector is provided with a locking mechanism (at least two distinct actions are needed to separate the connector from its mating component) and there are other components that must be removed in order to separate the connector from its mating component and these cannot be removed without the use of tools; or

(d) The connector cannot be separated without the use of tools.

S5.4.1.6 Vehicle charge inlet. Direct contact protection for a vehicle charge inlet shall be provided by meeting the requirements specified in S5.4.1.4 when the charge connector is connected to the vehicle inlet and by meeting at least one of the requirements of subparagraphs (a) or (b).

(a) The vehicle charge inlet meets the requirements of S5.4.1.4 when the charge connector is not connected to it; or

(b) The voltage of the high voltage live parts becomes equal to or less than 60 VDC or equal to or less than 30 VAC within 1 second after the charge connector is separated from the vehicle charge inlet.

S5.4.2 Protection against indirect contact.

S5.4.2.1 The resistance between all exposed conductive parts of electrical protection barriers and the electrical chassis shall be less than 0.1 ohms when tested according to the procedures specified in S9.2 of this section.

S5.4.2.2 The resistance between any two simultaneously reachable exposed conductive parts of the electrical protection barriers that are less than 2.5 meters from each other shall be less than 0.2 ohms when tested according to the procedures specified in S9.2 of this section.

S5.4.3 Electrical isolation.

S5.4.3.1 Electrical isolation of AC and DC high voltage sources. The electrical isolation of a high voltage source, determined in accordance with the procedure specified in S7.6 of this section must be greater than or equal to one of the following:

(a) 500 ohms/volt for an AC high voltage source;

(b) 100 ohms/volt for an AC high voltage source if it is conductively connected to a DC high voltage source, but only if the AC high voltage source meets the requirements for protection against direct contact in S5.4.1.4 of this section and the protection from indirect contact in S5.4.2 of this section; or

(c) 100 ohms/volt for a DC high voltage source.
S5.4.3.2 Exclusion of high voltage sources from electrical isolation requirements. A high voltage source that is conductively connected to an electric component which is conductively connected to the electrical chassis and has a working voltage less than or equal to 60 VDC, is not required to meet the electrical isolation requirements in S5.4.3.1 of this section if the voltage between the high voltage source and the electrical chassis is less than or equal to 30 VAC or 60 VDC.

S5.4.3.3 Electrical isolation of high voltage sources for charging the electric energy storage device. For the vehicle charge inlet intended to be conductively connected to the AC external electric power supply, the electric isolation between the electrical chassis and the high voltage sources that are conductively connected to the vehicle charge inlet during the charging of the electric energy storage device shall be greater than or equal to 500 ohms/volt when the charge connector is disconnected. The electrical isolation is measured at the high voltage live parts of the vehicle charge inlet and determined in accordance with the procedure specified in S7.6.

During the measurement, the rechargeable electric energy storage system may be disconnected.

S5.4.4 Electrical isolation monitoring. Each DC high voltage sources of vehicles with a fuel cell system shall be monitored by an electrical isolation monitoring system that displays a warning for loss of isolation when tested according to S8 of this section. The system must monitor its own readiness and the warning display must be visible to the driver seated in the driver’s designated seating position.

S5.4.5 Electric shock protection during charging. For motor vehicles with an electric energy storage device that can be charged through a conductive connection with a grounded external electric power supply, a device to enable conductive connection of the electrical chassis to the earth ground shall be provided. This device shall enable connection to the earth ground before exterior voltage is applied to the vehicle and retain the connection until after the exterior voltage is removed from the vehicle.

S5.4.6 Mitigating driver error.

S5.4.6.1 Indicator of possible active driving mode. At least a momentary indication shall be given to the driver each time the vehicle is first placed in possible active driving mode after manual activation of the propulsion system. This requirement does not apply under conditions where an internal combustion engine provides directly or indirectly the vehicle’s propulsion power when the vehicle is first placed in a possible active driving mode after manual activation of the propulsion system.

S5.4.6.2 Indicator of possible active driving mode when leaving the vehicle. When leaving the vehicle, the driver shall be informed by an audible or visual signal if the vehicle is still in the possible active driving mode.

