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Electric road vehicles — Safety specifications —

Part 3: Protection of persons against electric hazards

Véhicules routiers électriques — Spécifications de sécurité —

Partie 3: Protection des personnes contre les dangers électriques

Reference number
ISO 6469-3:2001(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 6469 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 6469-3 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electric road vehicles*.

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

— *Part 1: On-board electrical energy storage*

— *Part 2: Functional safety means and protection against failures*

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

Annexes A and B form a normative part of this part of ISO 6469.

Electric road vehicles — Safety specifications —

Part 3:
Protection of persons against electric hazards

1 Scope

This part of ISO 6469 specifies requirements for the protection of persons against electrical hazards on exclusively battery-powered electric road vehicles (passenger cars and light commercial vehicles) when the vehicles are not connected to an external power supply.

It is applicable only if the maximum working voltage of an on-board electrical circuit is lower than 1 000 V a.c., or 1 500 V d.c. or lower, according to national standards or regulations (e.g. for qualification of service personnel). It does not necessarily apply to assembly, maintenance and repair of these vehicles.

NOTE Requirements for electric road vehicles connected to an external power supply are specified in IEC 61851-21.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 6469. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 6469 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3864:1984, *Safety colours and safety signs*

ISO 6469-1:2001, *Electric road vehicles — Safety specifications — Part 1: On-board electrical energy storage*

ISO 6469-2:2001, *Electric road vehicles — Safety specifications — Part 2: Functional safety means and protection against failures*

ISO 8713:—[1)], *Electric road vehicles — Terminology*

IEC 60417-1:2000, *Graphical symbols for used on equipment — Part 1: Overview and application*

IEC 60417-2:1998, *Graphical symbols for used on equipment — Part 2: Symbol originals*

IEC 60529:1989, *Degree of protection provided by enclosures (IP code)*

IEC 61851-21:—[2)], *Electric vehicle conductive charging system — Part 21: Electric vehicle requirements for conductive connection to an AC/DC supply*

1) To be published.

2) To be published.

3 Terms and definitions

For the purposes of this part of ISO 6469, the following terms and definitions apply.

3.1
conductive part
part capable of conducting electric current

[ISO 8713]

NOTE Although not necessarily electrically energized in normal operating conditions, it may become electrically energized under fault conditions of the basic insulation (see 3.3).

3.2
exposed conductive part
conductive part which can be touched by a test finger according to IPXXB (IEC protection code) as specified in IEC 60529

[ISO 8713]

NOTE This concept is relative to a specific electrical circuit: a live part in one circuit may be an exposed conductive part in another (e.g. the body of a passenger car may be a live part of the auxiliary network but an exposed conductive part of the power circuit).

3.3
live part
conductor or conductive part intended to be electrically energized in normal use

[ISO 8713]

3.4
electrical circuit
collection of connected live parts through which electrical current is intended to flow

[ISO 8713]

3.5
auxiliary electrical circuit
electrical circuit supplying vehicle functions other than for propulsion, such as lamps, windscreen- (windshield-) wiper motors and radios

[ISO 8713]

3.6
electrical chassis
conductive parts galvanically connected, whose potential is taken as a reference

[ISO 8713]

3.7
nominal voltage
value of the voltage used to name an electrical system and to which its characteristics are referred

[ISO 8713]

3.8
working voltage
highest value of a.c. voltage (rms) or d.c. voltage which may occur in an electrical system under any normal operating conditions, transients being disregarded

[ISO 8713]

3.9
power unit
combination of power control and electric motor

[ISO 8713]

3.10
power system
combination of power unit and the on-board energy source

[ISO 8713]

3.11
direct contact
contact of persons to live parts

[ISO 8713]

3.12
indirect contact
contact of persons to exposed conductive parts made live by a fault in the basic insulation of live parts

[ISO 8713]

3.13
basic insulation
insulation of live parts necessary to provide protection against direct contact (in a no-fault condition)

[ISO 8713]

NOTE Basic insulation does not necessarily include insulation used exclusively for a functional purpose.

3.14
supplementary insulation
independent insulation applied in addition to basic insulation, in order to provide protection against electric shock in the event of a failure of the basic insulation

[ISO 8713]

3.15
double insulation
insulation comprising both basic and supplementary insulation

[ISO 8713]

3.16
reinforced insulation
insulation system applied to live parts which provides protection against direct contact equivalent to double insulation

[ISO 8713]

NOTE The term "insulation system" does not imply that the insulation shall be a homogeneous piece. It may comprise several layers which cannot be tested individually as supplementary or basic insulation.

