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Electrically propelled road vehicles — Safety specifications —

Part 4: Post crash electrical safety

Véhicules routiers électriques — Spécifications de sécurité —

Partie 4: Exigences de sécurité électrique après accident

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electrically propelled road vehicles*.

ISO 6469 consists of the following parts, under the general title *Electrically propelled road vehicles — Safety specifications*:

— *Part 1: On-board rechargeable energy storage system (RESS)*

— *Part 2: Vehicle operational safety means and protection against failures*

— *Part 3: Protection of persons against electric shock*

— *Part 4: Post crash electrical safety*

Electrically propelled road vehicles — Safety specifications —

Part 4: Post crash electrical safety

1 Scope

This part of ISO 6469 specifies safety requirements for the electric propulsion systems and conductively connected auxiliary electric systems of electrically propelled road vehicles for the protection of persons inside and outside the vehicle. It specifies electrical safety requirements for vehicle post-crash conditions.

It applies to electrically propelled road vehicles with voltage class B electric circuits.

It does not apply to motorcycles and mopeds.

It does not specify any crash test procedure. The safety requirements of this part of ISO 6469 apply to applicable vehicles in accordance with published crash test procedures of each country or region. Applicable vehicles are those vehicles which are explicitly specified in these crash test procedures.

It does not provide comprehensive safety information for first responders, emergency services, maintenance, and repair personnel.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6469-3, *Electrically propelled road vehicles — Safety specifications — Part 3: Protection of persons against electric shock*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

ISO/TR 8713, *Electrically propelled road vehicles — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 8713 and the following apply.

3.1
auxiliary electric system
on-board vehicle system, other than the propulsion system, which operates on electric energy

3.2
barrier
part providing protection against direct contact from any usual direction of access

3.3
conductive part
part capable of conducting electric current

3.4
direct contact
contact of persons with live parts

3.5
electric chassis
conductive parts of a vehicle that are electrically connected and whose potential is taken as reference

3.6
electric drive
combination of traction motor, power electronics, and their associated controls for the conversion of electric to mechanical power and vice versa

3.7
electric shock
physiological effect resulting from an electric current passing through a human body

3.8
electrically propelled vehicle
vehicle with at least one electric drive for vehicle propulsion

3.9
enclosure
part providing protection of equipment against direct contact from any direction

3.10
exposed conductive part
conductive part of the electric equipment, that can be touched by a test finger according to IPXXB (see ISO 20653) after removing barriers/enclosures that can be removed without using tools and that is not normally live, but which may become live under fault conditions

3.11
isolation resistance
resistance between live parts of voltage class B electric circuit and the electric chassis as well as the voltage class A system

3.12
line conductor
conductor which is electrically energized in normal operation and capable of contributing to the transmission or distribution of electric energy

3.13
live part
conductor or conductive part intended to be electrically energized in normal operation

3.14
maximum working voltage
highest value of a.c. voltage (rms) or of d.c. voltage which may occur in an electric system under any normal operating conditions according to manufacturer's specifications, disregarding transients

3.15
potential equalisation
electric connections of exposed conductive parts of the electric equipment to minimize differences in potential between these parts

3.16
rechargeable energy storage system
RESS
system that stores energy for delivery of electric energy for vehicle propulsion and which is rechargeable

EXAMPLE Battery, capacitors.

3.17
voltage class A
classification of an electric component or circuit with a maximum working voltage of ≤30 V a.c. (rms) or ≤60 V d.c. respectively

3.18
voltage class B
classification of an electric component or circuit with a maximum working voltage of (>30 and ≤1 000) V a.c. (rms) or (>60 and ≤1 500) V d.c. respectively

3.19
X-capacitors
capacitors located between line conductors of different polarity

3.20
Y-capacitors
capacitors located between line conductor and electric chassis

4 Applied crash test procedures

The safety requirements of this part of ISO 6469 shall apply in accordance with the published crash test procedures of a country or region for vehicles or test configurations which are explicitly specified in these crash test procedures.

5 Electric safety requirements

5.1 General

The following requirements shall be fulfilled after a vehicle crash test or after a crash test with a test configuration according to 4.

NOTE Retention of voltage class B components, e.g. RESS, is not covered in this part of ISO 6469 because it is not relevant for electrical safety.

5.2 Protection against electric shock

5.2.1 General

After the crash test at least one of the criteria specified in 5.2.2 through 5.2.5 shall be met for each voltage class B electric circuit. This includes all voltage class B electric circuits which are disconnected or electrically separated in post-crash situations. For different parts of a circuit, different criteria specified in 5.2.2 through 5.2.5 may apply.

If the test is performed under the condition that part(s) of the voltage class B electric circuits are not electrically energized because of specific crash test conditions different from normal operation, the protection against electric shock shall be proved by either 5.2.3 or 5.2.4 for the relevant part(s). Examples for such specific test conditions are as follows:

— fuel cell vehicle crash test performed with alternative fuel;

— crash test performed with energy sources disconnected prior to the crash test.

NOTE Electronic switches can be used for disconnection.