S5.4.6.3 Prevent drive-away. If the on-board electric energy storage device can be externally charged, vehicle movement of more than 150mm by its own propulsion system shall not be possible as long as the charge connector of the external electric power supply is physically connected to the vehicle charge inlet in a manner that would permit charging of the electric energy storage device.
S6. Test requirements

Each vehicle to which this TSD standard applies, under the conditions of S7, must be capable of meeting the requirements of any applicable single barrier crash/static rollover test sequence, without alteration of the vehicle during the test sequence. A particular vehicle need not meet further test requirements after having been subjected to a single barrier crash/static rollover test sequence.

S6.1 Frontal barrier crash

The vehicle must meet the requirements of S5.1, S5.2 and S5.3 when it is traveling longitudinally forward at any speed, up to and including 48 km/h, and impacts a fixed collision barrier that is perpendicular to the line of travel of the vehicle, or at any angle up to 30 degrees in either direction from the perpendicular to the line of travel of the vehicle.

S6.2 Rear moving barrier impact

The vehicle must meet the requirements of S5.1, S5.2, and S5.3, when it is impacted from the rear by a barrier that conforms to S7.3(b) of the U.S. Code of Federal Regulations (CFR), Title 49, Part 571, Standard No. 301 (hereinafter referred to as 49 CFR 571.301) of this chapter and that is moving at any speed up to and including 80 km/h (50 mph) with dummies in accordance with S6.2 of 49 CFR 571.301 of this chapter.

S6.3 Side moving deformable barrier impact

The vehicle must meet the requirements of S5.1, S5.2, and S5.3 when it is impacted from the side by a barrier that conforms to 49 CFR part 587 of this chapter that is moving at any speed up to and including 54 km/h, with the appropriate 49 CFR part 572 test dummies specified in 49 CFR 571.214 of this chapter.

S6.4 Post-impact test static rollover

The vehicle must meet the requirements of S5.1, S5.2, and S5.3, after being rotated on its longitudinal axis to each successive increment of 90 degrees after each impact test specified in S6.1, S6.2, and S6.3.

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4 Please see subsection 305(2) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.

5 Please see subsection 305(4) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.

6 Please see subsection 305(2) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.
S7. Test conditions

When the vehicle is tested according to S6, the requirements of S5.1 through S5.3 must be met under the conditions specified in S7.1 through S7.7. All measurements for calculating voltage(s) and electrical isolation are made after a minimum of 5 seconds after the vehicle comes to rest in tests specified in S6. Where a range is specified, the vehicle must be capable of meeting the requirements at all points within the range.

S7.1 Electric energy storage device state-of-charge

The electric energy storage device shall be at the state-of-charge specified in either subparagraph (a), (b), or (c):

(a) At the maximum state-of-charge in accordance with the vehicle manufacturer’s recommended charging procedures, as stated in the vehicle owner’s manual or on a label that is permanently affixed to the vehicle; or

(b) If the manufacturer has made no recommendation for charging procedures in the owner’s manual or on a label permanently affixed to the vehicle, at a state-of-charge of not less than 95 percent of the maximum capacity of the electric energy storage device; or

(c) If the electric energy storage device(s) is/are rechargeable only by an energy source on the vehicle, at any state-of-charge within the normal operating voltage defined by the vehicle manufacturer.

S7.2 Vehicle conditions

The switch or device that provides power from the electric energy storage/conversion system to the propulsion system is in the activated position or the ready-to-drive position.

S7.2.1 The parking brake is disengaged and the transmission, if any, is in the neutral position. In a test conducted under S6.3, the parking brake is set.

S7.2.2 Tires are inflated to the manufacturer’s specifications.

S7.2.3 The vehicle, including test devices and instrumentation, is loaded as follows:

(a) A passenger car is loaded to its unloaded vehicle weight, secured in the luggage area, plus the necessary test dummies as specified in S6, restrained only by means that are installed in the vehicle for protection at its seating position.

