INTERNATIONAL STANDARD

IEC 62196-1

First edition
2003-04

Plugs, socket-outlets, vehicle couplers and vehicle inlets – Conductive charging of electric vehicles –

Part 1: Charging of electric vehicles up to 250 A a.c. and 400 A d.c.

Fiches, socles de prise de courant, prises mobiles et socles de connecteur pour véhicule – Charge conductive des véhicules électriques –

Partie 1: Charge des véhicules électriques jusqu'à 250 A c.a. et 400 A c.c.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PLUGS, SOCKET-OUTLETS, VEHICLE COUPLERS AND VEHICLE INLETS – CONDUCTIVE CHARGING OF ELECTRIC VEHICLES –

Part 1: Charging of electric vehicles up to 250 A a.c. and 400 A d.c.

FOREWORD

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International Standard IEC 62196-1 has been prepared by IEC subcommittee 23H: Industrial plugs and socket-outlets, of IEC technical committee 23: Electrical accessories.

The text of this standard is based on the following documents:

FDIS	Report on voting
23H/132/FDIS	23H/135/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual edition of this standard may be issued at a later date.

INTRODUCTION

IEC 61851-1 specifies electric vehicle conductive charging equipment. This International Standard, referred to as the IEC 60309 series in IEC 61851-1, specifies the requirements for plugs, socket-outlets, connectors, inlets and cable assemblies as described in IEC 61851-1. Some charging can be achieved by direct connection from an electric vehicle to common mains socket outlets. Some modes of charging require a dedicated supply and charging equipment incorporating control and communication circuits. This standard covers the mechanical, electrical and performance requirements for dedicated plugs, socket outlets, vehicle connectors and vehicle inlets for interfacing between such dedicated charging equipment and the electric vehicle.

This International Standard may be published in several parts, as necessary, including this Part 1, comprising clauses of a general character, and subsequent parts, presenting particular requirements for individual types.

PLUGS, SOCKET-OUTLETS, VEHICLE COUPLERS AND VEHICLE INLETS – CONDUCTIVE CHARGING OF ELECTRIC VEHICLES –

Part 1: Charging of electric vehicles up to 250 A a.c. and 400 A d.c.

1 Scope

This part of IEC 62196 is applicable to plugs, socket-outlets, connectors, inlets and cable assemblies for electric vehicles, intended for use in conductive charging systems which incorporate control means, with a rated operating voltage not exceeding:

– 690 V a.c., 50 – 60 Hz, at a rated current not exceeding 250 A;

– 600 V d.c., at a rated current not exceeding 400 A.

These accessories and cable assemblies are intended to be used for circuits specified in IEC 61851-1 which operate at different voltages and frequencies and which may include ELV and communication signals.

These accessories and cable assemblies are to be used in an ambient temperature of between –30 °C and +50 °C. In some countries, other requirements may apply.

These accessories are intended to be connected only to cables with copper or copper-alloy conductors.

The accessories covered by this standard are for use in certain modes of charging EV's. These modes are defined in IEC 61851-1. These definitions and a description of the types of connection (cases A, B and C), also described in IEC 61851-1, are reproduced herein as Annex A.

Table 1 illustrates the types of accessories (B, U_{32}, U_A, U_D) permitted for each charging situation (mode and case) and identifies where it is mandatory to use the accessories covered by this standard. These are indicated by the entries in the columns headed "62196" in Table 1.

The table also describes situations in which either an accessory covered by this standard, or other standardized accessories, are permitted to be used. They are identified by an entry in the column headed "62196" and the word "Any" under the column headed "Type".

This standard does not apply to those standardised accessories used in charging systems where the use of such accessories constructed to the requirements of other standards is permitted (e.g. in mode 1 and mode 2). Such standardized accessories may be used for those situations (mode and case) identified in Table 1 by the word "Any" under the column headed "Type" and with no corresponding entry under the column headed "62196".

This standard can be used as a guide for accessories with a lesser number of contacts and lower ratings for use with light duty vehicles.

Table 1 – Modes and permissible connections specified in IEC 61851-1

Mode	Amps	Phases	Plug & socket					EV connector & inlet						Comments
			Power pins used & prot. earth	Control pins incl. pilot	Type	62196	Case	In line control box	Power pins used & prot. earth	Control pins incl. pilot	Type	62196	Case	
1	16	1	1+N, or 2	None	Any		A		1+N, or 2	None			A	See Note 1
					Any		B				Any	B or U_{32}	B	
		3	3 + N	None	Any		A		3 + N	None			A	
					Any		B				Any	B or U_{32}	B	
2	32	1	1+N, or 2	None	Any		B	yes	1+N, or 2 3 + N	1		B or U_{32}	B	Uses in-line control box
		3	3 + N	None	Any		B	yes	3 + N	1		B or U_{32}	B	Uses in-line control box
3	32	1	1+N, or 2	4		B or U_{32}	A B C		1+N, or 2 3 + N	4		B or U_{32}	A B C	
		3	3 + N	4		B or U_{32}	A B C		3 + N	4		B or U_{32}	A B C	
	250	1							1+N, or 2 @ 32A 1+N, or 2 @ 250A 3 @ 32A + N 3 @ 250A	4		U_A	C	
		3							3 @ 32A + N 3 @ 250A	4		U_A	C	
4	400	-							3 @ 32A + N 2 @ 400A dc	4		U_D	C	

NOTE 1 Restrictions regarding load less than 16 A should be recognized by the vehicle maker.

NOTE 2 In the column headed “62196”, the items listed are defined as:

B Basic

U_{32} Universal interface rated for 32 A a.c. only

U_A Universal interface rated for 32/250 A a.c. only

U_D Universal interface prepared for 32/400 A d.c. only

NOTE 3 In the column headed “Type”, the word “Any” indicates that any IEC standard plug/socket-outlet interface can be used.

NOTE 4 Either “L_1 with N” or “L_1 with L_2” are used for single-phase to match the supply.

NOTE 5 Earth-contact is mandatory in all accessories, pilot contact is mandatory in accessories in modes 2, 3, and 4. The other contacts are provided as required by the user.

2 Normative references

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

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60227 (all parts): *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*

IEC 60228:1978, *Conductors of insulated cables*

IEC 60245-4:1994, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables*

IEC 60269-1:1998, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-2:1986, *Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorised persons (fuses mainly for industrial application*

IEC 60529, *Degrees of protection provided by enclosures (IP code)*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*[1]

IEC 60664-3:1992, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coatings to achieve insulation coordination of printed board assemblies*

IEC 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60999-1:1999, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm^2 up to 35 mm^2 (included)*

IEC 60999-2:1999, *Connecting devices – Safety requirements for screw-type and screwless-type clamping units for electrical copper conductors – Part 2: Particular requirements for conductors from 35 mm^2 up to 300 mm^2*

IEC 61851-1:2001, *Electric vehicle conductive charging system – Part 1: General requirements*

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[1] There exists a consolidated edition 1.2 (2002) including edition 1.0 and its Amendments 1 (2000) and 2 (2002).

3 Definitions

For the purpose of this document, the following terms and definitions apply. Additional definitions may be found in IEC 61851-1.

Where the terms voltage and current are used, they imply r.m.s. values, unless otherwise specified.

Throughout this standard, the word “earthing” is used for “protective earthing”.

NOTE 1 The terms “basic interface” and “universal interface” refer to terms described in IEC 61851–1.

The application of accessories is shown in Figure 1.

NOTE 2 The term “accessory” is used as a generic term covering plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies.

3.1
basic insulation
insulation necessary for the proper functioning of the accessory and for basic protection against electric shock

3.2
cable assembly
piece of equipment which is used to establish the connection between the electric vehicle and the electric vehicle supply equipment. It may be either fixed to and included in one of these devices, or detachable. It includes the flexible cable, the vehicle connector and/or plug that are required for proper connection

NOTE A cable assembly may include one or more cables, with or without a fixed jacket, which may be in a flexible tube, conduit or wire way.

3.3
cable management system
device which is intended to protect a cable assembly from mechanical damage and/or to facilitate its handling

NOTE A cable suspension device is an example of a cable management system.

3.4
cap
part separated or attached, which may be used to provide the degree of protection of a plug or vehicle inlet, when it is not engaged with a socket-outlet or connector

3.5
clamping unit
part of a terminal necessary for the clamping and the electrical connection of the conductor

3.6
conditional short-circuit current
prospective current that an accessory, protected by a specified short-circuit protective device, can withstand satisfactorily for the total operating time of that device under specified conditions of use and behaviour

NOTE This definition differs from IEV 441-17-20 by broadening the concept of current-limiting device into a short-circuit protective device, the function of which is not only to limit the current.

3.7
connection
a single conductive path

3.8
cover
means providing the degree of protection of an accessory when it is not engaged with a socket-outlet or vehicle connector. It can be used as the retaining means or a part of the retaining means

NOTE Caps, lids, shutters and similar devices can perform the function of a cover.

3.9
domestic
intended for household and similar purposes, up to a maximum current rating of 30 – 32 A a.c.

3.10
double insulation
insulation comprising both basic insulation and supplementary insulation.

3.11
electric vehicle (EV)
any vehicle propelled by an electric motor drawing current from a rechargeable storage battery or from other portable energy storage devices (rechargeable using energy from a source off the vehicle such as residential or public electric service), which is manufactured primarily for use on public streets, roads or highways

3.12
in-cable control box
device which is incorporated in the cable assembly and which performs control functions. It is located within the plug or within 0,3 m of the plug or the electric vehicle supply equipment

3.13
insulation voltage
the voltage assigned to the accessory by the manufacturer and to which dielectric tests, clearances and creepage distances are referred

3.14
integral switching device
mechanical switching device constructed as a part of an accessory covered by this standard

3.15
interlock
device, either electrical or mechanical, which prevents the contacts of a socket-outlet from becoming live before it is in proper engagement with a plug, and which either prevents the plug from being withdrawn while its contacts are live or makes the contacts dead before separation

3.16
intermateability
the ability of like accessories to join together with the mating accessories they are intended to be used with

3.17
lid
a means to ensure the degree of protection on a socket-outlet or a vehicle connector

3.18
mechanical switching device
switching device designed to close and open one or more electric circuits by means of separable contacts

3.19
non-rewireable accessory
accessory so constructed that the cable or wiring cannot be separated from the accessory without making it permanently useless

NOTE A plug which is integrally moulded to the cable is an example of a non-rewireable accessory.

3.20
plug and socket-outlet
a means enabling the connection at will of a flexible cable to fixed wiring. It consists of two parts: a socket-outlet and a plug

3.20.1
plug
the part of a plug and a socket-outlet integral with or intended to be attached to one flexible cable connected to the electric vehicle or to a vehicle connector. It may include mechanical, electrical or electronic components and circuitry, which perform control functions

3.20.2
socket-outlet
the part of a plug and a socket-outlet intended to be installed with the fixed wiring or incorporated in equipment

3.21
rated current(s)
current assigned to each pole of the accessory by the manufacturer

3.22
rated operating voltage
nominal voltage of the supply(ies) for which the pole of the accessory is intended to be used

3.23
reinforced insulation
an improved basic insulation with such mechanical and electrical qualities that it provides the same degree of protection against electric shock as double insulation

3.24
retaining means
a mechanical arrangement which holds a plug or vehicle connector in position when it is in proper engagement, and prevents its unintentional withdrawal

3.25
rewireable accessory
accessory so constructed that the cable or wiring can be replaced. It can be either a user-serviceable accessory or a field-serviceable accessory

3.26
user-serviceable accessory
accessory so constructed that it can be rewired, or parts can be replaced, using commonly available tools and without having to replace individual parts of the accessory

NOTE An ordinary plug, which can be disassembled and wired using a common screwdriver, is an example of user-serviceable accessory.

3.27
field-serviceable accessory
accessory so constructed that it shall only be rewired by the manufacturer's authorised personnel

3.28
switched socket-outlet
socket-outlet with an associated switching device to disconnect the supply from the socket-outlet contacts

3.29
supplementary insulation (protective insulation)
independent insulation provided in addition to the basic insulation, in order to ensure protection against electric shock in the event of a failure of the basic insulation

3.30
terminal
conductive part provided for the connection of a conductor to an accessory

3.30.1
pillar terminal
terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw or screws. The clamping pressure may be applied directly by the shank of the screw or through an intermediate clamping member to which pressure is applied by the shank of the screw

NOTE See Figure 13a.

3.30.2
screw terminal
a terminal in which the conductor is clamped under the head of the screw. The clamping pressure may be applied directly by the head of the screw or through an intermediate part, such as a washer, clamping plate or anti-spread device

NOTE See Figures 13b and 13c.

3.30.3
stud terminal
a terminal in which the conductor is clamped under a nut. The clamping pressure may be applied directly by a suitably shaped nut or through an intermediate part, such as a washer, clamping plate or anti-spread device

NOTE See Figure 13d.

3.30.4
saddle terminal
a terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts

NOTE See Figure 13e.

3.30.5
lug terminal
a screw terminal or stud terminal designed for clamping a cable lug or bar by means of a screw or nut

NOTE See Figure 13f.

3.30.6
mantle terminal
terminal in which the conductor is clamped against the base of a slot in a threaded stud by means of a nut. The conductor is clamped against the base of the slot by a suitably shaped washer under the nut, by a central peg if the nut is a cap nut, or by equally effective means for transmitting the pressure from the nut to the conductor within the slot

NOTE See Figure 13g.

3.31
vehicle coupler (EV coupler)
a means enabling the connection at will of a flexible cable to an electric vehicle. It consists of two parts: a vehicle connector and a vehicle inlet

3.31.1
vehicle connector (EV connector)
the part of a vehicle coupler integral with, or intended to be attached to, one flexible cable connected to the supply

3.31.2
vehicle inlet (EV inlet)
the part of a vehicle coupler incorporated in, or fixed to, the electric vehicle

4 General

4.1 General requirements

Accessories shall be so designed and constructed that in normal use their performance is reliable and minimises the risk of danger to the user or surroundings.

Compliance is checked by meeting all of the relevant requirements and tests specified.

4.2 General notes on tests

4.2.1 Tests according to this standard are type tests. If a part of an accessory has previously passed tests for a given degree of severity, the relevant type tests shall not be repeated if the severity is not greater.

4.2.2 Unless otherwise specified, the samples are tested as delivered and under normal conditions of use, at an ambient temperature of (20 ± 5) °C; the tests are made at rated frequency.

4.2.3 Unless otherwise specified, the tests are carried out in the order of the clauses of this standard.

4.2.4 Three samples are subjected to all the tests, except if necessary for the test of Clause 30, one new additional sample is tested. If, however, the tests of Clauses 21, 22 and 23 have to be made with both d.c. and a.c., the tests with a.c. in Clauses 21, 22 and 23 are made on three additional samples. For the tests of Clauses 21.3 and 33, three new samples are to be used.

4.2.5 Accessories are deemed to comply with this standard if no sample fails in the complete series of appropriate tests. If one sample fails in a test, that test and those preceding which may have influenced the test result are repeated on another set of three samples, all of which shall then pass the repeated tests.

NOTE In general, it will only be necessary to repeat the test which caused the failure, unless the sample fails in one of the tests of Clauses 22 and 23, in which case the tests are repeated from that of Clause 21 onwards.

The applicant may submit, together with the first set of samples, the additional set which may be wanted should one sample fail. The testing station, without further request, will then test the additional samples and will reject only if a further failure occurs. If the additional set of samples is not submitted at the same time, the failure of one sample will entail a rejection.

4.2.6 When the tests are carried out with conductors, they shall be copper and comply with IEC 60227, IEC 60228 [Clause 2, solid (class 1), stranded (class 2), flexible (class 5 and 6)], and IEC 60245-4 as accessories according to this standard are intended to be connected to cables with copper or copper-alloy conductors only.

5 Ratings

5.1 Preferred rated operating voltages:

0 to 30 V (signal or control purposes only);

230 V a.c.

400 V a.c.

500 V a.c.

600 V d.c.

5.2 Rated currents:

30 A a.c. or 32 A a.c., 250 A a.c., 400 A d.c.

NOTE 1 In the following countries the branch circuit overcurrent protection device is based upon 125 % of the accessory rating: USA.

NOTE 2 Throughout this standard, reference to a 30 A or 32 A rating is made in accordance with national requirements.

5.3 Rated current for signal or control purposes: 2 A

5.4 An accessory rated 250 A a.c. or 400 A d.c. shall be rated for disconnecting use only, not for current interruption.

5.5 An accessory, rated 32 A, with a pilot circuit contact may be rated as suitable for or not suitable for making and breaking an electrical circuit. See 7.1.4.

6 Connection between the power supply and the electric vehicle

6.1 This section provides a description of the physical conductive electrical interface requirements between the vehicle and the power supply, which allows two designs at the vehicle interface:

a) a universal interface for all modes of charging which provides for either:
   1) high power a.c. and 32 A a.c., or
   2) high power d.c. and 32 A a.c. power;
b) a basic interface for mode 1, 2 and 3 charging only, which provides for 32 A a.c.

6.2 There shall be three types of vehicle inlets, each identified by the marking specified in 8.2:

universal, high power a.c.	(U_A)
universal, high power d.c.	(U_D)
basic	(B)

6.3 There shall be four types of vehicle connectors, each identified by the marking specified in Clause 8.2:

universal, high power a.c.	(U_A)
universal, high power d.c.	(U_D)
universal, 32 A a.c.	(U_{32})
basic	(B)

NOTE The letters U_A, U_D, U_{32} and B have been chosen to correlate with the terms “universal”, “a.c. high power”, d.c. high power”, “low power” and “basic”, as used in IEC 61851-1.