3.17
protection degree
protection related to the contact to live parts of a test finger (IPXXB), a test rod (IPXXC), or a test wire (IPXXD), as defined in IEC 60529

[ISO 8713]

NOTE IEC 60529 also defines protection degrees related to the ingress of water through enclosures (e.g. IPX3 by spray water, or IPX5 by a water jet).

3.18
class I equipment
equipment in which protection against direct contact is ensured by using basic insulation over live parts and connecting together the exposed conductive parts of this equipment using a protective conductor

[ISO 8713]

3.19
class II equipment
equipment in which protection against direct contact is ensured by using double insulation or reinforced insulation

[ISO 8713]

3.20
opening part
part of an electric road vehicle such as door, bonnet (hood), boot (trunk), access lid (e.g. charging inlet cover or fuel tank opening), sun roof or hardtop

[ISO 8713]

3.21
potential equalization
galvanical connection of exposed conductive parts of the electrical equipment

[ISO 8713]

3.22
insulation resistance monitoring system
system which monitors periodically or permanently the insulation resistance between traction battery and vehicle chassis

[ISO 8713]

4 Voltage classes of an electric circuit

Depending on its working voltage, U, an electrical circuit will belong to one of the voltage classes specified in Table 1.

5 Protection against electrical hazards

5.1 General

Protection against electrical hazards shall comprise protection against direct contact to live parts and protection under fault condition of basic insulation of live parts.

For voltage class A electrical circuits no specific protection means against electrical hazards are required.

Table 1 — Voltage classes of electric circuits

Voltage class	Working voltage	
	d.c. systems V	**a.c. systems** (15 Hz to 150 Hz) V(rms)
A	$0 < U \leqslant 60$	$0 < U \leqslant 25$
B	$60 < U \leqslant 1\,500$	$25 < U \leqslant 1\,000$

NOTE 1 The value 60 V d.c. or 25 V a.c. is selected taking into account humid weather conditions. For non a.c. but repetitive pulse voltages, if peak duration is above 10 ms, the considered working voltage is then the maximum peak value. If the peak duration is less than 10 ms, the working voltage is then the rms value. The reported a.c. voltage values are the most critical within the specified frequency range.

NOTE 2 d.c. voltage with $\leqslant$ 10 %: ripple voltage (rms).

NOTE 3 The upper voltage of class B can be lower in accordance with national standards or regulations (see also clause 1).

NOTE For functional reasons, means similar to those specified in 5.2 and 5.3 can also be provided for voltage class A electrical circuits. Such means are not covered by this part of ISO 6469.

5.2 Protection against direct contact

Persons shall be protected against any electrical hazard resulting from direct contact to live parts of any voltage class B electrical circuits.

Protection against direct contact shall be provided either by basic insulation of live parts, or by barriers/enclosures, or by a combination of both, in accordance with the requirements of 6.2 and 6.3.

5.3 Protection under fault condition of basic insulation

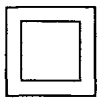
Persons shall be protected against any electrical hazard resulting from contact to exposed conductive parts in case of a fault condition of the basic insulation of live parts of any class B electrical circuits.

Protection under fault conditions shall be provided using either class I or class II equipment or by a combination of both.

Supplementary, double or reinforced insulation of class II equipment shall comply with the requirements given in 6.2.

The potential equalization of class I equipment shall comply with the requirements given in 6.4.

Class II equipment shall be identified by the following symbol, according to IEC 60417:



6 Requirements for protection against electrical hazards

6.1 General

Verification of the means of protection according to 5.2 and 5.3 shall be performed on each voltage class B electrical circuit on the vehicle.

If the safety aspects in relation to the whole vehicle are not affected, the tests may instead be performed on individual components.

6.2 Requirements for basic, supplementary, double and reinforced insulation

6.2.1 General

If protection is provided by insulation, the live parts of the electrical system shall be totally encapsulated by insulation which can only be removed by destruction.

The insulating material shall be suitable to the nominal voltage or working voltage and temperature ratings of the electrical vehicle and system. Insulating varnish, dope, enamel, and other similar materials are not acceptable as basic insulation.

The insulation shall have sufficient insulation resistance and shall withstand a voltage test.

Compliance is checked by the tests given in 6.2.2 and 6.2.3.

6.2.2 Insulation resistance measurement

Each electrical circuit of the electric vehicle shall have an insulation resistance

— between it and the electrical chassis, and

— between it and other electrical circuits.