(b) A multipurpose passenger vehicle, truck, or bus with a GVWR of 4 536 kg or less is loaded to its unloaded vehicle weight plus the necessary dummies, as specified

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7 Please see subsection 305(3) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.
in S6, plus 136 kg or its rated cargo and luggage capacity weight, whichever is less. Each dummy is restrained only by means that are installed in the vehicle for protection at its seating position.

**S7.3 Static rollover test conditions**

In addition to the conditions of S7.1 and S7.2, the conditions of S7.4 of Sec. 49 CFR 571.301 apply to the conduct of static rollover tests specified in S6.4.

**S7.4 Rear moving barrier impact test conditions**

In addition to the conditions of S7.1 and S7.2, the conditions of S7.3(b) and S7.6 of 49 CFR 571.301 apply to the conducting of the rear moving deformable barrier impact test specified in S6.2.

**S7.5 Side moving deformable barrier impact test conditions**

In addition to the conditions of S7.1 and S7.2, the conditions of S8.9, S8.10, and S8.11 of 49 CFR 571.214 apply to the conduct of the side moving deformable barrier impact test specified in S6.3.

**S7.6 Electrical isolation test procedure**

In addition to the conditions of S7.1 and S7.2, the conditions in S7.6.1 through S7.6.7 apply to the measuring of electrical isolation specified in S5.3(a).

**S7.6.1** Prior to any barrier impact test, the energy storage/conversion system is connected to the vehicle’s propulsion system, and the vehicle ignition is in the “on” (propulsion system energized) position. Bypass any devices or systems that do not allow the propulsion system to be energized at the time of impact when the vehicle ignition is on and the vehicle is in neutral. For a high voltage source that has an automatic disconnect that is physically contained within itself, the electrical isolation measurement after the test is made from the side of the automatic disconnect connected to the electric power train or to the rest of the electric power train if the high voltage source is a component contained in the power train. For a high voltage source that has an automatic disconnect that is not physically contained within itself, the electrical isolation measurement after the test is made from both the high voltage source side of the automatic disconnect and from the side of the automatic disconnect connected to the electric power train or to the rest of the electric power train if the high voltage source is a component contained in the power train.

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8 Please see subsection 305(2) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.

9 Please see subsection 305(2) of Schedule IV to the Motor Vehicle Safety Regulations (MVSR) for an additional requirement.
S7.6.2 The voltmeter used in this test has an internal resistance of at least 10 MΩ.

S7.6.3 The voltage(s) is/are measured as shown in Figure 1 and the high voltage source voltage(s) (Vb) is/are recorded. Before any vehicle impact test, Vb is equal to or greater than the nominal operating voltage as specified by the vehicle manufacturer.

S7.6.4 The voltage V1 between the negative side of the high voltage source and the electrical chassis is measured as shown in Figure 2.

S7.6.5 The voltage V2 between the positive side of the high voltage source and the electrical chassis is measured as shown in Figure 3.

S7.6.6 If V1 is greater than or equal to V2, insert a known resistance (Ro) between the negative side of the high voltage source and the electrical chassis.

With the Ro installed, measure the voltage (V1') as shown in Figure 4 between the negative side of the high voltage source and the electrical chassis. Calculate the electrical isolation resistance (Ri) according to the formula shown. Divide Ri (in ohms) by the working voltage of the high voltage source (in volts) to obtain the electrical isolation (in ohms/volt).

S7.6.7 If V2 is greater than V1, insert a known resistance (Ro) between the positive side of the high voltage source and the electrical chassis. With the Ro installed, measure the voltage (V2') as shown in Figure 5 between the positive side of the high voltage source and the electrical chassis. Calculate the electrical isolation resistance (Ri) according to the formula shown. Divide Ri (in ohms) by the working voltage of the high voltage source (in volts) to obtain the electrical isolation (in ohms/volt).

S7.7 Voltage measurement.