6.4 The universal interface shall contain up to 12 power or signal contacts, with only one physical configuration of contact positions. These positions may be used or not, according to the mode of charging of the vehicle. The electrical ratings and their function are described in Table 3.

The universal vehicle inlet shall be intermateable with either the high power a.c. vehicle connector or the high power d.c. vehicle connector. This vehicle inlet shall be intermateable with the 32 A a.c. vehicle connector, as shown in Table 2. A means shall be provided to prevent the connection of d.c. power from the vehicle connector with the a.c. vehicle inlet and vice versa.

Table 2 – Intermateability of mating devices at vehicle

Inlet	**Vehicle connector**			
	U_A	**U_D**	**U_{32}**	**B**
U_A	Yes	No	Yes	No
U_D	No	Yes	Yes	No
B	No	No	No	Yes

Table 3 – Overview of the universal vehicle interface

Position n°	High power a.c./a.c.	High power d.c./a.c.	Functions [a]
1	500 V 250 A [b]	600 V 400 A [b]	High power d.c. or a.c.
2	500 V 250 A	600 V 400 A	High power d.c. or a.c.
3	500 V 250 A	–	High power a.c.
4	400 V 32 A	400 V 32 A [c]	L1 (mains 1)
5	400 V 32 A	400 V 32 A	L2 (mains 2)
6	400 V 32 A	400 V 32 A	L3 (mains 3)
7	400 V 32 A	400 V 32 A	N (neutral)
8	Rated for fault	Rated for fault	PE (ground/earth)
9	30 V 2 A	30 V 2 A	Control pilot
10	30 V 2 A	30 V 2 A	Communication 1 (+)
11	30 V 2 A	30 V 2 A	Communication 2 (–)
12	30 V 2 A	30 V 2 A	Clean data earth

[a] For contacts 9 to 12, environmental conditions may demand larger conductor cross-sections.

[b] For high power contacts, a duty cycle is under consideration.

[c] In the following countries, the branch circuit overcurrent protection is based upon 125 % of the device rating: USA.

6.5 The basic interface shall contain up to 8 power or signal contacts, with unique physical configurations of contact positions for single phase and for three phase. The electrical ratings and their function are described in Table 4.

The basic vehicle inlet shall be intermateable with either the single phase or the three phase vehicle connector. The basic vehicle connector shall not mate with a universal a.c. or d.c. vehicle inlet.

This vehicle coupler is rated 230 V, 32 A single phase or 230/400 V, 32 A, three phase. It may include additional contacts for control pilot and power indicator.

Table 4 – Overview of the basic vehicle interface

Position n°	a.c.	Functions [a]
1	–	High power d.c./a.c.
2	–	High power d.c./a.c.
3	–	High power a.c.
4	400 V 32 A [b]	L1 (mains 1)
5	400 V 32 A	L2 (mains 2)
6	400 V 32 A	L3 (mains 3)
7	400 V 32 A	N (neutral)
8	Rated for fault	PE (ground/earth)
9	30 V 2 A	Control pilot
10	–	Communication 1 (+)
11	–	Communication 2 (–)
12	–	Clean data earth
13	30 V 2 A	Power indicator
14	30 V 2 A	Power indicator

[a] For contacts 9 to 14, environmental conditions may demand larger conductor cross-sections.

[b] In the following countries, the branch circuit overcurrent protection is based upon 125 % of the device rating: USA.

6.6 Contact sequencing

The contact sequence during the connection process shall be such that the earth connection is made first and the pilot connection is made last. The order of connection of the other contacts is not specified. During disconnection, the pilot connection shall be broken first and the earth connection shall be broken last. The neutral contact N shall make before or simultaneously with contacts L_1, L_2 and L_3 and break after or simultaneously with contacts L_1, L_2 and L_3. See 10.2.

7 Classification

7.1 Accessories are classified:

7.1.1 according to purpose: plugs, socket-outlets, vehicle connectors, vehicle inlets, and cable assemblies;

7.1.2 according to the method of connecting the conductors:

– rewireable accessories;
– non-rewireable accessories;

7.1.3 according to serviceability:

– field serviceable;
– user serviceable;

7.1.4 according to electrical operation:

– suitable for making and breaking an electrical circuit under load;
– not suitable for making and breaking an electrical circuit under load;

7.1.5 according to function as specified in Clause 6:

– basic;
– universal high power a.c.;
– universal high power d.c.;
– universal 32;

7.1.6 according to use with cable management systems.

(Under future consideration)

8 Marking

8.1 Accessories shall be marked with:

– symbol according to the intermateability of the accessories;
– rated current(s) in amperes for power;
– rated maximum operating voltage(s) in volts;
– either the name or trade mark of the manufacturer or of the responsible vendor;
– type reference, which may be a catalogue number.

Compliance is checked by inspection.

8.2 When symbols are used, they shall be as follows:

A.....amperes
V.....volts
Hz.....hertz
 .....protective earth
 .....alternating current
 .....direct current
 .....universal, high power a.c. (U_A)
 .....universal, high power d.c. (U_D)
 .....universal, low power a.c. (U_{32})
 .....basic (B)

Compliance is checked by inspection.

8.3 For all accessories, the marking for the intermateability symbol shall be on the outside of main part, visible to the user during use. For plugs and vehicle connectors, the marking for either the name or trade mark of the manufacturer or the responsible vendor and the type reference, catalogue number or designation shall also be on the outside of the accessory, visible to the user.

8.4 The intermateability symbol shall be at least 10 mm in height and prominent, may be in contrasting colour, and may be provided on a pressure sensitive label or similar means which can be attached to the vehicle inlet cover and connector.

Compliance is checked by inspection.

8.5 For all accessories, the marking for the maximum rated operating voltage and rated current shall be on a place which is visible before installation of the accessory. For socket-outlets and vehicle inlets, the marking for either the name or trademark of the manufacturer or the responsible vendor and the type reference, catalogue number or designation shall be on a place which is visible before installation of the accessory. It need not be visible after installation.

Compliance is checked by inspection.

8.6 For rewireable accessories, the contacts shall be indicated by the position numbers 1 to 12 as indicated in Table 3, or position numbers 4 to 14 as indicated in Table 4.

These position numbers shall be placed close to the relevant terminals; they shall not be placed on screws, removable washers or other removable parts.

Compliance is checked by inspection.

8.7 For rewireable accessories, wiring instructions shall be provided.

Compliance is checked by inspection.

8.8 For non-rewireable accessories, the markings in Clauses 8.6 and 8.7 are not required.

8.9 Marking shall be indelible and easily legible.

Compliance is checked by inspection and by the following test.

After the humidity treatment of 20.3, the marking is rubbed vigorously by hand for 15 s with a piece of cloth soaked in water and again for 15 s with a piece of cloth soaked with petroleum spirit.

NOTE It is recommended that the petroleum spirit used consist of a solvent hexane with an aromatic content of maximum 0,1 volume percentage, a kauributanol value of approximately 29, an initial boiling point of approximately 65 °C, a dry point of approximately 69 °C, and a density of approximately 0,68 g/cm^3.

8.10 Cable assemblies comprised of the cable and one accessory, shall be provided with information to identify the wire terminations, terminals, etc, to provide wiring and installation instructions.

The unwired end of a cable assembly intended for connection to a rewireable accessory shall be marked to identify the conductors.

9 Dimensions

9.1 EV accessories shall comply with the appropriate standard sheets, if any. If no standard sheet is available, the accessories shall comply with the specifications provided by the manufacturer.

9.2 EV accessories may be compatible only with other standardised EV accessories. It shall not be possible to engage plugs or vehicle connectors with socket-outlets or vehicle inlets having different ratings, or having different contact combinations unless safe operation is ensured or other means are provided to ensure safe operation.

In addition, the design shall be such that improper connections shall not be possible between:

– signal and control contacts and a live (power) contact;
– the earth and/or pilot plug-contact and a live socket-contact, or a live plug-contact and the earth and/or pilot socket-contact;
– the phase plug-contacts and the neutral socket-contact, if any;
– a neutral plug-contact and a phase socket-contact.

Compliance is checked by inspection and manual test.

9.3 It shall not be possible to make single-pole connections between plugs and socket-outlets or vehicle connectors, or between vehicle inlets and vehicle connectors or socket-outlets within a single family of accessories.

Compliance is checked by inspection and manual test.

10 Protection against electric shock

10.1 Accessories shall be so designed that live parts of socket-outlets and vehicle connectors, when they are wired as in normal use, and live parts of plugs and vehicle inlets, when they are in partial or complete engagement with the complementary accessories, are not accessible.

In addition, it shall not be possible to make contact between a live part of a plug or vehicle inlet and a live part of a socket-outlet or vehicle connector while any live part is accessible.

NOTE Neutral contacts and pilot contacts of socket-outlets and vehicle connectors are deemed to be live parts. Signal, data earth and earth contacts are not considered live parts.

This clause does not apply to contacts and conductors used for signal, data, communications and control circuits.

Compliance is checked by inspection and, if necessary, by a test on the sample wired as in normal use.

The standard test finger shown in Figure 2 is applied in every possible position, an electrical indicator, with a voltage not less than 40 V, being used to show contact with the relevant part.

10.2 Accessories shall be so designed that:

a) when inserting the plug or vehicle connector,
   1) the earth connection is made before the phase connections and neutral, if any, are made;
   2) the control pilot connection, if any, is made after the phase connections and neutral are made;
b) when withdrawing the plug or vehicle connector,
   1) the phase connections and neutral, if any, are broken before the earth connection is broken;
   2) the control pilot connection, if any, is broken before the phase connections and neutral are broken.

Compliance is checked by inspection and manual test, if required.

10.3 It shall not be possible to inadvertently assemble either the part carrying plug or inlet contacts into the enclosure of a socket-outlet or vehicle connector or the part carrying the socket-outlet or vehicle connector contacts into the enclosure of a plug or inlet.

Compliance is checked by inspection and manual test, if required.

11 Size and colour of earthing conductors

The core connected to the earthing terminal shall be identified by the colour combination green/yellow. The nominal cross-sectional area of the earthing conductor and of the neutral conductor, if any, shall be at least equal to that of the phase conductors, or as specified in Table 6.

NOTE In the following countries, the colour green may be used to identify the earthing conductor: JP, USA, CA.

12 Provision for earthing

12.1 Accessories shall be provided with a protective earthing contact and earthing terminal.

Protective earthing contacts shall be directly and reliably connected to the protective earthing terminals.

Compliance is checked by inspection.

12.2 Accessible metal parts of accessories, which may become live in the event of an insulation fault, shall be reliably connected to the internal earthing terminal(s) by construction.

NOTE 1 For the purpose of this requirement, screws for fixing bases, covers and the like are not deemed to be accessible parts which may become live in the event of an insulation fault.

If accessible metal parts are screened from live parts by metal parts which are connected to an earthing terminal or earthing contact, or if they are separated from live parts by double insulation or reinforced insulation, they are not, for the purpose of this requirement, regarded as likely to become live in the event of an insulation fault.

Compliance is checked by inspection and by the following test:

A current of 25 A derived from an a.c. source having a no-load voltage not exceeding 12 V is passed between the earthing terminal and each of the accessible metal parts in turn.

The voltage drop between the earthing terminal and the accessible metal part is measured, and the resistance calculated from the current and this voltage drop.

In no case shall the resistance exceed 0,05 Ω.

NOTE 2 Care should be taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

12.3 Earthing contacts shall comply with the test requirement in either 12.3.1 or 12.3.2–12.3.4, as specified by the manufacturer.

12.3.1 Earthing contacts shall be capable of carrying a current equal to that specified for the phase contacts without overheating.

Compliance is checked by the test of Clause 24.

12.3.2 The assembly of mating accessories with protective earthing contacts shall carry the current specified in Table 5 for the time specified in that table. The current is to be based on the minimum size equipment earthing conductor for the ampere rating of the device. The components in the earthing path shall not crack, break, or melt.

12.3.3 The mating accessories are to be mounted and assembled as intended. An earthing conductor of the minimum intended size, not less than 0,6 m long, is to be connected to the protective earthing terminal of each device, with the terminals employed to hold the conductor tightened using a torque as specified by the manufacturer. Socket-outlets and vehicle inlets are to be wired with the minimum allowable size copper conductor. Plugs and vehicle connectors are to be wired with flexible, stranded conductors or cable sized based on the ampere rating of the device. The test current shall be passed through the mating accessories and earthing wires in series.

Table 5 – Short-time test currents

Device rating A	**Time** s	**Test current** A
30 – 32	4	750
250	6	2450
400	6	3100

12.3.4 After having carried the current specified in 12.3.2, continuity shall exist on the test assembly when measured between the earthing conductors. Any indicating device such as an ohmmeter, battery-and-buzzer combination, or the like, may be used to determine whether continuity exists.

Compliance is checked by inspection and test.

12.4 Earthing contacts shall be so shrouded or guarded that they are protected against mechanical damage.

Compliance is checked by inspection.

NOTE This requirement precludes the use of side earthing contacts.

12.5 Clean data (signal) earth contacts shall be capable of carrying a current of 2 A without overheating.

Compliance is checked by the test of Clause 24.

13 Terminals

13.1 Connections to terminals of contacts rated 250 A or more shall provide a permanent and secure connection. These terminals shall not be rewireable or user serviceable.

13.2 Rewireable accessories shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices.

Compliance is checked by inspection.

13.3 Parts of terminals, other than screws, nuts, washers, stirrups, clamping plates and the like, shall be either of:

- copper;
- an alloy containing at least 58 % copper for parts that are worked cold or at least 50 % copper for other parts;
- or other metal not less resistant to corrosion than copper and having mechanical and electrical properties no less suitable.

Steel screws shall be adequately protected against corrosion.

Compliance is checked by inspection and by chemical analysis.

13.4 If the body of an earthing terminal is not part of the metal frame or housing of the accessory, the body shall be of material as prescribed in 13.3 for parts for terminals. If the body is part of the metal frame or housing, the clamping screw or nut shall be of such material.

If the body of the earthing terminal is part of a frame or housing of aluminium or aluminium alloy, precautions shall be taken to avoid the risk of corrosion resulting from contact between copper and aluminium or its alloys.

NOTE The requirement regarding the avoidance of the risk of corrosion does not preclude the use of adequately coated metal screws or nuts.

Requirements that are more detailed are under consideration.

Compliance is checked by inspection and by chemical analysis.

NOTE A test for determining the resistance to corrosion is under consideration.

13.5 Terminals shall provide for the connection of copper or copper-alloy conductors. For rewireable accessories, these terminals shall provide for the connection of conductors having nominal cross-sectional areas as shown in Table 6. For non-rewireable accessories, these terminals shall provide for the connection of conductors having nominal cross-sectional areas as specified by the manufacturer of the cable assembly.

For terminals other than lug terminals, compliance is checked by the following test and by the tests of 13.8, 13.9 and 13.10.

Gauges as specified in Figure 12, having a measuring section for testing the insertability of the maximum specified cross-sectional area of Table 6 shall be able to penetrate into the terminal aperture under their own weight to the designated depth of the terminal.

For pillar terminals in which the end of a conductor is not visible, the hole to accommodate the conductor shall have a depth such that the distance between the bottom of the hole and the last screw will be equal to at least half the diameter of the screw, and in any case not less than 1,5 mm.

Compliance is checked by inspection.

For terminals complying with Figure 13f), the lug shall accept conductors having nominal cross-sectional areas within the appropriate range specified in Table 6.

Terminals that cannot be checked by the gauges specified in Figure 12 are tested by suitably shaped gauges having the same cross-section as those of the appropriate gauges given in Figure 12.

Table 6 – Size for power and signal conductors

Contact rating	**Internal connection**					
Current A	**Flexible cables for plugs and vehicle connectors** **Solid or stranded cables for vehicle inlets** [a]			**Solid or stranded cables for socket-outlets** [a]		
	mm²	AWG/MCM [b]	PE	mm²	AWG/MCM [b]	PE
2	0,5	18	–	0,5	18	–
30 – 32	2,5 to 6	14 to 10	6	2,5 to 10	14 to 8	10
250	150	0000	70	185	250	95
400	240	500	120 [c]	300	600	150 [c]

[a] Classification of conductors: according to IEC 60228.

[b] The nominal cross-sectional areas of conductors are given in square millimetres (mm²). AWG/MCM values are considered as equivalent to mm² for the purpose of this standard.

Reference IEC 60999-1 (Annex A), 60999-2 (Annex C).

AWG: American Wire Gauge is a system of identifying wires in which the diameters are found in geometric progression between size 36 and size 0000.

MCM: Mille Circular Mils denotes circle surface unit. 1 MCM = 0,5067 mm².

[c] For isolated d.c. equipment – PE conductor size based on a.c. mains (branch) circuit over-current protective size.

13.6 Terminals shall have appropriate mechanical strength.

Screws and nuts for clamping shall have an ISO thread or a thread comparable in pitch and mechanical strength.

NOTE Provisionally, SI, BA and UN threads are considered as being comparable in pitch and mechanical strength.

Compliance is checked by inspection, measurement and the test of 27.1. In addition to the requirements of 27.1, the terminals shall not have undergone changes after the test that adversely affects their future use.

13.7 Terminals shall be properly fixed to the accessory and shall not work loose when the clamping screws or nuts are tightened or loosened.

Screws and nuts for clamping the conductors shall not serve to fix any other component.

NOTE The clamping means for the conductor may be used to stop rotation or displacement of the plug or socket contacts.

Compliance is checked by inspection and, if necessary, by the test of 27.1.

NOTE These requirements do not preclude terminals that are floating or terminals so designed that rotation or displacement of the terminal is prevented by the clamping screw or nut, if their movement is appropriately limited and does not impair the correct operation of the accessory.

Terminals may be prevented from working loose by fixing with two screws, by fixing with one screw in a recess such that there is no appreciable play or by other suitable means.