The equipment shall be subjected to a

a) preconditioning period of at least 8 h at (5 ± 2) °C,

b) followed by a conditioning period of 8 h at

— a temperature of (23 ± 5) °C,

— a humidity of $\left(90^{+10}_{-5}\right)$ %, and

— an atmospheric pressure of from 86 kPa [860 mbar [3)]] to 106 kPa (1 060 mbar).

Alternative preconditioning and conditioning parameters may be selected, provided transition across the dew point occurs shortly after the beginning of the conditioning period.

The insulation resistance shall be measured periodically throughout the conditioning period.

The measurements shall be performed using suitable instruments (e.g. megohmmeter) between the live parts of

— the power system and the electrical chassis of the vehicle, and

— the power system and the auxiliary electrical circuit.

This shall be done by applying a test voltage of at least 1,5 times the nominal voltage of the power system or 500 V d.c., whichever is higher, long enough to obtain a stable reading. The traction and auxiliary batteries shall be disconnected, and both sides of the auxiliary electrical circuits shall be connected to the chassis of the vehicle.

NOTE See ISO 6469-1 for the insulation resistance of the traction battery.

For the power system the insulation resistance shall comply with the values given in Table 2.

6.2.3 Applied voltage test

The tests shall be performed after disconnecting the traction battery and electrically connecting any other electrical circuits to the electrical chassis, by applying an a.c. voltage of a frequency of between 50 Hz and 60 Hz for 1 min between the different sections of the electrical circuit and the exposed parts. See Table 3.

3) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2

Table 2 — Minimum insulation resistance

Equipment	Min. transient insulation resistance measured during conditioning period	Min. insulation resistance measured at conclusion of the conditioning period
Class I	0,1 KΩ/V	1 KΩ/V
Class II	0,5 KΩ/V	5 KΩ/V
Resistance values refer to the nominal working voltage of the equipment.		

If some electronic components connected between the electrical chassis and the live part cannot withstand the test voltage, they shall be disconnected from the test electrical circuit.

Neither dielectric breakdown nor flashover shall occur during the test.

Table 3 — Test voltages

Test voltage		
Class I equipment	**Class II equipment**	
Basic insulation	Supplementary insulation	Double or reinforced insulation
a.c.	a.c.	a.c.
V	V	V
$2U$ + 1 000, but minimum of 1 500	$2U$ + 2 250, but minimum of 2 750	$2U$ + 3 250, but minimum of 3 750
U is the maximum working voltage of the equipment.		

6.3 Requirements for barriers/enclosures

6.3.1 General

If protection is provided by barriers or enclosures, live parts shall be placed inside enclosures or behind barriers. These shall provide sufficient mechanical resistance under normal operating conditions, as specified by the manufacturer (see also clause 4 of ISO 6469-2:2001).

Depending on the size of openings in the enclosures/barriers and the distance to the live parts, certain protection degrees as specified in IEC 60529 are defined.

6.3.2 Directly accessible enclosures/barriers

Enclosures or barriers that are directly accessible shall at least comply with the requirements of the protection degree IPXXD.

If the floor of the vehicle is closer than 30 cm to the ground, IPXXB is sufficient for equipment fitted underneath the vehicle and accessed from the ground.

6.3.3 Enclosures/barriers accessible behind a cover

For enclosures or barriers accessible only after removal or opening of an additional cover, there are three types (S0, S1 and S2) of enclosure/barrier.

Type S0: Enclosures/barriers where removal of the cover does not affect the live parts within the enclosure.

Type S1: Enclosures/barriers where removal of the cover opens the circuits containing live parts within the enclosure.

Type S2: Enclosures/barriers where removal of the cover switches off the electrical power supply to live parts within the enclosure.

Table 4 specifies the requirements of the enclosures/barriers, depending on the type, location and method of opening.

Table 4 — Types of and requirements for enclosures/barriers

Type	Method of opening	Requirements	
		In passenger and load compartments	Elsewhere
S0	With tools or maintenance keys	If the degree of protection is lower than IPXXB when the cover is removed, the enclosures shall be marked according to IEC 60417K and ISO 3864.	
	Without tools or maintenance keys	Not allowed	
S1	With tools or maintenance keys	Separable enclosures shall maintain IPXXB protection criteria in the open condition.	
	Without tools or maintenance keys	Not allowed	Separable enclosures shall maintain IPXXB protection criteria in the open condition.
S2	With tools or maintenance keys	Switching on again shall only be possible after replacing the enclosure or barrier.	
	Without tools or maintenance keys	Not allowed	Switching on again shall only be possible after replacing the enclosure or barrier.

6.4 Specifications for potential equalization

6.4.1 General

The resistance of the connecting parts shall comply with the continuity test given in 6.4.2.