For the purpose of determining the voltage level of the high voltage source specified in S5.3(b), voltage is measured as shown in Figure 1. Voltage Vb is measured across the two terminals of the voltage source. Voltages V1 and V2 are measured between the source and the electrical chassis. For a high voltage source that has an automatic disconnect that is physically contained within itself, the voltage measurement after the test is made from the side of the automatic disconnect connected to the electric power train or to the rest of the electric power train if the high voltage source is a component contained in the power train. For a high voltage source that has an automatic disconnect that is not physically contained within itself, the voltage measurement after the test is made from both the high voltage source side of the automatic disconnect and from the side of the automatic disconnect connected to the electric power train or to the rest of the electric power train if the high voltage source is a component contained in the power train.

S8 Test procedure for on-board electrical isolation monitoring system.

Prior to any impact test, the requirements of S5.4.4 for the on-board electrical isolation monitoring system shall be tested using the following procedure.

(1) The electric energy storage device is at the state-of-charge specified in S7.1.
(2) The switch or device that provides power from the electric energy storage/conversion system to the propulsion system is in the activated position or the ready-to-drive position.

(3) Determine the isolation resistance, Ri, of the high voltage source with the electrical isolation monitoring system using the procedure outlined in S7.6.2 through S7.6.7.

(4) Insert a resistor with resistance Ro equal to or greater than 1/(1/(95 times the working voltage of the high voltage source)-1/Ri) and less than 1/(1/(100 times the working voltage of the high voltage source)-1/Ri) between the positive terminal of the high voltage source and the electrical chassis.

(5) The electrical isolation monitoring system indicator shall display a warning visible to the driver seated in the driver’s designated seating position.

S9 Test methods for physical barrier protection from electric shock due to direct and indirect contact with high voltage sources.

S9.1 Test method to evaluate protection from direct contact with high voltage sources.

(a) Any parts surrounding the high voltage components are opened, disassembled, or removed without the use of tools.

(b) The selected access probe is inserted into any gaps or openings of the electrical protection barrier with a test force of 10 N ± 1 N with the IPXXB probe or 1 to 2 N with the IPXXD probe. If the probe partly or fully penetrates into the electrical protection barrier, it is placed in every possible position to evaluate contact with high voltage live parts. If partial or full penetration into the electrical protection barrier occurs with the IPXXB probe, the IPXXB probe shall be placed as follows: starting from the straight position, both joints of the test finger are rotated progressively through an angle of up to 90 degrees with respect to the axis of the adjoining section of the test finger and are placed in every possible position.

(c) A low voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp may be connected between the access probe and any high voltage live parts inside the electrical protection barrier to indicate whether high voltage live parts were contacted.

(d) A mirror or fiberscope may be used to inspect whether the access probe touches high voltage live parts inside the electrical protection barrier.

(e) Protection degree IPXXD or IPXXB is verified when the following conditions are met:

   (i) The access probe does not touch high voltage live parts. The IPXXB access probe may be manipulated as specified in S9.1(b) for evaluating contact with high
voltage live parts. The methods specified in S9.1(c) or S9.1(d) may be used to aid the evaluation. If method S9.1(c) is used for verifying protection degree IPXXB or IPXXD, the lamp shall not light up.

(ii) The stop face of the access probe does not fully penetrate into the electrical protection barrier.

S9.2 Test method to evaluate protection against indirect contact with high voltage sources.

At the option of the manufacturer, protection against indirect contact with high voltage sources shall be determined using the test method in subparagraph (a) or subparagraph (b).

(a) Test method using a resistance tester.

The resistance tester is connected to the measuring points (the electrical chassis and any exposed conductive part of electrical protection barriers or any two simultaneously reachable exposed conductive parts of electrical protection barriers that are less than 2.5 meters from each other), and the resistance is measured using a resistance tester that can supply current levels of at least 0.2 Amperes with a resolution of 0.01 ohms or less. The resistance between two exposed conductive parts of electrical protection barriers that are less than 2.5 meters from each other may be calculated using the separately measured resistances of the relevant parts of the electric path.

(b) Test method using a DC power supply, voltmeter and ammeter.

(1) Connect the DC power supply, voltmeter and ammeter to the measuring points (the electrical chassis and any exposed conductive part or any two simultaneously reachable exposed conductive parts that are less than 2.5 meters from each other) as shown in Figure 8 to this section.