Covering with sealing compound without other means of locking is not deemed sufficient. Self-hardening resins may, however, be used to lock terminals which are not subject to torsion in normal use.

13.8 Terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without damage to the conductor.

Compliance is checked by inspection and the type tests of the terminals of 13.9 and 13.10, applied to three separate terminals.

13.9 *First test*:

Verification is made successively with conductors of the largest and smallest cross-sectional areas specified in Table 6, using class 1 or class 2 conductors for terminals of socket-outlets or vehicle inlets and class 5 conductors for terminals of plugs or vehicle connectors.

The conductors shall be connected to the clamping unit, and the clamping screws or nuts tightened to two-thirds of the torque indicated in Table 18, unless the torque is specified by the manufacturer on the product or in an instruction sheet.

Each conductor is subjected to a pull according to the value in Table 7, exerted in the opposite direction to that in which the conductor was inserted. The pull is applied without jerks for 1 min. The maximum length of the test conductor shall be 1 m.

During the test, the conductor shall not slip out of the terminal nor shall it break at, or in, the clamping unit.

Table 7 – Value for terminal pull test

Nominal cross-sectional area mm²	**Pulling force** N
0,5	15
1	30
2,5	50
4	50
6	60
10	80
35	120
50	140
150	220
185	240
240	270
300	300

13.10 *Second test:*

This test is carried out first with the smallest cross-sectional area and then with the largest cross-sectional area of the relevant values in Table 6 for class 1 (up to and including 4 mm^2) and class 2 conductors. The clamping screws or nuts are tightened with the torque according to Table 18, unless the torque is specified by the manufacturer on the product or in an instruction sheet.

The terminal is fastened to a conductor whose length is at least 75 mm longer than the height specified in Table 8, and is secured rigidly in a vertical position simulating actual service conditions. The free end of the cable is passed through a bushing of the size specified in Table 8. The bushing is attached to an arm, driven by a motor at a rate of approximately 9 rpm and for approximately 135 revolutions, and in such a manner that the centre of the bushing is made to describe a circle in a horizontal plane (see Figure 14).

The circle shall have a diameter of (75 ± 2) mm, and its centre shall be vertically below the centre of the conductor opening in the terminal. The bushing is lubricated to prevent binding, twisting or rotation of the insulated cable. A weight as specified in Table 8 is suspended from the free end of the conductor.

During the test, the conductor shall not pull out of the clamping unit.

Breaking of the conductor or of any strand of a stranded conductor is determined by examining the entire terminal while the conductor is still connected after the test. The conductor or strand of a stranded conductor shall not be visibly detached.

Table 8 – Value for flexing under mechanical load test

Nominal cross-sectional area of conductor mm²	**Diameter of bushing** (see note) mm	**Height**[a] ***H*** mm	**Mass for conductor** kg
0,5	6,5	260	0,3
1,0	6,5	260	0,4
1,5	6,5	260	0,4
2,5	9,5	280	0,7
4	9,5	280	0,9
6	9,5	280	1,4
10	9,5	280	2,0
35	14,5	320	6,8
50	16	340	9,5
150	22	410	15,0
185	25	430	16,8
240	29	460	20,0
300	29	460	22,7
NOTE If a bushing with the hole diameter given is not adequate to accommodate the conductor without binding, a bushing having the next largest hole may be used.			
[a] Tolerance for height *H* ± 15 mm.			

13.11 Lug terminals shall be used only for accessories having a rated current of at least 63 A. If such terminals are provided, they shall be fitted with spring washers or equally effective locking means.

Compliance is checked by inspection.

13.12 Each terminal shall be located in proximity to its corresponding terminal or terminals of different polarity, and to the internal earthing terminal, if any, unless there is a sound technical reason to the contrary.

Compliance is checked by inspection.

13.13 Clamping screws or nuts of earthing terminals shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a tool.

Unless two screws in pillar type terminals are used, a test is required to prove the locking capabilities.

A test is under consideration.

Compliance is checked by inspection and by manual test.

13.14 Terminals shall be so located or shielded that:

– screws becoming loose from the terminals cannot establish any electrical connection between live parts and metal parts connected to the earthing terminal;
– conductors becoming detached from live terminals cannot touch metal parts connected to the earthing terminal;
– conductors becoming detached from the earthing terminal cannot touch live parts.

This requirement applies also to terminals for pilot conductors.

Compliance is checked by inspection and by manual test.

13.15 When the conductors have been correctly fitted, there shall be no risk of accidental contact between live parts of different polarity or between such parts and accessible metal parts, and, should a wire of a stranded conductor escape from a terminal, there shall be no risk that wires emerge from the enclosure.

The requirement with regard to the risk of accidental contact between live parts and accessible metal parts does not apply to accessories having rated voltages not exceeding 50 V.

Compliance is checked by inspection and, where the risk of accidental contact between live parts and other metal parts is concerned, by the following test.

An 8 mm length of insulation is removed from the end of a flexible conductor having a cross-sectional area in the middle of the range specified in 13.5. One wire of the stranded conductor is left free and the other wires are fully inserted into and clamped in the terminal. The free wire is bent, without tearing the insulation back, in every possible direction, but without making sharp bends round barriers.

The free wire of a conductor connected to a live terminal shall neither touch any metal part, which is not a live part, nor emerge from the enclosure, and that of a conductor connected to the earthing terminal shall not touch any live part.

NOTE If necessary, the test is repeated with the free wire in another position.

14 Interlocks

Accessories rated “Not for current interruption” shall be provided with a control pilot contact.

NOTE Switching, related interlocks and control systems, other than the control pilot contact, are part of the equipment or part of the EV. No provision is made in this standard for these items.

15 Resistance to ageing of rubber and thermoplastic material

Accessories with enclosures of rubber or thermoplastic material, and parts of elastomeric such as sealing rings and gaskets, shall be sufficiently resistant to ageing.

Compliance is checked by an accelerated ageing test made in an atmosphere having the composition and pressure of the ambient air.

The samples are suspended freely in a heating cabinet, ventilated by natural circulation. The temperature in the cabinet and the duration of the ageing test are:

(70 ± 2) °C and 10 days (240 h), for rubber;

(80 ± 2) °C and 7 days (168 h), for thermoplastic material.

NOTE The ageing temperatures for materials used at higher ambient temperatures are under consideration.

After the samples have been allowed to attain approximately room temperature, they shall be examined and show no crack visible to the naked eye, nor shall the material have become sticky or greasy.

After the test, the samples shall show no damage which would lead to non-compliance with this standard. If there is a doubt as to whether the material has become sticky, the sample is placed on one of the pans of a balance and the other pan is loaded with a mass equal to the mass of the sample plus 500 g. Equilibrium is then restored by pressing the sample with the forefinger, wrapped in a dry piece of coarse woven cloth.

No trace of the cloth shall remain on the sample and the material of the sample shall not stick to the cloth.

NOTE The use of an electrically heated cabinet is recommended. Natural circulation may be provided by holes in the walls of the cabinet.

16 General construction

16.1 Accessible surfaces of accessories shall be free from burrs, flashes and similar sharp edges.

Compliance is checked by inspection.

16.2 Screws or other means for fixing the part carrying the socket-outlet contacts or the part carrying the plug contacts to its mounting surface, in a box or in an enclosure, shall be easily accessible.

These fixings and those which fix the enclosure shall not serve any other purpose except in the case whereby an internal earthing connection is established automatically and in a reliable way by such a fixing.

Compliance is checked by inspection.

16.3 It shall not be possible for the user to alter the position of the earthing contact, or of the neutral contact, if any, in relation to the means of non-interchangeability of the socket-outlet or vehicle connector, or in relation to the means of non-interchangeability of the plug or vehicle inlet.

Compliance is checked by manual test to ensure that only one mounting position is possible.

16.4 Socket-outlets and vehicle connectors when mounted as in normal use and without a plug in position shall ensure the degree of protection specified on its marking.

In addition, when a plug or vehicle inlet is fully engaged with the socket-outlet or vehicle connector, the lower degree of protection of the two accessories shall be ensured.

Compliance is checked by inspection and by the tests of Clauses 20 and 21.

16.5 The maximum permissible temperature of those parts of the plug and the vehicle connector that can be grasped during normal operation, when tested with the accessory carrying the maximum rated current, shall not exceed:

– 50 °C for metal parts;
– 60 °C for non-metal parts.

For parts which may be touched but not grasped the permissible temperature are:

– 60 °C for metal parts;
– 85 °C for non-metal parts.

Compliance is checked by an ambient temperature of (25 ± 5) °C and corrected to an ambient of 40 °C. See 24.2.

16.6 Contacts shall be so designed as to ensure adequate contact pressure when completely engaged with the corresponding accessory. Contacts of vehicle connectors and socket-outlets shall be self-adjusting to ensure adequate contact pressure.

Compliance is checked by inspection and the temperature-rise test of Clause 24.

16.7 The pressure exerted between the socket and plug contacts or the vehicle connector and vehicle inlet shall not be so great as to make insertion and withdrawal of the plug or vehicle connector difficult.

Compliance is checked by inspection.

16.8 A latching mechanism shall be provided on mating accessories. The latching mechanism shall prevent the plug or vehicle connector from working out of the socket-outlet or vehicle inlet, respectively, in normal use.

Compliance is checked by inspection and test of 16.9.

16.9 With the latching mechanism in place, the mating accessory shall be pulled with a force equal to the weight of the accessory and a length of the maximum size cable or cable assembly used with the accessory, as specified in Table 9. The latch shall not release.

Table 9 – Cable length used to determine pull force on latch assembly

Device	Cable length m
U_A	1,5
U_D	1,5
U_{32}	4
B	4

Compliance is checked by inspection and test.

16.10 Rewireable accessories shall be so constructed as to permit:

– the conductors to be easily introduced into the terminals and secured therein;

– the correct positioning of the conductors, without their insulation coming into contact with live parts of a polarity different from that of the conductor; or without reducing the creepage distances and clearances below the values in 28.1;

– the covers or enclosures to be easily removable for inspection and easily fixed after connection of the conductors.

Compliance is checked by inspection and by an installation test with conductors of the largest cross-sectional area specified in Table 6.

16.11 Field serviceable accessories shall be so designed and constructed to discourage user servicing, rewiring or accessing live parts by non-qualified personnel. This can be accomplished through one or more of the following means:

– Necessity of the use of speciality tools (i.e. – crimping tool, soldering equipment,)

– Necessity of replacing individual parts of the accessory (i.e. – replacement of terminals, pins,)

– Necessity to break seals to disassemble the accessory.

16.12 Enclosures and parts of accessories providing protection against electric shock shall have adequate mechanical strength; they shall be securely fixed in such a way that they will not work loose in normal use. It shall not be possible to remove these parts without the aid of a tool.

Compliance is checked by inspection and test.

16.13 Cable entries shall allow the introduction of the conduit or the protective covering of the cable to afford complete mechanical protection.

Compliance is checked by inspection and by an installation test with conductors of the largest cross-sectional area specified in Table 6.

16.14 Insulating linings, barriers and the like shall have adequate mechanical strength. They shall be secured to the enclosure or body in such a way that they cannot be removed without being seriously damaged, or be so designed that they cannot be replaced in an incorrect position.

Compliance is checked by inspection and by the tests of 20.2 and 26.3

NOTE The use of adhesives is allowed for fixing insulating linings.

16.15 The force to insert and withdraw a plug or a vehicle connector shall be less than 80 N. The movement of either of these accessories need not necessarily be a single linear movement. The insertion and withdrawal force shall be applied as required by each stage of the insertion and withdrawal movement. The manufacturer shall state the position and direction at which this force(s) shall be applied.

Compliance may be checked by a spring scale or the following test.

The fixed accessory (the socket-outlet or vehicle inlet) shall be mounted such that the mating accessory moves vertically downward into it during the first stage of insertion. A principal weight of 7,2 kg is suitable suspended from the matching accessory. A supplementary weight of 0,8 kg is allowed to fall from a height of 5 cm onto the principal weight. The moving accessory shall enter the fixed accessory to the position required to engage the contacts properly.

The operation is then repeated for any subsequent movements.

The test is repeated using a fixed weight of 2,0 kg and no supplementary weight. The moving accessory shall not become inserted in the fixed accessory to the extent specified by the manufacturer. These tests are carried out in reverse also to check the withdrawal force to determine that the contacts disengage properly.

17 Construction of socket-outlets

When a plug is not engaged, socket-outlets shall be totally enclosed when fitted with screwed conduits, or sheathed cables. Polyvinyl chloride sheathed cables are not excluded. The means for achieving total enclosure and that for ensuring the marked degree of protection, if any, shall be securely fixed to the socket-outlet. In addition, when a plug is completely engaged, the socket-outlet shall incorporate means for ensuring the marked degree of protection.

Lid springs, if any, shall be of corrosion-resistant material, such as bronze, stainless steel, or other suitable material adequately protected against corrosion.

IP44 socket-outlets, designed for only one mounting position, may have provision for opening a drain-hole at least 5 mm in diameter or 20 mm^2 in area with a width of at least 3 mm which is effective when the socket-outlet is in the mounting position.

NOTE 1 The total enclosure and the marked degree of protection may be achieved by means of a lid.

NOTE 2 A drain-hole in the back of the enclosure of a socket-outlet, up to IP44 intended to be mounted on a vertical wall, is deemed to be effective only if the design of the enclosure ensures a clearance of at least 5 mm from the wall, or provides a drainage channel of at least the size specified.

Compliance is checked by inspection, by measurement and by the tests of Clauses 20, 21 and 23.

18 Construction of plugs and vehicle connectors

18.1 The enclosure of plugs and vehicle connectors shall completely enclose the terminals and the ends of the flexible cable.

The construction of rewireable plugs and vehicle connectors shall be such that the conductors can be properly connected and the cores kept in place so that there is no risk of contact between them from the point of separation of the cores to the terminals.

Accessories shall be so designed that they can only be reassembled so as to ensure the correct relationship between the components as originally assembled.

Compliance is checked by inspection and, if necessary, by manual test.

18.2 The various parts of a plug or vehicle connector shall be reliably fixed to one another in such a way that they will not work loose in normal use. It shall not be possible to dismantle plugs or vehicle connectors without the aid of a tool.

Compliance is checked by manual test and by the test of 25.3.

18.3 Plugs shall incorporate means for ensuring the marked degree of protection when in complete engagement with the complementary accessory.

Where there is an attached cap, which cannot be removed without the aid of a tool, then the plug shall also meet this requirement when that cap is correctly fitted.

It shall not be possible to dismantle these means without the aid of a tool.

Compliance is checked by inspection and by the tests of Clauses 20 and 21.

18.4 Vehicle connectors shall be totally enclosed when fitted with a flexible cable as in normal use and when not in engagement with the vehicle inlet. In addition, they shall incorporate means for ensuring the marked degree of protection when in complete engagement with the vehicle inlet.

NOTE The marked degree of protection when not in engagement with the vehicle inlet may be achieved by means of a lid or cover.

The means for ensuring the marked degree of protection shall be securely fixed to the vehicle connector.

Lid springs shall be of corrosion-resistant material, such as bronze, stainless steel or other suitable materials adequately protected against corrosion.

Compliance is checked by inspection and by the tests of Clauses 20, 21 and 23.

19 Construction of vehicle inlets

19.1 Vehicle inlets shall incorporate means for ensuring the marked degree of protection when an appropriate vehicle connector is completely engaged.

The IP degree of protection of the vehicle inlet must be considered, assuming that any accessible parts that may be live when a vehicle connector is connected are not live when the vehicle connector is removed and may be touched by the test finger.

Where there is an attached cap, which cannot be removed without the aid of a tool, then the vehicle inlets shall also meet this requirement when that cap is correctly fitted.

It shall not be possible to dismantle these means without the aid of a tool.

Compliance is checked by inspection and by the tests of Clauses 19 and 20. If the degree of protection when no connector is present, the vehicle manufacturer must ensure the IP degree.

19.2 Vehicle inlets having rated operating voltage exceeding 50 V shall be provided with earthing contacts.

Compliance is checked by inspection.

19.3 IP44 vehicle inlets, designed for only one mounting position, may have provision for opening a drain-hole at least 5 mm in diameter or 20 mm^2 in area with a width of at least 3 mm which is effective when the socket-outlet is in the mounting position.

20 Degrees of protection

20.1 Accessories shall have the minimum degrees of protection of IP44. The vehicle inlet, in road position and in combination with the protection provided by the vehicle manufacturer, shall have the minimum degrees of protection of IP55.

NOTE "In road position" means that the vehicle is stationary and ready to be driven.

Compliance is checked by the appropriate tests mentioned in the subclauses below.

The tests are made on accessories fitted with the cables or conduits for which they are designed, screwed glands and fixing screws of enclosures and covers being tightened with a torque equal to two-thirds of that applied in the tests of 26.5 or 27.1, as appropriate.

Screwed caps or lids, if any, are tightened as in normal use.

Socket-outlets are mounted on a vertical surface so that the open drain-hole, if any, is in the lowest position and remains open.

Vehicle inlets are mounted in position as intended in the vehicle. Tests shall be conducted with any doors, access panels, covers, etc. provided by the vehicle both in the unmated, open, and closed (in the road position) positions. Vehicle connectors are placed in the most unfavourable position and the drain-hole, if any, remains open.

Socket-outlets and vehicle connectors are tested with and without the complementary accessory in engagement, the means for ensuring the required degree of protection against moisture being positioned as in normal use.

Plugs and vehicle inlets are tested as described in 18.3 or 19.1.

20.2 Accessories shall be tested in accordance with 20.1 and IEC 60529. When the first characteristic numeral is 5, category 2 shall apply.