6.4.2 Continuity test for the connected parts

Pass a current derived from a source having a no-load voltage not exceeding 60 V d.c., and equal to 1,5 times the maximum current of the power circuit, or 25 A, whichever is the greater, between any two exposed conductive parts for at least 5 s.

Measure the voltage drop between any two exposed conductive parts.

The resistance calculated from the current and this voltage drop shall not exceed 0,1 Ω.

Care shall be taken that neither the resistance of the supply cord nor the contact resistance between the tip of the measuring probe and the exposed conductive parts under test affects the test results.

7 Protection against water effects

7.1 General

Protection against water effects shall be provided by an insulation resistance monitoring system, or by shielding the voltage class B equipment from exposure to water, or by other suitable means. If the vehicle is equipped with an insulation resistance monitoring system, the requirements of 7.3.1 shall apply. If the vehicle is not equipped with an insulation resistance monitoring system, the tests given in 7.2 shall be performed in order that the requirements of 7.3.2 are met.

7.2 Test procedures

7.2.1 General

The following test procedures simulate washing of the vehicle, a heavy rainstorm and flooding.

7.2.2 Washing

This test is intended to simulate the normal washing of an electric road vehicle, but not specific cleaning using high water pressure or underbody washing. The vehicle manufacturer shall specify detailed conditions for such specific cleaning or washing in the owner's manual.

The critical areas of the vehicle regarding this test are border lines, i.e. a seal of two parts such as flaps, glass seals, outline of opening parts, outline of front grille and seals of lamps.

This test uses a hose nozzle in accordance with IPX5 as specified in IEC 60529 (see annex A).

Using fresh water with a flow rate of 12,5 l/min, all border lines shall be exposed and followed in all directions with the water stream at a speed rate of 0,1 m/s, with a distance of 3 m maintained between the nozzle aperture and the border line.

7.2.3 Heavy rainstorm

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

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

The critical areas of the vehicle for this test are those that are accessible with opening parts that are open.

This test uses a spray nozzle in accordance with IPX3 as specified in IEC 60529 (see annex B).

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

7.2.4 Flooding

This test is intended to simulate the driving of an electric road vehicle on flooded streets or through water puddles.

The vehicle shall be driven in a wade pool, 10 cm in depth, over a distance of 500 m at a speed of 20 km/h, in a time of approximately 1,5 min.

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

7.3 Requirements

7.3.1 If an insulation resistance monitoring system is provided, detection of a loss insulation below 100 Ω/V should activate an automatic disconnect. If the vehicle is in operation when a loss of insulation resistance is detected, the disconnection shall occur when the power-off mode is activated (see ISO 6469-2). The loss of insulation and the disconnection shall be indicated to the driver by an obvious device, (e.g. a visual or audible signal).

The insulation resistance monitoring system should not allow the vehicle to be re-energized until the fault is cleared. If the system is designed to allow the forced re-energize operation by the driver, obvious warning shall be given to the

driver during forced operation. If a second fault occurs, the vehicle shall be automatically de-energized regardless of its mode of operation.

7.3.2 If the test procedures specified in 7.2 are performed, just after each exposure, and with the vehicle still wet, the vehicle shall then comply with the insulation resistance test given in 7.1 of ISO 6469-1:2001, but keeping the power equipment connected to the traction battery (main switch closed), and with the additional requirement of at least 100 Ω/V (referred to the nominal voltage of the power circuit).

In addition, after a 24 h pause, the insulation resistance test specified in 7.1 of ISO 6469-1:2001 shall again be performed with the power equipment connected to the traction battery, and again with the requirement of at least 100 Ω/V.

Annex A
(normative)

Hose nozzle for the washing test — Dimensions

Figure A.1 specifies the dimensions of the hose nozzle to be used for the IPX5 test procedure specified in IEC 60529.