5.2.2 Voltage limit

The voltages V_b, V_1, and V_2 (see Figure 1) of the voltage class B electric circuits shall be equal to or less than 30 V a.c. (rms) or 60 V d.c. at a point in time t_m which is specified as

— either 10 s after the initial impact, if the vehicle comes to rest within 5 s after the initial impact, or

— 5 s after the vehicle comes to rest, if the vehicle does not come to rest within 5 s after the initial impact.

Compliance shall be tested in accordance with 7.2.2.

5.2.3 Isolation resistance

5.2.3.1 General

The isolation resistance shall fulfil the requirements according to 5.2.3.2 and 5.2.3.3.

If direct contact to one potential of the voltage class B electric circuit is possible, the energy in Y-capacitors, TE_y, as calculated in 7.2.5.2.2 shall be less than 0,2 J.

NOTE A potential body current caused by Y-capacitors is not limited by isolation resistance.

The isolation resistance criterion shall not apply if direct contact to more than one single potential of a part of the voltage class B electric circuit is possible; see 5.2.4 (physical protection). However, isolation resistance criterion is applicable if the voltage difference between those accessible live parts meets the voltage limit specified in 5.2.2 or the potential energy between them meets the energy limit specified in 5.2.5.

Compliance shall be tested in accordance with 7.2.3.

If test procedures include a static rollover test after a crash, evaluation of isolation resistance can be conducted before, during, and/or after the rollover test.

5.2.3.2 Separated d.c. and a.c. voltage class B electric circuits

If the a.c. voltage class B electric circuits and the d.c. voltage class B electric circuits are not conductively connected to each other, isolation resistance, divided by the maximum working voltage, shall have a minimum value of 100 Ω/V for d.c. circuits, and a minimum value of 500 Ω/V for a.c. circuits.

5.2.3.3 Combined d.c. and a.c. voltage class B electric circuits

If the a.c. voltage class B electric circuits and the d.c. voltage class B electric circuits are conductively connected, they shall meet one of the following requirements:

a) isolation resistance, divided by the maximum working voltage, shall have a minimum value of 500 Ω/V;

b) isolation resistance, divided by the maximum working voltage, shall have a minimum value of 100 Ω/V and the a.c. circuit meets the physical protection as described in 5.2.4;

c) isolation resistance, divided by the maximum working voltage, shall have a minimum value of 100 Ω/V and the a.c. circuit meets the voltage limit as described in 5.2.2;

d) isolation resistance, divided by the maximum working voltage, shall have a minimum value of 100 Ω/V and the a.c. circuit meets the electrical energy limit as specified in 5.2.5.

5.2.4 Physical protection

For protection against direct contact with voltage class B live parts, the protection degree IPXXB in accordance with ISO 20653 shall be provided. Compliance shall be tested in accordance with 7.2.4.1.

In addition, one of the following requirements [a) or b)] shall be fulfilled:

a) The potential equalisation paths intended by design shall be clarified in advance in accordance with the manufacturer's specification, e.g. using diagrams, etc. The potential equalisation paths intended by design are the relevant electric connections or potential equalisation in accordance with ISO 6469-3 for the vehicle as built. The resistance between all exposed conductive parts and the electric chassis shall be less than or equal to 0,1 Ω. This requirement is deemed to be satisfied if the connection is established and maintained by welding. Compliance shall be tested in accordance with 7.2.4.2.

   In addition, one of the following requirements shall be fulfilled.

   — A short circuit current, if any, shall be interrupted.

   — The isolation resistance divided by the maximum working voltage shall be ≥0,01 Ω/V for d.c. circuits or 0,05 Ω/V for a.c. circuits. This requirement is deemed to be satisfied if the system meets isolation requirements in 5.2.3. Compliance shall be tested in accordance with 7.2.4.3.

b) At t_m (see 5.2.2), the voltage between any two exposed conductive parts that can be touched simultaneously by a person shall be equal to or less than 30 V a.c. or 60 V d.c.. Compliance shall be tested in accordance with 7.2.4.4.

NOTE For overcurrent protection see 5.3.

If test procedures include a rollover test after crash, evaluation of physical protection shall be conducted after and might be additionally conducted before the rollover test.

5.2.5 Electrical energy limit

At t_m (see 5.2.2), the total energy stored in X- and Y-capacitors shall meet the following requirement: (TE_d + TE_{dyr}), (TE_d + TE_{yr}), or (TE_x + TE_y) shall be less than 0,2 J.

— TE_d is the measured electrical energy of X- and Y-capacitors (see 7.2.5.1.2).

— TE_{dyr} is the measured remaining electrical energy of Y-capacitors (see 7.2.5.1.2).

— TE_{yr} is the calculated remaining electrical energy in Y-capacitors (see 7.2.5.2.3)

— TE_x is the calculated stored electrical energy in X-capacitors (see 7.2.5.2.1).

— TE_y is the calculated stored electrical energy in Y-capacitors (see 7.2.5.2.2).