Immediately after the tests the samples, while still mounted in the test position, shall withstand the dielectric strength test specified in 21.3, and inspection shall show that water has not entered the samples to any appreciable extent and has not reached live parts.

20.3 All accessories shall be proof against humid conditions which may occur in normal use.

Compliance is checked by the humidity treatment described in this subclause, followed immediately by the measurement of the insulation resistance and by the dielectric strength test, specified in Clause 21. Cable entries, if any, are left open; if knockouts are provided, one of them is opened.

Covers, which can be removed without the aid of a tool, are removed and subjected to the humidity treatment with the main part; spring lids are open during this treatment.

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %. The temperature of the air, at all places where samples can be located, is maintained within 1 °C of any convenient value T between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the samples are brought to a temperature between T and T + 4 °C.

The samples are kept in the cabinet for 7 days (168 h).

NOTE In most cases, the samples may be brought to the temperature specified by keeping them at this temperature for at least 4 h before the humidity treatment.

A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water, having a sufficiently large contact surface with the air.

In order to achieve the specified conditions within the cabinet, it is necessary to ensure constant circulation of the air within it and, in general, to use a cabinet that is thermally insulated.

After this treatment, the samples shall show no damage within the meaning of this standard.

21 Insulation resistance and dielectric strength

21.1 The insulation resistance and the dielectric strength of accessories shall be adequate.

Compliance is checked by the tests of 21.2 and 21.3, which are made immediately after the test of 20.3 in the humidity cabinet or in the room in which the samples were brought to the prescribed temperature, after reassembly of covers that may have been removed.

Accessories with enclosures of thermoplastic material are subjected to the additional test of 21.4.

NOTE For the purpose of these tests, the neutral contact, the pilot contact, the communications contacts, and any other contacts for signal or control purposes (positions 9 – 14 for “universal” accessories, positions 9 – 12 for “basic” accessories) if any, are each considered as a pole.

21.2 *The insulation resistance is measured with a d.c. voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage.*

The insulation resistance shall be not less than 5 MΣ.

21.2.1 *For socket-outlets and vehicle connectors, the insulation resistance is measured consecutively:*

a) between all poles connected together and the body, the measurement being made with and also without a plug or vehicle inlet engaged;

b) between each pole in turn and all others, these being connected to the body, with a plug or vehicle inlet engaged;

c) between any metal enclosure and metal foil in contact with the inner surface of its insulating lining, if any, a gap of approximately 4 mm being left between the metal foil and the edge of the lining.

NOTE The term “body” includes all accessible metal parts, metal foil in contact with the outer surface of external parts of insulating material, other than the engagement face of vehicle connectors and plugs, fixing screws of bases, enclosures and covers, external assembly screws and earthing terminals, if any.

21.2.2 *For plugs and vehicle inlets, the insulation resistance is measured consecutively:*

a) between all poles connected together and the body;

b) between each pole in turn and all others, these being connected to the body;

c) between any metal enclosure and metal foil in contact with the inner surface of its insulating lining, if any, a gap of approximately 4 mm being left between the metal foil and the edge of the lining.

21.3 *A test voltage of substantially sine-wave form, having a frequency of 50 Hz/60 Hz and the value shown in Table 10, is applied for 1 min between the parts indicated in 21.2.1 and 21.2.2.*

NOTE For the parts indicated in 21.2.1(a) and 21.2.2(a), which are used in non-power circuits [control pilot circuit, communications circuits, including clean data earth, or other signal or control circuits (positions 9 – 14 for «universal» accessories, positions 9 – 12 for “basic” accessories)], each circuit may be tested separately, using a test voltage based on the highest voltage in the circuit. For the parts indicated in 20.2.1(b) and 20.2.2(b), which are used in non-power circuits [control pilot circuit, communications circuits, including clean data earth, or other signal or control circuits (positions 9 – 14 for “universal” accessories, positions 9 – 12 for “basic” accessories)], the test voltage between these circuits and the power circuits shall be based on the voltage of the power circuit.

Table 10 – Test voltage for dielectric strength test

Insulation voltage of the accessory [a]	**Test voltage** V
Up to and including 50	500
over 50 up to and including 415	2 000 [b]
over 415 up to and including 500	2 500
over 500	3 000
[a] The insulation voltage is at least equal to the highest rated operating voltage.	
[b] This value is increased to 2 500 V for metal enclosures lined with insulating material.	

Initially, no more than half the prescribed voltage is applied, and then it is raised rapidly to the full value.

No flashover or breakdown shall occur during the test.

NOTE Glow discharges without drop in voltage are neglected.

21.4 Immediately after the test of 21.3, it shall be verified that for accessories with enclosures of thermoplastic material, the means of providing non-interchangeability have not been impaired.

22 Breaking capacity

22.1 Accessories intended for current interruption (making and breaking under load) shall have adequate breaking capacity.

NOTE Accessories rated 250 A a.c. or 400 A d.c. are rated for disconnecting use only, not for current interruption, and are intended to be used with a control pilot circuit system and interlock provided as a part of the equipment or part of the EV. These accessories are not identified as being for current interruption.

Compliance is checked by testing mating complementary accessories in accordance with 22.2.

22.2 *The test position shall be horizontal or, if not possible, as in normal use.*

The plug or vehicle connector is inserted into and withdrawn from the socket-outlet or vehicle inlet at a rate of 7,5 strokes per minute, or at the rate recommended by the manufacturer, whichever is less. The speed of insertion and separation of the plug or vehicle connector shall be (0,8 ± 0,1) m/s.

The measurement of speed is made by recording the interval of time between insertion or separation of the main contacts and the insertion or separation of the earthing contact, relative to the distance.

Electrical contacts shall be maintained for no more than 4 s and no less than 2 s.

The movement(s) of a plug or vehicle connector during insertion into the mating accessory may be more complex than a single linear movement. At the manufacturer's option, the test may be made with the insertion and withdrawal made manually or by machine. The movement may be limited to provide adequate separation of the mating contacts.

The number of cycles is specified in Table 11. A stroke is an insertion or a withdrawal of a plug or vehicle connector with its mating accessory. A cycle is composed of two strokes, one for insertion and one for withdrawal.

Accessories are tested as defined in Table 11.

For accessories rated for both a.c. and d.c. operation, a new set of accessories shall be tested on each circuit.

The test is made using the connections shown in Figure 3 except that for accessories having a rated voltage of 380 V – 415 V, the metal support is permanently connected to the neutral. In all other cases, for two-pole accessories, the selector switch C connecting the metal support and the accessible metal parts to one of the poles of the supply, is operated after half the number of strokes. For three-pole accessories, the selector switch C is operated after one-third of the number of strokes and again after two-thirds of the number of strokes, so as to connect each pole in turn.

Resistors and inductors are not connected in parallel, except that, if an air-core inductor is used, a resistor taking approximately 1 % of the current through the inductor is connected in parallel with it. Iron-core inductors may be used, provided the current has substantially sine-wave form. For the tests on three-pole accessories, three-core inductors are used.

After the test, the samples shall show no damage impairing their further use.

Table 11 – Breaking capacity

Rated current A	Test current A	Test voltage	cos φ ± 0,05	Number of cycles on load
30 – 32	40	1,1 × maximum rated	0,8	50
250	250	1,1 × maximum rated	0,8	– [a]
400 (d.c.)	[b]	0,55 × maximum rated	–	– [a]

[a] A device rated as "not being for current interruption" tested in accordance with 22.3.

[b] Under consideration.

22.3 An accessory rated 250 A a.c. or 400 A d.c. shall have sufficient breaking capacity to interrupt the circuit in case of a fault, without any indication of a fire or shock hazard. The accessory need not remain functional after the completion of the test. It shall not be used for any further tests.

Compliance is checked by testing the mating accessories in accordance with 22.2. for up to three making and breaking operations under the indicated load.

Following the test, the accessories shall comply with a dielectric test in accordance with 21.3, with voltage applied between the parts as indicated in 21.2.1 b) or 21.2.2 b), as applicable.

23 Normal operation

23.1 Accessories shall withstand, without excessive wear or other harmful effect, the mechanical, electrical and thermal stresses occurring in normal use.

Compliance is checked by testing any accessory with a new complementary accessory.

This test is carried out by the same means as in Clause 22 used in the manner indicated and in the test position as specified in Clause 22.

The test is made using the connections indicated in Clause 22, the selector switch C being operated as prescribed in that clause.

The samples are tested at maximum rated operating voltage and rated current.

Accessories are tested for the number of cycles of operation specified and as defined in Table 12, where a cycle is composed of two strokes, one for insertion and one for withdrawal.

Accessories are tested with a.c. in a circuit with cos φ as specified in Table 12.

23.2 *For accessories rated for both a.c. and d.c. operation, a separate set of accessories shall be tested on each circuit.*

23.3 During the test, no sustained arcing shall occur.

After the test, the samples shall show:

– no wear impairing the further use of the accessory or of its interlock, if any;
– no deterioration of enclosures or barriers;
– no damage to the entry holes for the plug contacts that might impair proper working;
– no loosening of electrical or mechanical connections;
– no seepage of sealing compound;
– the continuity between mating signal and pilot contacts are maintained.

The samples shall then withstand a dielectric strength test made in accordance with 21.3, the test voltage, however, being decreased by 500 V.

NOTE The humidity treatment is not repeated before the dielectric strength test of this subclause.

Table 12 – Normal operation

Rated current A	**cos φ ± 0,05**	**Cycles of operation**	
		load	**no-load**
2	0,8	6 000	4 000
30 – 32	0,6	5 000 [a]	5 000
250	0,8	5 000 [a]	5 000
400 (d.c.)	–	–	10 000

[a] For an accessory provided with an interlock (e.g. – pilot circuit) or rated as “not intended for current interruption”, the number of cycles of operation under load is 50 and no-load is 10,000.

23.4 *Lid springs or other devices which are not automatically operated during the normal operation test, if any, are tested separately by completely opening and closing the part, the number of times the part is opened being the same as the maximum number of insertions of the plug specified in Table 12.*

24 Temperature rise

24.1 Accessories shall be so constructed that the temperature rise in normal use is not excessive.

Compliance is checked by testing any accessory with a new complementary accessory.

Accessories are to be mounted as intended in normal use.

The test current is an alternating current of the value shown in Table 13.

Unless a dedicated cable is provided as specified by the manufacturer, rewireable accessories are fitted with conductors of a cross-sectional area as specified in Table 13, the terminal screws or nuts being tightened with a torque specified on the product or in the instruction sheets by the manufacturer or equal to two-thirds of that specified in Table 18.

For the purpose of this test, a length of at least 2 m of the cable shall be connected to the terminals.

Non-rewireable accessories are tested as delivered.

For accessories having three or more poles per circuit, for multiphase circuits, the test current during the test shall be passed through the phase contacts. If there is a neutral contact, a separate test shall be carried out passing the test current through the neutral contact and the nearest phase contact.

A current of 2 A shall be passed through the pilot contact and clean data (signal) earth, if any, at the same time as any of these tests.

Table 13 – Test current and nominal cross-sectional areas of copper conductors for temperature rise test

Rated current A	**Test current** A	**Cross-sectional area(s) of the conductors** mm²	
		Plugs, vehicle inlets, vehicle connectors	**Socket-outlets**
2	2	0,5	0,5
30 – 32	42	6	10
250	Rated current [a]	150	185
400	Rated current [a]	250	300
[a] A duty cycle is under consideration.			

The test shall be continued until thermal stabilisation is reached.

NOTE Thermal stabilisation is considered to have occurred when three successive readings, taken at intervals of not less than 10 min, indicate no increase greater than 2 K.

The temperature is determined by means such as melting particles, colour-changing indicators, or thermocouples, which are so chosen and positioned that they have negligible effect on the temperature being determined.

The temperature rise of terminals shall not exceed 50 K.

24.2 Accessories shall be so constructed that the surface temperatures in normal use are not excessive, as indicated in 16.5.

Compliance is checked by repeating the test in 24.1, except for the test on the neutral contact. The accessory is tested at rated current.

NOTE At the manufacturer's option, surface temperature measurements may be made during the temperature rise tests in 24.1.

25 Flexible cables and their connection

25.1 Plugs and vehicle connectors shall be so designed that the conductors are relieved from strain, including twisting, where they are connected to the terminals or terminations, and that their covering is protected from abrasion.

The construction shall ensure that the cable cannot touch accessible metal parts or internal metal parts, for example cable anchorage screws, if these are electrically connected to accessible metal parts, unless the accessible metal parts are connected to the internal earth terminal.

Compliance is checked by inspection.

25.2 Requirements for plugs and vehicle connectors

25.2.1 Non-rewireable plugs and vehicle connectors Accessories shall be provided with a suitable flexible cable appropriate for the rating of the accessory and as specified by the manufacturer.

Non-rewireable plugs and vehicle connectors shall be tested as a cable assembly.

Compliance is checked by inspection and by the test of 25.3.

25.2.2 Rewireable plugs and vehicle connectors

Rewireable accessories shall be provided with a strain relief means designed to prevent the twisting of the cable that may occur. If any one of the components is not in position in the accessory as provided, an instruction sheet shall be provided to identify the necessary parts, the method of assembly and the maximum and minimum size cable for which it is suitable.

The design of the cable anchorage shall be such that the anchorage or components are properly positioned relative to the accessory when assembled.

Cable anchorages shall present no sharp edges to the cable and shall be so designed that the anchorages or their components are not likely to be lost when the enclosure of the accessory and not the cable anchorage is being opened.

Makeshift methods, such as tying the cable into a knot or tying the ends with string, shall not be used.

Cable anchorages and cable inlets shall be suitable for the different types of flexible cable that may be connected.

If a cable entrance is provided with a sleeve to prevent damage to the cable, this sleeve shall be of insulating material and shall be smooth and free from burrs.

If a bell-mouthed opening is provided, the diameter at the end shall be at least 1,5 times the diameter of the cable with the largest cross-sectional area to be connected.

Helical metal springs, whether bare or covered with insulating material, are not allowed as cable sleeves.

Compliance is checked by inspection and by the test of 25.3.

25.3 *Plugs and vehicle connectors provided with a flexible cable are subjected to a pull test in apparatus similar to that shown in Figure 4, followed by a torque test.*

Non-rewireable accessories are tested as delivered.

Rewireable accessories are tested with the maximum and minimum size cables recommended by the manufacturer.

Conductors of the cable of rewireable accessories are introduced into the terminals, the terminal screws being tightened just sufficiently to prevent the conductors from easily changing their position.

The cable anchorage is used in the normal way, clamping screws being tightened with a torque equal to two-thirds of that specified in 27.1. After reassembly of the sample, with cable

glands, if any, in position, the component parts shall fit snugly and it shall not be possible to push the cable into the sample to any appreciable extent.

The sample is fixed in the test apparatus so that the axis of the cable is vertical where it enters the sample.

The cable is then subjected 100 times to a pull of the value shown in the Table 14. Each pull is applied without jerks and has a duration of 1 s.

Immediately afterwards, the cable is subjected to a torque of the value shown in the Table 14 for 1 min.

Table 14 – Pull force and torque test values for cable anchorages

Rated current A	Pulling force N	Torque Nm	Maximum displacement mm
30 – 32	200	0,7	2
250	500	11,0	5
400	500	11,0	5

During the tests, the cable shall not be damaged.

After the tests, the cable shall not have been displaced by more than the values indicated in Table 14. For rewireable accessories, the ends of the conductors shall not have moved noticeably in the terminals; for non-rewireable accessories, there shall be no break in the electrical connections.

For the measurement of the longitudinal displacement, a mark is made on the cable at a distance of approximately 2 cm from the end of the sample or the cable anchorage before starting the tests. If, for non-rewireable accessories, there is no definite end to the sample, an additional mark is made on the body of the sample.

After the tests, the displacement of the mark on the cable in relation to the sample or the cable anchorage is measured.

26 Mechanical strength

26.1 Accessories shall have adequate mechanical strength so as to withstand the stresses imposed during installation and use.

Compliance is checked by the appropriate tests of 26.2 to 26.5 as follows:

- *for socket-outlets and vehicle inlets, 26.2;*
- *for rewireable plugs and vehicle connectors, 26.3;*
- *for non-rewireable plugs and vehicle connectors, 26.3 and 26.4;*
- *for rewireable cable assemblies intended to be used with cable management systems, 26.2;*
- *for non-rewireable cable assemblies intended to be used with cable management systems, 26.2 and 26.4*
- *for glands of splash proof and watertight accessories, 26.5;*
- *for accessories with a degree of protection IP44 or higher, 26.5.*

Before starting the test of 26.2 or 26.3, accessories with enclosures of resilient or thermoplastic material are placed, with their bases or flexible cables, in a chamber at a temperature of (–30 ± 2) °C for at least 16 h; they are then removed from the chamber and immediately subjected to the test of 26.2 or 26.3, as appropriate.

26.2 *Accessories shall have adequate strength to maintain the integrity of the marked degree of protection after being subjected to impact blows occurring in normal use.*

26.2.1 *Blows shall be applied to the samples by swinging or dropping a 50.8 mm diameter steel sphere, weighing 0,535 kg, from a height (H), which will produce an impact as indicated in Table 15. The sample being tested shall be rigidly supported and the impact made normal to sample by means of the ball impact test apparatus. The ball impact test apparatus is shown in Figure 5.*

It is intended that blows applied to samples in these tests will not strike mounting flanges or male contacts of vehicle inlets. The ball impact test apparatus shall be adjusted to apply blows as they might occur in actual use and according to 26.2.2.