(2) Adjust the voltage of the DC power supply so that the current flow becomes more than 0.2 Amperes.

(3) Measure the current I and the voltage V shown in Figure 8 to this section.

(4) Calculate the resistance R according to the formula, \( R = \frac{V}{I} \).

(5) The resistance between two simultaneously reachable exposed conductive parts of electrical protection barriers that are less than 2.5 meters from each other may be calculated using the separately measured resistances of the relevant parts of the electric path.
S9.3 Test method to determine voltage between exposed conductive parts of electrical protection barriers and the electrical chassis and between exposed conductive parts of electrical protection barriers.

(a) Connect the voltmeter to the measuring points (exposed conductive part of an electrical protection barrier and the electrical chassis or any two simultaneously reachable exposed conductive parts of electrical protection barriers that are less than 2.5 meters from each other.

(b) Measure the voltage.

(c) The voltage between two simultaneously reachable exposed conductive parts of electrical protection barriers that are less than 2.5 meters from each other may be calculated using the separately measured voltages between the relevant electrical protection barriers and the electrical chassis.
Figure 1 — S7.6.3 and S7.7 Voltage Measurements of the High Voltage Source

Electrical Chassis

Energy Conversion System

Energy Conversion Device

+ -

Propulsion System

Energy Storage System

Energy Storage Device

V1

V2

Vb
Figure 2 — S7.6.4 Measurement for V1 Voltage between the Negative Side of the High Voltage Source and the Electrical Chassis

Electrical Chassis

![Diagram showing the relationship between energy conversion, propulsion, and energy storage systems with measurement of V1 voltage between the negative side of the high voltage source and the electrical chassis.]

Effective: May 18, 2018
Figure 3 — S7.6.5 Measurement for V2 Voltage between the Positive Side of the High Voltage Source and the Electrical Chassis

Electrical Chassis

Energy Conversion System

Energy Storage System

Energy Conversion Device

Propulsion System

Energy Storage Device

V2
Figure 4 — S7.6.6 Measurement for V1' Voltage across Resistor between Negative Side of the High Voltage Source and Electrical Chassis

Electrical Chassis

\[ R_i = R_o \left( \frac{1+V_2/V_1}{(V_1-V_1')/V_1'} \right) \]
Figure 5 — S7.6.7 Measurement for V2' Voltage across Resistor between Positive Side of High Voltage Source and Electrical Chassis

![Electrical Chassis diagram]

Ri = Ro \left(1 + \frac{V1}{V2}\right) \left(\frac{(V2-V2')/V2'}{V2'}\right)

Figure 6 — Marking of High Voltage Equipment
Figure 7a — Access Probes for the Tests of Direct Contact Protection. Access Probe IPXXB (top) and Access Probe IPXXD (bottom).

<table>
<thead>
<tr>
<th>First numeral</th>
<th>Addit. letter</th>
<th>Access probe (Dimensions in mm)</th>
<th>Test force</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>B</td>
<td>Jointed test finger</td>
<td>10 N±10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>See Fig. 1 for full dimensions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulating material</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jointed test finger (Metal)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

| 4, 5, 6       | D            | Test wire 1.0 mm diameter, 100 mm long | 1N±10% |
|               |              | Approx. 100                      |        |
|               |              | Handle (Insulating material)     |        |
|               |              | Stop face (Inert material)       |        |
|               |              | Rigid test wire (Metal)          |        |
|               |              | Edges free from burrs            |        |
Material: metal, except where otherwise specified.
Linear dimensions in millimetres
Tolerance on dimensions without specific tolerance:
– on angles: 0/-10°
– on linear dimensions: up to 25 mm: 0/-0.05 mm; over 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.
Figure 8 — Connection to Determine Resistance between Exposed Conductive Parts of Electrical Protection Barrier and Electrical Chassis

D.C. Power Supply

Connection to Electrical Chassis

Barrier/Enclosure

Electrical Chassis

$I$

$V$

$R$