NOTE The criterion of 0,2 J is based on IEC/TS 60479–1:2005, Figure 22 and considering capacitor discharge characteristics.

Compliance shall be tested in accordance with 7.2.5.

5.3 Protection against overcurrent

A potential overcurrent shall not lead to a hazardous situation after the crash test. This requirement is deemed to be satisfied if overcurrent protection is provided.

6 RESS electrolyte spillage

In the period from the impact until 30 min after the initial impact, no electrolyte from the RESS shall spill into the passenger compartment and not more than 5 l of electrolyte shall spill from the RESS outside of the passenger compartment.

Compliance shall be tested in accordance with 7.3.

If test procedures include a rollover test after crash, RESS electrolyte spillage during the rollover test shall also be included.

7 Testing

7.1 Test conditions

7.1.1 General

The environmental conditions during the test shall be according to the crash test procedures as defined in Clause 4.

For the preparation of the vehicle or the test configuration (see Clause 4) the conditions specified in 7.1.2 shall apply.

7.1.2 Preparation of vehicle or test configuration

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

Prior to the vehicle crash test, the voltage class B electric circuit shall be electrically energized according to normal operating conditions. For exemptions, see 5.2.1.

If an automatic disconnect exists, the test can be performed with the automatic disconnect being opened before the crash test. In this case, the demonstration of the activation of the automatic disconnect might be required if 5.2.3 is applied to the electrical load, depending on the limit chosen for the isolation resistance. The demonstration shall include monitoring of automatic activation signal as well as the proper operation of the automatic disconnect under similar conditions according to the crash test.

Modifications necessary for the measurement can be carried out such as installation of measurement lines, disabling of isolation monitoring device, change of software, etc. These modifications shall not have significant influence on the results of the measurement.

The fuel supply system can be modified so that an appropriate amount of fuel can be used to run an internal combustion engine or a fuel cell system, to the extent permissible under the applicable crash test procedure.

NOTE The purpose to run the internal combustion engine or the fuel cell system is to electrically energize the voltage class B electric circuit.

7.2 Test procedures for electrical safety

7.2.1 Test setup and equipment

Before the vehicle crash test is conducted, the voltage class B electric circuit voltage, V_b (see Figure 1), shall be measured and recorded to confirm that it is within the operating voltage of the vehicle as specified by the vehicle manufacturer.

The measurement points of an electric circuit to be measured shall be clarified in advance, e.g. using electrical circuit diagrams, etc.

Measurements of voltage or energy or isolation resistance shall be taken on each disconnected or separated circuit, where applicable.

If the voltage class B disconnect device is integral to the RESS or the fuel cell system and the voltage class B electric circuit of the RESS or the fuel cell system fulfils physical protection according to 5.2.4 after the crash test, the measurements shall only be taken for the evaluation of the electrical loads.

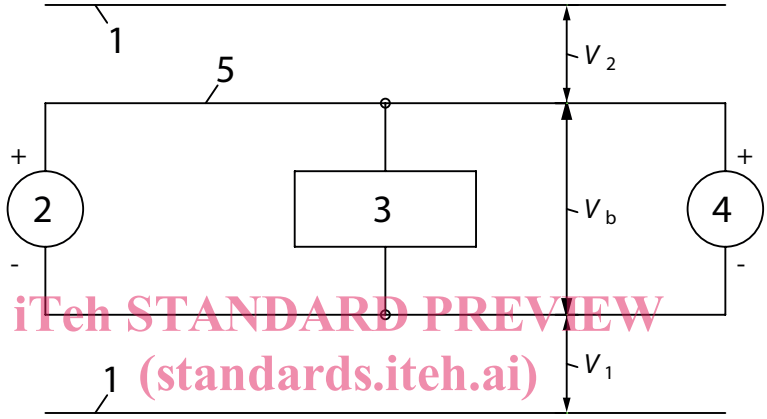
NOTE According to the circuit structure analysis, additional measurements at some places of the voltage class B electric circuit might be necessary. In this case, different criteria can be applied to different places.

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

7.2.2 Voltage limit

The voltages V_b, V_1, and V_2 (see Figure 1) of the voltage class B electric circuit shall be measured after the crash test.

The voltage measurement shall be made at t_m (see 5.2.2).



Key

1 electric chassis
2 fuel cell system
3 traction system or load
4 RESS
5 voltage class B electric circuit

Figure 1 — Measurement of V_b, V_1, V_2

7.2.3 Isolation resistance

7.2.3.1 General

The isolation resistance measurement of the voltage class B d.c. circuits and a.c. circuits shall be conducted with an appropriate method selected by the vehicle manufacturer from those specified in 7.2.3.2. or 7.2.3.3.

The measurement shall be conducted within a period of 1 h after the initial impact maintaining the same conditions as in the crash test procedure.

NOTE The protection against electric shock is evaluated by the resistance value measured according to 7.2.3.2. The resistance value measured according to 7.2.3.3 is equal to or lower than that according to 7.2.3.2. Therefore, the resistance value according to 7.2.3.3 also can be used for the evaluation as it produces a conservative result.