26.2.2 *Five blows shall be applied to each test sample by means of the ball impact test apparatus.*

The first four blows are applied when the accessory is mounted as in normal use on a vertical board. The ball pendulum shall be mounted so that it swings parallel to that board. The impact face of the ball pendulum shall be arranged such that when the ball pendulum hangs freely, the impact face just touches the side of the accessory. The point of contact shall be substantially at the geometric centre of the side face of the accessory, or the appropriate projections of that face. The ball pendulum is then raised, released and the blow applied. The accessory is then revolved 90° about an axis perpendicular to the mounting face and its relationship to the impact face corrected, if necessary. A second blow is then applied.

The same procedure is repeated for two successive rotations of 90°, with a total of 4 blows being applied.

The fifth blow is applied with the plane of the ball pendulum perpendicular to the plane of the mounting board such that the ball pendulum strikes the sample at its furthermost projection from the mounting board.

Each blow shall have an impact energy according to Table 15.

Table 15 – Impact energy for ball impact test

Rating A	**Energy** J	
	Vehicle inlets	**Socket-outlets**
30 – 32	1	1
250	2	2
400	2	–

26.2.3 *Socket outlet and vehicle inlet samples shall each be fixed to a rigid mounting board as in normal use, cable entries are left open and fixing screws of covers and enclosures are tightened with a torque equal to two-thirds of that specified in Table 18. Lids on socket outlets are left normally closed. Caps supplied with vehicle inlets will be installed.*

After the test, the samples shall show no damage within the meaning of this standard, in particular, no part shall have become detached or loosened.

Accessories with a degree of protection IP44 and higher shall withstand the relevant test specified in Clause 20.

Accessories with enclosures of thermoplastic material shall withstand the test of 21.4.

NOTE Small chips, cracks and dents, which do not adversely affect the protection against electrical shock or moisture, are neglected. In case of doubts, appropriate tests of Clauses 19 and 20 are carried out.

26.3 *Rewireable plugs and vehicle connectors are fitted with a small section (approximately 200 mm) of the lightest type of flexible cable of the smallest cross-sectional area recommended by the manufacturer.*

Non-rewireable plugs and vehicle connectors are tested with a small section (approximately 200 mm) of the flexible cable as delivered.

Cable assemblies specified to be used with cable management systems are to be tested per 26.2

The free end of the cable and an additional rope or other flexible means, etc, attached to the flexible cable, both having a total length of 2,25 m, is fixed to a wall at a height of 1 m above the floor, as shown in Figure 6.

The sample is held so that the cable is horizontal and then it is allowed to fall on to a concrete floor. This is done eight times, the cable being rotated through 45° at its fixing each time.

After the test, the samples shall show no damage within the meaning of this standard; in particular, no part shall have become detached or loosened.

Accessories with a degree of protection IP44 and higher shall withstand the relevant test specified in Clause 20.

Accessories with enclosures of thermoplastic material shall withstand the test of 21.4.

NOTE Small chips and dents, which do not adversely affect the protection against electric shock or moisture, are neglected.

26.4 *Non-rewireable accessories are subjected to a flexing test in an apparatus similar to that shown in Figure 7.*

The sample is fixed to the oscillating member of the apparatus so that, when this is at the middle of its travel, the axis of the flexible cable, where it enters the sample, is vertical and passes through the axis of oscillation.

The oscillating member is so positioned that the flexible cable makes the minimum lateral movement when the oscillating member of the test apparatus is moved over its full travel.

The cable is loaded with a weight such that the force applied is as shown in the following Table 16.

Table 16 – Mechanical load flexing test

Rated current A	**Force** N
30 – 32	25
250	75
400	100

A current equal to the rated current of the accessory is passed through the conductors, the voltage between them being the rated voltage.

The oscillating member is moved backwards and forwards through an angle of 90° (45° on either side of the vertical), the number of flexings being 20 000 and the rate of flexing 60 per minute.

After the test, the samples shall show no damage within the meaning of this standard.

NOTE A flexing is one movement, either backwards or forwards.

26.5 Screwed glands are fitted with a cylindrical metal rod having a diameter, in millimetres, equal to the nearest whole number below the internal diameter of the packing, in millimetres. The glands are then tightened by means of a suitable spanner, the force shown in Table 17 being applied to the spanner for 1 min, at a point 25 cm from the axis of the gland.

Table 17 – Torque test values for glands

Diameter of test rod mm	**Force** N	
	Metal glands	**Glands of moulded material**
Up to and including 20	30	20
Over 20 up to and including 30	40	30
Over 30	50	40

After the test, the glands and the enclosures of the samples shall show no damage within the meaning of this standard.

27 Screws, current-carrying parts and connections

27.1 Connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use.

Screws transmitting contact pressure and screws which are operated when connecting the accessory, and have a nominal diameter less than 3,5 mm, shall screw into a metal nut or metal insert.

Compliance is checked by inspection and by the following test for screws and nuts which transmit contact pressure or which are operated when connecting the accessory.

The screws or nuts are tightened and loosened:

– ten times for screws in engagement with a thread of insulating material;
– five times for nuts and other screws.

Screws in engagement with a thread of insulating material are completely removed and reinserted each time.

This removal and insertion of the screws or nuts shall be carried out at such a rate that the thread in the insulating material suffers no appreciable temperature rise owing to friction.

When testing terminal screws and nuts, a copper conductor having the largest cross-sectional area in Table 7, rigid (solid or stranded) for socket-outlets and vehicle inlets and flexible for plugs and vehicle connectors, is placed in the terminal.

The test is made by means of a suitable screwdriver or spanner. The maximum torque applied when tightening is equal to that shown in Table 18 except that the torque is increased by 20 % for screws in engagement with a thread in a hole which is obtained by plunging, if the length of the extrusion exceeds 80 % of the original thickness of the metal.

When the manufacturer specifies, for terminal screws, a torque greater than values given in Table 18, this specified torque shall be applied for the test.

Table 18 – Tightening torque for verification of mechanical strength of screw-type terminals

Metric standard values	Nominal diameter of thread mm	Torque Nm		
		I	II	III
2,5	Up to and including 2,8	0,2	0,4	0,4
3,0	Over 2,8 up to and including 3,0	0,25	0,5	0,5
–	Over 3,0 up to and including 3,2	0,3	0,6	0,6
3,5	Over 3,2 up to and including 3,6	0,4	0,8	0,8
4,0	Over 3,6 up to and including 4,1	0,7	1,2	1,2
4,5	Over 4,1 up to and including 4,7	0,8	1,8	1,8
5,0	Over 4,7 up to and including 5,3	0,8	2,0	2,0
6,0	Over 5,3 up to and including 6,0	1,2	2,5	3,0
8,0	Over 6,0 up to and including 8,0	2,5	3,5	6,0
10,0	Over 8,0 up to and including 10,0		4,0	10,0
12,0	Over 10,0 up to and including 12,0			14,0
14,0	Over 12,0 up to and including 15,0			19,0
16,0	Over 15,0 up to and including 20,0			25,0
20,0	Over 20,0 up to and including 24,0			36,0
24,0	Over 24,0			50,0

Column I *applies to screws without heads which when tightened do not protrude from the hole, and to screws which cannot be tightened by means of a screwdriver having a blade wider than the diameter of the screw.*

Column II *applies to other screws and nuts which are tightened by means of a screwdriver.*

Column III *applies to screws and nuts which can be tightened by means other than a screwdriver.*

Each time the clamping screw(s) or nut(s) is (are) loosened, a new conductor shall be used for a further connection.

When a screw has a hexagonal head with means for tightening with a screwdriver and the values in columns II and III are different, the test is made twice, first applying the torque specified in column III to the hexagonal head and then, on another set of samples, applying the torque specified in column II by means of a screwdriver. If the values in columns II and III are the same, only the test with the screwdriver is made.

After the test for clamping screws or nuts, the clamping unit shall not have undergone changes that adversely affect its further use.

NOTE For mantle terminals, the specified nominal diameter is that of the slotted stud.

For mantle terminals in which the nut is tightened by means other than a screwdriver and for which the nominal screw diameter is over 10 mm, the value of the torque is under consideration.

Screws or nuts which are operated when connecting up the accessory include terminal screws or nuts, assembly screws, screws for fixing covers, etc. but not connections for screwed conduits and screws for fixing socket-outlets or vehicle inlets to the mounting surface.

The shape of the blade of the test screwdriver shall suit the head of the screw to be tested.

The screws and nuts shall not be tightened in jerks.

NOTE Damage to covers is neglected. Connections made by screws will have been partially checked by the test of Clauses 23 and 26.

27.2 Screws in engagement with a thread of insulating material and which are operated when connecting up the accessory shall have a length of engagement of at least 3 mm plus one-third of the nominal screw diameter, or 8 mm, whichever is the shorter.

Correct introduction of the screw into the threaded hole shall be ensured.

Compliance is checked by inspection, by measurement and by manual test.

NOTE The requirement with regard to correct introduction is met if introduction of the screw in a slanting manner is prevented, for example by guiding the screw by the pan to be fixed, by a recess in the threaded hole or by the use of a screw with the leading thread removed.

27.3 Electrical connections shall be so designed that the contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics no less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any shrinkage or yielding of the insulating material.

Compliance is checked by inspection.

NOTE The suitability of the material is considered with respect to its dimensional stability.

27.4 Screws and rivets, which serve as electrical as well as mechanical connections, shall be locked against loosening.

Compliance is checked by inspection and by manual test.

NOTE Spring washers may provide satisfactory locking.

For rivets, a non-circular shank or an appropriate notch may be sufficient.

Sealing compound, which softens on heating, provides satisfactory locking only for screw connections not subject to torsion in normal use.

27.5 Current-carrying parts, other than terminals, shall be either of:

– copper,
– an alloy containing at least 50 % copper,
– or other metal no less resistant to corrosion than copper and having mechanical properties no less suitable.

Compliance is checked by inspection and, if necessary, by chemical analysis.

NOTE The requirements for terminals are included in Clause 13.

27.6 Contacts, which are subjected to a sliding action in normal use, shall be of a metal resistant to corrosion. Springs ensuring the resiliency of contact tubes shall be of metal resistant to corrosion or be adequately protected against corrosion.

Compliance is checked by inspection and, if necessary, by chemical analysis.

NOTE A test for determining the resistance to corrosion or the adequacy of the protection against corrosion is under consideration.

28 Creepage distances, clearances and distances

28.1 Creepage distances, clearances and distances:

– between live parts of different polarity;
– between live parts and:
  - accessible metal parts;
  - earthing contacts, fixing screws and similar devices;
  - external assembly screws, other than screws which are on the engagement face of plugs and are isolated from the earthing contacts;
  - metal enclosures, if not lined with insulating material, including fittings for conduit or armoured cable;
  - the surface on which the base of a socket-outlet is mounted;
  - the bottom of any conductor recess in the base of a socket-outlet;
– through sealing compound (as solid insulation)
  - between live parts covered with at least 2,5 mm of sealing compound and the surface on which the base of a socket-outlet is mounted;
  - between live parts covered with at least 2 mm of sealing compound and the bottom of any conductor recess in the base of a socket-outlet

shall be evaluated in accordance with IEC 60664-1 and IEC 60664-3, according to 28.4. The control pilot and signal circuits shall be treated as “accessible metal parts” for the purpose of this clause.

For rewireable accessories, compliance is checked using samples fitted with conductors of the largest cross-sectional area specified in Table 6, and also without conductors. For non-rewireable accessories, compliance is checked using samples as delivered.

Socket-outlets and vehicle connectors are checked when in engagement with a plug and also without a plug.

NOTE Any air gap less than 1 mm wide is ignored in computing the total clearance.

The surface on which the base of a socket-outlet is mounted includes any surface with which the base is in contact when the socket-outlet is installed. If the base is provided with a metal plate at the back, this plate is not regarded as the mounting surface.

28.2 Sealing compound shall not protrude above the edge of the cavity in which it is contained.

Compliance is checked by inspection.

28.3 Unless otherwise stated, the normal use environment for indoor use equipment is pollution degree 3 according to IEC 60664-1. For outdoor use equipment, pollution degree 4 is expected, unless protection is afforded by a suitable enclosure appropriate for the installation in which case a lower pollution degree can be achieved. The interior of equipment with enclosure types IP54 can be considered pollution degree 3. Hermetically sealed or encapsulated enclosures are considered pollution degree 1

If other pollution degrees are needed, creepage and clearance distances have to be in accordance with IEC 60664-1. The comparative tracking index (CTI) value shall be evaluated in accordance with IEC 60112.

28.4 In conducting evaluations in accordance with IEC 60664-1 and IEC 60664-3, the guidelines noted in 28.4.1 to 28.4.8 shall be used:

28.4.1 All accessories shall be considered Over voltage Category II.

28.4.2 Pollution degree 2 may be considered to exist on a printed wiring board between adjacent conductive material which is covered by any coating, which provides an uninterrupted covering over at least one side, and the complete distance up to the other side of conductive material.

28.4.3 Pollution degree 1 may be achieved at a specific printed wiring board location by application of at least 0,8 mm thick layer of suitable silicone rubber or for a group of printed wiring boards through potting, without air bubbles, in epoxy or a suitable potting material.

28.4.4 Evaluation of clearances, only, may be conducted in accordance with IEC 60664-1, Section 4, Tests and Measurements.

28.4.5 Evaluation of clearances and creepage distances shall be conducted in accordance with IEC 60664-1, Section 3, Requirements and dimensioning rules, Clause 3.1, Dimensioning of clearances, and Clause 3.2, Dimensioning of creepage distances.

28.4.6 Evaluation of permanent protective coatings applied to rigid printed board assemblies used to improve the insulation properties shall be conducted in accordance with IEC 60664-3.

28.4.7 The phase-to-ground rated system voltage used in the determination of clearances shall be the equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product if no isolating transformer is provided. The system voltage used in the evaluation of secondary circuitry may be interpolated with the interpolation continued across the table for rated impulse withstand voltage peak and clearance.

28.4.8 Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with 4.2 of IEC 60664-1.

29 Resistance to heat, fire and tracking

29.1 Accessories shall be sufficiently resistant to heat.

Compliance is checked by the tests of 29.2 and 29.3.

29.2 The samples are kept for 1 h in a heating cabinet at a temperature of (110 ± 5) °C.

They shall not undergo any change impairing their further use, and sealing compound shall not flow to such an extent that live parts are exposed.

Marking shall still be easily legible.

NOTE A slight displacement of the sealing compound is neglected.

29.3 Parts of insulating material are subjected to a ball-pressure test by means of the apparatus shown in Figure 8.

The surface of the part to be tested is placed in the horizontal position and a steel ball of 5 mm diameter is pressed against this surface by a force of 20 N.

The test is made in a heating cabinet at a temperature of:

– (125 ± 5) °C for parts supporting live parts of rewireable accessories;
– (80 ± 3) °C for other parts.

After 1 h, the ball is removed and the diameter of the impression measured. For materials which show deformation, this diameter shall not exceed 2 mm.

NOTE For elastomeric materials a test is under consideration. The test is not made on parts of ceramic material.

29.4 External parts of insulating material and insulating parts supporting live parts of accessories shall be resistant to abnormal heat and to fire.

Compliance is checked by the glow-wire test given in IEC 60695-2-10, with the following specifications.

The test apparatus is shown in Figures 9 and 10.

A piece of white pinewood board, approximately 10 mm thick and covered with a single layer of tissue paper, is positioned at a distance of (200 ± 5) mm below the place where the glow-wire is applied to the accessory.

The temperature of the tip of the glow-wire is:

(650 ± 10) °C for parts of insulating material not necessary to retain current-carrying parts and parts of the earthing circuits in position, even though they are in contact with them.

NOTE Tests are not made on glands and sealing compounds.

(850 ± 15) °C for parts of insulating material necessary to retain current-carrying parts and parts of the earthing circuits in position.

Duration of the application, the force applied is (30 ± 1) s. Value of the force: 1 N.

The accessories are stored for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 % before starting the test.

The tip of the glow-wire is applied to the following places:

– *in the middle of one external part for each material, with the exception of glands and sealing compounds;*
– *in the middle of an insulating contact-carrying part for each material.*

The tip is applied to flat surfaces and not to grooves, knockouts, narrow recesses or sharp edges and if possible not less than 9 mm from the edges of the accessories. The movement of the tip of the glow-wire into the accessory shall be mechanically limited to 7 mm.

The test is made on one specimen. In case of doubt regarding the results of the test, the test shall be repeated on two further specimens.

The specimen is regarded as having passed the glow-wire test if:

– *there is no visible flame and no sustained glowing, or if*

– *flames or glowing of the specimen or of the surroundings extinguish within 30 s after removal of the glow-wire, and the surrounding parts have not burned away completely. There shall be no ignition of the tissue paper or scorching of the board.*

29.5 Insulating parts supporting live parts shall be of material resistant to tracking.

Unless otherwise specified, parts of insulating material retaining live parts in position shall be of material resistant to tracking.

For materials other than ceramic, compliance is checked by the following test on three specimens. The test is performed according to IEC 60112.

A flat surface of the part to be tested at least 15 mm – 15 mm and at least 3 mm thick is placed in the horizontal position on the apparatus.

The material under test shall pass at a proof tracking index of 175 V using test solution A with an interval between drops of 30 s ± 5 s.

NOTE If the part requiring test does not meet the dimensional criteria, it is permitted to stack specimens to reach the 3 mm thickness value or else a plaque of the identical material 3 mm thick may be used.

In case of doubt, the test is repeated on a new set of specimens, which shall then pass the test. The test is not made on accessories having rated operating voltages not exceeding 50 V.

30 Corrosion and resistance to rusting

Ferrous parts, including enclosures, shall be adequately protected against rusting.

NOTE Where corrosion can be a problem on electrical parts, IP67 accessories are recommended.

For specific conditions and the provisions for these conditions, special consideration should be given to the product by the manufacturer with regard to resistance to corrosion.

Compliance is checked by the following test.