Dimensions in millimetres

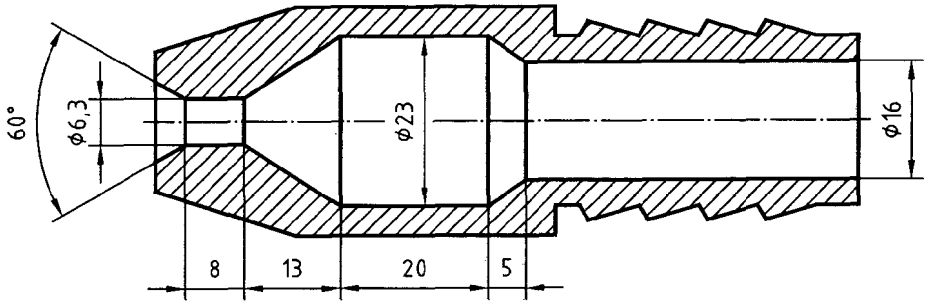


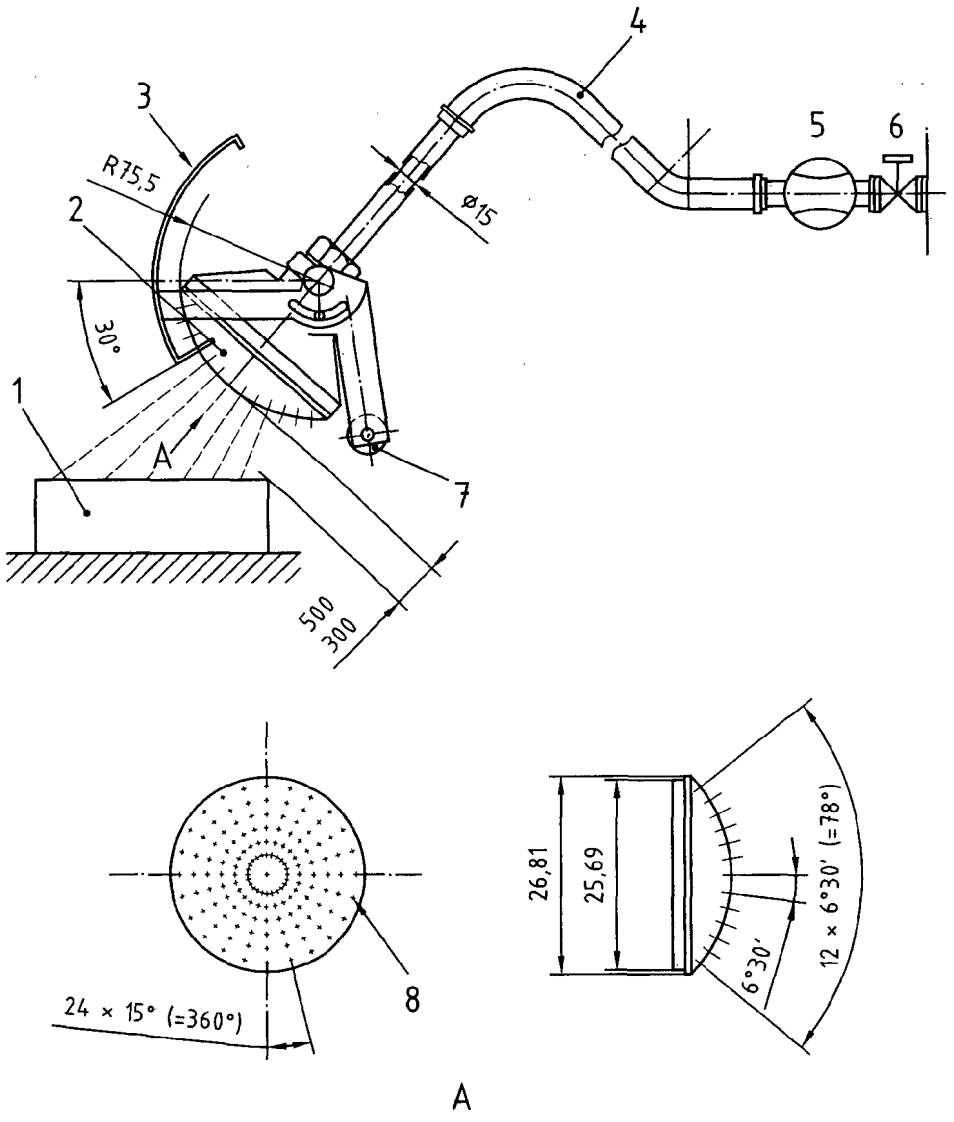
Figure A.1 — Hose nozzle dimensions

Annex B
(normative)

Spray nozzle for the heavy rainstorm test

Figure B.1 specifies the spray nozzle to be used for the IPX3 test procedure specified in IEC 60529.

Dimensions in millimetres



Key

1 Test specimen
2 Spray nozzles (brass)
- — 121 holes of Ø 0,5 mm
- — 4 outer circles of 24 holes at 15° pitch
- — 1 hole at the centre
- — 2 inner circles of 12 holes at 30° pitch

3 Moving shield (aluminium)
4 Hose
5 Pressure gauge
6 Cock
7 Counterweight
8 Diameter of holes: 0,5 mm

Figure B.1 — Spray nozzle

ICS 43.120

Price based on 12 pages