All grease is removed from the parts to be tested, by immersion in ethyl acetone, acetone, methylethyl ketone or an equivalent degreasing agent for 10 min. The parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of (20 ± 5) °C.

Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of (20 ± 5) °C.

After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C, their surfaces shall show no signs of rust.

NOTE Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

For small helical springs and the like, and for inaccessible parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are subjected to the test only if there is doubt about the effectiveness of the grease film and the test is then made without previous removal of the grease.

31 Conditional short-circuit current withstand test

Socket-outlets and mating plugs shall be submitted to the tests listed below:

31.1 Ratings and test conditions

The test is applied to a new socket-outlet and mating plug mounted as in normal use and connected according to the indications of 30.2.

Different numbers of poles for the same rated current and the same construction are considered as representative of the type. Compliance is checked by testing each socket-outlet and mating plug with a new complementary socket-outlet and mating plug complying with this standard.

The short-circuit protective device shall be a "gG" type fuse for general application complying with the requirements of IEC 60269-1 and IEC 60269-2 and having rating identical to those of the socket-outlets and mating plugs.

In the case a fuse with a rated current equal to that of the socket-outlets and mating plugs being tested does not exist, a fuse having the next higher rated value shall be used.

Fuse technical data as well as its cut-off value shall be stated in the test report.

The fuse (F1) shall be installed between the supply source and the socket-outlets and mating plugs being tested.

The minimum prospective short-circuit current withstand of 10 kA or of a higher value specified by the manufacturer shall be applied to a socket-outlet and mating plug and a complementary accessory in the connected position.

NOTE Higher short-circuit test currents are under consideration for accessories rated 250 A or higher.

The test voltage shall be identical to the rated operating voltage of the socket-outlets and mating plugs tested.

No power-factor value or time constant is specified for this test.

The following tolerances shall be applied during the test:

- *current: from 90 % to 110 %;*
- *voltage: from 100 % to 105 %;*
- *frequency: from 95 % to 105 %.*

31.2 Test-circuit

a) Figures 15, 16 and 17 give the diagrams of the circuit to be used for the test:
   - *two-pole accessories on single-phase a.c. or d.c. (Figure 15);*
   - *three-pole accessories on three-phase a.c. (Figure 16);*
   - *four-pole accessories on three-phase four-wire a.c. (Figure 17).*

b) The supply S feeds a circuit including resistors R_1, reactors X and the accessories D under test.

   In all cases, the supply shall have sufficient power to permit the verification of the characteristics given by the manufacturer.

c) In each test circuit (Figures 15, 16 and 17), the resistors and reactors are inserted between the supply source S and the equipment D under test. The position of the closing device A and the current sensing devices (I_1, I_2, I_3) may be different.

There shall be one and only one point of the test circuit which is earthed; this may be the short-circuit link of the test circuit of the neutral point of the supply or any other convenient point.

d) All parts of the accessories normally earthed in service, including the earth contact and pilot contact, the enclosure or the screens, shall be insulated from earth and connected to a point as indicated in Figures 15, 16 and 17.

This connection shall comprise a fuse element F2 consisting of a copper wire 0,8 mm in diameter and at least 50 mm long, or of a fuse element of 30/35 A for the detection of the fault current.

The connection of the accessories under test shall be made with copper wires having cross-sectional areas as indicated in Table 7, and lengths as short as possible, not exceeding 1 m on either side.

31.3 Calibration

The calibration of the test circuit is carried out by placing temporary connections B of negligible impedance as close as reasonably possible to the terminals provided for connecting the accessories under test.

31.4 Test procedure

Temporary connections B are replaced by the accessories under test. The circuit is closed on a value of the prospective current at least equal to the conditional short-circuit withstand current of the accessories under test.

31.5 Behaviour of the equipment under test

During the test, the accessories shall not endanger the operator nor damage the adjacent equipment.

There shall be neither arcing nor flashover between poles, and no melting of the fault detection circuit fuse of the exposed conductive parts (F2).

31.6 Acceptance conditions

– The accessories shall remain mechanically operable.

– Contact welding, such as to prevent an opening operation using normal operating means, is not permitted.

– Immediately after the test, the accessories shall comply with a dielectric test in accordance with 19.3, with voltage applied between the parts as indicated in 19.2.1 b) or 19.2.2 b), as applicable.

32 Electromagnetic compatibility

32.1 Immunity

The operation of accessories within the scope of this standard in normal use is not affected by electromagnetic disturbances.

32.2 Emission

Accessories within the scope of this standard are intended for continuous use. In normal use, they do not generate electromagnetic disturbances.

33 Vehicle driveover

33.1 A plug or vehicle connector shall have adequate resistance to damage from being driven over by a vehicle, unless it is provided with a cable management system which prevents the accessory from being left on the ground.

Compliance is checked by the test mentioned in subclauses 33.2 and 33.3.

33.2 *Accessories wired with the minimum size cable of a type recommended by the manufacturer shall be placed on a concrete floor in any normal position of rest. A crushing force of (5000 ± 250) N shall be applied by a conventional automotive tire, P225/75R15 or an equivalent tire suitable for the load, mounted on a steel rim and inflated to a pressure of (2,2 ± 0,1) bar. The wheel is to be rolled over the vehicle connector or plug at a speed of (8 ± 2) km/h. The accessory is to be oriented in a natural resting position before applying the force in a different direction for each sample. The accessory under test shall be held or blocked in a fixed position so that it does not move substantially during the application of the applied force. In no case is the force to be applied to the projecting pins.*

There shall be no severe cracking, breakage, or deformation to the extent that:

– live parts, other than exposed wiring terminals, or internal wiring are made accessible to contact by the standard test finger shown in Figure 2. See 10.1;
– the integrity of the enclosure is defeated so that acceptable mechanical or environmental (degree of) protection is not afforded to the internal parts of the accessory, or polarisation of the accessory is defeated;
– there is interference with the operation, function or installation of the accessory;
– the accessory does not provide adequate strain relief for the flexible cable;
– the creepage distances and clearances between live parts of opposite polarity, live parts and accessible dead or earthed metal are reduced below the values in 28.1;
– other evidence of damage that could increase the risk of fire or electric shock occurs;
– the accessory does not comply with a repeated dielectric test in accordance with 21.3.

33.3 *The procedure described in 33.2 is to be repeated on additional samples, with an applied crushing force of (11000 ± 550) N using a conventional automotive tire suitable for the load, and inflated to its rated pressure.*

33.4 As a result of the test in 33.3, the accessories shall either comply with 33.1 or be damaged or broken to the extent that the accessory is rendered unusable and will be removed from service.

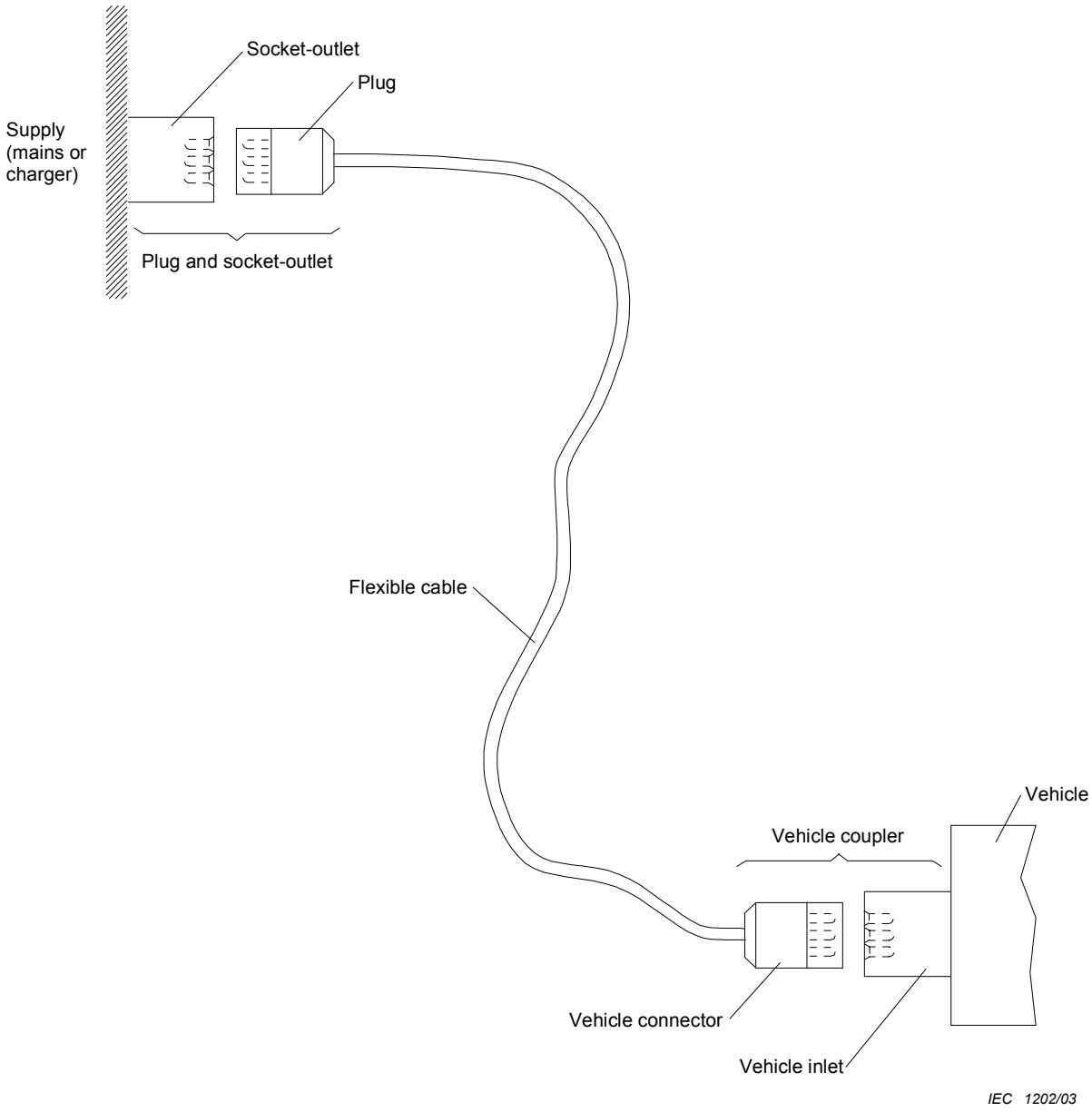
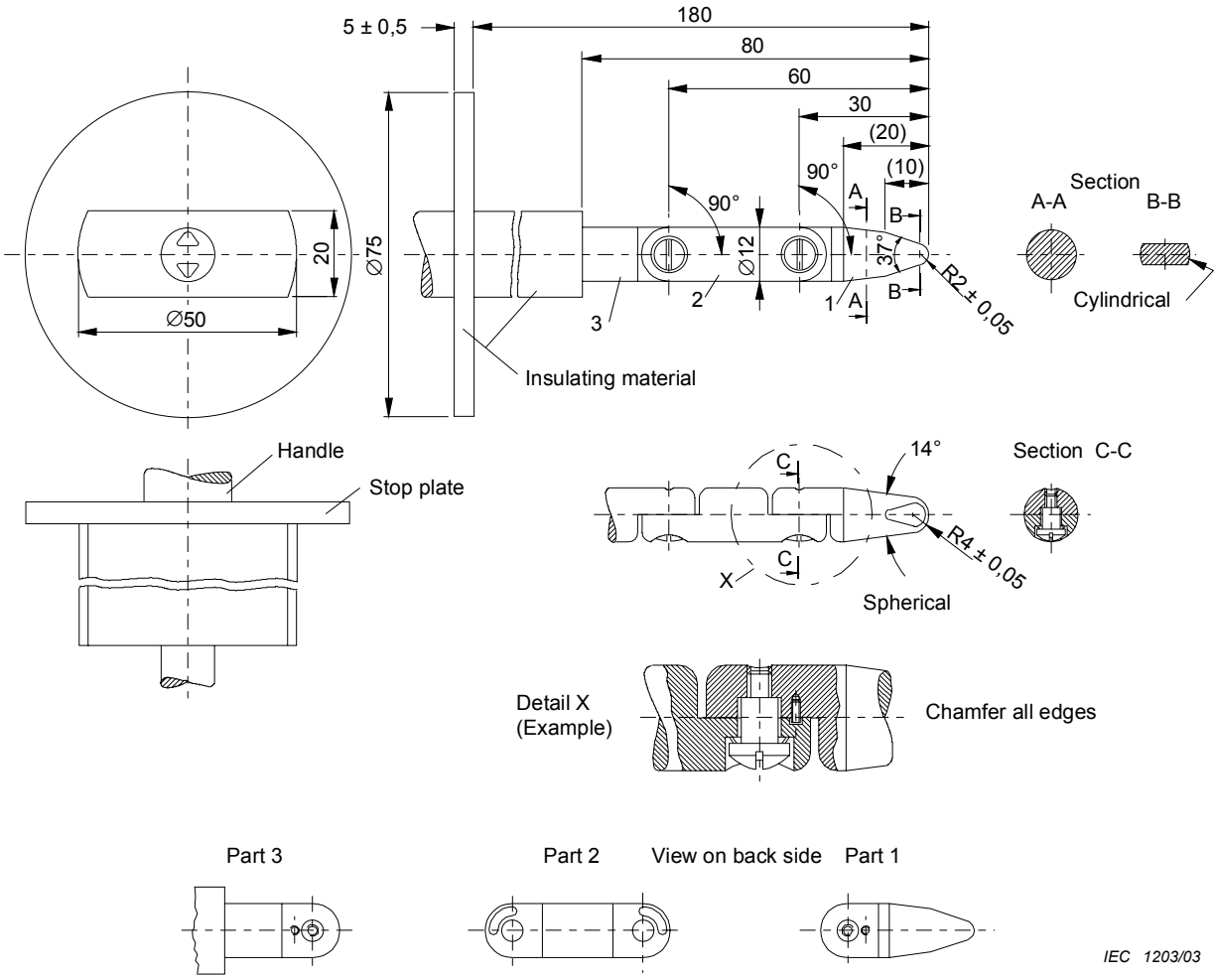


Figure 1 – Diagram showing the use of the accessories



Linear dimensions in millimetres

Tolerances on dimensions without specific tolerance:

– on angles: $^{0°}_{-10}$
– on linear dimensions:
  - up to 25 mm: $^{0}_{-0,05}$
  - over 25 mm: ±0,2

Material of finger: for example heat-treated steel

Both joints of this finger may be bent through an angle of $90\,^{+10°}_{0}$ but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a 90° bending angle with a 0° to +10° tolerance.

Figure 2 – Standard test finger

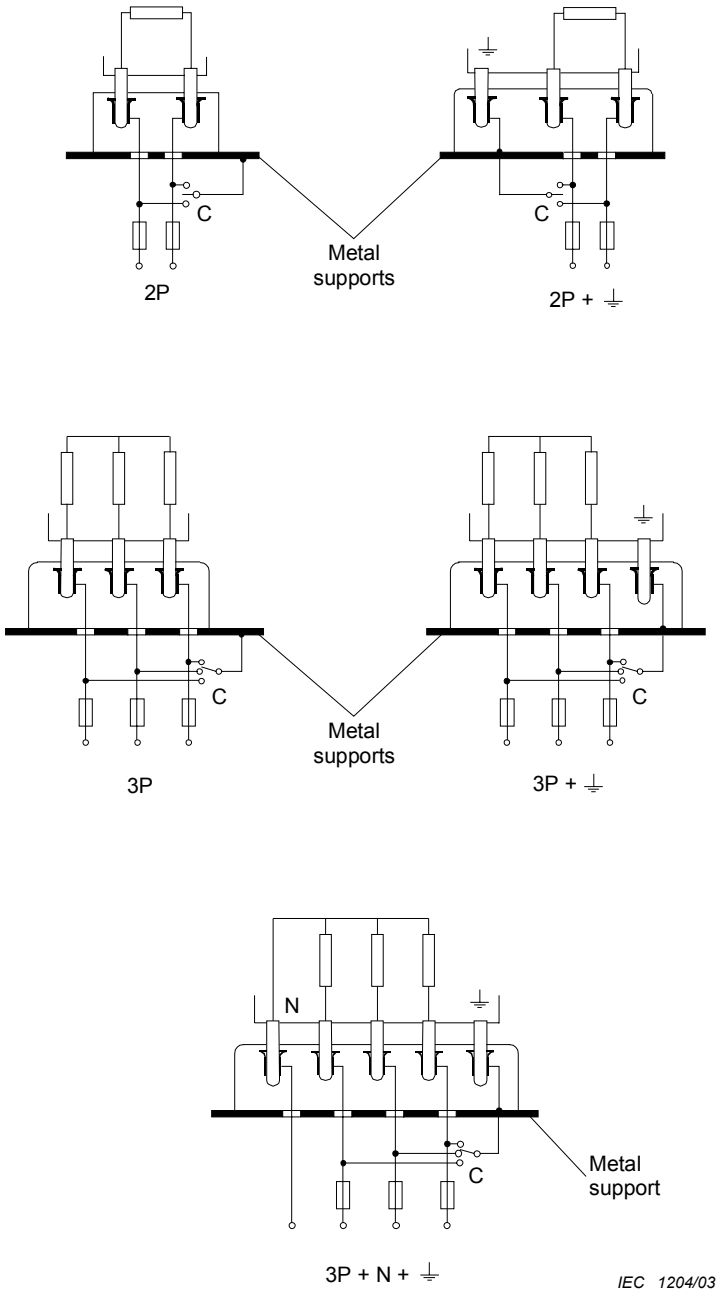
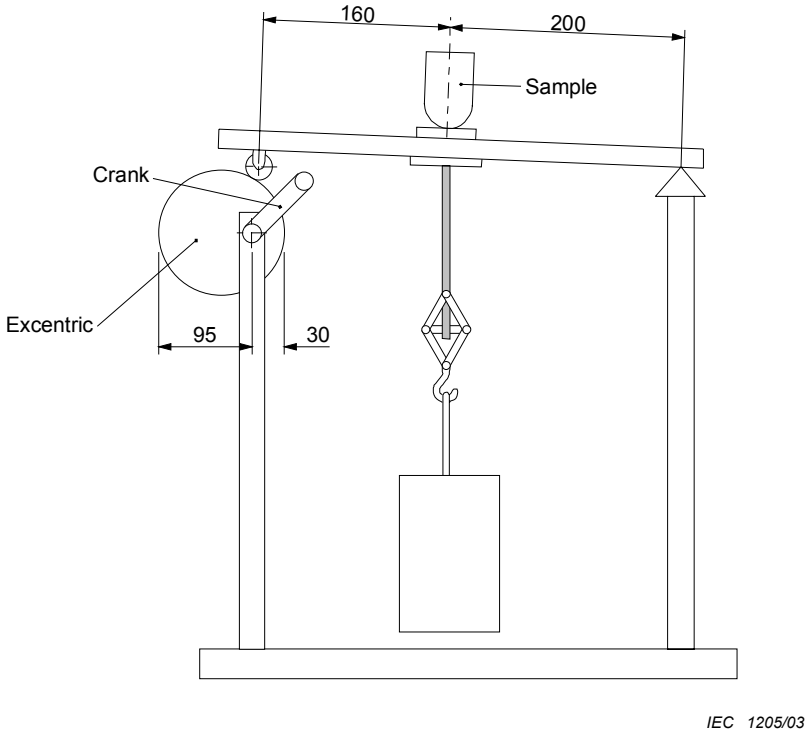
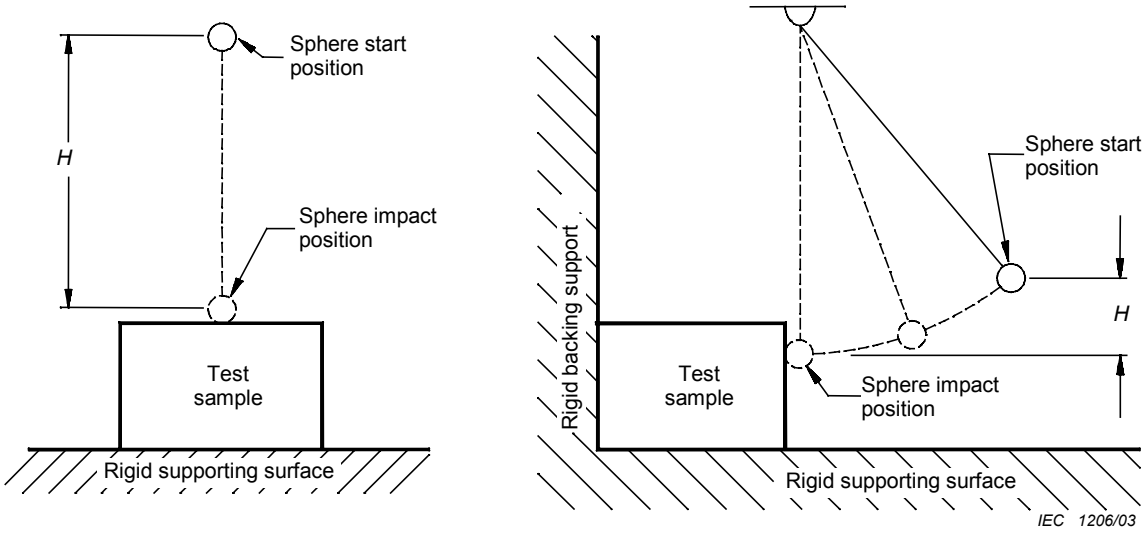


Figure 3 – Circuit diagrams for breaking capacity and normal operation tests



Dimensions in millimetres

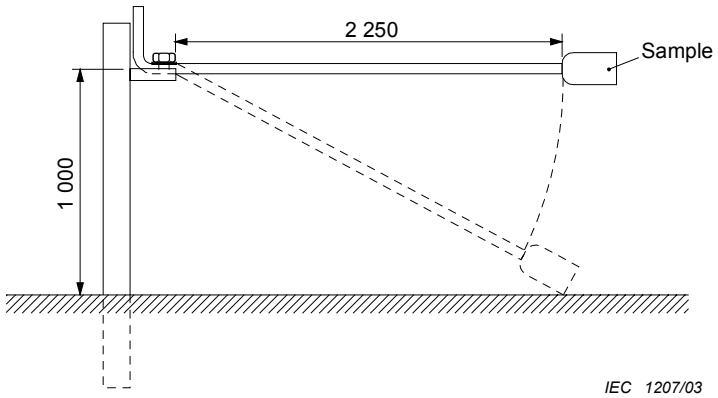
Figure 4 – Apparatus for testing the cable anchorage



Key

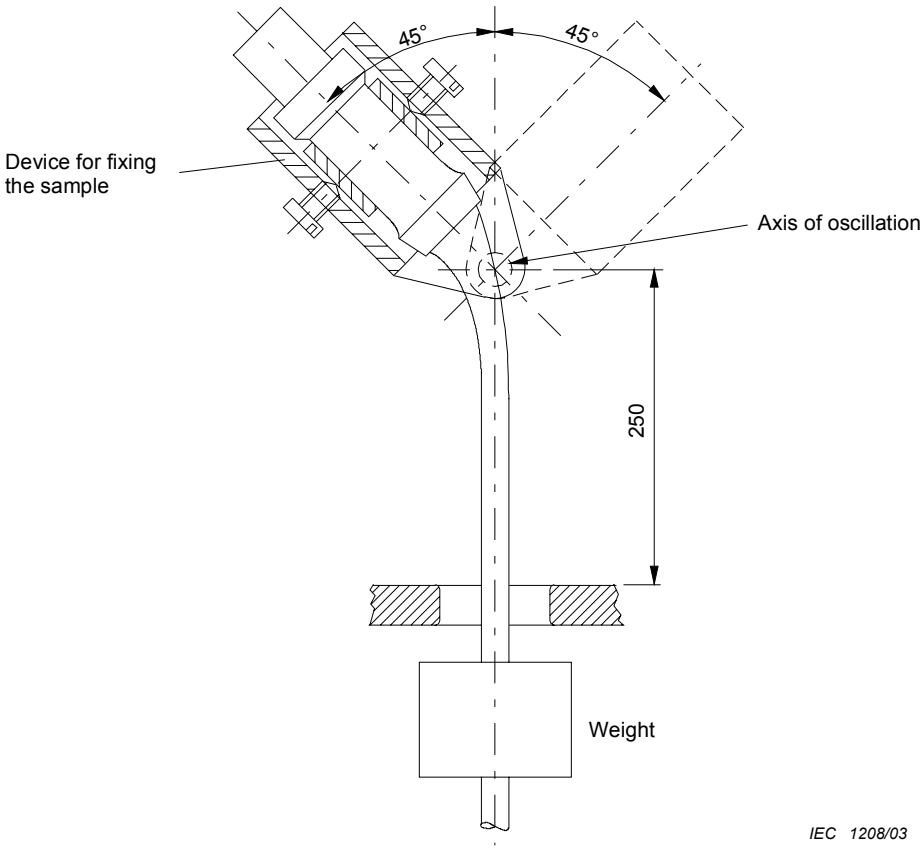
H = height

Figure 5 – Ball Impact test



Dimensions in millimetres

Figure 6 – Arrangement for mechanical strength test for plugs and vehicle connectors



Dimensions in millimetres

Figure 7 – Apparatus for flexing test

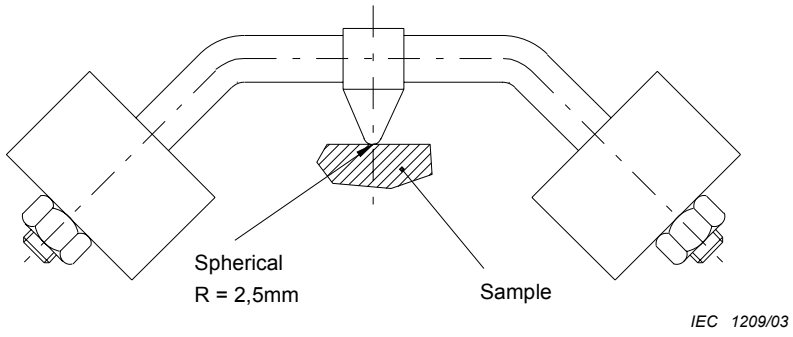
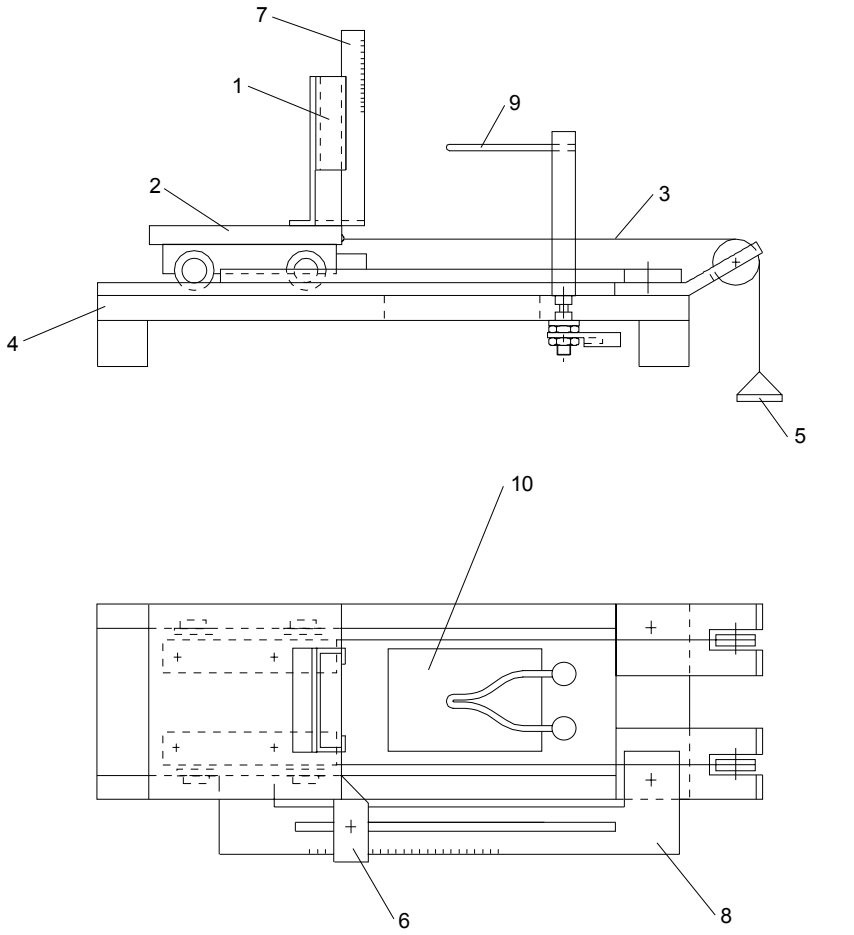


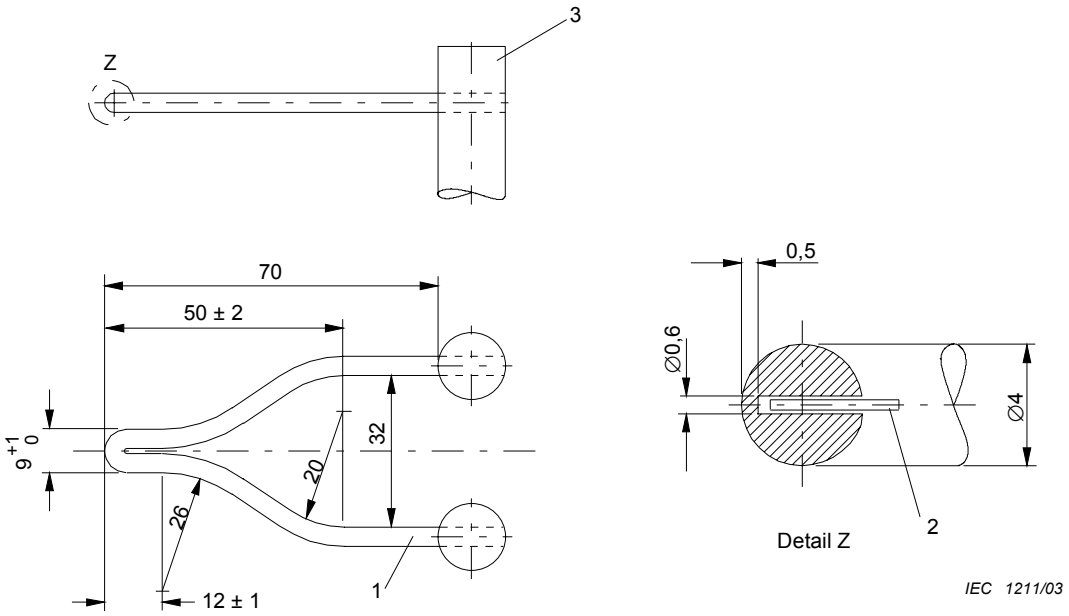
Figure 8 – Ball-pressure apparatus



Key

1 Positioning clamp
2 Carriage
3 Tensioning cord
4 Base plate
5 Weight
6 Step
7 Scale for measure of flame
8 Scale for penetration
9 Glow-wire
10 Break-through in base plate for particles falling from the specimen

Figure 9 – Test apparatus (example)



Dimensions in millimetres

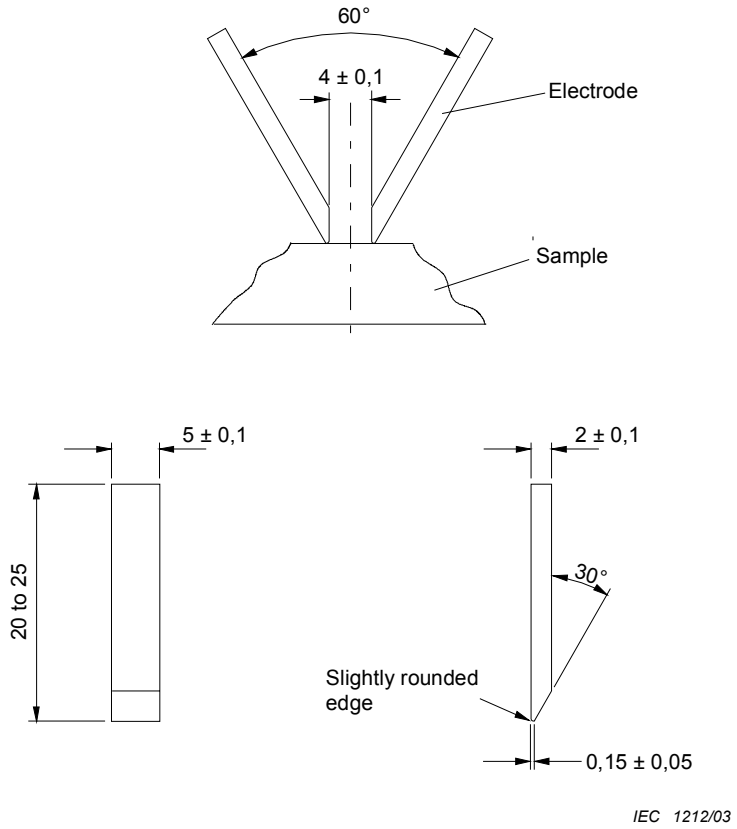
Key

1 Glow-wire hard soldered at 3

2 Thermocouple

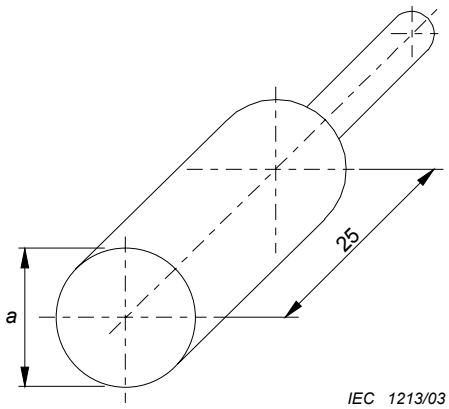
3 Stud

Figure 10 – Glow-wire and position of the thermocouple



Dimensions in millimetres

Figure 11 – Arrangement and dimensions of the electrodes for the tracking test



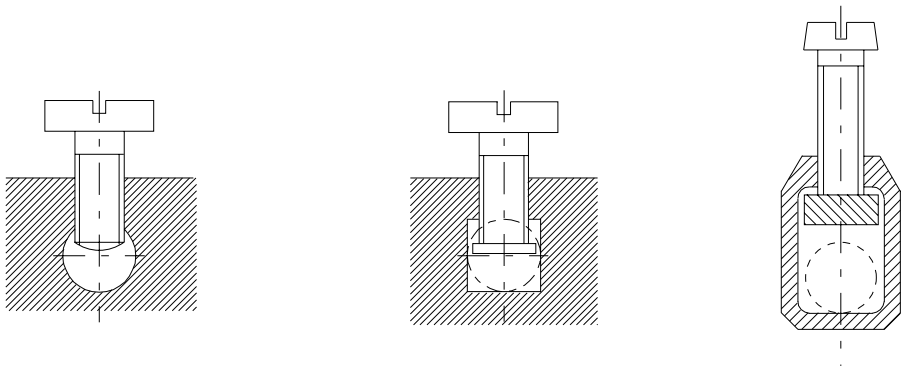
Conductor cross-sectional area		Gauge	
Flexible mm^2	**Rigid (solid or stranded)** mm^2	**Diameter *a*** mm	**Tolerances for *a*** mm
1,5	1,5	2,4	$^{0}_{-0,05}$
2,5	4	2,8	$^{0}_{-0,05}$
4	6	3,6	$^{0}_{-0,06}$
6	10	4,3	$^{0}_{-0,06}$
10	–	5,3	$^{0}_{-0,06}$
16	25	6,9	$^{0}_{-0,07}$
50	70	12,0	$^{0}_{-0,08}$
70	–	14,0	$^{0}_{-0,08}$
–	150	18,0	$^{0}_{-0,08}$
150	185	20,0	$^{0}_{-0,08}$

Dimensions in millimetres

Maximum cross-section of conductors and corresponding gauges.

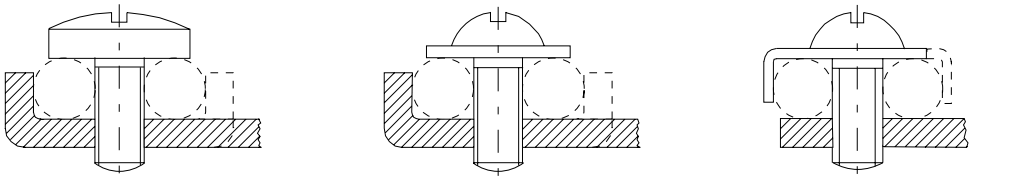
Material: steel.

Figure 12 – Gauges for testing insertability of round unprepared conductors having the maximum specified cross-section



IEC 1214/03

Figure 13a – Pillar terminals

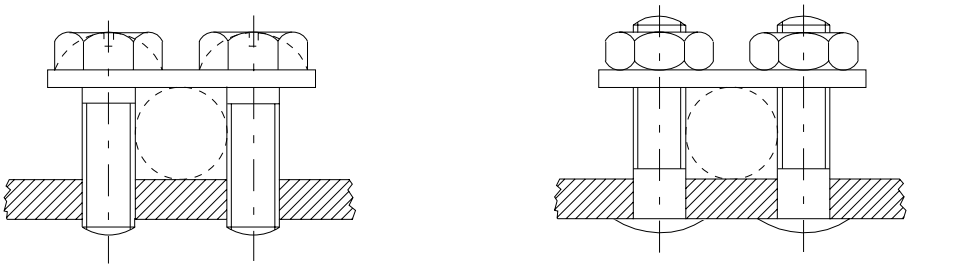


IEC 1215/03

Figures 13b and 13c – Screw terminals

IEC 1216/03

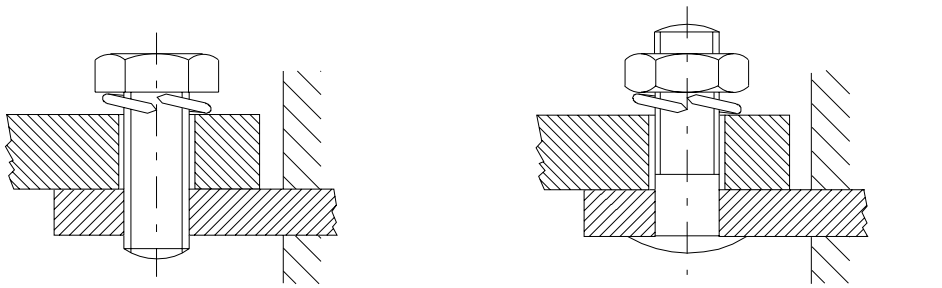
Figure 13d – Stud terminals



IEC 1217/03

Figure 13e – Saddle terminals

Figure 13 – Examples of terminals



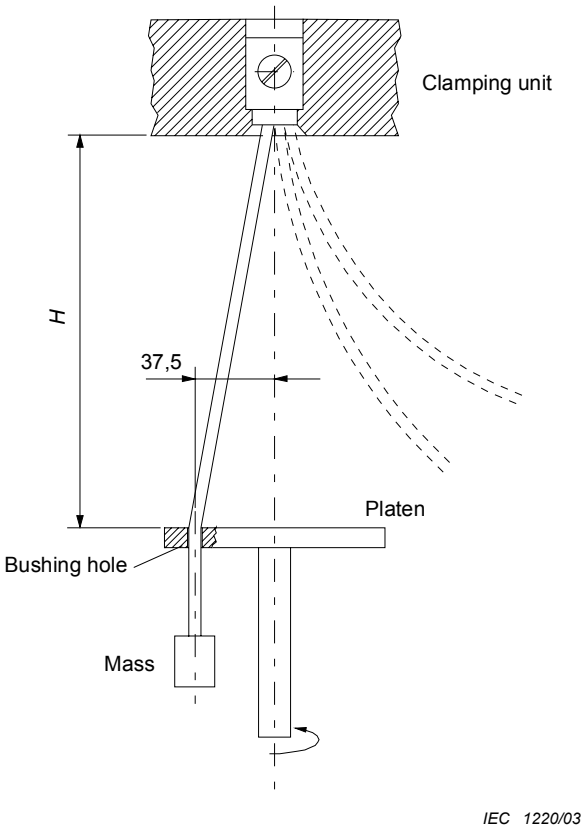
IEC 1218/03

Figure 13f – Lug terminals

IEC 1219/03

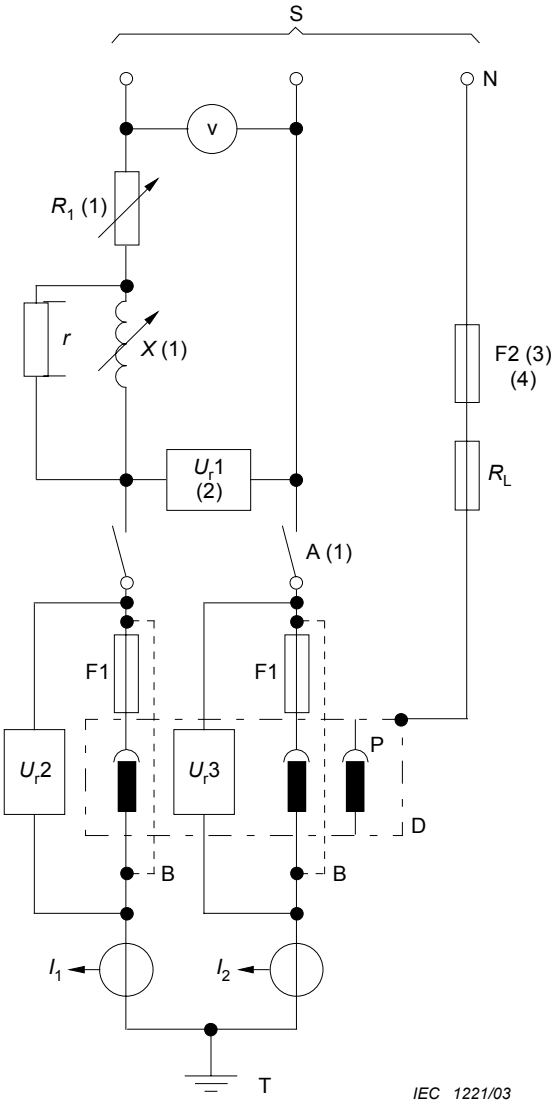
Figure 13g – Mantle terminals

Figure 13 – Examples of terminals *(continued)*



Dimensions in millimetres

Figure 14 – Equipment test arrangement



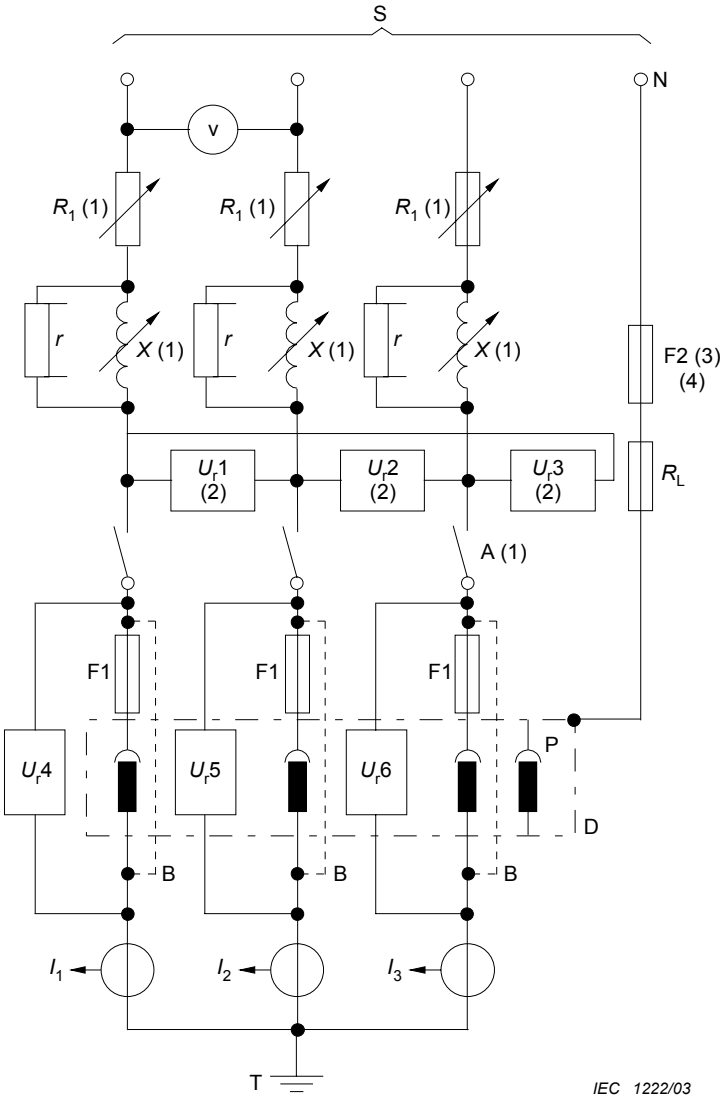
Key

S	=	Supply
U_r1, U_r2, U_r3	=	Voltage sensors
V	=	Voltage measuring device
A	=	Closing device
R_1	=	Adjustable resistor
N	=	Neutral of supply (or artificial neutral)
F2	=	Fusible element
X	=	Adjustable reactor
R_L	=	Fault current limiting resistor
D	=	Equipment under test (including connecting cables)
F1	=	Fuses
B	=	Temporary connections for calibration
I_1, I_2	=	Current sensors
T	=	Earth – One earthing point only (load side or supply side)
r	=	Shunt resistor
P	=	Pilot contact

NOTE 1 Adjustable loads X and R_1 may be located either on the high-voltage side or on the low-voltage side of the supply circuit, the closing device A being located on the low-voltage side.

NOTE 2 U_r1, U_r2 and U_r3, may, alternatively, be connected between phase and neutral.

Figure 15 – Diagram of the test circuit for the verification of short-circuit current withstand of a two-pole equipment on a single-phase a.c. or d.c.



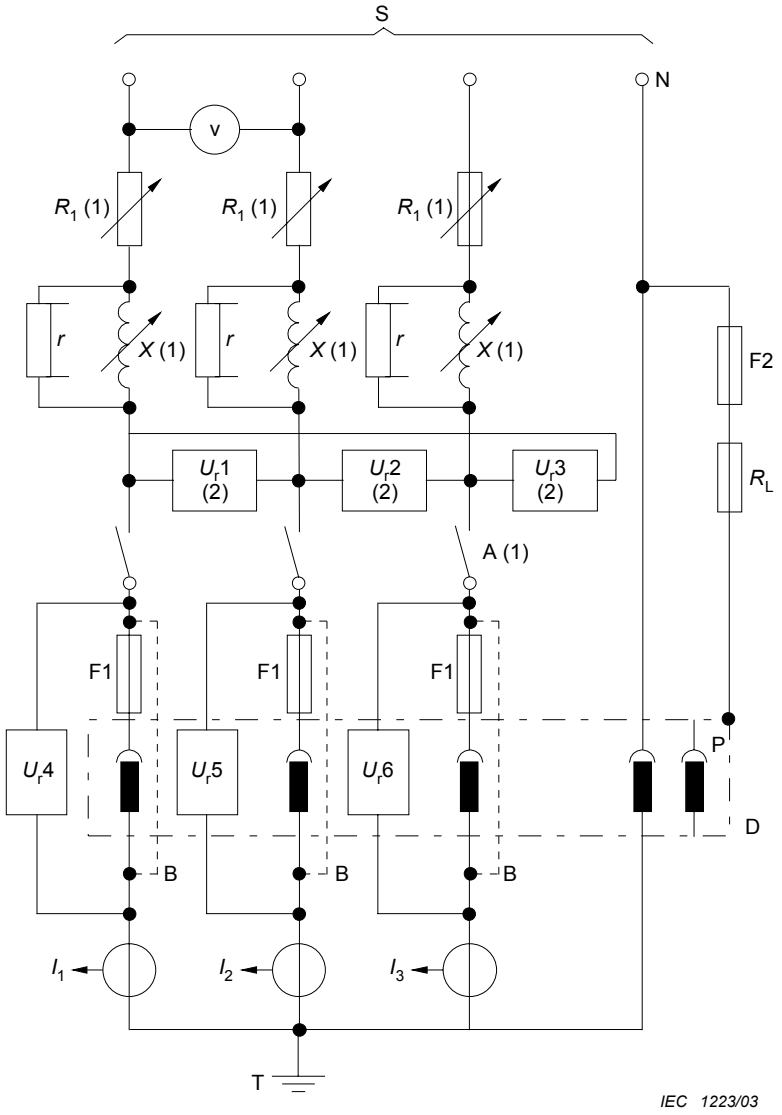
Key

S	=	Supply
U_r1, U_r2, U_r3, U_r4, U_r5, U_r6	=	Voltage sensors
V	=	Voltage measuring device
A	=	Closing device
R_1	=	Adjustable resistor
N	=	Neutral of supply (or artificial neutral)
F2	=	Fusible element
X	=	Adjustable reactors
R_L	=	Fault current limiting resistor
D	=	Equipment under test (including connecting cables)
F1	=	Fuses
B	=	Temporary connections for calibration
I_1, I_2, I_3	=	Current sensors
T	=	Earth – one earthing point only (load side or supply side)
r	=	Shunt resistor
P	=	Pilot contact

NOTE 1 Adjustable loads X and R_1 may be located either on the high-voltage side or on the low-voltage side of the supply circuit, the closing device A being located on the low-voltage side.

NOTE 2 U_r1, U_r2 and U_r3, may, alternatively, be connected between phase and neutral.

Figure 16 – Diagram of the test circuit for the verification of short-circuit current withstand of a three-pole equipment



Key

S	=	Supply
U_r1, U_r2, U_r3, U_r4, U_r5, U_r6	=	Voltage sensors
V	=	Voltage measuring device
R_1	=	Adjustable resistor
N	=	Neutral of supply (or artificial neutral)
F2	=	Fusible element
X	=	Adjustable reactors
R_L	=	Fault current limiting resistor
D	=	Equipment under test (including connecting cables)
F1	=	Fuses
B	=	Temporary connections for calibration
I_1, I_2, I_3	=	Current sensors
T	=	Earth – one earthing point only (load side or supply side)
r	=	Shunt resistor
P	=	Pilot contact

NOTE 1 Adjustable loads X and R_1 may be located either on the high-voltage side or on the low-voltage side of the supply circuit, the closing device A being located on the low-voltage side.

NOTE 2 U_r1, U_r2 and U_r3, may, alternatively, be connected between phase and neutral.

Figure 17 – Diagram of the test circuit for the verification of short-circuit current withstand of a four-pole equipment

Annex A
(informative)

EV charging

A.1 EV Charging Modes

There are four possible modes of charging, as follows.

Mode 1 charging: connection of the EV to the a.c. supply network (mains) utilizing standardized socket-outlets, rated up to 16 A, at the supply side, single-phase or three-phase, and utilizing phase(s), neutral and protective earth conductors. The use of mode 1 charging depends on the presence of a residual current device (RCD) on the supply side. Where the presence of an RCD on the supply side can not be ensured by national codes, mode 1 charging is not permissible.

NOTE 1 In some countries, mode 1 charging may be prohibited by national codes.

NOTE 2 A standardised socket-outlet is one which meets the requirements of any IEC and/or national standard.

NOTE 3 In France, Germany and Italy, the limitation to 16 A for mode 1 charging is not applicable.

Mode 2 charging: connection of the EV to the a.c. supply network (mains) utilizing standardized socket-outlets, single-phase or three-phase, and utilizing phase(s), neutral, and protective earth conductors together with a control pilot conductor between the EV and the plug or in-cable control box.

Mode 3 charging: direct connection of the EV to the a.c. supply network (mains) utilizing dedicated EV supply equipment where the control pilot conductor extends to equipment permanently connected to the a. c. supply network (mains).

Mode 4 charging: indirect connection of the EV to the a.c. supply network (mains) utilizing an off-board charger where the control pilot conductor extends to equipment permanently connected to the a.c. supply.

A.2 Types of EV Connection (Cases A, B, and C)

The connection of electric vehicles may be carried out in one or more of three different ways:

Case "A" connection: connection of an EV to the a.c. supply network (mains) utilizing a supply cable and plug permanently attached to the EV.

Case "B" connection: connection of an EV to the a.c. supply network (mains) utilizing a detachable cable assembly with a vehicle connector and a.c. supply equipment.

Case "C" connection: connection of an EV to the a.c. supply network (mains) utilizing a supply cable and vehicle connector permanently attached to the supply equipment. Only case "C" is allowed for mode 4 charging.

Bibliography

IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, control gear and fuses.*

IEC 60068-2-75:1997, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

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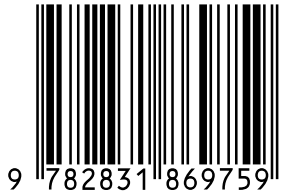

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